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联系方式
中国科学院动物进化与系统学重点实验室
中国科学院动物研究所
北京市朝阳区北辰西路 1 号院 5 号
邮编：100101
办公室电话: 010-64807216
试验室电话: 010-64807211
手机：13910738928
传真：010-64807099
电子邮箱：lisq@ioz.ac.cn

Dr. Shuqiang Li
Key Laboratory of Zoological Systematics and Evolution
Institute of Zoology
Chinese Academy of Sciences
1 Beichen West Road
Beijing 100101, PR. China
Tel.: 0086-10-64807216 (office)
Fax : 0086-10-64807099 (office)
e-mail: lisq@ioz.ac.cn

获奖

- 2008 年获贵州省贵州省科技进步三等奖。
  获奖项目：贵州喀斯特洞穴动物物种多样性及保护研究.
- 2008 年获湖南省自然科学优秀论文二等奖。
  获奖论文： Xu Xiang & Shuqiang Li. 2007. Taxonomic study on the spider family Pimoidae (Arachnida: Araneae) from China. *Zoological Studies* 46(4): 483-502.

杂文

- 因材施教，事半功倍

2008 论文

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贵州省科学技术进步奖

证 书

为表彰贵州省科学技术进步奖获得者，特颁发此证书。

成果名称： 贵州喀斯特洞穴动物物种多样性及保护研究

获奖等级： 三等奖

完 成 人： 李枢强

证 书 号： 2007J-3-12-4

贵州省人民政府

二〇〇七年十二月二十日

湖南省自然科学

优秀学术论文证书

徐 湘 李枢强同志撰写的论文《中国派模蛛科蜘蛛的分类研究》被评为湖南省第12届自然科学二等优秀学术论文。

特发此证

湖南省科协 湖南省人事厅 湖南省科技厅

2008年10月

编号:3016-N-059

因材施教，事半功倍

李枢强 研究员　博士生导师

（中国科学院动物进化与系统学重点实验室）

我是从 1999 年开始指导研究生的。到 2008 年共有 7 届学生，包括 9 名博士和 1 名硕士按时毕业，顺利获得了学位。据《中国科学院生物类研究所论文与引文》统计，2002-2007 年第一著者论文被 SCI 收录最多的前 100 位著者中，我有 4 位学生榜上有名，分别是位于第 3 名的侯仲娥（Hou ZE）、第 21 名的图立红（Tu LH）、第 36 名的彭贤锦（Peng XJ）和第 50 名的徐湘（Xu X）。在其它统计指标上，如 2007 年第一著者论文被 SCI 收录最多的前 50 位著者、2002-2007 年全部著者论文被 SCI 收录最多的前 300 位著者、2002-2007 年 SCI 第一著者论文被 WOS 引用最多的前 100 位著者、2002-2007 年 CSCD 第一著者论文被 CSCD 引用最多的前 100 位著者，我也有多位学生上榜。

在就业方面，毕业的 10 名学生中有 1 名到国外从事博士后研究，其它 9 名目前都活跃在国内高校与科研院所，包括中国科学院成都生物研究所、中国科学院上海生命科学院、中国科学院动物研究所和湖南师范大学等，成为国内科研、教学的新生力量。在新的工作岗位，这 10 名毕业生已经有 2 位晋升为教授（其中 1 名还是博士研究生导师），4 位晋升为副教授或副研究员。他们在新的工作岗位还 8 人次分别获得国家自然科学基金面上项目的资助，标志着他们的工作得到国内同行的认可。

借此机会愿抛砖引玉，向各位老师和同学们汇报一下我在研究生培养方面的一点心得，与大家共勉。

因材施教，事半功倍

无脊椎动物学研究组主要从事无脊椎动物的多样性和多样性形成机制研究的。无脊椎动物是一个大类群，按照目前广泛接受的动物界 34 门分类系统，动物界中 33 个门是无脊椎动物。在国内，有活跃在科研一线的刘瑞玉院士、唐崇惕院士、郑守仪院士等无脊椎动物研究大家，还有刚刚离开我们的沈蕴芬院士、

宋大祥院士等无脊椎动物学界名流。但总的来说，国内无脊椎动物研究力量还十分薄弱，仅在一些单位有成型的队伍，是一个小学科。南开大学、南京大学本科教育过去曾设有动物学专业，是国内无脊椎动物学研究重要的后备力量和生力军。1998 年教育部颁布的高等学校本科专业目录中取消了动物学专业的设置，对无脊椎动物学的学科建设和发展产生了不利影响。动物研究所无脊椎动物学研究组目前研究生来源主要是综合大学和师范院校生物科学专业、农业院校昆虫专业、林业院校森林保护专业的毕业生。来到无脊椎动物学研究组的研究生中，一些人甚至以前还没听说过有这样一个专业。只是因为原来报考老师名额已满等原因，多少有些“不得已”来到无脊椎动物学研究组。

于是，寻找每一个学生“闪光点”就成为我主要的任务。我坚信尺有所长，寸有所短。每一个同学都有他擅长的地方，找到学生的长项并安排与此对应的研究课题，就能做到事半功倍。所谓锥之处囊, 脱颖而出。一般说来，有形态学天赋的同学安排从事分类学和系统学方面的研究；有数学天赋的同学安排从事多样性和行为学方面的研究；擅长室内试验、动手能力强的同学从事分子系统学和物种形成机制方面的研究。几年下来，研究组不仅没有因为这种多样化的安排导致研究方向不集中，相反更多的同行认为我们这种多样化的发展符合现代学科的发展趋势。不同方向的研究对同一个问题相互印证，也增加了国际同行对我们工作的认可。我们投出的稿件国外同行审核时，也常常一路绿灯，使我们论文发表的速度也得到提高。例如从2008年1月到11月，我们无脊椎动物学研究组10名学生和职工已经正式发表了24篇SCI论文，其中包括 *Systematic Biology* (影响因子 8.8), *Molecular Phylogenetics and Evolution* (影响因子 3.9), *Journal of Biogeography* (影响因子 3.5)等一批本领域高影响因子的论文。我们在今年还获得了贵州省科技进步三等奖、湖南省自然科学优秀论文二等奖等奖励。在洞穴蜘蛛的化学生态学、热带雨林蜘蛛的多样性研究等方面也取得了突出的进展，相关成果被本专业高影响因子期刊接受。

注重基础，厚积薄发

过去10年，虽然在研究生培养方面小有成绩，但我的学生们却较少获得研究生培养方面的奖励。这是因为很多评委过多考虑科研产出的数量所致。我的学

生在第一年一般忙于打基础、选题目，第二年才真正开始与项目相关的科研。我仍然记得我带的前 2 个学生参加中期考核时尴尬的情景，他们给人的印象是没有开展太多的工作，没有实际的科研进展。不过，他们现在一个已经发表了将近 30 篇 SCI 论文，是公认的活跃的科研工作者；另外一个毕业不久就成为博士研究生导师。

我常常告诫自己的学生：基础越厚，走得越远。我组侯仲娥副研究员 2007 发表的一篇关于钩虾属的分子系统学研究，被国外同行认为揭示了甲壳纲端足目演化的重要步骤，是一个“基准研究“。侯仲娥在攻读博士学位时先从事一段时间的形态分类学研究，在有良好的形态学基础的前提下再开展分子系统学研究这一培养模式，现在也被同行认为是经典的培养方式。我的学生们毕业后改行的非常少。我想这也许是因为他们在打基础阶段投入太多，不舍得改行吧。

我常常要求学生的工作与国际接轨。新的时代对研究思路、研究方法和研究结果与国际接轨提出了更高的要求。与国际接轨的核心问题是工作质量问题。无论你选择什么样的题目，都要力争精益求精。很多事情看起来容易，做起来也不难。但真正要想做好，成为最好或最好的之一，可以说非常难。我们应该清醒的认识到，我们所面临的现实要求我们必须成为最好或最好的之一。在全球一体化程度越来越高的今天，如果我们不能成为某一领域、某一类群最好的，或者最好的之一，不能被本研究领域国内外专家广泛接受，就不能算是一个成功的基础科学工作者。

德才兼备，任重道远

新的时代对德才兼备提出了更高的要求。“德”包括在政治方向、政治立场上的表现，也包括思想道德品质的状况。“才”包括理论素养、专业知识和工作能力。要坚持德才兼备，有德无才要误事，有才无德要坏事。一个人志大才疏当然成不了才，反过来，如果只有才气，没有优秀的思想品德，也难以成就事业。

同样重要的是，新的时代对团队精神提出了更高的要求。团队（TEAM）是近年来非常流行的一个词汇，它几乎成为将个体利益与整体利益相统一而实现高效率运作的代名词。在中国科学院目前的创新文化氛围中，散兵游勇式的工作方法已经很难再有大的作为，而团队力量的发挥已成为赢得胜利的必要条件。那么

“团队精神”的具体表现是什么？我认为“团队精神”意味着宽容与理解，意味着奉献精神、实干精神和协作精神。当然，不仅团队中每个成员要从大局出发，服从团队的统一安排，而且团队的领导者更要尊重和爱惜每个成员。取得成绩的时候，不能把功劳归于自己；出了问题的时候，不能把失误推给别人。

以上是我在研究生培养方面的一点体会。作为指导教师，前面的路还很长。我愿意和我的学生们一起努力，继续攀登科学的高峰。我愿以保尔・柯察金的一段名言与大家共勉：人最宝贵的东西是生命。生命对于我们只有一次。一个人的生命应当这样度过：当他回首往事的时候，他不因虚度年华而悔恨，也不因碌碌无为而羞愧这样，在临死的时候，他能够说：“我整个的生命和全部精力，都已献给世界上最壮丽的事业为人类的解放而斗争”。

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Inferring Species Membership Using DNA Sequences with Back-Propagation Neural Networks

A. B. ZHANG,[1,4,*] D. S. SIKES,[2] C. MUSTER,[3] AND S. Q. LI[1,*]

[1] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100080, P. R. China; E-mail: zhangab2008@yahoo.com.cn; zhangab@ioz.ac.cn*
[2] *University of Alaska Museum, 907 Yukon Drive, Fairbanks, Alaska 99775-6960, USA*
[3] *Molecular Evolution and Animal Systematics, University of Leipzig, Talstrasse 33, D-04103 Leipzig, Germany*
[4] *Current Address: Albanova University Center, Royal Institute of Biotechnology, SE-106 91 Stockholm, Sweden; E-mail: abzh@kth.se*
[*] *To whom correspondence should be sent.*

Abstract.—DNA barcoding as a method for species identification is rapidly increasing in popularity. However, there are still relatively few rigorous methodological tests of DNA barcoding. Current distance-based methods are frequently criticized for treating the nearest neighbor as the closest relative via a raw similarity score, lacking an objective set of criteria to delineate taxa, or for being incongruent with classical character-based taxonomy. Here, we propose an artificial intelligence–based approach—inferring species membership via DNA barcoding with back-propagation neural networks (named BP-based species identification)—as a new advance to the spectrum of available methods. We demonstrate the value of this approach with simulated data sets representing different levels of sequence variation under coalescent simulations with various evolutionary models, as well as with two empirical data sets of COI sequences from East Asian ground beetles (Carabidae) and Costa Rican skipper butterflies. With a 630- to 690-bp fragment of the COI gene, we identified 97.50% of 80 unknown sequences of ground beetles, 95.63%, 96.10%, and 100% of 275, 205, and 9 unknown sequences of the neotropical skipper butterfly to their correct species, respectively. Our simulation studies indicate that the success rates of species identification depend on the divergence of sequences, the length of sequences, and the number of reference sequences. Particularly in cases involving incomplete lineage sorting, this new BP-based method appears to be superior to commonly used methods for DNA-based species identification. [Back-propagation; DNA barcoding; incomplete lineage sorting; neural networks; species identification.]

DNA barcoding has attracted considerable recent attention with promises to aid in species identification and bioinventory efforts (Hebert et al., 2003a, 2003b; Ebach and Holdrege, 2005; Gregory, 2005; Marshall, 2005; Schindel and Miller, 2005; Ratnasingham and Hebert, 2007). Although still controversial (Will and Rubinoff, 2004; Prendini, 2005; Hickerson et al., 2006; Meier et al., 2006; Whitworth et al., 2007), and certainly not a replacement of traditional taxonomy, numerous potential benefits of DNA barcoding have been generally acknowledged (Savolainen et al., 2005; Ratnasingham and Hebert, 2007).

However, one major issue that needs to be resolved is how to read the organismal barcode once it is generated (DeSalle et al., 2005). Most recently published approaches to DNA barcoding have used distance measures to infer species affiliation (Hebert et al., 2003a, 2003b, 2004). These include two frequently used methods—a simple BLAST approach (Altschul et al., 1990, 1997) and a tree-based genetic distance approach (Hebert et al., 2003a, 2003b; Steinke et al., 2005). These approaches generally use a raw similarity score to produce a nearest neighbor that is not necessarily the closest relative (Koski and Golding, 2001). Furthermore, an *a priori* similarity cut-off is needed to determine species status using these methods. It remains questionable whether such universal cut-off values exist, even among congeneric species (Ferguson, 2002; Hickerson et al., 2006; Whitworth et al., 2007). Thirdly, information is inevitably lost when differences among sequences are converted into genetic distances (Steel et al., 1988). Finally, these non–character-based methods are also criticized as being incompatible with classical character-based taxonomy (DeSalle et al., 2005).

Recently, two new strategies based on a Bayesian framework and decision theory, respectively (Nielsen and Matz, 2006; Abdo and Golding, 2007), have advanced DNA barcoding practice considerably by incorporating statistical approaches that include more information available in DNA sequences. However, these two methods, in essence, are still distance-based in the way they use sequence information, although they use the information in different ways. As we have mentioned above, it has been pointed out by Steel et al. (1988) that genetic information will inevitably be lost when the difference between two sequences is converted into genetic distances, regardless of the way the genetic distance is later used. Furthermore, as pointed out by Abdo and Golding (2007), the Bayesian method as currently implemented (Nielsen and Matz, 2006) cannot handle more than two populations/species at a time and requires a two-step procedure to resolve a "species tie," thereby limiting its use in the practice of DNA barcoding. Although the decision-theory method (Abdo and Golding 2007) uses more of the information in the data than simple distance-based methods, this power comes with a computational expense; e.g., the performance deteriorates even with a small sample size of 25 (in their study they claim that this was a large sample size). Finally, both of these methods rely on some rather restrictive assumptions, such as phylogenetic hypotheses, population genetic postulates, and evolutionary models that may not always apply to real data (Nielsen and Matz, 2006; Abdo and Golding, 2007).

In this paper, we propose a new method of allocating specimens to species using DNA sequence data, based on existing back-propagation neural network methods. Artificial neural networks (ANNs) were originally developed to model the function of connected neurons in the brain (Rosenblatt, 1958) and they continue to be used in cognitive science. However, their utility as a general computational method was realized with the development of the back-propagation method (Werbos, 1974; Rumelhart et al., 1986; Parker, 1987). Smith (1993) described neural networks and the back-propagation procedure in detail. The method is nonlinear, can represent any function to an arbitrary precision, and makes no assumptions about the frequency distributions of the data. Although each individual neuron implements its function rather slowly and imperfectly, collectively a network can perform a surprising number of tasks quite efficiently (Reilly and Cooper, 1990). This information-processing characteristic makes ANNs a powerful computational device, able to learn from examples and capable of generalizing to examples never seen before (Zhang et al., 1998). They have been applied successfully in many fields, including the prediction of financial markets, speech synthesis, handwriting recognition, and medical diagnostics. In the fields of evolutionary biology and molecular biology, artificial neural networks have been applied to DNA/RNA and protein sequence analysis (Wu, 1997; Wu and Chen, 1997) such as protein and ribosomal RNA classification (Wu and Shivakumer, 1994; Wu et al., 1995; Wang, 1998) and phylogenetic reconstruction (Dopazo and Carazo, 1997).

Below we demonstrate using a set of simulated data sets and two empirical data sets how such an artificial intelligence–based approach can be used to assign an unknown sequence to a species name. The empirical data sets include examples of different phylogenetic distances comprising sets of related species and genera (ground beetles) and a complex of closely related cryptic species (skipper butterfly).

MATERIALS AND METHODS

Neural Network

Definition of a neural network.—A neural network is a parallel computational model comprised of a large number of adaptive processing units (neurons) that communicate through interconnections with variable strengths (weights), in which the learned information is stored. A multiple layer network has one or more layers of hidden neurons, which enables the learning of complex tasks by extracting progressively more meaningful features from the input patterns (Wu, 1997). Figure 1a shows a typical neural network that contains one input layer, a few hidden layers, and one output layer (Zhang et al., 1998; Zhang et al., 2002; Appendix 1). In this figure, the circles indicate input neurons and the rectangles represent neurons that are extremely simple analog computing devices. In this study, we always use three layers (described as n-h-m network); the input layer contains the values for vector $X = [x_1, x_2, \ldots, x_n]$, a hidden layer that contains h codes ($h = int(\log_2(n))$), and one output vector $O = [o_1, o_2, \ldots, o_m]$ that gives the values of output. The lines connecting the neurons represent weights that could be described by two matrices:

$$W_{(1)} = \begin{pmatrix} w_{11} & \ldots & w_{1j} \\ \vdots & \ddots & \vdots \\ w_{i1} & \cdots & w_{hn} \end{pmatrix} \tag{1}$$

and

$$W_{(2)} = \begin{pmatrix} w_{11} & \ldots & w_{1j} \\ \vdots & \ddots & \vdots \\ w_{i1} & \cdots & w_{mh} \end{pmatrix} \tag{2}$$

The following activation function,

$$f(x) = \frac{1}{1 + e^{-x}} \tag{3}$$

was used to compute the value of a neuron. Let the activation value for neuron j be o_j. Let the weight between neuron j and neuron i be $w_{ij}(1, 2)$. These weights are what determine the output of the neural network. Therefore, it can be said that the connection weights form the memory of the neural network. Let the net input to neuron be net_j, then

$$net_j = \sum_{i=1,k} w_{ij} o_j \tag{4}$$

where k is the number of neurons feeding into neuron j and

$$o_j = f(net_j) = \frac{1}{1 + e^{-\sum\limits_{i=1,k} w_{ij} o_j}} \tag{5}$$

Training a network using reference sequences.—Reference sequences were digitized using the following codes: A = 0.1, T = 0.2, G = 0.3, C = 0.4 and were used to train the network (Fig. 1b). A layer's weights and biases were initialized according to the Nguyen-Widrow initialization algorithm (Nguyen and Widrow, 1990), which chooses values in order to distribute the active region of each neuron in the layer evenly across the layer's input space. Each row vector $t_i (i = 1, 2, \ldots, m$, where m is the number of species) was contained in the following diagonal matrix

$$T = \begin{pmatrix} a_{11} & \ldots & 0 \\ \vdots & a_{ii} & \vdots \\ 0 & \cdots & a_{mm} \end{pmatrix} \tag{6}$$

where a_{ii} is equal to 1, representing species i. The training process is usually as follows (Zhang et al., 1998). First, examples of the training set are entered into the input nodes. The activation values of the input nodes are weighted and accumulated at each node in the first hidden layer. The total is then transformed by an activation function into the node's activation value. It in turn becomes an input into the nodes of the next layer, until eventually the output activation values are found. The training algorithm is used to find the weights that minimize some overall error measure such as mean squared

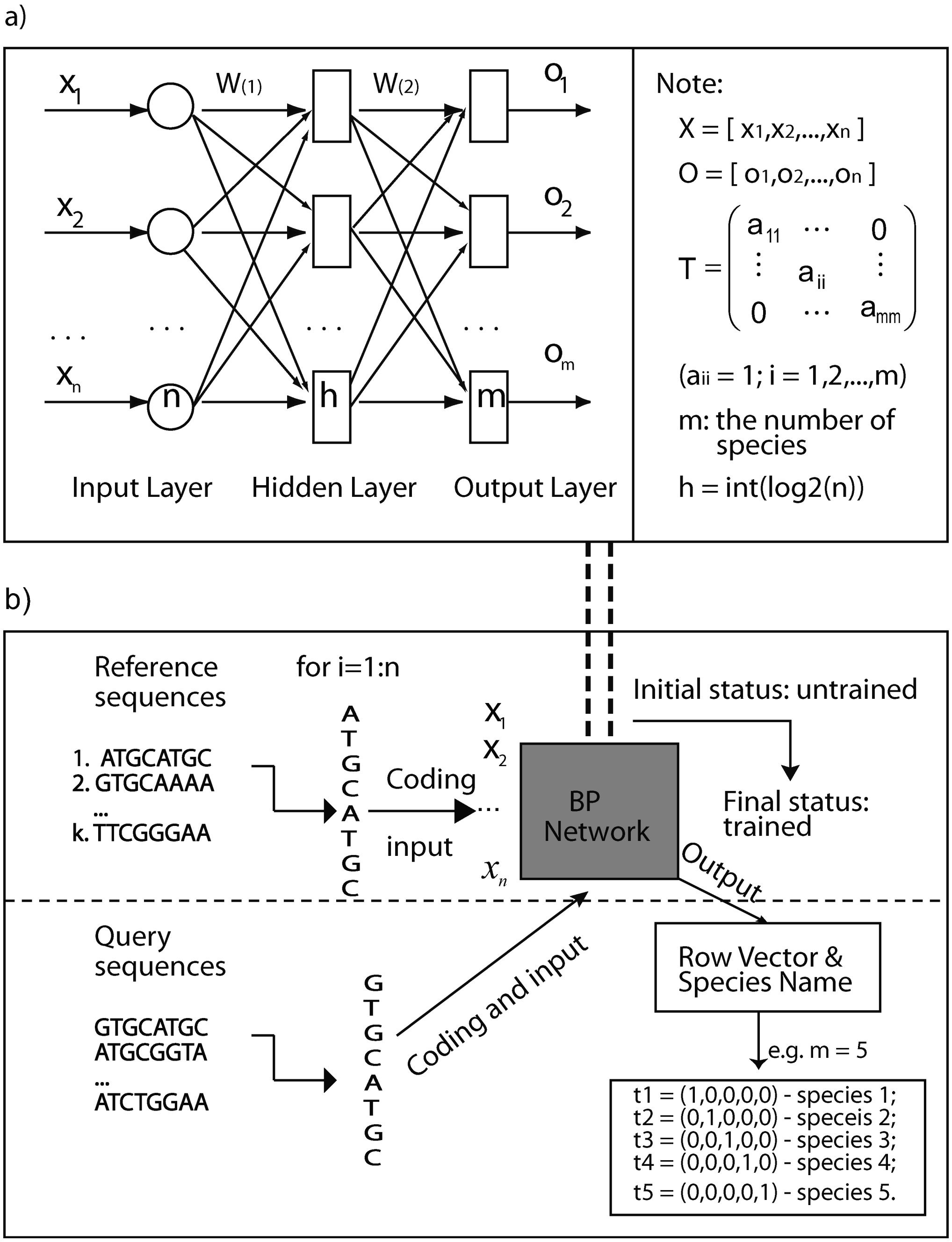
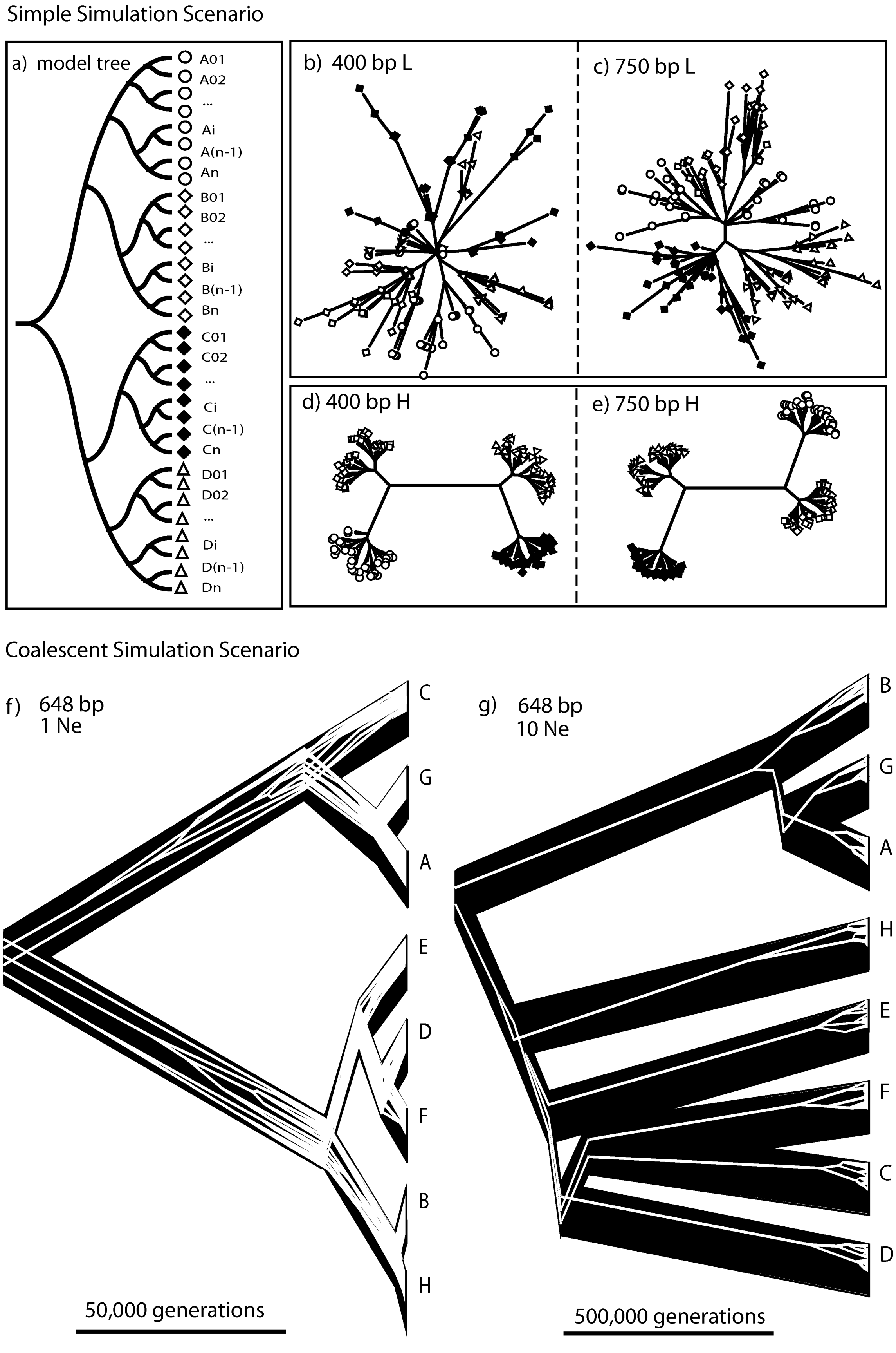


FIGURE 1. Neural network and processing scheme of sequences involved. (a) A typical neural network, including one input layer, a few hidden layers, and one output layer. In this study, we use a three-layer BP network (see text). $X = [x_1, x_2, \ldots, x_n]$ is the input layer vector, and $O = [o_1, o_2, \ldots, o_m]$ is the output layer vector. The circles or rectangles are the neurons. $W_{(1)}$, $W_{(2)}$, together with the lines connecting the neurons, represent the weights for each layer respectively (see text for the definitions). (b) Processing scheme of references sequences (training data set) and query sequences (test data set). Above the dotted line is the training data set and below are the test data set cases. The line with arrow indicates the direction of processing. The sequences were coded using the method described in the text. A set of weights and biases were obtained once a network was trained. A trained network is ready to assign a query sequence to a known species by producing a corresponding row vector. The double vertical dashed line indicates how the top graph fits into the bottom graph.

errors (MSEs). Hence the network training is actually an unconstrained nonlinear minimization problem. Before a network is trained, the weights and biases are evaluated using the Nguyen-Widrow initialization algorithm (Nguyen and Widrow, 1990). To put it simply, the training process will try to adjust the weights so that the network will generate correct target outputs for given network inputs. We used mean squared error (MSE)—the average squared error between the networks and the target outputs as a performance function. The weights and biases are updated in the direction of the negative gradient of the performance function using a technique called


Simple Simulation Scenario
a) model tree
A01
A02
...
Ai
A(n-1)
An
B01
B02
...
Bi
B(n-1)
Bn
C01
C02
...
Ci
C(n-1)
Cn
D01
D02
...
Di
D(n-1)
Dn
b) 400 bp L
c) 750 bp L
d) 400 bp H
e) 750 bp H
Coalescent Simulation Scenario
f) 648 bp
1 Ne
C
G
A
E
D
F
B
H
50,000 generations
g) 648 bp
10 Ne
B
G
A
H
E
F
C
D
500,000 generations

back-propagation (Werbos, 1974; Parker, 1982; Rumelhart and McClelland, 1986; Smith, 1993), which involves performing computations backwards through the network. To provide faster convergence and allow a network to respond not only to the local gradient but also to recent trends in the error surface, momentum has been added to back-propagation learning by making weight changes equal to the sum of a fraction of the last weight change and the new change suggested by the back-propagation rule. Briefly, back-propagation is used to calculate derivatives of performance $perf$ with respect to the weight and bias variables X. Each variable is adjusted according to gradient descent with momentum,

$$dX = mc \times dXprev + lr \times (1 - mc) \times {}^{dperf}/_{dX} \qquad (7)$$

where $dXprev$ is the previous change to the weight or bias, mc is the value of momentum, and lr represents the learning parameters. One hundred thousand or more iterations (epochs) were used to achieve smaller values of mean square errors. For a trained network, the main parameters, weights and the bias, were saved. A value of 0.95 (the highest theoretical value is 1) for the projected vector as the BP identification score was used because higher values would need longer training times.

Identifying query sequences using a trained network.—The query sequences were coded using the method described above. Each numeral coding of each nucleotide site became one element of the input vector X (Fig. 1b). Then, the input vector X was fed into the trained network, and one output row vector O, corresponding to a different species following Formula 6, was obtained for each input vector X (see Fig. 1 for details). The aim of training a network is to let $o_1, o_2, ..., o_m$ be close to target vector T, whose sub-row-vectors, such as $(1, 0, 0, 0)$ for a four-species example, represent species 1 (predefined). After training, the output vector of the network for one of sequences selected from species 1 could be like $(0.9989, 0, 0, 0)$. In our study, we use 0.95 as a threshold. Higher values (than 0.95) could be used but may need longer training time (the highest theoretical value is 1). In the example above, the vector would refer to species 1, whereas species 2 would correspond to $(0, 1, 0, 0)$. The success rate of species identification was based on the following formula:

$$Rate_{success} = \frac{Number_{hit}}{Number_{test}} \qquad (8)$$

where $Number_{hit}$ and $Number_{test}$ are the numbers of sequences successfully hit by the present method and the number of total query sequences examined, respectively.

Simulated Data Sets

We used computer simulations to investigate the power of our new approach in different situations. Firstly, using a relatively simple model of molecular evolution, we evaluated the effects of sequence length and the size of the training data set on the success rate of species identification with different methods. Secondly, we fixed the length of sequences and further evaluated the influence of the size of the training data sets, together with incomplete lineage sorting, on the success rate of species identification under coalescent simulations with more complex evolutionary models.

Simulation with simple evolutionary models.—A total of 128 sequences was generated using Monte Carlo simulation of DNA sequence evolution implemented in Seq-Gen (Rambaut and Grassly, 1997) for a model tree with four species (A, B, C, D), each including 32 individuals (Fig. 2a). We randomly chose 4, 8, 16, 24, and 28 sequences from each species to construct data sets containing 16, 32, 64, 96, and 112 reference sequences, respectively. The remaining sequences from the corresponding data set were used as query sequences.

The F84 model (Felsenstein, 1984; Yang, 1993) was used to generate the simulated data (Fig. 2a). We set the transition/transversion ratio (k) equal to 10, the gamma parameter (Γ) to 10, and the frequencies of nucleotides A, C, G, and T, g_A, g_C, g_G, and g_T, respectively, to 0.35, 0.15, 0.15, and 0.35. The L1 and L2 values, which indicate the levels of sequence divergence on the model trees, were set to represent a range of divergence levels from high to low (L2/L1 = 0.01/0.2 and L2/L1 = 0.001/0.0015, respectively), where L1 and L2 represent substitution rate per site among species and within species, respectively. Each branch length is assumed to denote the mean number of nucleotide substitutions per site that will be simulated along that branch. For each parameter combination, the topologies displayed in Fig. 2a were simulated 20 times, generating random data sets of 400 bp and 750 bp in length, respectively. The longer sequence corresponds to the standard fragment length that is used in animal barcoding (Herbert et al., 2003a, 2003b). The 400-bp fragment was used to investigate the feasibility of using shorter sequences in DNA barcoding. The resulting sets of sequences were used to generate the data sets of reference sequences and query sequences described

←

FIGURE 2. Simple/coalescent simulation scenario. (a–e) Model tree and neighbor-joining (NJ) trees (one example each from twenty simulated datasets) of the simulated sequences of different divergence in the simple simulation scenario. (a) Model tree, which contains four species, each including 32 individuals; (b) NJ tree of 400-bp sequence with low sequence variation (400 bp L); (c) NJ tree of 750-bp sequence with low sequence variation (750 bp L); (d) NJ tree of 400-bp sequence with high sequence variation (400 bp H); (e) NJ tree of 750-bp sequence with high sequence variation (750 bp H). The different terminal symbols on each tree correspond to the four species in (a) (f, g) Gene tree (white, inside) simulated by neutral coalescence within simulated species tree (black, outside) in the coalescent simulation scenario ($GTR + \Gamma + I$ model). (f) Example of a gene tree contained in a species tree of recent divergence (total depth of species tree $= 1\ N_e$, where $N_e = 100,000$). (g) Example of a gene tree contained in a species tree of ancient divergence (total depth of species tree $= 10\ N_e$, where $N_e = 100,000$). Thirty-two sequences were simulated for each species. More topologies of species trees simulated in this study can be found in online Appendix 1.

above. The success rate was calculated using Equation 8. The average success rate of 20 runs was used for comparisons.

Coalescent simulations with complex evolutionary models.—For these simulations, we took into account the possible discordance between species trees and gene trees resulting from incomplete lineage sorting (divergence time in generations less than 1 N_e), together with complex evolutionary models. All simulations were performed using Mesquite version 1.12 (Maddison and Maddison, 2006).

The simulation strategy is illustrated in Figure 2f, g. First, species trees were generated by a pure birth process using Mesquite's Uniform Speciation (Yule) module. We generated 20 species trees with different topologies (online Appendix 1; available at www.systematicbiology.org). Within each species tree, coalescent simulations were performed to generate gene trees. We then simulated sequence evolution along those gene trees to generate a set of sequence matrices using the $GTR + \Gamma + I$ model (two different settings: GTR_1 and GTR_2; see below). We fixed the length of the sequence to 648 base pairs, which is a commonly used length (Hebert et al., 2003a, 2003b), and we had already investigated the effect of sequence lengths on the success rate of species identification in the simulations above. For both GTR models, we considered deeper species trees (total depth of 10 N_e generations) and shallower species trees (depth $= 1N_e$). Parameter values used in GTR_1 ($GTR + \Gamma + I$) were derived from Roe and Sperling's (2007) study, although they could be assigned arbitrarily: base frequencies 0.35 A, 0.15 C, 0.25 G, 0.25 T; rates AC = 2, AG = 4, AT = 1.8, CG = 1.4, CT = 6, and GT = 1; gamma shape parameter was set as 0.5, and proportion of invariable sites was equal to 0.26. For GTR_2 ($GTR + \Gamma + I$), we used the following settings: base frequencies 0.32 A, 0.10 C, 0.12 G, 0.46 T; rates matrix 10.6 AC, 16.7 AG, 8.8 AT, 1.5 CG, 122.9 CT, and 1.0 GT; gamma shape parameter 0.85; and proportion of invariable sites 0.58. An effective population size (N_e) of 100,000 and a scaling factor of 3×10^{-8} were used for all simulations.

We simulated eight species, each containing 32 individuals, resulting in 256 OTUs for each sequence matrix. We selected 1, 4, 12, 24, and 28 individuals from each of eight species as training data in each sequence matrix, resulting in training data sets with 8, 32, 96, 192, and 224 sequences, respectively. The remaining sequences were used as query sequences.

To compare with commonly used approaches, we also calculated success rates using both the simple BLAST approach (Altschul et al., 1990, 1997) and a distance-based approach (Hebert et al., 2003a, 2003b; Steinke et al., 2005) in each simulated data set. We used a standalone BLAST program for Windows (BLASTN 2.2.14; Altschul et al., 1997, ftp://ftp.ncbi.nlm.nih.gov/blast/executables/LATEST-BLAST/), whose main advantage is the ability to create our own BLAST databases using reference sequences. Each query sequence was submitted and compared with the contents of the BLAST databases. The sequence producing the maximum score in the database was considered to be conspecific with the query sequence. We also calculated corrected pairwise genetic distances between each query sequence and reference sequence under the F84 or GTR models using PAUP* version 4.0b10 (Swofford, 2002). The query sequence was considered conspecific with the least distant reference sequence. The success rate of species identifications were calculated using Equation 8 as above. To study the relationship of the success rate among these methods and our BP-based method, we further performed correlation analysis among the three methods under complex simulations.

Ground Beetle Data

We examined an empirical data set taken from Zhang et al. (2005, 2006) and Zhang and Sota (2007), consisting of 159 mitochondrial COI sequences (690 bp) from nine ground beetle species that belong to two subgenera of *Carabus* (Coleoptera: Carabidae), *Leptocarabus* and *Coptolabrus* (online Appendix 2; available at www.systematicbiology.org). Six to 30 individuals of each species were sampled from different locations on the Korean peninsula and Japanese islands. The beetles were determined based on characters of external and genital morphology. We divided the sequences into two categories, reference sequences and query sequences, by randomly choosing half of the individuals from each species. This resulted in 79 reference sequences and 80 query sequences (online Appendix 2). The former were used to train a three-layer network, and the latter were fed into the trained network to output row vectors corresponding to species. The success rate of species identification was calculated using Equation 8. Additionally, as mentioned above, to examine the power of shorter sequences in species identification, we simply divided the 690-bp COI sequence into the first half and the second half, each 345 bp in length. As above, with these shorter lengths we used 79 reference sequences and 80 query sequences. Two new networks were constructed and trained, corresponding to these two data sets.

Neotropical Skipper Butterfly Data

We also used an empirical data set of the Neotropical skipper butterfly "*Astraptes fulgerator*" (Lepidoptera: Hesperiidae), which recently has been proposed to form a complex of at least 10 separate species on the basis of DNA barcoding (Hebert et al., 2004; but see Brower, 2006). Four hundred and seven mitochondrial COI sequences of *Astraptes fulgerator* were obtained from the published DNA barcoding project (Code-EPAF: http://barcodinglife.org/views/projectlist.php?&). We removed sequences that were too short or contained ambiguous characters. The remaining sequences were aligned using ClustalX version 1.83 (Chenna et al., 2003), resulting in an alignment of 630 bp (online Appendix 2). This empirical data set provides an ideal basis for comparison of our approach with other recently developed barcoding identification strategies, because it was used in both the Nielsen and Matz (2006) and Abdo and Golding (2007) studies. Abdo and Golding (2007) have shown that their decision-theory method resulted in higher rates of correct species assignment than the Nielsen and Matz (2006) method, we therefore focused on the comparison between Abdo and Golding's and our approaches. In their simulation, Abdo and Golding took almost all available sequences as training data, and only one sequence was drawn as the query sequence from all the available sequences. To contrast against the Abdo and Golding (2007) method, we only chose one third, half, and all except for one of the sequences of each species randomly as training data (note: in this latter case, we still used fewer training data since we withheld nine sequences as query sequences). The corresponding remaining sequences were used as query sequences. Obviously, our training data sets were much smaller than theirs. As the number of available training sequences is limited in most real barcoding projects, we regard the method that requires fewer reference sequences for an equally good performance as superior.

Phylogenetic Analysis

Phylogenetic trees, under the maximum likelihood (ML) criterion, were inferred using PAUP* 4.0b10 (Swofford, 2002) and Garli v.0.951 (Zwickl, 2006); Bayesian methods were implemented using MrBayes v3.1.2 (Ronquist and Huelsenbeck, 2003). We used the $GTR + \Gamma + I$ (carabid data set) and $HKY + \Gamma + I$ (hesperiid data set) models chosen by implementation of the AIC in the program MrModelTest v2.2 (Nylander, 2004). For the carabid data set PAUP* was used to first optimize parameter values via an iterative fixation and relaxation of parameters combined with heuristic searching with TBR branch swapping. This strategy is described in Sullivan et al. (2005). Once parameter values stabilized with additional searches, we fixed them for subsequent ML bootstrapping. Bootstrapping entailed heuristic searching with TBR branch swapping on starting trees obtained by neighbor joining with a limitation of 1000 rearrangements evaluated for each of 100 searches. This was repeated and the (nearly identical) bootstrap values of the two runs were averaged for reporting on the presented trees. Due to the large size of the hesperiid data set (407 OTUs), PAUP* could not be used to perform ML bootstrapping. Instead, we used the genetic algorithm approach implemented in the program Garli v.0.951 (Zwickl, 2006), which enabled us to complete 100 pseudoreplicate ML bootstrap analyses for these 407 OTUs in 2 CPU days (on a 2.16-GHz Intel Core Duo Macintosh).

Bayesian analyses were conducted by using MrBayes' default strategy of running two simultaneous analyses, allowing for monitoring of the average standard deviation of the split frequencies to help assess when stationarity of the MCMC chains had been reached. These chains were run for 5 million steps, sampling one of every 1000 trees. This was repeated for a total of four independent runs. For the carabid data set, the average standard deviation of the split frequencies reached 0.015 by step 2.5 million, so burn-in was set at 50%, resulting in 2500 trees from each run. For the hesperiid data set, the average standard deviation of the split frequencies of the first analysis never got below 0.9, whereas this metric dropped below 0.05 for the second analysis by step 2.5 million, indicating that the runs had converged. The uncorrected potential scale reduction factor (PSRF) of Gelman and Rubin (1992), which should approach 1 as runs converge, was 1.00 for all post–burn-in parameter estimates. Examination of the trace files for these MCMC runs also showed all four analyses had reached the same parameter space. The carabid data set chains reached stationarity with nearly identical harmonic means of the marginal log-likelihoods (−4133 to −4134, combined ESS of 954). Tracer v1.3 was used to calculate the autocorrelation times (the distance separating independent samples) of each of these four runs, which were 9585 to 11,460, suggesting our sampling strategy of one tree per 1000 was oversampling by a factor of 10. The harmonic means of the marginal log-likelihoods for the hesperiid data set were also virtually identical (−2001 to −2010) and the combined ESS for all parameters was >309, indicating that sufficient independent samples had been taken to estimate the model parameters. The 50% majority-rule consensus phylogram built from the post–burn-in trees of the first two independent runs of the carabid data set and the second two runs of the hesperriid data set was used to present the inferred phylogenies.

RESULTS

Simulated Data Sets

Simple model scenario.—The network was trained using the reference sequences with 100,000 iterations (epochs) for each simulation data set. This produced a mean squared error less than 0.0001. It took 10 min for a data set of 16 sequences of 400 bp from four species to about 5 h for a data set of 224 sequences of 648 bp from eight species to train a network on a Windows PC (Intel (R), Core (TM) 2 CPU 6400, 2.13 GHz, 0.99 GB of RAM, depending on the size of data set. Once a data set was trained, it could identify thousands of test sequences within a few seconds or minutes. It's also possible to continue the training of one network by adding additional training data. This could be very useful in the DNA-barcoding practice.

All compared methods—BP-based species identification, BLAST, and distance-based approaches—can identify species with almost 100% average success rates in the case of high levels of sequence variation (interspecific divergence greatly exceeding intraspecific divergence), regardless of the length of sequences and the number of reference sequences (results not shown). In simulations with extremely low levels of sequence variation, the success rate of species identification to a large extent depends on the size of data set (number of reference sequences) and length of sequence (Fig. 3a, b). However, our method can identify species with higher success rate than traditional BLAST and distance-based

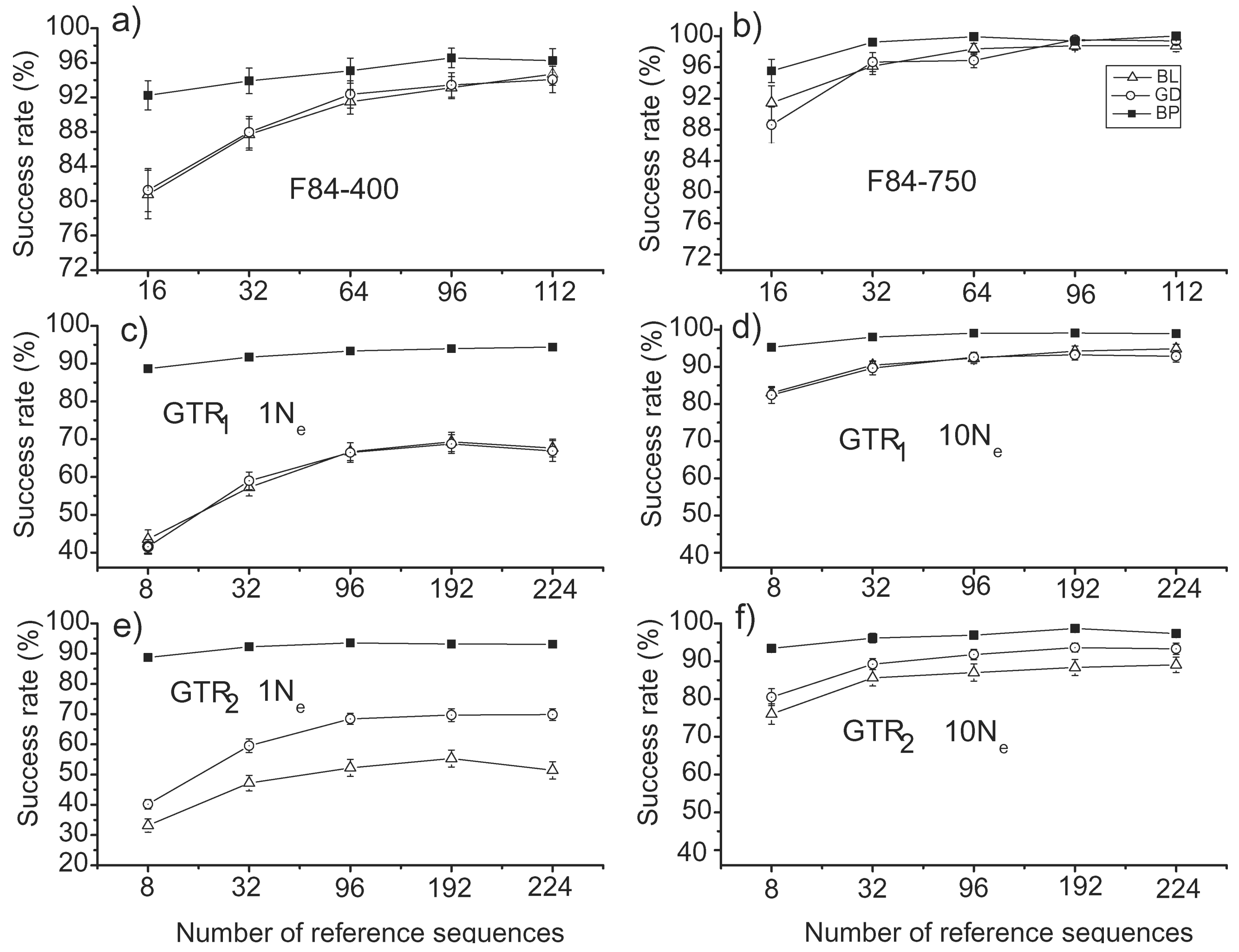


FIGURE 3. Success rates of species identifications with BLAST method, genetic distance method, and BP-based method in the simple simulation/model scenario (with low sequence divergence) and under coalescent simulation with the $GTR + \Gamma + I$ model. All above simulations were conducted with 8, 32, 96, 192, and 224 reference sequences, respectively. Detailed settings of parameters of each model can be found in the text. Triangle, circle, and solid squares indicate the success rates of BLAST method (BL), genetic distance (GD), and BP-based methods (BP), respectively. Horizontal bars below and above each symbol represent standard errors.

approaches in almost all cases of low levels of sequence variation, especially with smaller data sets. For example, for the 16-sequence data set with 750-bp length sequence, the BLAST and distance-based methods only assigned 91.43% ± 2.19% and 88.61% ± 2.31% of the query sequences to the correct species, respectively, whereas our BP-based species identification approach allowed correct identifications with a substantially higher success rate (95.54% ± 0.08%; Fig. 3b).

Generally, with low sequence variation, an overall increase in the success rate of species identification was observed with increasing reference sequence data set size for all methods; e.g., from 91.43% ± 2.19% success rate (16 sequences data set) to 98.75% ± 0.73% success rate (112 sequences database) for BLAST method, and from 95.54% ± 1.50% success rate to 100.00% ± 0.00% success rate for our BP-based method (Fig. 3b). Short sequences (400 bp) yielded much lower success rates than long sequences (750 bp), regardless of the number of reference sequences in the data set (80.76% ± 2.80% with 400 bp versus 91.43% ± 2.19% with 750 bp for the BLAST method; 92.23% ± 1.70 % with 400 bp versus 95.54% ± 1.50% with 750 bp for our BP-based method; Fig. 3a, b).

Coalescent simulations with complex models.—Figure 3c to f summarizes the simulation results of two different coalescent models (GTR_1 and GTR_2). In all cases using these more complex simulated data, the average success rate of the BP-based method was significantly greater than that of BLAST or distance-based methods (Fig. 3c to f; online Appendix 3; available at www.systematicbiology.org), especially in cases involving incomplete lineage sorting ($1N_e$). Both distance-based and BLAST methods performed poorly in situations of incomplete lineage sorting with a small number of reference sequences; e.g., BLAST and distance-based methods could only identify species with success rates of 33.16% ± 2.19% and 40.18% ± 1.57%, respectively, when only one sequence of each species was selected as the reference sequence (Fig. 3c, e). With increasing of numbers of reference sequences, both the BP-based method and the BLAST and distance-based methods attained higher success rates (Fig. 3c to f). There is a large difference in correct species identification between deeper and shallower species trees (total depth of 10 N_e generations versus 1 N_e) for all three methods (Fig. 3c to f). All presented higher success rates with deeper internal branches than with shallower, regardless of the underlying evolutionary models and the number of reference sequences. For example, the BLAST and the genetic distance methods obtained success rates of 51.54% ± 2.84% and 69.84 ± 1.94%, respectively, under the model of GTR_2 with 224 reference sequences (shallow species trees: 1 N_e), whereas the BP-based method attained a 93.13% ± 1.29% success rate in the same situation. However, they achieved success rates of 89.06%, 93.28%, and 97.34%, respectively, with deeper species trees (deep species trees: 10 N_e). The distance-based method demonstrated slightly higher success rate of species identification than the simple BLAST approach under the model of GTR_2, although both methods identified species with lower success rates than the BP-based method (Fig. 3c to f, online Appendix 3).

Significant correlations of success rates between the BLAST and distance-based methods were found ($P = 0.00128$ or <0.0001), whereas no correlation was found between the BP-based method and the BLAST or genetic distance methods ($P = 0.78$–0.96 in all cases). This analysis indicates that the BP-based method performs species identifications in a quite different (and more successful) way than distance-based and BLAST approaches.

Empirical Data Sets

Bayesian trees from four independent runs for nine ground beetle species are presented in Figure 4a. Detailed relationships for three closely related, nonmonophyletic *Carabus* species, *C. (L.) arboreus, C. (L.) procerulus,* and *C. (L.) hiurai,* are presented in Figure 4b. Figure 5 shows Bayesian trees from four independent runs for the species *Astraptes fulgerator* for 407 OTUs.

The network was trained for the empirical data sets using the same method used for the simulated data; the connection weights and output vectors are shown in online Appendix 4 (available at www.systematicbiology.org). A total of 159 identified ground beetle specimens were used. We randomly selected 79 sequences from all of the nine ground beetle species (half of each species) as reference sequences to train a three-layer network. Among 80 query sequences, 78, 76, and 78 sequences were successfully assigned to the correct species (97.50%, 95.00%, and 97.50% success rate, respectively) with the first half (345 bp), the second half (345 bp), and the entire 690 bp of COI. The sequences not assigned to their correct species belong to two closely related species, *Carabus* (*Leptocarabus*) *arboreus* and *C. (L.) hiurai,* which may exhibit trans-species mitochondrial polymorphism (Kim et al., 2000a, 2000b; see also Fig. 4b).

For the skipper butterfly, the training data sets included 132, 202, and 398 sequences, and the corresponding sizes of query data sets were 275, 205, and 9 sequences (Fig. 5). Of these, 263, 197, and 9 sequences were successfully assigned to their correct species (95.63%, 96.10%, and 100% success rates, respectively). We have not achieved a 100% success rate in the situations of training data sets with sizes of 132 and 202, which were one third and half of the total 407 sequences, due to the low level of divergence of sequences among these putative "species." However, our method attained a success rate of 100% when 398 sequences from a total of 407 sequences (97.78%) were used as training data, whereas the decision-theory method attained the same success rate with 462 training sequences from a total of 463 sequences (99.78% of the total sequences; Abdo and Golding, 2007). Because these authors did not conduct a study on smaller training data sets, like we have done here, we cannot make a thorough comparison with their methods. With large training data sets, we found that our method achieved the same success rate (100%) as theirs.

DISCUSSION

Our results suggest that a BP approach has potential to become a powerful tool for inferring species membership via DNA sequence comparison. This artificial intelligence–based approach, which is entirely different from current distance-based approaches, does not require *a priori* cut-off to identify species. The neural network used will obtain and remember this information from the reference sequences via adjusting weights and biases of the network automatically. Our method uses more sequence information than other currently available methods, such as BLAST, simple genetic distance–based methods, the Bayesian method of Nielsen and Matz (2006), or the decision-theory method of Abdo and Golding (2007). These approaches identify species on the basis of differences between two sequences via raw scores, simple genetic distances, or genetic distances corrected by evolutionary models. In contrast, our BP approach takes into account not only differences between sequences but also the pattern of the differences; e.g., the relative position of variable sites. Our correlation analysis of success rates of species identification among the BLAST approach, the genetic distance method, and the BP-based method also indicates that the BP-based method performs species identification in a fundamentally different way from distance-based and BLAST approaches.

The second apparent advantage to our method is that it is based on fewer or almost no assumptions when making inferences, whereas almost all current methods rely on a number of more or less restrictive assumptions that may not apply to real data (Nielsen and Matz, 2006). For example, BLAST and simple distance methods assume that extreme scores or minimal genetic distances indicate close relationship between species, which does not hold

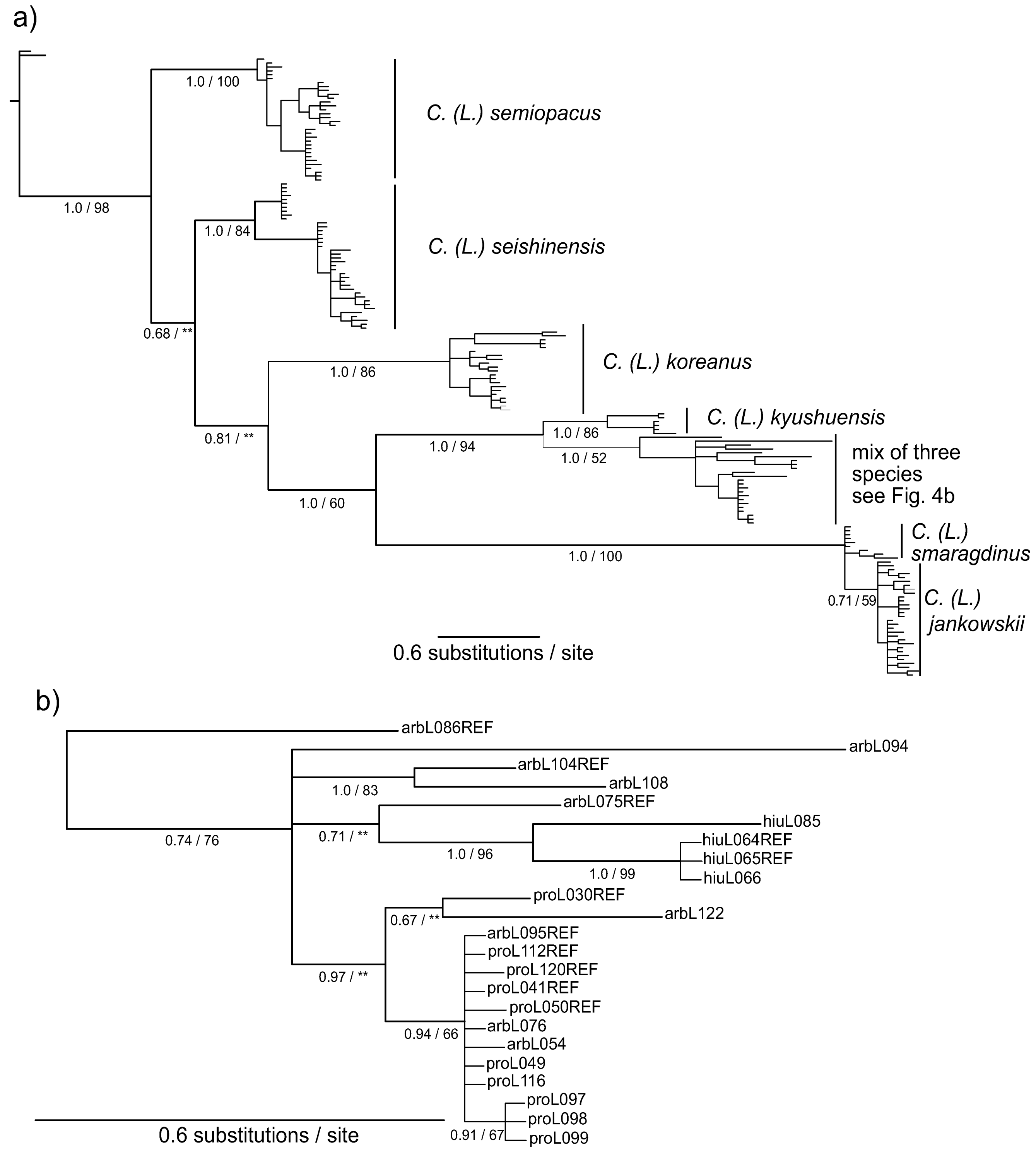


FIGURE 4. Analyses conducted using MrBayes v3.1.2 with $GTR + \Gamma + I$ model chosen by MrModelTest. Branch support values are estimated posterior probabilities on the left, maximum likelihood bootstrap proportions on the right, based on 100 pseudoreplicate heuristic searches using PAUP* with parameter values fixed. Double asterisks indicate branches not recovered in >50% of ML bootstrap searches. (a) The 50% majority-rule consensus phylogram of 5000 post–burn-in Bayesian trees from four independent runs for nine ground beetle species based on 690 base pairs of mitochondrial DNA sequences (COI). (b) Three closely related, nonmonophyletic *Carabus* species (from (a); see text for detail). Terminal codes starting with "arb," "pro," and "hiu" indicate *C. (L.) arboreus*, *C. (L.) procerulus*, and *C. (L.) hiurai*, respectively. The data matrix was listed in online Appendix 2.

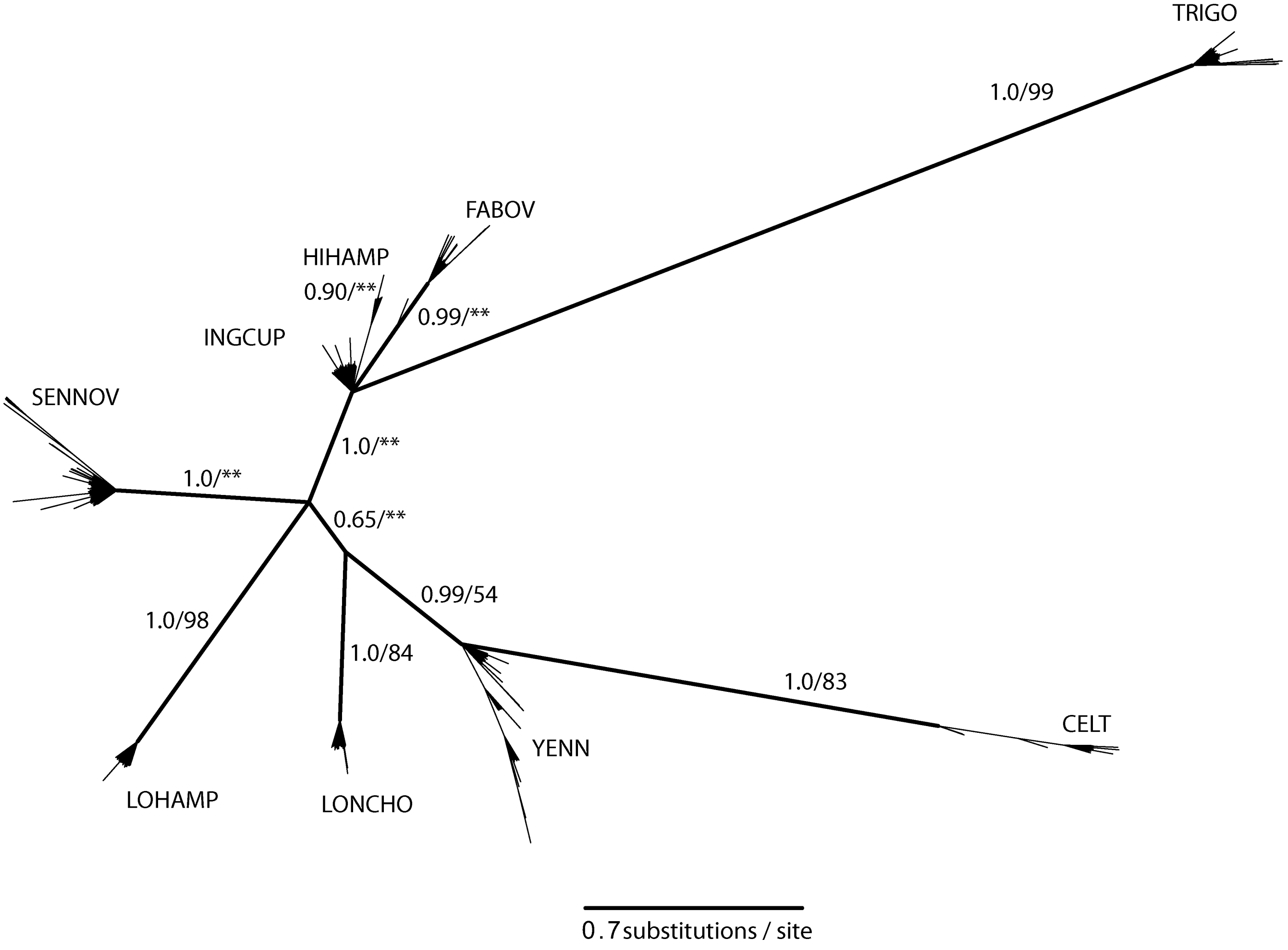


FIGURE 5. The 50% majority-rule consensus (unrooted) phylogram of 5000 post–burn-in Bayesian trees from four independent runs for the species *Astraptes fulgerator* (Lepidoptera: Hesperiidae) based on 630 base pairs of mitochondrial DNA sequences (COI) for 407 OTUs (sequences listed in online Appendix 2). Note: For clarity, only branches with greater than 0.89 posterior probability are provided with branch support values. Clade names correspond to those used in Hebert et al. (2004). Analyses conducted using MrBayes v3.1.2 with $HKY + \Gamma + I$ model chosen by MrModelTest. Branch support values are estimated posterior probabilities on the left, maximum likelihood bootstrap proportions on the right, based on 100 pseudoreplicate heuristic searches using GARLI with parameter values fixed. Double asterisks indicate branches not recovered in >50% of ML bootstrap searches.

true in the obvious case of incomplete lineage sorting. The Bayesian method of Nielsen and Matz (2006) and the decision-theory method of Abdo and Golding (2007) depend on various phylogenetic or population genetic assumptions. For example, the latter assumes an ideal panmictic population for all species or groups under study without recombination, migration, and so on, so that the evolutionary process within each group is governed by only one parameter; i.e., the number of mutational steps between two individuals within that group. Even so, both of these methods cannot estimate population genetic parameters in the case where only one sequence is known from each species. In this extreme case, the BP-based method has a clear advantage, as we have shown with simulated data (e.g., Fig. 3c, e).

Our method has the potential to use other kinds of characters easily, such as morphological characters, or even behavioral data, by simply coding them together with DNA data. This would reduce the danger of relying on a single DNA fragment for identifying and delimiting species (Roe and Sperling, 2007), although it would increase the per specimen processing cost. Our method therefore would be compatible with current taxonomic practices, and it is more appropriate for the construction of a barcode reader (DeSalle et al., 2005). The BLAST and genetic distance methods are obviously not able to incorporate nonmolecular characters, whereas the Bayesian (Nielsen and Matz, 2006) and model-based decision methods (Abdo and Golding, 2007) require extra assumptions.

We also note that our BP-based method is not without problems, although we have shown its powerful capacity in species identification compared to other currently employed methods. The first limitation of our approach is that an input sequence will always be assigned to a known species when a sequence is successfully assigned. This means that our BP-based method is only useful for identification purposes in samples of predefined taxa, and it is neither applicable for ambiguous cases of species identification nor for the discovery of unknown species, because this method, in essence, is governed by a process of supervised training. Second, the parameter settings that were used to train the networks, such as choosing a three-layer network, a hidden layer that contains h codes ($h = int(\log_2(n))$), a value range of 0.0001 to 0.00001 of mean squared errors, and 0.2 to 0.5 learning rates, could have been set differently. Although these settings worked well in our study, changing these parameters, theoretically, may have an effect on the training process. Presumably this will not affect our basic conclusions. We have tested some cases with different settings of parameters and found that the output vectors always tended to converge to values that corresponded to certain species, despite the values of the main parameters used to train the network. The only differences were observed in the training times. A full exploration of the training parameter space is beyond the scope of this study, because we decided that it was more important to propose this new method that resolves some problems of current methods for the ongoing DNA-barcoding practice as soon as possible. Third, we used a very simple approach of sequence encoding that seemed to perform well in our study. However, we have not examined whether our encoding method is better than other encoding methods (Brunak et al., 1991; Demeler and Zhou, 1991; Uberbacher and Mural, 1991).

Undoubtedly, using a larger DNA fragment would help to minimize the influence of nucleotide variability caused by random variation (Roe and Sperling, 2007), and larger fragments of DNA contain more information than short ones. Although both computer simulations and the real data used in this study have shown that long and short sequences differed in their success rates in identifying species, it is still difficult to address questions like "How long does a gene sequence need to be to achieve correct assignment of specimens to known species?" because the ability to identify species using DNA-barcoding methods may rely on many factors, such as the number of reference sequences, the level of sequence divergence, and patterns of DNA sequence evolution (Roe and Sperling, 2007). Therefore, we suggest that researchers should use as long fragments in species identification as possible in addition to considering the underlying variability of sequences.

Although the retention of ancestral polymorphisms (simulated cases) or possible introgressive hybridization (ground beetles data) are problematic issues in DNA barcoding (Moritz and Cicero, 2004), our simulations under coalescent models have demonstrated that the proposed artificial intelligence–based approach has more power than BLAST and distance-based methods in such a situation. Its power may be ascribed to its specific capacity of dealing with complicated nonlinear systems. However, even so, the maximal success rate with the BP-based method in our simulated cases of incomplete lineage sorting ($GTR + \Gamma + I$ model, 1 N_e) was less than 95%, whereas both the BLAST and genetic distance methods could reach a maximum success rate of less than 70% (the minimum success rate was around 40%; Fig. 3c). On the other hand, our simulations demonstrate that increasing the number of references could improve the success rates of species identification for all three methods even in such difficult situations. But, with an increasing number of reference sequences, the success rates of species identifications tended to plateau (the BLAST and genetic distance methods yielded success rates in the range of 50% to 70%, whereas rates of 93% to 94% were seen for the BP-based method). In our beetle data, there are three nonmonophyletic species, *C. (L.) arboreus*, *C. (L.) procerulus*, and *C. (L.) hiurai* (Fig. 4b). The average within- and between-species differences for these taxa overlap (not shown). Under these difficult circumstances of possible retention of ancestral polymorphisms or introgressive hybridization, it is unlikely that any sequence-based identification method would succeed for all taxa. To achieve higher success rates in such difficult cases, we suggest going beyond DNA barcoding. Standard DNA barcoding can be used to identify groups of closely related species, then longer sequences, or more loci can be used for refined species identification within this group. Phenotypic characters can also be used to solve such difficult problems. We have subsequently successfully applied four nuclear genes to this beetle group and obtained correct species identifications (Zhang and Sota, 2007). However, generalizations are not possible in the absence of more thorough studies of more empirical data. Such an inherent problem of DNA barcoding will continue to challenge systematists for some time.

To implement our approach, we have developed a new program in C++ named BPSI (BP-based Species Identification) that was used to assist this analysis (the program is freely available from zhangab2008@yahoo.com.cn).

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APPENDIX 1

General definitions of terms related to BPNN.

Activation function/transfer function:	The general function used to compute the value of a neuron can be any differentiable function, such as logistic function.
Back propagation (BP):	A supervised learning technique used for training artificial neural networks. It was first described by Werbos (1974) and further developed by Rumelhart et al. (1986).
Convergence:	The approach towards the target vector (a fixed state of the output) via adjustments to the weights of the network as the training of the network proceeds.
Epoch/iteration:	An epoch consists of a few steps during the training of a network—take the values of input vector, find the values of nodes for the hidden and output layers, adjust the weights of the output and hidden layers according to the target vector. The whole process is repeated many times so that the output vector becomes closer to target vector.
Error surface:	A (k+1)-dimensional surface representing the error terms of a model depending on k parameters. The coordinates of the error surface consist of the k parameters of the model function and the error term. The error surface can be used to find the best fit of a model by finding the minimum of the error surface.
Initialization algorithm:	A technique to initialize a layer's weights and biases before a network is trained; e.g., with minor random weights and biases.
Layer:	A common style in which the neurons in a network are arranged. A typical BP network contains an input layer, one or more hidden layers and an output layer. Each layer consists of a certain number of neurons depending on problems being solved.
Momentum/momentum factor:	A numerical value incorporated into the BP algorithm by making weight changes equal to the sum of a fraction of the last weight change and the new change suggested by the back-propagation rule, which avoids getting trapped in a local minimum in the error surface during the training process.
Neuron/node:	A model of a neural cell in animals and humans in a NN context, an extremely simple analog computing device, which can take values from one or more neurons and output to other neurons via an activation or transfer function.

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A phylogenetic analysis of the frog genera *Vibrissaphora* and *Leptobrachium*, and the correlated evolution of nuptial spine and reversed sexual size dimorphism

Yuchi Zheng [a], Shuqiang Li [a], Jinzhong Fu [b,*]

[a] *Division of Animal Evolution and Systematics, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China*
[b] *Department of Integrative Biology, University of Guelph, Guelph, Ont., Canada N1G 2W1*

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Abstract

A phylogeny of the frog genus *Vibrissaphora* and seven *Leptobrachium* species was reconstructed based on 3808 base pairs of mitochondrial and nuclear DNA sequence data. Maximum parsimony, Bayesian, and statistical parsimony approaches were employed to reveal the historical relationships among the recovered haplotypes. The species of the genera *Vibrissaphora* and *Leptobrachium* failed to form their respective monophyletic groups. Therefore, *Vibrissaphora* should be part of the genus *Leptobrachium*. Our analysis also further delineated several species boundaries; *Leptobrachium chapense* is not a single species, rather, a species complex. On the other hand, although *L. liui* demonstrated substantial morphological variation, all populations belong to one species. The RAG-1 data revealed a case of species-level non-monophyly; when studying slowly evolving genes, population coalescence may not have been reached within species. The phylogenetic comparative analysis revealed a positive correlation between evolution of male nuptial spines and reversed sexual size dimorphism in this group. Resource defense polygyny and male parental care are possible explanations for the presence of large male size.

Keywords: *Vibrissaphora*; *Leptobrachium*; Phylogeny; Mitochondrial DNA; RAG-1; Cryptic species; Nuptial spines; RSSD

1. Introduction

Southeastern Asia fosters some of the most unusual fauna and flora, and frogs of the genus *Vibrissaphora* are among them. Male *Vibrissaphora* possess keratinized nuptial spines on their upper jaws during the breeding season, and are the only frogs having such structures (Fig. 1; Duellman and Trueb, 1994). Females do not have spines; instead, they have white spots at the corresponding positions. The numbers of the spines are consistent within species and have been used as a diagnostic character (e.g. Fei et al., 2005). For example, *Vibrissaphora boringiae* generally has six spines on each side of the upper jaw. Furthermore, within all but one species, males are significantly larger than females, another rare character among anurans. For instance, body length of male *V. boringiae* may reach 69.8–89.0 mm, whereas females fall within the range of 58.6–76.0 mm (Liu and Hu, 1961). This is known as reversed sexual size dimorphism (RSSD; Shine, 1979). Such unusual characters have inspired much speculation regarding the function of the nuptial spines and potential link with sexual selection. For example, Dubois and Ohler (1998) suggested that the spines are possibly used for direct male to male combat, while Ho et al. (1999) considered a large male body size possibly associated with male parental care. To understand the evolution of RSSD and the nuptial spines, several questions need to be addressed.

First, the monophyly of the genus *Vibrissaphora* needs to be tested and the number of independent origins of RSSD and the nuptial spines needs to be examined. The

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[*] Corresponding author. Fax: +1 519 767 1656.
E-mail address: jfu@uoguelph.ca (J. Fu).

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Fig. 1. Male *Vibrissaphora boringiae* with the nuptial spines.

genus *Vibrissaphora* possesses several unique derived characteristics (synapormorphies). All species have keratinized nuptial spines; all except *Vibrissaphora promustache* express RSSD (Fei et al., 2005; Orlov, 2005; Rao et al., 2006). The tadpoles possess a distinct yellow "Y"-shaped mark on top of their tails. The *Vibrissaphora* species are all mountain stream dwellers. In the breeding season, males of *Vibrissaphora ailaonica*, *V. boringiae*, *Vibrissaphora leishanensis*, and *Vibrissaphora liui* move to streams and construct submerged nests underneath rocks, and make mating calls in the water. Despite these synapormorphies, the genus is morphologically and ecologically very similar to the genus *Leptobrachium*, and several taxonomists considered *Vibrissaphora* specialized *Leptobrachium* with nuptial spines (e.g. Dubois and Ohler, 1998). If so, *Vibrissaphora* may not be a valid genus. The genus *Vibrissaphora* was initially separated from the genus *Leptobrachium* (Liu, 1945), and the close association between the two genera has long been established (e.g. Dubois, 1980; Lathrop, 1997; Zheng et al., 2004). Nevertheless, no phylogenetic analysis has been performed to resolve the relationships among the *Vibrissaphora* and *Leptobrachium* species.

Second, the genus *Vibrissaphora* may have more species than are currently recognized. Frost (2007) listed seven species in the genus, *V. ailaonica*, *V. boringiae*, *Vibrissaphora echinata*, *V. leishanensis*, *V. liui*, *Vibrissaphora ngoclinhensis*, and *V. promustache*. The validity of *V. echinata* is questionable and many considered it a synonymy of *V. ailaonica* (e.g. Ho et al., 1999, but see Ohler et al., 2000 and Grosjean, 2001). Their distribution is limited to southern China and northern and central Vietnam, and is particularly concentrated along the edge and the extension of the Tibetan Plateau; only *V. liui* extends toward the east along the Nanling Mountains (Fig. 2). Several observations suggest that cryptic species likely exist within the group. The distribution of the *Vibrissaphora* species is largely discontinuous and forms many pockets across their range, especially for the widespread species, *V. liui*. With the use of molecular data, widespread and/or discontinuous species have been frequently revealed as species complexes, particularly in morphologically conservative groups such as amphibians (e.g. Bain et al., 2003; Stuart et al., 2006). Furthermore, some taxonomic disputes also reflect the large extent of variation among and within species. In addition to the *V. echinata* controversy, two other names have been proposed and recently synonymized. Hu et al. (1981) described *Vibrissaphora yaoshanensis*, which was synonymized with *V. liui* by Wu and Zhao (1987), and many considered it a subspecies of *V. liui* (e.g. Fei et al., 2005); Wei and Zhao (1981) described *Vibrissaphora jiulongshanensis*, which was also synonymized with *V. liui* (Huang et al., 1984). Lastly, two species were discovered in the last two years (*V. ngoclinhensis,* Orlov, 2005; *V. promustache*, Rao et al., 2006), suggesting that the species diversity of the genus is far from being thoroughly understood.

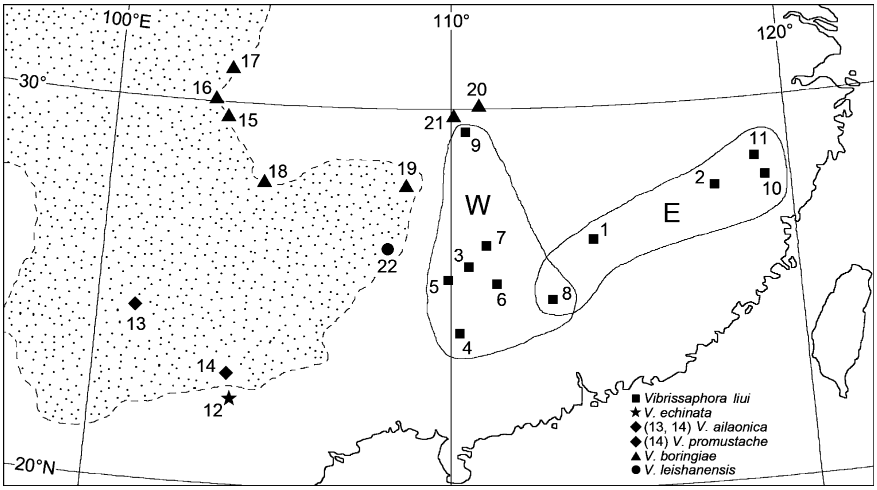

Fig. 2. Sampling sites of six *Vibrissaphora* species. Site names and coordinates are listed in Table 1. The dotted area outlines the highland including southeast part of the Tibetan Plateau, the Hengduan Mountains Region, and the Yunnan-Guizhou Plateau. The two circular areas represent the eastern and western groups of *V. liui*.

Phylogenetic analysis of molecular data provides an excellent solution to these questions. In particular, the analysis of DNA sequence data has been routinely used to determine species boundaries and evolutionary relationships among species as well as other taxa (e.g. Avise, 2000). Various mitochondrial and nuclear genes supply enormous amounts of information and many levels of variability. Furthermore, phylogenetic analysis also provides a platform to study character evolution, such as the origin of RSSD. The recently developed phylogenetic comparative methods (PCM) also offer means of testing correlated evolution between characters (e.g. Felsenstein, 1985b; Pagel, 1994).

In this study, we extensively sampled most known populations of the genus *Vibrissaphora*. Using both mitochondrial and nuclear DNA sequence data, we reconstructed a phylogeny of all *Vibrissaphora* species and seven *Leptobrachium* species. From the phylogeny, we test the species boundaries of the *Vibrissaphora* species, explore the relationship between the genera *Vibrissaphora* and *Leptobrachium*, and examine the correlation between the evolution of the nuptial spine and RSSD within this group.

2. Materials and methods

2.1. Taxon sampling

The genera *Vibrissaphora* and *Leptobrachium* are our ingroup in this study. All seven described species of *Vibrissaphora*, a total of 52 specimens from 24 collecting sites, were included. The genus *Leptobrachium* currently includes 15 species (Frost, 2007), and we included seven species to test the monophyly of the genus *Vibrissaphora*. A total of 13 specimens from 11 collecting sites of *Leptobrachium* were sampled. Sampling effort was particularly concentrated in the genus *Vibrissaphora,* of which most known distribution regions were sampled (Fei et al., 2005). The detailed sample locations of six species, *V. ailaonica*, *V.boringiae*, *V. echinata*, *V. leishanensis*, *V. liui*, and *V. promustache* are presented in Fig. 2.

Three species from the genera *Leptolalax* and *Oreolalax* were selected as our outgroup based on the current understanding of their phylogenetic relationships (Lathrop, 1997; Zheng et al., 2004). All specimen information and Genbank accession numbers are presented in Table 1. Voucher specimens are deposited in the herpetological collections of the Institute of Zoology (IZCAS; Beijing), the Chengdu Institute of Biology (CIB; Chengdu), the Royal Ontario Museum (ROM; Toronto), the Field Museum of Natural History (FMNH; Chicago), and the California Academy of Sciences (CAS; San Francisco).

2.2. Laboratory protocols

For phylogenetic reconstruction, two fragments from the mitochondrial genome and one fragment of the nuclear RAG-1 gene were selected for sequencing. The first mitochondrial fragment includes part of the 12S and 16S genes and the tRNA^{Val} gene between them, and was approximately 1940 base pairs before alignment. The second mitochondrial fragment includes part of the tRNA^{Leu} and tRNA^{Ile} genes and the ND1 gene between them, and was approximately 1010 base pairs before alignment. The RAG-1 fragment was 800 base pairs in length. All three fragments have been previously used for phylogenetic reconstruction in anurans (e.g. Roelants and Bossuyt, 2005; Frost et al., 2006).

DNA was extracted from liver or muscle tissues preserved in 95% ethanol using the genomic DNA extraction protocols of the Qiagen QIAamp DNA Mini Kit. A standard polymerase chain reaction (PCR) was used to amplify the genomic DNA. PCR products were purified and directly sequenced with BigDye-labeled terminator sequencing protocols in conjunction with an ABI 3700 automatic sequencer (Applied Biosystems). For the RAG-1 gene, when more than one dimorphic site resulting from heterozygosity were detected, the related PCR products were cloned and one clone was sequenced using universal primers T7 or SP6. All other primers used in PCR and sequencing are listed in Table 2.

Sequence editing was conducted with BioEdit (versioin 7.0.5; Hall, 1998). Alignment was conducted with ClustalX (version 1.83; Thompson et al., 1997) and checked against the rRNA secondary structures of *Xenopus laevis* (Cannone et al., 2002) or against the amino acid sequences for coding regions.

2.3. Test for recombination of the RAG-1 fragment

The RAG-1 fragment was tested for recombination between haplotypes using two methods, the Geneconv test (Sawyer, 1989) and the Homoplasy test (Maynard Smith and Smith, 1998). Using simulations and empirical data, Posada and Crandall (2001) and Posada (2002) evaluated the two methods and concluded that the Homoplasy test is most adequate when sequence divergence is low (*p*-distance ≅ 1% or less) and recommended the Geneconv test for higher levels of divergence (>1%). The pairwise uncorrected *p*-distances between the RAG-1 haplotypes were calculated using PAUP* (version 4.0b10; Swofford, 2002) and ranged from 0.125% to 11.3% (including outgroup). Therefore, the Geneconv test was applied to the entire dataset using program RDP (version 2b08; Martin et al., 2005). Running parameters were set to the highest acceptable *P*-value 0.05, Bonferroni correction, scanning sequence pairs, and different combinations between the different mismatch penalties (G-scale = 0 or 1) and variable datasets (Padidam et al., 1999). Furthermore, since the majority of pairwise *p*-distances were smaller than 1%, the Homoplasy test was applied to several subsets of the data, within which the *p*-distances ranged from 0.125% to 1.375%. The program START (version 1.0.8; Jolley et al., 2001) was used with 10 replicates, and the effective number of sites (S_e) was empirically determined equal to the number of sites at risk (S) multiplied by 0.7.

Table 1
Sample information and haplotype designation

Species	Specimen Catalogue No.	Locality	Coordinates	mtDNA		RAG-1	
				Haplotype	GenBank Accession Nos.	Haplotype	GenBank Accession Nos.
Vibrissaphora ailaonica	IZCASH30027	(13) Ailaoshan	N24°31.055′, E101°00.777′	13A	EF544224, 92	(13A)	EF544348
V. ailaonica	IZCASH30046	(13) Ailaoshan	N24°32.721′, E101°01.701′	(13B)	EF544225, 93	(13A)	EF544366
V. ailaonica	IZCASH30047	(13) Ailaoshan	N24°32.721′, E101°01.701′	(13B)	EF544226, 94	(13A)	EF544365
V. ailaonica	IZCASH30030	(14) Daweishan	N22°54.870′, E103°41.890′	14A	EF544222, 90	(14A)	EF544367
V. ailaonica	IZCASH30031	(14) Daweishan	N22°54.870′, E103°41.890′	14B	EF544223, 91	(14A)	EF544368
V. boringiae	IZCASH30021	(15) Emeishan	N29°33.498′, E103°24.988′	15A	EF544207, 73	(15/16/17A), (15B)	EF544372, 3
V. boringiae	IZCASH30022	(15) Emeishan	N29°33.498′, E103°24.988′	(15/16B)	EF544208, 74	(15/16/17A), (15B)	EF544374, 5
V. boringiae	CIB-XM454	(15) Emeishan	N29°34.589′, E103°23.476′	15C	EF544209, 75	15C, 15D	EF544376, 7
V. boringiae	IZCASH30023	(16) Bifengxia	N30.1°, E103.0°	(15/16B)	EF544210, 76	(15/16/17A)	EF544378
V. boringiae	IZCASH30024	(16) Bifengxia	N30.1°, E103.0°	16A	EF544211, 77	(15/16/17A)	EF544379
V. boringiae	IZCASH30038	(17) Qingchengshan	N30°56′, E103°28′	17A	EF544242, 80	(15/16/17A)	EF544388
V. boringiae	IZCASH30039	(17) Qingchengshan	N30°56′, E103°28′	17B	EF544243, 81	(15/16/17A)	EF544387
V. boringiae	IZCASH30025	(18) Junlian	N27°59.028′, E104°25.780′	18A	EF544215, 78	(18/19A)	EF544380
V. boringiae	IZCASH30026	(18) Junlian	N27°59.028′, E104°25.780′	18B	EF544214, 79	18B	EF544381
V. boringiae	CIB-ZYC665	(19) Fanjingshan	N27°53.772′, E108°42.918′	19A	EF544212, 71	19A, 19B	EF544333, 4
V. boringiae	CIB-ZYC667	(19) Fanjingshan	N27°53.772′, E108°42.918′	19B	EF544213, 72	19C, (18/19A)	EF544335, 6
V. boringiae	IZCASH30040	(20) Hupingshan	N30°06.084′, E110°49.640′	20A	EF544216, 82	(20)	EF544386
V. boringiae	IZCASH30041	(20) Hupingshan	N30°01.593′, E110°34.413′	(20/21B)	EF544217, 83	(20)	EF544385
V. boringiae	IZCASH30042	(21) Badagongshan	N29°47.117′, E110°05.551′	21A	EF544218, 84	21A	EF544384
V. boringiae	IZCASH30043	(21) Badagongshan	N29°47.117′, E110°05.551′	(20/21B)	EF544219, 85	21B, 21C	EF544382, 3
V. echinata	ROM38023	(12) Sa Pa	N22°20′, E103°46′	12A	EF544220, 88	–	–
V. echinata	ROM38026	(12) Sa Pa	N22°20′, E103°46′	12B	EF544221, 89	–	–
V. leishanensis	IZCASH30003	(22) Leigongshan	N26°23.086′, E108°15.105′	22A	EF544199, 246	(6/8/22A)	EF544311
V. leishanensis	IZCASH30004	(22) Leigongshan	N26°23.086′, E108°15.105′	22B	EF544200, 47	–	–
V. leishanensis	IZCASH30005	(22) Leigongshan	N26°23.898′, E108°17.663′	22C	EF544201, 48	(6/8/22A), (4/22D)	EF544312, 3
V. liui	IZCASH30001	(1) Jinggangshan	N26°29.807′, E114°04.807′	1A	EF544180, 244	(1A), 1B	EF544308, 9
V. liui	IZCASH30002	(1) Jinggangshan	N26°29.807′, E114°04.807′	1B	EF544181, 245	(1A)	EF544310
V. liui	IZCASH30006	(2) Guadun	N27°44.219′, E117°38.185′	2A	EF544182, 249	(2/10/11B)	EF544318
V. liui	IZCASH30007	(2) Guadun	N27°44.219′, E117°38.185′	2B	EF544183, 250	2A, (2/10/11B)	EF544319, 20
V. liui	IZCASH30008	(3) Maoershan	N25°54.705′, E110°27.910′	3A	EF544184, 251	(3/5A), 3B	EF544321, 2
V. liui	IZCASH30009	(3) Maoershan	N25°53.416′, E110°29.138′	3B	EF544185, 252	(3/5A)	EF544323
V. liui	IZCASH30010	(4) Jinxiu	N24°06.944′, E110°14.069′	(4A)	EF544186, 253	(4/6A), 4B	EF544324, 5
V. liui	IZCASH30011	(4) Jinxiu	N24°06.944′, E110°14.069′	(4A)	EF544187, 254	4C, (4/22D)	EF544326, 7
V. liui	IZCASH30012	(4) Jinxiu	N24°06.944′, E110°14.069′	4B	EF544188, 255	4E, 4F	EF544328, 9
V. liui	IZCASH30013	(5) Longsheng	N25°37.112′, E109°55.510′	5A	EF544189, 256	(3/5A)	EF544330
V. liui	IZCASH30014	(5) Longsheng	N25°37.112′, E109°55.510′	5B	EF544190, 257	(5/8A), 5B	EF544331, 2
V. liui	IZCASH30015	(6) Dupangling	N25°33.619′, E111°20.019′	6A	EF544191, 258	(6/8/22A), 6B	EF544358, 9
V. liui	IZCASH30016	(6) Dupangling	N25°33.619′, E111°20.019′	6B	EF544192, 259	6C, (4/6A)	EF544356, 7
V. liui	IZCASH30017	(7) Shunhuangshan	N26°24.196′, E111°10.800′	7A	EF544193, 260	–	–
V. liui	IZCASH30018	(7) Shunhuangshan	N26°24.196′, E111°10.800′	7B	EF544194, 261	7	EF544340
V. liui	IZCASH30019	(8) Mangshan	N24°58.073′, E112°57.447′	8A	EF544195, 262	(6/8/22A), 8A	EF544341, 2
V. liui	IZCASH30020	(8) Mangshan	N24°58.073′, E112°57.447′	8B	EF544196, 263	(5/8A), 8B	EF544343, 4
V. liui	CIB-20020871	(9) Zhangjiajie	N29.3°, E110.5°	(9A)	EF544197, 264	(9)	EF544345
V. liui	CIB-ZYC636	(9) Zhangjiajie	N29.3°, E110.5°	(9A)	EF544198, 265	(9)	EF544346
V. liui	CIB-ZYC602	(9) Zhangjiajie	N29.3°, E110.5°	9B	EF544202, 66	(9)	EF544347
V. liui	IZCASH30032	(10) Fengyangshan	N27°54.714′, E119°11.853′	10A	EF544203, 67	(2/10/11B)	EF544349
V. liui	IZCASH30033	(10) Fengyangshan	N27°54.714′, E119°11.853′	10B	EF544204, 68	(2/10/11B)	EF544350

V. liui	IZCASH30034	(11) Jiulongshan	N28°21.642′, E118°55.794′	(11)	EF544205, 69	(2/10/11B)	EF544351
V. liui	IZCASH30035	(11) Jiulongshan	N28°21.642′, E118°55.794′	(11)	EF544206, 70	(2/10/11B)	EF544352
V. ngoclinhensis	ROMFS39612	(23) Ngoc Linh	N15°05′, E107°57′	23	EF544228, 97	23	EF544360
V. promustache	IZCASH30044	(14) Daweishan	N22°54.870′, E103°41.890′	14C	EF544240, 86	(14C)	EF544371
V. promustache	IZCASH30045	(14) Daweishan	N22°54.870′, E103°41.890′	14D	EF544241, 87	14B, (14C)	EF544369, 70
Leptobrachium banae	ROM32200	(24) Krong Pa	N14°20.48′, E108°28.77′	24	EF544229, 98	24	EF544314
L. chapaense	ROM38038	(12) Sa Pa	N22°20′, E103°46′	12C	EF544227, 96	–	–
L. chapaense	ROM32176	(25) Tam Dao	N21°27.25′, E105°38.48′	25	EF544232, 301	25	EF544317
L. chapaense	IZCASH30048	(26) Longling	N24°30.839′, E98°46.560′	26	EF544239, 95	26	EF544361
L. chapaense	AMNHA163791	(27) Ha Giang	N22°45.98′, E104°49.93′	27	DQ283052	–	–
L. hainanense	CIB-SN030043	(28) Dali	N18°45′, E109°56′	28A	EF544233, 302	28A, (28B)	EF544337, 8
L. hainanense	CIB-ZYC1552	(28) Dali	N18°45′, E109°56′	28B	EF544234, 303	(28B)	EF544339
L. hasseltii	CAS222293	(29) Gwa	N17°42.233′, E94°38.905′	29	DQ283239, EF672275	29A, 29B	EF672277, 8
L. hasseltii	CAS222215	(33) Kyaik Hto	N17°31.227′, E97°03.646′	33	EF672271, 3	33	EF672276
L. montanum	VUB0628	(30) Borneo	No detailed location data	30	AY523767	30	AY523738
L. mouhoti	FMNH261758	(34) Pichrada	N12°32.27′, E107°32.00′	34	EF672272, 4	34A, 34B	EF672279, 80
L. xanthospilum	ROM32185	(31) Tram Lap	N14°26.40′, E108°32.97′	(31)	EF544230, 99	(31)	EF544315
L. xanthospilum	ROM32186	(31) Tram Lap	N14°26.40′, E108°32.97′	(31)	EF544231, 300	(31)	EF544316
Oreolalax jingdongensis	IZCASH30028	(13) Ailaoshan	N24°32.721′, E101°01.701′	13C	EF544235, 304	(13B)	EF544362
O. jingdongensis	IZCASH30029	(13) Ailaoshan	N24°32.721′, E101°01.701′	13D	EF544236, 305	13C, (13B)	EF544363, 4
O. lichuanensis	IZCASH30036	(32) Hanchi	N30°31.788′, E109°05.610′	32	EF544237, 306	32	EF544353
Leptolalax liui	IZCASH30037	(4) Jinxiu	N24°06.944′, E110°14.069′	4C	EF544238, 307	4G, 4H	EF544354, 5

Coordinates with minutes are GPS readings, and others were obtained from maps. Haplotypes shared by multiple individual were bracketed. Location numbers correspond with numbers in Fig. 2. AY523767, AY523738, DQ283052, and DQ283239 were obtained from previous studies.

2.4. Phylogenetic analysis

The mitochondrial data set and the RAG-1 data set were analyzed independently. We did not pursue a combined analysis because of the largely unbalanced dataset sizes. The information from the nuclear RAG-1 gene would be swamped by the much larger mitochondrial DNA dataset. Each unique haplotype was treated as a taxon and each nucleotide site was treated as a character. Both maximum parsimony (MP) and Bayesian approaches were conducted on the mitochondrial data. For the RAG-1 data, in addition to parsimony and Bayesian analysis, a statistical parsimony approach (Templeton et al., 1992) was also employed to resolve relationships among haplotypes with extremely low divergence.

For the parsimony analysis, all characters were unordered and equally weighted. A heuristic search was conducted using PAUP*4.0b10 (Swofford, 2002) with TBR branch-swapping and 1000 random step-wise addition replicates. For estimating nodal support, bootstrap proportions (Felsenstein, 1985a) with 1000 replicates were used. Templeton's test (Templeton, 1983) and the Kishino–Hasegawa test (Kishino and Hasegawa, 1989) were used to evaluate alternative tree topologies.

For the Bayesian analysis, the hierarchical likelihood ratio test was first conducted using MrModeltest (version 2.2; Nylander, 2004) to select an evolutionary model that best fit the observed data. The GTR+I+G model was selected for both the 12S-16S fragment and the ND1 fragment. The HKY+I+G model was chosen for the RAG-1 gene data. The Bayesian analysis was conducted using MrBayes (version 3.1.2; Ronquist and Huelsenbeck, 2003). Four Markov chains were used and the data set was run for 12 million generations to allow adequate time for convergence. Trees were sampled every 100 generations and the last 10,000 sample trees were used to estimate the consensus tree and the Bayesian posterior probabilities. All the early sample trees were treated as "burn-in".

We have an extensively sampled *Vibrissaphora liui*, which has the largest morphological variation and is the only widespread species within the genus. A network approach was employed to resolve the relationships among the haplotypes of RAG-1. The statistical parsimony analysis of RAG-1 sequences of *Vibrissaphora liui* was performed using TCS (version 1.21; Clement et al., 2000). Ambiguous connections in the haplotype network were resolved with the following criteria: (1) haplotypes are more likely to be connected to interior than to exterior haplotypes; and (2) haplotypes are more likely to be connected to haplotypes from the same population than to haplotypes from different populations (Crandall and Templeton, 1993).

2.5. Phylogenetic comparative method (PCM) analysis

To test for correlated evolution of the male nuptial spines and reversed sexual size dimorphism in *Leptobrach-*

Table 2
Primers used in PCR and sequencing

Fragment	Primer	Sequence (5′ → 3′)	Reference
12S, tRNA-Val, 16S	12S-1L	CAAACTGGGATTAGATACCCCACTAT	Kocher et al. (1989)
	12S-3L	GGATTAGATACCCCACTATGCCT	This study
	1602L	GTATACCGGAAGGTGTACTTGGAACAG	Fu et al. (2007)
	16S-1L	CCGACTGTTTACCAAAAACAT	Fu (1998)
	16S-2H	CCGGATCCCCGGCCGGTCTGAACTCAGATCACG	Palumbi (1996)
	16S-4H	CGGTCTGAACTCAGATCACGTAG	This study
	16S-10H	CCTGAGCAACCAGCTATCACT	This study
	2571H	TACCTTCGCACGGTCAGAATACCGC	Fu et al. (2007)
tRNA-Leu, ND1, tRNA-Ile	Gln-2H	AGGAAGTACGGGGAGTTTTGATCTC	This study
	Ile-2H	CGAACCCCTATATTACACTCTATCAAAGT	This study
	Ile-4H	CAACCTTCTAAAGATCCGAGGGGAT	This study
	Ile-8H	CGAACCCCTATATTACACTCTATC	This study
	Leu-1L	TAACGTGGCAGAGACAGGTAATTGC	This study
	Leu-5L	GCAGAGACAGGTAATTGCAAAAGC	This study
	ND1-2H	GTTTGAGCGACTGCTCGAAG	This study
RAG-1	Rag1-2H	GGTATGGGTTGGCTCTCCATG	This study
	Rag1-3L	CAGGACTGTGAAAGCCACAAC	This study
	Rag1-6H	GGGTTGGCTCTCCATGTCT	This study

ium and *Vibrissaphora*, a maximum likelihood test was conducted with 10 replicates using BayesTraits (Pagel, 1994). The test compares two likelihood values derived from an independent model and a dependent model, and the likelihood ratio test was used to determine which one better describes the data (Pagel, 1994). This analysis requires a rooted species tree with branch lengths and numerical codes for the two characters of each species.

Spine and body size (measured by snout-vent length, SVL) data were collected from the literature (e.g. Dubois and Ohler, 1998; Ohler et al., 2004; Rao et al., 2006; Stuart et al., 2006). Intraspecific variations and, in some cases, insufficient data made it difficult to code sexual size dimorphism as a continuous character. Following Shine (1979), both spine and sexual size dimorphism were treated as discrete characters with two states. Spine absence was coded as 0, and presence was coded as 1. Based on a cut-off value of 1 (Lovich and Gibbons, 1992), $a < 1$ ratio [(mean male SVL)/(mean female SVL)] was coded as 0 for typical sexual size dimorphism, and $a > 1$ ratio was coded as 1 for RSSD.

3. Results

3.1. Sequences

A total of 67 specimens were successfully sequenced for the two mitochondrial fragments including four outgroups. Because of poor preservation of tissue samples, sequences of the 12S–16S fragment were incomplete for three specimens (EF544198, EF544209, EF544221), and sequences of both the 12S–16S and ND1 fragments were incomplete for another two specimens (EF544220, EF54427, EF54488, EF54496). A total of 62 specimens were successfully sequenced for the nuclear RAG-1 fragment. All sequences are deposited in GenBank and the Accession numbers are provided in Table 1. Additionally, we obtained three related mitochondrial and one RAG-1 sequences from previous studies (AY523738, AY523767; Roelants and Bossuyt, 2005; DQ283052, DQ283239; Frost et al., 2006).

3.2. Phylogenetic analysis

The alignment for the ND1 fragment was straightforward, but aligning the 12S-16S fragment proved to be challenging. The alignment of several loop regions of the rRNA genes was ambiguous, and therefore, 32 segments of a total of 431 sites with questionable homology were excluded from the rest of the analysis. The $tRNA^{Val}$ sequence of one outgroup member (*Leptolalax liui*, EF544238) was much shorter than the others. It was difficult to align it with other sequences, and therefore, the $tRNA^{Val}$ sequence of *L. liui* was also excluded. After the exclusion, the combined mitochondrial data set had 62 haplotypes and 2577 nucleotide sites. Of them, 879 sites were variable and 744 were phylogenetically informative among the ingroup members. The parsimony analysis produced 1351 equally most parsimonious trees with 3169 steps, a consistency index of 0.443 (excluding the uninformative characters), and a retention index of 0.779. A strict consensus tree is presented in Fig. 3. The Bayesian analysis produced a nearly identical topology (Fig. 3). The genera *Vibrissaphora* and *Leptobrachium* did not form reciprocally monophyletic groups. Rather, both MP and Bayesian approaches recovered three well-supported major clades, A, B, and C. Clade A included most *Vibrissaphora* species, and most *Leptobrachium* species were split into clades B and C. The only major difference between the MP and Bayesian trees concerned the relationships among the three major clades. While the MP tree resolved clade B and C as sister groups, the Bayesian tree suggested that A and B were sister groups, although neither solution was well-supported by

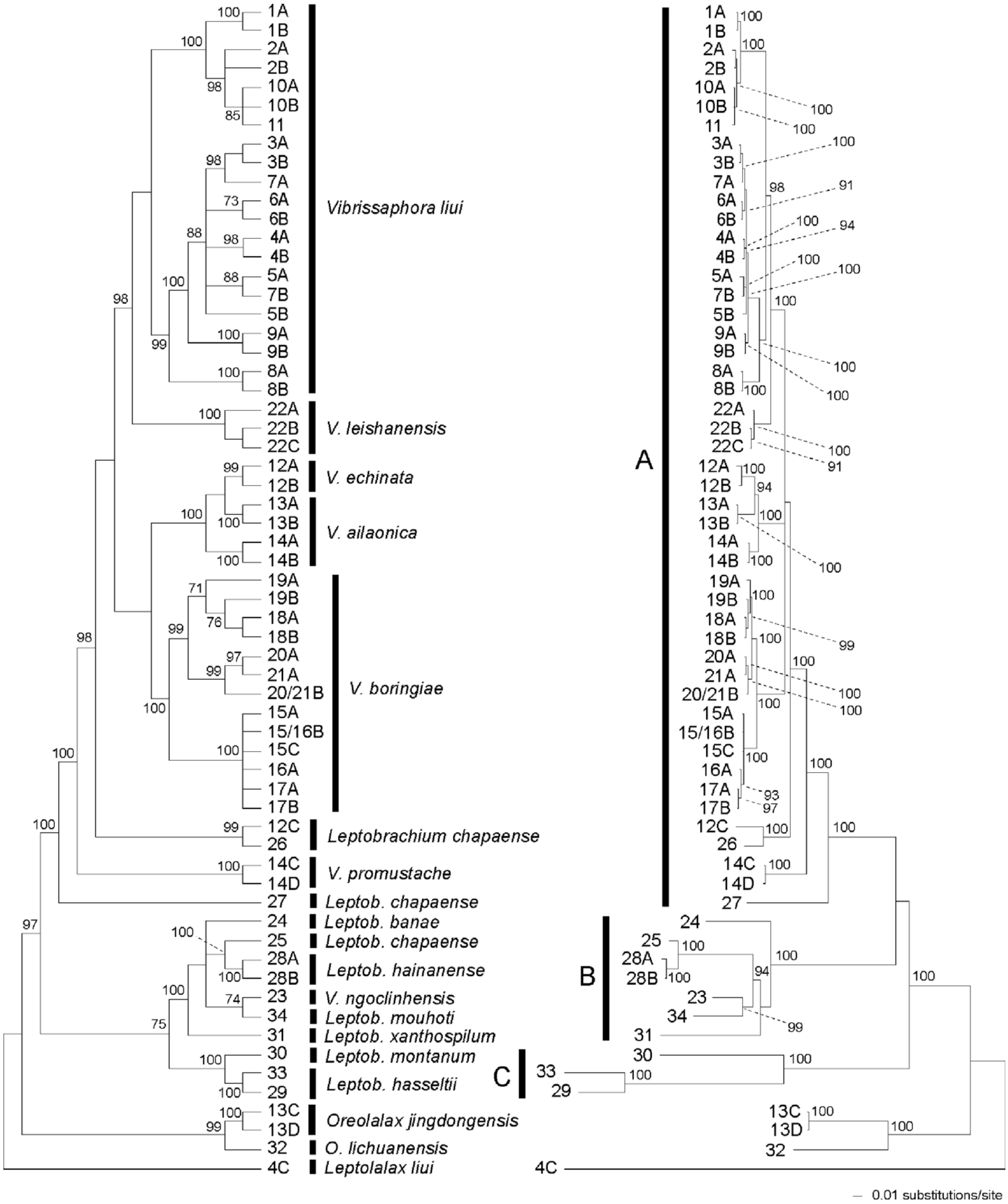

Fig. 3. The strict consensus tree from the parsimony analysis (left) and the 50% majority consensus tree from the Bayesian analysis (right) based on the combined mitochondrial DNA data. Taxa are haplotypes. Vertical bars indicate species designation or the clade assignment. For the parsimony tree, numbers beside nodes are bootstrap proportions greater than 70. For the Bayesian tree, numbers beside nodes are Bayesian posterior probabilities greater than 90.

the data (Fig. 3). All nominal species, except *Leptobrachium chapaense* and *V. ailaonica*, formed monophyletic groups. The four haplotypes of *L. chapaense* (12C, 25, 26, and 27, Table 1) were located in three separated positions. Two were in Clade A and one was in Clade B (Fig. 3). The Ailaoshan population (13) of *V. ailaonica* was more closely related to *V. echinata* than to the conspecific Daweishan population (14). Most recovered nodes were strongly supported by the data (Fig. 3).

Templeton's test and the Kishino-Hasegawa test were conducted on the mitochondrial data to evaluate alternative tree topologies. Forcing samples from *Vibrissaphora* or *Leptobrachium* to form a monophyletic group produced significantly less optimal tree topologies ($P < 0.05$ in both tests). Forcing any two of three clades of *L. chapaense* to form a monophyletic group also produced significantly less optimal tree topologies ($P < 0.05$ in both tests). Nevertheless, neither Templeton's nor KH test rejected the topology when the two *V. ailaonica* populations were forced together.

For the RAG-1 data set, the alignment was straightforward and produced 56 haplotypes and a total of 800 nucleotide sites. Among the sites, 85 were variable and 61 were phylogenetically informative among the ingroup members. Both the Homoplasy test and the Geneconv test failed to detect any potential recombination event. The parsimony analysis produced 19680 equally most parsimonious trees with 200 steps, a consistency index of 0.758 (excluding the uninformative characters), and a retention index of 0.887. The topology of the strict consensus tree is completely compatible with the Bayesian 50% majority consensus tree. The latter is presented in Fig. 4. Both Bayesian posterior probabilities and bootstrap proportions from the parsimony analysis are mapped on the tree (Fig. 4). Similar to the mitochondrial phylogeny, the ingroup members were divided into three major clades A, B and C (Fig. 4). The composition of the three major clades was identical to the mitochondrial gene tree, and all three clades were well supported. Clade A and B formed a sistergroup relationship, although the nodal support for the association was mediocre (bootstrap proportion = 83%). Not surprisingly, the haplotypes of *L. chapaense* (25 and 26) did not form a monophyletic group. Instead, haplotype 26 was part of clade A and haplotype 25 was part of clade B (Fig. 4). However, differing from the mitochondrial gene tree, most of the inter- and intra-specific relationships were unresolved. Furthermore, haplotypes of four *Vibrissaphora* species, *V. ailaonica, V. boringiae, V. leishanensis,* and *V. liui*, failed to form their respective monophyletic groups. All recovered haplotypes of *V. leishanensis* (4/22D, 6/8/22A) were shared with *V. liui*.

The statistical parsimony analysis of the RAG-1 data of *Vibrissaphora liui* produced one network (Fig. 5). Although its haplotypes did not form a monophyletic group on the RAG-1 gene tree, *V. liui* is a well established species and represents an independent evolutionary lineage. Therefore, it was reasonable to assume that all the haplotypes of *V. liui* form an enclosed gene pool and a network of the haplotypes represents the evolutionary history of the species. On the network, all the haplotypes from the East gathered together, while haplotypes from the West clustered together. Our samples of population 8 (Mangshan), geographically located in the middle, have one haplotype (8B) from the eastern group and three (8A, 5/8A, 6/8/22A) from the western group (Fig. 5).

3.3. PCM analysis

We selected the Bayesian tree derived from the mitochondrial DNA data for the PCM analysis. We did not use the RAG-1 gene tree because the lack of resolution of the RAG-1 data. One haplotype from each described species was arbitrarily selected as representative to establish branch lengths for each species. All species of *Leptobrachium* and *Vibrissaphora* express sexual size dimorphism. The numerical character state codes are listed here in the sequence of species name, haplotype representative, spine state code, and sexual size dimorphism state code: *V. ailaonica*, 13A, 1, 1; *V. boringiae*, 17B, 1, 1; *V. leishanensis*, 22C, 1, 1; *V. liui*, 1A, 1, 1; *V. ngoclinhensis*, 23, 1, 1; *V. promustache*, 14C, 1, 0; *Leptobrachium banae*, 24, 0, 0; *L. chapaense*, 26, 0, 0; *L. chapaense*, 27, 0, 0; *Leptobrachium hainanensis*, 28A, 0, 0; *Leptobrachium hasseltii*, 29, 0, 0; *Leptobrachium montanum*, 30, 0, 0; *Leptobrachium mouhoti,* 34, 0, 0; *Leptobrachium xanthospilum*, 31, 0, 0; and *Oreolalax lichuanensis*, 32, 0, 0.

On the gene tree, the male nuptial spine and the reversed sexual size dimorphism both independently evolved multiple times. The likelihood ratio values, ranging from 11.89 to 12.07, were greater than the critical value 9.49 for significance at 0.05 level with 4 degrees of freedom. This indicates a significantly correlated evolution between the presences of nuptial spines and the reversed sexual size dimorphism.

4. Discussion

4.1. The invalidity of the genus Vibrissaphora

Our phylogenetic hypothesis does not support the validity of the genus *Vibrissaphora*, and therefore, *Vibrissaphora* should be synonymized with *Leptobrachium*. Neither *Leptobrachium* nor *Vibrissaphora* formed monophyletic groups on the mitochondrial or the nuclear gene trees (Figs. 3 and 4). Furthermore, clade A primarily groups *Vibrissaphora* species, and is a well-supported clade. Clades B and C are primarily *Leptobrachium* species. If clade A were the sister group to clade (B+C), the two generic names could be maintained with minor modification, i.e. placing part of *L. chapaense* in *Vibrissaphora* and placing *V. ngoclinhensis* in *Leptobrachium* (Figs. 3 and 4). However, both analysis of RAG-1 gene and the Bayesian analysis of the mitochondrial DNA suggested a ((A, B) C) relationship. Therefore, a better taxonomic solution would be to keep all species in a single genus, *Leptobrachium*. We sampled only seven *Leptobrachium* species in this study; a more thorough sampling should only enforce this conclusion.

Several taxonomic solutions have been proposed from previous morphological and molecular studies. Lathrop

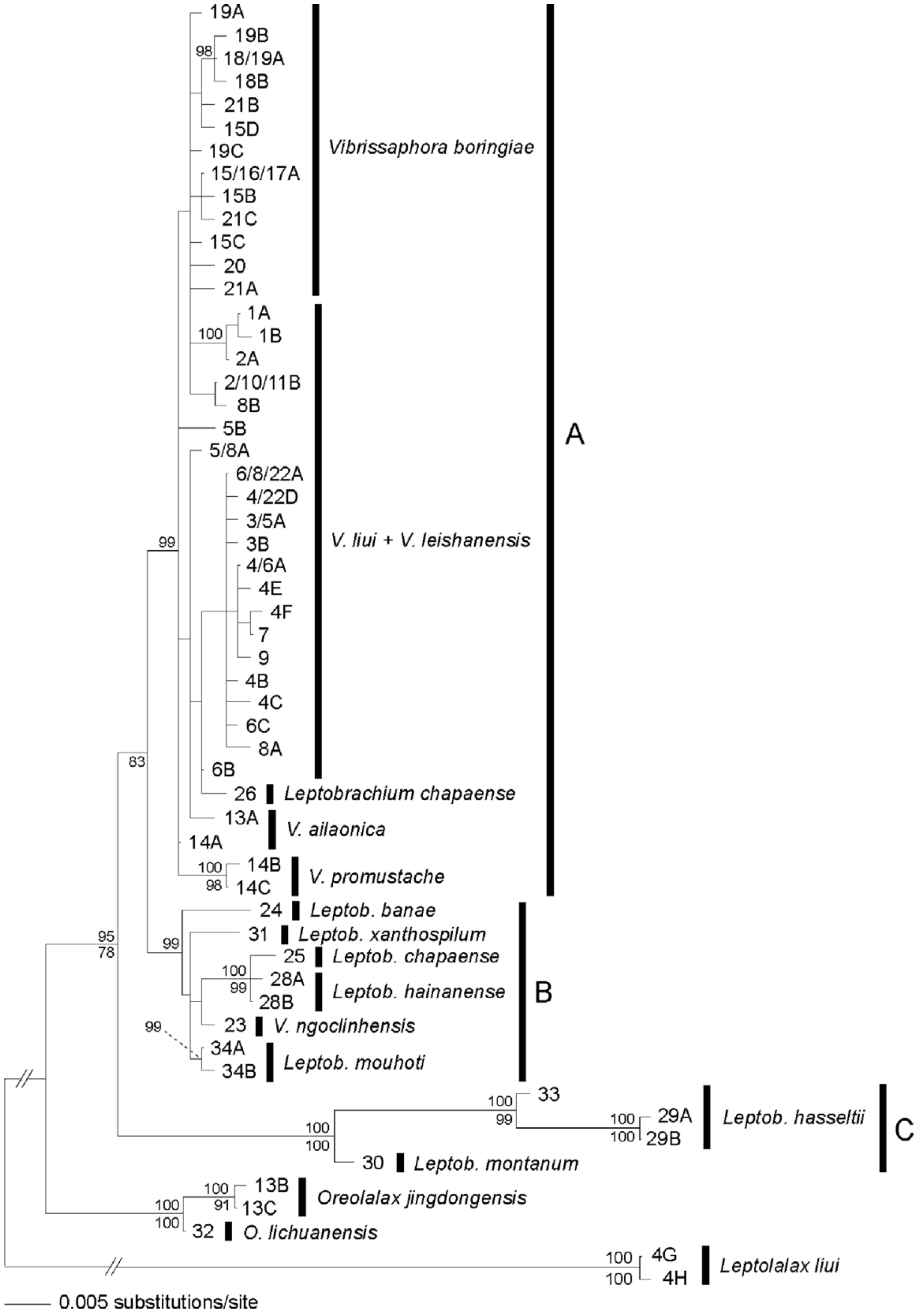

Fig. 4. Phylogenetic hypothesis derived from the Bayesian analysis of the nuclear RAG-1 data. Taxa are haplotypes. Numbers above branches are Bayesian posterior probabilities greater than 90. Bootstrap proportions greater than 70 of recovered nodes on the strict MP consensus tree are also marked below branches of this Bayesian tree. Vertical bars indicate species and clade designation.

(1997) and Zheng et al. (2004) suggested the sistergroup relationship of *Leptobrachium* and *Vibrissaphora*. Dubois (1983) proposed a single genus *Leptobrachium* including all species without subgeneric division. Tian and Hu (1985) and Dubois and Ohler (1998) preferred a single genus *Leptobrachium*, but with two subgenera *Leptobrach-*

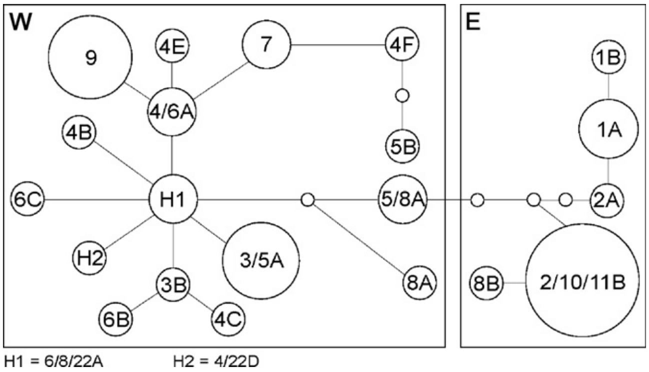

Fig. 5. Network for RAG-1 haplotypes from *Vibrissaphora liui*. Each line in the network represents a single mutational change. Circles are haplotypes drawn in sizes proportional to their frequency. Empty circles represent haplotypes that are necessary intermediates but were not found in the samples.

ium and *Vibrissaphora*. Zhao and Adler (1993) and Fei et al. (2005) recognized both genera as valid. Clearly, our phylogenetic hypothesis supports Dubois' (1983) proposal. Taxonomy should reflect evolutionary history and only monophyletic groups should be recognized as taxonomic ranks. Our phylogeny also supports Dubois and Ohler's (1998) claim that *Vibrissaphora* are specialized *Leptobrachium* with nuptial spines.

The primary diagnostic character of the genus *Vibrissaphora*, keratinized nuptial spines on male's upper jaw, also appears to have at least two independent origins according to our phylogenetic hypothesis. One occurred in *V. ngoclinhensis* in clade B, while the other one evolved in clade A. The best explanation in clade A is a single origin within the common ancestor of clade A excluding haplotype 27, followed by a single loss within the ancestor of haplotypes 12C and 26 (Fig. 3). The two independent origins of the nuptial spines also explain the two different arrangement patterns of the spines in this group. The spines of *L. ngoclinhensis* occur not only in the maxillary region, but also at the top of the head including the interorbital region, while the spines of other species are present only in the maxillary region (Orlov, 2005; Rao et al., 2006).

4.2. Determining species boundaries

Leptobrachium chapaense is likely a species complex, rather than a single species. Both mitochondrial and nuclear data suggested that the populations currently under the name *L. chapaense* belong to at least three independent evolutionary lineages (Figs. 3 and 4). Haplotype 12C was collected from Sa Pa (12), the type locality of *L. chapaense*, and therefore, populations from Sa Pa and Longling of Yunnan Province of China (26) are likely "true" *L. chapaense*. The population from Tam Dao (25) of northern Vietnam represents the sister group to *L. hainanense*, a species restricted to Hainan Island (28). This relationship is strongly supported by both mitochondrial and nuclear data and the divergence between them is minimal (Figs. 3 and 4). Therefore, the population is possibly *L. hainanense*. The northern Vietnam fauna shares many common elements with Hainan Island, and several other species have a similar distribution across Tonkin Gulf (e.g. *Bufo galeatus*; Orlov et al., 2002). The population from Ha Giang of northern Vietnam (27) likely represents an undescribed species. Some morphological variations within "*L. chapaense*" have been recognized. Tadpoles of the Yunnan populations have the typical yellow "Y"-shaped marks on the top of their tails (Yang, 1991), a characteristic of *Vibrissaphora sensu lato* but rarely found in *Leptobrachium* (Dubois and Ohler, 1998). Lathrop et al. (1998) reported that specimens from Tam Dao have a strikingly white colour on the dorsal half of their iris, and are easily distinguished from those of the other populations. The colour of the dorsal part of the eye is a widely used character for species diagnosis in this group (e.g. Matsui et al., 1999; Ohler et al., 2004). Rao et al. (2006) also noted *L. chapaense* might represent a species complex that requires further investigation.

"*Vibrissaphora*" *echinata* is not a valid species and should be part of "*V.*" *ailaonica*. Ho et al. (1999) first questioned the validity of this species and suggested that this species is a synonym of "*Vibrissaphora*" *ailaonica*. More recently, Ohler et al. (2000) and Grosjean (2001) argued for the validity of "*V.*" *echinata*. The two specimens used in this study were collected from the type locality of "*V.*" *echinata*, Fan Si Pa near Sa Pa in Lao Cai Province. Morphologically, the two specimens resemble the description of "*V.*" *echinata*, but their haplotypes unambiguously nested within the clade of "*V.*" *ailaonica* (Fig. 3). Therefore, our data support Ho et al.'s (1999) hypothesis that "*V.*" *echinata* is a synonym of *L. ailaonica*.

Leptobrachium liui is a single species. This species has a large and discontinuous distribution, and recognized morphological variation. However, the mitochondrial gene tree unambiguously grouped all populations together. Although both mitochondrial and nuclear gene data found an east-west split with population (8) located in the middle, this split most likely represents geographical population structure rather than reproductive isolation. The two mitochondrial haplotypes from the population (8A and 8B) were both clustered with the western group, but among the four nuclear haplotypes, three were clustered with the western group and one was with the eastern group. This suggests that gene flow exists between the eastern and western groups. The Jiulongshan population (11) was once named *V. jiulongshanensis* (Wei and Zhao, 1981) and the Jinxiu population (4) was *V. yaoshanensis* (Hu et al., 1981). Both populations have recognizable morphological variation. Nevertheless, haplotypes from these two populations were deeply nested within *L. liui* (Figs. 3 and 4), and therefore, are unambiguously part of this species.

Leptobrachium leishanensis shared two identical RAG-1 haplotypes (4/22D, 6/8/22A) with *L. liui*, and four of the five species in clade A failed to form a monophyletic group on the RAG-1 gene tree. Substantial amounts of morphological, behavioural and molecular data support the validity of *L. ailaonica, L. boringiae, L. leishanensis*, and *L. liui* (e.g. Fei et al., 2005), and few taxonomists would question the legitimacy of these species, yet, they are not monophyletic on the RAG-1 gene tree. This phenomenon has been noticed by Funk and Omland (2003). Genes with dramatically different evolutionary rates have different coalescence times. It is possible that some slowly evolving genes may have not reached coalescence within species, and therefore, incomplete ancestral lineage sorting would result in incorrect inferences about species boundaries (Funk and Omland, 2003; Lessios et al., 2003). When haplotype coalescence is used to test the validity of a species, an appropriate level of variability of the gene used should be considered before the fate of a species is determined.

4.3. Nuptial spines and sexual size dimorphism

A positive evolutionary correlation between the presence of nuptial spines and reversed sexual size dimorphism occurs in this group. Therefore, the function of the spines is likely associated with RSSD. Several hypotheses have been proposed to explain the large male size in *Leptobrachium.* The RSSD is possibly associated with mating system and reproductive strategy (Ding and Blanckenhorn, 2002). Generally, resource defense polygyny is the mating system most commonly found in animal species with large males (Blanckenhorn, 2005). In anurans, relatively large male body size seems also to be associated with this mating system (Pough et al., 2001). At least four *Leptobrachium* species, *L. ailaonica*, *L. boringiae*, *L. leishanensis*, and *L. liui*, all have RSSD and an inferred resource defence polygyny mating system (e.g. Chen et al., 1984; Ye et al., 1993; Ho et al., 1999). The resource, in these cases, would be the limited breeding nest, which was constructed and defended by males. Under this scenario, the nuptial spines are likely weaponry for combat (Dubois and Ohler, 1998). However, field observation does not support this hypothesis. During two seasons of detailed field study of *V. boringiae*, we did not observe a single occasion of male-male combat, and did not find any wounds or scars near the heads of 105 breeding males, which we examined (Zheng and Fu, unpublished data). Alternatively, the selective advantage of large males can be realized by male parental care. Several authors have noted or suggested paternal care, in the form of guarding egg clutches, in *V. ailaonica* and *V. boringiae*. After depositing eggs, females leave the nest immediately while the males remain with the clutches for some time (Chen et al., 1984; Fei and Ye, 1984; Ho et al., 1999). Ho et al. (1999) rationalized the nuptial spines being used to fend off predators from the developing embryos.

Many other factors are also likely correlated with sexual dimorphism, such as life history traits (Gustafsson et al., 1995). Alternatively, sexual dimorphism in these frogs may have nothing to do with sexual selection as suggested by Monnet and Cherry (2002). The age difference between the sexes in breeding populations may be sufficient to explain most of the dimorphism. In short, this is an area of research that remains largely unexplored, and the rapidly accumulated natural history data and the maturation of phylogenetic comparative methods will likely foster an influx of research in this area.

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ORIGINAL ARTICLE

Biogeographical patterns of Chinese spiders (Arachnida: Araneae) based on a parsimony analysis of endemicity

Kaibaryer Meng[1], Shuqiang Li[1*] and Robert W. Murphy[2]

[1]*Institute of Zoology, Chinese Academy of Sciences, Beijing, China and* [2]*Department of Natural History, Royal Ontario Museum, Toronto, ON, Canada*

*Correspondence: Shuqiang Li, Institute of Zoology, Chinese Academy of Sciences, Da-Tun Road, Chaoyang District, Beijing 100101, China.
E-mail: lisq@ioz.ac.cn

ABSTRACT

Aim The distributions of Chinese spiders are used to form biotic regions and to infer biogeographical patterns.

Location China.

Methods China was initially divided into 294 quadrats of 2° latitude by 2° longitude. The distributions of 958 species of spiders were summarized for each quadrat. Subsequently, these quadrats were pooled into 28 areas based on topographical characteristics and to a lesser extent on the distributions of spiders. Parsimony analysis of endemicity (PAE) was used to classify the 28 areas based on the shared distributional patterns of spiders.

Results China was found to have seven major biogeographical regions based on the distributional patterns of spiders: Western Northern region (clade B_2: Tibetan Plateau and Inner Mongolia-Xinjiang subregions), Central Northern region (clade B_3), Eastern Northern region (clade B_4), Central region (clade C_2), Eastern Southern region (clade C_3), Western Southern region (clade C_4), and Central Southern region (clade C_5).

Main conclusions The distributional patterns of Chinese spiders correspond broadly to geological provinces. A comparison of the geological provinces and the distributional patterns of spiders reveals that the spiders occur south of the geological provinces. Furthermore, a general biogeographical classification with five natural areas is suggested as follows: Tibetan Plateau, Central Northern, Eastern Northern, Western Northern (excluding Tibetan Plateau), and Southern regions.

Keywords
Biogeographical realm, biogeography, China, distributional patterns, geological provinces, Oriental realm, Palaearctic realm, PAE.

INTRODUCTION

Historical biogeography plays an important role in deciphering the evolution of biodiversity as well as in revealing the geological history of the Earth. The patterns and processes of biotic distribution are essential elements in the reconstruction of this history. From a biogeographical perspective, plate tectonics continually changes the surface of the Earth by keeping continents and ocean basins in constant motion. Continental movements, together with the rise and fall of sea levels, radically alter the configuration of land and sea, giving rise to vicariant events that isolate species of terrestrial plants and animals within specific regions (Scotese, 2004).

Although China lies in south-eastern Eurasia, it has a relatively independent geological history. Six primary plates are involved in its tectonic history, namely the North China, Tarim, Yangtze, Cathaysian plates, and parts of the Siberia and Gondwana plates. By the Pleistocene, seven collisions and integrations of these plates had united the ancient Siberian and European plates (Hsü & Chen, 1999; Wan, 2003). With approximately 200 tectonic-facies (Hsü & Chen, 1999), China has a complex topography, including towering mountains, basins of various sizes, undulating plateaus and hills, and fertile plains. Mountains occur as north-south terraced terrain with slopes that descend to the east and west. The highest terrace, the Qinghai-Tibetan Plateau – the 'roof of the world' – has an

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average elevation of over 4000 m. The second highest terrace consists of Inner Mongolia, the Loess Plateau, the Yunnan-Guizhou Plateau, and the Tarim, Junggar and Sichuan basins. It averages 1000–2000 m in elevation. The third terrace, with an elevation of 500–1000 m, involves the Da Xingan, Taihang, Wushan, and Xuefeng mountains on the eastern coast of China. Sub-littoral areas on the Chinese continental shelf comprise the fourth terrace; the average depth of water is less than 200 m.

Geological complexity and history usually have a profound influence on the distributions of living organisms, and China is no exception to this rule. The complex topography and historical processes make the biogeographical study of the Chinese biota both intriguing and challenging.

Traditionally, China has been divided into two realms and seven biological provinces. The Palaearctic realm includes the North-eastern, Northern, Inner Mongolia-Xinjiang, and Qinghai-Tibetan biological provinces. The Oriental realm includes the South-western, Central, and Southern biological provinces. This division, originally established by Cheng & Zhang (1959), was later modified by Zhang & Zhao (1978) and Zhang (1998, 2004). To a great extent, this biogeographical classification was based on the distributions of vertebrates, primarily mammals and birds. Recently, MacKinnon *et al.* (1996) provided an empirical evaluation of the biogeographical patterns, and Xie *et al.* (2004) clustered overall similarity coefficients. Although these papers make significant contributions, the biogeographical patterns of other speciose taxonomic groups, such as arthropods, have been poorly assessed.

Unique in producing and using silk, spiders constitute the seventh largest order of animals (Coddington & Levi, 1991). They occur in almost every habitat, from marine intertidal zones to tundra and rocky peaks. Most spiders have limited dispersal abilities and thus may be affected by vicariant events. Fortunately, in comparison to many other Chinese animals, spiders have been well collected and studied. They are therefore ideal subjects for biogeographical studies (Fattorini, 2002).

Chinese spiders occur in 58 families (Table 1) and include 2858 species (see Appendix S1 in Supplementary Material). Herein, we define biogeographical regions of China based on the distributional patterns of spiders by applying a parsimony analysis of endemicity (PAE; Rosen, 1988; Rosen & Smith, 1988).

MATERIALS AND METHODS

Areas

A map of China was initially divided into 294 quadrats of 2° latitude by 2° longitude without consideration of physiographical features (Fig. 1). Many neighbouring quadrats had very similar climatic and geological characteristics, whereas other quadrats contained considerable physiographical and climatic variation. In addition, collecting efforts were inadequate in some quadrats. It was therefore desirable subjectively

Table 1 Numbers of the currently valid spider genera and species occurring in China.

Family	No. of genera	No. of species
Agelenidae C. L. Koch, 1837	4	22
Amaurobiidae Thorell, 1870	19	206
Anapidae Simon, 1895	3	3
Anyphaenidae Bertkau, 1878	1	2
Araneidae Simon, 1895	41	335
Atypidae Thorell, 1870	2	8
Clubionidae Wagner, 1887	1	80
Corinnidae Karsch, 1880	8	36
Ctenidae Keyserling, 1877	3	5
Ctenizidae Thorell, 1887	3	11
Cybaeidae Banks, 1892	2	7
Deinopidae C. L. Koch, 1850	1	1
Dictynidae O. P.-Cambridge, 1871	11	36
Dipluridae Simon, 1889	1	1
Dysderidae C. L. Koch, 1837	1	1
Eresidae C. L. Koch, 1851	1	2
Filistatidae Ausserer, 1867	3	17
Gnaphosidae Pocock, 1898	30	153
Hahniidae Bertkau, 1878	2	17
Hersiliidae Thorell, 1870	1	8
Hexathelidae Simon, 1892	1	8
Hypochilidae Marx, 1888	1	1
Leptonetidae Simon, 1890	1	15
Linyphiidae Blackwall, 1859	112	274
Liocranidae Simon, 1897	4	6
Liphistiidae Thorell, 1869	1	12
Lycosidae Sundevall, 1833	21	259
Mimetidae Simon, 1881	2	14
Miturgidae Simon, 1885	2	30
Nemesiidae Simon, 1892	3	6
Nesticidae Simon, 1894	1	5
Oecobiidae Blackwall, 1862	2	8
Oonopidae Simon, 1890	8	19
Oxyopidae Thorell, 1870	3	31
Palpimanidae Thorell, 1870	1	1
Philodromidae Thorell, 1870	3	47
Pholcidae C. L. Koch, 1851	7	40
Pisauridae Simon, 1890	6	28
Prodidomidae Simon, 1884	1	1
Psechridae Simon, 1890	2	11
Salticidae Blackwall, 1841	88	436
Scytodidae Blackwall, 1864	2	11
Segestriidae Simon, 1893	2	5
Selenopidae Simon, 1897	1	4
Sicariidae Keyserling, 1880	1	3
Sparassidae Bertkau, 1872	8	51
Telemidae Fage, 1913	1	3
Tetragnathidae Menge, 1866	17	77
Theraphosidae Thorell, 1870	4	5
Theridiidae Sundevall, 1833	36	270
Theridiosomatidae Simon, 1881	1	3
Thomisidae Sundevall, 1833	30	167
Titanoecidae Lehtinen, 1967	3	11
Trochanteriidae Karsch, 1879	1	4
Uloboridae Thorell, 1869	6	23

Table 1 Continued

Family	No. of genera	No. of species
Zodariidae Thorell, 1881	4	15
Zoridae F. O. P.-Cambridge, 1893	1	3
Zoropsidae Bertkau, 1882	2	3

to combine or divide some quadrats into biologically similar areas. Because it was very likely that these physiographical features would influence the distributions of species (Crisci *et al.*, 2003), adjacent quadrats that had very similar topographical characteristics were combined (cf. Fan, 1990). In doing so, natural barriers to dispersal were used to identify and separate dissimilar physiographic areas within and between quadrats. Sometimes these barriers corresponded to pre-existing subdivisions, such as provinces, districts and ecoregions. For example, combined quadrats with similar topographic characteristics formed the following areas: Inner Mongolia Plateau (area A10), Sichuan basin (A15), Qinghai-Tibetan Plateau (A11 and A21), Yunnan-Guizhou Plateau (A27, and A16), islands (A26 and A23), river deltas (A24 and A04), and mountains (A22). Other areas were designated on the basis of natural barriers, including the following: A21 was separated from A19 along the Karakorm Mountains; A21 was divided from A11 along the Tanggula Mountains; A15 was separated from A11 along the Hengduan Mountains; and A27 was isolated from adjacent regions along the Yunnan-Guizhou Plateau. The remaining areas were either combined because the distributional data of spiders indicated similarity with their surrounding areas, such as in separating area A28 from A05, A09 and A14, or divided on the basis of topographic characteristics, e.g. A19.

The combining and splitting of the 294 quadrats reduced the total number of study areas to 28. As an empirical test of validity, the new areas were compared with the distributions of species of spiders. This test revealed a good correspondence between the study areas and the distributions of many species. Consequently, this approach probably obtained the optimal results (Morrone & Escalante, 2002).

In total, 28 biological and physiographical areas (Fig. 1) were evaluated by PAE. The inclusion of geographically larger and smaller quadrats did not affect the analyses because PAE does not require all quadrats to be equal in size and shape (Posadas, 1996).

Distribution matrix

Detailed distributional data were obtained from both the literature and the collections at the Chinese Academy of Sciences, Beijing. The initial data set included 2858 species of Chinese spiders. A taxon/area data matrix scored the presence of a species in an area as ‘1’ and the absence as ‘0’. Ambiguous distributional data were clarified from unpublished dissertations, or the ambiguity was coded as ‘?’. In total, 1809 species were removed from the analysis because their distributional data were not useful; these species either occurred in a single area only, and thus appeared as phylogenetically uninformative autapomorphies, or they occurred in all areas (Wiley, 1981). An additional 91 species were removed owing to inadequate distributional information. Areas were required to be grouped and defined by at least two species of spiders. These areas were delimited and mapped (Morrone, 1994). Thus, data from 958 species were included in the analysis (Appendix S2).

The data set contains 958 species and 5012 detailed collection records. At least 300 records occur in areas A02,

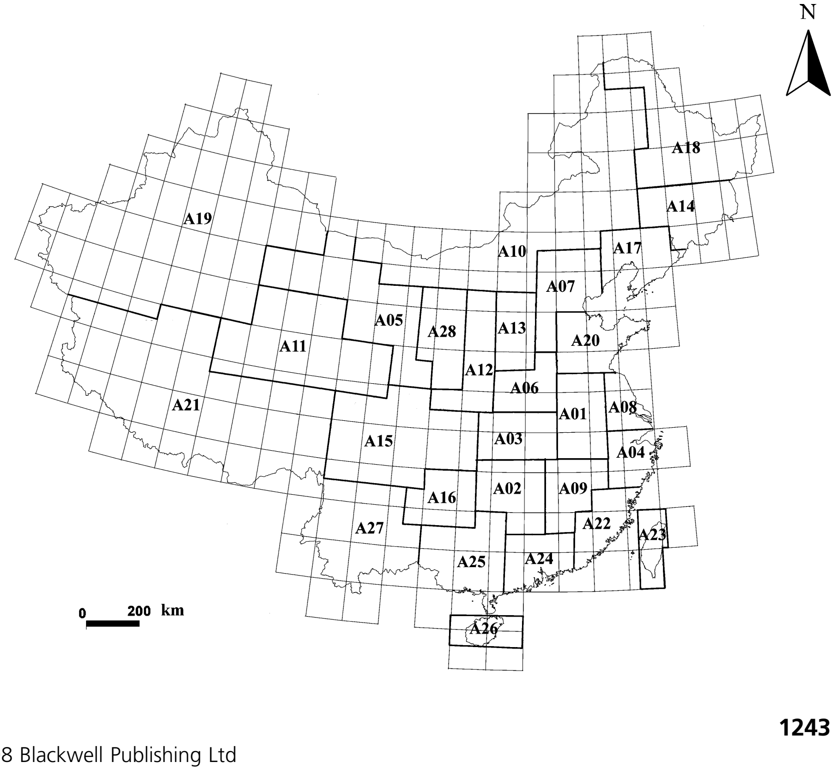

Figure 1 Map of China (excluding islands in the South China Sea) showing the 28 areas (A01–A28) used in the analysis after pooling 294 quadrats of 2° longitude by 2° latitude, primarily based on topographical characteristics.

Table 2 The number of species of spiders occurring in each of the areas defined for China.

Area	Number of species
A01	152
A02	343
A03	205
A04	306
A05	199
A06	143
A07	261
A08	92
A09	131
A10	169
A11	176
A12	191
A13	176
A14	221
A15	302
A16	122
A17	142
A18	96
A19	211
A20	167
A21	171
A22	185
A23	196
A24	158
A25	151
A26	104
A27	176
A28	66

A04, and A15. Areas A03, A07, A14, and A19 contain from 200 to 300 records. Most areas, namely A01, A05, A06, A09, A10, A11, A12, A13, A16, A17, A20, A21, A22, A23, A24, A25, A26, and A27, have from 100 to 200 records of spiders. In the last two areas, A08 and A28, there are fewer than 100 records (Table 2).

Parsimony analysis of endemicity

PAE encapsulates the natural patterns of biotic distributions (Rosen, 1988; Rosen & Smith, 1988). It is analogous to a cladistic analysis, with areas equivalent to taxa and the occurrences of species forming the characters. Groups are formed by the occurrence of shared species. A hypothetical area that had no taxa was used as an outgroup to root the cladogram (Rosen, 1988; Rosen & Smith, 1988; Cracraft, 1991; Morrone & Crisci, 1995; Geraads, 1998; Waggoner, 1999; Morrone & Escalante, 2002; Brooks & van Veller, 2003; Porzecanski & Cracraft, 2005). Although PAE can provide a summary of localities, areas of endemism, or quadrats (Crisci *et al.*, 2003), herein it is applied to combined quadrats only.

The taxon × area data matrix was analysed with the criterion of maximum parsimony using PAUP* 4.0 (Swofford, 1998) with a heuristic search of 1000 replicates and random sequence addition. Bootstrapping (Felsenstein, 1985) with 100 replications and 1000 random sequence additions was used to estimate the confidence intervals for the recovered nodes. All characters were weighted equally.

RESULTS

The parsimony analysis obtained four most-parsimonious trees (3143 steps; CI = 0.3048; RI = 0.4079). The trees differed in the positions of areas A05 and A23. Area A05 was included either within clade A10 + A19 + A11 + A21 or at its base. The second arrangement was more strongly supported, with a bootstrap support value of 40% as opposed to 12% for the first. Area A23 clustered either as ((A23, A27) A16) or as (A23 (A15 (A02, A04))). In the first arrangement the bootstrap support value was 13%, and in the second possibility the bootstrap support value was 11%. The arrangement with the highest bootstrap proportion for areas A05 and A23 was selected for discussion (Fig. 2).

Two clear groups, B and C (Fig. 2), were discovered by the analysis. The bootstrap proportion of group B (90%) was nearly twice that of group C (44%). When mapped, clades B and C corresponded to a geographical barrier within the confines of the Qinling Mountains and Huai River, and east of the Hengduan Mountains (Fig. 3). In group B, four clades were identified: B_1 (A28), B_2 (A05 + A10 + A11 + A19 + A21), B_3 (A06 + A07 + A12 + A13 + A20), and B_4 (A14 + A17 + A18) (Fig. 2). Clade B_2 had a bootstrap proportion of 40%. It contained three sub-clades, A05, A10 + A19, and A11 + A21, each of which corresponded to a landform. For example, A10 + A19 were contained within the steppe and desert of north-western China, and A11 + A21 corresponded to the Tibetan plateau. Area A05 included the transition zone between A10 + A19 and A11 + A21. Having the greatest bootstrap support of any clade (75%), B_3 corresponded to Central Northern region. Clade B_4 corresponded to Eastern Northern region, including the Changbai and Xiao Xingan mountains (Fig. 3); its bootstrap support value was 49%.

Five clades were identified in group C: C_1 (A09), C_2 (A01 + A02 + A03 + A04 + A15 + A08), C_3 (A22 + A24), C_4 (A16 + A23 + A27), and C_5 (A25 + A26) (Fig. 2). Bootstrap proportions of C_1 to C_4 were smaller than the values obtained for B_2, i.e. <40%. Clade C_5 had the greatest bootstrap value (75%). The range of C_2, Central region, included areas north of the Qinling and Hengduan mountains and the Huai River, and regions south of the Yangtze River. C_3, Eastern Southern region included the south-eastern coast. Areas A27 and A16 and area A23 (Taiwan Island) formed two sub-clades in C_4. Clade C_5 contained areas with similar arachnifaunas: areas A25 and A26 (Hainan Island).

Based on the patterns of distributions of the spiders, seven major regions can be recognized in China: Western Northern region (B_2), including the Tibetan Plateau subregion and Inner Mongolia-Xinjiang subregions; Central Northern region (B_3); Eastern Northern region (B_4); Central region (C_2); Eastern Southern region (C_3); Western Southern region (C_4); and

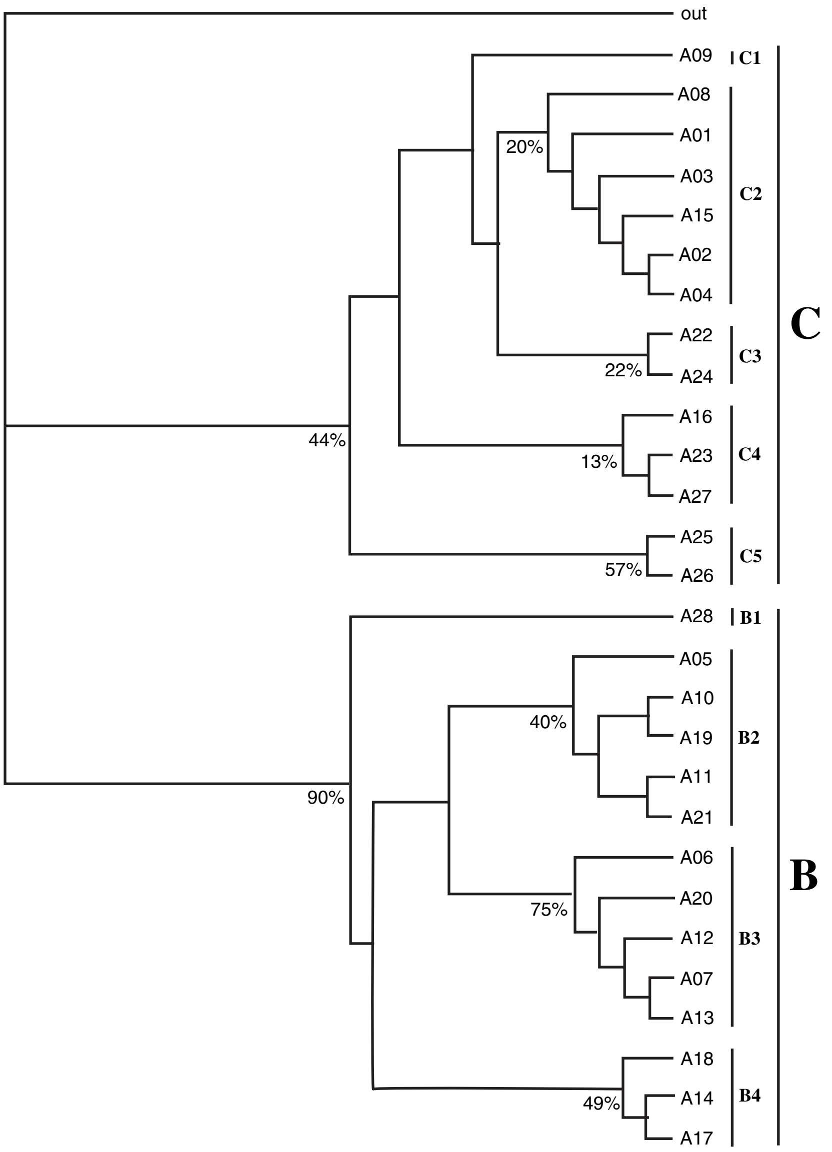

Figure 2 Selected area cladogram illustrating the relationships of the 28 areas based on a parsimony analysis of 958 distributions shared by species of spiders. Numbers below the lines indicate bootstrap proportions. Outgroup: 'out'.

Central Southern region (C_5). Clades B_1 and C_1 exhibited no clear patterns, and their associations remained ambiguous.

Western Northern region – Clade B_2

The Western Northern region includes the Tibetan Plateau subregion (A11 + A21) and north-western provinces (Xinjiang and Inner Mongolia; A10 + A19). Although these subregions share a similar, arid climate, they have two dramatically different topologies. To the south, the Tibetan Plateau subregion has an average elevation of about 4000 m and a typical continental climate. It receives more sunshine than any other region of the country, but is quite cold as a result of its high elevation. Glaciers and permanent snowfields abound, and the central and north-western parts of the plateau have permafrost soils. There are numerous lakes and marshes, with many lakes being saline. More than 320 species of spiders have been recorded in this subregion. These species belong to 33 families (Appendix S3), of which the Lycosidae (67 species), Salticidae (44 species) and Theridiosomatidae (27 species) dominate.

The northern part of this region, the Inner Mongolia-Xinjiang subregion, consists of the Xinjiang and Inner Mongolia provinces. Steppe and deserts dominate. It includes some of the hottest and driest areas on Earth. The climate ranges from being cool-temperate in the north to temperate and warm-temperate in the south, and ranges dramatically from being arid in the west to sub-humid in the east. About 340 species of spider have been recorded in this subregion. They belong to 34 families (Appendix S3), of which the Lycosidae (75 species), Salticidae (55 species), Araneidae (29 species) Theridiosomatidae (23 species) and Philodromidae (20 species) dominate.

Central Northern region – Clade B_3

This region includes the low-lying basin of the Yellow River. It has a warm, temperate, relatively dry climate. Much of the land has been developed for agricultural use, and only a few patches of forest remain. About 300 species of spiders have been recorded in this region, but no species appears to be endemic. Species in this region belong to 35 families (Appendix S3), of which the Lycosidae (64 species) and Salticidae (48 species) are most speciose.

Eastern Northern region – Clade B_4

The Eastern Northern region consists of the Xiao Xingan and Changbai mountains. The climate is humid and cold-temperate. Several forest species of birds and mammals are similar to those found in northern Europe, Asia and North America (Zhao & Adler, 1993). About 290 species of spiders have been recorded in this region, but none of them is endemic. Species belong to 33 families (Appendix S3), of which the Araneidae (25 species) dominates.

Central region – Clade C_2

The Central region consists of the Yangtze River and its tributaries. It has a subtropical monsoonal climate with plentiful rainfall. The four landscapes in this region are mountains, hills, basins, and plains. The mountains, which are located in the west, slope eastwards, forming the alluvial deposits of the Yangtze River. Spiders in this region belong to 34 families (Appendix S3), of which the Lycosidae (58 species) and Araneidae (26 species) are most abundant.

Eastern Southern region – Clade C_3

The Eastern Southern region consists of Guangdong and Fujian provinces. Generally, its staircase topography descends from the north-west to the south-east seaboard. Its principal mountains run from the north-east to the south-west. Long, narrow plains occur along the coast. Marked climatic differences occur between the north and south, coastal and inland regions, and valleys and mountains. Coastal regions frequently receive typhoons between May and November. About 310 species have been recorded but none is endemic. They are assigned to 33 families (Appendix S3), of which the Lycosidae (63 species), Salticidae (57 species) and Araneidae (31 species) are most speciose.

Western Southern region – Clade C_4

The Western Southern region includes two distinct landforms at the same latitude: Taiwan Island and the Yunnan-Guizhou Plateau. The plateau is contiguous with the Qinghai-Tibetan Plateau to the north-west. High, north-western regions descend south-eastwardly. A great difference in elevation occurs between these regions. In the eastern Yunnan Plateau, karst topography occupies wide areas and involves spectacular pinnacles, caverns and subterranean streams. The western Yunnan valley, part of the Hengduan Range, consists of many intermontane valleys arranged vertically from north to south and from west to east. From north to south, the complicated terrain results in three climatic zones: temperate, subtropical and tropical. These climatic zones are distributed from low to high elevations over four regions: low, hot river valley ba zi (small upland plains), mountain areas, and cold highlands. These form a peculiar 'three-dimensional' climate.

Taiwan Island is close to the South-eastern Central area (C_3). About 270 species of spiders are found in this region, none of them endemic. They belong to 31 families (Appendix S3), of which the Salticidae (40 species) and Araneidae (32 species) dominate.

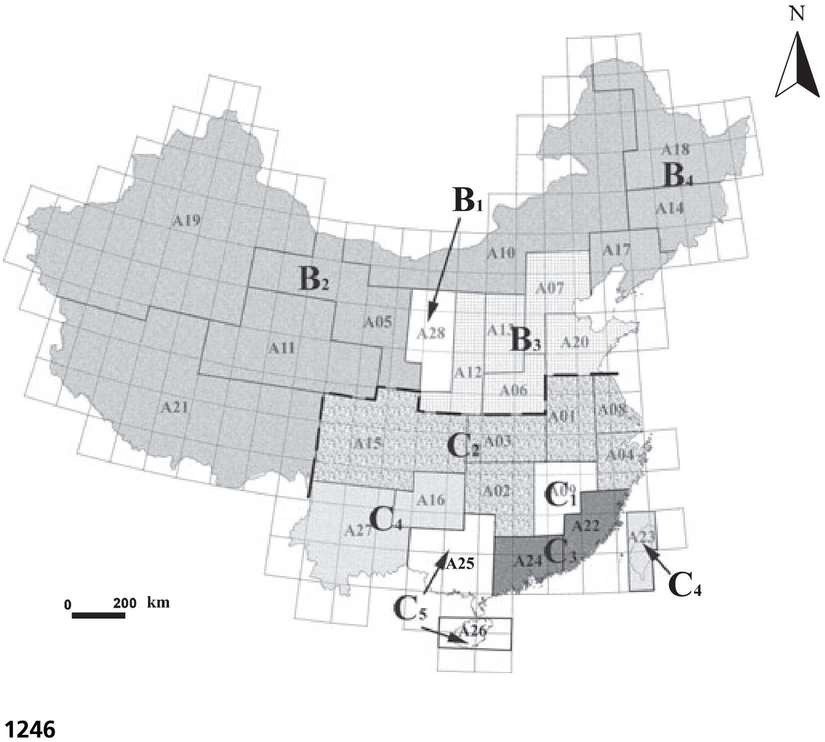

Figure 3 Generalized pattern of the distribution of Chinese spiders based on a parsimony analysis of endemicity. The broken line is the boundary between clades B and C. Different backgrounds indicate the clades in Fig. 2. B_1, area A28; B_2, Western Northern region; B_3, Central Northern region; B_4, Eastern Northern region; C_1, area A09; C_2, Central region; C_3, Eastern Southern region; C_4, Western Southern region; C_5, Central Southern region.

Central Southern region – Clade C_5

The Central Southern region includes Hainan Island and the Guangxi Basin. Hainan Island consists of hills, mountains, and arid tablelands. The north-western portion of the Guangxi Basin is part of the Yunnan-Guizhou Plateau. Its northern portion is locked within the Jiuwandashan, Damiao and Tianping mountains. North-eastern Guangxi Basin is part of the Nanling Mountains, comprising the Yuechengling, Haiyang, Dupangling and Mengzhuling ranges that extend south-westwards parallel to one another. The Yunkaidashan, Liuwandashan, Shiwandashan and Daqingshan mountains are situated in the south. The majority of the mountains are 1000–1500 m above sea level. The Central Southern region has a subtropical monsoonal climate with long summers, warm winters, plentiful rainfall, and frequent rainstorms and typhoons in the summer and autumn. About 290 species of spiders occur in this region. They belong to 32 families (Appendix S3), of which the Lycosidae (62 species), Salticidae (43 species), and Araneidae (30 species) are the most speciose.

DISCUSSION

Spider distributional patterns and the geological provinces of China

The archipelago model of orogenesis (Hsü & Chen, 1999) divides China into six geological provinces: Laurentian/Cathaysian Southern and South-western Margin, North-western China, Central China, Southern China, Tibet, and Pacific China. This arrangement incorporates 31 map-units based on 200 tectonic-facies (Hsü & Chen, 1999). These geological provinces broadly match the distributional patterns of spiders. For example, the North-western China geological province, excluding the Northern China region, is comparable with the Central Northern region (clade B_3) with the Inner Mongolia-Xinjiang subregion. The northern part of the Pacific China geological province is similar to the Eastern Northern region (clade B_4). The Laurentian/Cathaysian Southern and South-western Margin geological province combined with the Tibetan geological province corresponds to the Tibetan Plateau biogeographical subregion. The Central China geological province is similar to the Central region (clade C_2). The Southern China geological province generally corresponds to the Eastern Southern (clade C_3), Western Southern Central (clade C_4), and Central Southern (clade C_5) regions combined.

A comparison of the geological provinces and the distributional patterns of spiders reveals that the spiders occur south of the geological provinces. This anomaly may be explained by two hypotheses: distributional stability, and post-orogenic change. In the distributional stability hypothesis, the patterns of spider distribution did not change after the last plate movement. This scenario seems extremely unlikely because orogenesis may be the only way to universally influence biogeographical patterns. The most recent orogenesis occurred over 0.78 Ma (Wan, 2003). Although this amount of time is sufficient to influence the distributional patterns of spiders, the spiders occur south of the geological provinces. In contrast, the post-orogenic-change hypothesis stipulates that the patterns of spider distribution were altered after the last plate movement. In this case, dispersal, extinction, invasion, and/or speciation are important factors. Pleistocene glaciation must have caused dispersal, extinction, invasion, or speciation of organisms. Of these two hypotheses, the post-orogenic-change hypothesis provides the only reasonable explanation of the distribution of spiders relative to the geological provinces.

Spider distributional patterns and other biogeographical patterns

Different organisms may share a general distribution pattern because they are influenced by the same geological history. In order to infer a general pattern, it is necessary to compare patterns based on different groups of organisms, such as the traditional biogeographic patterns obtained by Zhang (2004) and Xie *et al.* (2004), with the patterns of spiders. Interestingly, five areas are congruent: the Tibetan Plateau, Central Northern, Eastern Northern, Western Northern (excluding Tibetan Plateau), and Southern regions.

Some differences occurred between our results and those of Zhang (2004) and Xie *et al.* (2004). First, Xie *et al.* and Zhang separated the Hengduan Mountains and the south-facing Himalayas from the Tibetan Plateau subregion, unlike our regions. The separation was based on the distributions of various mammals and plants, as well as on particular geographical characteristics. This discrepancy may be a result of the general absence of fine-scaled distributional data for spiders.

Second, distributional patterns of spiders revealed novel borders between the Eastern Northern region (Clade B_4) and the Inner Mongolia-Xinjiang subregion. The biological associations of the Da Xingan Mountains are controversial. Plants in the Xiao Xingan and Changbai mountains are similar, but differ from plants in the Da Xingan Mountains (Xie *et al.*, 2004). Superimposing the analysis of Xie *et al.* (2004) on our data, the Da Xingan Mountains are placed with the Inner Mongolia-Xinjiang subregion of spiders. In contrast, Zhang (2004) suggested that the Da Xingan Mountains should be placed in our Eastern Northern region (Clade B_4), based on mammalian distributions. This difference may be attributable to the taxa analysed. Plants and spiders have relatively poor migratory abilities and may be more affected by vicariant events (Fattorini, 2002).

Third, southern China, including clades C_2, C_3, C_4, and C_5 (Fig. 3), has a complex pattern. This area was divided into the Central and Southern regions with six subregions by Zhang (2004). Xie *et al.* (2004) considered this area to be one region with three subregions. The position of the islands complicates division into subregions. Zhang (2004) suggested that each island was a subregion, but Xie *et al.* (2004) asserted that they constituted a single subregion. Our analyses suggest that the islands have had geologically recent biological contact with the mainland. Therefore, we suggest that the biogeographical patterns in southern China are reticulate. The reticulation is best explained by sea-level changes caused by Pleistocene glaciation (Yang, 2004): coastlines advanced and retreated with each glacial cycle. Reticulate area relationships cannot be analysed by PAE (Brooks & van Veller, 2003), although PAE-PCE, i.e. PAE with progressive character elimination (García-Barros *et al.*, 2002), may help to unravel reticulate relationships. Notwithstanding, it seems preferable to consider southern China as a single area without subregions.

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SUPPLEMENTARY MATERIAL

The following supplementary material is available for this article online:

Appendix S1 List and distribution of Chinese spiders.
Appendix S2 The data matrix for PAE analysis.
Appendix S3 Numbers of species of spiders per region.

This material is available as part of the online article from: http://www.blackwell-synergy.com/doi/abs/10.1111/j.1365-2699.2007.01843.x

BIOSKETCHES

Kaibaryer Meng obtained his MSc from Xinjiang University, China, and is an assistant curator at the Chinese Academy of Sciences.

Shuqiang Li obtained a PhD from the University of Hohenheim in Stuttgart in 1998 and is currently a full professor at the Institute of Zoology, Chinese Academy of Sciences. Both Meng and Li work on Chinese spiders.

Robert Murphy obtained his PhD from the University of California, Los Angeles in 1982. He is a full professor at the University of Toronto and an adjunct professor at East China Normal University and Hainan Normal University. He studies Southeast Asian biogeography.

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[1]*Institute of Zoology, Chinese Academy of Sciences, Beijing, China;* [2]*College of Life Science, Peking University, Beijing, China;* [3]*Department of Biology, Portland State University, Portland, OR, USA;* [4]*Graduate School of Chinese Academy of Sciences, Beijing, China*

Phylogeographic analysis of Pimoidae (Arachnida: Araneae) inferred from mitochondrial cytochrome *c* oxidase subunit I and nuclear 28S rRNA gene regions

Q. WANG[1,4], S. LI[1], R. WANG[2] and P. PAQUIN[3]

Abstract

Using mitochondrial DNA cytochrome *c* oxidase subunit I and nuclear DNA 28S rRNA data, we explored the phylogenetic relationships of the family Pimoidae (Arachnida: Araneae) and tested the North America to Asia dispersal hypothesis. Sequence data were analysed using maximum parsimony and Bayesian inference. A phylogenetic analysis suggested that vicariance, instead of dispersal, better explained the present distribution pattern of Pimoidae. Times of divergence events were estimated using penalized likelihood method. The dating analysis suggested that the emergence time of Pimoidae was approximately 140 million years ago (Ma). The divergence time of the North American and Asian species of *Pimoa* was approximately 110 Ma. Our phylogenetic hypothesis supports the current morphology-based taxonomy and suggests that the cave dwelling might have played an important role in the speciation of pimoids in arid areas.

Key words: Araneae – phylogeography – Pimoidae – cytochrome *c* oxidase subunit I – 28S rRNA

Introduction

Phylogenetic analysis allows inferences about the distribution patterns and time of divergence between lineages (Biswas and Pawar 2006). The family Pimoidae has a discontinuous distribution and provides an excellent model system to test the power of phylogenetic analysis. The current distribution range of pimoids includes the west coast of North America, the Alps and Cantabrian Mountains of northern Spain, the Himalayas and adjacent areas, and Japan (Hormiga 1994, 2003). Thaler (1976) and Hormiga (1994) hypothesized this disjunctive pattern as an ancestral widespread Holarctic distribution with subsequent extinction in the intervening area. Furthermore, Hormiga (1994) suggested that the common ancestor of the Asian clade dispersed from North America to Asia because the Asian species formed a monophyletic group and nested within the North American taxa on his phylogeny.

The species diversity and the evolutionary history of the family Pimoidae is far from being clear. According to Platnick (2007) and Hormiga et al. (2005), the family includes 26 known species classified in three genera: 22 species in *Pimoa*, three species in *Weintrauboa* and one species in *Nanoa*. The Himalayas and the adjacent Hengduan Mountains of south-western China are particularly rich in species. Twelve pimoids have been reported from the area, including two species of *Weintrauboa* and three species of *Pimoa* recently described by Xu and Li (2007). Yet, it is believed that many new species of pimoids remain to be discovered (Hormiga et al. 2005). Some species are cave dwellers. Recently, *Pimoa clavata*, a newly described species, was found from six caves at Fangshan District of the Beijing City in northern China, approximately 2000 km from its nearest distribution in south-western China. Little is known about the role of cave dwelling in the speciation of these spiders.

Recent developments in phylogenetic methods and molecular technology provides powerful means to test evolutionary hypotheses. Using both mitochondrial and nuclear DNA sequences, we tested the phylogenetic relationships of species within the family Pimoidae and evaluated Hormiga's (1994) hypothesis of dispersal from North America to Asia. We also explored the role of caves in speciation of pimoids.

Materials and Methods

Sampling

A total of 65 individuals from 13 species of Pimoidae were sequenced. Thirty-four individuals of *P. clavata* Xu and Li, 2007 were collected from six caves in the vicinity of Beijing City (Fig. 1). Thirteen individuals of *P. reniformis* Xu and Li, 2007, collected in Sichuan Province of south-western China, were divided into three geographical populations: I, south-western Gongga Mountain; II, northern Gongga Mountain and III, eastern Gongga Mountain (Fig. 1). One individual of *P. trifurcata* Xu and Li, 2007, five individuals of *Weintrauboa chikunii*, (Oi, 1979) one individual of undescribed species of *Pimoa* sp1 and one individual of undescribed species of *Weintrauboa* sp2 were also collected in Sichuan Province. *Pimoa* sp1 were collected both in cave and in field out of cave. One individual of *P. anatolica* Hormiga, 1994 and *P. lihengae* Griswold, Long, and Hormiga, 1999, respectively, were collected in Yunnan Province of south-western China. Six individuals of five North American species, *P. breviata* Gertsch and Ivie, 1943, *P. curvata* Chamberlin and Ivie, 1943, *P. jellisoni* Gertsch and Ivie, 1936, *P. haden* Chamberlin and Ivie, 1943, *P. edenticulata* Hormiga, 1994 were included in this study. We also sequenced seven specimens belong to four species that were difficult to identify because of lack of male specimens. Seven individuals of five linyphiid species were selected as outgroups, which are traditionally considered as the closest taxa to the family Pimoidae (Wunderlich 1986). Detailed specimen information is provided in Table 1.

DNA extraction, amplification and sequencing

Specimens were preserved in 95% ethanol in the field, and stored at −20°C in lab. Genomic DNA was extracted using the Dnease tissue kit (Qiagen, Hilden, Germany) following the manufacturer's recommendations. The tissues used for DNA extractions were the legs, cephalothoraxes, abdomens, or a combination of the above, depending on the size of the specimens. The female epigyna and male palps were preserved if the abdomens or cephalothoraxes were used for DNA extraction. Partial fragments of the mitochondrial cytochrome *c* oxidase subunit I (COI) gene were amplified with the polymerase chain reaction (PCR) using the universal primer LCO-1628 (5′-ATAATGTAATTGTTACTGCTCATGC-3′), paired with HCO-2396

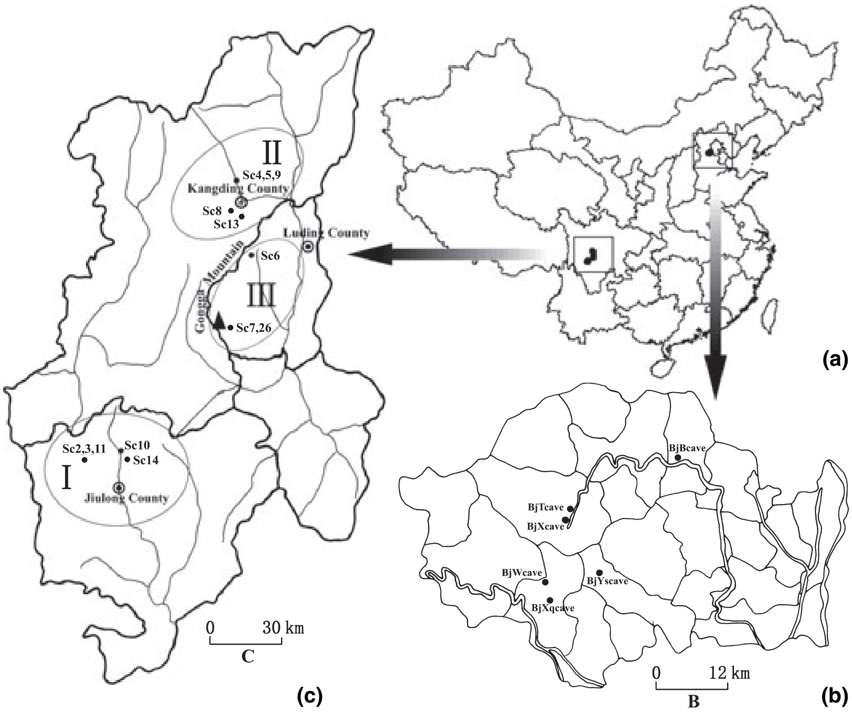

Fig. 1. Map of sample sites. (a) Collection localities of *Pimoa clavata* and *P. reniformis*. (b) The six caves localities of *P. clavata* in Fangshan District, Beijing City. (c) The collection localities of *P. reniformis* in Sichuan Province. I, II, III indicate the geographical unites

(5′-ATTGTAGCTGAGGTAAAATAAGCTCG-3′) (Gillespie 2004). Only specimens USA1 and USA2 were amplified by the primers combination of CL-J-1751SPID and CL-N-2776 (Hedin and Maddison 2001). Amplification was carried out in a Biometra thermal cycle, in a volume of 25 μl containing 0.15 μl *Taq* Polymerase (5000 U ml^{-1}; Promega Corporation, Madison, WI, USA), 2.5 μl 10× PCR buffer (2.0 mM MgCl$_2$), 0.8 μl dNTPs (10 mM), 1 μl of each primer (10 pmol/μl), 1 μl template DNA and 18.55 μl dH$_2$O. PCR conditions were as follows: 94°C initial denaturation for 3 min, 35 cycles of 94°C for 30 s, 50°C for 60 s, 72°C for 60 s, final extension for 10 min at 72°C. Double-stranded products from the nuclear ribosomal DNA 28S D1–D3 region were amplified using 28SB1 (5′-GACCGATAGC-AAACAAGTACCG-3′) and 28SB2 (5′-GATTAGTCTTTCGCCCC-TATA-3′) primers (Bruvo-Maðarić 2005). The PCR procedures were the same as the conditions for COI gene. PCR products were purified using QiaQuick columns (Qiagen) and the amounts of products were quantified using agarose gel electrophoresis with a DNA Ladder. The purified PCR products were sequenced from both directions on an ABI377 with the BigDye terminator cycle sequencing ready reaction kit (Applied Biosystems, Foster, CA, USA). The same primers used in PCR amplifications were used for sequencing. All sequence data were deposited in GenBank (Accession Numbers EF128085–EF128171, EF567081–EF567108).

DNA sequence alignment

Sequences of 28S rRNA gene were aligned using Clustal W 1.7 (Thompson et al. 1997). We used the following gap opening/extensions costs: 15/6.66 (default), 10/5, 10/1, 5/5, 5/1, 2/2, 2/1 to align the 28S rRNA sequences. Analyses of the seven different aligned data sets produced almost identical trees. The few differences between these trees were in poorly supported nodes. As there was no objective justification for choosing any particular set of alignment parameters, we chose to use the default parameter. Alignment of the COI gene was relatively straightforward, and no insertion or deletion was needed. BioEdit 7.0 (Hall 1999) was used for sequence editing.

Phylogenetic analysis

As significant heterogeneity in base composition can lead to erroneous grouping of unrelated taxa with similar composition (Lockhart et al. 1994), homogeneity chi-square analysis of each gene was undertaken using PAUP 4.0b10 (Swofford 2000) to identify significant differences in base composition (Murphy et al. 2006). The best-fit model of DNA evolution was selected by comparing log-likelihood scores of 56 models of base substitution using hierarchical likelihood ratio test (hLRT; Huelsenbeck and Crandall 1997), which was implemented in the program Modeltest 3.2 (Posada and Crandall 1998). The partition homogeneity test (incongruence-length difference test; Farris et al. 1995) was conducted using PAUP to test the congruence between genes.

Maximum parsimony (MP) analyses were performed in PAUP using the heuristic search algorithm with 1000 random sequence addition replicates to reduce potential bias from taxon ordering in the data sets. Gaps were treated as missing data. Support for nodes on the MP trees was assessed from 1000 non-parametric bootstrap pseudoreplications. All characters were unordered and weighted equally.

Bayesian analyses were performed using the Markov chain Monte Carlo simulation program, MrBayes 3.0b4 (Huelsenbeck and Ronquist 2001). Modeltest selected the GTR + I + G as the best-fit model using both hLRTs and Akaike Information Criterion (AIC) for COI date. Modeltest selected the TrN + G model using hLRTs and the GTR + G model using AIC for 28S rRNA data. We chose GTR + G as the best fit model for 28S rRNA data for the Bayesian analysis. For the combined analysis, the data from the two fragments were separated into two partitions, each following its own model.

We also used statistical parsimony (Templeton et al. 1992) with the TCS 1.18 software (Clement et al. 2000) and a 100-step connection limit to estimate a phylogeographical network for the *P. reniformis* and *P. clavata* COI haplotypes, as networks allow a more detailed display of population information than do strictly bifurcating trees (Posada and Crandall 2001).

Divergence times

To estimate divergence times of each genes and combined data set without assuming a molecular clock, we used the penalized likelihood method (Sanderson 2002), implemented in r8s 1.71 (Sanderson 2003). Its starting point was Bayesian trees with estimated branch lengths. The run included five searches from random starts and five restarts after each search. We used 100 as the smoothing parameter value, which determines the variation in the rates of evolution across branches. The algorithm of truncated Newton was recommended by

Table 1. Species information in this study

					Accession number	
					COI	28S
	Tong Cave, Fangshan County, Beijing City, China	39°42.318′N, 115°42.559′E	BjBcave1	IZCBjBcave1	EF128123	EF128085
			BjBcave2-9	IZCBjBcave2-9	EF567081-88	–
			BjXcave2	IZCBjXcave2	EF128126	EF128089
			BjXcave3-7	IZCBjXcave3-7	EF567098-102	–
			BjYscave3	IZCBjYscav3	EF128124	EF128090
			BjYscave2, 4–10	IZCBjYscave2, 4-10	EF567089-96	–
			BjTdcave4	IZCBjTdcave4	EF128128	EF128086
			BjXqcave5	IZCBjXqcave5	EF128127	EF128088
			BjXqcave2–4, 6–8	IZCBjXqcave2–4, 6–8	EF567103-108	–
			BjWcave6	IZCBjWcave6	EF128125	EF128087
			BjWcave1	IZCBjWcave1	EF567097	–
	Wuxuhai, Jiulong County, Sichuan Province, China	No detailed location data	Sc2	IZCPSc2	EF128132	–
	Wuxuhai, Jiulong County, Sichuan Province, China	No detailed location data	Sc3	IZCPSc3	EF128133	–
	Wuxuhai, Jiulong County, Sichuan Province, China	29°09.206′N, 101°21.490′E	Sc11	IZCPSc11	EF128131	EF128093
	Huojianqiao, Jiulong County, Sichuan Province, China	29°10.657′N, 101°27.968′E	Sc10	IZCPSc10	EF128129	EF128091
	Helagou, Jiulong County, Sichuan Province, China	29°08.645′N, 101°30.321′E	Sc14	IZCPSc14	EF128130	EF128092
	Mugecuo, Kangding County, Sichuan Province, China	No detailed location data	Sc4	IZCPSc4	EF128136	–
	Mugecuo, Kangding County, Sichuan Province, China	No detailed location data	Sc5	IZCPSc5	EF128137	–
	Mugecuo, Kangding County, Sichuan Province, China	30°10.201′N, 101°52.146′E	Sc9	IZCPSc9	EF128135	EF128094
	Yulin, Kangding County, Sichuan Province, China	29°55.261′N, 101°57.648′E	Sc13	IZCPSc13	EF128138	EF128096
	Paomashan, Kangding County, Sichuan Province, China	30°02.929′N, 101°58.003′E	Sc8	IZCPSc8	EF128134	EF128095
	Yajiageng, Luding County, Sichuan Province, China	29°50.454′N, 102°02.507′E	Sc6	IZCPSc6	EF128139	EF128103
	Hailuogou, Luding County, Sichuan Province, China	29°34.557′N, 102°00.201′E	Sc7	IZCPSc7	EF128140	EF128102
	Hailuogou, Luding County, Sichuan Province, China	29°34.557′N, 102°00.201′E	Sc26	IZCPSc26	EF128141	EF128101
P. trifurcata	Hailuogou, Luding County, Sichuan Province, China	29°34.558′N, 102°00.223′E	Sc22	IZCPSc22	EF128142	EF128098
P. anatolica	Shuanglong Town, Kunming City, Yunnan Province, China	25°08.903′N, 102°54.057′E	Yn1	IZCPYn1	EF128158	EF128114
P. lihengae	Fugong County, Lishadi, Yunnan Province, China	27.214°N, 98.700°E	Yn2	IZCPYn2	EF128157	–
	Mendocino County, CA, USA	39°35.844′N, 123°49.512′W	USA1	IZCPUSA1	EF128151	EF128109
	Humboldt County, CA, USA	40°26.997′N, 124°00.964′W	USA2	IZCPUSA2	EF128152	EF128110
P. curvata	CA, USA	No detailed location data	USA3	IZCPUSA3	EF128153	–
P. jellisoni	Spokane County, WA, USA	47°51.605′N, 117°14.223′W	USA4	IZCPUSA4	EF128154	EF128111
P. haden	Mineral County, MT, USA	47°26.026′N, 115°39.871′W	USA5	IZCPUSA5	EF128155	EF128112
P. edenticulata	Trinity County, WA, USA	40°50.615′N, 122°51.411′W	USA6	IZCPUSA6	EF128156	EF128113
	Shuiluo Cave, Lushan County, Sichuan Province, China	30°16.414′N, 102°57.542′E	Sccave20	IZCPSccave20	EF128150	EF128105
	Yaoji, Baoxing County, Sichuan, Province, China	No detailed location data	Sc38	IZCPSc38	EF128149	–
	Longmen, Lushan County, Sichuan Province, China	30°16.173′N, 103°00.42.4′E	Sc21	IZCPSc21	EF128148	EF128104
	Fengtongzai, Baoxing County, Sichuan Province, China	No detailed location data	Sc30	IZCPSc30	EF128162	–
	Hailuogou, Luding County, Sichuan Province, China	29°34.682′E 102°00.375′	Sc23	IZCPSc23	EF128143	EF128099
	Hailuogou, Luding County, Sichuan Province, China	29°37.555′N, 102°06.577′E	Sc24	IZCPSc24	EF128144	EF128100
	Moxi, Luding County, Sichuan Province, China	29°42.153′N, 102°01.039′E	Sc18	IZCPSc18	EF128145	EF128108
	Yihaizi, Mianni County, Sichuan Province, China	28°44.124′N, 102°14.063′E	Sc17	IZCPSc17	EF128146	EF128106
	Yele, Mianni County, Sichuan Province, China	28°55.137′N, 102°12.193′E	Sc12	IZCPSc12	EF128147	EF128107
	Moxi, Luding County, Sichuan Province, China	Nodetailed location data	Sc39	IZCPSc39	EF128159	
	Yajiageng, Luding County, Sichuan Province, China	29°50.454′N, 102°02.507′E	Sc27	IZCSc27	EF128160	–
	Hailuogou, Luding County, Sichuan Province, China	29°34.648′N, 102°00.220′E	Sc32	IZCSc32	–	EF128115
	Yihaizi, Mianni County, Sichuan Province, China	28°44.124′N 102°14.063′E	Sc33	IZCSc33	EF128163	EF128117

Table 1. (Continued)

					Accession number	
					COI	28S
	Yele, Mianni County, Sichuan Province, China	28°55.137′N, 102°12.193′E	Sc34	IZCSc34	EF128164	EF128118
sp4	Hailuogou, Luding County, Sichuan Province, China	29°34.682′N 102°00.375′ E	Sc31	IZCSc31	EF128161	EF128116
sp6	Wumingshan, Kangding County, Sichuan Province, China	No detailed location data	Sc35	IZCSc35	–	EF128097
Capsulia sp.	Zhangjiajie National Nature Reserve, Hunan Province	29°22.035′N, 110°36.787′E	*Capsulia*	IZCL201	EF128170	EF128122
Bathyphantes tongluensis	Longmen, Lushan County, Sichuan Province, China	30°16.173′N, 103°00.424′E	*Bathyphantes*1, 2	IZCL202, 3	EF128165,6	EF128121
Erigone prominers	Banshanting, Hengshan Mountain, Hunan Province	No detailed location data	*Erigone*	IZCL204	EF128171	–
Dicymbium serratus	Zhangshiyan, Zanhuang County, Hebei Province, China	No detailed location data	*Dicymbium*1, 2	IZCL205, 6	EF128167,8	EF128119
Gnathonarium denatum	Weita, Lushan County, Sichuan Province, China	30°16.414′N, 102°57.542′E	*Gnathonarium*	IZCL207	EF128169	EF128120

Codes are the abbreviations for the populations and also are locations numbers in Fig. 1.

the author to use with penalized likelihood method. A fossil species of *Pimao* from 50 million years ago (Ma) (Wunderlich 2004) was used to calibrate the origin of *Pimoa* species. The time of 125–135 Ma was used to calibrate outgroups, based on the fossil record of Linyphiinae (Penney and Selden 2002). Considering the Pimoidae as the sister clade of Linyphiidae, we constrained the low time of Pimoidae as 125 Ma.

Result

Cytochrome *c* oxidase subunit I genes

Parts of the COI gene (718bp) were successfully sequenced in 65 individuals for Pimoidae, five unidentified specimens (two of sp3, one of sp4, two of sp5) and five species of outgroups. For the COI alignment, sequence lengths were conserved and gaps were not found. The amino acid translations with invertebrate mitochondrial code revealed no stop codons. For *P. clavata*, we sequenced 1–10 specimens from each of the six caves, and only one haplotype was found in each cave, the pairwise distances of six haplotypes were 2.4–3.6%. A total of 49 haplotypes of COI were identified and used in phylogenetic analysis. Of the 718 base sites, 311 were variable and 276 were parsimony informative. A chi-squared test of homogeneity of base frequencies indicated that the sequence were not significantly heterogeneous ($\chi^2 = 126.90$, $df = 138$, $p = 0.74$).

The Bayesian tree defined two major groups (Fig. 2): genera *Pimoa* and *Weintrauboa*. The monophyly of these two groups were well supported with posterior probabilities of 0.99 and 1, respectively. *Pimoa* was divided into two clades, a North American clade and an Asian clade. Haplotypes from the three predefined geographical populations of *P. reniformis* formed the monophyletic clades, respectively. The five unidentified specimens were divided into two groups: two specimens of sp3 were grouped with Pimoidae, while one specimens of sp4 and two specimens of sp5 formed a clade with Linyphiidae. The topology of Bayesian tree was consistent with the current morphology-based taxonomy.

A heuristic search of the parsimony analysis found 27 equally most parsimonious trees with 1704 steps and a consistency index (CI) of 0.3069, a retention index (RI) of 0.6619 excluding uninformative characters. The strict consensus tree showed three major unresolved clades (tree not shown). All populations of *P. reniformis*, *P. clavata*, *P. anatolica*, *P. lihengae*, *P. trifurcata* and *P.* sp1 formed a clade; *W. chikunii*, *W.* sp2 and two unidentified specimens (sp3) formed the second clade; and the last clade included all North American species. Although the relationships of the three clades were not resolved, the relationships within the three major clades were similar with the Bayesian tree, with strong support.

For *P. reniformis*, the COI network suggested three clades corresponding to three geographical groups (Fig. 2). There are more substitution steps among three geographical groups than within each group. For *P. clavata*, the COI haplotypes network revealed the geographical patterns of different caves (Fig. 2).

28S ribosomal RNA gene

Approximately 760 bp of the 28S gene (spanning the D1–D3 regions) were sequenced for 38 individuals belonging to 12 pimoids species, five unidentified specimens (one of sp4, three of sp5, one of sp6) and four outgroups. After alignment, a

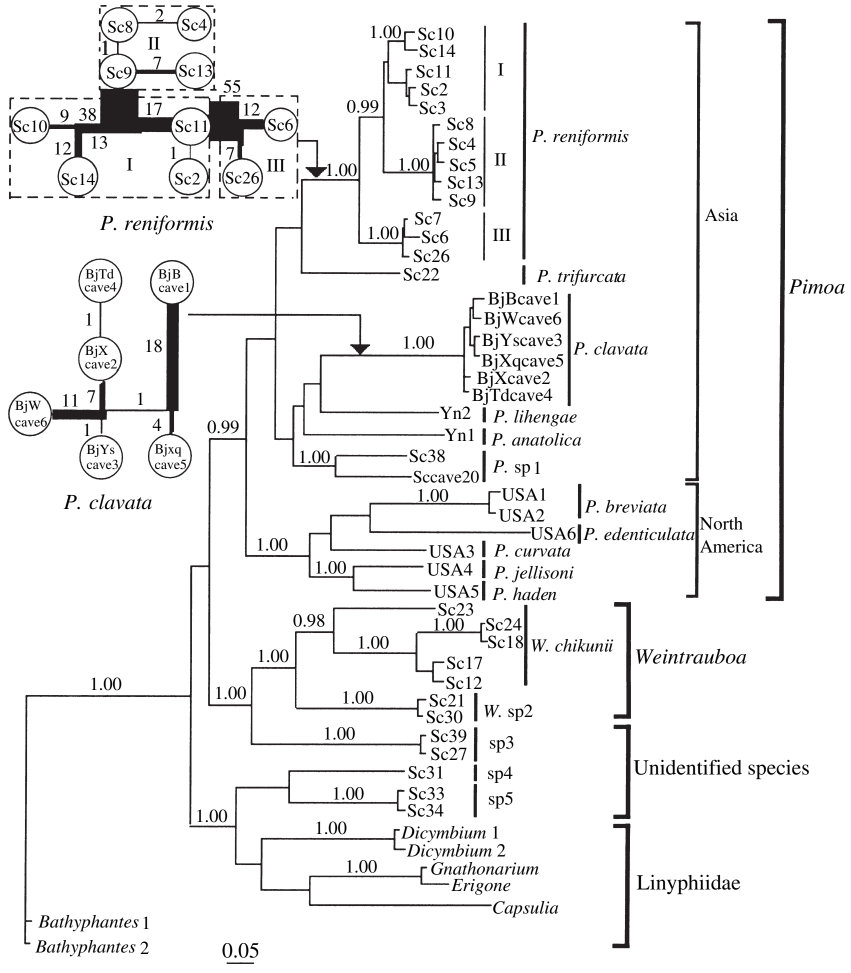

Fig. 2. A phylogeny derived from Bayesian analysis of cytochrome *c* oxidase subunit I (COI) data set. Posterior probabilities above 0.90 are indicated near the nodes. The species and major groups are labelled. I, II, III indicate the geographical unites of *Pimoa reniformis*. Reconstructed TCS plot of COI haplotypes of *P. reniformis* and *P. clavata*. Connection limit: 100 steps. Three geographical groups can be separated for *P. reniformis*. Haplotypes within are separated by one to 55 substitutions. The number besides branches are numbers of substitutions between nodes

total of 800 nucleotide sites, including gaps, were analysed. Among them, 452 sites were variable and 258 were parsimony informative. No significant difference in base composition across taxa was detected for the 28S gene ($\chi^2 = 32.52$, df = 216, p = 1.00).

The topology of 28S Bayesian tree was similar to that of the COI Bayesian analysis (tree not shown). *Pimoa* sp1 collected from Sichuan Province, both cave and field dwellers, formed the sister lineage of six cave populations of *P. clavata* from Beijing City. Unexpectedly, *P. anatolica* and *P. trifurcata* formed a clade and nested within *P. reniformis*. The sp4, sp5, sp6 were grouped into Linyphiidae. Although the 28S Bayesian tree resolved the relationships of major clades, the posterior probabilities of some clades were low.

A heuristic search found 5617 equally most parsimonious trees with 805 steps and a CI of 0.6623, a RI of 0.8611 excluding uninformative characters. A strict consensus tree produced a phylogeny that was the same as the 28S Bayesian tree in term of major clades (tree not shown).

COI and 28S combined data set

The result of partition-homogeneity test (p = 0.086) with heuristic search showed no significant heterogeneity of the evolution of COI and 28S genes. There were 29 individuals of 11 species of Pimoidae, three unidentified specimens (one of sp4, two of sp5) and four species of outgroups that we had sequences from both the COI and 28S fragments. These sequences produced a combined data set of 36 haplotypes. Bayesian tree of the combined data set was showed in Fig. 3 and all the clades were strongly supported. Species from Beijing caves (*P. clavata*) had a common ancestor with the species from Sichuan caves (*P.* sp1).

The combined Bayesian tree differed from the result of 28S in the position of *P. trifurcata* and *P. anatolica*. They were sister groups of *P. reniformis* in the combined Bayesian tree, but formed a clade and nested in the geographical populations of *P. reniformis* in the 28S Bayesian tree. The combined Bayesian tree was consistent with the result of COI Bayesian analysis. The combined COI and 28S data set resulted in two equally most parsimonious trees with 2161 steps and a CI of 0.4609, a RI of 0.7128 excluding uninformative characters (tree not shown). These two trees were slightly different with the relationships of three populations of *P. reniformis*. The topology of strict consensus tree showed an identical topology with the Bayesian tree and also had strong statistical support.

Divergence time

The divergence time derived from the r8s analyses of the COI, 28S and the combined data set, respectively, were given in Table 2. Time estimates based on COI, 28S and combined data set were broadly consistent. So we chose the time estimates

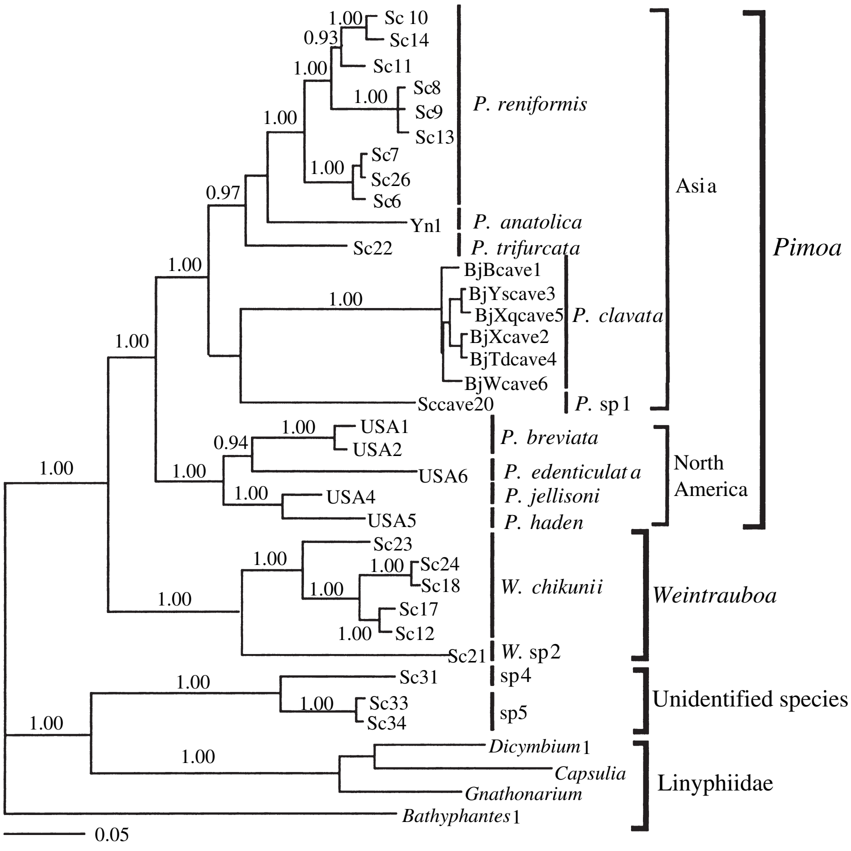

Fig. 3. A phylogeny derived from Bayesian analysis of combined cytochrome *c* oxidase subunit I and 28S data set. Posterior probabilities above 0.90 are indicated near the nodes. The species and major groups are labelled

Table 2. Divergence time estimated from COI, 28S and combination of them for major lineages of Pimoidae

Data set node diversification (Ma)	COI	28S	Combination
A Pimoidae	136.09	144.06	138.29
B *Pimoa*	113.17	108.12	113.43
C *Weintrauboa*	109.19	80.00	90.33
D Asian	95.96	82.33	84.20
E North American	50.00	50.00	50.00
F cave groups	83.45	–	71.61
G field groups	79.47	42.17	66.06
H *P. clavata*	5.11	9.61	8.28
I *P. reniformis*	49.04	–	37.08
J Linyphiidae	125.00	125.00	125.00

Estimates in millions of years for each gene (cytochrome *c* oxidase subunit I and 28S) and the combined data set are given for major nodes as named in Fig. 4.

based on combined data set as our preference. The emergence time of Pimoidae was approximately 140 Ma. The divergence time of the North American and Asian species of *Pimoa* were approximately 110 Ma.

Discussion

Preferred phylogeny

The Bayesian and parsimony analyses resulted in very similar topologies. Parsimony methods are widely used for estimating evolutionary relationships, are intuitively appealing and use a simple model of evolution (Vink and Paterson 2003). The Bayesian approach to phylogeny is relatively new and closely related to likelihood methods (Huelsenbeck and Ronquist 2001). Although several issues are still open, especially with respect to choosing priors and the interpretation of posterior probabilities, it has been widely used in systematics over the past few years (Lewis 2001; Holder and Lewis 2003). This partially owes to the Bayesian method providing measures of support faster than ML bootstrapping and allowing complex models of sequence evolution to be implemented (Holder and Lewis 2003). Our MP and Bayesian trees have the almost same topology. We selected the phylogeny (Fig. 3) produced by the Bayesian analysis of COI and 28S combined data set as our preferred hypothesis. The Bayesian trees with branch lengths were also used as the starting point for the r8s analysis.

Our results based on molecular markers revealed considerable underlying phylogenetic structure across the Pimoidae. Phylogenetic trees consistently recovered the monophyly of two well-supported monophyletic groups, *Pimoa* and *Weintrauboa*. This result strongly supported the current morphology-based taxonomy. *Pimoa* also had two well-supported clades, the Asian species and North American species. Phylogenetic analysis showed that the Asian species have two sister groups: the two cave species (*P. clavata* and *P.* sp1) had a common ancestor; *P. anatolica* was the sister group of *P. reniformis*, then *P. trifurcata* was added and formed another group. About the North American species, *P. breviata* and *P. curvata* were sister group, *P. jellisoni* and *P. haden* were sister group, but the relationships of the two clades and *P. edenticulata* were not resolved.

The diagnostic characters of the family Pimoidae are primarily male characters. Although males are easily identified, females are nearly impossible to distinguish from the sister

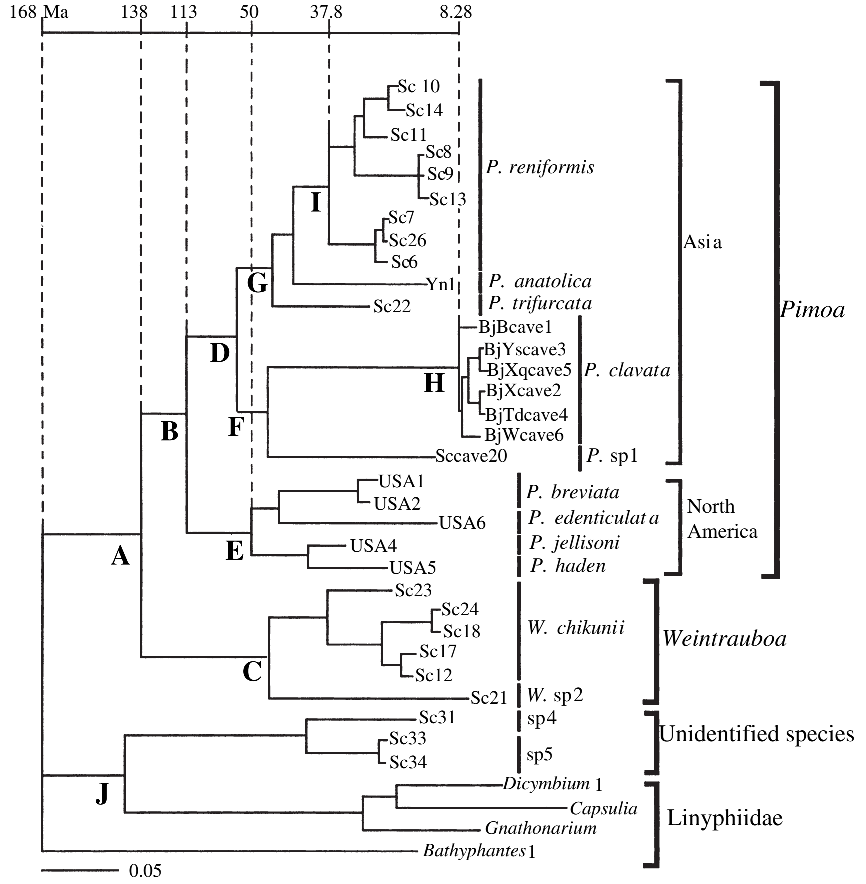

Fig. 4. Bayesian phylogenetic analysis of combined cytochrome *c* oxidase subunit I and 28S data set, drawn to a time scale. E and J denote nodes used for calibrating molecular date estimates. Letters, node names as in Table 2, denote internal nodes of interest

group of pimoids, the family Linyphiidae. Hormiga (1993, 1994) did not mention the specific female characters to distinguish Pimoidae from the Linyphiidae. On the cladogram of Hormiga (1993: Fig. 1), there were nine characters distinguishing Pimoidae from the Linyphiidae. All of them, however, were male and somatic characters. Although Hormiga provided the description of females, the characters were not useful for species identification without males. Hormiga also described two internal genitalic characters in pimoid females: the epigynum was protruding, with a dorsal to lateral fold or groove with the copulatory opening at the distal end (Hormiga 1994: Figs 14, 414, 3A); fertilization ducts were anteriorly (*Pimoa*) or mesally (*Weintrauboa*) orientated (Hormiga 2003). Some linyphiids, however, also show these two characters. For example, genus *Laperousea* carries the genital openings on its dorsal side (Millidge 1984: Figs 51, 54, 57). The fertilization duct of *Hypselistes jacksoni* is mesally orientated (Millidge 1984: Fig. 115). We have several specimens for which assignment to family are difficult because only female specimens are available. DNA technology provides a solution to this problem. The current ongoing project, Barcoding life, exemplified this approach (Cameron et al. 2006; Witt et al. 2006). We have given the seven unidentified specimens suitable taxonomic placement. Sp3 grouped into *Weintrauboa* of Pimoidae with strong support of 1.00 (Fig. 2). Sp3 is a new species of *Weintrauboa*. Sp4 and sp5 formed a clade with Linyphiidae with the strong support of 1.00 (Fig. 3). Sp6 were grouped into Linyphiidae based on the 28S data set (tree not shown). So sp4, sp5 and sp6 belong to the family of Linyphiidae. More taxonomic work needs to be done on these species.

The hypothesis of a dispersal event from North America to Asia

Our phylogenetic hypothesis suggested a vicariance explanation for the divergence of North American and Asian *Pimoa*, and therefore rejected the dispersal hypothesis of Hormiga (1994). In Hormiga's phylogeny (1994: Figs 440, 442), there were five defined groups. The relationships among these groups on the strict consensus tree (Fig. 440) were not completely resolved. These groups were clustered into three main clades on the preferred phylogeny (Fig. 442): *Altioculata* group and *Breviata* group (North American species) formed sister groups with the *Gandhii* group (Asian species), then *Hespera* group (North American species) was added as the third clade. That is, the Asian clade nested within the two North American clades. Hormiga (1994) concluded that a dispersal event occured from North America to Asia mainly based on the preferred cladogram in Fig. 442. Our phylogeny included species from the *Hespera* group, *Breviata* group and *Gandhii* group, and extensive sampling from Asia. Unlike Hormiga's phylogenetic hypothesis, the North American species, *P. curvata*, *P. edenticulata*, *P. breviata* of the *Breviata* group and *P. haden*, *P. jellisoni* of the *Hespera* group formed the sister lineages to the Asian species. Both the independent and combined gene analyses showed the same result. As such, a vicariance explanation was preferred over dispersal one. Our phylogenetic tree suggested that vicariance, rather than dispersal, played a major role in the origin of the Asian and North American groups of *Pimoa*. The vicariance pattern was also consistent with the distribution pattern of *P. reniformis*. The three monophyletic populations of *P. reniformis* presented three clades distributed on the different sides of Gongga

Mountain: Sc2, Sc3, Sc10, Sc11, Sc14 in the south-west side (I), Sc4, Sc5, Sc8, Sc9, Sc13 in the north side (II) and Sc6, Sc7, Sc26 in the east side (III) (Figs 1 and 2). The network analysis revealed the same populations information of *P. reniformis*. The possible explanation was that the 7556 m altitude of Gongga Mountain and the distribution of the valleys and rivers reduced the gene flow of *P. reniformis*. Vicariance may have dictated the history of the *Pimoa*.

From the result of r8s analysis, we deduced that the Pimoidae originated approximately 140 Ma. The Asian and North American species diverged approximately 110 Ma. The supercontinent Pangea broke into two new continents, Laurasia and Gondwana, about 180 Ma (Nance et al. 1988). A Laurasian origin of Pimoidae explains the Holarctic distribution pattern of Pimoidae. About 135 Ma, Laurasia broke up into the continents of North America, Europe and Asia (Eurasian plate) (Pratt 2000). The divergence time of North American and Asian species of *Pimoa* was consistent with the timing of the Laurasia breakup. Therefore, the formation of the North American and Asian clades is a likely consequence of the split of the Laurasia. Subsequently, climate change and the advance of glaciers led to the extinction in the intervening areas and the cavernicolous life of Pimoidae.

The genus *Weintrauboa* is only reported from Japan and its adjacent islands (Hormiga 2003), and from south-western China (Yang et al. 2006; Xu and Li 2007). The distribution of the genus may have always been restricted on the Eurasian Plate, and therefore, escaped any vicariance separation. Alternatively, an Asian origin followed by an Asia-to-North America dispersal event may also explain the current distribution of Pimoidae. However, when vicariance and dispersal equally explain the data, vicarience explanation is preferred because it can be easily tested (Futuyma 1998).

The role of caves in speciation of the Pimoidae

Many studies revealed that caves played an important role in animal speciation, similar to islands, mountaintops, or desert springs. Many examples suggested multiple cave invasions by one or a few widely distributed epigean ancestors (Mayr 1963; Barr 1968). After initial cave colonization, gene flow between cave systems was greatly reduced by various mechanisms including postglacial climates becoming drier (Barr and Holsinger 1985). Hormiga (1994) suggested that pimoids are likely restricted to humid areas, such as caves with high humidity. In our study, the two specimens of *P.* sp1 were collected both in caves and fields of Sichuan Province and *P. clavata* only can be seen in caves. Our phylogenetic analysis suggested that *P. clavata*, and *P.* sp1 had a common ancestor. The best explanation is that the common ancestor of them diverged first, and populations of the south-west Chinese species invaded the caves and others remained in the field because of the moist environment of south-western China. However the situation in northern China was different. It was impossible for pimoids to survive in the dry climate out of the caves. There was only one COI haplotype per cave of *P. clavata* but the pairwise distances of 2.4–3.6% indicated the obvious divergence among the different cave populations. The network analysis was consisted with the phylogenetic result and showed the geographical patterns of different caves. The BjBcave had the longest distance from all other caves, and the steps were 18; the distance between BjTdcave and BjXcave were smallest, and the step was one (Fig. 2). *Pimoa clavata* formed approximately 8 Ma, but the detailed divergence time of the cave populations was not possible by the r8s estimates. From the branch lengths, we can conclude that the cave populations undergo a recent separation. A possible explanation is that *P. clavata* invaded the caves and started the cave life during the Pleistocene climatic changes. The gene flow was reduced by the existence of the caves and the drier, cold climate of northern China area. Now the highly divergent populations are in the process of speciation and show the trend to form new species. *Pimoa clavata* is a troglobite although it has not presented characters adapted to cave life. Cave dwelling has played a more important role in the speciation of pimoids in arid areas than in moist areas.

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Kurzfassung

Phylogeographische Analyse der Pimoidae (Arachnida: Araneae) nach mitochondrialen COI und nuklearen 28S rRNA Genabschnitten.

Die verwandtschaftlichen Verhältnisse der Spinnenfamilie Pimoidae (Arachnida: Araneae) wurden mit Hilfe von mtDNA COI und nuDNA 28S rRNA-Daten untersucht und die Ausbreitungshypothese von Nordamerika nach Asien getestet. Sequenzen wurden mit Maximum Parsimonie und Bayesian Inferenz analysiert. Die Analyse zeigte, dass das rezente Verbreitungsmuster der Pimoidae durch Vikarianz besser erklärt wird als durch Ausbreitung. Zeiten für Aufspaltungsereignisse wurden geschätzt mit Hilfe der Bayesischen Molekularen Analyse. Diese legt eine Abspaltung der Pimoidae vor etwa 140 Millionen Jahren nahe. Die Aufspaltung zwischen Nordamerika und Asien hat demzufolge vor 110 Millionen Jahren stattgefunden. Unsere phylogenetische Analyse unterstützt die aktuelle auf Morphologie basierende Taxonomie und zeigt, dass das Höhlenleben eine größere Rolle bei der Speziation in trockenen als in feuchten Gebieten spielte.

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Authors' addresses: Qian Wang, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China. Graduate University of Chinese Academy of Sciences, Beijing100039, China. E-mail: wangqian@ioz.ac.cn; Shuqiang Li (for Correspondence), Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China. Fax: 86 10 62565689. E-mail: lisq@ioz.ac.cn; Rongjing Wang, College of Life Sciences, Peking University, Beijing 100871, China. Tel: 86 10 64807099. E-mail: rjwang@bio.pku.edu.cn; Pierre Paquin, Department of Biology, Portland State University, Portland, OR 92182 4614, USA. E-mail: ppaquin@sciences.sdsu.

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Tetrablemmidae (Arachnida, Araneae), a spider family newly recorded from China

Yanfeng Tong, Shuqiang Li*

Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, PR China

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Abstract

The family Tetrablemmidae is reported for the first time from China, with five new species and one new genus. *Lehtinenia* gen. n., which is erected to accommodate *Lehtinenia bicornis* sp. n., is characterized by the modified embolus, special modifications on chelicerae, and a *Tetrablemma*-type vulva. The other four new species are: *Ablemma prominens* sp. n., *Brignoliella caligiformis* sp. n., *Brignoliella maoganensis* sp. n., and *Tetrablemma brevidens* sp. n., all collected from caves. A phylogenetic analysis of the subfamily Tetrablemminae based on 41 morphological characters shows that the tribe Brignoliellini is the most basal group in the subfamily, rather than the sister group to the tribe Fallablemmini. *Lehtinenia* gen. n. and the genera *Ablemma*, *Sulaimania*, and *Maijana* together form a monophyletic group.

Keywords: Phylogenetic analysis; Morphological characters; Cave; New genus; New species; China

Introduction

Tetrablemmidae are known as "armoured spiders" because of the complicated patterns of their abdominal scuta. They have long been among the little-known animals distributed in tropical or subtropical regions worldwide. Much work has been done on them in recent years (Brignoli 1972a, b, 1973, 1974, 1975, 1976, 1978a, b, 1980; Shear 1978, 1979, 1988; Bourne 1980, 1981; Deeleman-Reinhold 1980, 1993; Lehtinen 1981; Schwendinger 1989, 1994; Wunderlich 1994; Burger 2005). So far, a total of 29 genera and 125 species (Platnick 2006) were recorded in two subfamilies: Pacullinae (medium to small species) and Tetrablemminae (small to minute species, usually shorter than 2 mm).

Attempts to discover natural groups within Tetrablemmidae using phylogenetic methods have been few. Shear (1978) treated Tetrablemmidae and Pacullidae as separate families. In his cladogram, he divided Tetrablemmidae in two subfamilies: Brignoliellinae (including *Fallablemma*, *Brignoliella*, *Singaporemma*, and *Ablemma*) and Tetrablemminae (including *Cuangoblemma*, *Matta*, *Monoblemma*, and *Tetrablemma*). In his world revision, Lehtinen (1981) united Pacullidae and Tetrablemmidae in a single family Tetrablemmidae. In Lehtinen's classification, tetrablemmids were divided in two subfamilies: Pacullinae and Tetrablemminae. Tetrablemminae included five tribes: Ablemmini, Brignolliellini, Fallablemmini, Mattini, and Tetrablemmini. There has been little discussion of Lehtinen's results in the last

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*Corresponding author.
E-mail address: lisq@ioz.ac.cn (S. Li).

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years, and a parsimony analysis is needed in order to test his hypotheses.

The natural history of Tetrablemmidae is still little known. Most tetrablemmids live in litter or mosses. A few species are cavernicolous or occur under bark, whereas a species of *Shearella* lives mainly in dry, sandy, coastal habitats (Lehtinen 1981). Very little is known about the behaviour of tetrablemmids. One species, *Brignoliella vulgaris*, has been observed to construct a dense sheet web on the surface of dry leaves, with the egg-sac attached to the centre of the web (Lehtinen 1981). Recently, Burger et al. (2006) described the mating behaviour of a tetrablemmid spider from Thailand for the first time.

On an expedition to Hainan Province with the objective of collecting cave fauna, some tetrablemmid specimens were collected. It is the first time the family Tetrablemmidae is reported from China. Of the five new species in this study, four were collected from caves: *Ablemma prominens* sp. n., *Brignoliella caligiformis* sp. n., *Brignoliella maoganensis* sp. n., and *Tetrablemma brevidens* sp. n. The fifth, *Lehtinenia bicornis* sp. n., was collected from Mount Wuzhishan. *L. bicornis* sp. n. is unique by having a modified embolus, a special modification on the chelicerae, and a *Tetrablemma*-type vulva; therefore, a new genus, *Lehtinenia* gen. n., is erected for it.

In addition to the descriptions of the new taxa, a phylogenetic analysis of the subfamily Tetrablemminae is presented in this study, to determine the taxonomic position of *Lehtinenia* gen. n. within Tetrablemminae. This study is the first attempt to apply parsimony methods to Tetrablemminae.

Material and methods

Specimens were examined and measured using an Olympus SZX12 stereo microscope. Further details were studied under an Olympus BX51 compound microscope. All illustrations were made using a drawing tube, and inked on ink jet plotter paper. Male palps and female vulva were examined and illustrated after they had been dissected from the spiders' bodies. Female vulvae were cleared in lactic acid, as were some male palpi in order to show the course of the ejaculatory duct. For each species, locality names and distribution data are given according to current Chinese standard (Peng et al. 2003).

All measurements are given in millimetres. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus).

Terminology follows Lehtinen (1981). Abbreviations: ALE = anterior lateral eyes; CP = central process; EF = epigynal fold; EP = epigynal pit; IVP = inner vulval plate; LH = lateral horn; PA = preanal plate; PLE = posterior lateral eyes; PME = posterior median eyes; POG = postgenital plate; SR = seminal receptacula; VS = vulval stem.

The specimens studied here are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS).

Cladistic analysis

A total of 30 taxa (Burger 2005; Platnick 2006) were included in the phylogenetic analysis. The ingroup includes all 26 genera of the subfamily Tetrablemminae: *Ablemma* Roewer, 1963; *Afroblemma* Lehtinen, 1981; *Anansia* Lehtinen, 1981 [in his world revision, Lehtinen (1981) described the genus *Anansia*; in his cladogram on p. 89, however, the name "Bellator" appeared instead of *Anansia*, apparently, Lehtinen first intended to call the genus "Bellator" and forgot to change the figure caption later]; *Bacillemma* Deeleman-Reinhold, 1993; *Borneomma* Deeleman-Reinhold, 1980; *Brignoliella* Shear, 1978; *Caraimatta* Lehtinen, 1981; *Choiroblemma* Bourne, 1980; *Cuangoblemma* Brignoli, 1974; *Fallablemma* Shear, 1978; *Gunasekara* Lehtinen, 1981; *Hexablemma* Berland, 1920; *Indicoblemma* Bourne, 1980; *Lehtinenia* gen. n.; *Maijana* Lehtinen, 1981; *Mariblemma* Lehtinen, 1981; *Matta* Crosby, 1934; *Micromatta* Lehtinen, 1981; *Monoblemma* Gertsch, 1941; *Pahanga* Shear, 1979; *Rhinoblemma* Lehtinen, 1981; *Shearella* Lehtinen, 1981; *Singalangia* Lehtinen, 1981; *Singaporemma* Shear, 1978; *Sulaimania* Lehtinen, 1981; and *Tetrablemma* O. P.-Cambridge, 1873. Based on the phylogenetic hypothesis of Lehtinen (1981), all four genera of the subfamily Pacullinae, i.e. *Lamania* Lehtinen, 1981, *Paculla* Simon, 1887, *Perania* Thorell, 1890, and *Sabahya* Deeleman-Reinhold, 1980, were selected as outgroups.

Fourty-one morphological characters were numerically coded (Appendix B), mostly based on previous publications. The genera were used as terminal taxa, and represented by the respective type species in each case.

The cladistic analysis was conducted in PAUP* 4.0b10 (Swofford 2002) using heuristic searches, with TBR branch swapping, random sequence addition at 1000 replicates, collapsed branches, and "MulTrees" options in effect. Character 1 was treated as ordered, all other characters as unordered. All characters were weighted equally. A total of eight characters were parsimony uninformative but included in the analysis nonetheless. All characters, including the uninformative ones, are listed in Appendix A. Bootstrapping was carried out (1000 replicates) to test node support. Trees from the results in PAUP* were examined for character-state changes, and alternative topologies investigated using MacClade 4.0 (Maddison and Maddison 2000).

Taxonomic section

Family Tetrablemmidae O. P.-Cambridge, 1873
Subfamily Tetrablemminae O. P.-Cambridge, 1873

Genus *Ablemma* Roewer, 1963

Ablemma prominens sp. n.
(Figs. 1A–G and 6)

Etymology. Specific name from the Latin prominens = projecting, in reference to the modifications at the basal part of the embolus; to be treated as adjectival for the purposes of nomenclature.

Type material. *Holotype*. Male (IZCAS), Xian'an'shilin Cave (18°36′N, 109°25′E); Maogan Town, Baoting County, Hainan Province, China, 13 April 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

Paratypes. 4 males, 10 females (IZCAS); same data as holotype.

Diagnosis. Similar to *Ablemma kaindi avios* Lehtinen, 1981, but can be distinguished by the absence of

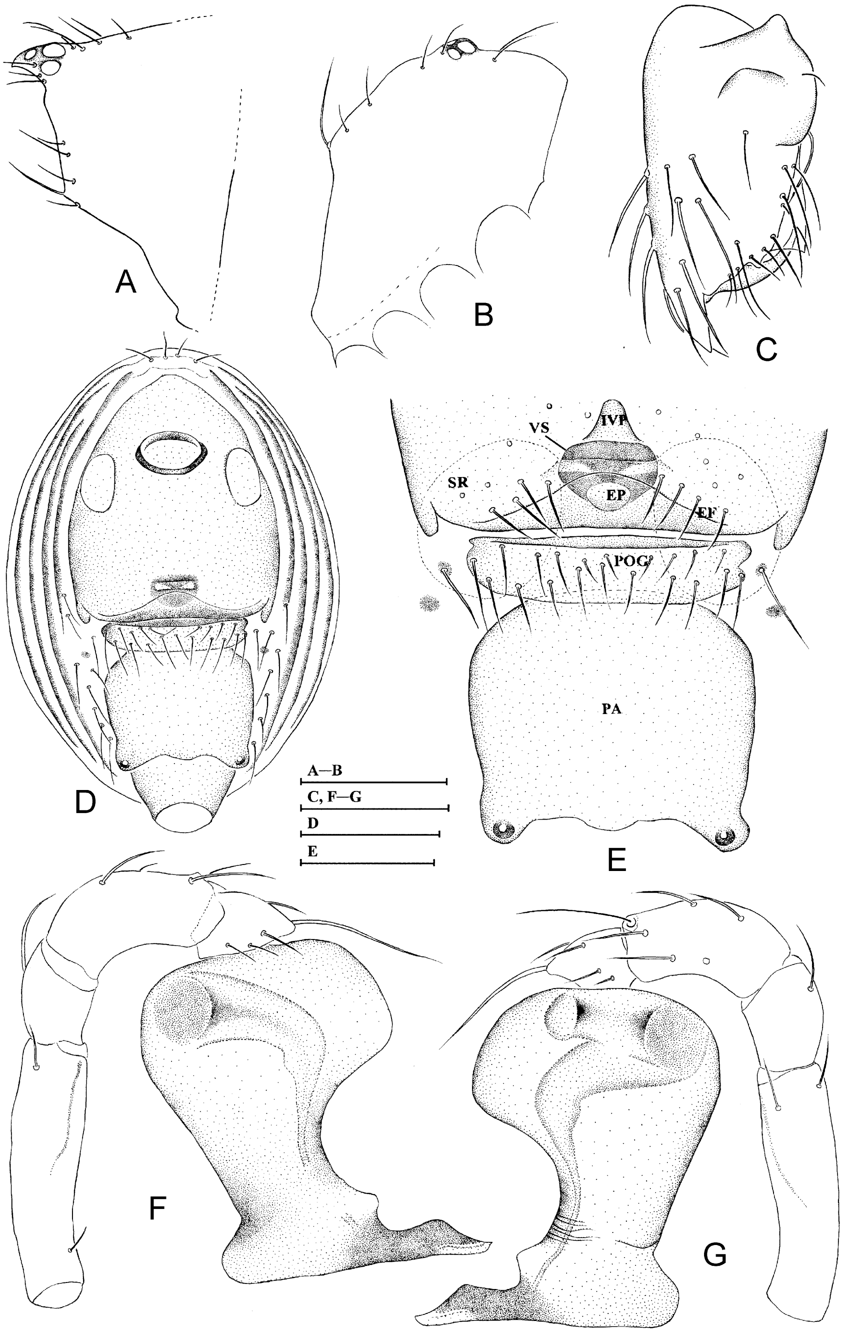

Fig. 1. *Ablemma prominens* sp. n. (A) Male carapace, lateral view. (B) Female carapace, lateral view. (C) Male chelicerae, anterior view. (D) Female abdomen, ventral view. (E) Female genital area and cleared vulva, ventral view. (F) Male left palp, prolateral view. (G) Male left palp, retrolateral view. Scale bars: A, B, D = 0.2 mm; C, E–G = 0.1 mm.

rounded ridges behind ocular area, smaller PME, basal modifications of embolus, longer preanal plate in female, and different shape and position of thick figure on female genital area.

Description. Colouration orange. Male 1.02–1.15. Carapace length 0.47–0.48, width 0.40–0.42, maximum height 0.49–0.53. Abdomen length 0.65–0.69, width 0.44–0.51. Carapace highest anteriorly at eye group, slightly sloping backwards. Six eyes in one group; sharp, erect tooth behind them. ALE > PLE > PME. Distal cheliceral tooth strong, basal cheliceral boss large. Sternum centrally smooth, marginally reticulate. Leg measurements: I 1.19 (0.39, 0.13, 0.29, 0.19, 0.19); II 1.09 (0.38, 0.12, 0.23, 0.18, 0.18); III 0.91 (0.29, 0.12, 0.18, 0.16, 0.16); IV 1.25 (0.40, 0.13, 0.31, 0.21, 0.20). Leg formula: 4 1 2 3. Abdominal dorsal scutum long oval. Lateral scutum I long, reaching posterior margin of pulmonary plate. One pair of perigenital plates.

Male palpal bulbus basally subglobular, but distally continued by a narrow extension. Embolus relatively wide. Tip of bulbus with rounded projection opposite embolus, and small projection near base of embolus.

Female 1.16–1.20. Carapace length 0.53–0.54, width 0.38–0.40, maximum height 0.40–0.41. Abdomen length 0.77–0.80, width 0.56–0.59. Ocular area unmodified. Six eyes in one group, all smaller than corresponding part of male. ALE > PLE > PME. Chelicerae without modification. Leg measurements: I 1.12 (0.40, 0.15, 0.26, 0.16, 0.15); II 1.01 (0.33, 0.14, 0.23, 0.16, 0.15); III 0.90 (0.30, 0.12, 0.18, 0.16, 0.14); IV 1.17 (0.36, 0.13, 0.33, 0.19, 0.16). Leg formula: 4 1 2 3. Preanal plate about 1.5 times as long as that of male; paired pits present on posterolateral corners.

Epigynal pit transversely oval, with strongly sclerotized margins, anteriorly limited by thick transverse figure. Vulval stem thick, with dorsal triangular prolongation attached to anterior one-third of vulval stem. Central vulval process absent, inner vulval plate triangular, basally wide.

Genus *Brignoliella* Shear, 1978

***Brignoliella caligiformis* sp. n.**
(Figs. 2A–G and 6)

Etymology. Specific name from the Latin caliga = boot, and formis = shaped, in reference to the shape of the distal part of the male embolus; to be treated as adjectival for the purposes of nomenclature.

Material examined. *Holotype*. Male (IZCAS); unnamed cave (19°01′N, 109°04′E), Nanlang Village, Donghe Town, Dongfang City, Hainan Province, China, 29–30 March 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

Paratypes. 4 males, 13 females (IZCAS); same data as holotype.

Additional material. 2 males, 11 females (IZCAS); Mihou Cave (18°56′N, 109°04′E), Datian National Natural Reserve, Dongfang City, Hainan Province, China, 28 March 2005; 1 male, 4 females (IZCAS), unnamed cave (18°59′N, 108°53′E), Yalong Village, Donghe Town, Dongfang City, Hainan Province, China, 1 April 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

Diagnosis. Similar to *B. vulgaris* Lehtinen, 1981, but can be distinguished by the short clypeal horn, distinctly serrated margin of carapace, shape of distal part of male embolus, and shorter posterior fold in female.

Description. Colouration reddish. Male 1.22–1.31. Carapace length 0.58–0.60, width 0.46–0.48, maximum height 0.45–0.48. Abdomen length 0.75–0.82, width 0.59–0.62. Cephalic area of carapace reticulate, remainder of carapace surface strongly rugose with wrinkled microstructure, except for longitudinal smooth fields on clypeus lateral to clypeal horn. Margin of carapace distinctly serrated. Clypeal horn relatively short, distally bifid. PME, PLE and ALE almost equal in size. Chelicerae without well-defined basal cavity on anterior surface, but with strong lateral tooth and two additional black denticles. Sternal pits relatively large. Leg measurements: I 1.33 (0.44, 0.14, 0.31, 0.22, 0.22); II 1.23 (0.41, 0.15, 0.28, 0.19, 0.20); III 1.11 (0.33, 0.13, 0.23, 0.21, 0.21); IV 1.38 (0.44, 0.15, 0.35, 0.22, 0.22). Leg formula: 4 1 2 3. Dorsal abdominal scutum long oval and pitted. Ventral plates slightly pitted. Lateral scutum I interrupted in middle, nearly reaching pulmonary plate, but continued by row of small plates. Anterior corners of preanal plate with weakly developed pits, corresponding in position to those of female.

Male palpal femur and patella unmodified, tibia slightly swollen. Bulbus subglobular. Embolus straight but distinctly narrowed distally, boot-shaped.

Female 1.24–1.35. Carapace length 0.62–0.64, width 0.46–0.48, maximum height 0.45–0.47. Abdomen length 0.91–0.95, width 0.65–0.70. Clypeus and chelicerae without modifications. Leg measurements: I 1.34 (0.44, 0.16, 0.31, 0.21, 0.22); II 1.30 (0.41, 0.16, 0.29, 0.21, 0.23); III 1.17 (0.34, 0.15, 0.25, 0.22, 0.21); IV 1.54 (0.46, 0.15, 0.39, 0.29, 0.25). Leg formula: 4 1 2 3. Dorsal abdominal scutum larger than in male, but similar in shape. Preanal plate with fairly large pits at anterolateral corners.

Posterior fold thin and long, but not extending over whole length of posterior margin. Epigynal pit small, distinctly surrounded by a V-shaped dark area. Vulval stem thick. Sclerotization surrounding unpaired copulatory channel and basal part of paired vulval ducts is especially stronger on area near branching point of vulval ducts.

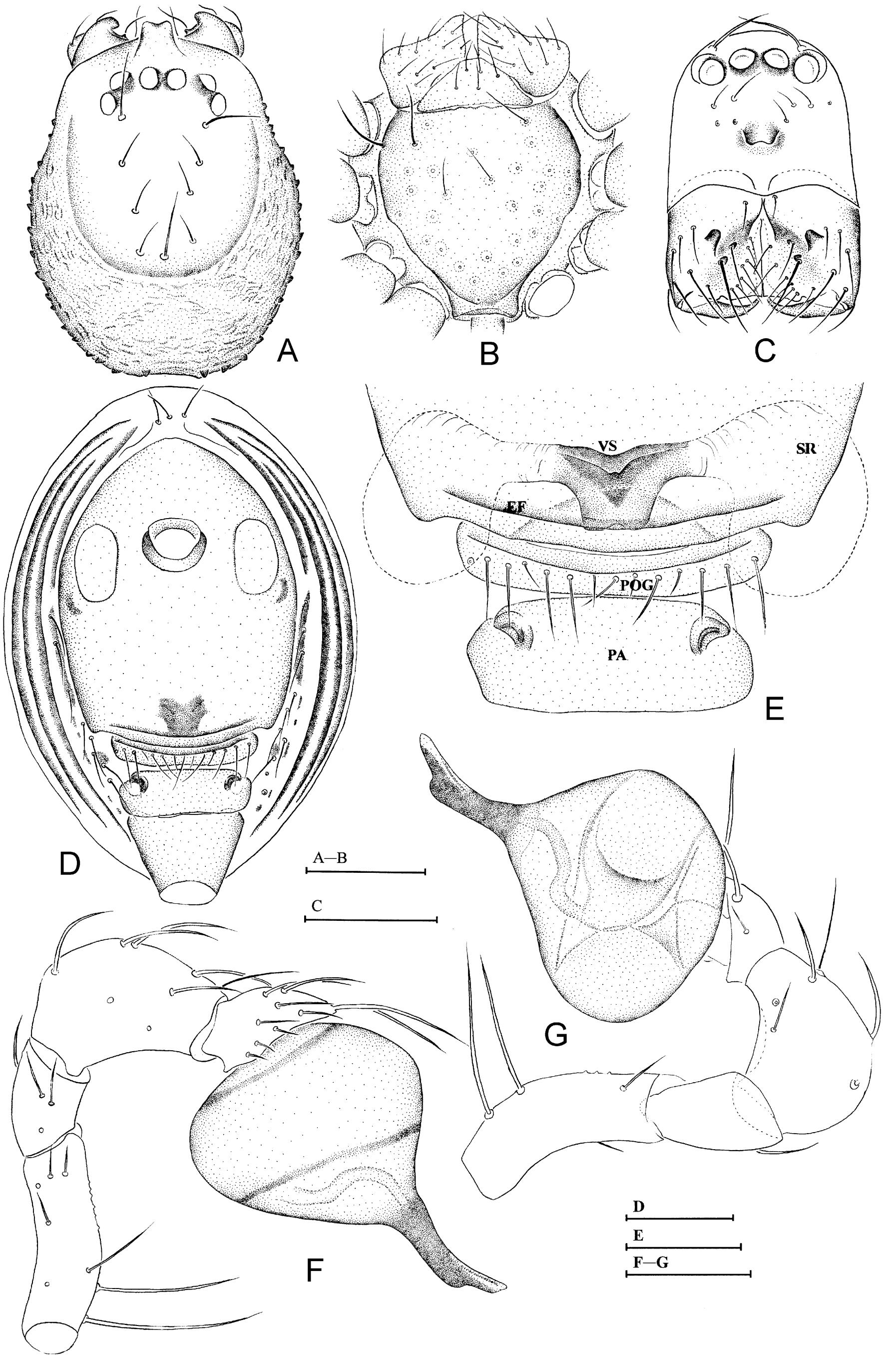

Fig. 2. *Brignoliella caligiformis* sp. n. (A) Male carapace and chelicerae, dorsal view. (B) Female sternum, ventral view. (C) Male carapace and chelicerae, anterior view. (D) Female abdomen, ventral view. (E) Female genital area and cleared vulva, ventral view. (F) Male left palp, prolateral view. (G) Male left palp, retrolateral view. Scale bars: A–D = 0.2 mm; E–G = 0.1 mm.

Brignoliella maoganensis **sp. n.**
(Figs. 3A–G and 6)

Etymology. Specific name referring to the type locality; to be treated as adjectival for the purposes of nomenclature.

Type material. *Holotype*. Male (IZCAS); Xian'an'shilin Cave (18°36′N, 109°25′E), Maogan Town, Baoting County, Hainan Province, China, 13 April 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

Paratypes. 2 males, 10 females (IZCAS); same data as holotype.

Diagnosis. Similar to *B. vulgaris* Lehtinen, 1981 and *B. caligiformis* sp. n., but can be distinguished from both by the cheliceral modifications in the male, shape and

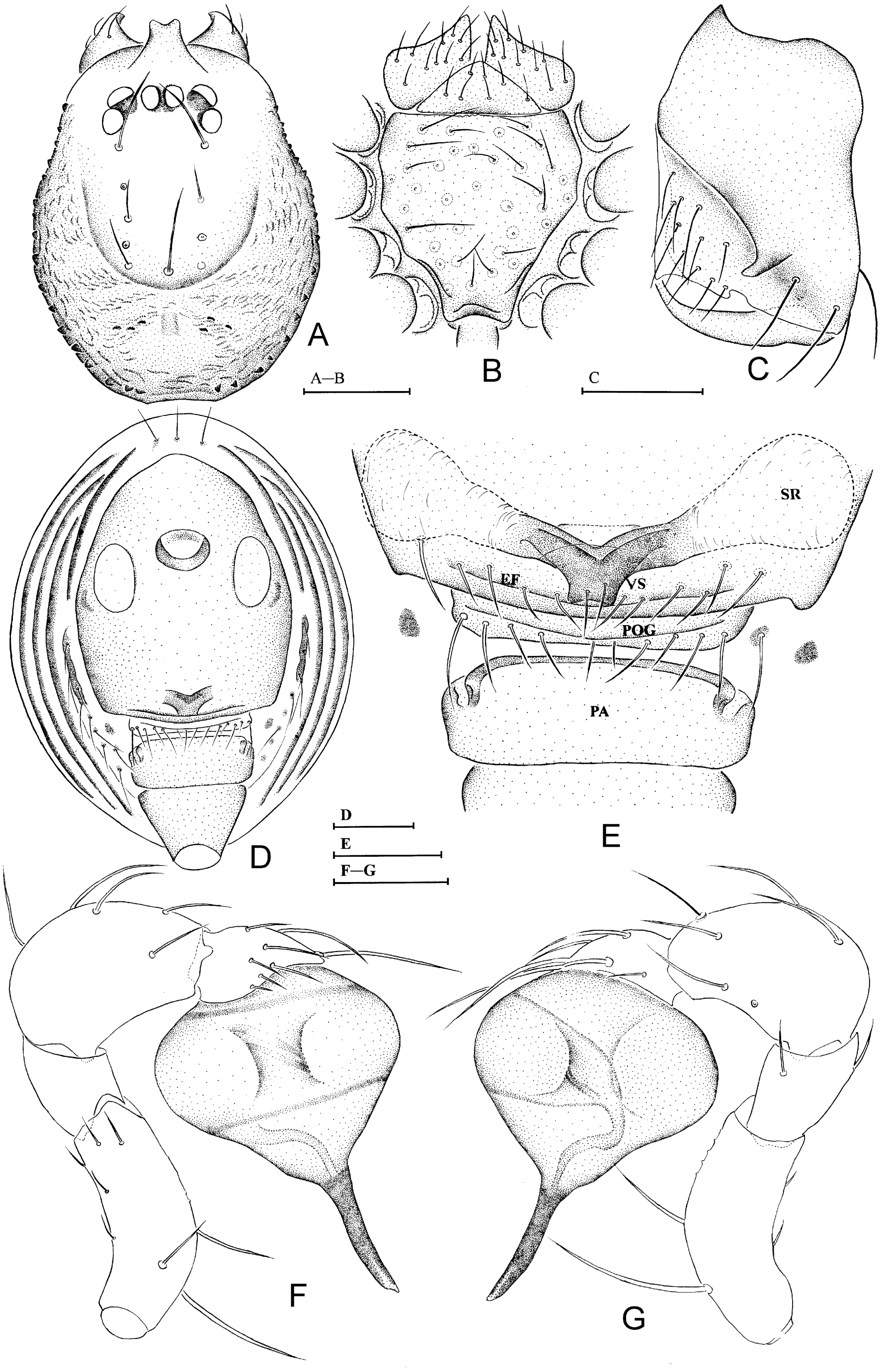

Fig. 3. *Brignoliella maoganensis* sp. n. (A) Male carapace and chelicerae, dorsal view. (B) Female sternum, ventral view. (C) Male chelicerae, anterior view. (D) Female abdomen, ventral view. (E) Female genital area and cleared vulva, ventral view. (F) Male left palp, prolateral view. (G) Male left palp, retrolateral view. Scale bars: A, B, D = 0.2 mm; C, E–G = 0.1 mm.

position of pits on preanal plate, shape of vulval dark area in female, and larger size in both sexes.

Description. Colouration reddish. Male 1.30–1.39. Carapace length 0.65–0.66, width 0.53–0.54, maximum height 0.53–0.54. Abdomen length 0.85–0.96, width 0.66–0.73. Carapace, clypeal horn and eyes as in *B. caligiformis* sp. n., but PME slightly closer to each other. Anterior surface of chelicerae with apophysis directed anteriorly, but without distinct additional small denticle as in *B. caligiformis* sp. n. Sternal pits as in *B. caligiformis* sp. n., but denser. Leg measurements: I 1.60 (0.53, 0.17, 0.38, 0.26, 0.26); II 1.44 (0.46, 0.17, 0.33, 0.24, 0.24); III 1.34 (0.40, 0.16, 0.30, 0.24, 0.24); IV

1.65 (0.54, 0.17, 0.37, 0.32, 0.25). Leg formula: 4 1 2 3. Dorsal abdominal scutum long oval and pitted. Ventral plates slightly pitted. Lateral scutum I interrupted in middle. Anterior corners of preanal plate with weakly developed pits, in same positions as in female.

Male palpal femur and patella unmodified, tibia slightly thickened. Bulbus subglobular. Embolus straight, without significant modifications.

Female 1.40–1.48. Carapace length 0.70–0.72, width 0.52–0.55, maximum height 0.49–0.52. Abdomen length 1.04–1.17, width 0.81–0.87. Clypeus and chelicerae without modifications. Leg measurements: I 1.63 (0.55, 0.16, 0.38, 0.27, 0.27); II 1.55 (0.48, 0.17, 0.36, 0.27, 0.27); III 1.37 (0.42, 0.15, 0.31, 0.26, 0.23); IV 1.82 (0.56, 0.17, 0.44, 0.36, 0.29). Leg formula: 4 1 2 3. Dorsal abdominal scutum as in male. Preanal plate with relatively large and narrow pits at anterolateral corners, but closer to lateral margin than in *B. caligiformis* sp. n. Posterior fold thin and long, but not extending over whole length of posterior margin. Epigynal pit small, distinctly surrounded by V-shaped dark area. Vulval stem as in *B. caligiformis* sp. n., but copulatory channel narrower, sclerotization equally strong, and sclerotized part of vulval ducts longer.

Genus *Lehtinenia* gen. n.

Type species: *Lehtinenia bicornis* sp. n.

Etymology. Genus named in honour of Dr. Pekka T. Lehtinen, for his contributions to our knowledge of the family Tetrablemmidae. Gender of genus name: feminine.

Diagnosis. Small, light reddish spiders. Six eyes in compact group, PME smaller than ALE and PLE, ALE largest. Carapace, clypeus and ocular area without any modifications in both sexes. Male chelicerae with small tooth centrally, and with additional small tooth near base of cheliceral tooth. Abdomen long oval. Palpal bulbus pear-shaped. Embolus flattened, more or less perpendicular to end of bulbus. Preanal plate of female without pits, but with pair of flake-shaped prominences on posterior margin. Vulval pit small. Vulval stem *Tetrablemma*-type, with distinctly lateral horns supporting base of vulval ducts posteriorly. Lateral horns with complicated anterior modifications. Central process absent, but central branch of inner vulval plate long and distally curved towards ventral.

Relationships. The new genus is related to *Ablemma* Roewer and *Sulaimania* Lehtinen by the male palpal characters, but can be distinguished from *Ablemma* by the unmodified carapace and ocular area, the central cheliceral tooth and the female vulva; from *Sulaimania* by the number of eyes, the modifications of the chelicerae and the smaller sized male postgenital plate. The vulva in *Lehntinenia* gen. n. is similar to that in *Tetrablemma*, with distinctly long lateral horns on the vulval stem and a long thin central branch on the inner vulval plate. However, modifications of chelicerae and embolus rule out relations between the new genus and the genera of Tetrablemmini.

Lehtinenia bicornis sp. n.

(Figs. 4A–I and 6)

Etymology. Specific name from the Latin prefix bi- = two-, and cornis = horned, in reference to the modifications of the male chelicerae; to be treated as adjectival for the purposes of nomenclature.

Type material. *Holotype*. Male (IZCAS); Mount Wuzhishan (18°49′N, 109°39′E), Wuzhishan City, Hainan Province, China, 16 April 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

Paratypes. 1 male, 1 female (IZCAS); same data as holotype.

Diagnosis. The new species can be distinguished from other tetrablemmids by the special modifications of the chelicerae, the modified embolus, and the conformation of the vulva.

Description. Colouration light reddish. Male 1.12. Carapace length 0.51, width 0.40, maximum height 0.39. Abdomen length 0.72, width 0.48. Cephalic area of carapace horizontal in profile, no modifications on clypeus or ocular area. Clypeus marginally rounded, but sharp in middle. Six eyes in one group, AME > PLE > PME. Cheliceral tooth small, situated almost at central parts of chelicerae. Additional small tooth near base of cheliceral tooth, resulting in two triangular projections in profile. Carapace and sternum both reticulate. Leg measurements: I 1.13 (0.38, 0.14, 0.25, 0.18, 0.18); II 1.07 (0.36, 0.14, 0.23, 0.17, 0.17); III 0.94 (0.28, 0.13, 0.19, 0.17, 0.17); IV 1.22 (0.38, 0.14, 0.30, 0.20, 0.20). Leg formula: 4 1 2 3. Abdominal scutum long oval. Lateral scutum I short. Pulmonary plate slightly pitted.

Palpal bulbus pear-shaped, with small tubercle present on anteroventral surface. Embolus flattened, more or less perpendicular towards end of bulbus. Ejaculatory duct with one half coil in basal part of bulbus.

Female 1.28. Carapace length 0.58, width 0.42, maximum height 0.38. Abdomen length 0.81, width 0.52. Similar to male, but carapace relatively long, chelicerae without modifications, and clypeus marginally rounded. Leg measurements: I 1.15 (0.38, 0.15, 0.26, 0.17, 0.19); II 1.08 (0.35, 0.14, 0.24, 0.17, 0.18); III 0.97 (0.29, 0.13, 0.20, 0.17, 0.18); IV 1.25 (0.40, 0.13, 0.32, 0.21, 0.19). Leg formula: 4 1 2 3. One pair of perigenital plates, slightly larger than in male. Pits absent, but with

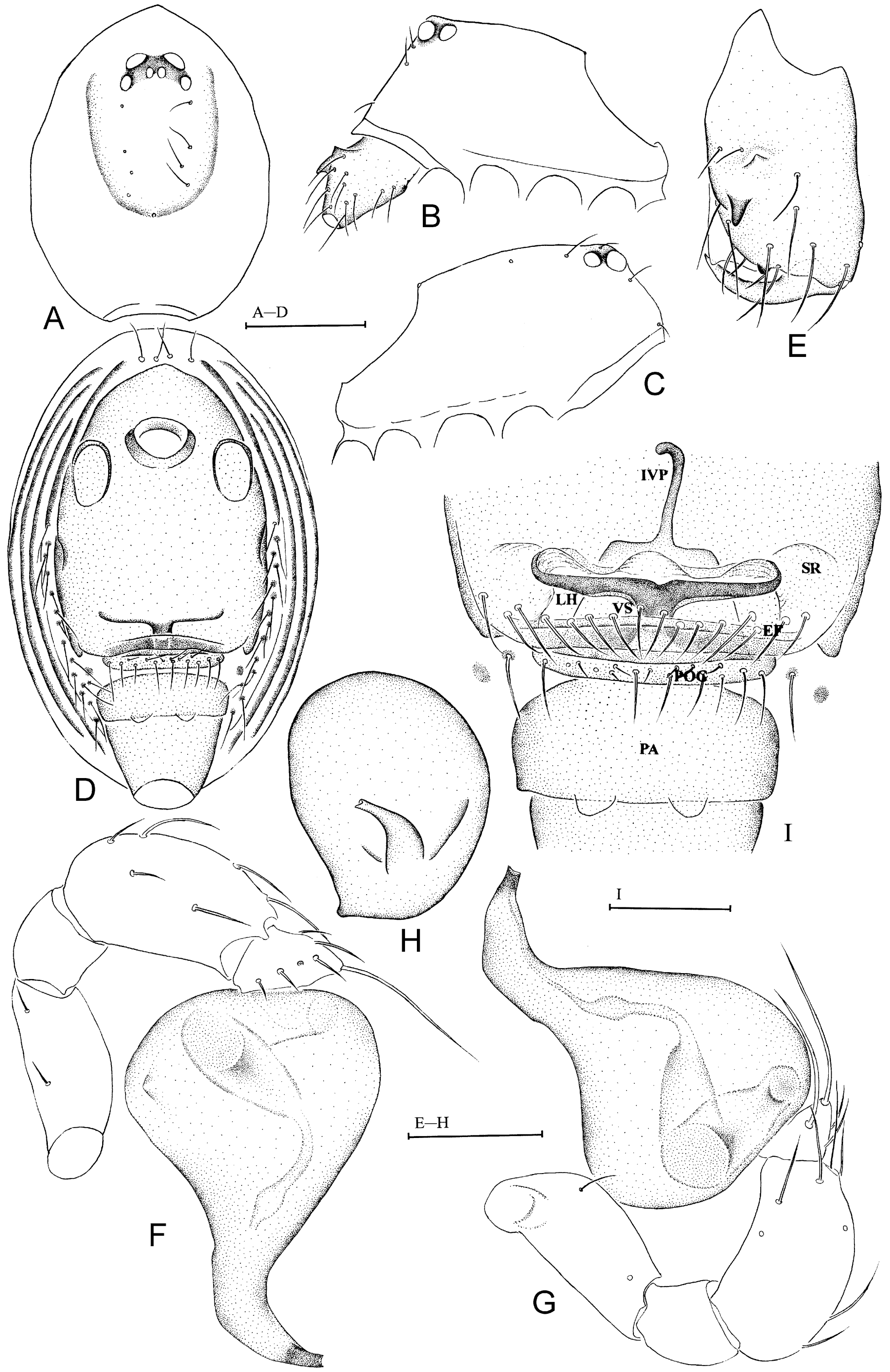

Fig. 4. *Lehtinenia bicornis* sp. n. (A) Male carapace, dorsal view. (B) Male carapace and chelicerae, lateral view. (C) Female carapace, lateral view. (D) Female abdomen, ventral view. (E) Male chelicerae, anterior view. (F) Male left palp, prolateral view. (G) Male left palp, retrolateral view. (H) Male palpal bulbus, ventral view. (I) Female genital area and cleared vulva, ventral view. Scale bars: A–D = 0.2 mm; E–I = 0.1 mm.

pair of flake-shaped prominences on posterior margin of preanal plate.

Epigynal pit small. Vulval stem with long and strong lateral horns with complicated anterior modifications. Central process absent, but central branch of inner vulval plate long and distally curved towards ventral.

Genus *Tetrablemma* O. P.-Cambridge, 1873

Tetrablemma brevidens sp. n.

(Figs. 5A–I and 6)

Etymology. Specific name from the Latin brevis = short, and dens = tooth, in reference to the modifications

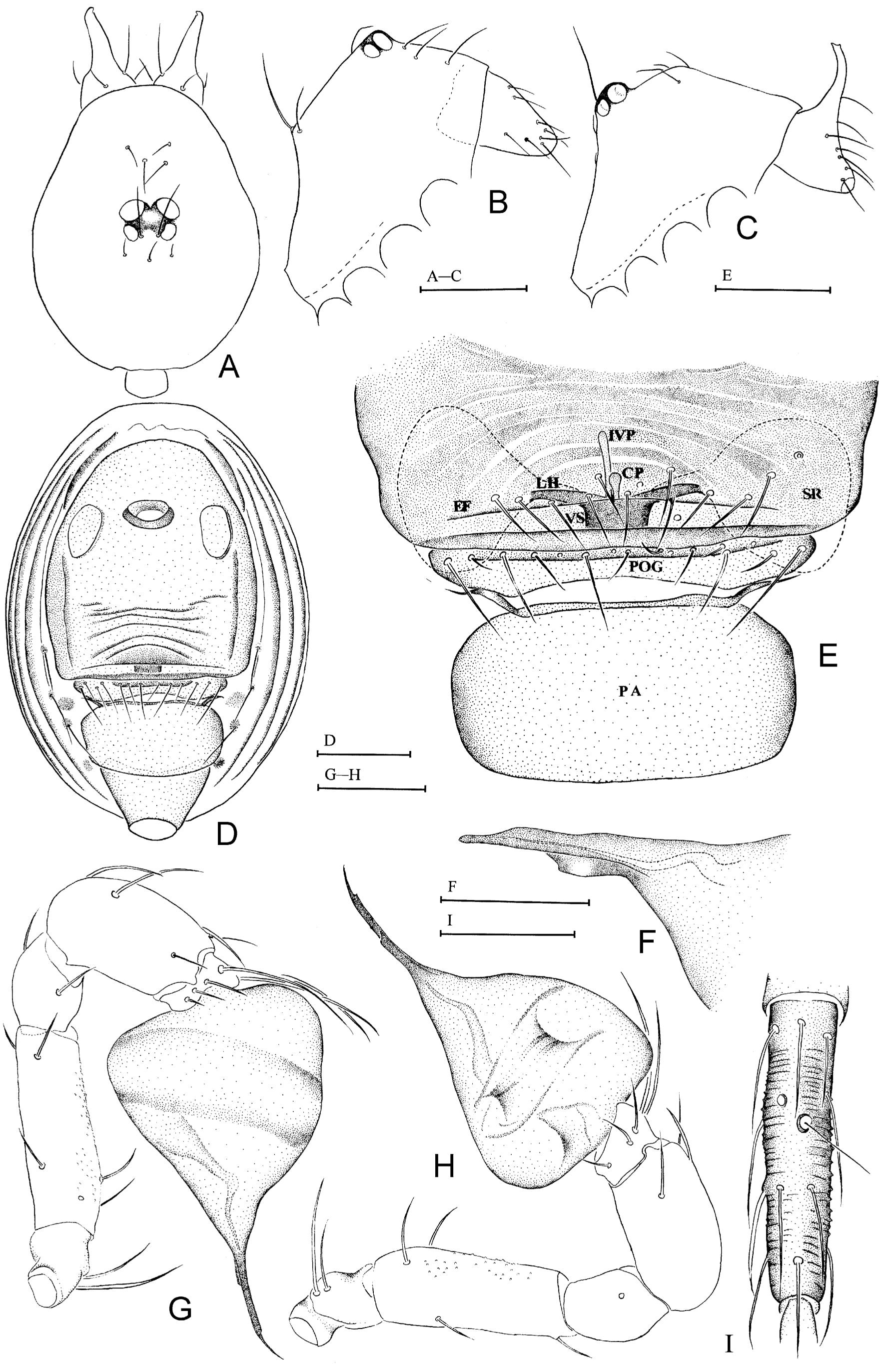

Fig. 5. *Tetrablemma brevidens* sp. n. (A) Male carapace and chelicerae, dorsal view. (B) Female carapace and chelicerae, lateral view. (C) Male carapace and chelicerae, lateral view. (D) Female abdomen, ventral view. (E) Female genital area and cleared vulva, ventral view. (F) Male embolus. (G) Male left palp, prolateral view. (H) Male left palp, retrolateral view. (I) Male metatarsi I, dorsal view. Scale bars: A–D = 0.2 mm; E–I = 0.1 mm.

on male metatarsus I; to be treated as a noun for the purposes of nomenclature (Fig. 6).

Material examined. *Holotype*. Male (IZCAS); Baoyou Cave (19°06′N, 109°01′E), Qicha Town, Changjiang County, Hainan Province, China, 2 April 2005, leg. Yanfeng Tong, Yanjing Song, and Gaoyun Deng.

Paratypes. 9 males, 13 females (IZCAS); same data as holotype.

Additional material. 2 males, 7 females (IZCAS); unnamed cave (18°59′N, 108°53′E), Yalong Village, Donghe Town, Dongfang City, Hainan Province, China, 31 March 2005, leg. Yanfeng Tong, Yanjing Song, Xu Han, and Gaoyun Deng.

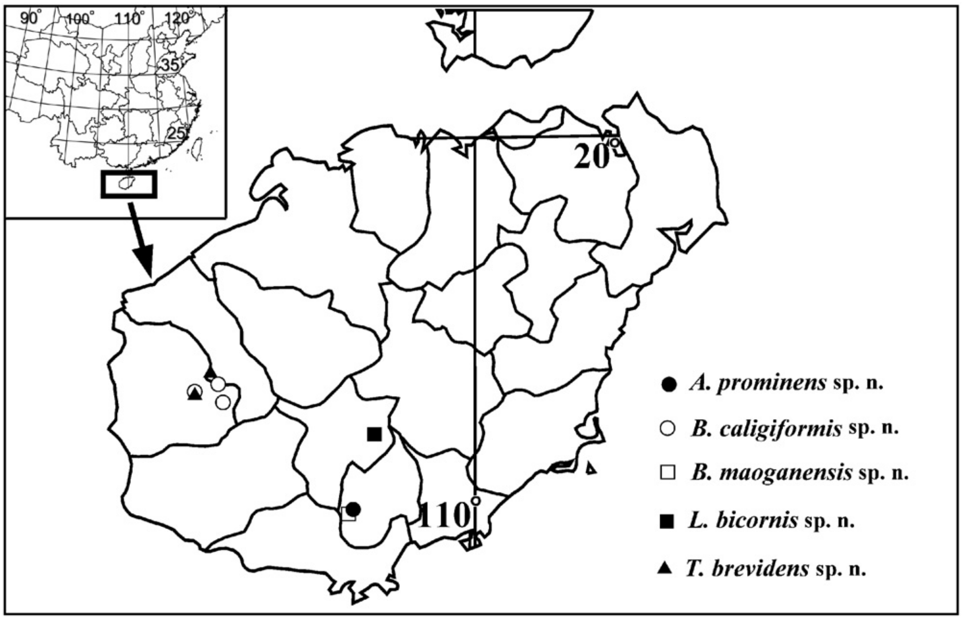

Fig. 6. Collection localities of Chinese Tetrablemmidae in Hainan Island.

Diagnosis. The new species can be easily distinguished from most species of *Tetrablemma* by the process on the basal part of the embolus. Three species, *T. rhinoceros*, *T. brignolii* and *T. okei*, have a similar structure (Lehtinen 1981), but the new species can be distinguished from them by the following details: central position of eye group in male, absence of paired tubercles on clypeal area, modifications on metatarsus I of male, absence of sharp medial cone on male palpal femur, and more or less distinct furrows on genital area of female.

Description. Colouration from orange to reddish. Male 1.19–1.24. Carapace length 0.52–0.55, width 0.42–0.44, maximum height 0.44–0.45. Abdomen length 0.78–0.81, width 0.51–0.59. Clypeus marginally rounded. Anterior hump of male carapace slightly convex, rounded posteriorly. ALE larger than PLE, PLE separated by more than twice their diameter. Cheliceral horn narrowed, slightly curved in apical half. Carapace and sternum completely reticulate. Leg measurements: I 1.35 (0.44, 0.13, 0.32, 0.23, 0.23); II 1.18 (0.40, 0.13, 0.25, 0.20, 0.20); III 1.13 (0.35, 0.12, 0.25, 0.21, 0.20); IV 1.49 (0.46, 0.13, 0.40, 0.27, 0.23). Leg formula: 4 1 2 3. Dorsal abdominal scutum long oval, slightly reticulate. Lateral scutum I short, perigenital plates present. Metatarsi I with small denticles on anterior and posterior sides.

Palpal femur long and slender, with small granules on anterior and posterior surfaces. Palpal bulbus large, distal part abruptly narrowed at base of embolus. Embolus thin, straight, basally with a wide and simple process.

Female 1.19–1.28. Carapace length 0.57–0.58, width 0.38–0.43, maximum height 0.41–0.42. Abdomen length 0.82–0.90, width 0.57–0.63. Clypeus sloping. Size of eyes as in male. Leg measurements: I 1.33 (0.43, 0.14, 0.31, 0.22, 0.23); II 1.23 (0.40, 0.13, 0.28, 0.21, 0.21); III 1.14 (0.35, 0.13, 0.25, 0.21, 0.20); IV 1.52 (0.47, 0.14, 0.38, 0.28, 0.25). Leg formula: 4 1 2 3. Lateral scutum I anteriorly short, but posteriorly also represented by a continuous narrow fold. Before preanal plate with a pair of pleat-shaped, slightly sclerotized membranes (absent in specimens from Yalong Cave).

Genital area with more or less distinct furrows (indistinct in specimens from Yalong Cave) and with one strong fold. Vulval stem with lateral horns supporting basal parts of ducts of seminal receptacula, as in all species of *Tetrablemma*. Central process thin. Inner vulval plate trifurcate as in all known species of *Tetrablemma*.

Phylogeny

The cladistic analysis produced 1016 equally parsimonious trees (LE = 102, CI = 0.6078, CI for informative characters = 0.5745, RI = 0.7546). The strict consensus tree is shown in Fig. 7. Bootstrap support for the tree is low, thus bootstrap values greater than 40% are arbitrarily chosen and labelled in Fig. 7.

In the cladogram Tetrablemminae is monophyletic with 99% bootstrap support (node 1). Within the subfamily, four clades (labelled A, B, C, and D) and one group (E) are recognised, which is generally congruent with the phylogeny of Lehtinen (1981) but different in some aspects.

Group E, including the genera *Borneomma*, *Brignoliella*, *Choiroblemma*, *Indicoblemma*, *Pahanga*, and

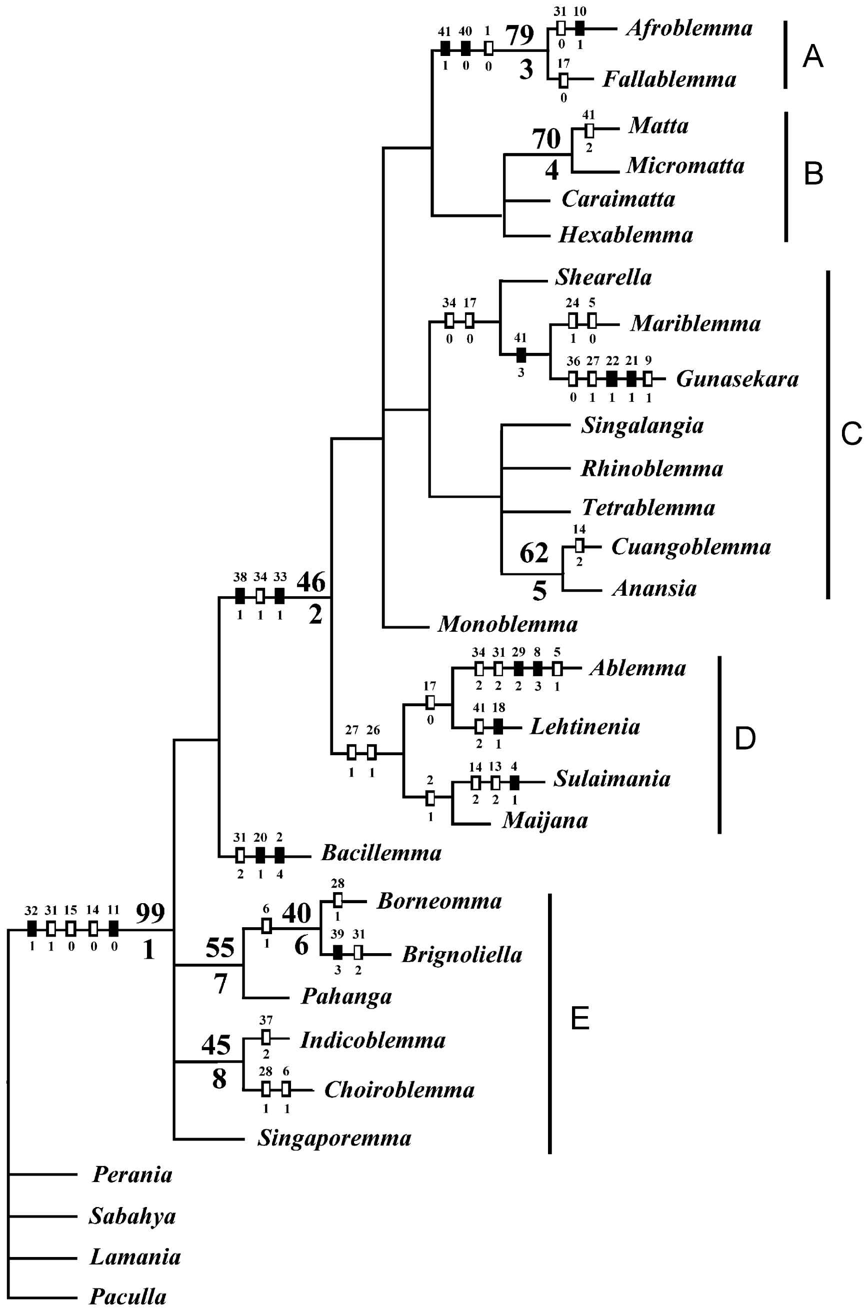

Fig. 7. Strict consensus of 1016 most parsimonious trees resulted under equal weights. Tree statistics: length = 102, CI = 0.6078, CI for informative characters = 0.5745, RI = 0.7546. Bootstrap value (above lines) and node numbers referred to in the text (below lines) are given near representative nodes. Open and solid rectangles represent homoplasious and nonhomoplasious transformations, respectively.

Singaporemma, corresponds to Brignoliellini of Lehtinen (1981). The simple structure of the inner vulval plate is recognised as a primitive character here. Thus, Brignoliellini is the most basal group in Tetrablemminae, rather than the sister group of Fallablemmini as supposed by Lehtinen (1981). Within this group, the genera *Borneomma*, *Brignoliella* and *Pahanga* form a monophyletic group (node 7). *Choiroblemma* and *Indicoblemma* form a monophyletic group (node 8). However, the relationships among these two groups and to *Singaporemma* are unresolved. An explanation for this might be that the group represents a clade of closely related genera; alternatively, it may be simply a basal paraphyletic group "unified" by symplesiomorphies.

The genus *Bacillemma*, characterised by the absence of eyes, long legs and the large epigynal pit moved towards anterior, was considered (Deeleman-Reinhold 1993) as closely related to *Chavia* (as junior synonym of

Indicoblemma; Burger 2005) and *Indicoblemma*. In the present study, *Bacillemmma* is the sister group to all the remaining genera in the subfamily Tetrablemminae, except for the six genera included in group E.

Clades A, B, C, and D form a monophyletic group (node 2) supported by the trifurcate inner vulval plate and the separate sclerotized structures embracing or supporting the vulval ducts.

Lehtinenia gen. n. and the genera *Ablemma*, *Sulaimania*, and *Maijana* are included in clade D, which corresponds to Ablemmini of Lehtinen (1981); this is supported by the modified embolus, but with low bootstrap support. Within this clade, the genera *Lehtinenia* gen. n. and *Ablemma* form a monophyletic group, supported by the pitted pulmonary plate. The genus *Ablemma* has two autapomorphies, the special vulva and strongly modified ocular area. *Lehtinenia* gen. n. has a *Tetrablemma*-type vulva but an *Ablemma*-type embolus. It may represent an intermediate type between *Ablemma* and *Tetrablemma*. The genera *Maijana* and *Sulaimania* form a monophyletic group, but supported only by highly homoplastic characters, such as the number of eyes and the unmodified chelicerae. Both genera are only known from one sex only, so the relationship between them is unclear.

Clade A (79% bootstrap support), including *Fallablemma* and *Afroblemma* (node 3) and corresponding to Fallablemmini of Lehtinen (1981), is characterised by the primitive eye pattern and the special vulval stem. Fallablemmini is the most primitive group in the cladogram of Lehtinen (1981). However, in the present analysis, clade A is a more advanced group and forms a monophyletic group with clade B, although the relationship was not supported by any unique shared derived characters and had low bootstrap support. This may be partially due to the fact that the morphological characters used in the analysis are few and highly homoplastic.

Clades B and C (corresponding to Mattini and Tetrablemmini, respectively) are generally congruent with the phylogeny of Lehtinen (1981), but the relationships among the genera *Tetrablemma*, *Rhinoblemma*, *Singalangia* (in clade C) are unresolved. However, the diagnostic characters seem to be distinct; for example, the posterior part of the sternum is strongly modified in *Singalangia* but unmodified in the other two genera, and the details of cheliceral and clypeal modifications are also different among the three genera. This might be a result of the lack of shared derived characters and too much missing information in them.

The present phylogenetic analysis is based on descriptions from previous publications, and used genera as terminal taxa. Some genera were described ambiguously or only from one sex. Much more work needs to be done in order to obtain a better understanding of phylogenetic relationship within such a little-known animal group as the Tetrablemmidae.

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Appendix A

Character list for 41 binary and multistate characters. Characters 4, 10, 16, 18, 20–22, and 25 are parsimony uninformative. LE = length, CI = consistency index, RI = retention index.

1. *Eye patterns*. (0) one row of six eyes; (1) other types. Comments: one row of six eyes is identical to the configuration in Diguetidae, Segestriidae and many other groups. Therefore, all other eye patterns within Tetrablemminae are apomorphic. This character was ordered. LE = 2; CI = 0.50; RI = 0.91.
2. *Number of eyes*. (0) usually 6; (1) reduced to 4; (2) reduced to 2; (3) ALE fused; (4) no trace of eyes. Comments: number in *Ablemma* is 6, 4, or 2, but coded "0" here, as most species of this genus have six eyes. LE = 7; CI = 0.57; RI = 0.63.
3. *Distance between ALE*. (0) not very large; (1) ALE separated far from each other. Comments: only *Matta* and *Micromatta* have widely separated ALE; this character is a synapomorphy for these two genera. LE = 1; CI = 1.00; RI = 1.00.
4. *Size of ALE*. (0) not distinctly larger than other eyes; (1) much larger than other eyes. Comments: state "1" occurs in *Sulaimania* only. LE = 1; CI = 1.00; RI = 0.0.
5. *Ocular area*. (0) unmodified; (1) more or less modified. Comments: modification of the ocular area is common in Tetrablemminae. The most specialised genus is *Ablemma*. LE = 3; CI = 0.33; RI = 0.71.
6. *Male clypeus modifications*. (0) unmodified; (1) modified. LE = 4; CI = 0.25; RI = 0.40.

7. *Male cheliceral modifications*. (0) absent; (1) insignificant anterior cheliceral modification; (2) distinct modifications. LE = 3; CI = 0.67; RI = 0.89.
8. *Types of male chelicerae modifications*. (0) sublateral small tooth; (1) basally wide horn; (2) distal tooth. LE = 2; CI = 1.00; RI = 1.00.
9. *Types of basally wide horn*. (0) shorter; (1) long. LE = 2; CI = 0.50; RI = 0.50.
10. *Male chelicerae*. (0) not wide; (1) distinctly wide, divergent. LE = 1; CI = 1.00; RI = 0.0.
11. *Structure of hair pits on carapace and sternum*. (0) large; (1) small or minute. LE = 1; CI = 1.00; RI = 1.00.
12. *Total size of spider*. (0) larger than 5 mm; (1) usually 3–5 mm; (2) smaller than 2 mm. LE = 2; CI = 1.00; RI = 1.00.
13. *Size of postgenital plate in female*. (0) reduced; (1) not reduced; (2) relatively larger or subequal to preanal plate. LE = 4; CI = 0.50; RI = 0.0.
14. *Surface of sternum*. (0) reticulate; (1) pitted; (2) smooth. Comments: Lehtinen (1981) suggested that pitted sternum and smooth sternum represent derived patterns evolved in different directions. LE = 4; CI = 0.50; RI = 0.75.
15. *Posterior part of sternum*. (0) unmodified; (1) strongly modified. LE = 2; CI = 0.50; RI = 0.75.
16. *Structure of pulmonary plate*. (0) without separate stigmal plate; (1) with separate stigmal plate. LE = 1; CI = 1.00; RI = 0.0.
17. *Surface of pulmonary plate*. (0) pitted; (1) not pitted. LE = 5; CI = 0.20; RI = 0.69.
18. *Flake-shaped prominences on preanal plate*. (0) absent; (1) present. Comments: state “1” is an autapomorphy of *Lehtinenia* gen. n. LE = 1; CI = 1.00; RI = 0.0.
19. *Lateral plate I*. (0) totally reduced at least in one sex; (1) present. LE = 2; CI = 0.50; RI = 0.80.
20. *Leg I*. (0) not especially long; (1) especially long. LE = 1; CI = 1.00; RI = 0.0.
21. *Metatarsi*. (0) unmodified; (1) strongly modified. LE = 1; CI = 1.00; RI = 0.0.
22. *Male gnathocoxae*. (0) unmodified; (1) modified. LE = 1; CI = 1.00; RI = 0.0.
23. *Shape of cymbium*. (0) long, unmodified; (1) shortened, apex bilobate; (2) very short, distally obtuse. LE = 2; CI = 1.00; RI = 1.00.
24. *Origination of embolus*. (0) distal; (1) mesial. LE = 2; CI = 0.50; RI = 0.0.
25. *Shape of bulbus*. (0) subglobular or pyriform; (1) U-shaped. LE = 1; CI = 1.00; RI = 0.0.
26. *Orientation of embolus*. (0) not perpendicular to apex of bulbus; (1) more or less perpendicular to apex of bulbus. LE = 2; CI = 0.50; RI = 0.75.
27. *Modifications of embolus*. (0) unmodified; (1) modified. Comments: state “1” is characteristic for *Ablemma*, *Lehtinenia* gen. n., and *Sulaimania*, but also evolved in *Gunasekara*. LE = 2; CI = 0.50; RI = 0.67.
28. *Conductor*. (0) absent; (1) present. Comments: state “1” is a synapomorphy of clade B, but also present in *Borneomma* and *Choiroblemma*. LE = 3; CI = 0.33; RI = 0.50.
29. *Pits on preanal plate*. (0) absent; (1) anterolateral, central or anterior; (2) posterolateral or posterior. Comments: state “1” is characteristic for clade E, state “2” is an autapomorphy of *Ablemma*. LE = 2; CI = 1.00; RI = 1.00.
30. *Epigynal pit*. (0) paired; (1) unpaired. LE = 1; CI = 1.00; RI = 1.00.
31. *Size of epigynal pit*. (0) large; (1) small; (2) large and anteriorly moved. LE = 5; CI = 0.40; RI = 0.50.
32. *Inner vulval plate*. (0) only one large vulval plate; (1) separate from other vulval sclerotizations. Comments: state “1” is a synapomorphy of Tetrablemminae. LE = 1; CI = 1.00; RI = 1.00.
33. *Structure of inner vulval plate*. (0) simple transverse bar; (1) trifurcate. Comments: state “0” is characteristic for clade E; cladistic analysis suggests that it is primitive. LE = 1; CI = 1.00; RI = 1.00.
34. *Types of central branch*. (0) absent; (1) usually relatively long and narrow; (2) distally rounded, basally wide; (3) short and wide, semicircular. LE = 5; CI = 0.60; RI = 0.75.
35. *Lateral branches of inner vulval plate*. (0) without modifications; (1) with anterior modifications. Comments: state “1” is a synapomorphy of *Anansia* and *Cuangoblemma*. LE = 1; CI = 1.00; RI = 1.00.
36. *Central process of vulva*. (0) absent; (1) present. LE = 3; CI = 0.33; RI = 0.82.
37. *Types of central process of vulva*. (0) large soft sac, attached by long duct; (1) bifurcate chitinous strip; (2) small; (3) well developed; (4) membranous. LE = 6; CI = 0.67; RI = 0.50.
38. *Separate sclerotized structures embracing or supporting vulval ducts*. (0) absent; (1) present. LE = 1; CI = 1.00; RI = 1.00.
39. *Degree of sclerotization of vulval ducts*. (0) basal parts of vulval ducts weakly sclerotized; (1) basal parts of vulval ducts strongly sclerotized; (2) basal halves of seminal receptacula sclerotized; (3) thick, and sclerotization equally strong around unpaired copulatory channel and basal parts of vulval ducts. LE = 3; CI = 1.00; RI = 1.00.
40. *Vulval stem*. (0) not surrounding branching point of vulval ducts; (1) surrounding branching point of vulval ducts. Comments: state “0” is unique to clade A. LE = 1; CI = 1.00; RI = 1.00.
41. *Types of lateral horns of vulval stem*. (0) absent; (1) ventral separate plate with rounded branch; (2) very long; (3) short and thick; (4) weakly developed. LE = 6; CI = 0.67; RI = 0.71.

Appendix B

Character matrix of 41 characters for 30 taxa

Character no.	000000000	1111111111	2222222222	3333333333	44
Taxon	123456789	0123456789	0123456789	0123456789	01
Lamania	0000000--	0111110000	0001000000	100---0-0-	--
Paculla	0000000--	0111110000	0001000000	000---0-0-	--
Perania	0000000--	0100111000	0000010000	?00---0-0-	--
Sabahya	0000000--	0112110000	0001000000	000---0-0-	--
Ablemma	10001022-	0021000001	0002001102	1211200-1-	10
Afroblemma	0000001--	1021000101	0002000000	101110101-	01
Anansia	120010211	0021000101	0002001000	111111121-	12
Bacillemma	1400????-	0021000101	1002?????0	1210000-01	10
Borneomma	00000120-	0021100001	0002000011	1110000-02	10
Brignoliella	00000120-	0021100001	0002000001	1210000-03	10
Caraimatta	1100001--	0021000101	0002000010	111120121-	10
Choiroblemma	00000120-	0021000101	0002000011	1110001300	10
Cuangoblemma	120011211	0021200101	0002001000	111111121-	12
Fallablemma	0000001--	0021000001	0002000000	111110111-	01
Gunasekara	100010211	0021000001	0112000100	1111000-1-	13
Hexablemma	1000????-	0021000001	0002?????0	111120121-	10
Indicoblemma	00000020-	0021000101	0002000001	1110001200	10
Lehtinenia	10000020-	0021000011	0002001100	1111100-1-	12
Maijana	1100????-	0021000101	0002?0???0	1111300-1-	10
Mariblemma	100000210	0021000001	0002100000	111100131-	13
Matta	1210001--	0021000101	0002000010	1111?0141-	12
Micromatta	1210001--	0021000101	0002000010	1111?0??1-	10
Monoblemma	130000210	0021200101	0002000000	1111????1-	1?
Pahanga	00000020-	0021100001	0002000001	1110000-02	10
Rhinoblemma	110011211	0021000101	0002000000	??????????	??
Shearella	100010210	0021000001	0002000000	111100131-	12
Singalangia	11001???1	0020010100	0002000000	111110131-	14
Singaporemma	0000000--	0021000100	0002100000	1110001301	10
Sulaimania	1101000--	00222001?1	000200110?	?????????-	??
Tetrablemma	110011211	0021000101	0002000000	111110131-	12

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A taxonomic study of Chinese *Nematogmus* species (Araneae, Linyphiidae)

Yanjing Song[a,b], Shuqiang Li[a,*]

[a]*Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, PR China*
[b]*Graduate University, Chinese Academy of Sciences, Beijing 100039, PR China*

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Abstract

Four species of *Nematogmus* Simon, 1884 from China were studied: *N. sanguinolentus* (Walckenaer, 1842; the type species), *N. digitatus* Fei & Zhu, 1994 (re-examined from its type material), *N. longior* sp. n., and *N. membranifer* sp. n. Descriptions of the new and redescriptions of the previously known species are provided, as well as the recorded distributions of all four species in China.

Keywords: Erigoninae; Morphological characters; Type material; New species

Introduction

The erigonine spider genus *Nematogmus* was created by Simon (1884) to accommodate *Theoridion sanguinolentus* Walckenaer, 1842 and *Erigone florens* O. P. Cambridge, 1875. In 1894, the same author transferred the latter species to *Hypselistes* Simon, 1894, which has also accommodated a few other species from the Old and New World. *Nematogmus sanguinolentus* was indicated as the type species of the genus by Simon (1894).

Nematogmus has housed a fluctuating number of species (van Helsdingen 1979). Currently it comprises six species (Platnick 2008): *N. dentimanus* Simon, 1886 (Sri Lanka to Malaysia, Java, Krakatau); *N. digitatus* Fei & Zhu, 1994 (China); *N. nigripes* Hu, 2001 (China); *N. rutilis* Oi, 1960 (Japan); *N. sanguinolentus* (Walckenaer, 1842) (Palaearctic, including China); and *N. stylitus* (Bösenberg & Strand, 1906) (Japan). Zhu (1983) recorded *N. stylitus* from China, but by examining the corresponding material we have found that to be the result of a misidentification of *N. digitatus*. Consequently, three *Nematogmus* species were known from China so far.

During our further study of *Nematogmus* material from China, two new species have been identified; these are described in the present paper. Therefore, a total of five *Nematogmus* species are currently known from China. Except for *N. nigripes*, the type material of which could not be located, these species are reviewed in the present paper.

Material and methods

All specimens studied here are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS), in Beijing or at Jilin University (JLU) in Changchun.

Specimens were examined under an Olympus SZ11 stereomicroscope, and illustrated using an Olympus

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[*] Corresponding author.
E-mail address: lisq@ioz.ac.cn (S. Li).

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BX41 compound microscope equipped with a drawing tube. Male left palps and female epigyna were illustrated after being separated from the body. Embolic divisions were dissected from the palpal bulb using sharp pins and tweezers. Genital organs were immersed in 75% alcohol and examined under a compound microscope; embolic divisions and vulvae were mounted in Hoyer's Solution and examined in strong transmitted light against a white background. In addition, the ventral tegument of epigyna was removed with sharp pins and tweezers to study the duct system of the vulvae under a microscope.

Eye diameters were measured at the eyes' widest points. Leg measurements are given as: total length (femur, patella, tibia, metatarsus, tarsus). All measurements are recorded in millimeters. The terminology for genitalic structures follows Hormiga (2000). In the sections on the individual species, only the respective original description is cited; for additional synonyms and references, see Platnick (2008).

Abbreviations of morphological structures

Somatic morphology. ALE = anterior lateral eye; AME = anterior median eye; PLE = posterior lateral eye; PME = posterior median eye; Tm I = position of first metatarsal trichobothrium; Tm IV = fourth metatarsal trichobothrium.

Male palp. C = column; DSA = distal suprategular apophysis; E = embolus; EM = embolic membrane; PC = paracymbium; PT = protegulum; R = radix; RTA = retrolateral tibial apophysis; RTT = retrolateral tibial tooth; SPT = suprategulum; ST = subtegulum; T = tegulum; TP = tailpiece of radix.

Epigynum. CD = copulatory duct; CO = copulatory opening; DP = dorsal plate; FD = fertilization duct; FO = fertilization opening; S = spermatheca; VP = ventral plate; VPD = ventral plate depression; VPS = ventral plate scape.

Taxonomic section

Family Linyphiidae Blackwall, 1859
Genus *Nematogmus* Simon, 1884

Nematogmus digitatus Fei & Zhu, 1994

(Figs. 1, 2 and 11)

Nematogmus digitatus Fei & Zhu – Fei and Zhu (1994, p. 293, figs. 1–5)

Material examined

Holotype (JLU): male; Manjiang (41.95°N, 127.61°E), Changbaishan Mountain, Jilin Province, China, 28 June 1990.

Paratypes (JLU): 2 males and 2 females; same data as holotype.

Additional material (JLU): 2 males; data as holotype, except 30 June 1990.

Diagnosis

This species can be distinguished by a stout tubercle on the dorsal side of the cymbium (Fig. 1F), the presence of an additional finger-like, strongly curved apophysis on the ventral side of the paracymbium (Fig. 1D), the rectangular retrolateral tibial apophysis (Fig. 1B), the large, slender retrolateral tibial tooth, the presence of a small fragile triangular lamina on the dorsal side of the tibia (Fig. 1B), the somewhat oblong ventral plate with deeply concave posterior margin (Fig. 2E), and the dorsal plate visible in ventral view (Fig. 2E). The simple copulatory ducts are similar to those in *N. sanguinolentus*, but much more slender (Fig. 2G).

Description

Male (holotype). Total length 1.48. Carapace 0.78 long, 0.70 wide, bright reddish-orange, bearing a fairly large cephalic lobe and cephalic pits within the post-ocular sulci, as well as several hairs scattered in the ocular area (Fig. 1A). Abdomen grayish. Clypeus 0.26 high. AME diameter 0.04, ALE 0.06, PME 0.06, PLE 0.06, AME interdistance 0.50 times their diameter, AME–ALE interdistance 1.11 times ALE diameter, PME interdistance 0.94 times their diameter, PME–PLE interdistance 1.53 times PLE diameter. Sternum 0.45 long, 0.50 wide. Coxa IV interdistance 1.48 times their width. Chelicerae with 5 promarginal and 5 retromarginal teeth (Fig. 1C). Tibia of leg I 8.00 times longer than deep. Tm I 0.37, Tm IV absent. Legs straw yellow. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 2.50 (0.72, 0.19, 0.60, 0.59, 0.39); II: 2.29 (0.59, 0.19, 0.56, 0.57, 0.38); III: 1.99 (0.58, 0.19, 0.43, 0.46, 0.34); IV: 2.49 (0.73, 0.20, 0.59, 0.60, 0.37).

Palp: tibia short, widened distally, with one retrolateral and one prolateral trichobothrium (Fig. 1B). Paracymbium with the most slender basal arm of all known *Nematogmus* species. Instead of an obvious cone-shaped apophysis, the cymbium (Fig. 1F) has an evenly curved ridge like in *N. membranifer*. Protegulum gradually narrowing from wide base (Fig. 1F). Tegulum mesal to subtegulum in unexpanded palp, with obtuse ventral tip (Fig. 1E). Suprategulum (Fig. 1E) narrower and shorter than in *N. sanguinolentus* and *N. longior*. Tailpiece of radix blunt at tip, twisted slightly upwards (Fig. 1E). Embolic membrane slightly sclerotized, strongly narrowed, basally widened, with a long lamina erected upwards (Figs. 2A and D). Embolus long, coiled (Fig. 2D).

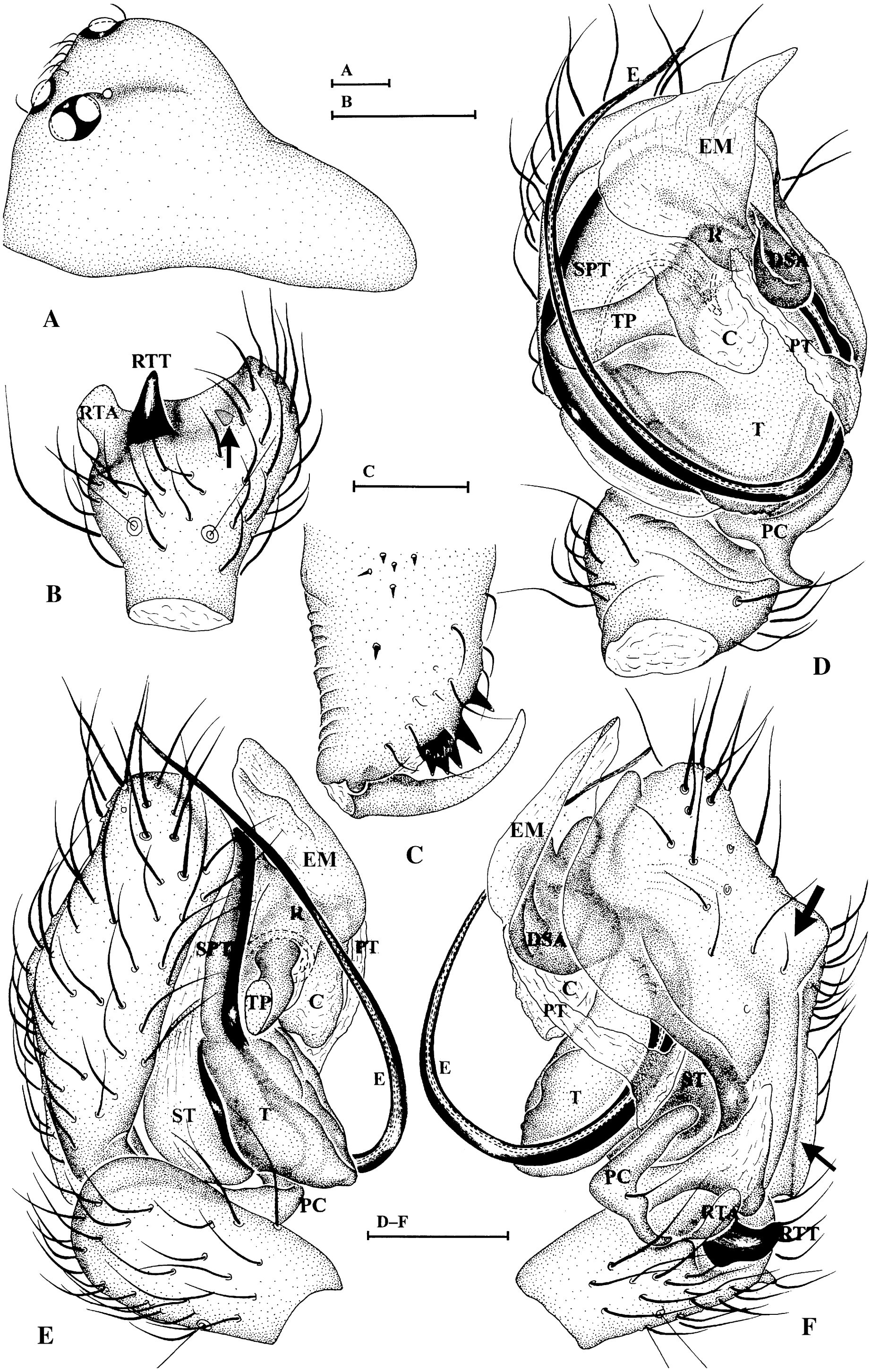

Fig. 1. (A–F) *Nematogmus digitatus*: (A) Male carapace, lateral view. (B) Tibia of male left palp, dorsal view (arrow points to a small fragile triangular lamina). (C) Male left chelicera, posterior view. (D) Male left palp, ventral view. (E) Male left palp, prolateral view. (F) Male left palp, retrolateral view (bold arrow points to stout tubercle on dorsal side of cymbium; regular arrow points to evenly curved ridge). Scale bars: 0.1 mm. For abbreviations of morphological structures, see text.

Female (paratype). Total length 2.03. Carapace 0.81 long, 0.69 wide, similar to male in coloration, but without any cephalic lobe and pits. Clypeus 0.19 high. AME diameter 0.05, ALE 0.07, PME 0.06, PLE 0.07, AME interdistance 0.50 times their diameter, AME–ALE interdistance 0.39 times ALE diameter, PME interdistance 0.75 times their diameter, PME–PLE interdistance 0.86 times PLE diameter. Sternum 0.46 long, 0.53 wide. Coxa IV interdistance 1.52 times their width. Chelicerae with 4 promarginal and

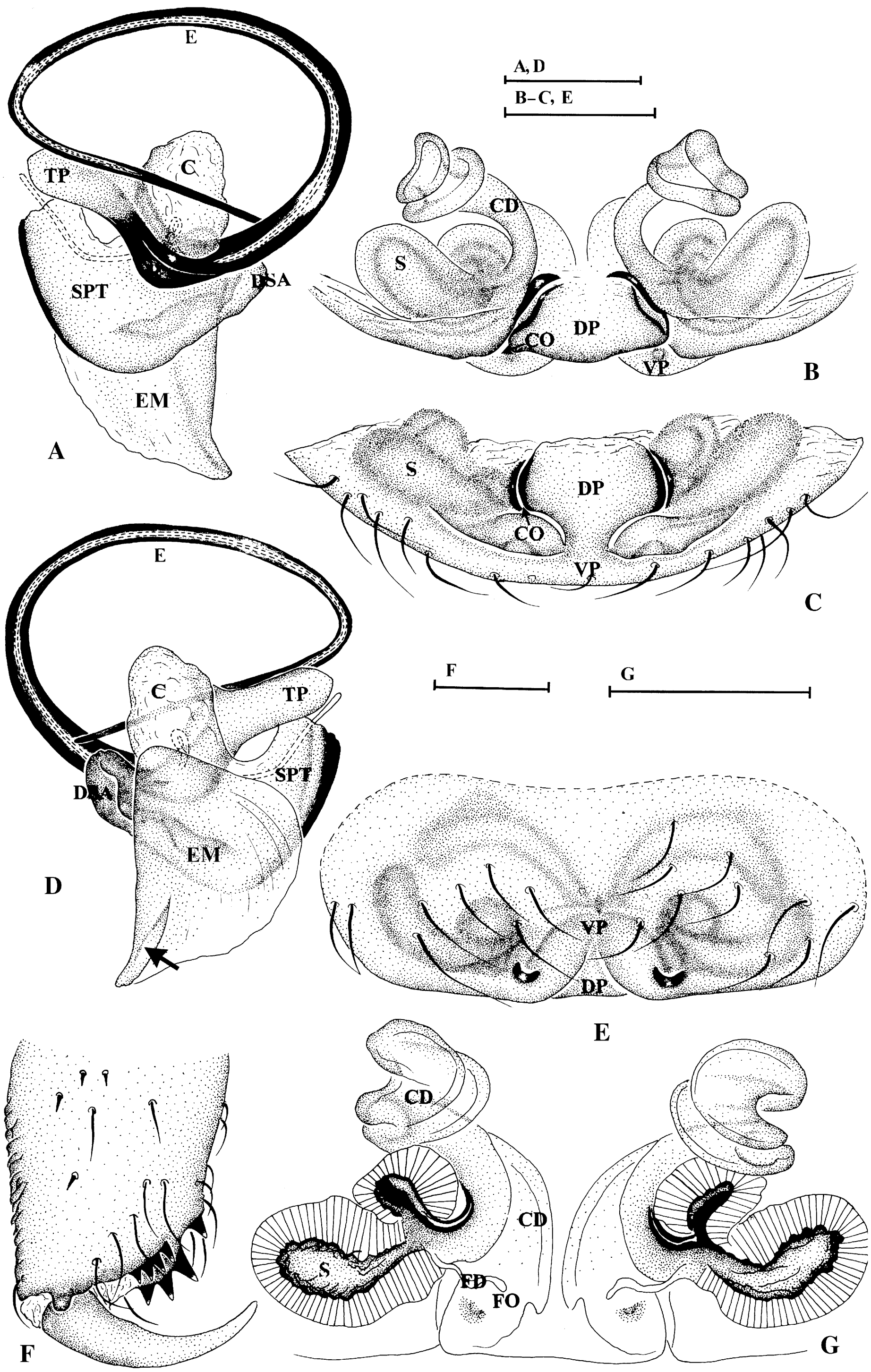

Fig. 2. (A–G) *Nematogmus digitatus*: (A) Embolic division (with DSA), dorsal view. (B) Epigynum, dorsal view. (C) Epigynum, posterior view. (D) Embolic division (with DSA; arrow points to a long lamina erected upwards), ventral view. (E) Epigynum, ventral view. (F) Female left chelicera, posterior view. (G) Vulva, dorsal view. Scale bars: 0.2 mm. For abbreviations of morphological structures, see text.

4 retromarginal teeth (Fig. 2F). Tibia of leg I 7.00 times longer than deep. Tm I 0.36, Tm IV absent. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 2.46 (0.74, 0.23, 0.57, 0.56, 0.38); II: 2.31 (0.69, 0.23, 0.54, 0.51, 0.35); III: 1.89 (0.56, 0.21, 0.40, 0.44, 0.29); IV: 2.49 (0.78, 0.22, 0.58, 0.55, 0.36).

In posterior view, ventral and dorsal plates are fused together forming a narrow 'bridge', which measures nearly one-third of dorsal plate width (Fig. 2C). In lateral view, ventral plate hardly protruding from ventral surface. Copulatory ducts simple, encapsulated in a double helix that has one coil in anterior direction, then turns around and runs backwards (Figs. 2B and G). Spermathecae U-shaped; fertilization ducts short, mesally oriented (Fig. 2G).

Variation

Five males and two females have been measured. Total length varies from 1.41 to 1.52 in males and from 2.03 to 2.34 in females. The carapace ranges in length from 0.78 to 0.80 in males and from 0.81 to 0.84 in females; in width from 0.68 to 0.72 in males and from 0.69 to 0.70 in females.

Distribution

Known only from Jilin Province, China (Fig. 11).

Nematogmus longior sp. n.

(Figs. 3, 4 and 11)

Etymology

The specific epithet (Latin: longior = longer) refers to the protegulum and embolus being longer than in the similar species, *N. sanguinolentus*. It is to be treated as a noun in apposition for the purposes of nomenclature.

Material examined

Holotype (IZCAS): male; Yushu Town (30.09°N, 101.93°E), Kangding County, Sichuan Province, China, 13 July 2004, leg. L. Tu, S. Li and Y. Song.

Paratypes (IZCAS): 1 male and 5 females; same data as holotype. 1 male, Sanhe Town (30.08°N, 101.95°E), Kangding County, Sichuan Province, China, 19 July 2004, leg. L. Tu, S. Li and Y. Song. 1 male; Yulong Mountain (27.20°N, 100.20°E), Lijiang Naxi Autonomous County, Yunnan Province, China, 21 July 2006, leg. Y. Song, Z. Cui and J. Xu. 17 females; Lashihai Plateau Wetland (27.17°N, 100.22°E), Lijiang Naxi Autonomous County, Yunnan Province, China, 19 July 2006, leg. Y. Song, Z. Cui and J. Xu.

Diagnosis

Nematogmus longior and *N. sanguinolentus* share a number of characters, including the same somatic appearance and similar genital structures, but differ in details. Males of the two species can be distinguished by the following features: (1) the two retrolateral teeth on the male palp are widely separated and can be clearly seen from retrolateral in *N. longior* (Fig. 3F), whereas in *N. sanguinolentus* the teeth are much closer to each other and the smaller one is covered by the larger one and invisible from retrolateral (Fig. 9F); (2) proximal end of cymbium pointed in *N. longior* (Figs. 3C and F), blunt in *N. sanguinolentus* (Fig. 9F); (3) conspicuous outwardly curved cymbial apophysis (Figs. 3C and 9D) slightly shorter in *N. longior*; (4) protegulum rather long in *N. longior* (Fig. 3F), shorter and thicker in *N. sanguinolentus* (Fig. 9F); (5) slightly sclerotized embolic membrane slightly curved upwards and nearly three times longer than wide in *N. longior* (Figs. 3D and 4D), only two times longer than wide in *N. sanguinolentus* (Fig. 10E); and (6) embolus nearly nine times longer than its tailpiece in *N. longior* (Fig. 4A), only six times in *N. sanguinolentus* (Fig. 10E). Females can be distinguished further by: (7) the presence of one deep depression in the low middle of the ventral plate in *N. longior* (Fig. 4G), versus two shallow depressions in *N. sanguinolentus* (Fig. 10D); (8) the width of the fusion region between dorsal plate and ventral plate being nearly one-third the width of the dorsal plate in *N. longior* (Fig. 4C), whereas that width ratio equals one-fifth in *N. sanguinolentus* (Fig. 10C); and (9) the copulatory duct having two coils in anterior direction in *N. longior* (Fig. 4B), but only one in *N. sanguinolentus* (Fig. 10B).

Description

Male (holotype). Total length 1.92. Carapace 0.94 long, 0.82 wide, lemon yellow, bearing a shallow cephalic lobe and cephalic pits within the post-ocular sulci (Fig. 3A). Abdomen light orange in middle, becoming deep orange towards posterior margin. Clypeus 0.37 high. AME diameter 0.03, ALE 0.06, PME 0.04, PLE 0.07, AME interdistance 2.00 times their diameter, AME–ALE interdistance 1.42 times ALE diameter, PME interdistance 1.21 times their diameter, PME–PLE interdistance 1.50 times PLE diameter. Sternum 0.51 long, 0.57 wide. Coxa IV interdistance 1.27 times their width. Chelicerae with 5 promarginal and 4 retromarginal teeth. Legs lemon yellow proximally, gradually changing to gray yellow distally. Tibia I 9.93 times longer than deep. Tm I 0.35, Tm IV absent. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 3.51 (0.96, 0.26, 0.87, 0.83, 0.59); II: 3.33 (0.96, 0.26, 0.78, 0.76, 0.57); III: 2.66 (0.78, 0.26, 0.58, 0.60, 0.44); IV: 3.20 (0.97, 0.24, 0.79, 0.74, 0.46).

Palp: tibia short, widened distally, with one rectangular retrolateral apophysis, two strong retrolateral teeth, as well as one retrolateral and one prolateral trichobothrium (Fig. 3B). Paracymbium duck-shaped (Fig. 3F). Cymbium of peculiar shape, with a conspicuous outwardly curved apophysis; dorsal side of cymbium with a row of minute warts, each bearing a seta (Fig. 3F). Tegulum mesal to subtegulum in unexpanded palp, with a thumb-shaped ventral apophysis (Fig. 3E). Protegulum ribbonlike, accommodating one proximal section of embolus (Fig. 3E). Column cone-shaped in ventral view (Fig. 3D). Tailpiece

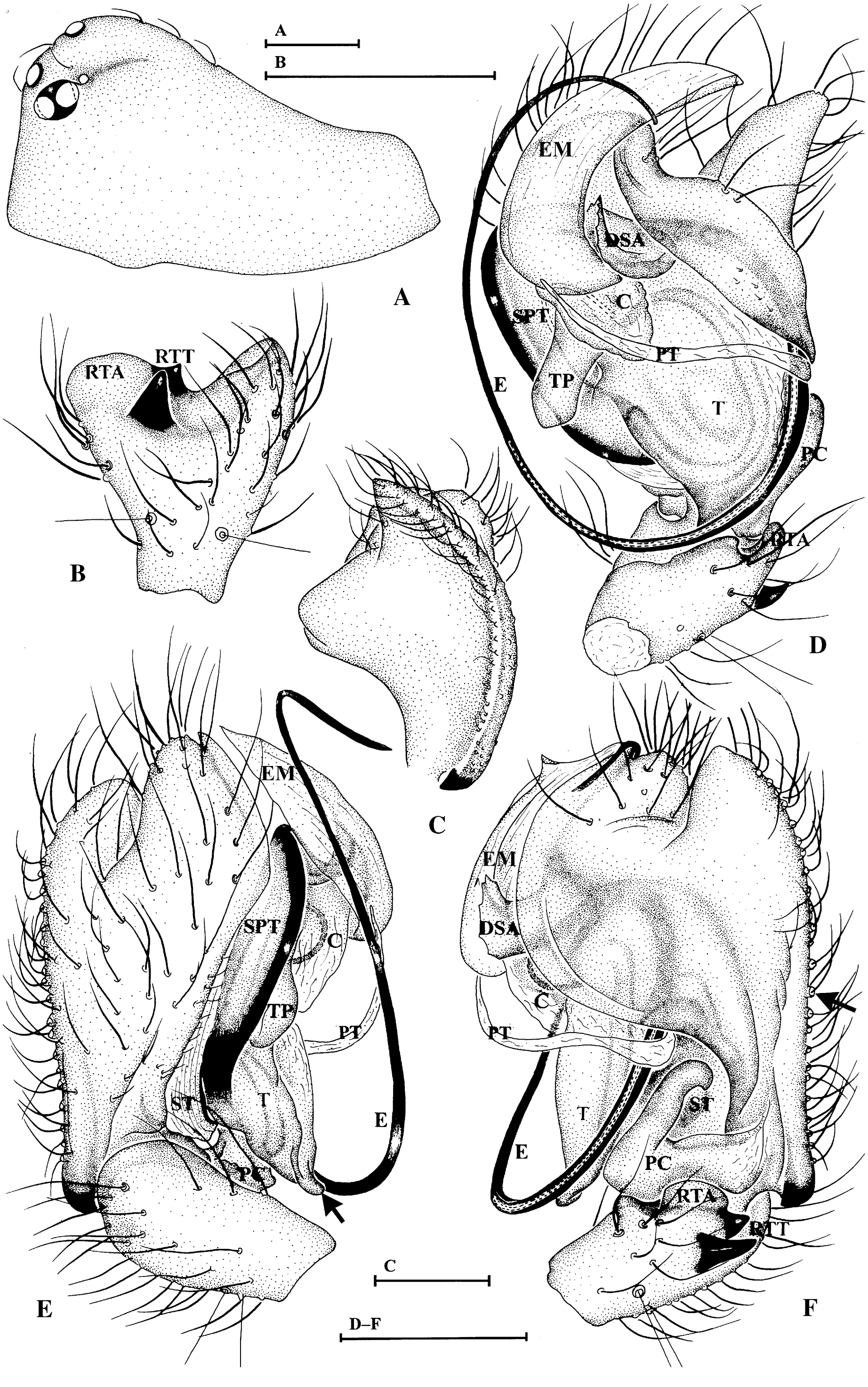

Fig. 3. (A–F) *Nematogmus longior* sp. n. (A) Male carapace, lateral view. (B) Tibia of male left palp, dorsal view. (C) Cymbium, dorsolateral view. (D) Left male palp, ventral view. (E) Left male palp, prolateral view (arrow points to a thumb-shaped ventral apophysis). (F) Left male palp, retrolateral view (arrow points to minute warts on dorsal side of cymbium). Scale bars: 0.2 mm. For abbreviations of morphological structures, see text.

of radix nearly straight, with a pointed end (Fig. 4D). Distal suprategular apophysis (Figs. 3D and F) with indented outer margin, arranged closely to base of slightly sclerotized embolic membrane (Fig. 4D), which has a triangular lamina extending upright. Embolus long, coiled.

Female (paratype). Total length 2.28. Carapace 0.86 long, 0.85 wide, light orange, without any cephalic lobe

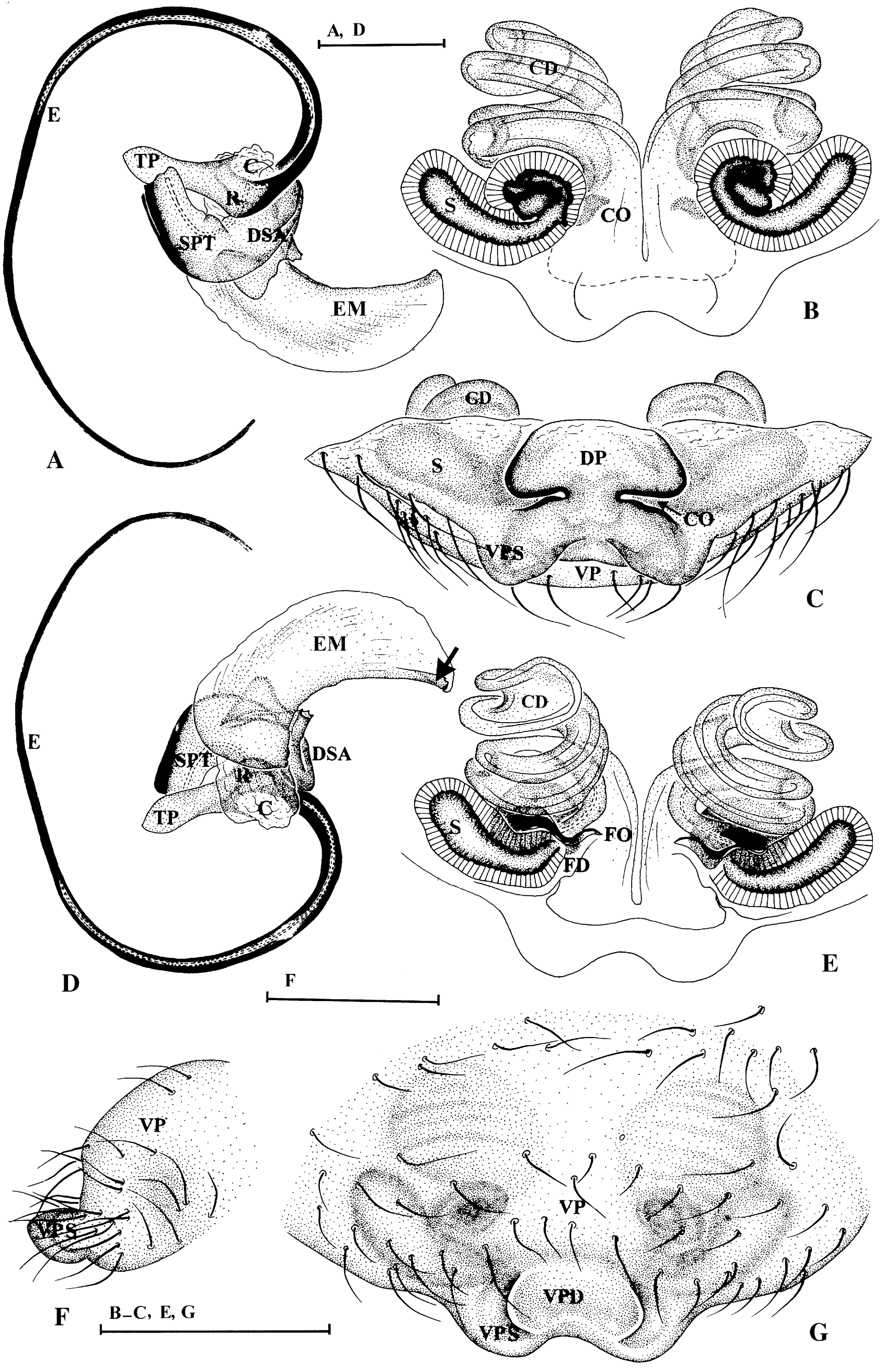

Fig. 4. (A–G) *Nematogmus longior* sp. n. (A) Embolic division (with DSA), dorsal view. (B) Vulva, ventral view. (C) Epigynum, posterior view. (D) Embolic division (with DSA; arrow points to a mini lamina extended upright), ventral view. (E) Vulva, dorsal view. (F) Epigynum, lateral view. (G) Epigynum, ventral view. Scale bars: 0.2 mm. For abbreviations of morphological structures, see text.

and pits. Abdomen coloration similar to male. Clypeus 0.41 high. AME diameter 0.05, ALE 0.07, PME 0.06, PLE 0.07, AME interdistance 0.60 times their diameter, AME–ALE interdistance 0.83 times ALE diameter, PME interdistance 0.84 times their diameter, PME–PLE interdistance 0.95 times PLE diameter. Sternum 0.51 long, 0.59 wide. Coxa IV interdistance 1.41 times their width. Chelicerae with 6 promarginal and 5 retromarginal teeth. Legs light orange proximally, gradually changing to tan distally. Tibia of leg I 10.64 times longer than deep. TmI 0.42, Tm IV absent. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 3.80 (1.08, 0.28, 0.93, 0.89, 0.61); II: 3.56 (1.03, 0.28, 0.82, 0.83, 0.59); III: 2.74 (0.81, 0.25, 0.59, 0.64, 0.45); IV: 3.46 (1.10, 0.26, 0.82, 0.79, 0.49).

There is a deep depression bounded posteriorly and laterally by a thicker lip-like structure (Fig. 4G). Ventral plate with a short scape (Fig. 4F). Dorsal plate trapezoidal, fused with ventral plate in posterior view (Fig. 4C). Copulatory ducts (Figs. 4B and E) similar to those in *N. membranifer*, but with two coils in *N. longior* instead of one and a half. Spermathecae U-shaped. Fertilization ducts short, mesally oriented (Fig. 4E).

Variation

Four males and 22 females have been measured. Total length varies from 1.91 to 2.00 in males and from 2.03 to 2.34 in females. The carapace ranges in length from 0.94 to 0.97 in males and from 0.81 to 0.84 in females; in width from 0.81 to 0.83 in males and from 0.69 to 0.70 in females.

Distribution

Known only from Sichuan and Yunnan Provinces, China (Fig. 11).

Habitat

The species occurs near the grass roots in marshes or in mountains at high altitudes.

Nematogmus membranifer sp. n.

(Figs. 5–8 and 11)

Etymology

The specific epithet (Latin: membranifer = carrying a membrane) refers to the narrow membrane along the inner margin of the long, curled embolus. It is to be treated as a noun in apposition for the purposes of nomenclature.

Material examined

Holotype (IZCAS): male; Fucai Village (28.00°N, 98.52°E), Bingzhongluo Town, Gongshan County, Yunnan Province, China, 23 August 2006, leg. Jeremy A. Miller.

Paratype (IZCAS): 1 female; same data as holotype.

Diagnosis

The male can be easily distinguished from all other *Nematogmus* species by the presence of a patch of short, densely distributed hairs in the middle of the cephalic lobe (Fig. 5A); the slightly sclerotized embolic membrane with anterior and retrolateral margins extended upright forming a semiclosure structure (Figs. 5D–F); and the presence of a membrane along the inner margin of the proximal half of the embolus (Fig. 5F). The female can be distinguished from *N. dentimanus*, *N. nigripes*, *N. longior* and *N. sanguinolentus* by the absence of a ventral plate scape; from *N. digitatus* and *N. nigripes* by the presence of two copulatory duct coils (Figs. 6A and B); and from *N. stylitus* by the dorsal plate being completely hidden in ventral view (Fig. 6G).

Description

Male (holotype). Total length 2.48. Carapace 1.17 long, 1.09 wide, clear orange, bearing a large cephalic lobe and cephalic pits within the post-ocular sulci, as well as a patch of short, densely distributed hairs in the center of the cephalic lobe (Fig. 5A). Abdomen grayish white in middle, darker towards outer margin. Clypeus 0.38 high. AME diameter 0.07, ALE 0.07, PME 0.06, PLE 0.07, AME interdistance 0.45 times their diameter, AME–ALE interdistance 1.45 times ALE diameter, PME interdistance 1.45 times their diameter, PME–PLE interdistance 1.18 times PLE diameter. Sternum 0.68 long, 0.68 wide. Coxa IV interdistance 1.41 times their width. Chelicerae with 4 promarginal and 4 retromarginal teeth (Fig. 6C). Proximal two-thirds of femur segments clear orange, gradually changing to pitch-black distally. Tibia of leg I 7.47 times longer than deep. Tm I 0.24, Tm IV present. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 6.66 (1.88, 0.34, 1.75, 1.70, 0.98); II: 6.20 (1.72, 0.34, 1.58, 1.59, 0.97); III: 4.53 (1.33, 0.34, 1.08, 1.13, 0.66); IV: 5.70 (1.45, 0.34, 1.64, 1.48, 0.78).

Palp: tibia short, somewhat cylindrical, with one triangular retrolateral apophysis, one small, strongly curved retrolateral tooth and one retrolateral trichobothrium (Fig. 5B). Paracymbium with the ventral part extended upwards forming a triangular lamina, basal arm upheaved (Fig. 5C). Cymbium (Fig. 5F) of peculiar shape, with a cone-shaped tubercle on the dorsal side, shorter than those in *N. sanguinolentus* and *N. longior* but longer than in *N. digitatus*; dorsal side of proximal half of cymbium with evenly curved ridge. Protegulum elongated with nearly parallel margins (Fig. 5F). Tegulum mesal to subtegulum in unexpanded palp, with a highly sclerotized and rather complicated ventral structure, through which the sperm duct runs (Figs. 5E and F). Tailpiece of radix foot-shaped (Figs. 5D and E). Distal suprategular apophysis broad, with several parallel folds (Fig. 5D). Embolic membrane slightly sclerotized, swollen near the connection of column, radix and distal suprategular apophysis. Embolus long, coiled, with narrow membrane along inner margin of proximal half of embolus (Fig. 5F).

Female (paratype). Total length 2.98. Carapace 1.30 long, 1.17 wide, bright reddish-orange, without cephalic lobe and pits. Clypeus 0.29 high. Abdomen grayish white in middle, darker towards outer margin. AME

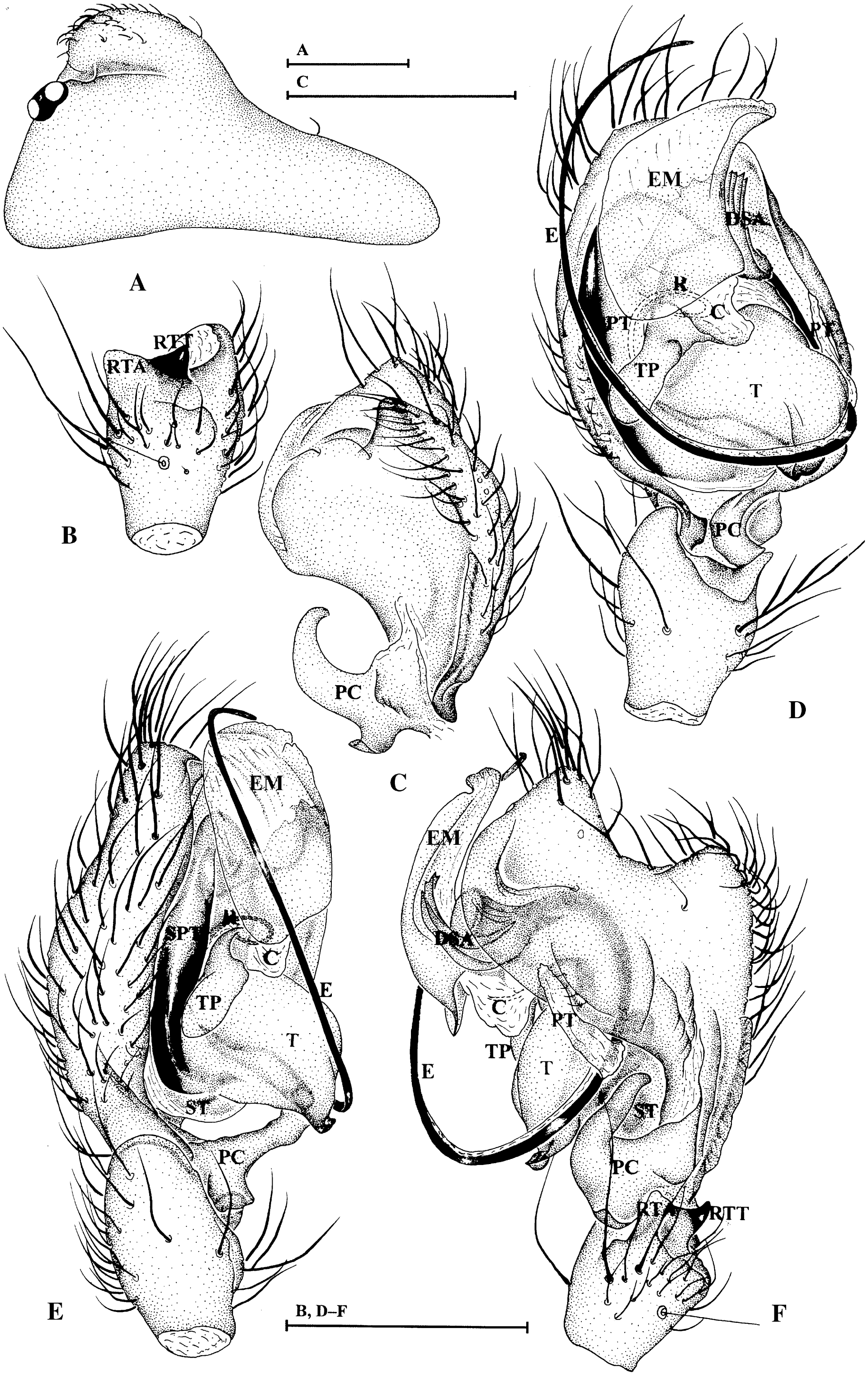

Fig. 5. (A–F) *Nematogmus membranifer* sp. n. (A) Male carapace, lateral view. (B) Tibia of male left palp, dorsal view. (C) Cymbium and paracymbium, dorsolateral view. (D) Left male palp, ventral view. (E) Left male palp, prolateral view. (F) Left male palp, retrolateral view. Scale bars: 0.3 mm. For abbreviations of morphological structures, see text.

diameter 0.07, ALE 0.08, PME 0.07, PLE 0.07, AME interdistance 0.30 times their diameter, AME–ALE interdistance 1.28 times ALE diameter, PME interdistance 1.48 times their diameter, PME–PLE interdistance 1.52 times PLE diameter. Sternum 0.72 long, 0.80 wide. Coxa IV interdistance 1.36 times their width. Chelicerae with 5 promarginal and 5 retromarginal teeth (Fig. 6E). Proximal two-thirds of femur

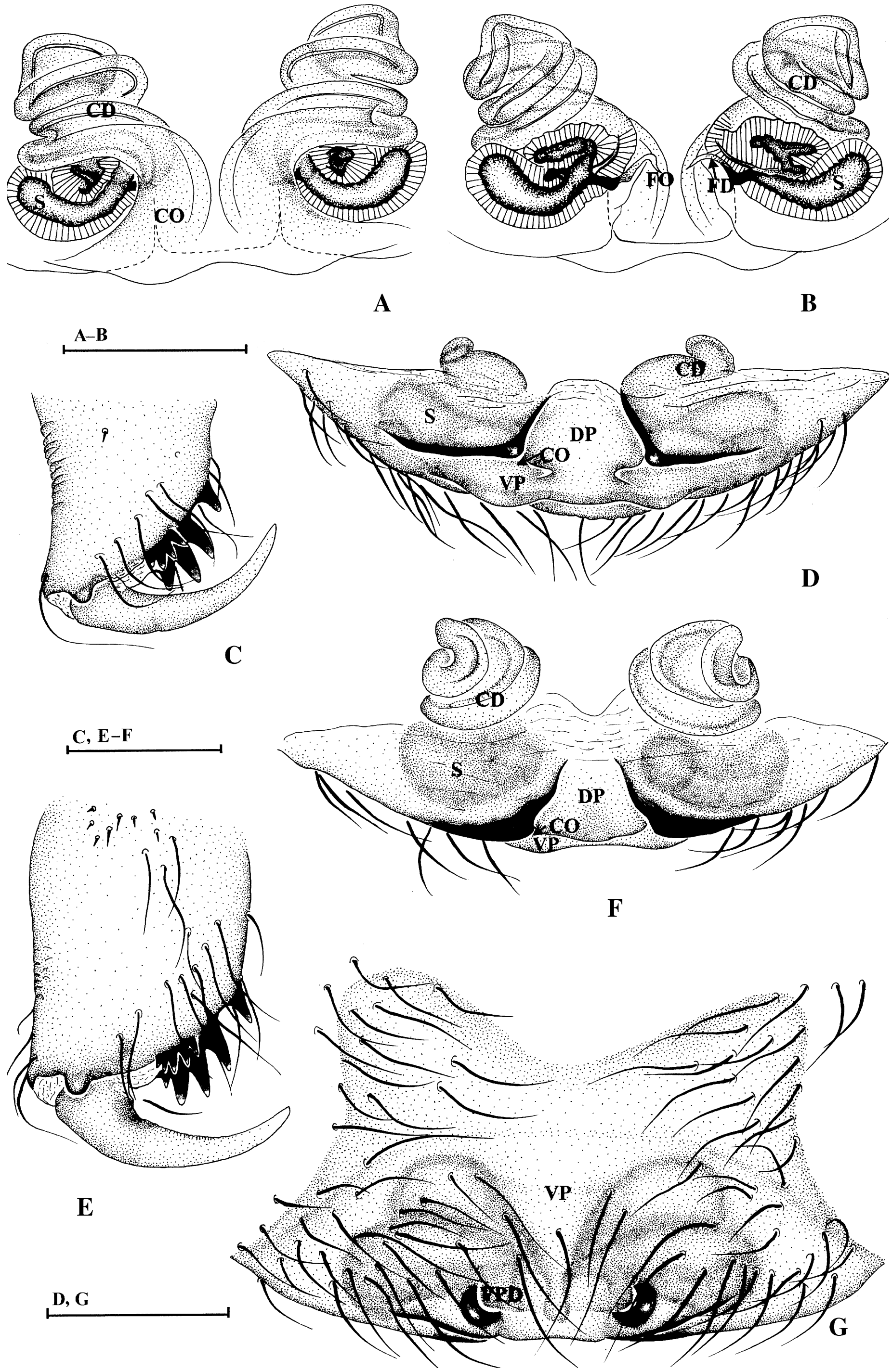

Fig. 6. (A–G) *Nematogmus membranifer* sp. n. (A) Vulva, ventral view. (B) Vulva, dorsal view. (C) Male left chelicera, posterior view. (D) Epigynum, posterior view. (E) Female left chelicera, posterior view. (F) Epigynum, dorsal view. (G) Epigynum, ventral view. Scale bars: 0.2 mm. For abbreviations of morphological structures, see text.

segments bright reddish-orange, gradually changing to pitch-black distally. Tibia of leg I 4.95 times longer than deep. Tm I 0.27, Tm IV present. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 6.05 (1.80, 0.41, 1.55, 1.44, 0.86); II: 5.75 (1.73, 0.39, 1.48, 1.33, 0.81); III: 4.50 (1.39, 0.39, 1.05, 1.02, 0.66); IV: 5.36 (1.72, 0.41, 1.34, 1.19, 0.70).

Ventral plate with two small shallow semirounded depressions, posterior margin nearly straight in ventral view (Fig. 6G), hardly protruding from ventral surface in lateral view, and fused with dorsal plate forming a narrow 'bridge', which measures nearly one-half of dorsal plate width (Fig. 6D). Dorsal plate small, trapezoidal (Fig. 6F). Copulatory ducts running along outer margins of encapsulated double helix, which narrows from a broad base, showing one and a half coils in anterior direction, clockwise through one helix, reversing direction at the distal end, and running posteriorly through the second helix, still in clockwise direction (Figs. 6A and B). Spermathecae distinctly U-shaped; one arm long and oblong, the other small and almost globular (Fig. 6B). Fertilization ducts short, mesally oriented (Fig. 6B).

Distribution

Known only from Yunnan Province, China (Fig. 11).

Habitat

These spiders occur in a forest at an altitude of 2800 m, preferring to build sheet webs under rocky outcrops covered with thick moss (Figs. 7 and 8).

Fig. 8. Sheet web of *Nematogmus membranifer* sp. n., viewed from above (photo: Jeremy A. Miller). Scale bar: 1.5 cm.

Nematogmus sanguinolentus (Walckenaer, 1842)

(Figs. 9–11)

Theridion sanguinolentum (Walckenaer) – Walckenaer (1842, p. 326).

Nematogmus sanguinolentus Simon – Simon (1884, p. 615, figs. 431 and 432).

Material examined

Six females and 1 male (JLU); Jinshan Forestland (51.78°N, 126.35°E), Huma County, Heilongjiang Province, China, 22 June 1990. Two males (JLU); no detailed data. Fifteen females and 4 males (JLU); Dajiuhu Basin and Panshui Village, Shennongjia Forest Region (31.72°N, 110.75°E), Hubei Province, China, 4–8 August 1986. One female and 1 male (IZCAS); Hachioji (35.71°N, 139.25°E), Tokyo, Japan, 29 May 2004, leg. Andoh Akihisa.

Fig. 7. Adult female of *Nematogmus membranifer* sp. n. (photo: Jeremy A. Miller).

Diagnosis

See diagnosis of *N. longior* sp. n.

Description

Male. Total length 1.69. Carapace 0.78 long, 0.69 wide, bearing a shallow lobe and cephalic pits within the post-ocular sulci (Fig. 9A). Abdomen grayish. Clypeus 0.28 high. AME diameter 0.04, ALE 0.07, PME 0.06, PLE 0.07, AME interdistance 0.92 times their diameter, AME–ALE interdistance 0.67 times ALE diameter, PME interdistance 0.60 times their diameter, PME–PLE interdistance 0.81 times PLE diameter. Sternum 0.44 long, 0.48 wide. Coxa IV interdistance 1.23 times their width. Chelicerae with 4 promarginal and 4 retromarginal teeth. Tibia of leg I 14.27 times longer than deep. Tm I 0.33, Tm IV absent. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 3.78 (0.98, 0.24, 0.98, 1.02, 0.57); II: 3.39 (0.91, 0.23, 0.83, 0.91, 0.51); III: 2.56 (0.74, 0.21, 0.56, 0.66, 0.38); IV: 3.18 (0.93, 0.21, 0.78, 0.84, 0.42).

Palp: tibia short, widened distally, with one retrolateral and one prolateral trichobothrium; with a semirounded retrolateral apophysis and two closely arranged retrolateral teeth (Fig. 9B). Paracymbium duck-shaped (Fig. 9F). Cymbium with a horn-shaped apophysis and a longitudinal ridge bearing numerous

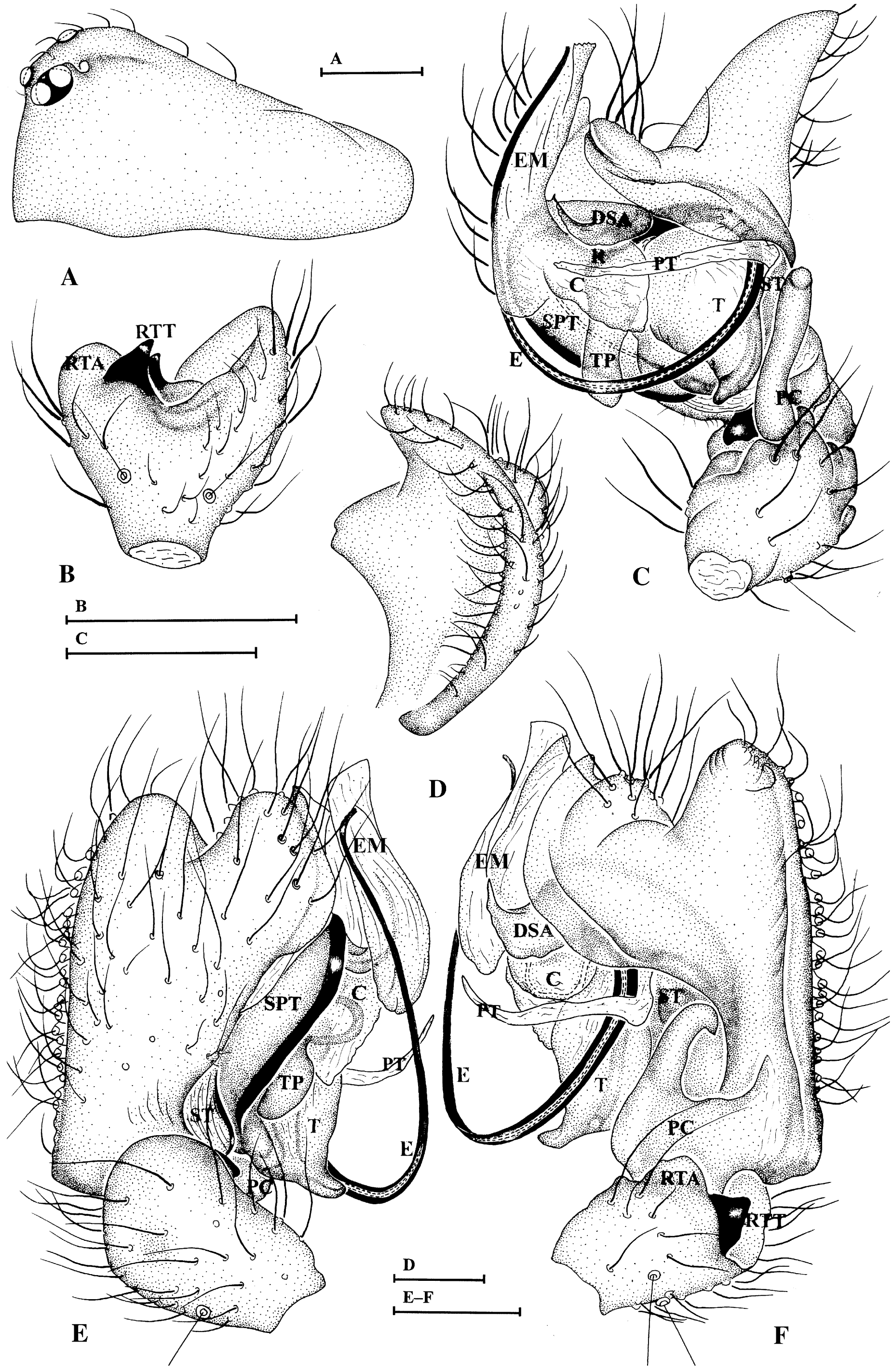

Fig. 9. (A–F) *Nematogmus sanguinolentus*. (A) Male carapace, lateral view. (B) Tibia of male left palp, dorsal view. (C) Male left palp, ventral view. (D) Cymbium, dorsolateral view. (E) Male left palp, prolateral view. (F) Male left palp, retrolateral view. Scale bars: 0.2 mm. For abbreviations of morphological structures, see text.

warts, each carrying a seta (Figs. 9E and F). Tegulum mesal to subtegulum in unexpanded palp, with a thumb-shaped ventral apophysis (Figs. 9C–F). Protegulum comparatively long, slightly twisted, tapering, nearly perpendicular to long, coiled embolus (Fig. 9F).

Female. Total length 1.88. Carapace 0.68 long, 0.69 wide. Clypeus 0.29 high. Abdomen grayish. AME diameter 0.04, ALE 0.06, PME 0.06, PLE 0.06, AME interdistance 0.64 times their diameter, AME–ALE interdistance 0.65 times ALE diameter, PME interdistance 1.82 times their diameter, PME–PLE interdistance 0.80 times PLE diameter. Sternum 0.48 long, 0.52 wide. Coxa IV interdistance 0.88 times their width. Chelicerae with 5 promarginal and 4 retromarginal teeth. Tibia of leg I 13.73 times longer than deep. Tm I 0.37, Tm IV absent. Dorsal spine in tibia of leg IV: 1-1-1-1; dorsal spine in patella of leg IV: 1-1-1-1. Leg measurements: I: 3.73 (1.04, 0.24, 0.94, 0.91, 0.58); II: 3.49 (1.06, 0.24, 0.83, 0.83, 0.53); III: 2.68 (0.83, 0.23, 0.58, 0.64, 0.41); IV: 3.46 (1.09, 0.24, 0.88, 0.80, 0.45).

Ventral plate with two shallow depressions in ventral view (Fig. 10D) and a comparatively long scape in lateral view (Fig. 10G). Dorsal plate trapezoidal (Fig. 10F), fused with ventral plate forming a narrow 'bridge', which measures one-fifth of dorsal plate width (Fig. 10C). Copulatory ducts similar to those of

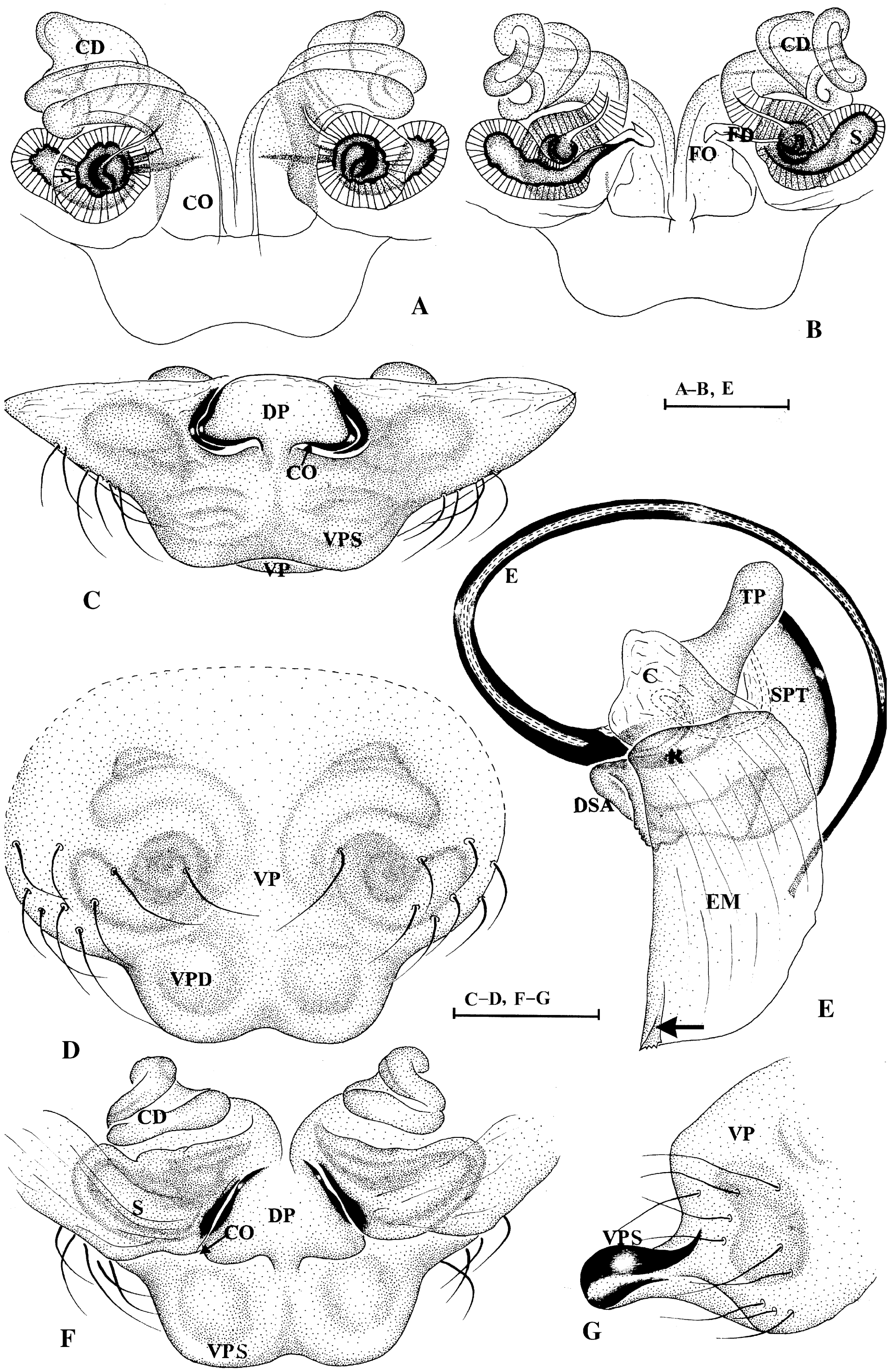

Fig. 10. (A–G) *Nematogmus sanguinolentus*. (A) Vulva, ventral view. (B) Vulva, dorsal view. (C) Epigynum, posterior view. (D) Epigynum, ventral view. (E) Embolic division (with DSA; arrow points to a mini lamina erected upwards), ventral view. (F) Epigynum, dorsal view. (G) Epigynum, lateral view. Scale bars: 0.1 mm. For abbreviations of morphological structures, see text.

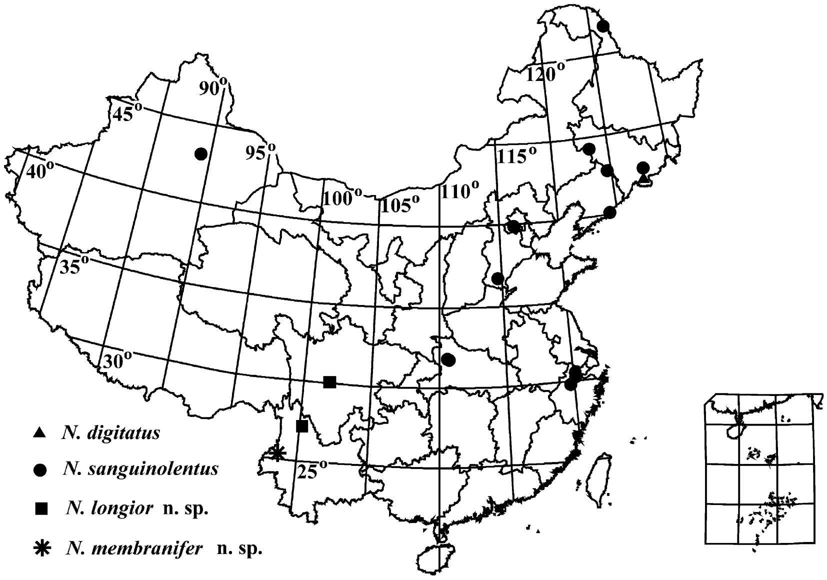

Fig. 11. Recorded distributions of four *Nematogmus* species in China.

N. digitatus, but shorter and thicker at the beginning (Figs. 2G and 10A). Spermathecae somewhat U-shaped, with short globular arms totally overlapping with long, oblong arms (Figs. 10A and B). Fertilization ducts short, mesally oriented (Fig. 10B).

Variation

Five males and 20 females have been measured. Total length varies from 1.67 to 1.72 in males and from 1.81 to 2.13 in females. The carapace varies in length from 0.77 to 0.80 in males and from 0.63 to 0.72 in females; in width from 0.69 to 0.71 in males and from 0.66 to 0.75 in females. Coloration of carapace varies from lemon yellow to bright reddish-orange. Legs vary from lemon yellow to bright reddish-orange proximally, gradually changing to dark greenish distally.

Distribution

Palaearctic (Platnick 2008). In China, the species has been recorded from Beijing, Jilin, Hebei, Heilongjiang, Hubei, Liaoning, Xinjiang, and Zhejiang Provinces (Hu and Wu 1989; Chen and Zhang 1991; Song et al. 1999) (Fig. 11).

Habitat

This species occurs in grass or under leaves on the ground in marshes. It becomes sexually mature in late July and early August, and probably overwinters as adults (Oi 1960).

Acknowledgments

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MYSMENID SPIDERS OF CHINA (ARANEAE: MYSMENIDAE)

YUCHENG LIN and SHUQIANG LI*

Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P.R. China
**Corresponding author: e-mail: lisq@ioz.ac.cn*

Abstract.— Eleven new species of the family Mysmenidae occurring in China, in addition to one known species, *Mysmenella gongi* Yin, Peng et Bao, 2004, that was reported from Hunan Province, are diagnosed, described and illustrated. Three genera, i.e., *Calodipoena*, *Mysmena*, and *Trogloneta*, are firstly reported in China. *Mysmenella pseudojobi* **sp. nov.**, where is found hitherto at the northest range of distribution of the family in China, and *Trogloneta denticocleari* **sp. nov.** is collected in caves. *Mysmena spirala* **sp. nov.** is collected from rainforest in Hainan Province. *Calodipoena biangulata* **sp. nov.**, *C. cornigera* **sp. nov.**, *Mysmena zhengi* **sp. nov.**, *M. rostella* **sp. nov.**, *M. furca* **sp. nov.**, *M. arcilongus* **sp. nov.**, *Mysmenella menglunensis* **sp. nov.** and *Trogloneta speciosum* **sp. nov.**, from Xishuangbanna in Yunnan Province, are collected by fogging. Natural history and distributional map are provided.

⁂

Key words.— Taxonomy, new species, natural history, cave, rainforest.

INTRODUCTION

Mysmenids are small in size (usually total length 0.4–2.0 mm), lungless, web-spinning entelegyne spiders. The family Mysmenidae was first described as a group Mysmeneae within Theridiidae (Simon 1922). Petrunkevitch (1928) combined Simon's Mysmeneae and Theonoeae into subfamily Mysmeninae, which was transferred to Symphytoganathidae by Gertsch (1960). The subfamily was warranted to family rank by Forster and Platnick (1977) according the following synapomorphies: the presence of clasping spurs on male metatarsus I (sometimes on tibia I as well as), the presence of lobes or apophyses on male cymbium, the presence of ventral and subdistal slcerotized spot on female femur I and the presence of cheliceral denticles in both male and female.

According to the spider catalog of Platnick (2008), the family Mysmenidae includes 22 genera and 92 species, including one species, *Mysmenalla gongi,* reported from Hunan Province in China (Yin *et al.*, 2004). *Achaearanea extumida* Xing, Gao et Zhu, 1994 placed currently in the family Theridiidae (Xing *et al.* 1994), could also be a mysmenid judging by the original description, but further decisions will be difficult due to the lost of types. However, our recent survey revealed that mysmenids are far more diverse than expected. Most reason for the ignorance of their diversity might due to their small size and difficulties to collect them because mysmenids usually occur in cryptic microhabitats such as leaf litter, humid moss and caves.

Twelve mysmenid species of China are reported in the current paper, including one known species and eleven new species. Among those, eight mysmenid species were collected using fogging technique in tropical rainforest at Xishuangbanna, Yunnan Province. This fact indicates that the tropic rainforest has outstanding spider diversity and the insecticide fogging is an effective method in collecting subminiature spiders. The rest species were collected from Hainan Island (*Mysmena spirala* sp. nov.), caves of Yunnan-Guizhou Plateau (*Trogloneta denticoclearis* sp. nov.), and a cave near Beijing (*Mysmenella pseudojobi* sp. nov.).

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MATERIALS AND METHODS

Specimens were examined and measured under an SZX12-Olympus stereomicroscope. Further details were studied under an Olympus BX51 compound microscope. All drawings were made using a drawing tube that attached to Olympus BX51 compound microscope, and then inked on ink jet plotter paper. Male palpi and female epigyna were examined and illustrated after they were dissected and detached from the spiders' bodies. Vulvae were removed and treated in KOH solution or lactic acid before illustration. To reveal the course of the ejaculatory duct, embolus or embolic divisions were also treated in lactic acid and mounted in Hoyer's Solution. All left palpi of male spiders were illustrated, in the case of missing left palp, right palpi were illustrated. All type specimens are preserved in 85% ethanol solution.

The localities and distribution data of each species are given according to current Chinese standard (see Peng *et al*. 2003). All measurements are in millimeters. Leg measurements are given in the following sequence: total length (femur, patella, tibia, metatarsus, tarsus). We mostly follow Baert's terminology (1982, 1984a, b, and 1988, 1990) in describing morphology and genital structures. The abbreviations used in text and figures including:

AER – anterior eye row;
ALE – anterior lateral eye;
AME – anterior median eye;
AME–ALE – interval between AME and ALE;
AME–AME – interval between AMEs;
MOQ – median ocular quadrangle;
MOQL – MOQ length;
MOQW – MOQ width;
PER – posterior eye row;
PLE – posterior lateral eye;
PME – posterior median eye;
PME–PLE – interval between PME to PLE;
PME–PME – interval between PMEs.

Type specimens used in the current study are deposited in the:

IZCAS – Institute of Zoology, Chinese Academy of Sciences in Beijing;
HNU – College of Life Science, Hunan Normal University in Changsha.

Photos of the type specimens can be viewed from website http://www.ChineseSpecies.com which was created and maintained by Shuqiang Li and Xinping Wang (2008).

TAXONOMY

Mysmena Simon, 1894

Mysmena spirala sp. nov.
(Figs 1A–D, 2A–I, 20)

Diagnosis. This new species is similar to *Mysmena gibbosa* Snazell, 1986, but can be distinguished by the following distinct characters: the long helical, tube-shaped conductor in male palp and the strongly coiled copulatory ducts which link up between spermathecae and membranous sacs by rugose chalazae in female vulva.

Description. Male. Total length: 0.71.

Carapace. Length 0.38, width 0.37. Dorsally near round, with straight anterior margin. Dark brown, with black hairs on anterior margin of clypeus. Cephalic area abruptly raised and sharply vertical down forward.

Eyes. Ocular area black. Eight eyes in two rows. In dorsal view, AER recurved more than PER; ALE and PLE contiguous. All eyes nearly round; AME 0.04 same size as PME 0.04; ALE 0.06 two times diameter of PLE 0.03. AME–ALE 0.02 closer together than AME–AME 0.03; PME–PLE 0.04 wider separated than PME–PME 0.03; MOQ square, MOQL 0.09 equal to MOQW 0.09. AME and ALE surrounded by dim ring.

Clypeus. Height 0.20, 5 times AME diameter; ALE separated by about 4 times its diameter from anterolateral edge of carapace.

Chelicerae. Darkish yellow, shorter than endites. Cheliceral groove with 7 promarginal teeth and retromarginal tiny denticles, 4 plumose hairs near fang furrow.

Labium. Yellow, fused to sternum.

Endites. Yellow, rhombus-shaped, longer than wide, with serrula.

Sternum. Length 0.24, width 0.22. Dusky yellow and heart-shaped, with a pair of glum spots in median.

Legs. Formula: I, II, IV, III. Ashen dark, with black annular splash in each distal segment. Leg measurements: I: 1.16 (0.36 + 0.16 + 0.26 + 0.18 + 0.21); II: 0.99 (0.30 + 0.14 + 0.20 + 0.14 + 0.20); III: 0.72 (0.22 + 0.10 + 0.12 + 0.11 + 0.17); IV: 0.86 (0.27 + 0.10 + 0.18 + 0.13 + 0.18). Distally and ventrally sclerotized spot absent; metatarsus I with a long bended, medially situated clasping spur. Each patella with a distally dorsal spine; tibiae I–IV with 1 proximally dorsal spine and 3 trichobothria.

Abdomen. Length 0.39, width 0.39. Almost rounded, black, with 4 pair of spots on abdominal dorsum; 3 pair of conjoint white pigment strips circled abdominal bilateral surface; venter thinner color than dorsum. Spinnerets ashen; the anterior slightly larger than the posterior. Anal tubercle indistinct.

Male palp. Palp bulb relatively large, light brown. Femur without modification. Patella short, with a few

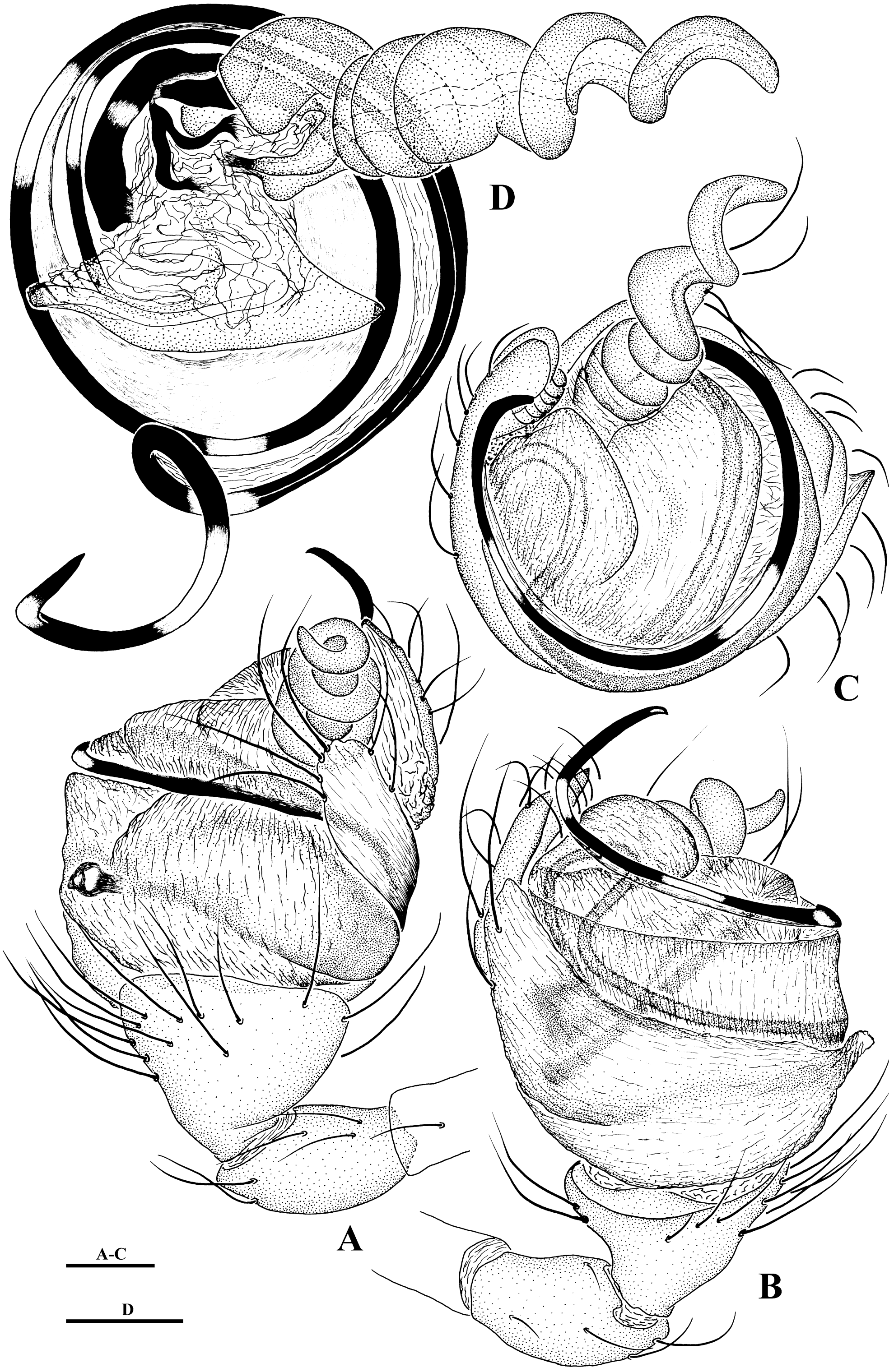

Figure 1. *Mysmena spirala* sp. nov., holotype (male). (A) Palp, prolateral; (B) ditto, retrolateral; (C) ditto, apical; (D) conductor and embolic division, ventral. Scale bars: 0.05.

hairs. Tibia cup-shaped, without apophysis, with a row of long hairs along the distal margin. Cymbium wrinkled translucent membranous, which is divided by a furrow into two membranous flakes. Cymbial spur absent, but having a small membranous tuber. Distal cymbial margin bears several long hairs. A row of short setae extending outward, curved on the apical lobe, which might serve as protection of embolus apex. Basal haematodocha rugose, weakly slcerotized. Tegulum thin, membranous, internal ejaculation duct visible through wrinkled transparent sac. Conductor uniquely shaped, like a twist drill standing on apical palp. Embolus long, coiled with two loops under surrounding tegulum and extended to apex of palp.

Female. Total length: 0.92.

Carapace. Length 0.40, width 0.37. Same coloration and shape but without raised cephalic region as in male.

Eyes. Ocular area black. Array mode same as in male. AME 0.04 equal to ALE 0.04 but larger than PME 0.03 and PLE 0.03, AME–AME 0.02 same as PME–PME 0.02; AME–ALE 0.01 close together, PME–PLE 0.04 distinctly separated; MOQ square, with width same as length 0.09.

Clypeus. Height 0.10, equal to 2.50 times AME diameter. ALE separated by about 3 times AME diameter from anterolateral verge of carapace.

Chelicerae, labium and endites. Same as in male.

Sternum. Length 0.26, width 0.23. Shape and pattern like as in male.

Legs. Formula: I, II, IV, III. Coloration and pattern same as in male. Leg measurements: I: 1.31 (0.43 + 0.17 + 0.28 + 0.21 + 0.22); II: 1.10 (0.34 + 0.14 + 0.23 + 0.17 + 0.21); III: 0.79 (0.22 + 0.11 + 0.14 + 0.13 + 0.18); IV: 1.03 (0.33 + 0.12 + 0.21 + 0.17 + 0.20). One distal and ventral sclerotized spot on femora I and II (Fig. 17G); Spine and trichobothria on each leg as in male.

Abdomen. Length 0.58, width 0.57. Coloration and color pattern as in male.

Epigynum. Scape long finger-shaped, rugose and membranous, protruded posteriorly, with a tiny end but without sclerotized notch. Epigynal posterior area densely covered wtih hairs.

Vulva. Spermathecae round, strongly sclerotized. Copulatory ducts sclerotized and coiled into three loops under spermathecae. The proximal part of copulatory ducts connected with transparent glandulous, tissue. Rugose membranous chalazae through middle of helical copulatory ducts and joined in glandulous tissue.

Etymology. The specific name of this new species derived from Latin *spiralis* = spiral, refers to the presence of a spiral polar apophysis in male palpal bulb, and the spiral copulatory duct in female vulva.

Type material. Holotype male (IZCAS), Mt. Diaoluoshan National Nature Reserve (18.729°N, 109.864°E; at an elevation of 1010 meters above sea level), Hainan Province, China. 15 August, 2007. Paratypes: 2 females, same data as holotype; 1 male, 4 females, Huoshankou Park (19.927°N, 110.214°E; at an elevation of 222 meters above sea level), Shishan Town, Qiongshan District, Haikou City, Hainan Province, China. 21 August, 2007; 1 male, 4 females, Qulinggulin Gardens in Mt. Limushan Provincial Nature Reserve (19.178°N, 109.742°E; at an elevation of 655 meters above sea level), Qiongzhong County, Hainan Province, China. 12 August, 2007. All these types collected by Shuqiang Li and Chunxia Wang.

Variation. The total length ranges from 0.68 to 0.75 in males (n = 3) and from 0.87 to 1.14 in females (n = 10).

Natural history. This species was found under litter leaves below tropical rainforest.

Distribution. Known only from the type localities (Fig. 20).

Mysmena zhengi sp. nov.
(Figs 3A–E; 4A–H; 20)

Diagnosis. This new species is similar to *Mysmena leucoplagiata* (Simon, 1879), but can be distinguished from the latter by the absence of a cymbial spur but presence of an acuate prominence on cymbium, the short and thick embolus, the presence of a clasping spur on tibia I in male. Female epigynum of this new species has no extended finger-shaped scape but with a wider bulge, and the reniform spermathecae with small horn that embedded into rugose saccular tissue. There is a long hump on abdominal rearward in both sexes.

Description. Male. Total length: 1.06.

Carapace. Length 0.36, width 0.33. Dimmish brown, median fovea area lighter color. Dorsally ovoid, lateral viewed as nearly trigonal, marginally smooth. Cephalic region upheaved, sharply down forward and slowly sloping backward in lateral view. Several hairs forward along mesial line.

Eyes. Ocular area thicker brown. All eyes circular, each eye with tiny black ring. Eight eyes in two rows. At dorsal view, AER recurved and PER slightly procurved; ALE and PLE contiguous. AME 0.07 larger than ALE 0.05, but PLE 0.04 smaller than PME 0.06; AME–AME 0.03 same as PME–PME 0.03; AME–ALE 0.01 narrower than PME–PLE 0.04. ALE separated by about four times its diameter from the lateral margin of carapace.

Clypeus. Height 0.17, about equal to 2.40 times AME diameter. Slightly concave below AME.

Chelicerae. Dark-brown, length nearly equal to that of endites, cheliceral groove with 3 promarginal, 2 retromarginal teeth and tiny retromarginal denticles.

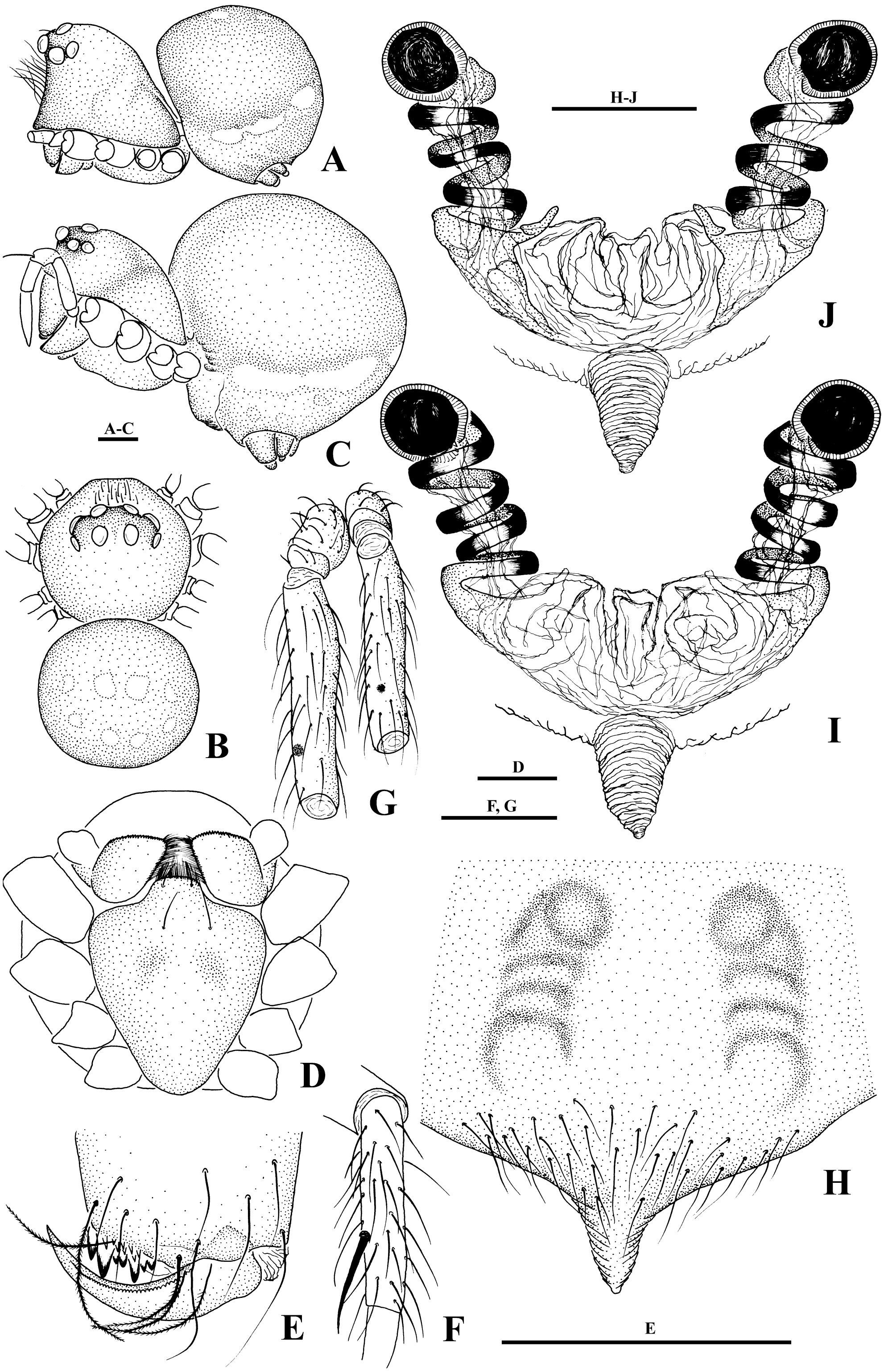

Figure 2. *Mysmena spirala* sp. nov. (A) Male body, lateral; (B) ditto, dorsal; (C) female body, lateral; (D) male sternum, labium, endites and coxae, ventral; (E) male chelicera, frontal; (F) male metatarsus I, prolateral; (G) female femurs I and II, ventral; (H) epigynum, ventral; (I) vulva cleared, ventral; (J) ditto, dorsal. Scale bars: 0.10.

Anterior surface without modification but bears several hairs. Posterior surface with 7 or 8 plumose hairs, thereinto, 4 along retromargin of fang furrow. Cheliceral fang short but sturdy.

Labium. Pale brown, short, fused to sternum.

Endites. Darkish, longer than wide, with serrula.

Sternum. Length 0.22, width 0.24. Cordiform, with some short hairs on surface, posterior corner blunt between coxae IV. Brown-yellow, a pair of dusky spots on posterolateral margin.

Legs. Formula: I, II, IV, III. Greyish, each section of legs with darkish pigment at the distal. Leg measurements: I 1.27 (0.41 + 0.16 + 0.29 + 0.16 + 0.24); II 1.06 (0.33 + 0.13 + 0.23 + 0.14 + 0.21); III 0.74 (0.22 + 0.11 + 0.13 + 0.11 + 0.17); IV 0.90 (0.28 + 0.12 + 0.19 + 0.13 + 0.18). One small but obviously sclerotized ventral spot on distally femur I. One prolateral distal clasping spur on tibia I and metatarsus I. Each patella with one distally dorsal spine. Tibiae I–IV with one proximally prolateral spine and three trichobothria. Metatarsi I–IV bearing one short trichobothrium.

Abdomen. Length 0.71, width 0.47. Dusky black with pale-grey irregular spots on dorsum; several white pigment spots on bilateral; with a long hump in rearward; venter color lighter than on dorsum. Spinnerets tiny and black.

Male palp. Brown, thin sclerotized, palpal bulb very large and similar to a globe, embedded partly in a translucent membranous cymbium. Tibia unmodified but with a row of setae along the distal margin. Paracymbium tiny and nearly invisible. Cymbium undeveloped, bearing a tuft of apical hairs which protected the end of embolus, long hairs along cymbial brim and a sharp membranous projection on cymbial retrolateral side. Embolus very long, strongly sclerotized, its end approached to the apex of cymbium through several curved and coiled loops under the tegulum which is a translucent membrane bursa of having radial furrow on surface. Basal haematodocha thick brown, smooth surface and distinctly sclerotized.

Female. Total length: 1.00.

Carapace. Length 0.33, width 0.24. Same coloration and modification but with a “Y”-shaped pale spot on thoracic median and cephalic area no upheaved as in male.

Eyes. Similar to that of male but AME smaller than in male. AME 0.04, ALE 0.04 and PME 0.04 same in size, larger slightly than PLE 0.03. AME–ALE 0.01 closer together than AME–AME 0.03; PME–PME 0.02 separated same as PME–PLE 0.02, equal to half of PME diameter.

Clypeus. Height 0.04, equated with diameter of AME; ALE departs a distance from lateral edge of carapace, but not as in male.

Chelicerae, labium and endites. As in male.

Sternum. Length 0.23, width 0.24. Grey-black and heart-shaped, centre lighter color than margin.

Legs. Formula: I, II, IV, III. Coloration same as in male. Leg measurements: I: 1.04 (0.33 + 0.14 + 0.22 + 0.14 + 0.20); II: 0.93 (0.29 + 0.12 + 0.20 + 0.13 + 0.19); III: 0.71 (0.22 + 0.10 + 0.12 + 0.11 + 0.16); IV: 0.86 (0.27 + 0.11 + 0.18 + 0.13 + 0.17). One distally ventral sclerotized spot on femora I and II (Fig. 13 E); of each section of legs spine and trichobothria as in male but without clasping spur.

Abdomen. Length 0.64, width 0.41. Coloration, pattern and shape as in male.

Epigynum. Scape absent, but posterior median slightly projected and mildly rugose. Epigynal area covered densely with hairs on mesially posterior margin.

Vulva. Spermatheca nearly ovoid and obviously sclerotized, with anterior prolateral short corner. Copulatory bursae lying over spermathecae, semitransparent and helical wrinkled in median. Copulatory ducts derived from the anterolateral of copulatory bursae, and hidden in sideward rugose membranous sac which enclose the spermathecae and copulatory bursae.

Etymology. The specific name is dedicated to the collector of the type specimens.

Type material. Holotype male (IZCAS): Primary tropical seasonal rainforest in Xishuangbanna Botanical Garden (21.917°N, 101.275°E; at an elevation of 558±17 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 22 July, 2007. Paratypes. 6 males, 6 females, same data as for the holotype; 1 male, Menglun Nature Reserve (21.957°N, 101.217°E; at an elevation of 744±15 meters above sea level), Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 30 July, 2007.

Natural history. This species is found in the canopy above tropical wildwood.

Distribution. Known only from the type localities (Fig. 20).

Mysmena rostella sp. nov.
(Figs 5A–I, 20)

Diagnosis. This new species is similar to *Mysmena taiwanica* Ono, 2006, but can be distinguished from the latter by: The presence of horn-shaped paracymbium, the presence of a small tuber near apex of cymbium, the peculiar embolus on apex of palpal bulb and the five strong setae on frontal chelicerae in male.

Description. Male. Total length: 0.52.

Carapace. Length 0.26, width 0.27. Yellow-brown, with dusky quadrate markings on mesial area, dorsally circular, lateral viewed as nearly trigonal, marginally smooth, median fovea no distinct. Cephalic region

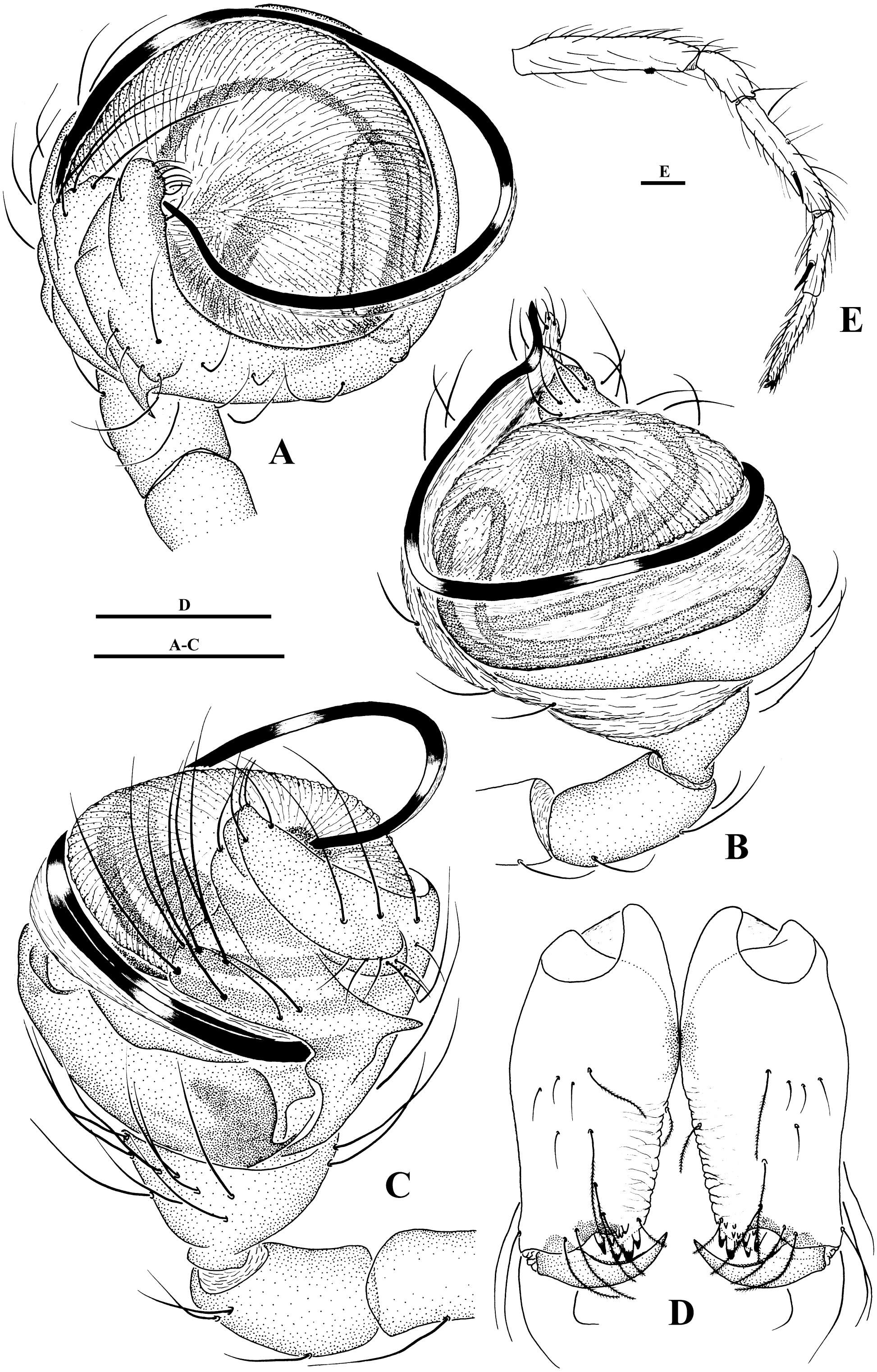

Figure 3. *Mysmena zhengi* sp. nov., holotype (male). (A) Left palp, apical; (B) ditto, prolteral; (C) ditto, retrolateral; (D) chelicerae; posterior; (E) leg I, prolateral. Scale bars: 0.10.

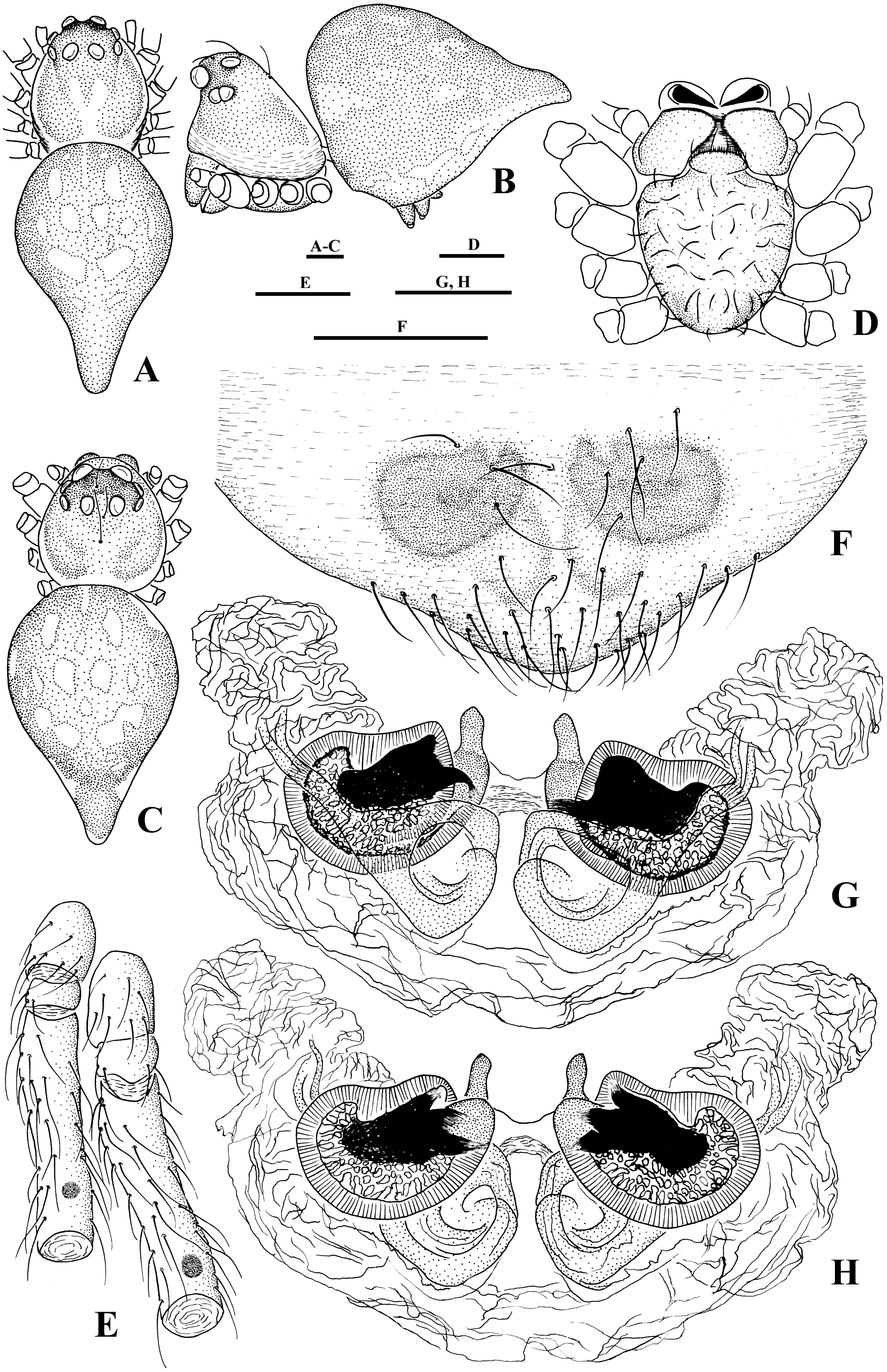

Figure 4. *Mysmena zhengi* sp. nov. (A) Female body, dorsal; (B) male body, lateral; (C) ditto, dorsal; (D) male sternum, labium, endites and coxae, ventral; (E) female femurs I and II, ventral; (F) epigynum, ventral; (G) vulva cleared, dorsal; (H) ditto, ventral. Scale bars: 0.10 for A–E; 0.05 for F–H.

slightly rised, slowly sloping backward in lateral. A few long hairs forward along mesial line.

Eyes. Ocular area coloration thicker than cephalic area. Eight eyes in two rows. In dorsal view, AER recurved and PER straight. All eyes circular, each eye base with black tiny ring. ALE and PLE almost contiguous. AME 0.03 same size as ALE 0.03, but smaller than PLE 0.04 and PME 0.04; AME–AME 0.04 wider than PME–PME 0.03; AME–ALE 0.01 narrower than PME–PLE 0.02. ALE separated by four times its diameter from edge of carapace.

Clypeus. Height 0.08, about equal to 3 times AMEs diameter. Concave below AME.

Chelicerae. Pale brown, shorter little than endites, with 3 promarginal teeth and retromarginal puny denticles. Four or five strong setae on cheliceral anterior surface near prolateral, black and needle-like, two plumose hairs on promargin; posterior surface with 6 long plumose hairs, three at mesial line and three on retromargin of fang furrow. Cheliceral fang short but sturdy, swollen somewhat at basa.

Labium. Pale yellow, short, fused to sternum.

Endites. Beige, longer slightly than wide, with serrula.

Sternum. Length 0.18, width 0.18. Cordiform, truncated between coxae IV. Brown-yellow, a horizontal stripe in anterior margin and mesially thin color, with some short hairs.

Legs. Formula: I, II, IV, III. Yellow grayish, each distal section of legs dusky black. Leg measurements: I 0.80 (0.23 + 0.11 + 0.18 + 0.13 + 0.17); II 0.67 (0.19 + 0.10 + 0.13 + 0.11 + 0.13); III 0.49 (0.13 + 0.08 + 0.08 + 0.08 + 0.12); IV 0.56 (0.16 + 0.09 + 0.10 + 0.09 + 0.12). One distal spine on each patella; tibiae I, II and III with three trichobothria; metatarsus I with a mesial clasping spur; metatarsi I, II and III bears one short trichobothrium.

Abdomen. Length 0.28, width 0.30. Circular in dorsal and ovoid viewed from lateral, greyish-black, with pale short hairs, irregular white pigment spots on abdominal bilateral. Spinnerets tiny and pale yellow.

Male palp. Pale brown and weakly sclerotized, palpal bulb relatively large, embedded in translucent membranous cymbium. Tibia short, without any apophysis. Paracymbium finger-like, bears long hairs on distal. Cymbium not developed, terminal sharp with an apophysis on dorsal, bearing some long hairs on bilateral distally. Embolus very long, strongly sclerotized, intertwisted with conductor which appended translucent velum at apex of peculiar structure. Its mesial and distal part coiled in a big crook. Proximal part of conductor and embolus embeded in the palpal bulbous membrane that shriveled distinctly. Tegulum recurved, small and finger-like.

Female. Unknown.

Etymology. The specific epithet is taken from Latin adjective made from *rostellus* = rostellum, means to the apophysis on distal part of cymbium.

Type material. Holotype male (IZCAS): Secondary tropical montane evergreen broad-leaved forest (21.963°N, 101.200°E; at an elevation of 895±10 meters above sea level), Menglun Nature Reserve, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunan Province, China, collected by Guo Zheng at 6 August, 2007.

Natural history. This species is found in the canopy above tropical artificial woodland.

Distribution. Known only from the type locality (Fig. 20).

Mysmena furca sp. nov.
(Figs 6A–G, 20)

Diagnosis. This new species is similar to *Mysmena taiwanica* Ono, 2006 and *Mysmena rostella*, but can be distinguished from both of them by the following characters: the presence of serrated modification on apex of cymbium, the furcate end of embolus, the intertwisted embolus and conductor, the different numbers of strong setae on anterior chelicerae in male (two spines in *M. taiwanica* and *M. furca*, four or five spines in *M. rostella*).

Description. Male. Total length: 0.54.

Carapace. Length 0.27, width 0.22. Coloration light on margin, dimmish on cephalic region and fuscous on ocular area. Circular in dorsal view and smooth margin. Cephalic region elevated, slowly sloping backward in lateral, few hairs forward on ocular area.

Eyes. Eight eyes in two rows. All eyes round, each eye base on tiny ring. From dorsal view, AER strongly recurved and PER straight; ALE and PLE contiguous. AME 0.04 equal to ALE 0.04 and PME 0.04, but larger than PLE 0.03; AME–AME 0.03 wider than PME–PME 0.02; AME–ALE 0.01 narrower than PME–PLE 0.02. ALE separated by about 2.5 times its diameter from the anterolateral margin of carapace.

Clypeus. Height 0.07, about equal to 2 times AMEs diameter. Concave below AME. With a tuft of hairs on anterior margin.

Chelicerae. Brown, obvious shorter than endites, fang furrow with 4 promarginal teeth and some tiny retromarginal denticles. Two long plumose hairs and 2 strong setae in anterior surface; 4 plumose hairs on posterior surface; few tufty shorter hairs on posteriorly median. Cheliceral fang short but sturdy.

Labium. Pale yellow, short, fused to sternum.

Endites. Brown, longer than wide, with serrula.

Sternum. Length 0.18, width 0.17. Cordiform, brown-yellow, posterior margin blunt between coxae IV. Some short hairs random scattered.

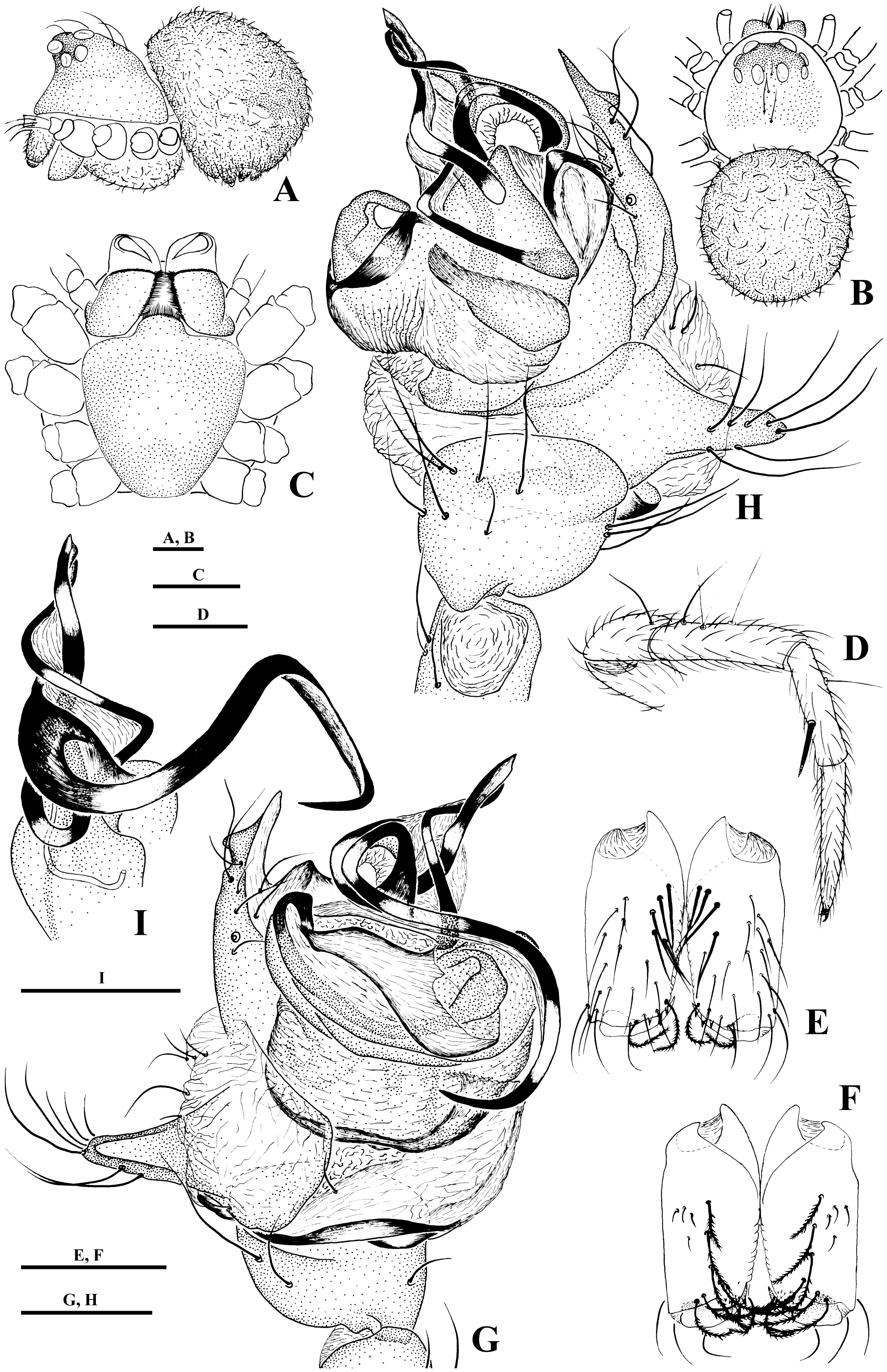

Figure 5. *Mysmena rostella* sp. nov., holotype (male). (A) Body, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxae, ventral; (D) leg I, prolateral; (E) chelicerae, anterior; (F) ditto, posterior; (G) left palp, prolateral; (H) ditto, retrolateral; (I) embolic division. Scale bars: 0.10 for A–F; 0.05 for G–I.

Legs. Formula: I, II, IV, III. Pale-yellow, each distal section of legs dim. Leg measurements: I 0.78 (0.24 + 0.09 + 0.17 + 0.12 + 0.16); II 0.66 (0.19 + 0.08 + 0.13 + 0.11 + 0.14); III 0.48 (0.13 + 0.07 + 0.09 + 0.08 + 0.11); IV 0.57 (0.17 + 0.07 + 0.11 + 0.10 + 0.12). Each patella with one long dorsal spine on distal; tibiae I–IV each with a proximally dorsal spine and three trichobothria; a clasping spur in near mesial of metatarsus I, metatarsi I and II each bears one short trichobothrium.

Abdomen. Length 0.30, width 0.31. Nearly circular in dorsum and ovoid seemed from lateral, greyish-black, coloration thicker in dorsum than in venter, with many short hairs; three irregular white pigment spots on abdominal bilateral. Spinnerets pale yellow, the anterior bigger than the posterior. Anal tuber almost same size as posterior spinneret.

Male palp. Thin brown, palpal bulb large, embedded in translucent, incomplete cup-like and membranous cymbium. Tibia short, without apophysis. Paracymbium inapparent. Cymbium not fine developed, modified on apex by a weird serrated tiles structure which derived from inside cymbium median and bears a row of inward-curved strong spines lying on the inside extension. An apophysis opposited to the serrated tiles structure. Embolus zonary, strongly sclerotized, intertwisted with conductor which were modified by translucent membrane at palpal apex, formed a small unsymmetrical furcate embolic end after curved at middle part. Proximal part of embolus connected with conductor and embeded in the rugose membranous palpal bulb. Tegulum large and obvious.

Female. Unknown.

Etymology. The specific epithet is derived from Latin *furc-* = forked and *cacumen* = top, means to the fork-shaped apex of embolus on male palp.

Type material. Holotype male (IZCAS): Rubber plantation in Xishuangbanna Botanical Garden (21.908°N, 101.266°E; at an elevation of 569±11 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 21 July, 2007.

Natural history. This species is found in the canopy above tropical rubber plantation.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

Mysmena arcilongus sp. nov.
(Figs 7A–I, 20)

Diagnosis. This new species is similar to *Mysmena calypso* Gertsch, 1960, *Mysmena furca* and *Mysmena rostella*, but can be distinguished by the following characters: the presence of long, bow-shaped embolus (but annular in *M. calypso*), the presence of serrated modification on apex of cymbium (present in *M. furca*, but absent in *M. calypso* and *M. rostella*), the non–intertwisted embolus and conductor (absent in *M. calypso*, but present in *M. furca* and *M. rostella*), the different shapes of tegulum, and the presence of four or five strong setae on anterior chelicerae in male (only same as in *M. rostella*).

Description. Male. Total length: 0.57.

Carapace. Length 0.29, width 0.28. Marginally yellow-brown, mesially tannish and ocular area dark-brown. Circular in dorsal view, cephalic region slightly elevated, slowly sloping backward in lateral view, radiate grooves extended from median fovea to around, marginally smooth.

Eyes. Eight eyes in two rows. All eyes round, bear visible black ring. In dorsal view, AER more recurved than PER; ALE and PLE adjoined. AME 0.03 equal to PME 0.03, but larger than ALE 0.02 and PLE 0.02; AME–AME 0.05 wider than its diameter and PME–PME 0.03; AME–ALE 0.02 narrower than PME–PLE 0.03. ALE kept 2.8 times its diameter distance away from anterolateral margin of carapace.

Clypeus. Height 0.09, equal to 3 times AMEs diameter. Strongly concave below AME.

Chelicerae. Brown, length about equal to that of endites, fang furrow with 3 promarginal teeth and tiny retromarginal denticles. Cheliceral anterior surface bears four or five strong long black setae. Cheliceral anterior surface without any plumose hair, but posterior surface with 7 plumose hairs (3 on retromarginal fang furrow and 4 at posteriorly mesial line), and a tuft of shorter hairs in middle area. Cheliceral fang normal and tender.

Labium. Pale yellow, tongue-shaped, fused to sternum.

Endites. Light brown, longer than wide, with serrula.

Sternum. Length 0.19, width 0.19. Heart-shaped, blunt between coxae IV. Grey-black, on margin thicker than in median. Short hairs evenly scattered.

Legs. Formula: I, II, IV, III. Pale-yellow, each distal section of legs grey-black. Leg measurements: I 0.92 (0.29 + 0.12 + 0.18 + 0.13 + 0.20); II 0.77 (0.21 + 0.11 + 0.16 + 0.12 + 0.17); III 0.53 (0.14 + 0.07 + 0.10 + 0.10 + 0.12); IV 0.66 (0.19 + 0.09 + 0.13 + 0.11 + 0.13). Each patella with one long dorsal spine on distal; tibiae I–IV each with a proximally dorsal spine and three trichobothria; a mesial clasping spur on prolateral metatarsus I, metatarsi I–IV each bears one short trichobothrium.

Abdomen. Length 0.32, width 0.30. Circular in dorsal and egg-shaped in lateral, dusky-black, coloration in dorsum thicker than that in venter, with densely short hairs, two nonstandard quadrate white pigment spots on abdominal bilateral. Spinnerets pale yellow,

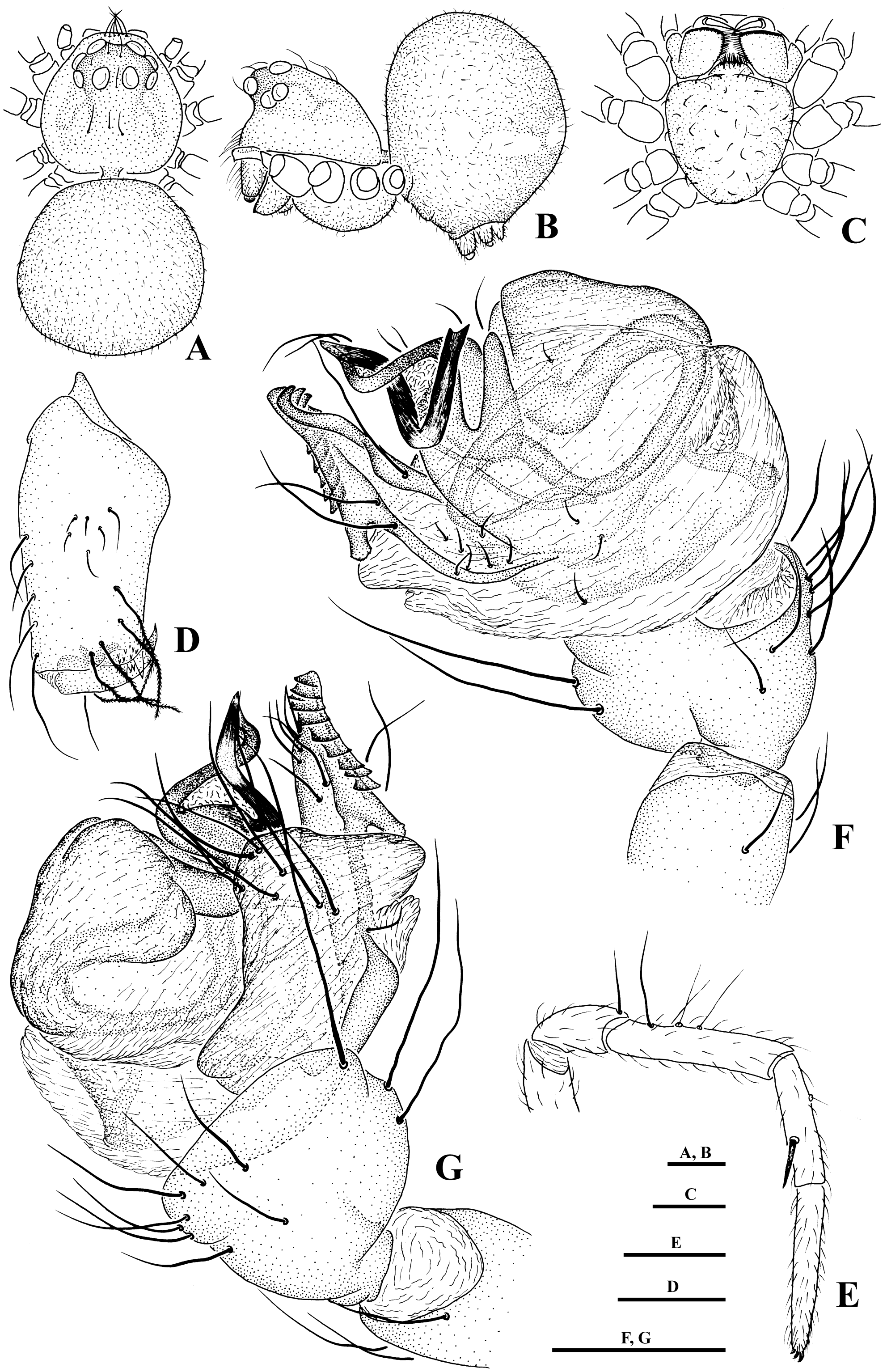

Figure 6. *Mysmena furca* sp. nov., holotype (male). (A) Body, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxae, ventral; (D) left chelicera, posterior; (E) left leg I, prolateral; (F) left palp, prolateral; (G) ditto, retrolateral. Scale bars: 0.10 for A–C, E; 0.05 for D, F–G.

the anterior obviously larger than the posterior. Anal tuber no longer as posterior spinneret.

Male palp. Light brown, palpal bulb very large and rugose. Patella short, except distal a few hairs, without any modification. Tibia short but broad, half cup-shaped, without apophysis. Cymbium not fine developed, with long hairs on retrolateral margin, its distal apex modified by a special serration structure that derived from inside cymbium, which bears a row of inward-curved strong short spines lying on the mesial line of the inside extension. A small projection located under the serration structure. Cymbial prolateral base with a small membrane apophysis. Embolus considerably long, strongly sclerotized, appended thin velum from base to apex. The long-bow-shaped embolus that spanned whole palpal bulb overhung above bulb surface. Proximal part of embo-lus wider obviously than distal part, connected with both conductor and rugose membrane after swerved at base. Tegulum sclerotized and distinctly shriveled.

Female. Unknown.

Etymology. Specific epithet is derived from Latin *arci-* = bow and *longus* = long, means to the palpal embolus especial long and curved as a nice bow.

Type material. Holotype male (IZCAS): Rubber plantation in Xishuangbanna Botanical Garden (21.908°N, 101.266°E; at an elevation of 569±11 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 21 July, 2007.

Natural history. This species is found in the canopy above tropical rubber plantation.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

Calodipoena Gertsch et Davis, 1936

Calodipoena biangulata sp. nov.
(Figs 8A–E, 9A–H, 20)

Diagnosis. This new species can be distinguisehd from other *Colodipoena* species by the presence of two curving, sclerotized horny apophyses on apex of cymbium; the circuitous course of embolus; the inter-twisted spermathecae with modified glandulous sac, and the short but broad scape of epigynum.

Description. Male. Total length: 0.60.

Carapace. Length 0.28, width 0.24. Cephalic region darkish, ocular area dusky black, thoracic region bilateral and posterior yellow. Dorsally nearly round, margin smooth. Ocular area raised and slightly protruded.

Eyes. Eight eyes in two rows. From dorsal view, AER recurved and PER procurved. Each eye circular and with black ring. AME, ALE and PLE contiguous and arrayed in line. AME 0.04 larger than ALE 0.03, and PME 0.05 larger also than PLE 0.03; AME–AME 0.07 wider remarkably than PME–PME 0.02 and PME–PLE 0.02.

Clypeus. Height 0.06, slightly concave below ocular area, equal to 1.50 times AME diameter.

Chelicerae. Darkish, length beyond end of endites, with 2 or 3 promarginal teeth and tiny retromarginal denticles. Cheliceral anteriorly prolateral surface striated modification; posterior surface with 4 plumose long hairs on adjacent retromargin and short spines on the middle. Cheliceral fang pale brown and sturdy.

Labium. Pale yellow and rectangular, fused to sternum.

Endites. Pale yellow, longer than wide but shorter than chelicerae, with serrula.

Sternum. Length 0.14, width 0.13. About a reverse equilateral triangle, pale-yellow, without any pattern but bears slender short hairs.

Legs. Formula: I, II, IV, III. Pale yellow. Each section of legs distal grey. Leg measurements: I 0.81 (0.26 + 0.11 + 0.16 + 0.13 + 0.16); II 0.69 (0.21 + 0.10 + 0.12 + 0.11 + 0.14); III 0.52 (0.16 + 0.07 + 0.10 + 0.09 + 0.11); IV 0.61 (0.19 + 0.07 + 0.13 + 0.10 + 0.12). Femural ventral sclerotized spot absent. One prolateral distal clasping spur on metatarsus I. Each patella bears one distally dorsal spine. Tibiae I–IV each with one proximally prolateral spine and three trichobothria. Metatarsi I–IV each bears one proximal short trichobothrium.

Abdomen. Length 0.36, width 0.30. Darkish black in dorsum and grey-yellow in venter; abdominal bilateral with white pigmentation spots. Two pair of short club-shaped spots located at abdominal dorsal median. A small hump at posterior rearward. Spinnerets pale yellow, the anterior slightly larger than the posterior. Anal tuber ashen and small.

Male palp. Light yellow-brown, weakly sclerotized. Femur distal slightly swollen and with a few hairs. Patella wider than femur, length almost same size as tibia. Tibia cup-shaped, a row of especially long hairs along its distal margin. Cymbium finely developed and broad translucent membranous; distally outer margin no modified except some hairs on apex. But two inverted “7”-shaped horns situated at cymbial inside, which base started at prolateral corner of cymbium. Palpal bulb nearly global, structure relatively simple: Basal haematodocha smooth and flimsy sclerotized; tegulum about round, wrinkled and transparent membranous bursa; embolus similar to a long thin tubule, its most part curved and coiled in tegulum, then come out under tegulum to reach behind apex of “7”-shaped horns of cymbium.

Female. Total length: 0.70.

Carapace. Length 0.28, width 0.28. Pear-shaped, same coloration and pattern as in male.

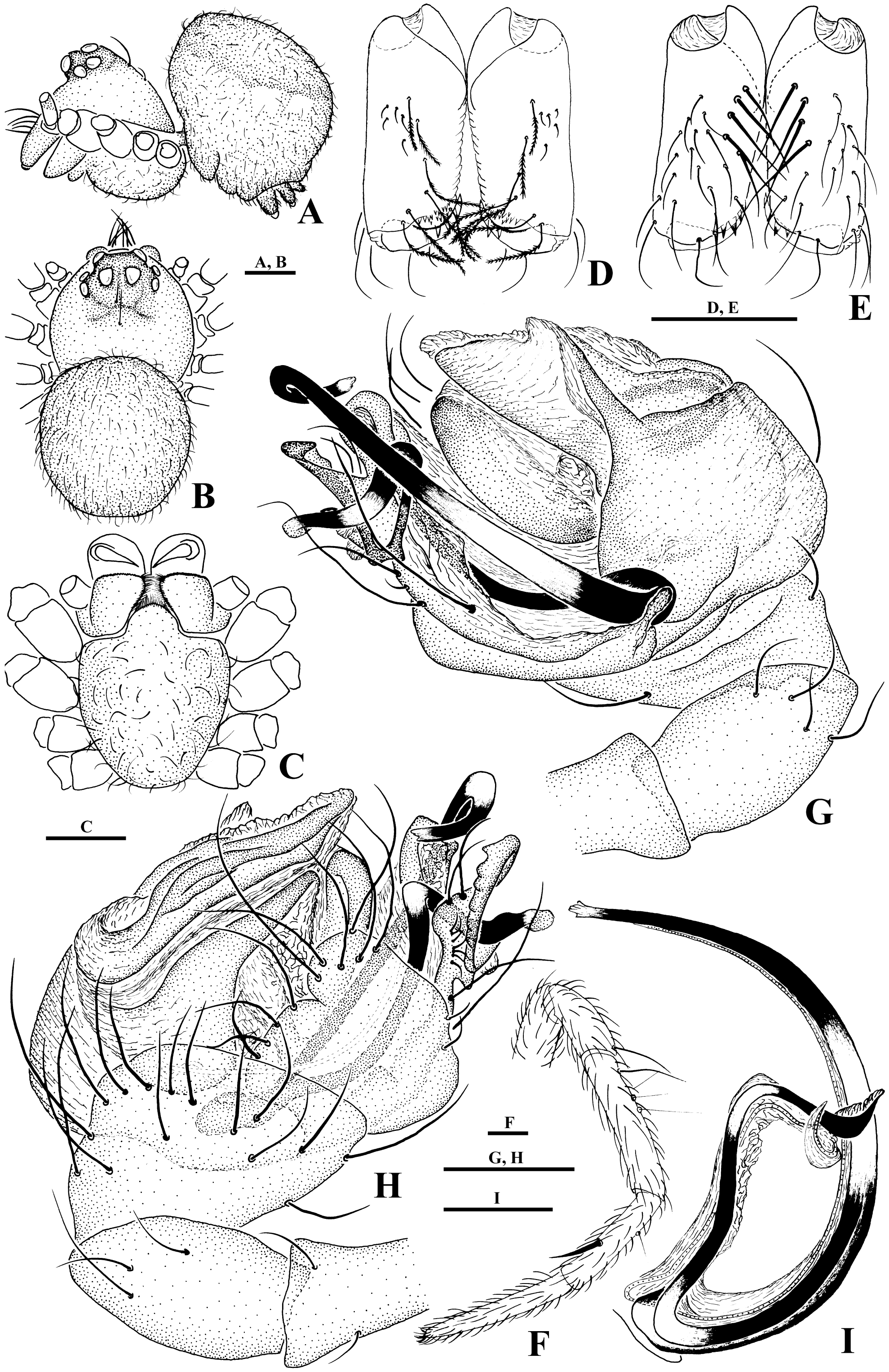

Figure 7. *Mysmena arcilongus* sp. nov., holotype (male). (A) Body, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxae, ventral; (D) chelicerae, posterior; (E) ditto, anterior; (F) left leg I, prolateral; (G) left palp, prolateral; (H) ditto, retrolateral; (I) embolus, ventral. Scale bars: 0.10 for A–F; 0.05 for G–I.

Eyes. Similar to in male. AME 0.04 same size as PME 0.04, ALE 0.03 equal to PLE 0.03. AME–AME 0.04 wider than PME–PME 0.01 and PME–PLE 0.02.

Clypeus. Height 0.03, equals to diameter of ALE; ALE separated a distance from anterolateral margin of carapace, but not far as in male.

Chelicerae, labium and endites. As in male.

Sternum. Length 0.20, width 0.20. Pale yellow.

Legs. Formula: I, II, IV, III. Coloration same as in male. Leg measurements: I: 0.80 (0.23 + 0.11 + 0.17 + 0.13 + 0.16); II: 0.70 (0.20 + 0.11 + 0.14 + 0.11 + 0.13); III: 0.58 (0.16 + 0.08 + 0.11 + 0.10 + 0.13); IV: 0.68 (0.20 + 0.10 + 0.14 + 0.11 + 0.12). One distally ventral sclerotized spot on femora I and II; except metatarsus I having no clasping spur, spine and trichobothria on legs same as in male.

Abdomen. Length 0.46, width 0.34. Coloration and shape as in male but dorsal spots pattern more than that of male.

Epigynum and vulva. Epigynal area bears sparse long hairs. Posteriorly mesial margin roguse and projected, formed a broad but short semiround scape. Spermathecae obviously sclerotized, each was composed of two intertwisted helical parts. Copulatory bursae smooth membranous, under the spermathecae. Between the two copulatory bursae appended thin-wall wrinkled transparent sac which fused to copulatory bursae at lateral corner. The posterior parts of copulatory bursae extended to form thin sclerotized apophyses. Genital opening and copulatory ducts no visible through integument.

Etymology. The specific name derived from Latin *bi-* = two and *angulatus* = angular, indicates the nice figure of the species.

Type material. Holotype male (IZCAS): Secondary tropical seasonal rainforest in Menglun Nature Reserve (21.924°N, 101.274°E; at an elevation of 598±17 meters above sea level), Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 22 July, 2007. Paratypes: 10 males, 7 females, same data as for the holotype; 6 males, 1 female, rubber plantation in Xishuangbanna Botanical Garden (21.908°N, 101.266°E; at an elevation of 569±11 meters above sea level), Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 27 July, 2007; 2 males, primal tropical rainforest in Menglun Nature Reserve (21.917°N, 101.275°E; at an elevation of 558±17 meters above sea level), Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 16 July, 2004.

Variation. The total length ranges from 0.56 to 0.74 in males (n = 19) and from 0.67 to 1.02 in females (n = 8). The carapace and abdomen have no measured. The abdomen in both sexual individual has unstable spots. There are variation at eye diameter in both male and female.

Natural history. This species is found in the canopy above tropical broad-leaved rainforest.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

Calodipoena cornigera sp. nov.
(Figs 10A–J, 20)

Diagnosis. This new species is similar to *Calodipoena caribbaea* (Gertsch, 1960) and *Calodipoena stathamae* (Gertsch, 1960), but can be distinguished by: The presence of a curved fingerlike projection on apex of cymbium, the compressed end of embolus which is not tapered as in *C. caribbaea* and *C. stathamae*, and the presence of a slcerotized unciform on tegulum.

Description. Male.

Total length. 0.62.

Carapace. Length 0.27, width 0.29. Marginally brown, mesially pale yellow and ocular area dark-brown. Circular from dorsal view, cephalic region slightly elevated, sharply down forward and slowly sloping backward; median fovea lacked, marginally smooth but rebordered on posterolateral corner.

Eyes. Eight eyes in two rows. Of eyes anteriorly round and posteriorly ovoid, each eye located on a black ring. In dorsal, AER recurved more than PER; ALE and PLE contiguous. AME 0.04, PME 0.04 and PLE 0.04 same as size, but smaller than ALE 0.05; AME–AME 0.04 amount to its diameter and PME–PME 0.04; AME–ALE 0.01 especially narrower than PME–PLE 0.04. PLE and PME each other separated by a distance same as diameter of them. Compared with ALE, AME more approach to anterolateral margin of carapace, but kept 2.4 times its diameter distance away from.

Clypeus. Height 0.07, equal to 1.75 times AMEs diameter. Inapparent concave below AME.

Chelicerae. Grey-brown, very tiny, apparent shorter than endites. Cheliceral fang furrow with 5 promarginal tooth and tiny retromarginal denticles. Cheliceral anterior surface without any modification except some long hairs. The lack of plumose hair on anterior surface, but 6 plumose hairs on posterior surface (4 long anear retromarginal fang furrow and 2 short on posteriorly mesial line), a cluster of shorter hairs on posteriorly mesial area. Cheliceral fang tender and slightly swollen at base.

Labium. Pale yellow, short, fused to sternum.

Endites. Dim brown, longer than wide, with serrula.

Sternum. Length 0.20, width 0.21. Cordiform, blunt at between coxae IV. Grey-black, bilateral shoulder and mesial area light coloration. Some short hairs evenly distributing.

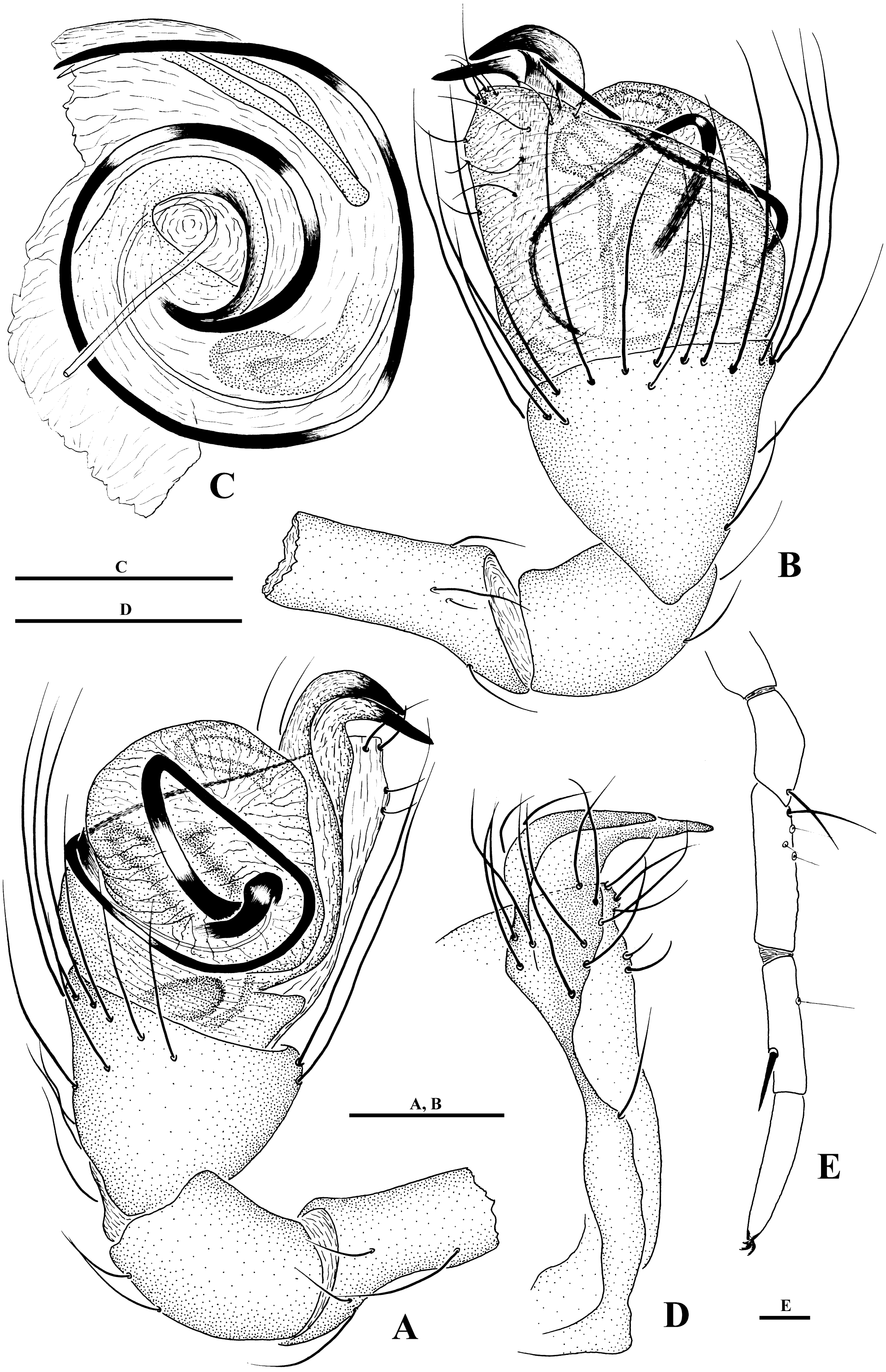

Figure 8. *Calodipoena biangulata* sp. nov., holotype (male). (A) Palp, prolateral; (B) ditto, retrolateral; (C) embolic division, dorsal; (D) cymbium partly, ventral; (E) leg I (omitted femur), prolateral. Scale bars: 0.05.

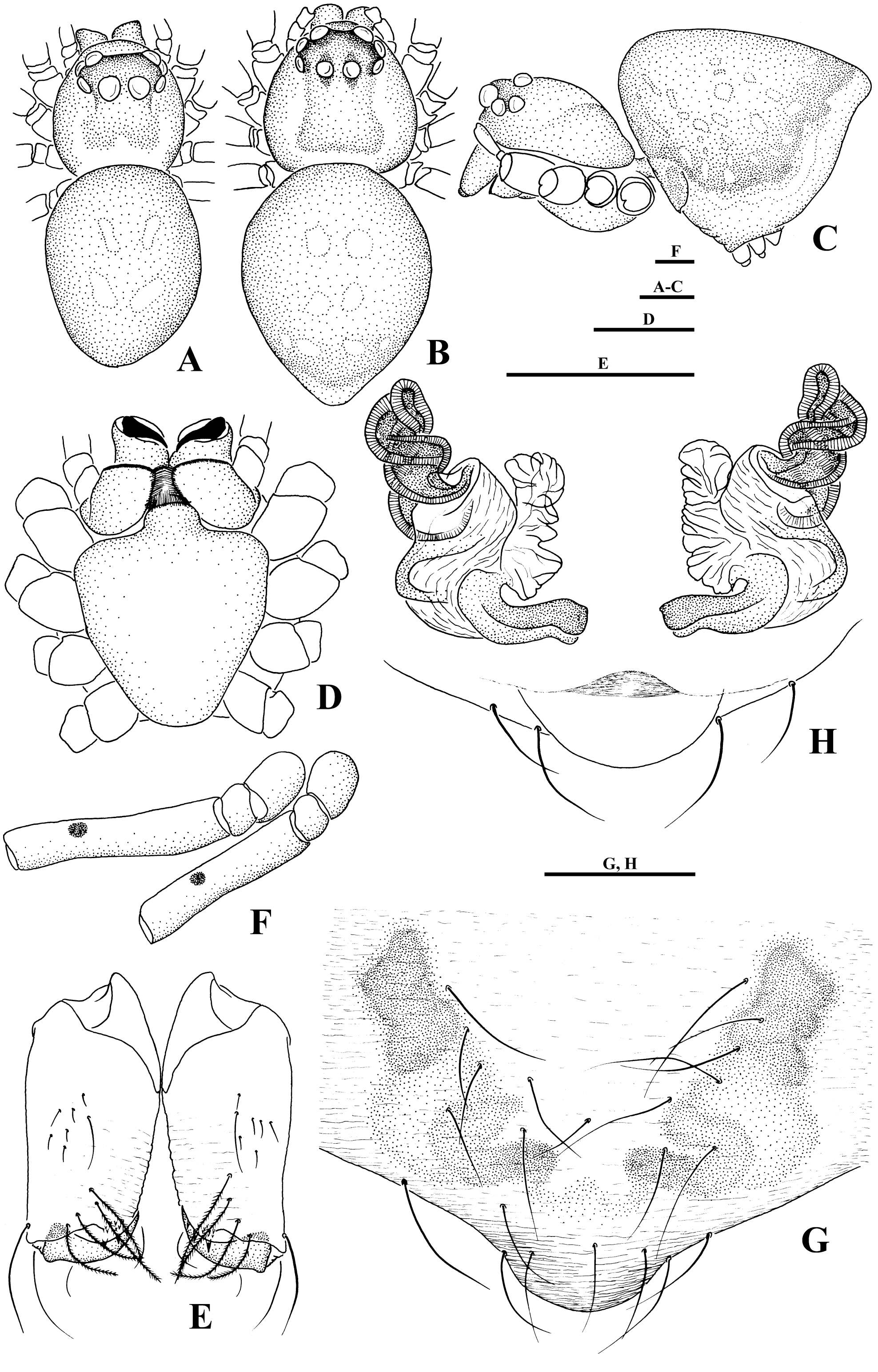

Figure 9. *Calodipoena biangulata* sp. nov. (A) Male body, dorsal; (B) Female body, dorsal; (C) ditto, lateral; (D) male sternum, labium, endites and coxae, ventral; (E) male chelicerae, posterior; (F) female femurs I and II, ventral; (G) epigynum, ventral; (H) vulva cleared, dorsal. Scale bars: 0.10 for A–F; 0.05 for G–H.

Legs. Formula: I, II, IV, III. Pale yellow-brown, each distal section of legs grey-black. Leg measurements: I 0.98 (0.31 + 0.13 + 0.19 + 0.16 + 0.19); II 0.83 (0.26 + 0.12 + 0.16 + 0.13 + 0.17); III 0.60 (0.18 + 0.09 + 0.10 + 0.10 + 0.13); IV 0.70 (0.22 + 0.10 + 0.12 + 0.11 + 0.14). Femora I and II each with a distally ventral sclerotized spot; each patella with one distal long spine; tibiae I–III each with a proximal spine and three trichobothria; tibia IV with a proximal spine and four trichobothria; a mesial clasping spur on prolateral metatarsus I, metatarsi I–IV each bears one short trichobothrium.

Abdomen. Length 0.34, width 0.36. Circular from dorsal view, grey-black, in dorsum thicker than in venter, bearing densely short hairs, white pigment patches on abdominal bilateral. Spinnerets pale yellow, the anterior obviously larger than the posterior. Anal tuber very tiny.

Male palp. Light brown, palpal bulb very large and nearly global. Tibia short and cup-shaped, without apophysis, bears a row of long spine on distal margin. Cymbium fine developed, likes as a rugose translucent membranous lamella, its distal top extended to form a curvulate horny projection. Inside apex, a tuft of upward-curved strong long spines protected the tip of embolus. Embolus considerably long, strongly sclerotized, which appended membrane from base to end, its tip nearly arrived at cymbial apex by spirally coiled about two loops under the translucent tegulum with radiate rugae. The end of embolus obviously broaden. A big italic sclerotized unciform with membrane leans on tegulum.

Female. Unknown.

Etymology. Specific epithet is derived from Latin *corniger* = cornute, means to the male palpal cymbium bears a horny modification on apex.

Type material. Holotype: male (IZCAS): Secondary tropical seasonal forest (21.907°N, 101.208°E; at an elevation of 612±11 meters above sea level), Menglun Nature Reserve, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 10 August, 2007.

Natural history. This species is found in the canopy above tropical rainforest.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

Mysmenella Brignoli, 1980

Mysmenella pseudojobi sp. nov.

(Figs 11A–H, 12A–F, 20)

Diagnosis. This new species is similar to *Mysmenalla jobi* (Kraus, 1967), but can be distinguished by the shape of male palp and the structure of female vulva. In *Mysmenella pseudojobi*, the cymbial spur is absent; the distal twisted embolic end is different; the epigynum has longer scape; the spermathecae has prolateral corner; and the copulatory ducts derived from the bottom of spermathecae and coiled into a loop.

Description. Male. Total length: 0.96.

Carapace. Length 0.44, width 0.42. Nearly circular in dorsal and triangular in lateral, forward vertical down and backward sloping down. Brown-yellow, without any pattern modification; lateral margin smooth, with round posterolateral corners.

Eyes. Ocular area strongly upheaved, bearing few black hairs from cephalic mesial line to whole ocular area. Eight eyes in two rows, circular, with brown ring at base. Both AER and PER recurved; ALE and PLE adjoined. AME 0.03 smaller than others. ALE 0.04, PLE 0.04 and PME 0.04 same as in size. AME–AME 0.06 wider than PME–PME 0.03; AME–ALE 0.02 narrower than PME–PLE 0.04; MOQ almost foursquare, MOQL 0.10 slightly narrower than MOQW 0.13.

Clypeus. Height 0.30, equal to 10 times AME diameter. Clypeal concave no distinct. ALE departs especially a far distance from anterolateral verge of carapace.

Chelicerae. Yellow, fang groove with 4 promarginal teeth and tiny retromarginal denticles. Cheliceral hairs long, black and needle-like, unevenly scattered. Cheliceral fang normal; basal slightly swollen.

Labium. Yellow, fused to sternum.

Endites. Pale yellow, shorter than wide, with serrula.

Sternum. Length 0.28, width 0.28. Cordiform, yellow, with a longitudinal pale-yellow stripe in mesial region.

Legs. Formula: I, II, IV, III. Yellow, each distal section with obvious annular pigmentation. Leg measurements: I: 1.46 (0.44 + 0.18 + 0.32 + 0.24 + 0.28); II: 1.20 (0.36 + 0.16 + 0.24 + 0.20 + 0.24); III: 0.94 (0.26 + 0.12 + 0.18 + 0.16 + 0.22); IV: 1.12 (0.36 + 0.12 + 0.24 + 0.18 + 0.22). Femur I with a distally ventral sclerotized spot, without spine; each patella with a proximal and dorsal spines; tibia I with two short clasping spur in distal; metatarsus I with a long clasping spur in mesial. Tibia I and IV with a proximal spine and 4 trichobothria; tibia II and III with a proximal spine and 3 trichobothria.

Abdomen. Length 0.54, width 0.50. Dorsal rounded, grayish-black, with pale-yellow spots. Spinnerets anterior dimmish and posterior grayish. Anal tubercle yellowish.

Male palp. Palpal bulb relatively large, pale brown. Femur long, no modified. Patella short, with few hairs. Tibia cup-shaped, a row of orderly long hairs along distal margin. Paracymbium absent. Cymbium no developed, rugose transparent membrane; cymbial spur absent; apical margin divided into two lobes, bears some hairs along margin. Basal haematodocha smooth

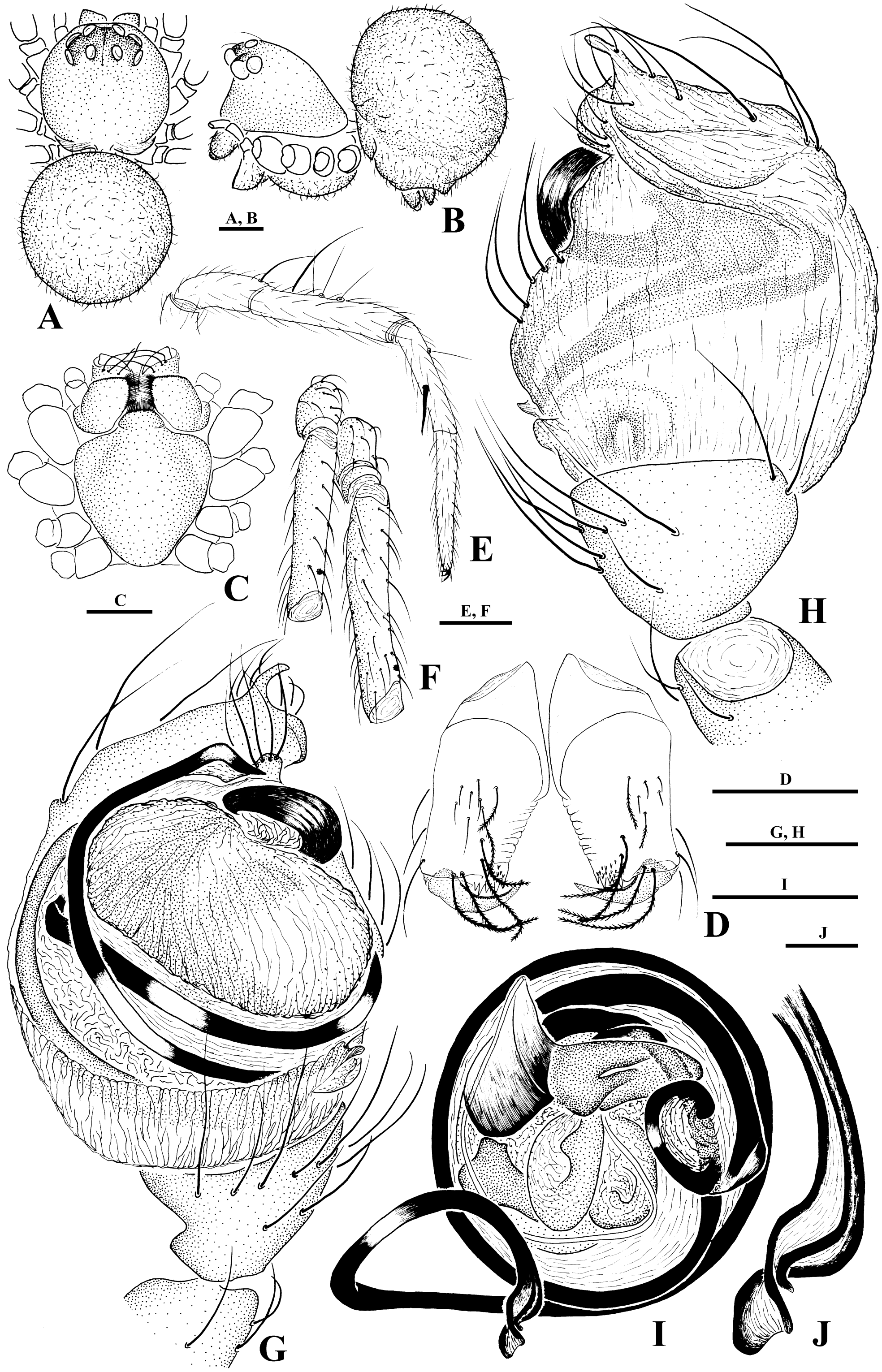

Figure 10. *Calodipoena cornigera* sp. nov., holotype (male). (A) Body, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxae, ventral; (D) chelicerae, posterior; (E) leg I, prolateral; (F) femurs I and II, ventral; (G) left palp, prolateral; (H) ditto, retrolateral; (I) embolic division, apical; (J) top of embolus. Scale bars: 0.10 for A–F; 0.05 for G–I; 0.01 for J.

and sclerotized. Tegulum translusnet membranous sac, wrinkled. Embolus comparatively long, which most part embedded under tegulum, revealed the rest part surrounding palpal bulb and extended to apex of palp; its end twisted into a complicated structure that appended velum.

Female. Total length: 1.38.

Carapace. Length 0.52, width 0.44. Dorsally ovoid, darkish brown, with radial dim stripes from thoracic median to around. Few long black hairs in cephalic portion; lateral margin smooth, rebordered corners in posterolateral.

Eyes. Ocular area normal. Eight eyes in two rows, each nearly rounded. From dorsal view, AER recurved more than PER; ALE and PLE almost adjoined. AME 0.04, ALE 0.04 and PME 0.04 same as in size, slightly larger than PLE 0.03. AME–AME 0.03 wider than AME–ALE 0.02; PME–PME 0.02 narrower than PME–PLE 0.03. MOQ inverted trapeziform, MOQL 0.10 narrower than MOQW 0.13. Each eye surrounded by a dark ring.

Clypeus. Height 0.10, equals to 2.50 times diameter of AME; ALE departs from anterolateral edge of carapace, but not as in male.

Chelicera, labium and endites. Same as in male.

Sternum. Length 0.30, width 0.28. Coloration and patterns same as in male.

Legs. Formula: I, II, IV, III. Yellow-brown, black annular splash in distal of each segment. Leg measurements: I: 1.54 (0.50 + 0.18 + 0.32 + 0.26 + 0.28); II: 1.40 (0.44 + 0.16 + 0.30 + 0.24 + 0.26); III: 1.10 (0.34 + 0.16 + 0.18 + 0.18 + 0.24); IV: 1.34 (0.44 + 0.16 + 0.28 + 0.22 + 0.24). One distally ventral sclerotized spot on femora I and II; of each leg spine and trichobothria as in male.

Abdomen. Length 0.96, width 0.80. Same modification as in male.

Epigynum. A long curved finger-shaped scape, variable in length, rugose and unsclerotized, with a small ventral notch in its end.

Vulva. Spermathecae ovoid, with a corner at its prolateral. Copulatory bursae overlapped to spermathecae, copulatory ducts derived from the bottom of spermathecae, coiled into a loop and upswept. Posterior margin with a pair of stigmas.

Etymology. The specific epithet of this new spider derives from Latin *pseudo-* = imitated and the name of known species *Mysmenella jobi* (Kraus, 1967), mostly owing to the new species quite similar to *M. jobi*. But there are also detailed differences between the both.

Type material. Holotype: male (IZCAS), Zhoukoudian Cave (39.683°N, 115.850°E), Fangshan District, Beijing City, China, collected by Shuqiang Li and Yanfeng Tong, 2 July 2006. Paratypes: 1 males, 4 females, same data as holotype.

Variation. The total length ranges from 0.96 to 1.00 in males (n = 2) and from 1.14 to 1.38 in females (n = 4). The carapace and abdomen have no measured. The abdomen in both sexual individual have irregular spots but character unstable.

Natural history. This species was found under small stones in dry habitat in cave.

Distribution. Known only from the type locality (Fig. 20).

Mysmenella menglunensis sp. nov.

(Figs 13A–I, 20)

Diagnosis. This new species is similar to *Mysmenalla jobi* (Kraus, 1967) and *Mysmenella gongi* Yin, Peng and Bao, 2004, but can be distinguished by the detailed structures of embolus and conductor; the presence of a "V"-shaped lobe on the top of cymbium; the cymbial mesial prominence which is wider than in *M. gongi* but narrower than in *M. jobi*; the non-twisted embolic end; the absence of cymbial spur (as in *M. jobi*, but absent in *M. gongi)*.

Description. Male. Total length: 0.77.

Carapace. Length 0.42, width 0.42. Brown-yellow, ovoid in dorsal and trapeziform in lateral, marginally smooth. Cephalic area sharply upheaved, flatted on top with some long frontward hairs.

Eyes. Ocular region projecting, eight eyes in two rows. All eyes circular, each eye surrounded by black ring. AER and PER recurved viewed from above; ALE and PLE contiguous. AME 0.06 slightly larger than ALE 0.04, PLE 0.04 and PME 0.05; AME–AME 0.04 wider than PME–PME 0.03; AME–ALE 0.02 narrower than PME–PLE 0.06.

Clypeus. Height 0.22, ALE observably separated from edge of carapace by a distance, nearly vertical in lateral.

Chelicerae. Light brown-yellow, shorter than endites. Cheliceral groove with 4 promarginal teeth and tiny retromarginal denticles. Cheliceral posterior retromargin with plumose hairs 5. Cheliceral fang normal; basal swollen.

Labium. Grayish brown, tongue-shaped, fused to sternum.

Endites. Brown-yellow, longer somewhat than wide, with serrula.

Sternum. Length 0.22, width 0.23. Cordiform, pale brown-yellow, with some short hairs, posterior margin blunt between coxae IV.

Legs. Formula: I, IV, II, III. Pale yellow, with grey annular stripes in each distal section; Leg measurements: I 1.33 (0.43 + 0.16 + 0.28 + 0.22 + 0.24); II 1.08 (0.32 + 0.14 + 0.22 + 0.17 + 0.22); III 0.78 (0.21 + 0.10 + 0.14 + 0.14 + 0.18); IV 0.94 (0.28 + 0.12 + 0.19 + 0.17 + 0.20). Each patella with a distal long spine; each tibia with 1 proximal long spine and 4 trichobothria;

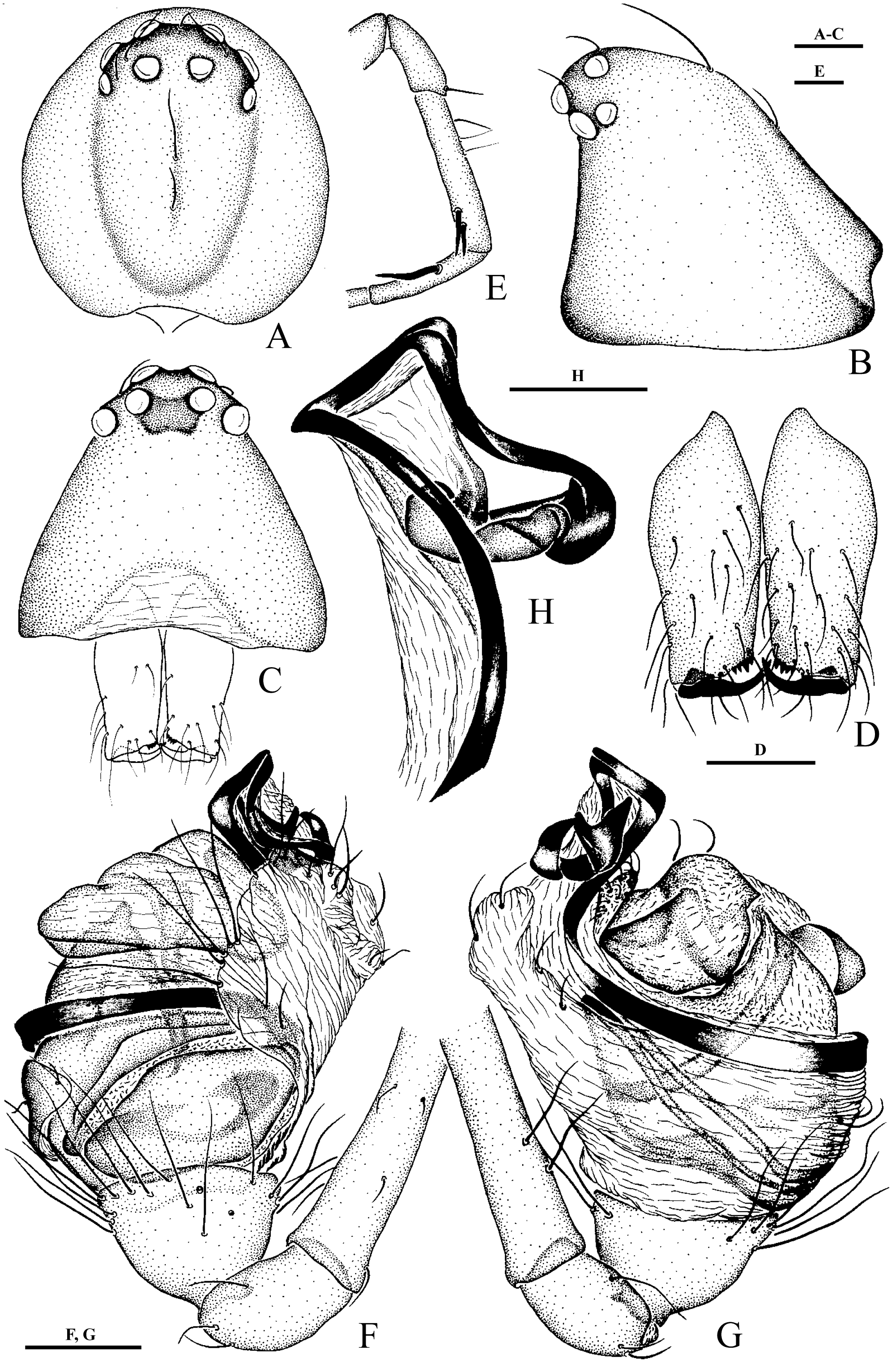

Figure 11. *Mysmenella pseudojobi* sp. nov., holotype (male). (A) Carapace, dorsal; (B) ditto, lateral; (C) ditto, anterior; (D) chelicerae, anterior; (E) tibia and metatarsus of leg I, anterior; (F) left palp, prolateral; (G) ditto, retrolateral; (H) embolus and conductor, retrolateral. Scale bars: 0.10 for A-G; 0.05 for H.

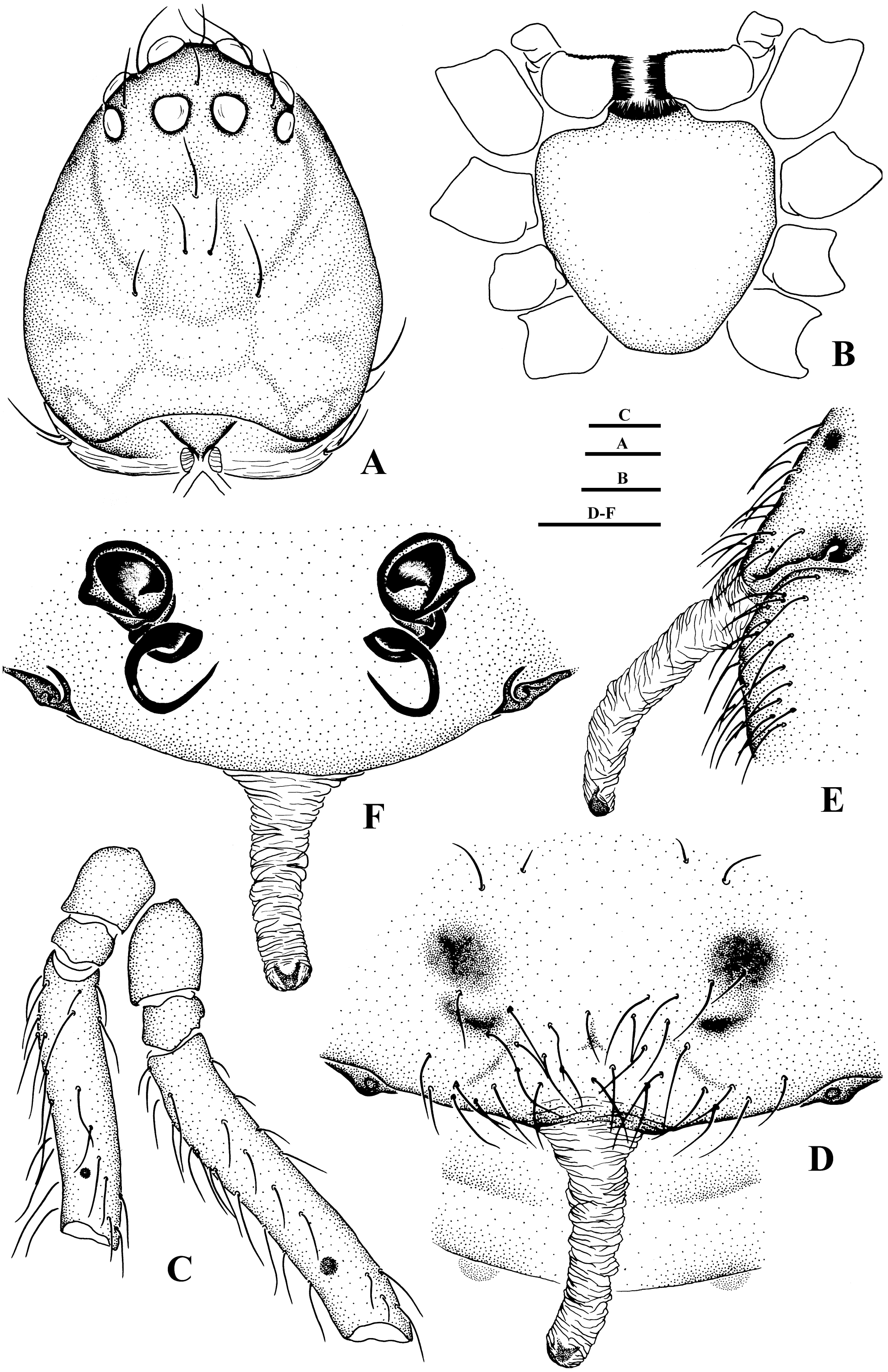

Figure 12. *Mysmenella pseudojobi* sp. nov., female. (A) Carapace, dorsal; (B) sternum, labium, endites and coxae, ventral; (C) femur I and II, ventral; (D) epigynum, ventral; (E) ditto, right lateral; (F) cleared vulvae, dorsal. Scale bars: 0.10.

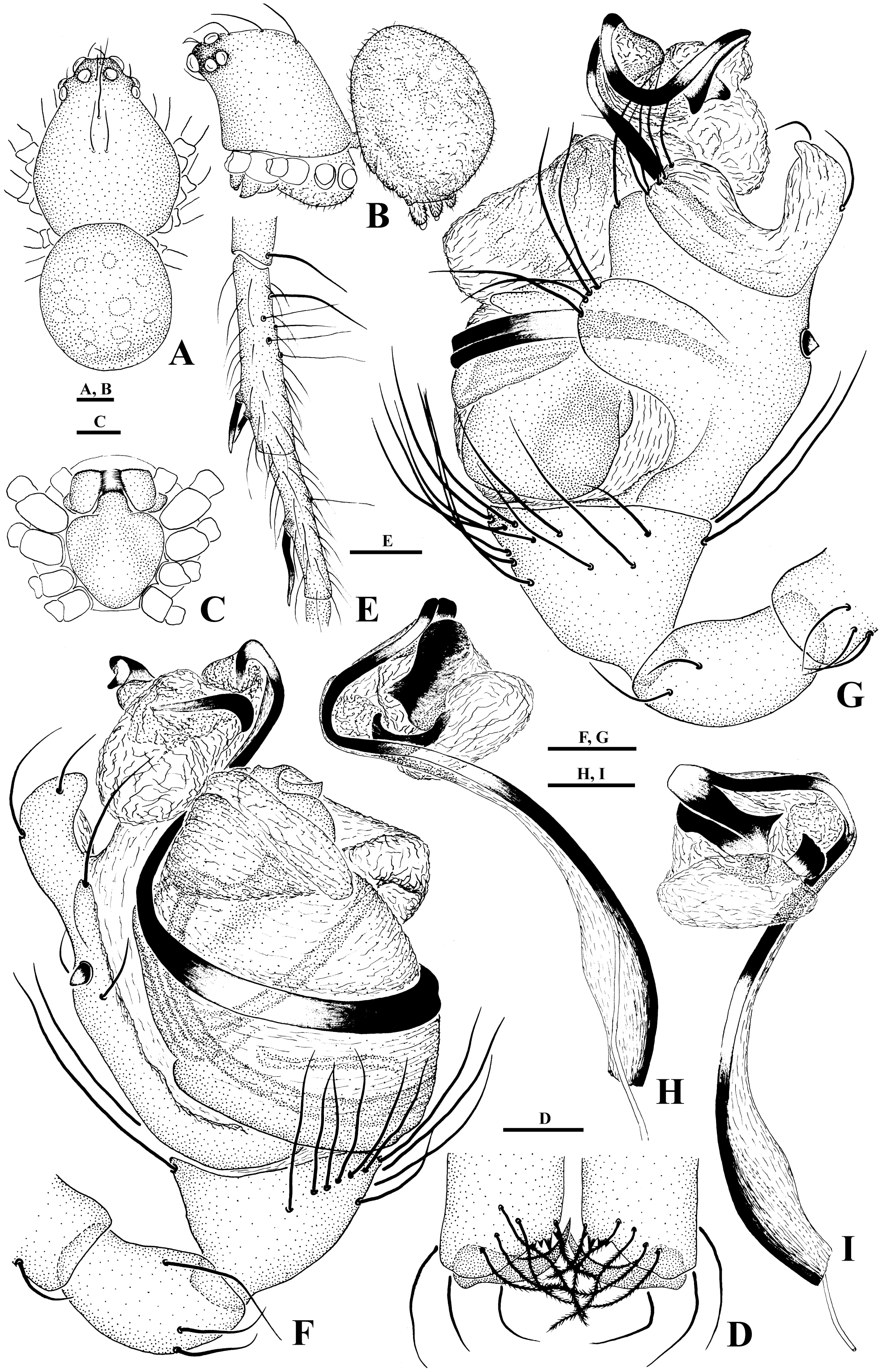

Figure 13. *Mysmenella menglunensis* sp. nov., holotype (male). (A) Body, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxa, ventral; (D) chelicera, posterior; (E) tibia and metatarsus of leg I, anterior; (F) left palp, retrolateral; (G) ditto, prolateral; (H) embolus and conductor, retrolateral; (I) ditto, prolateral. Scale bars: 0.10 for A–C, E; 0.05 for D, F–I.

tibia I with 2 clasping spur, metatarsus I with 1 mesial-curved clasping spur; each metatarsus bears 1 trichobothrium.

Abdomen. Length 0.41, width 0.37. Greyish-black, rounded in dorsum and elliptic in lateral, covered with pale short hairs and modified by 6 pairs of grey-white pigment spots in dorsum. Coloration of abdomen in lateral around thicker than in dorsum and in venter. Spinnerets pale yellow, the anterior larger than the posterior. Anal tubercle pale yellow.

Male palp. Orange, comparatively large; tibia cup-shaped, except for ventral region, a row of long setae almost encircled the distal margin. Cymbium nearly transparent, with a large cymbial spur at the ventral median; paracymbium wider tongue-shaped, located at the anterior-median of retromarginal cymbium. Palpal bulb distinct sclerotized, embedded in a translucent membrane. Embolus very long, integrated with the conductor at palpal apex by several times twisted; the apical structure of embolus considerably complicated. Most part of conductor and median apophyis hidden in the palpal bulb.

Female. Unknown.

Etymology. The specific name is a noun in apposition taken from the type locality, Menglun Town.

Type material. Holotype male (IZCAS): Botanical Garden of Menglun Nature Reserve (21.913°N, 101.267°E; at an elevation of 556±11 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng, 18 July, 2007. Paratypes: 1 male, Rubber plantation (21.908°N, 101.266°E; at an elevation of 569±11 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng, 21 July, 2007; 1 male, Primary tropical seasonal rainforest (21.917°N, 101.275°E; at an elevation of 558±17 meters above sea level), Menglun Town, Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng, 22 July, 2007.

Variation. The male total length ranges from 0.77 to 0.86 (n = 3), the female unknown. Carapace and abdomen no measured.

Natural history. This species was found in the canopy of the tropical rubber plantation.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

Mysmenella gongi Yin, Peng et Bao, 2004
(Figs 14A–D, 15A–H, 20)

Diagnosis. *Mysmenella gongi* is similar to *Mysmenella ogatai* Ono, 2007 from Itayama-cho, Handa-shi, Aichi Prefecture, Japan, but can be recognized by the detailed complex structures of palpal embolus and the copulatory ducts that originated from below the spermathecae and coiled into a loop, with attached membranous rugae.

Description. Male. Total length: 1.03.

Carapace. Length 0.44, width 0.43. Yellow-brown, with dusky markings on margin thicker than on median. Dorsally circular, lateral viewed as trapeziform, marginally smooth. Cephalic region sharply upheaved, flatted on top and forward sharply vertical down.

Eyes. Eight eyes in two rows, all eyes circular, each eye base with brown-black ring. In dorsal view, AER recurved and PER straight; ALE and PLE adjoined. AME 0.07 slightly larger than ALE 0.06, PLE 0.06 equal to PME 0.06; AME–AME 0.06 wider than PME–PME 0.03; AME–ALE 0.03 narrower than AME 0.07. ALE separated by considerable a distance from anterolateral edge of carapace.

Clypeus. Height 0.28, equal to 4 times AMEs diameter.

Chelicerae. Brown-yellow, slightly longer than endites, with 6 promarginal teeth and tiny retromarginal denticles. Cheliceral anterior surface bears long, black and needle-like hairs, unevenly scattered, with plumose hairs one in promargin and three in retromargin. Cheliceral fang normal, little swollen at base.

Labium. Grayish brown, lingulate, no fused to sternum.

Endites. Yellow, longer than wide, with serrula.

Sternum. Length 0.28, width 0.26. Inverted pyriform, pale brown-yellow, with some short hairs, truncated between coxae IV.

Legs. Formula: I, IV, II, III.Yellow greyish, all femora, petallae and tibiae with dusky annular pigmentation. Leg measurements: I 1.42 (0.43 + 0.17 + 0.29 + 0.24 + 0.29); II 1.19 (0.36 + 0.14 + 0.24 + 0.19 + 0.26); III 0.89 (0.26 + 0.12 + 0.14 + 0.17 + 0.20); IV 1.07 (0.33 + 0.13 + 0.20 + 0.19 + 0.21). Femur I with an inconspicuous distally ventral sclerotized spot. Each patella with one distal spine; each tibia with 1 proximal spine and 3 trichobothria; tibia I with two clasping spur, the proximal slightly longer than the distal; metatarsus I with a mesial-curved clasping spur.

Abdomen. Length 0.64, width 0.54. Round in dorsal view, greyish-black, with some pale short hairs, three pairs of grey round spots on dorsum. Spinnerets pale yellow. Anal tuber yellowish.

Male palp. Brown, relatively large. Palpal tibia cup-shaped with a row of long setae almost encircled the whole distal brim. Paracymbium cone-shaped, located at the anterior-median of retromarginal cymbium. Genital bulb thin sclerotized, embedded in a translucent membranous cymbium. Embolus very long, strongly sclerotized, integrated with the conductor at palpal apex after several times twists; the apical structure of embolus considerably complicated. Most part of conductor and median apophyis hidden in the

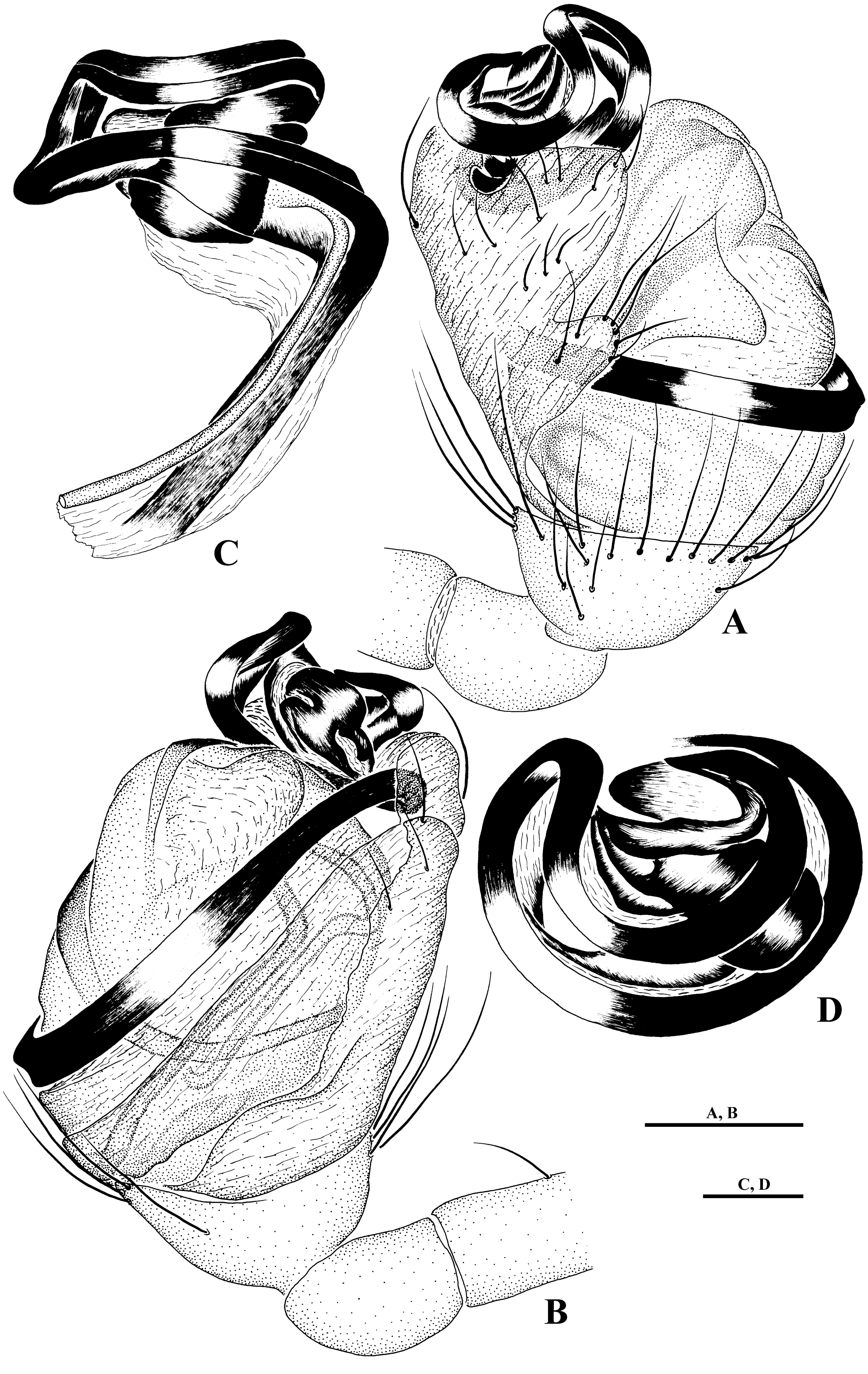

Figure 14. *Mysmenella gongi* Yin, Peng et Bao, 2004., paratype (male). (A) Right palp, prolateral; (B) ditto, retrolateral; (C) embolus and conductor, retrolateral; (D) ditto, apical. Scale bars: 0.10 for A, B; 0.05 for C, D.

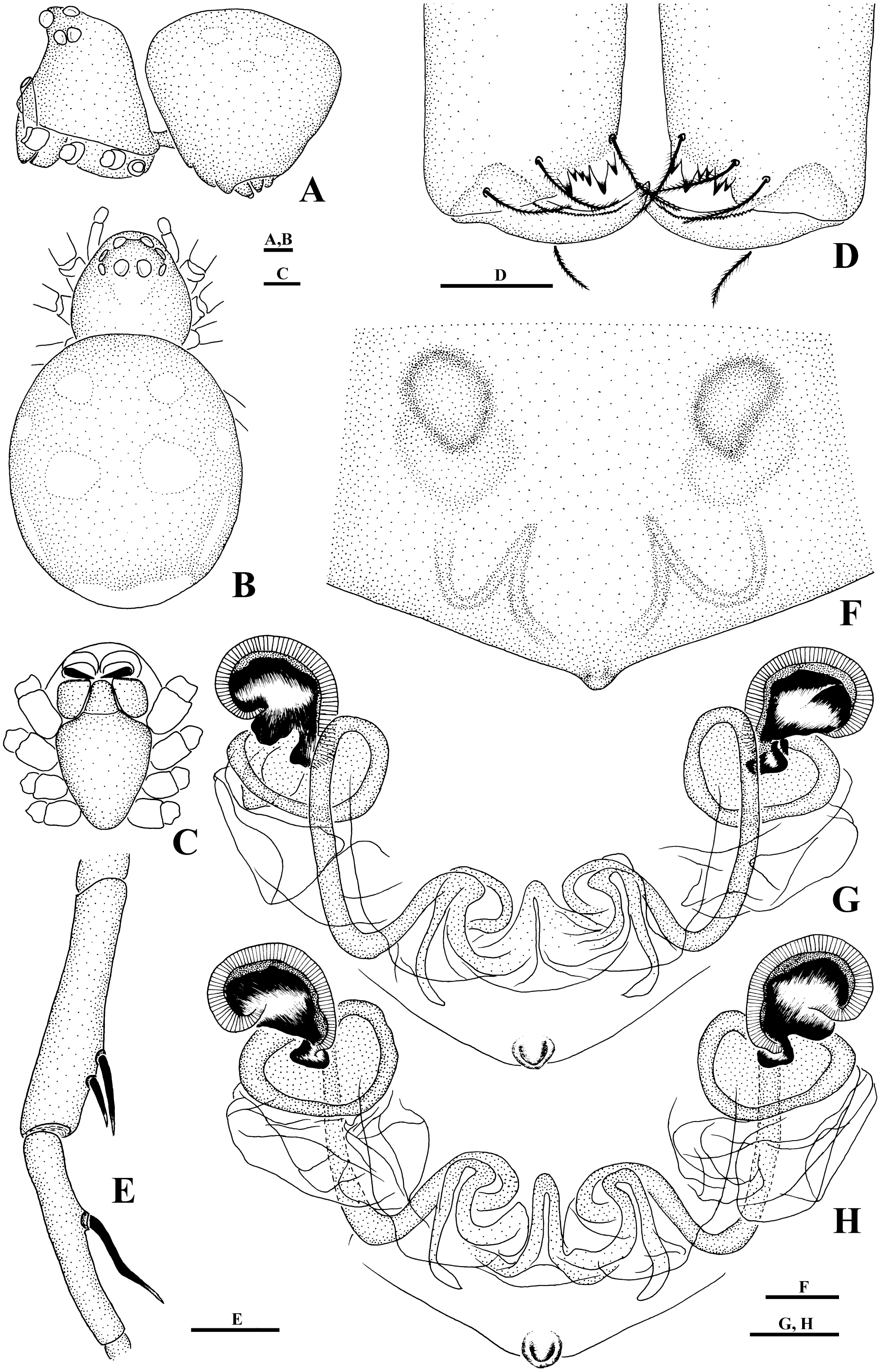

Figure 15. *Mysmenella gongi* Yin, Peng et Bao, 2004. (A) Male body, lateral; (B) female body, dorsal; (C) sternum, labium, endites and coax of female, ventral; (D) male chelicera, posterior; (E) male tibia and metatarsus of leg I, anterior; (F) female epiygnum, ventral; (G) vulvae, dorsal; (H) ditto, ventral. Scale bars: 0.10 for E, F, G and I. 0.05 for H, J–L.

genital bulb. It can be seen to the terminal ends of them.

Female. Total length: 1.29.

Carapace. Length 0.49, width 0.42.

Eyes. Arranged form of all eyes same as in male. AME 0.04 equal to PLE 0.04; PME 0.06 equal to ALE 0.06; AME–AME 0.05 wider than PME–PME 0.03; AME–ALE 0.02 narrower than PME–PLE 0.03.

Clypeus. Height 0.05, narrower than in male.

Chelicerae, endites and labium. Same as in male.

Sternum. Length 0.31, width 0.24. Shape and modification equated with in male.

Legs. Formula: I, IV, II, III. Leg measurements: I: 1.36 (0.42 + 0.19 + 0.28 + 0.22 + 0.24); II: 1.19 (0.34 + 0.18 + 0.23 + 0.20 + 0.23); III: 0.92 (0.27 + 0.13 + 0.17 + 0.16 + 0.20); IV: 1.16 (0.37 + 0.16 + 0.22 + 0.19 + 0.22). Spines and trichobothria of legs as in male. Femur I with a distally ventral sclerotized spot.

Abdomen. Length 0.97, width 0.86. Except for the posterior pair of spots separated in dorsum, coloration and patterns same as in male.

Epigynum. Broad, pale-brown, a tubercular scape on mesially posterior margin.

Vulva. Spermathecae irregular ovoid, connected with copulatory bursa. Copulatory ducts slender, which derived from the outerboard of copu-latory bursa, coiled into a loop and inflected in
“W”-shaped. Most part of copulatory ducts embedded in irregular transparent velum.

Type material. Paratypes: 2 males, 1 female (HNU): Shuangqiao Town (25.517°N, 111.550°E), Daoxian County, Hunan Province, China, collected by Liansu Gong at 1 June, 1987.

Variation. The total length ranges from 1.03 to 1.12 (n = 2) in males and from 1.18 to 1.32 (n = 8) in females. Carapace and abdomen no measured. The abdomen of both sexual has variable spots pattern.

Natural history. This species was found in moist brushwood.

Distribution. China (Hunan) (Fig. 20).

Trogloneta Simon, 1922

Trogloneta denticocleari sp. nov.

(Figs 16A–E, 17A–E, 20)

Diagnosis. This new species is similar to *T. paradoxum* Gertsch, 1960, but can be distinguished by the presence of a denticulate scoop with “V”-shaped handle that connected with cymbium, the short but sturdy embolus that bifurcated distally, the projecting broad epigynal plate with a short wrinkly scape, the copulatory opening that lies at scape backside and the ring-curving copulatory duct that attached with two rostriform apophyses.

Description. Male. Total length: 0.94.

Carapace. Length 0.40, width 0.44. Pale yellow, dorsally nearly round, lateral viewed as trigonal, margin smooth. Some faintly radial stripes extended from median to margin. Ocular area strongly upheaved, located at center, sharply sloping down around. Several hairs on ocular area.

Eyes. Ocular area dimmish. All eyes circular, AME very tiny to almost vanished, each eye base surrounded by darkest ring. Eight eyes in two rows. From dorsal view, AER and PER recurved distinctly. ALE, PME and PLE contiguous and combined a group. AME 0.01 remarkably smaller than ALE 0.04, but PLE 0.04 slightly larger than PME 0.03; AME–AME 0.04 wider than PME–PME 0.03; AME–ALE 0.01 same interval as PME–PLE 0.01. ALE and PLE separated by at least 6 times their diameter from the anterolateral verge of carapace.

Clypeus. Height 0.28, slightly concave below ocular area, equal to 28 times AME diameter.

Chelicerae. Pale yellow, length nearly same as endites, with 3 promarginal and 2 retromarginal teeth. Cheliceral surface without modification but bears several hairs. Cheliceral fang yellow and sturdy.

Labium. Pale yellow and triangular, fused to sternum.

Endites. Pale yellow, longer than wide, concaved at inner margin, apex with serrula.

Sternum. Length 0.30, width 0.28. Heart-shaped, pale-yellow, except offwhite short hairs, without any modified patterns.

Legs. Formula: I, II, IV, III. Pale yellow. Leg measurements: I 1.62 (0.50 + 0.16 + 0.38 + 0.32 + 0.26); II 1.40 (0.44 + 0.16 + 0.30 + 0.28 + 0.22); III 1.20 (0.36 + 0.14 + 0.26 + 0.24 + 0.20); IV 1.44 (0.46 + 0.14 + 0.34 + 0.26 + 0.24). One obviously ventral sclerotized spot on distally femur I. One prolateral distal clasping spur on metatarsus I. Each patella with one distally dorsal spine. Tibiae I–III each with one prolateral proximally dorsal spine and three trichobothria. Tibia IV with one prolateral proximal spine and four trichobothria. Metatarsi I–IV each bears one proximally prolateral trichobothrium.

Abdomen. Length 0.62, width 0.54. Pale yellow and global, without any modified patterns but some offwhite short hairs and tiny yellow dots. The anterior spinneret yellow, larger than the posterior. Anal tuber pale and small.

Male palp. Light yellow-brown, thin sclerotized. Patella smallish. Tibia nearly cup-shaped, with a prolateral trichobothria and surrounded by hairs. Cymbium peculiar, broad prolateral corner stretched for “V”-shaped structure which has a mesial shrunk spoone-shaped apophysis with tiny denticules, a row of hairs on outboard distal margin of and two layer overlapped membranous lobes on distally apex of “V”-shaped structure. Basal haematodocha smooth and sclerotized. Tegulum projected to embolic base. slightly rugose and inner lateral fused to cymbium. Embolus relatively long and strongly sclerotized, gradually diminishing from base to end and incurvated to form a "U"-shaped loop. A forficated embolus end emplaced on translucent wrinkled fishtail conductor apex. Median apophysis hidden behind embolus.

Female. Total length: 1.16.

Carapace. Length 0.46, width 0.42. Pear-shaped, bilateral and posterior thin margin, same coloration and modified patterns as in male but ocular area position forward and no more upheaved as in male.

Eyes. Similar to in male. AME 0.02 smallest, ALE 0.06 slightly larger than PME 0.04 and PLE 0.04. AME–ALE 0.01 narrower than AME–AME 0.04; PME–PME 0.04 wider than PME–PLE 0.02.

Clypeus. Height 0.14, equals to 7 times diameter of AME; ALE separated a distance from anterolateral margin of carapace, but not as in male.

Chelicerae, labium and endites. As in male.

Sternum. Length 0.32, width 0.28. Pale yellow.

Legs. Formula: I, II, IV, III. Coloration same as in male. Leg measurements: I: 1.68 (0.54 + 0.18 + 0.36 + 0.34 + 0.26); II: 1.50 (0.48 + 0.18 + 0.30 + 0.30 + 0.24); III: 1.30 (0.40 + 0.16 + 0.26 + 0.26 + 0.22); IV: 1.62 (0.52 + 0.16 + 0.38 + 0.30 + 0.26). One distally ventral sclerotized spot on femora I; spine and trichobothria on each section of legs same as in male but metatarsus I without clasping spur.

Abdomen. Length 0.78, width 0.82. Coloration, pattern and shape as in male.

Epigynum and vulva. Epigynal area covered with long hairs. A broad ventral plate projected, slightly sclerotized, length equal to width. A short scape on posteriorly mesial margin of ventral plate. Copulatory opening behind the short velar scape. Coiled copulatory ducts arise from the inward lateral round spernathecae that are above copulatory bursae. Copulatory ducts fused to copulatory bursa at median, which posterior end curved to turn into two sclerotized rostriform apophyses.

Etymology. The specific epithet is derived from Latin *dentatus* = denticular and *coclearium* = spoon, means to the distal denticulate spoon-shaped apophysis of cymbium in male palp.

Type material. Holotype male (IZCAS): Yanzidong Cave (25.188°N, 102.807°E; Temperature: 9°C; Humidity: 90%; at an elevation of 2042 meters above sea level), Xiaohe Town, Panlong District, Kunming City, Yunnan Province, China, collected by Yucheng Lin and Jie Liu at 4 April, 2007. Paratypes: 6 males, 29 females, same data as for the holotype; 7 males, 11 females, Baiyan Cave (25.151°N, 103.401°E; Temperature: 12°C; Humidity: 90%; at an elevation of 1875 m a.s.l.), Jiuxiang Town, Yiliang County, Yunnan Province, China, collected by Yucheng Lin and Jie Liu at 9 April, 2007; 5 males, 7 females, Qianxudong Cave (27.099°N, 105.671°E; Temperature: 15°C; Humidity: 95%; at an elevation of 1486±14 meters above sea level), Longdong Village, Yangchangba Town, Dafang County, Guizhou Province, China, collected by Yanfeng Tong and Yucheng Lin at 17 May, 2004; 2 males, 8 females, Yelaodadong Cave (27.182°N, 105.471°E; Temperature: 10°C; Humidity: 90%; at an elevation of 1438 meters above sea level), Sanhe Village, Wen'ge Town, Dafang County, Guizhou Province, China, collected by Yucheng Lin and Jie Liu at 3 May, 2007; 4 males, 5 females, Shilidadong Cave (25.626°N, 104.750°E; Temperature: 13°C; Humidity: 80%; at an elevation of 1680 meters above sea level), Shilipin Village, Zhudong Town, Panxian County, Guizhou Province, China, collected by Yucheng Lin and Jie Liu at 15 April, 2007.

Variation. The body length ranges from 0.78 to 1.04 in males (n = 25) and from 0.96 to 1.30 in females (n = 60). The carapace and abdomen have no measured. In different caves, there are some differences at coloration of ocular area, abdomen as well as male palp and female epigynum slcerotized degree.

Natural history. This species usually inhabitats in dark cave, is found under humid stones or in rock gap.

Distribution. Known only from the type localities in southwestern China (Fig. 20).

Trogloneta speciosum sp. nov.

(Figs 18A–E, 19A–I, 20)

Diagnosis. This new species is similar to *Trogloneta granulum* Simon, 1922 and *Trogloneta madeirense* Wunderlich, 1987, but can be distinguished by the detailed structures of male palp, the shape of female vulva and the following somatic characters: the absence of anterior median eye, the presence of peculiarly pretty pattern on dorsum surface in both sexes, the apically and mesially sunk cymbium in male palp, the interim tortile and distal blunt embolus, the shape of tegulum, the two inverted "U"-shaped spermathecae which intertwisted end to end, the smooth "U"-shaped membranous dorsal plate with a short wrinkly scape, the pair of almost contiguous copulatory bursae appended round velar sac.

Description. Male. Total length: 0.81.

Carapace. Length 0.32, width 0.32. Pale yellow, pear-shaped, lateral viewed as trigonal, margin smooth, with two longitudinal grey stripes. Ocular area strongly elevated, sharply sloping down around. Few hairs on cephalic region.

Eyes. Ocular area greyish. AME absent. Six eyes in two groups, each similar to circular, without black ring. From dorsal view, PER distinctly straight. ALE,

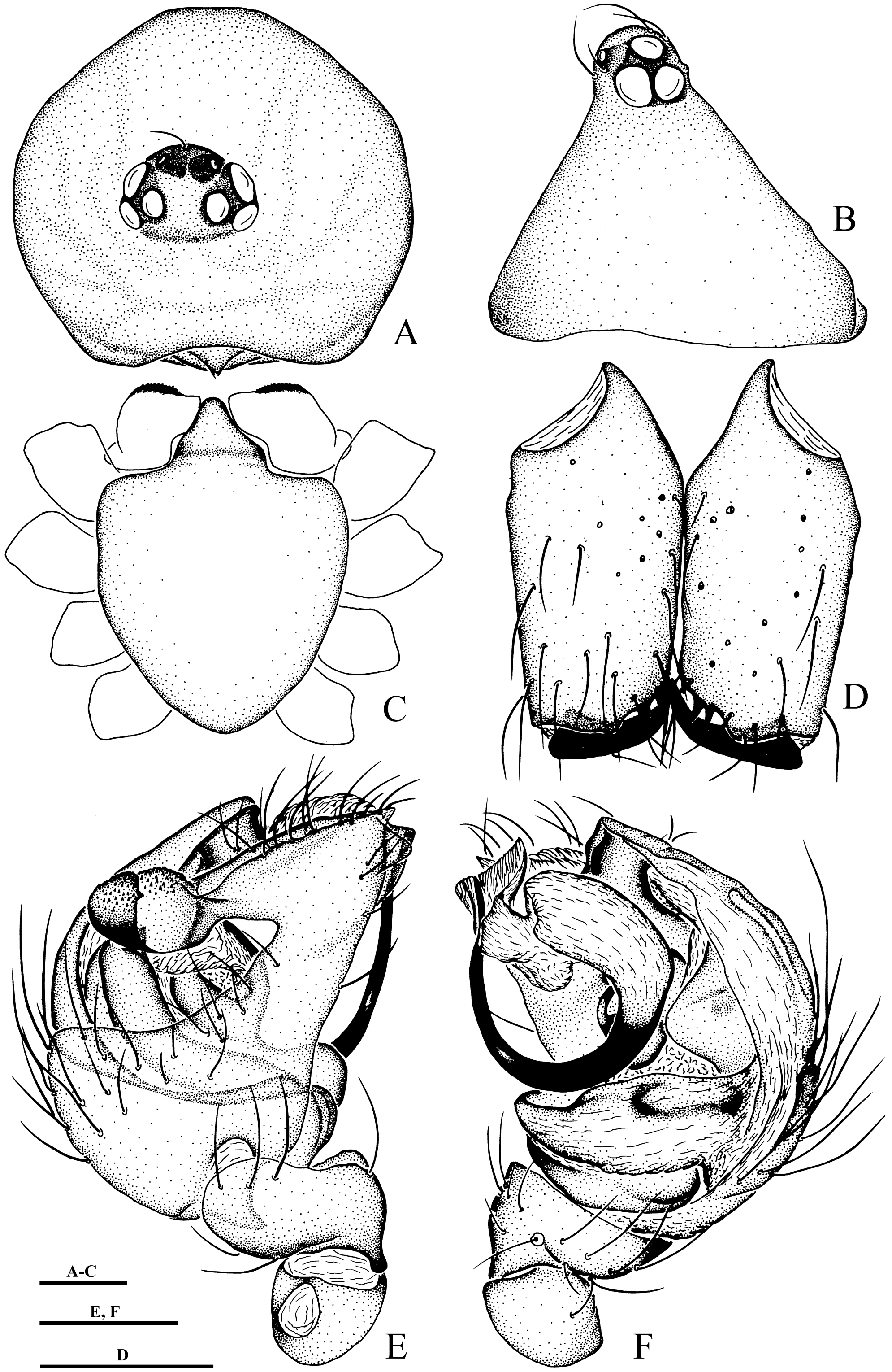

Figure 16. *Trogloneta denticocleari* sp. nov., holotype (male). (A) Carapace, dorsal; (B) ditto, lateral; (C) sternum, labium, endites and coxae, ventral view; (D) chelicerae, anterior view; (E) left palp, prolateral; (F) ditto, retrolateral. Scale bars: 0.10.

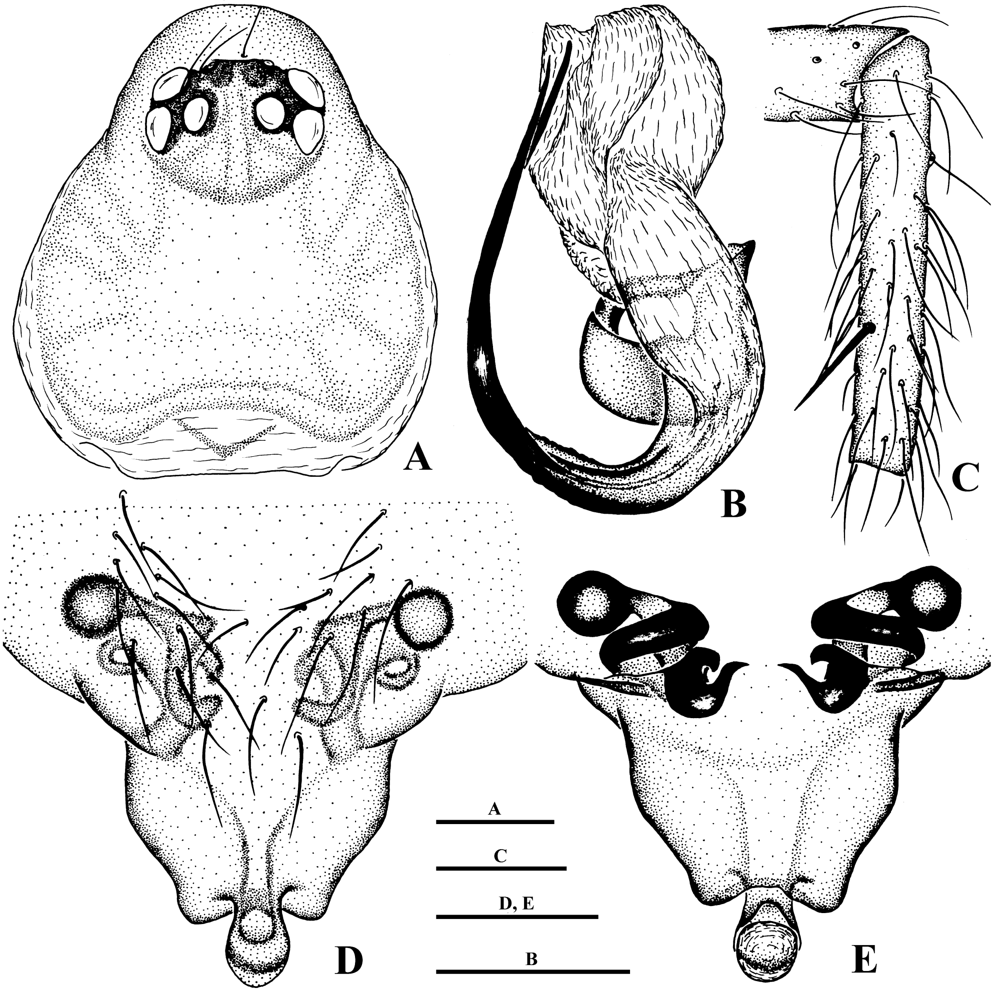

Figure 17. *Trogloneta denticocleari* sp. nov. (A) Female carapace, dorsal; (B) male embolic division, ventral; (C) metatarsus I of male, prolateral; (D) epigynum, ventral; (E) vulva cleared, dorsal. Scale bars: 0.10.

PME and PLE contiguous. ALE 0.06 largest, PLE 0.05 sub-size and PME 0.04 smallest; PME–PME 0.01 narrower obviously than ALE–ALE 0.04. ALE and PLE separated at least 2.50 times diameter of ALE from the anterolateral margin of carapace.

Clypeus. Distinctly concave below ocular area, height equal to 3 times ALE diameter.

Chelicerae. Pale yellow and small, shorter than endites, Cheliceral fang furrow with 2 promarginal teeth and 1 plumose hair; 1 retromarginal tooth and 4 plumose hairs. Cheliceral posteriorly mesial surface bears short spines. A long hair on distally bilateral.

Labium. Pale yellow and equilateral triangle, no fused to sternum.

Endites. Pale yellow, rhombic, long equal to wide, with tiny serrula.

Sternum. Length 0.22, width 0.23. Pale-yellow, nearly round, median plump, truncated between coxae IV. Without any modified pattern but densely covered with pale short hairs.

Legs. Formula: I, II, IV, III. Yellowy. Leg measurements: I 0.91 (0.29 + 0.12 + 0.18 + 0.17 + 0.16); II 0.83 (0.27 + 0.11 + 0.16 + 0.17 + 0.13); III 0.71 (0.22 + 0.10 + 0.12 + 0.14 + 0.12); IV 0.80 (0.27 + 0.10 + 0.17 + 0.66 + 0.12). One ventral sclerotized spot on distally femur I. Each patella with one distally dorsal spine. Tibiae I–IV each with one proximally prolateral spine and three trichobothria. A prolateral mesial clasping spur on metatarsus I. Metatarsi I–III each bears one proximal trichobothrium.

Abdomen. Length 0.44, width 0.42. Pale yellow, three pair of grey spots and two irregular longitudinal

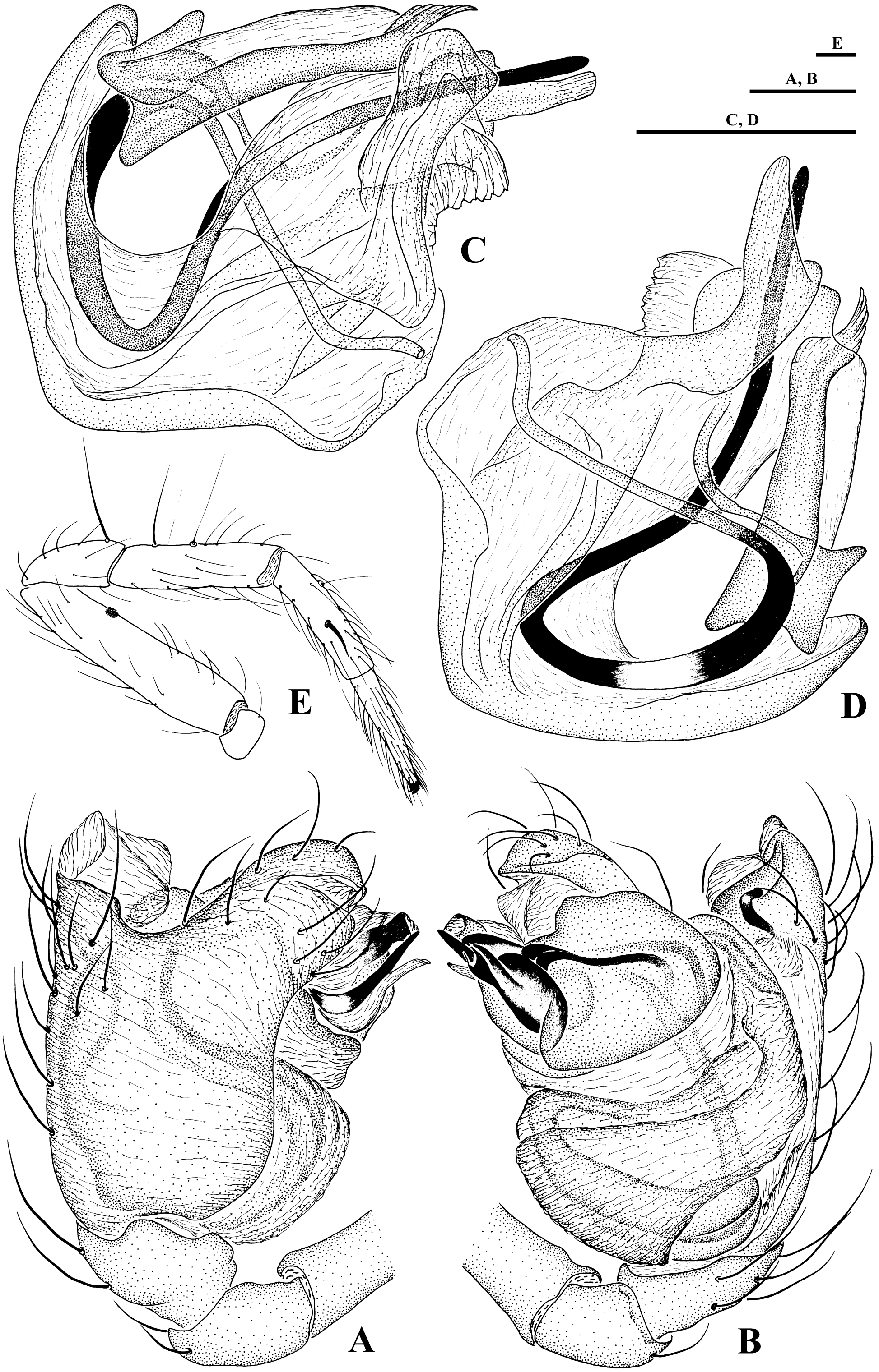

Figure 18. *Trogloneta speciosum* sp. nov., holotype (male). (A) Left palp, prolateral; (B) ditto, retrolateral; (C) embolic division, ventral; (D) ditto, dorsal; (E) left leg I, prolateral. Scale bars: 0.05.

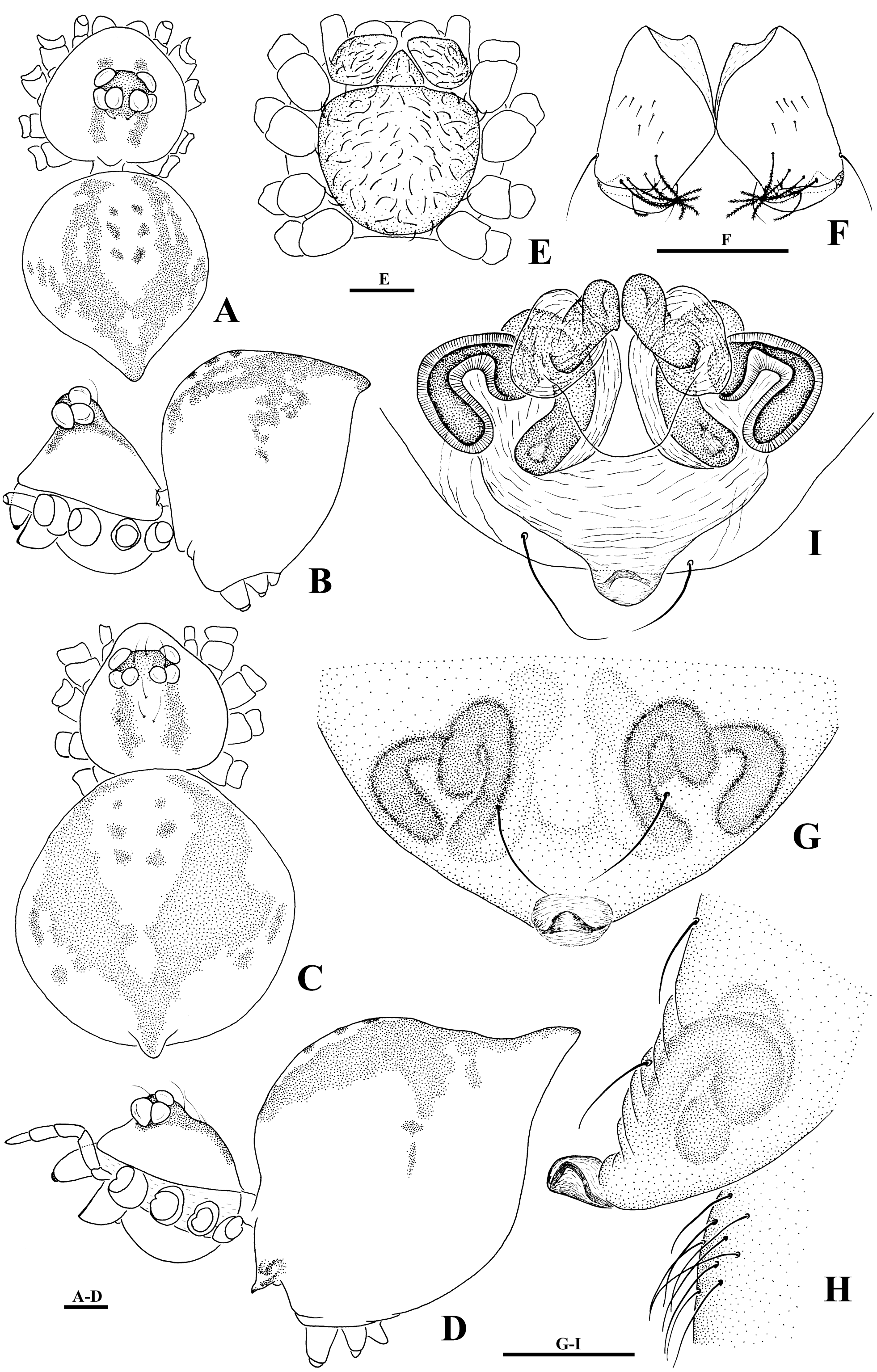

Figure 19. *Trogloneta speciosum* sp. nov. (A) Male body, dorsal; (B) ditto, lateral; (C) female body, dorsal; (D) ditto, lateral; (E) sternum, labium, endites and coxae of male, ventral; (F) male chelicerae, posterior; (G) epigynum, ventral; (H) ditto, lateral; (I) vulva cleared, dorsal. Scale bars: 0.01 for A–F; 0.05 for G–I.

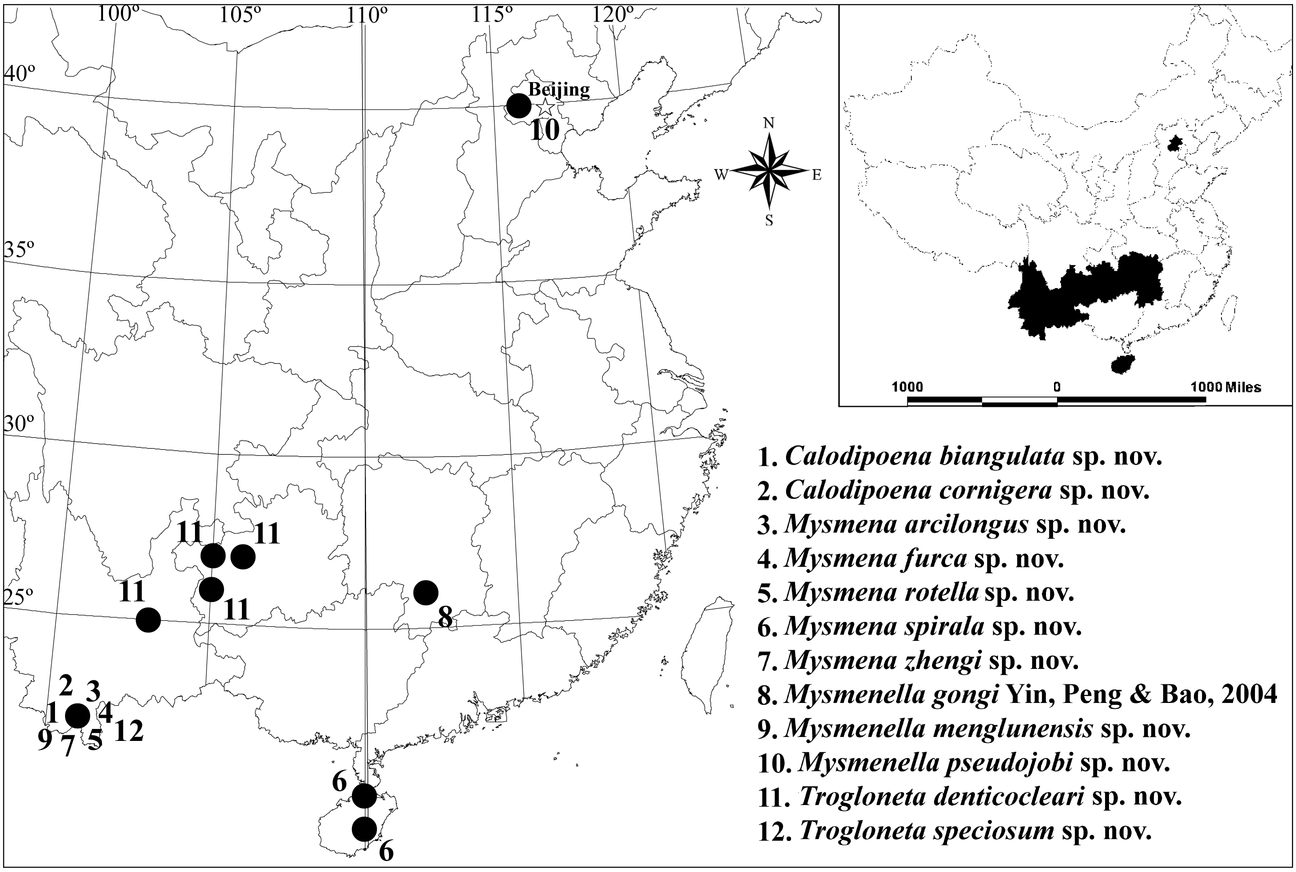

Figure 20. Locality records for twelve mysmenid spider species in China.

stripe patterns on anterior dorsum. A hump at posterior end. Anterior spinnerets yellow, larger than the pale yellow posterior. Anal tuber yellowy and smaller than posterior spinnerets.

Male palp. Light yellow, thin sclerotized. Femur long without modification. Patella and tibia subequal in length, no modified but few hairs on distal margin. Cymbium large, membranous, bears long hairs on outside and apical margin. Cymbial apex divided into velar lobes and distally mesial margin recurved. Basal haematodocha wrinkly membranous. Tegulum smooth and translucent. Embolus long and sclerotized, most part coiled into a loop and embedded in tegulum. Conductor paralleled distal embolus which end is rugose and tip-tilted.

Female. Total length: 1.12.

Carapace. Length 0.33, width 0.32. Coloration, shape and pattern same as in male.

Eyes. Similar to in male but ocular area raised no as in male. ALE 0.06 larger than PLE 0.04 and than PME 0.03. ALE–ALE 0.06 equal to diameter of ALE; PME–PME 0.02 narrower than diameter of PME. ALE departs 1.80 times ALE diameter from the anterolateral verge of carapace.

Clypeus. Narrower than in male.

Chelicerae. Larger than in male, subequal to endites in length.

Labium. As in male.

Endites. As in male.

Sternum. Length 0.22, width 0.27. Wider than and plump as that in male.

Legs. Formula: I, II, IV, III. Yellowy. Leg measurements: I: 0.97 (0.31 + 0.13 + 0.19 + 0.19 + 0.14); II: 0.89 (0.28 + 0.13 + 0.17 + 0.17 + 0.14); III: 0.73 (0.21 + 0.11 + 0.13 + 0.16 + 0.12); IV: 0.86 (0.28 + 0.11 + 0.18 + 0.17 + 0.12). One distally ventral sclerotized spot on femur I. Of each section of legs spine and trichobothria as in male, except without clasping spur.

Abdomen. Length 0.76, width 0.64. Coloration, shape and patterns as in male. The posterior hump tip-tilted, larger than that in male.

Epigynum. Posteriorly middle scape short, projected and weakly rugose membrane, but no extended; with a small slender sclerotized ventral notch in its end. Epigynal area scarcely hairs.

Vulva. Spermathecae clearly divided into two inverted “U”-shaped part which intertwisted end to end, and obviously sclerotized. Its middle part and copulatory bursae embedded in translucent membranous tissue. Copulatory ducts unconspicuous, behind translucent smooth dorsal plate.

Etymology. The specific name derived from Latin *speciosus* = beautiful, indicates the nice figure of the species.

Type material. Holotype male (IZCAS): Primary tropical seasonal rainforest in Menglun Nature Reserve (21.957°N, 101.217°E; at an elevation of 744±15 meters above sea level), Mengla County, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, China, collected by Guo Zheng at 30 July, 2007. Paratypes: 1 male, 3 female, same data as for the holotype.

Variation. The body length ranges from 0.81 to 0.86 in males (n = 2) and from 1.08 to 1.22 in females (n = 3). The carapace and abdomen have no measured data.

Natural history. This species usually lives at the canopy above tropical rainforest.

Distribution. Known only from the type locality in southwestern China (Fig. 20).

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Four new cave–dwelling *Platocoelotes* species (Araneae: Amaurobiidae) from Guangxi and Guizhou, China

JIE LIU[1, 2] & SHUQIANG LI[1, 3]

[1] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China*
[2] *Graduate University of Chinese Academy of Sciences, Beijing 100039, P. R. China*
[3] *Corresponding author. E-mail: lisq@ioz.ac.cn*

Abstract

Four new species of the genus *Platocoelotes*, collected from caves in Guangxi and Guizhou of southwestern China, are diagnosed, described and illustrated: *Platocoelotes ampulliformis* **sp. nov.**, *Platocoelotes brevis* **sp. nov.**, *Platocoelotes furcatus* **sp. nov.**, and *Platocoelotes strombuliformis* **sp. nov.**. The type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

Key words: Taxonomy, new species, copulatory organs, morphology, southern China

Introduction

Many cave animals are rare, and include ancient, basal forms no longer found on the surface. They can provide important information in studies of evolution and ecology. There is a growing agreement that more effort is needed to ensure the survival of present wildlife populations in caves, and success or failure will depend on our basic knowledge of these populations (Furman & Özgül, 2004).

In the past five years, a series of surveys on cave–dwelling spiders of China were made by the colleagues of the Chinese Academy of Sciences in more than 500 caves. The field work suggests that cave–dwelling spiders are highly diverse and abundant. However, many cave–dwelling spiders appear to be restricted to one or several caves. It shows that damage of some caves may likely cause the extinction of numerous cave species. Due to the rapid growth of cave tourism, the survey on Chinese cave spiders is becoming more and more urgent.

The current paper reports part of the results of our survey in 2007. Spiders were collected in 120 caves in Yunnan–Guizhou Plateau (including Yunan Province, Guizhou Province and part of Guangxi Zhuang Autonomous Region) of China. Four new species of the genus *Platocoelotes* were discoveried and are described in this paper.

The genus *Platocoelotes* was established and revised by Wang (2002; 2003), which contains five known species and all of them are distributed in China, i.e. *Platocoelotes impletus* (Peng & Wang, 1997), *Platocoelotes icohamatoides* (Peng & Wang, 1997), *Platocoelotes kailiensis* Wang, 2003, *Platocoelotes lichuanensis* (Chen & Zhao, 1998) and *Platocoelotes polyptychus* Xu & Li, 2007 (Platnick, 2008). All the cave–dwelling *Platocoelotes* species, including *P. polyptychus* and four new species reported in the current paper, exhibit several characters different from epigeal *Platocoelotes* species, i.e. a single patellar apophysis, a short cymbial furrow, and a different female genitalia. However, the presence of a ventral conductor apophysis on the male palp, the broad, shallow atrium and the distinct epigynal hoods in the female epigynum indicate that they are congeneric with the type species of *Platocoelotes*.

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Material and methods

Specimens were examined with an Olympus SZ40 stereomicroscope; details were studied with an Olympus BX41 compound microscope. All illustrations were made using an Olympus drawing tube. Male palps and female epigyna were examined and illustrated after being dissected from the spider bodies.

All measurements are given in millimeters. Leg measurements are given as: Total length (femur, patella + tibia, metatarsus, tarsus). Only structures (e.g., palp, legs) of the left body side were described and measured. The terminology used in text and figure legends follows Wang (2002).

Abbreviations used in text and legends: A = atrium; ALE = anterior lateral eye; Alt = altitude; AME = anterior median eye; AME–ALE = distance between AME and ALE; AME–AME = distance between AME and AME; ALE–PLE = distance between ALE and PLE; C = conductor; CD = copulatory duct; CDA = dorsal conductor apophysis; CF = cymbial furrow; E = embolus; FD = fertilization duct; H = epigynal hood; Hu = humidity; LTA = lateral tibial apophysis; PA = patellar apophysis; PLE = posterior lateral eye; PME = posterior median eye; PME–PLE = distance between PME and PLE; PME–PME = distance between PME and PME; RTA = retrolateral tibial apophysis; S = spermatheca; SH = spermathecal head; ST = subtegulum; T = tegulum; Te = temperature; TS = tegular sclerite.

All types of the new species are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS). Type specimen photos of the species included in this paper can be viewed from website http://www.ChineseSpecies.com which was created and maintained by Li & Wang (2008).

Taxonomy

Family Amaurobiidae Thorell, 1870

Subfamily Coelotinae F.O.P. –Cambridge, 1893

Genus *Platocoelotes* Wang, 2002

Diagnosis: Male palp with two patellar apophyses (one of them strongly reduced in some specimens), conductor with ventral and dorsal apophysis in most species, median apophysis reduced. Epigynal teeth absent, epigynal hoods distinct, atrium broad and shallow, copulatory ducts short in most species.

Distribution: China (Guangxi, Guizhou, Hubei, Hunan, Sichuan).

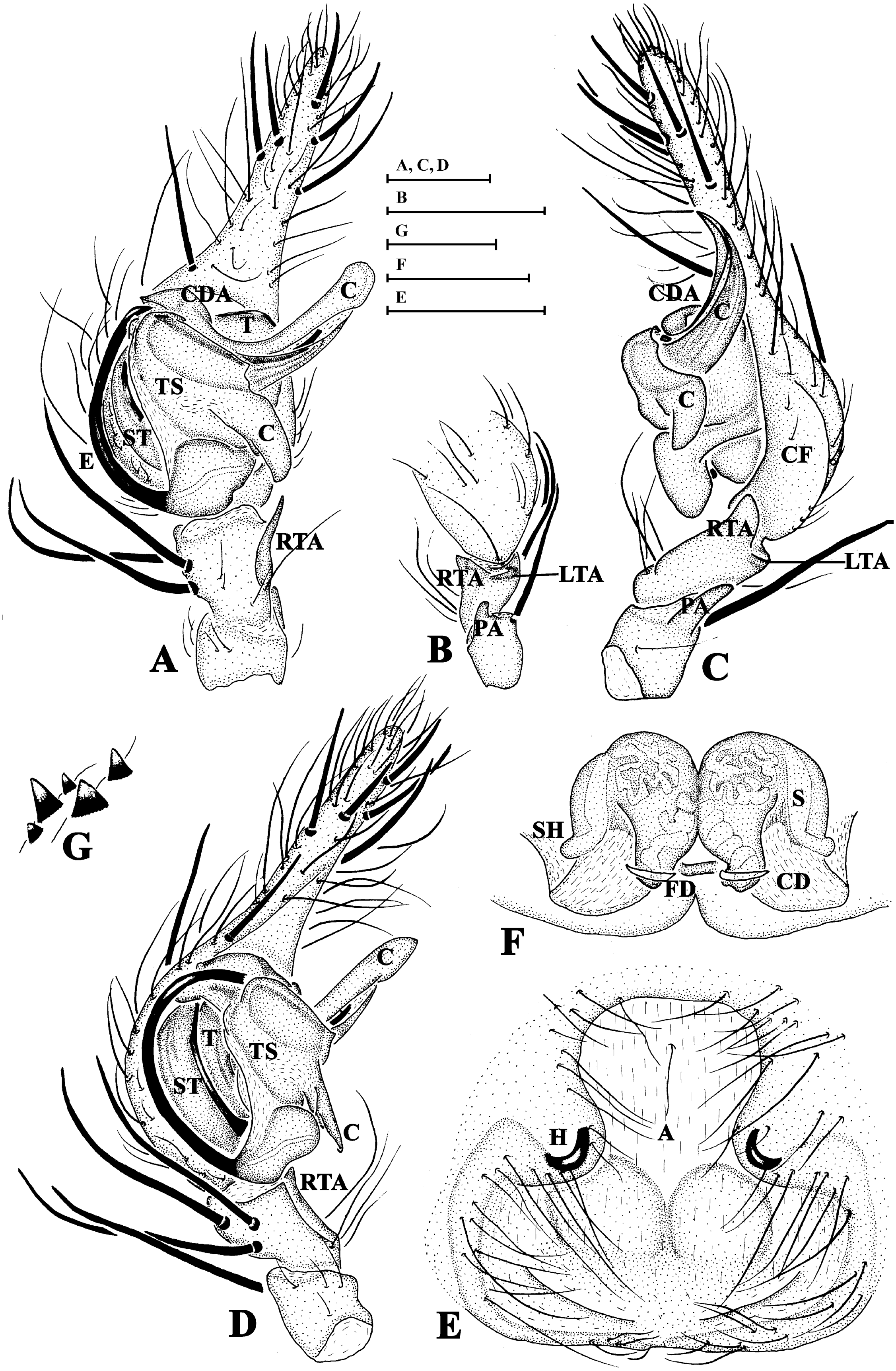
Platocoelotes ampulliformis sp. nov.

Figs 1A–G, 5

Type material: Holotype male, 2 male and 13 female paratypes, CHINA: Guizhou Province, Nayong County, Laowaba Town, Baqingjiao Village, Qingwadong Cave (26º50.309´N, 105º30.325´E, Alt: 1420m, Te: 10ºC, Hu: 90%), 27 April 2007, Yucheng Lin & Jie Liu leg.; 3 male and 7 female paratypes, CHINA: Guizhou Province, Xishui County, Donghuang Town, Mulanba Village, Rongdong Cave (28º19.500´N, 106º10.112´E, Alt: 1180m, Te: 13ºC, Hu: 94%), 9 May 2007, Yucheng Lin & Jie Liu leg.

Etymology: The specific name is a compound word from the Latin *ampulla*, meaning flask, ampulla, and the Latin suffix *-formis, -e,* meaning -shaped, and refers to the ampullate atrium of this species; adjective.

Diagnosis: The new species can be distinguished from other *Platocoelotes* species by its unique conductor that is strongly modified, having a long and narrow cavity in males, and by its uniquely ampullaceous atrium in females.



FIGURES 1A–G. *Platocoelotes ampulliformis* **sp. nov.**, A. Male pedipalpus, ventral view; B. Same, dorsal view; C. Same, retrolateral view; D. Same, prolateral view; E. Epigynum, ventral view; F. Vulva, dorsal view; G. Male cheliceral teeth, ventral view. Scale bars: A–C, D = 0.1 mm, E, F, G = 0.2 mm.

Description. Male (measurements of the holotype): Total length 5.8. Prosoma length 2.8, width 2.2; Opisthosoma length 3.0, width 2.1. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE subequal to PME and slightly smller than PLE; AME-AME, AME–ALE and ALE–PLE close together, PME–PLE about one-third AME diameter, PME–PME separated by roughly half of AME diameter. Clypeal height about half of AME diameter or slightly more. Leg formula: IV, I, II, III; leg measurements: I: 13.9 (3.5, 4.5, 2.4, 3.5); II: 11.3 (3.2, 3.2, 2.9, 2.0); III: 10.5 (2.8, 3.1, 2.8, 1.8); IV: 14.5 (3.6, 4.2, 4.5, 2.2). Chelicerae with three promarginal and two retromarginal teeth. Patellar apophysis long, its length subequal to the width of patella; RTA with its distal end blunt and slightly extending beyond distal margin of tibia; lateral tibial apophysis short, about less than one-fifth of RTA from a retrolateral view and adjacent to RTA; cymbial furrow about one-third of cymbial length; conductor exhibiting a long and narrow cavity (its length almost half of cymbial length, its width of the widest part about one-fourth its length from a ventral view), sheath-like; distal conductor margin slightly curved; dorsal conductor apophysis small; ventral conductor apophysis short and blunt (its length about one-fifth of cymbial length, its width of the widest part about half of its length from a ventral view); tegulum undeveloped, indistinct in a ventral view; embolus filiform, arising in a 6-o'clock-position, running prolaterally in a semicircle, then lying in conductor (Figs 1A–E).

Female (measurements of paratype): Total length 6.0. Prosoma length 2.8, width 2.0; Opisthosoma length 3.2, width 2.1. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PME subequal to PLE, and larger than ALE; AME-AME, AME–ALE and ALE–PLE close together, PME–PLE about one-third AME diameter, PME–PME separated by roughly half of AME diameter. Clypeal height about AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 11.8 (3.2, 3.8, 2.8, 2.0); II: 10.2 (2.8, 3.3, 2.5, 1.6); III: 9.3 (2.6, 2.9, 2.4, 1.4); IV: 12.3 (3.4, 3.8, 3.3, 1.8). Chelicerae with three promarginal and two retromarginal teeth. Epigynal hoods situated anteriorly, the distance between epigynal hoods and epigastric furrow about three-fifths of atrium length; atrium large, occupying about two-thirds of epigynum, ampullaceous; copulatory ducts wide (its width more than half of the width of the widest part of spermatheca), originating posteriorly and laterally; spermathecae simple and situated medially close together; spermathecal heads short (its length slightly less than one-fifth of the width of the widest part of spermatheca), situated posteriorly and laterally (Figs 1F–G).

Distribution: China (Guizhou) (Fig. 5).

Platocoelotes brevis **sp. nov.**

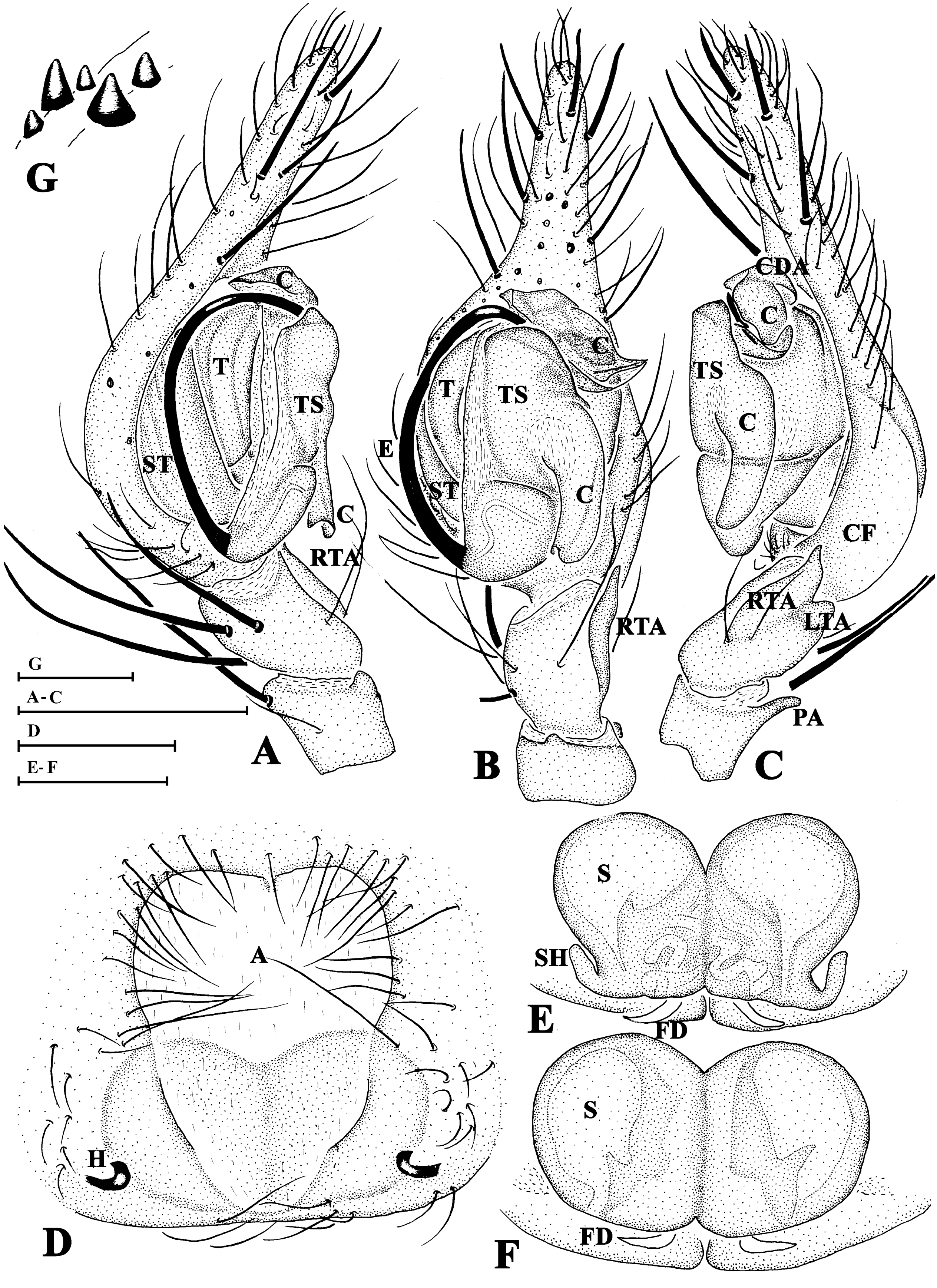
Figs 2A–G, 5

Type material: Holotype male, 1 male and 9 female paratypes, CHINA: Guizhou Province, Panxian County, Chengguan Town, Biyundong Cave (25º46.527´N, 104º38.278´E, Alt: 1468m, Te: 14ºC, Hu: 92%), 13 April 2007, Yucheng Lin & Jie Liu leg.; 1 male and 13 female paratypes, CHINA: Guizhou Province, Panxian County, Banqiao Town, Zhaoguan Village, Danxia Mountain, Zimudong Cave (25º40.505´N, 104º37.607´E, Alt: 1798m, Te: 12ºC, Hu: 90%), 14 April 2007, Yucheng Lin & Jie Liu leg.

Etymology: The specific name is derived from the Latin *brevis, -e*, meaning short, referring to the short conductor; adjective.

Diagnosis: The male of this new species can be distinguished from other *Platocoelotes* species by its short and wide conductor. The female can be separated from other *Platocoelotes* species by its simple, globular, closely situated spermathecae.

Description. Male (measurements of the holotype): Measurements: Total length 6.7. Prosoma length 3.3, width 2.4; Opisthosoma length 3.4, width 2.2. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME, ALE, PME and PLE subequal; AME–AME, AME–ALE and ALE–PLE close together, both PME–PLE and PME–PME about half of AME diameter. Clypeal height about



FIGURES 2A–G. *Platocoelotes brevis* **sp. nov.**, A. Male pedipalpus, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Epigynum, ventral view; E, F. Vulva, dorsal view (specimens from Biyundong Cave, Guizhou); G. Male cheliceral teeth, ventral view. Scale bars: 0.2 mm.

half of AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 14.5 (3.8, 4.7, 3.7, 2.3); II: 12.4 (3.4, 4.0, 3.3, 1.7); III: 11.8 (3.1, 3.6, 3.3, 3.8); IV: 14.9 (4.1, 4.3, 4.2, 2.3). Chelicerae with three promarginal and two retromarginal teeth. Patellar apophysis relatively long, its length slightly more than half of patellar width; RTA with its distal end sharp and slightly extending beyond distal margin of tibia; lateral tibial apophysis long, about one-fourth of RTA from a retrolateral view and close-by RTA; cymbial furrow about one-third of cymbial length; conductor exhibiting a short and wide cavity (its length shorter than one-third of cymbial length, its width of the widest part subequal to half of its length from a ventral view); dorsal conductor apophysis large, bell-shaped in a retrolateral view; ventral conductor apophysis slightly long and blunt (its length about one-third of cymbial length, its width of the widest part about one-third its length from a ventral view); tegulum well developed, distinct in a ventral view; embolus filiform, arising in a 6-o'clock-position, running prolaterally in a semicircle, then lying in conductor (Figs 2A–E).

Female (measurements of paratype): Measurements: Total length 8.9. Prosoma length 4.0, width 2.7; Opisthosoma length 4.9, width 3.6. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PME subequal to PLE, and larger than ALE; both AME–AME and AME–ALE about one-fourth of AME diameter, ALE–PLE close together, both PME–PLE and PME–PME about three-fourths of AME diameter. Clypeal height about AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 13.1 (3.5, 4.1, 3.4, 2.1); II: 12.1 (3.3, 4.0, 2.9, 1.9); III: 10.5 (3.0, 3.5, 2.9, 1.1); IV: 13.9 (3.0, 4.6, 4.3, 2.0). Chelicerae with three promarginal and two retromarginal teeth. Epigynal hoods situated posteriorly close to epigastric furrow, the distance between epigynal hoods and epigastric furrow about one-sixth atrium length; atrium relatively large, occupying more than half of epigynum, narrowing gradually from anterior to posterior; copulatory ducts not visible from dorsal view; spermathecae simple, rounded, situated close together; spermathecal heads relatively long (its length about one-third of the width of the widest part of spermatheca), situated posteriorly and laterally (Figs 2F–G).

Variation: Spermathecal heads of some individuals are covered by large spermathecae in a dorsal view (Fig. 2G).

Distribution: China (Guizhou) (Fig. 5).

Platocoelotes furcatus sp. nov.

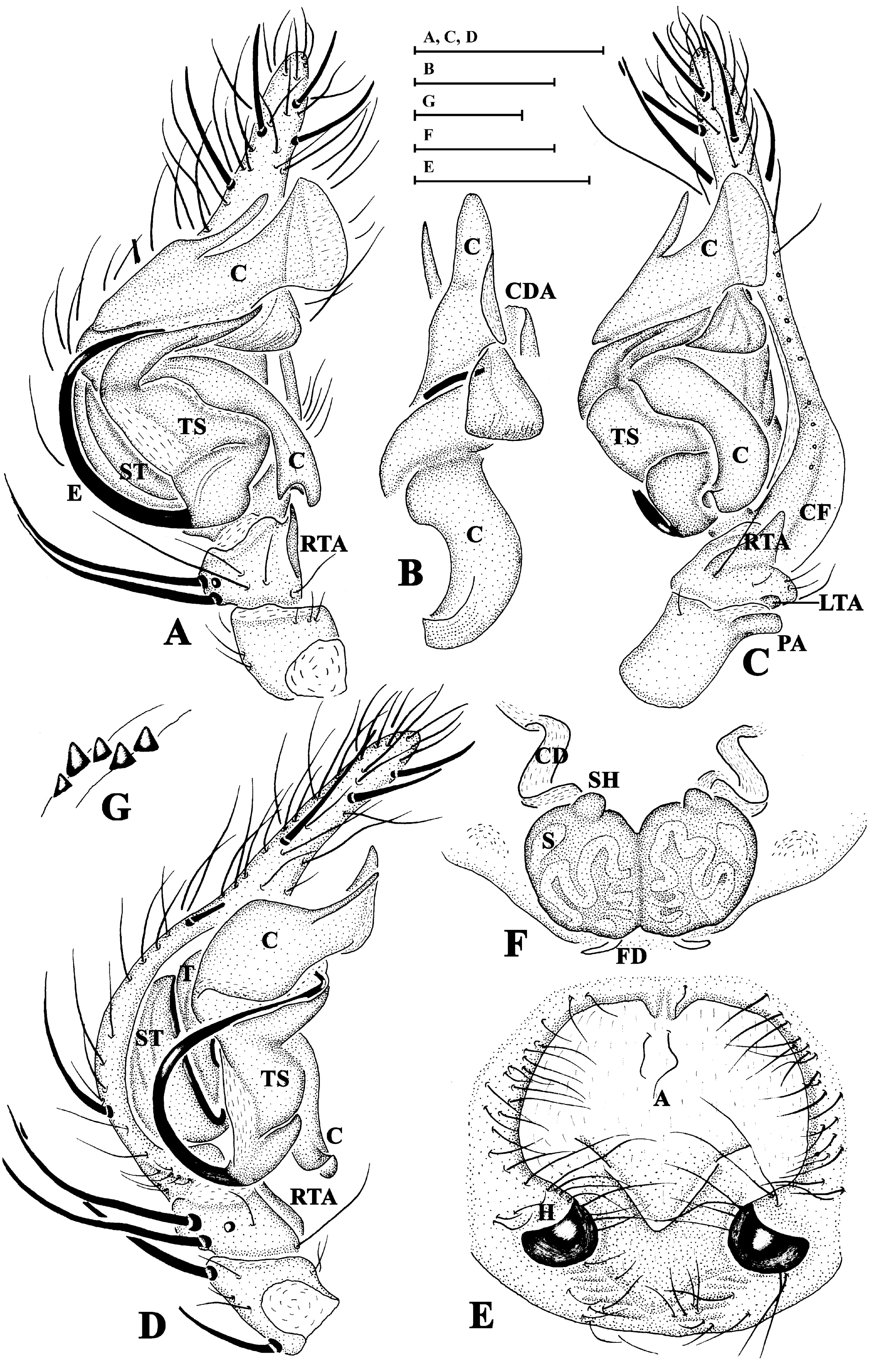
Figs 3A–G, 5

Type material: Holotype male, 3 male and 2 female paratypes, CHINA: Guangxi Zhuang Autonomous Region, Longlin County, Yanchang Town, Weiyao Village, Xiaoshuidong Cave (24º51.728´N, 105º10.694´E, Alt: 950m, Te: 14ºC, Hu: 85%), 17 March 2007, Yucheng Lin & Jie Liu leg.; 3 male and 2 female paratypes, CHINA: Guangxi Zhuang Autonomous Region, Longlin County, Yanchang Town, unnamed Cave (24º51.774´N, 105º12.032´E, Alt: 952m, Te: 15ºC, Hu: 80%), 17 March 2007, Yucheng Lin & Jie Liu leg.

Etymology: The specific name is taken from the Latin word *furca, -ae,* meaning fork, and refers to the furcate conductor of this species; adjective.

Diagnosis: The new species can be separated from other *Platocoelotes* species by its uniquely furcated distal conductor margin, the long and narrow copulatory ducts, originating laterally from the atrium.

Description. Male (measurements of the holotype): Measurements: Total length 5.4. Prosoma length 2.6, width 2.0; Opisthosoma length 2.8, width 1.6. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PME slightly smaller than PLE, but larger than ALE; AME–AME, AME–ALE and ALE–PLE close together, both PME–PLE and PME–PME about half of AME diameter. Clypeal height about four-fifths AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 11.5 (3.2, 3.2, 3.1, 2.0); II: 10.4 (2.9, 3.1, 2.6, 1.8); III: 9.8 (2.5, 3.0, 2.7, 1.6); IV: 13.6 (3.5, 4.0, 4.0, 2.1). Chelicerae with three promarginal and two retromarginal teeth. Patellar



FIGURES 3A–G. *Platocoelotes furcatus* **sp. nov.**, A. Male pedipalpus, ventral view; B. Dorsal conductor apophysis, retrolateral view; C. Male pedipalpus, retrolateral view; D. Same, prolateral view; E. Epigynum, ventral view; F. Vulva, dorsal view; G. Male cheliceral teeth, ventral view. Scale bars: 0.2 mm.

apophysis relatively long, its length subequal to half of patellar width; RTA with its distal end sharp and slightly extending beyond distal margin of tibia; lateral tibial apophysis small, less than one-fifth of RTA from a retrolateral view and widely separated from RTA (the distance between the RTA and the lateral tibial apophysis about half of tibial width); cymbial furrow about one-fourth of cymbial length; conductor exhibiting a long and wide cavity (its length more than half of cymbial length, its width of the widest part subequal to half of its length from a ventral view), distal conductor margin furcated, the branch clavate; dorsal conductor apophysis large; ventral conductor apophysis long (its length about half of cymbial length, its width of the widest part about one-fourth its length from a ventral view), blunt, strongly extended proximally, almost reaching the distal end of RTA; tegulum less developed, indistinct in a ventral view; embolus filiform, arising in a 6-o'clock-position, running prolaterally in a semicircle, then lying in conductor (Figs 3A–E).

Female (measurements of paratype): Measurements: Total length 6.2. Prosoma length 2.7, width 2.0; Opisthosoma length 3.5, width 2.5. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PME subequal to PLE, and larger than ALE; AME–AME, AME–ALE and ALE–PLE close together, both PME–PLE and PME–PME about half of AME diameter. Clypeal height about four-fifths AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 10.5 (2.8, 3.5, 2.5, 1.7); II: 8.1 (2.5, 2.2, 2.0, 1.4); III: 7.7 (2.1, 2.5, 2.0, 1.1); IV: 11.3 (2.8, 3.6, 3.1, 1.8). Chelicerae with three promarginal and two retromarginal teeth. Epigynal hoods situated posteriorly, the distance between epigynal hoods and epigastric furrow about one-fourth atrium length; atrium large, occupying two-thirds of epigynum; copulatory ducts narrow (its width less than one-third of the width of the widest part of spermatheca), originating laterally; spermathecae simple, situated close together; spermathecal heads short (its length about one-fifth of the width of the widest part of spermatheca), situated anteriorly (Figs 3F–G).

Distribution: China (Guangxi) (Fig. 5).

Platocoelotes strombuliformis **sp. nov.**

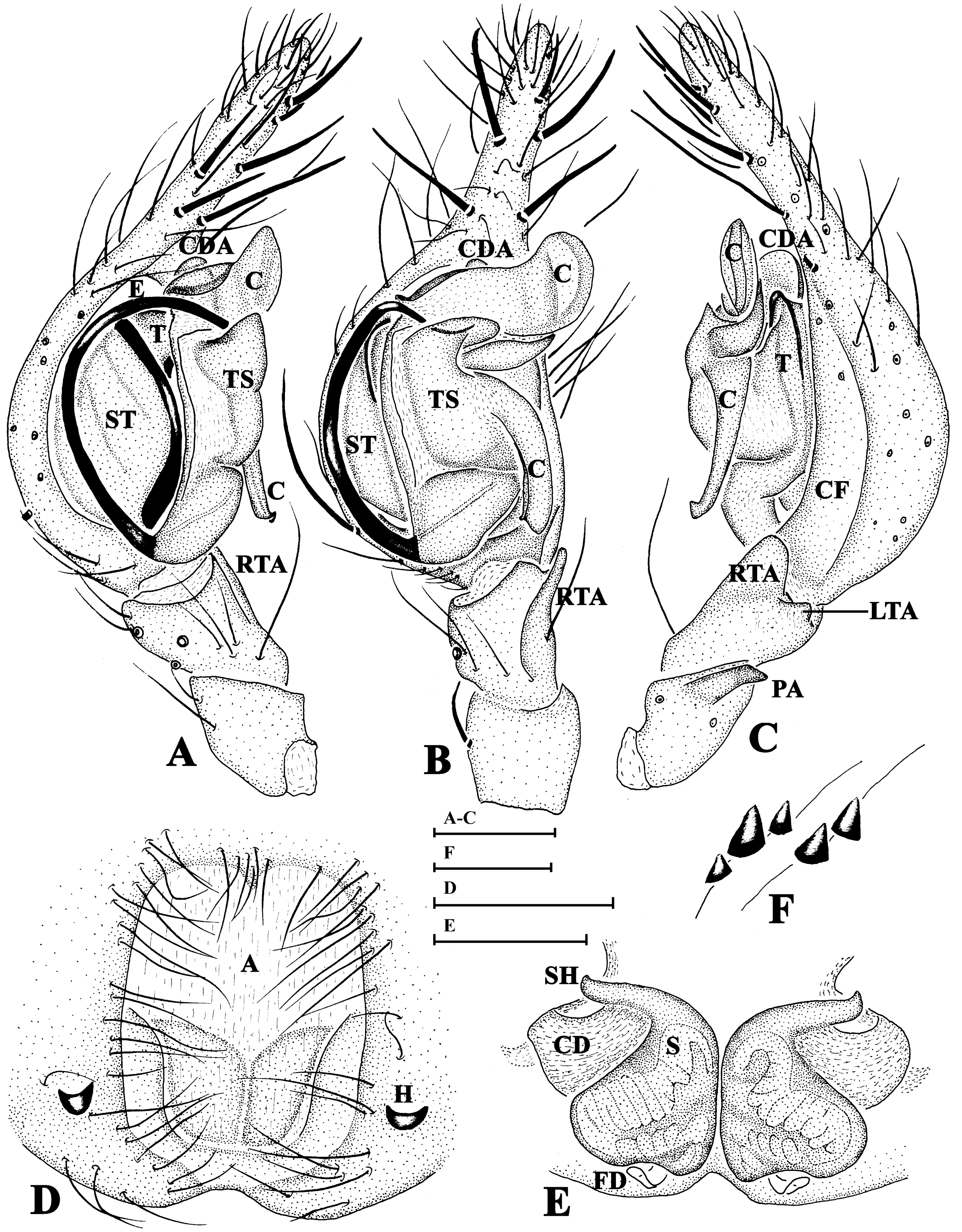
Figs 4A–F, 5

Type material: Holotype male, 2 male and 30 female paratypes, CHINA: Guangxi Zhuang Autonomous Region, Dahua County, Jiangnan Town, Damo Village, Huangniudong Cave (23º55.120´N, 107º37.479´E, Alt: 175m, Te: 19ºC, Hu: 90%), 8 March 2007, Yucheng Lin & Jie Liu leg.

Etymology: The specific name is derived from the Greek *strombos*, meaning a top, a spiral shell, and the Latin suffix -*formis*, -*e*, meaning -shaped, referring to the spiral shape of spermathecae of this species; adjective.

Diagnosis: The female of this species can be distinguished from other *Platocoelotes* species by the adjacent, uniquely strombuliform spermathecae, the wide copulatory ducts, originating posterolaterally in the genital atrium. The male is similar to *P. furcatus* **sp. nov.** in having a long ventral conductor apophysis, a large dorsal conductor apophysis and a modified conductor, but can be distinguished from *P. furcatus* **sp. nov.** by the absence of furcated distal conductor margin, and the relatively large lateral tibial apophysis situated close to the RTA.

Description. Male (measurements of the holotype): Measurements: Total length 7.3. Prosoma length 3.5, width 2.8; Opisthosoma length 3.8, width 2.0. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PME subequal to PLE, and larger than ALE; AME–AME, AME–ALE and ALE–PLE close together, both PME–PLE and PME–PME about half of AME diameter. Clypeal height about four-fifths AME diameter. Leg formula: IV, I, II, III; leg measurements: I: 16.0 (4.1, 5.7, 4.0, 2.2); II: 14.9 (3.7, 4.9, 3.9, 2.4); III: 14.4 (3.7, 4.5, 4.1, 2.1); IV: 19.5 (4.9, 5.9, 6.1, 2.6). Chelicerae with three promarginal and two retromarginal teeth. Patellar apophysis long, its



FIGURES 4A–F. *Platocoelotes strombuliformis* **sp. nov.**, A. Male pedipalpus, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Epigynum, ventral view; E. Vulva, dorsal view; F. Male cheliceral teeth, ventral view. Scale bars: A–C = 0.1 mm, D–F = 0.2 mm.

length subequal to the patellar width; RTA with its distal end blunt and slightly extending beyond distal margin of tibia; lateral tibial apophysis relatively large, about one-fourth of RTA from a retrolateral view and adjacent to RTA; cymbial furrow about half of cymbial length; conductor exhibiting a short and wide cavity (its length subequal to one-third of cymbial length, its width of the widest part slightly more than half of its length from a ventral view); dorsal conductor apophysis large; ventral conductor apophysis long (its length slightly more than one-third of cymbial length, its width of the widest part about one-sixth its length from a ventral view), strongly extending proximally; tegulum relatively undeveloped comparing to subtegulum in a prolateral view; embolus filiform, arising in a 6-o'clock-position, running prolaterally in a semicircle, then lying in conductor (Figs 4A–D).

Female (measurements of paratype): Measurements: Total length 8.0. Prosoma length 3.5, width 2.8; Opisthosoma length 4.5, width 3.1. From front, anterior eye row slightly recurved, posterior row procurved; eye sizes and arrangements: AME smallest, ALE slightly larger than AME, PLE slightly larger than ALE, but smaller than PME; AME–AME, AME–ALE and ALE–PLE close together, both PME–PLE and PME–PME about half of AME diameter. Clypeal height about AME diameter. Leg formula: IV, I, II, III; leg measurements as follows: I: 13.6 (3.5, 4.7, 3.3, 2.1); II: 11.4 (3.4, 4.0, 2.8, 1.2); III: 11.2 (3.2, 3.6, 2.9, 1.5); IV: 15.1 (4.0, 4.8, 4.3, 2.0). Chelicerae with three promarginal and two retromarginal teeth. Epigynal hoods situated posteriorly, the distance between epigynal hoods and epigastric furrow about one-fifth atrium length; atrium large, occupying two-thirds of epigynum, almost rectangular; copulatory ducts wide (its width more than half of the width of the widest part of spermatheca), originating posterolaterally; spermathecae simple, strombuliform and strongly adjacent to each other; spermathecal heads long (its length more than half of the width of the widest part of spermatheca), situated anterolaterally and extending transversely (Figs 4E–F).

Distribution: China (Guangxi) (Fig. 5).

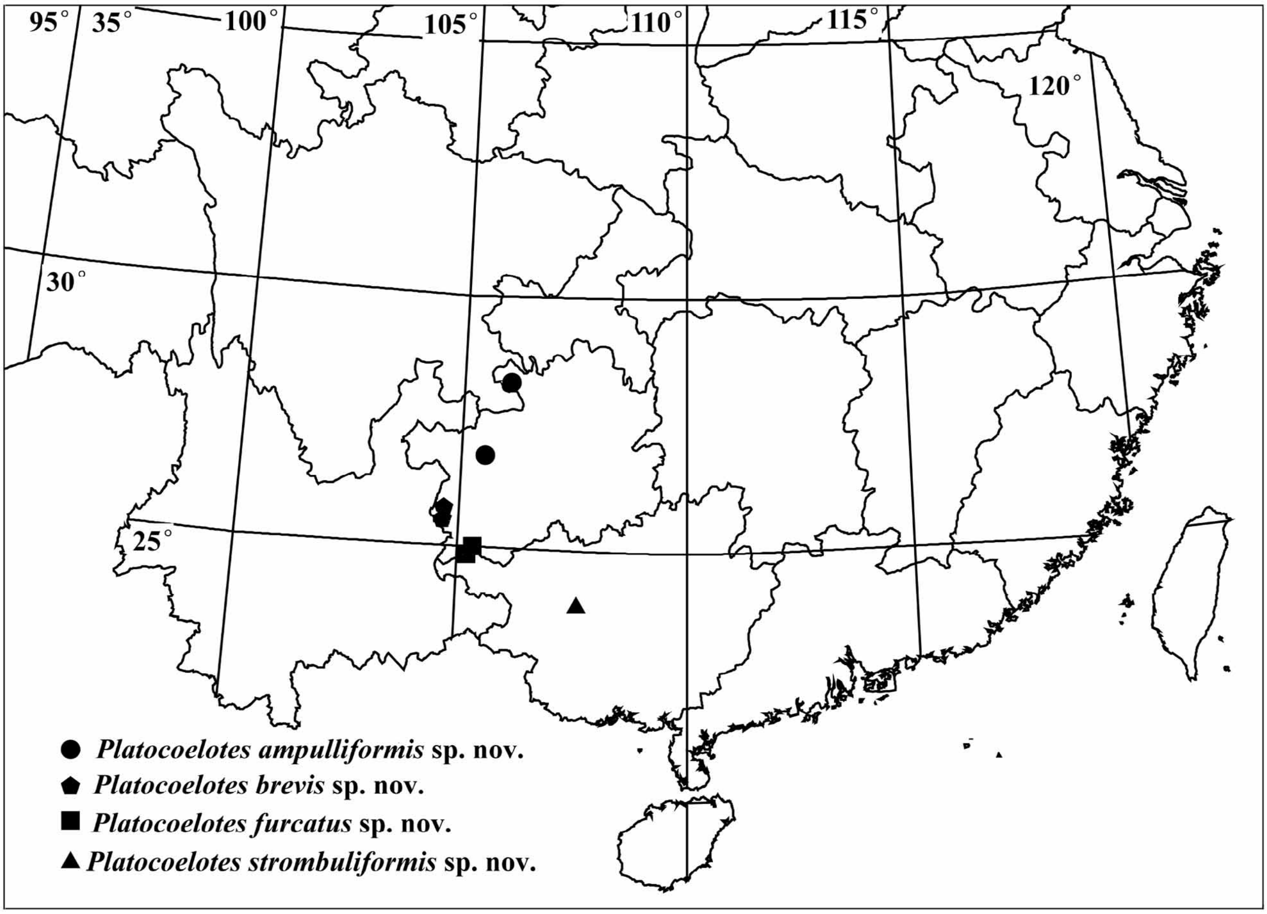


FIGURE 5. Collection localities of the four new *Platocoelotes* species.

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New cave-dwelling huntsman spider species of the genus *Sinopoda* (Araneae: Sparassidae) from southern China

JIE LIU[1], SHUQIANG LI[1] & PETER JÄGER[2, 3]

[1] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China*
[2] *Research Institute Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany*
[3] *Corresponding author: Peter.Jaeger@Senckenberg.de*

Abstract

Nine new species of the genus *Sinopoda*, collected from Yunnan-Guizhou Plateau and Hainan Island of southern China, are described: *Sinopoda anguina* **sp. nov.**, *Sinopoda crassa* **sp. nov.**, *Sinopoda fornicata* **sp. nov.**, *Sinopoda grandispinosa* **sp. nov.**, *Sinopoda nuda* **sp. nov.**, *Sinopoda semicirculata* **sp. nov.**, *Sinopoda triangula* **sp. nov.**, *Sinopoda undata* **sp. nov.** and *Sinopoda yaojingensis* **sp. nov.** The type specimen of *Sinopoda longshan* Yin, Peng, Yan & Bao 2000 is redescribed and illustrated. All nine new species were collected from caves. The type specimens of new species are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS) and Research Institute Senckenberg in Frankfurt am Main (SMF).

Key words: Taxonomy, new species, Yunnan-Guizhou Plateau, Hainan Island

Introduction

Sparassidae are mainly known as large hunting spiders, living under tree bark, in leaves of shrubs and trees, rock crevices or in synanthropic habitats. Sparassidae from caves have been poorly investigated (Jäger 2001, 2005), although most representatives may play an important role in subterranean ecosystems, such as caverns, caves and underground passages. A considerable number of huntsman spiders are reported as cave-dwellers in particular in Africa and Southeast Asia (Table 1). Additional species in the genera *Sinopoda* Jäger 1999 and *Heteropoda* Latreille 1806 have been collected in caves, most of them in China, Laos, Thailand and Malaysia (Jäger, unpublished data). Some *Sinopoda* species are only found close to rock crevices during the night, possibly living predominantly in subterranean habitats but occasionally ambushing prey at the surface (Jäger 1998). No cave-dwelling Sparassidae have so far been reported from Australia and the Americas.

Most species from underground environments are described in *Heteropoda* (Table 1) and it appears that they independently moved underground in different regions, i.e. cave-dwellers are more related to their respective local fauna than to each other (Jäger 2005). However, the percentage of cave-dwelling species and those with troglomorphic features is highest in *Sinopoda* (Jäger, unpublished data). Many members of this genus do not necessarily show troglomorphic features such as reduced eyes, elongated legs and palps, or reduced body pigmentation, but a number of species are exclusively found in caves or rock crevices. In some cave-dwelling species of *Sinopoda* pigmentation is somewhat less pronounced, i.e. annulations or other colour markings are absent and body colouration is paler. Some undescribed species have reduced eyes, one species known to the authors has only four eyes and another is completely eyeless (Jäger, unpublished data).

The genus *Sinopoda* is found in northeastern India, Thailand, Laos, Malaysia (including Sarawak), China (southern, central and eastern provinces), Japan and Korea (Jäger 1999; Jäger, unpublished data). Illustrations

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in Barrion & Litsinger (1995) do not depict *Sinopoda* suggesting the genus not to occur in the Philippines, whereas representatives of *Heteropoda* Latreille 1804, *Thelcticopis* Karsch 1884 and *Olios* Walckenaer 1837 have been reported from there. Of the 28 known species of *Sinopoda*, 20 are distributed in China and Taiwan (Platnick 2008).

In the past three years, a series of surveys on cave-dwelling spiders was conducted by scientists of the Chinese Academy of Sciences in more than 300 caves of the southern Chinese provinces Hainan, Guangxi, Guizhou and Yunnan. A total of 116 *Sinopoda* individuals were collected of which nine species are here described as new.

TABLE 1. Cave-dwelling huntsman spiders (Sparassidae).

Species	Distribution	Comment/reference
Berlandia tenebricola Simon & Fage 1922	Tanzania	(Simon & Fage 1922)
Heteropoda afghana Roewer 1962	Afghanistan	(Roewer 1962, Jäger 2005)
H. belua Jäger 2005	Borneo	(Jäger 2005)
H. beroni Jäger 2005	Sulawesi	(Jäger 2005)
H. fischeri Jäger 2005	northern India	(Jäger 2005)
H. maxima Jäger 2001	Laos	(Jäger 2005)
H. robusta Fage 1924	northern India	(Fage 1924, Jäger 2005)
H. schwendingeri Jäger 2005	Thailand	(Jäger 2005)
H. simplex Jäger & Ono 2000	Japan	Caves and rock crevices close to streams (Tanikawa, personal communication)
H. variegata (Simon 1874)	eastern Mediterraneis	(Jäger, unpublished data)
Sinopoda microphthalma (Fage 1929)	Malaysia	(Fage 1929)
Spariolenus secundus Jäger 2006	Oman	(Jäger 2006)

Material and methods

Specimens were examined using an Olympus SZ40 stereomicroscope. Further details of smaller structures were studied under an Olympus BX41 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Photos were taken with an Olympus C7070 wide zoom digital camera (7.1 megapixels) mounted on an Olympus SZX12 stereomicroscope. Male palps and female genitalia were examined and illustrated after they were dissected from the spiders' body. Some embolic divisions were dissected from male palps and mounted in Hoyer's Solution (Kraus 1984). Vulvae of females were cleared in 90% lactic acid. The dissected parts were returned to ethanol and stored in a microvial with the body.

All measurements were taken using an Olympus SZ40 stereomicroscope. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Spines are listed for each segment in the following order: prolateral, dorsal, retrolateral, ventral.

Abbreviations used in this paper: Alt—altitude, ALE—anterior lateral eyes, AME—anterior median eyes, AW—anterior width of prosoma, CH—clypeus height, Fe—femur, H—humidity, Mt—metatarsus, OL—opisthosoma (abdomen) length, OW—opisthosoma (abdomen) width, Pa—patella, PH—prosoma height, PL—prosoma length, PLE—posterior lateral eyes, PME—posterior median eyes, Pp—palp, PW—prosoma width, RTA—retrolateral tibial apophysis, T—temperature, Ta—tarsus; Ti—tibia; I, II, III, IV—legs I to IV.
Collections: HNU—Hunan Normal University Changsha, China; IZCAS—Institute of Zoology, Chinese Academy of Sciences, Beijing, China; SMF—Research Institute Senckenberg, Frankfurt, Germany.

Taxonomy

Family Sparassidae Bertkau 1872

Subfamily Heteropodinae Thorell 1873

Genus *Sinopoda* Jäger 1999

Type species: *Sarotes forcipatus* Karsch 1881

Diagnosis: Male *Sinopoda* species are characterised by the distally divided, S-shaped embolus and the typical shape of the two-branched tibial apophysis. Females can be recognised by the characteristically modified rims of the epigyne and the distinct shape of the fused vulva (Jäger 1999; Jäger & Ono 2000).

Distribution: China, East India (Assam), Japan, Korea, Laos, Malaysia (Selangor, Sarawak), Thailand (Jäger 1999, unpublished data)

Sinopoda anguina sp. nov.

Figs 1A–G, 9A–B, and 12

Type material: Holotype male and 1 male paratype (IZCAS), CHINA: Yunnan Province, Shilin County, Tianshengqiao Village, Zhangkoudong Cave (24º51.292'N, 103º17.342'E, Alt: 1740m, T: 17°C, H: 90%), 24 March 2007, Yucheng Lin, Jie Liu leg.

Etymology: The specific name is derived from the Latin *anguinus -a, -um*, meaning, "snake-shaped" referring to the shape of embolus; adjective.

Diagnosis: This new species may be recognised by the following combination of characters: 1. embolus tip shorter than embolic apophysis; 2. tip of embolic apophysis with a semicircular membrane; 3. RTA arising medially from tibia, dorsal part slightly longer and more slender (Figs 1A–G).

Description: Male (holotype). Measurements (in mm): PL 7.0, PW 6.7, AW 3.4, PH 5.2, OL 9.4, OW 5.1. Eyes: AME 0.42, ALE 0.57, PME 0.43, PLE 0.71, AME–AME 0.09, AME–ALE 0.10, PME–PME 0.33, PME–PLE 0.27, AME–PME 0.30, ALE–PLE 0.11, CH AME 0.26, CH ALE 0.43. Leg and palp measurements: Pp 10.8 (3.7, 1.3, 2.1, -, 3.7), I 36.0 (9.6, 3.9, 9.7, 10.0, 2.8), II 41.0 (11.3, 4.2, 11.3, 11.2, 3.0), III 32.6 (9.6, 3.3, 9.1, 8.4, 2.2), IV 34.9 (10.1, 3.0, 9.3, 9.7, 2.8). Leg formula: II-I-IV-III. Spination: Pp 323, 101, 2021; Fe I–III 323, IV 331; Pa 101; Ti I–II 2326, III–IV 2226; Mt I–II 1014, III 2026, IV 3036.

Palp as in diagnosis. Proximal part of embolus visible. Sperm duct slightly curved in ventral view. Dorsal RTA digitiform, pointed in ventral view; ventral RTA well developed, blunt in lateral view. Cymbium distinctly longer than tibia (Figs 1A–G).

Female. Unknown.

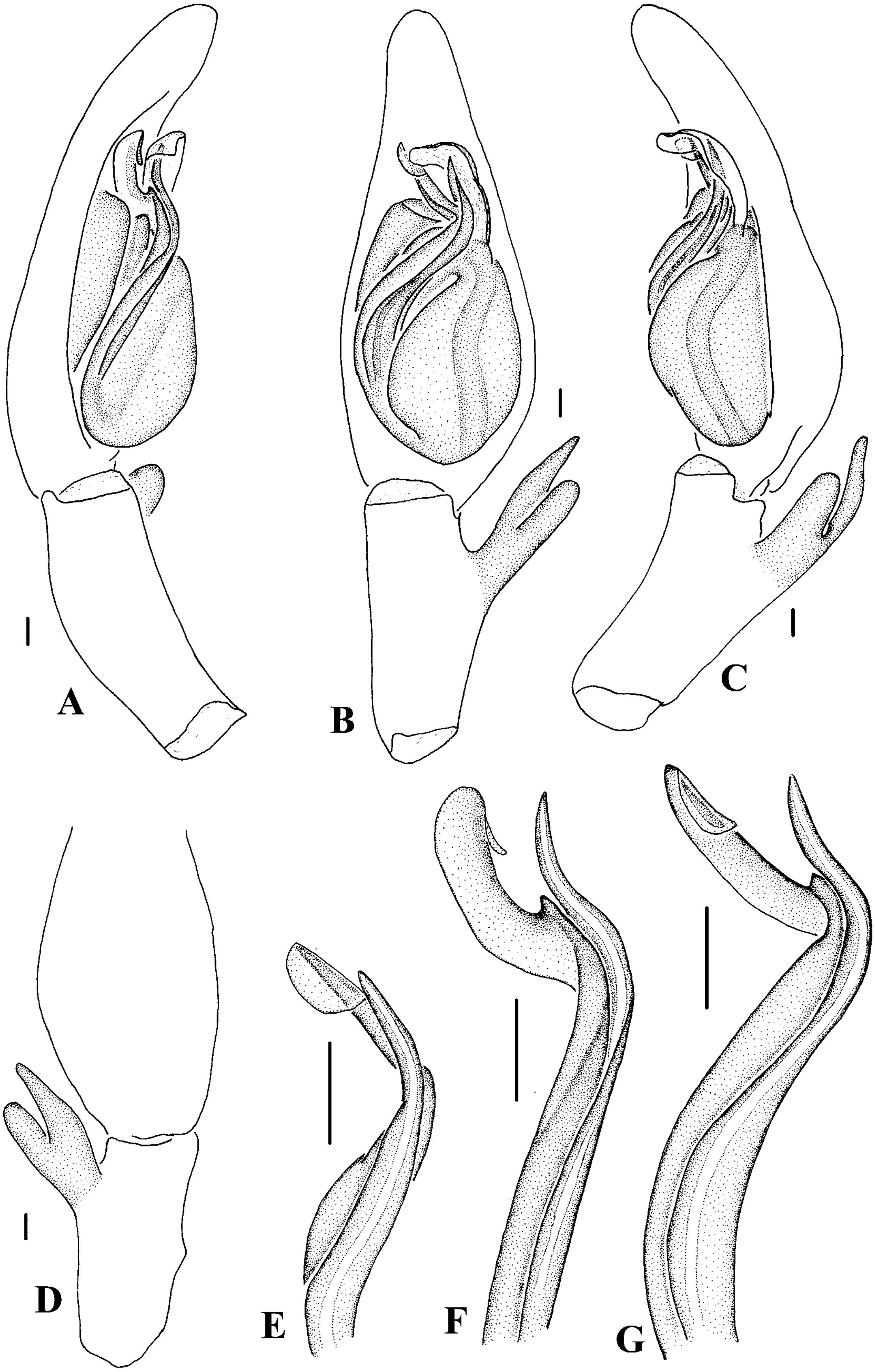
Distribution: China (Yunnan) (Fig. 12).

Sinopoda crassa sp. nov.

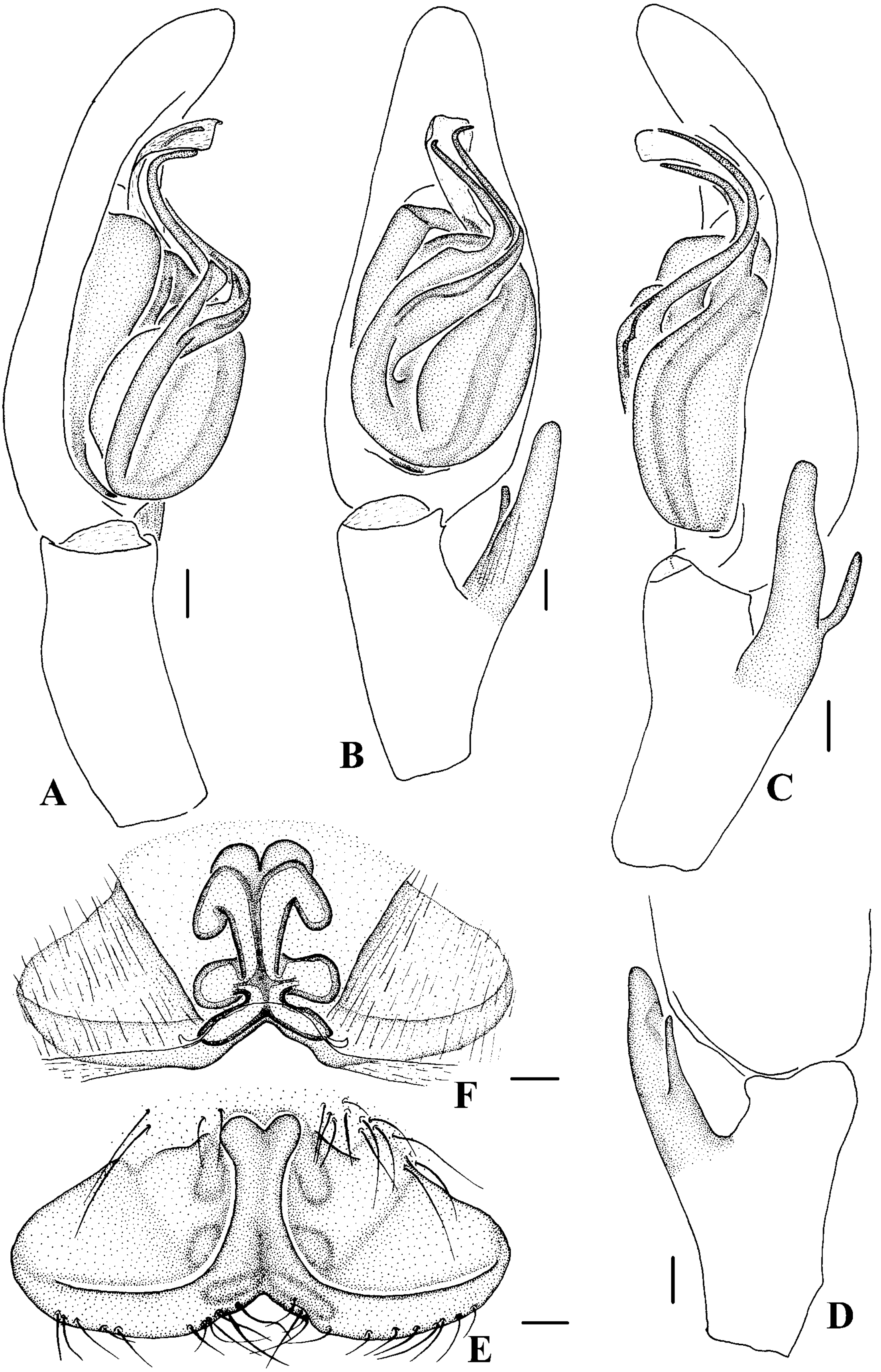
Figs 2E–F, 9C–D and 12

Type material: Holotype female, 1 female paratype (IZCAS), CHINA: Guangxi Zhuang Autonomous Region, Mashan County, Guling Township, Yangyu Village, Jinlundong Cave (23º33.378'N, 108º15.732'E, Alt: 210m, T: 14°C, H: 90%), Yucheng Lin, Jie Liu leg.

Etymology: The specific name is derived from the Latin *crassus, -a ,-um*, meaning "stout", referring to the shape of the vulva; adjective.



FIGURES 1A–G. *Sinopoda anguina* **sp. nov.**, holotype. A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Same, dorsal view; E. Embolus and embolic apophysis, retrolateral view; F. Same, prolateral view; G. Same, ventral view. Scale lines: 0.2 mm.



FIGURES 2A–F. A–B. *Sinopoda fornicata* **sp. nov.**, holotype. C–D. *Sinopoda yaojingensis* **sp. nov.**, holotype. E–F. *Sinopoda crassa* **sp. nov.**, holotype. (A, C, E, Epigyne, ventral view; B, D, F, Vulva, dorsal view). Scale lines: 0.2 mm.

Diagnosis: This new species (females) can be recognised by the following combination of characters: 1. anterior part of median epigynal field about 1/6 to 1/7 of epigynal width, 2. epigynal pockets slightly rounded, diverging posteriorly, 3. internal duct system wider than long, with anterior part slightly wider than posterior part, 4. anterior part with additional asymmetrical sclerotised structure (Figs 2E–F).

Description: Female (holotype). Measurements (in mm): PL 7.5, PW 6.4, AW 3.9, PH 5.2, OL 7.8, OW 4.5. Eyes: AME 0.31, ALE 0.56, PME 0.43, PLE 0.67, AME–AME 0.14, AME–ALE 0.10, PME–PME 0.33, PME–PLE 0.29, AME–PME 0.32, ALE–PLE 0.09, CH AME 0.31, CH ALE 0.40. Leg and palp measurements: Pp 11.0 (3.6, 1.8, 2.2, -, 3.4), I 31.8 (9.1, 3.4, 8.7, 8.1, 2.5), II 34.5 (10.1, 3.9, 9.6, 8.5, 2.4), III 27.8 (8.8, 2.7, 7.8, 6.3, 2.2), IV 31.7 (9.3, 3.0, 8.5, 8.5, 2.4). Leg formula: II-I-IV-III. Spination: Pp 131, 001, 2121, 1014; Fe I– IV 323; Pa I 101, II–IV 001; Ti I–II 2026, III–IV 2226; Mt I–II 1014, III 2026, IV 3036.

Copulatory organ as in diagnosis. Posterior margin of epigyne distinctly bilobate. Internal duct system stout, diverging in their anterior and posterior part, forming two reniform structures (Figs 2E–F).

Male. Unknown.

Distribution: China (Guangxi) (Fig. 12).

Sinopoda fornicata sp. nov.

Figs 2A–B, 9I–J and 12

Type material: Holotype female, 2 female (all IZCAS) and 1 female (SMF) paratypes, CHINA: Yunnan Province, Fumin County, Sandan Township, Panlong Village, Baoshidong Cave (25º17.679’N, 102º40.057’E, Alt: 1880m, T: 15°C, H: 90%), 4 April 2007, Yucheng Lin, Jie Liu leg.

Etymology: The specific name is derived from the Latin *fornicatus, -a, -um,* meaning “arched”, referring to the shape of the anterior swelling of the internal duct system; adjective.

Diagnosis: This new species may be recognised by 1. straight margins of lateral lobes roughly forming a triangle in the median epigyne and 2. unique anterior swelling of the internal duct system (Figs 2A–B).

Description: Female (holotype). Measurements (in mm): PL 7.8, PW 7.3, AW 4.0, PH 6.0, OL 9.7, OW 6.7. Eyes: AME 0.29, ALE 0.48, PME 0.57, PLE 0.70, AME–AME 0.22, AME–ALE 0.09, PME–PME 0.28, PME–PLE 0.39, AME–PME 0.36, ALE–PLE 0.24, CH AME 0.30, CH ALE 0.43. Leg and palp measurements: Pp 10.9 (3.4, 1.9, 2.2, -, 3.4), I 30.2 (8.5, 3.9, 7.9, 7.7, 2.2), II 33.0 (9.7, 4.2, 8.8, 8.1, 2.2), III 28.1 (8.4, 3.4, 7.5, 6.7, 2.1), IV 29.6 (8.5, 3.1, 7.9, 7.6, 2.5). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe I–III 323, IV 331; Pa I, III 101, II 001, IV 000; Ti I–II, IV 2026, III 2126; Mt I–II 1014, III 2026, IV 3036.

Copulatory organ as in diagnosis. Posterior margin of epigyne only slightly bilobate, with median fissure running up to median part of epigyne. Internal ducts running parallel along the median line, anterior part slightly wider than posterior part, posterior part with twin-structures (Figs 2A–B).

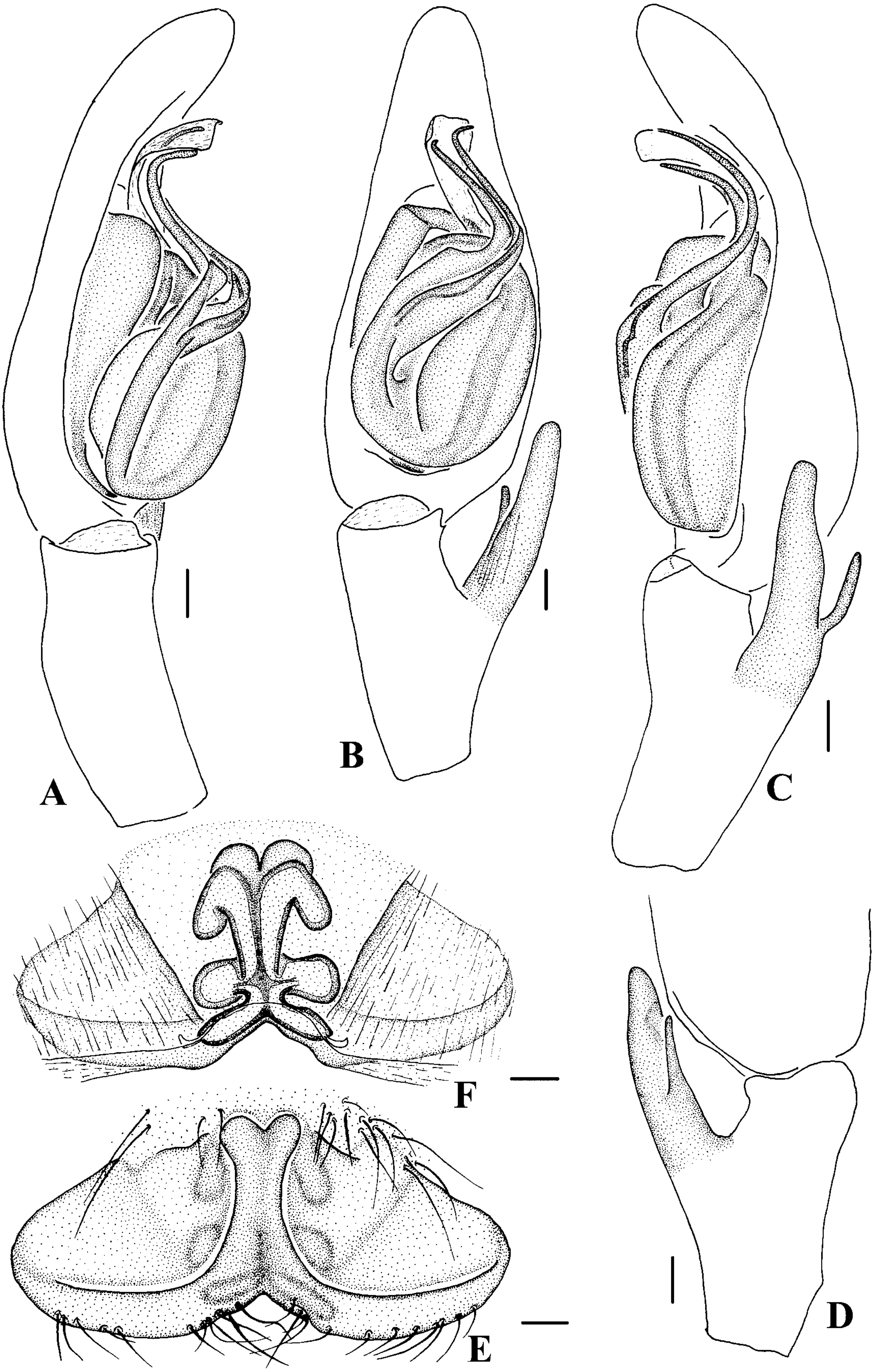
Male. Unkown.

Distribution: China (Yunnan) (fig 12).

Sinopoda grandispinosa sp. nov.

Figs 3A–F, 9M–P and 12

Type material: Holotype male, 3 female (all IZCAS) and 1 female (SMF) paratypes, CHINA: Hainan Province, Dongfang City, Yalong Village, Yalongdong Cave (18°58.72’N, 108°53.41’E), 31 March 2005, Yanjing Song, Xu Han, Yanfeng Tong and Gaoyun Deng leg.



FIGURES 3A–F. *Sinopoda grandispinosa* **sp. nov.**, holotype (A–D), paratype (E–F). A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Left male palpal tibia, dorsal view; E. Epigyne, ventral view; F. Vulva, dorsal view. Scale lines: 0.2 mm.

Etymology: The specific name is a compound word and derived from the Latin *grandis, -e*, meaning "large", and *spinosus, -a, -um*, meaning "spinose", referring to the shape of the branch of RTA; adjective.

Diagnosis: The new species can be separated from other *Sinopoda* species by 1. unique spine-shaped and small dorsal RTA, 2. distal part of the embolus including the embolic apophysis bent at a right angle, and 3. characteristic lobal pockets situated very close and running parallel to the posterior margin of the epigyne (Figs 3C–D, 3F).

Description: Male (holotype). Measurements (in mm): PL 4.5, PW 4.5, AW 2.4, PH 3.5, OL 5.3, OW 3.3. Eyes: AME 0.21, ALE 0.44, PME 0.32, PLE 0.48, AME–AME 0.13, AME–ALE 0.08, PME–PME 0.23, PME–PLE 0.18, AME–PME 0.22, ALE–PLE 0.09, CH AME 0.21, CH ALE 0.30. Leg and palp measurements: Pp 5.9 (2.4, 1.0, 1.1, -, 1.4), I 22.5 (6.5, 2.5, 6.4, 5.5, 1.6), II 25.9 (7.2, 2.8, 7.4, 6.5, 2.0), III 21.1 (6.0, 2.2, 5.8, 5.5, 1.6), IV 22.2 (6.2, 1.9, 6.2, 6.2, 1.7). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2110; Fe I–III 323, IV 331; Pa 101; Ti 2126; Mt I–II 1014, III 2024, IV 3036.

Palp as in diagnosis. Embolus long and slender, embolus tip as long as embolic apophysis, embolus slightly curved and parallel to the embolic apophysis, proximal part of embolus fully visible. Embolic apophysis long and slender. Sperm duct almost straight in ventral view. Ventral RTA well developed, much larger than dorsal RTA, blunt and long; dorsal RTA arising from the proximal half of ventral RTA. Cymbium distinctly longer than tibia (Figs 3A–D).

Female (paratype). Measurements (in mm): PL 5.5, PW 5.0, AW 3.3, PH 4.5, OL 6.0, OW 3.5. Eyes: AME 0.21, ALE 0.38, PME 0.27, PLE 0.50, AME–AME 0.13, AME–ALE 0.09, PME–PME 0.32, PME–PLE 0.34, AME–PME 0.41, ALE–PLE 0.18, CH AME 0.24, CH ALE 0.33. Leg and palp measurements: Pp 8.0 (2.5, 1.3, 1.7, -, 2.5), I 24.9 (6.8, 3.3, 7.0, 5.8, 2.0), II 26.0 (7.0, 3.5, 7.5, 6.0, 2.0), III 22.7 (6.5, 2.8, 6.1, 5.5, 1.8), IV 24.5 (7.0, 2.7, 6.5, 6.3, 2.0). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe I–III 323, IV 331; Pa 000; Ti I 1026 II 2026 III–IV 2126; Mt I–II 1014, III 2024, IV 3036.

Copulatory organ as in diagnosis. Median part of epigyne long and narrow with median fissure in posterior part. Posterior margin of epigyne distinctly bilobate. Internal duct system running partly parallel along the median line, anterior part slightly narrower than posterior part. Anterior parts bent at sharp angle, short (Figs 3E–F).

Distribution: China (Hainan) (Fig. 12).

Sinopoda longshan Yin, Peng, Yan & Bao 2000

Figs 4A–B

Sinopoda longshan Yin *et al*., 2000: 98, figs 1–3 [female holotype, Mt. Longshan (27°45'N, 105°54'E), Hunan Province, China, 8 September 1995, Hengmei Yan leg., Hunan Normal University, examined].

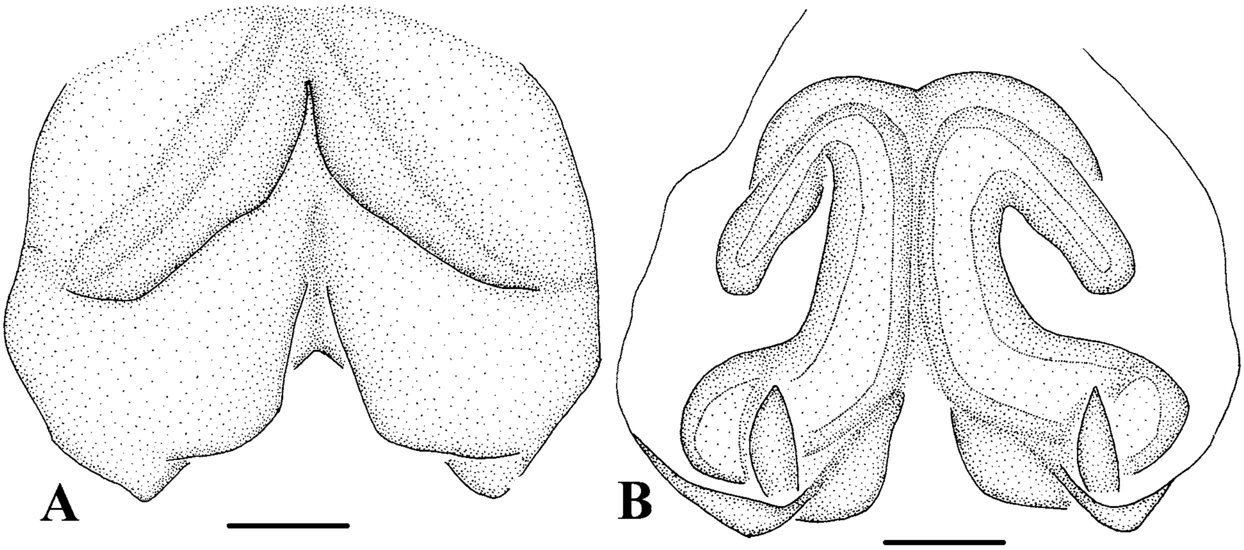
Note: *Sinopoda longshan* is similar to the following species and is illustrated and redescribed for comparison purpose.

Diagnosis: See diagnosis of *Sinopoda nuda* **sp. nov.** (below).

Redescription: Epigynal pockets situated close to each other. Median part of epigyne narrow, acuminate anteriorly, diverging posteriorly. Posterior margin of epigyne distinctly bilobate, with sharp indentation. Internal ducts with posterior part wider than anterior part, anterior part with anteriorad bilobate appendix (Figs 4A–B).

Further details and measurements see Yin *et al*. (2000)

Distribution: China (Hunan).



FIGURES 4A–B. *Sinopoda longshan* Yin, Peng, Yan & Bao 2000, holotype. A. Epigyne, ventral view; B. Vulva, dorsal view. Scale lines: 0.2 mm.

Sinopoda nuda sp. nov.

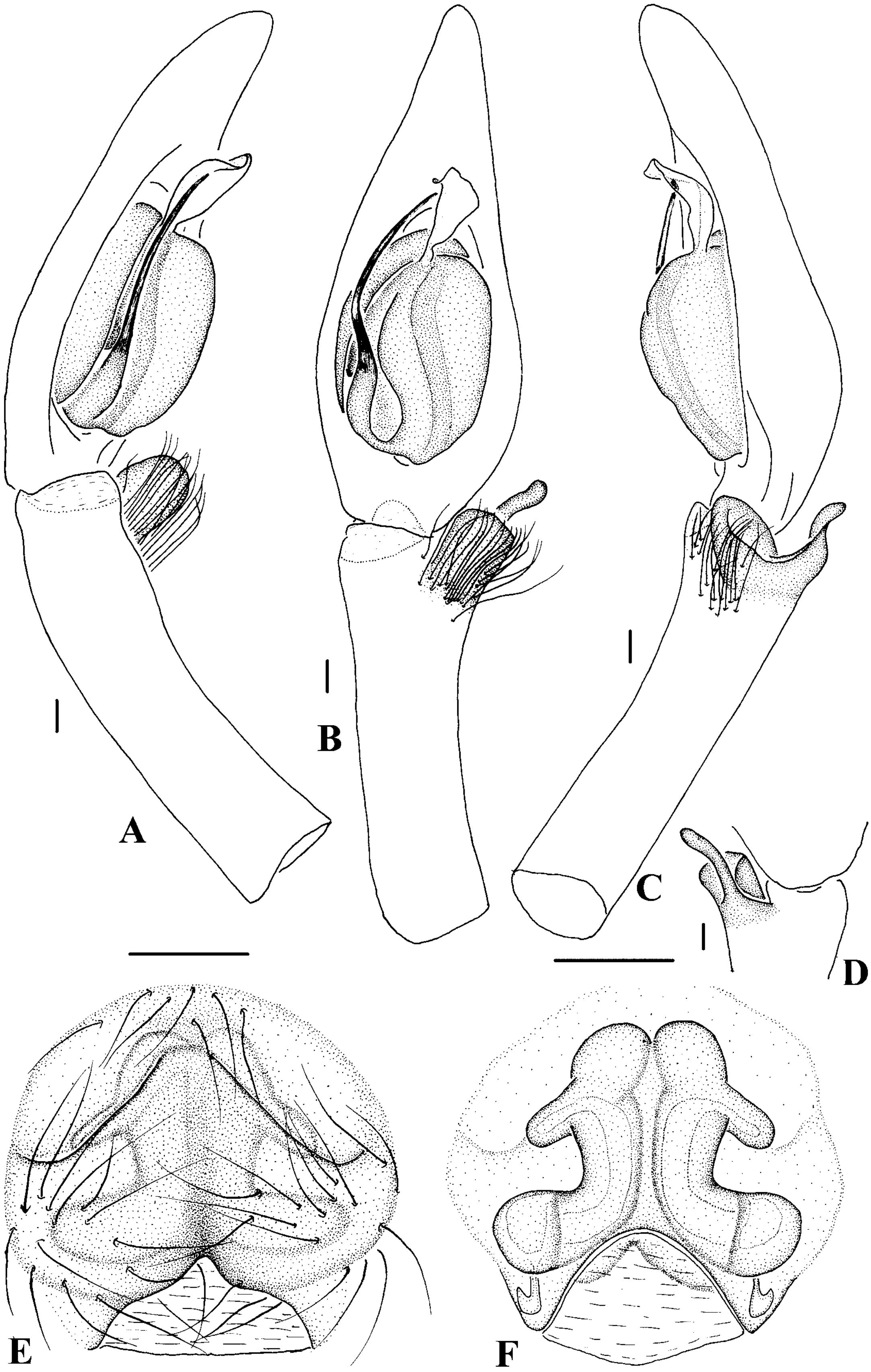
Figs 5A–F, 10A–D and 12

Type material: Holotype male, 5 females (all IZCAS) and 2 females (SMF) paratypes, CHINA: Guizhou Province, Suiyang County, Wenquan Town, Hejiaodong Cave (28º14.704'N, 107º17.304'E, Alt: 695m, T: 15°C, H: 90%), 12 May 2007, Yucheng Lin, Jie Liu leg; 1 male, 7 female (all IZCAS) paratypes, CHINA: Guizhou Province, Suiyang County, Wenquan Town, Shanwangdong Cave (28º14.724'N, 107º17.312'E, Alt: 765m, T: 14°C, H: 94%), 13 May 2007, Yucheng Lin, Jie Liu leg.

Etymology: The specific name is derived from the Latin *nudus, -a, -um*, meaning "nude, simple, umarmed", referring to the simple embolus of this new species that lacks the apophysis characteristic for representative of the genus *Sinopoda*; adjective.

Diagnosis: Based on the absence of the embolic apophysis and the presence of a distinct brush of stiff setae at the base of the RTA, this new species belongs to the *Sinopoda okinawana*-group, but it can be separated from other *okinawana*-group species by the developed ventral RTA (Figs 5A–D). Moreover, the shape of the basal embolus is not semicircular as in *S. albofasciata* Jäger & Ono 2002 or *S. derivata* Jäger & Ono 2002, but exhibits a distinct bend in *S. nuda* **sp. nov.** The female is similar to *Sinopoda longshan* in the shape of epigynal pockets and dorsad tips of posterior spermathecae, but can be distinguished by the following differences: 1. median part of epigyne wider in the new species (narrow in *S. longshan*); 2. anterior appendices of the internal duct system distinctly shorter in the new species (longer in *S. longshan*; Figs 4A–B, 5E–F).

Description: Male (holotype). Measurements (in mm): PL 6.7, PW 6.0, AW 2.8, PH 5.2, OL 8.2, OW 4.5. Eyes: AME 0.31, ALE 0.48, PME 0.40, PLE 0.64, AME–AME 0.13, AME–ALE 0.09, PME–PME 0.27, PME–PLE 0.12, AME–PME 0.28, ALE–PLE 0.08, CH AME 0.31, CH ALE 0.40. Leg and palp measurements: Pp 13.1 (4.8, 2.2, 3.0, -, 3.1), I 49.4 (12.7, 3.9, 13.9, 15.2, 3.7), II 54.2 (14.2, 4.2, 15.5, 16.4, 3.9), III 42.2 (11.5, 3.6, 11.6, 11.9, 3.6), IV 43.4 (12.2, 3.4, 12.5, 11.9, 3.4). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 1210; Fe 323; Pa 101; Ti 2326; Mt I–II 1014, III 2026, IV 3036.



FIGURES 5A–F. *Sinopoda nuda* **sp. nov.**, holotype (A–D), paratype from Hejiaodong Cave (E–F). A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Left male palpal tibia, dorsal view; E. Epigyne, ventral view; F. Vulva, dorsal view. Scale lines: 0.2 mm.

Palp as in diagnosis. Embolus long and slender, proximal part of embolus narrow and entirely visible. Embolic apophysis absent. Sperm duct slightly curved in ventral view. Dorsal RTA slender and blunt, distinctly curved in retrolateral view; ventral RTA well developed and stout from retrolateral view. Both palpal tarsus and tibia elongated, cymbium slightly longer than tibia (Figs 5A–D).

Female (paratype from Hejiaodong Cave). Measurements (in mm): PL 6.7, PW 5.7, AW 3.4, PH 5.5, OL 9.0, OW 4.6. Eyes: AME 0.32, ALE 0.63, PME 0.42, PLE 0.56, AME–AME 0.07, AME–ALE 0.09, PME–PME 0.30, PME–PLE 0.26, AME–PME 0.32, ALE–PLE 0.19, CH AME 0.32, CH ALE 0.39. Leg and palp measurements: Pp 11.5 (3.9, 1.8, 2.4, -, 3.4), I 35.7 (9.9, 3.6, 10.0, 9.6, 2.7), II 38.7 (10.9, 3.9, 11.0, 10.1, 2.7), III 31.9 (9.6, 3.3, 9.0, 7.6, 2.5), IV 34.5 (10.0, 3.1, 9.6, 8.8, 3.0). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe 323; Pa 101; Ti I 2126, II–IV 2226; Mt I–II 1014, III 3034, IV 3036.

Copulatory organ as in diagnosis. Median part of epigyne broad, diverging posteriorly. Posterior margin of epigyne distinctly bilobate. Anterior part of internal duct system with distinctly bilobate appendix; posterior part wider than anterior part, tips of the posterior spermathecae bent considerably (Figs 5E–F).

Distribution: China (Guizhou) (Fig. 12).

***Sinopoda semicirculata* sp. nov.**

Figs 6A–H, 10E–H and 12

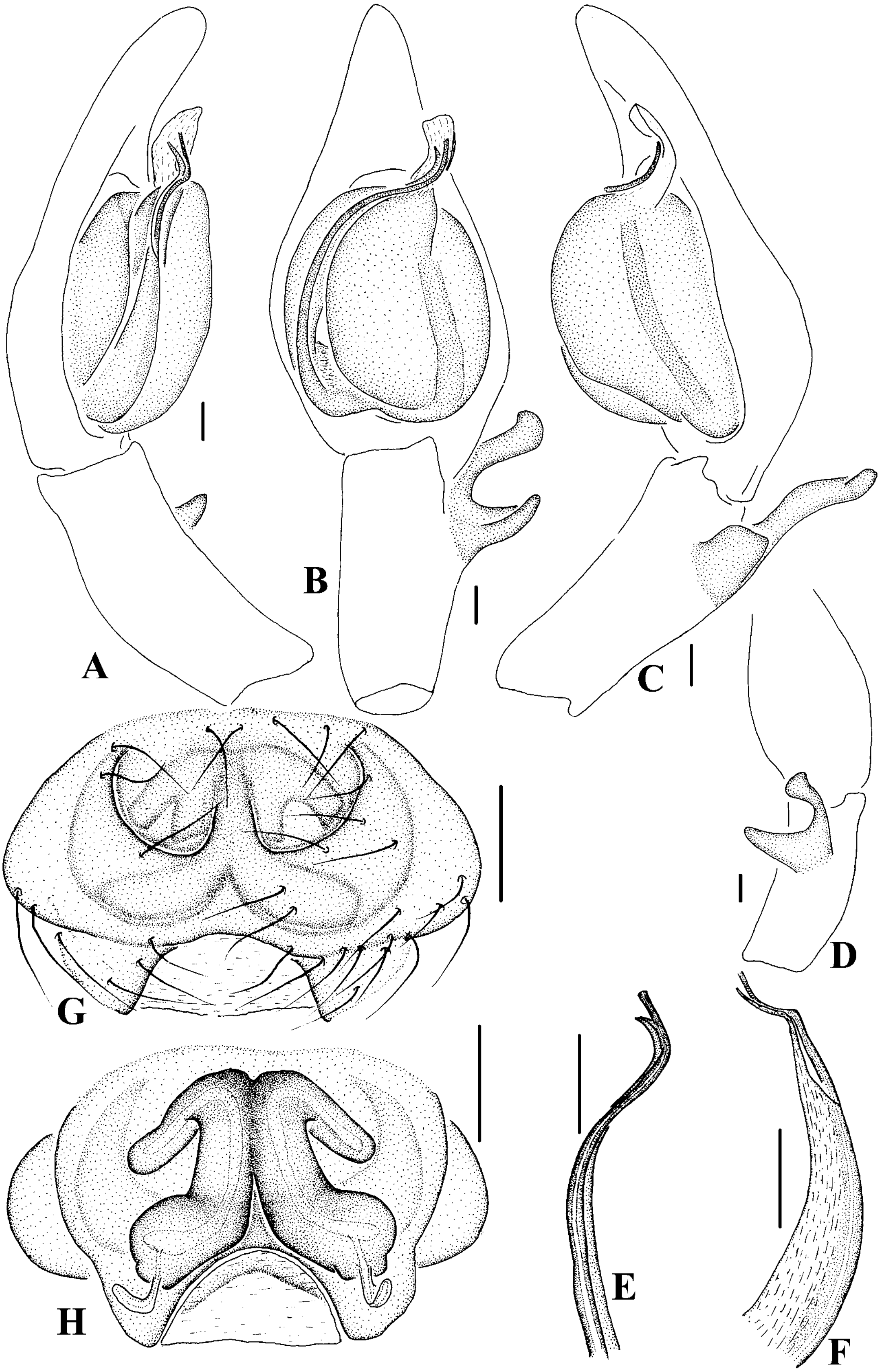
Type material: Holotype male and 1 female (IZCAS) paratype, CHINA: Guangxi Zhuang Autonomous Region, Lingyun County, Sishui Town, Fulongdong Cave (24º20.786’N, 106º33.476’E, Alt: 470m, T: 16°C, H: 90%), 15 March 2007, Yucheng Lin, Jie Liu leg.

Etymology: The specific name is derived from the Latin *semicirculatus, -a, -um*, meaning “semicircular”, referring to the shape of the epigynal rims; adjective.

Diagnosis: This new species may be recognised by the following combination of characters: Males — 1. embolus of this new species long, thin, distal part of the embolic apophysis thin; 2. tip of dorsal RTA distinctly widened; 3. dorsal and ventral RTA roughly of the same length (Figs 6A–F). Females — 1. lateral margins of epigynal pocket extending beyond median margins anteriorly; 2. posterior part of internal duct system distinctly swollen and larger than anterior part (Figs 6G–H). *Sinopoda wangi* Song & Zhu 1999 is somewhat similar to the new species described here, but may be distinguished in the male sex by having the basal embolus broad, embolic apophysis reduced and the dorsal RTA distinctly longer than the ventral RTA. Females may be distinguished by having anterior and posterior parts of internal duct system of about the same size and epigynal pockets extending more to lateral margins of epigynal field (cf. Jäger *et al*. 2002: figs 8–9, 13–15).

Description: Male (holotype). Measurements (in mm): PL 5.2, PW 4.6, AW 2.2, PH 4.5, OL 5.2, OW 3.3. Eyes: AME 0.21, ALE 0.36, PME 0.25, PLE 0.37, AME–AME 0.14, AME–ALE 0.12, PME–PME 0.22, PME–PLE 0.21, AME–PME 0.24, ALE–PLE 0.09, CH AME 0.31, CH ALE 0.40. Leg and palp measurements: Pp 8.9 (3.4, 1.3, 1.8, -, 2.4), I 27.8 (7.6, 2.5, 8.1, 7.5, 2.1), II 29.7 (8.4, 2.2, 9.0, 7.9, 2.2), III 25.1 (7.2, 2.4, 6.9, 6.7, 1.9), IV 26.9 (7.2, 2.4, 7.5, 7.6, 2.2). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2101; Fe 323; Pa 101; Ti 2226; Mt I–II 1014, III 3034, IV 3036.

Palp as in diagnosis. Embolus long and slender, embolus tip extending slightly beyond embolic apophysis, embolus distinctly curved and parallel to the embolic apophysis, proximal part of embolus partly visible. Distal part of the embolic apophysis thin. Sperm duct straight in ventral view. Dorsal RTA bent distally, ventral RTA well developed and pointed in dorsal view. Cymbium longer than tibia (Figs 6A–F).



FIGURES 6A–H. *Sinopoda semicirculata* **sp. nov.**, holotype (A–F), paratype (G–H). A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Left male palpal tibia, dorsal view; E. Embolus and embolic apophysis, ventral view; F. Same, prolateral view; G. Epigyne, ventral view; H. Vulva, dorsal view. Scale lines: 0.2 mm.

Female (paratype). Measurements (in mm): PL 6.0, PW 4.8, AW 2.7, PH 3.7, OL 6.9, OW 4.5. Eyes: AME 0.08, ALE 0.38, PME 0.30, PLE 0.37, AME–AME 0.14, AME–ALE 0.10, PME–PME 0.23, PME–PLE 0.20, AME–PME 0.28, ALE–PLE 0.11, CH AME 0.33, CH ALE 0.42. Leg and palp measurements: Pp 7.6 (2.2, 1.3, 1.6, -, 2.5), I 24.2 (6.9, 2.4, 6.4, 6.4, 2.1), II 25.0 (7.2, 2.7, 7.2, 6.0, 1.9), III 21.6 (6.1, 2.5, 6.0, 5.4, 1.6), IV 23.2 (6.6, 2.5, 6.6, 5.7, 1.8). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe 323; Pa 101; Ti I–II 2026, III–IV 2226; Mt I–II 1014, III 2026, IV 3036.

Copulatory organ as in diagnosis. Median part of epigyne short and narrow. Posterior margin of epigyne slightly bilobate. Internal ducts diverging posteriorly, anterior part as wide to slightly narrower than posterior part (Figs 6G–H).

Distribution: China (Guangxi) (Fig. 12).

Sinopoda triangula **sp. nov.**

Figs 7A–H, 10I–L and 12

Type material: Holotype male, 3 males, 8 females (IZCAS) and 1 male, 2 females (SMF) paratypes, CHINA: Guizhou Province, Panxian County, Biyundong Cave (25º46.527'N, 104º38.278'E, Alt: 1468m, T: 14°C, H: 92%), 13 April 2007, Yucheng Lin, Jie Liu leg.

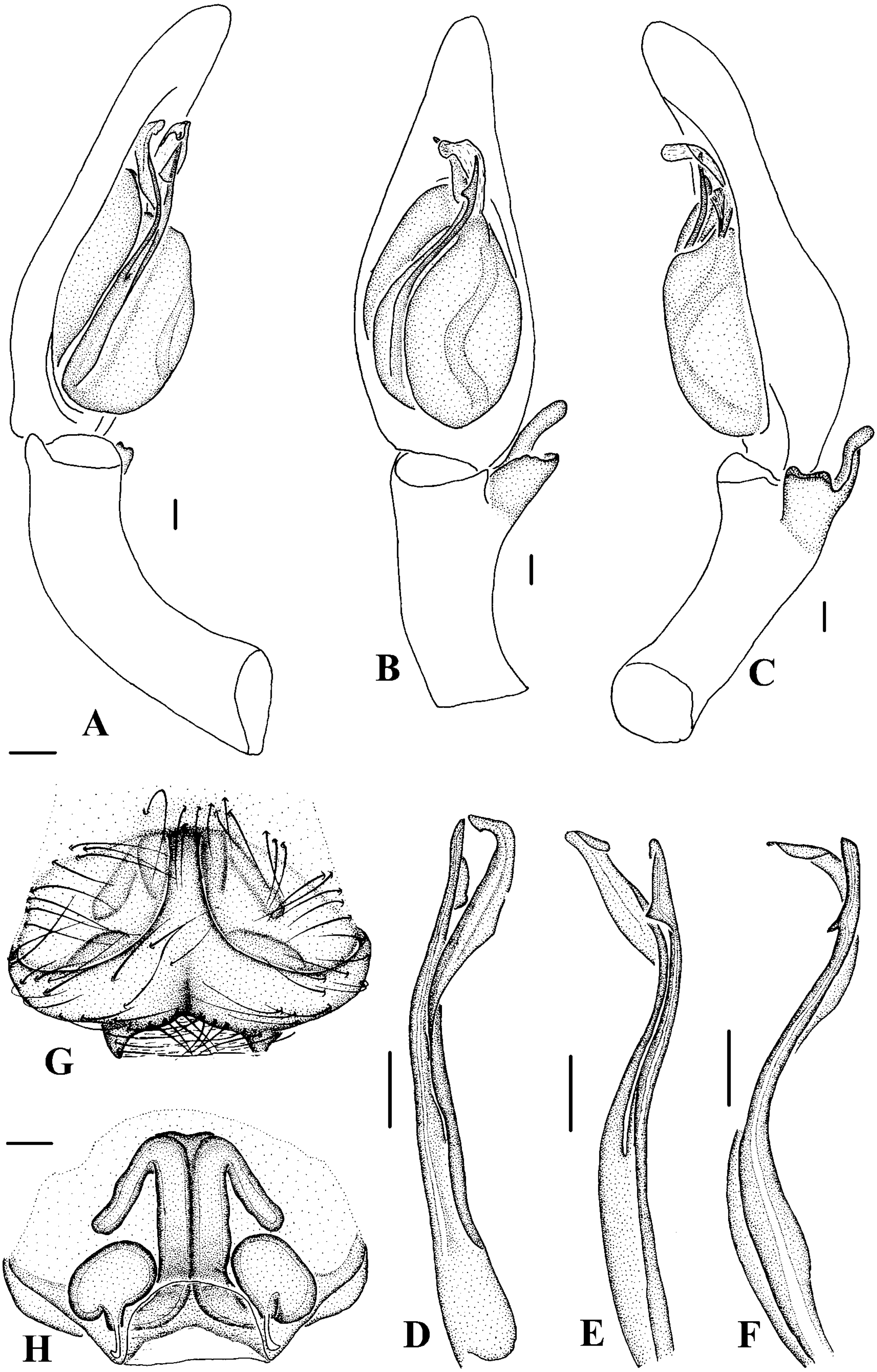
Etymology: The specific name is derived from the Latin *triangulus, -a, -um*, meaning "triangular", referring to the shape of the embolus tip; adjective.

Diagnosis: This new species can be distinguished from other *Sinopoda* species by its unique triangular embolus tip and the distinctly ovate posterior parts of the internal duct system (Figs 7A–F, 7H). There are two males known to the third author that exhibit a similar triangular structure at their embolus tips, one from Bailongdong Cave in Mile County, Yunnan, and another from Kangding, Sichuan. A differential diagnosis will be given, if these forms are recognised as new species.

Description: Male (holotype). Measurements (in mm): PL 6.9, PW 6.7, AW 3.3, PH 5.2, OL 9.0, OW 4.6. Eyes: AME 0.29, ALE 0.42, PME 0.41, PLE 0.64, AME–AME 0.09, AME–ALE 0.12, PME–PME 0.08, PME–PLE 0.21, AME–PME 0.32, ALE–PLE 0.09, CH AME 0.28, CH ALE 0.38. Leg and palp measurements: Pp 12.7 (4.5, 2.1, 2.4, -, 3.7), I 45.6 (11.9, 4.2, 12.5, 13.9, 3.1), II 50.9 (13.9, 4.2, 14.2, 14.9, 3.7), III 38.2 (11.2, 3.7, 10.1, 10.4, 2.8), IV 42.8 (11.9, 3.6, 11.2, 12.4, 3.7). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2011; Fe 323; Pa 101; Ti 2326; Mt I–II 1014, III 2026, IV 3036.

Palp as in diagnosis. Embolus tip slightly shorter than embolic apophysis, embolus curving parallel along the embolic apophysis basally, slightly diverging in the distal part, proximal part of embolus only partly visible in ventral view. Distal embolic apophysis wide and membranous. Sperm duct distinctly curved in ventral view. Dorsal RTA slender, curved distally; ventral RTA stout, blunt and concave in retrolateral view. Cymbium longer than tibia (Figs 7A–F).

Female (paratype). Measurements (in mm): PL 8.7, PW 7.9, AW 4.5, PH 6.0, OL 11.6, OW 7.2. Eyes: AME 0.42, ALE 0.58, PME 0.39, PLE 0.73, AME–AME 0.32, AME–ALE 0.12, PME–PME 0.38, PME–PLE 0.37, AME–PME 0.33, ALE–PLE 0.30, CH AME 0.26, CH ALE 0.37. Leg and palp measurements: Pp 12.7 (3.7, 2.1, 3.0, -, 3.9), I 36.9 (10.4, 3.7, 10.4, 9.7, 2.7), II 38.9 (11.2, 4.5, 10.6, 10.1, 2.5), III 32.7 (9.7, 3.7, 8.4, 8.2, 2.7), IV 33.1 (10.3, 3.3, 8.8, 8.2, 2.5). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121 1014; Fe 323; Pa 101; Ti I–II 2126, III–IV 2226; Mt I–II 1014, III 2026, IV 3036.



FIGURES 7A–H. *Sinopoda triangula* **sp. nov.**, holotype (A–F), paratype (G–H). A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Embolus and embolic apophysis, dorsal view; E. Same, ventral view; F. Same, prolateral view; G. Epigyne, ventral view; H. Vulva, dorsal view. Scale lines: 0.2 mm.

Copulatory organ as in diagnosis. Median part of epigyne long, narrow and diverging posteriorly. Posterior margin of epigyne slightly bilobate. Internal ducts running parallel along median line, anterior appendices long, slender and distinctly narrower than posterior part, spermathecae large and ovate (Figs 7G–H).

Distribution: China (Guizhou) (Fig. 12).

Sinopoda undata **sp. nov.**

Figs 8A–H, 9E–H and 11–12

Type material: Holotype male, 1 male, 3 females (all IZCAS) and 1 female (SMF) paratypes, CHINA: Yunnan Province, Xishuangbana Dai Autonomous Prefecture, Mengla County, Mengyuan Village, Yeniudong Cave (22°13.18’N, 100°59.22’E), 22 December 2006, Shuqiang Li, Guo Zheng leg.

Etymology: The specific name is derived from the Latin *unda*, meaning “wave”, referring to the wavy shape of the male embolic apophysis; adjective.

Diagnosis: Males of *Sinopoda undata* **sp. nov.** can be distinguished from those of other *Sinopoda* species by 1. uniquely wavy and well developed embolic apophysis, and 2. long and flagelliform embolus (Figs 8A–E); females may be recognised by 1. distinct and long anterior rim connecting the two lobal epigynal pockets, and 2. uniquely slender and distinctly bent internal duct system (Figs 8G–H).

Description: Male (holotype). Measurements (in mm): PL 7.3, PW 6.3, AW 3.1, PH 5.2, OL 9.7, OW 6.0. Eyes: AME 0.29, ALE 0.41, PME 0.38, PLE 0.65, AME–AME 0.10, AME–ALE 0.10, PME–PME 0.28, PME–PLE 0.08, AME–PME 0.39, ALE–PLE 0.10, CH AME 0.28, CH ALE 0.38. Leg and palp measurements: Pp 12.4 (4.2, 1.8, 2.2, -, 4.2), I 40.0 (10.4, 3.8, 11.3, 11.2, 3.3), II 42.9 (11.6, 4.3, 11.9, 12.1, 3.0), III 36.5 (10.1, 3.7, 10.3, 9.7, 2.7), IV 39.8 (10.3, 3.4, 11.0, 12.1, 3.0). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 1210; Fe I–III 323, IV 331; Pa 101; Ti 2326; Mt I 2024, II–III 3034, IV 3036.

Palp as in diagnosis. Embolus tip extending only slightly beyond embolic apophysis, bent parallel to embolic apophysis, proximal part of embolus freely visible. Sperm duct narrow and only slightly curved in ventral view. RTA with massive basal part, dorsal and ventral RTA ramified only in distal half. Cymbium longer than tibia (Figs 8A–F).

Female (paratype). Measurements (in mm): PL 9.3, PW 8.2, AW 4.5, PH 6.7, OL 14.9, OW 9.0. Eyes: AME 0.41, ALE 0.68, PME 0.41, PLE 0.93, AME–AME 0.12, AME–ALE 0.09, PME–PME 0.27, PME–PLE 0.26, AME–PME 0.41, ALE–PLE 0.32, CH AME 0.28, CH ALE 0.37. Leg and palp measurements: Pp 14.2 (4.5, 2.2, 3.0, -, 4.5), I 45.6 (12.7, 4.3, 12.5, 13.0, 3.1), II 48.3 (14.2, 5.2, 13.7, 12.2, 3.0), III 42.0 (12.2, 4.5, 11.9, 10.6, 2.8), IV 43.6 (12.1, 4.9, 12.4, 11.2, 3.0). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe I–III 323, IV 331; Pa 101; Ti I–III 2026, IV 2326; Mt I–II 1012, III 2014, IV 3036.

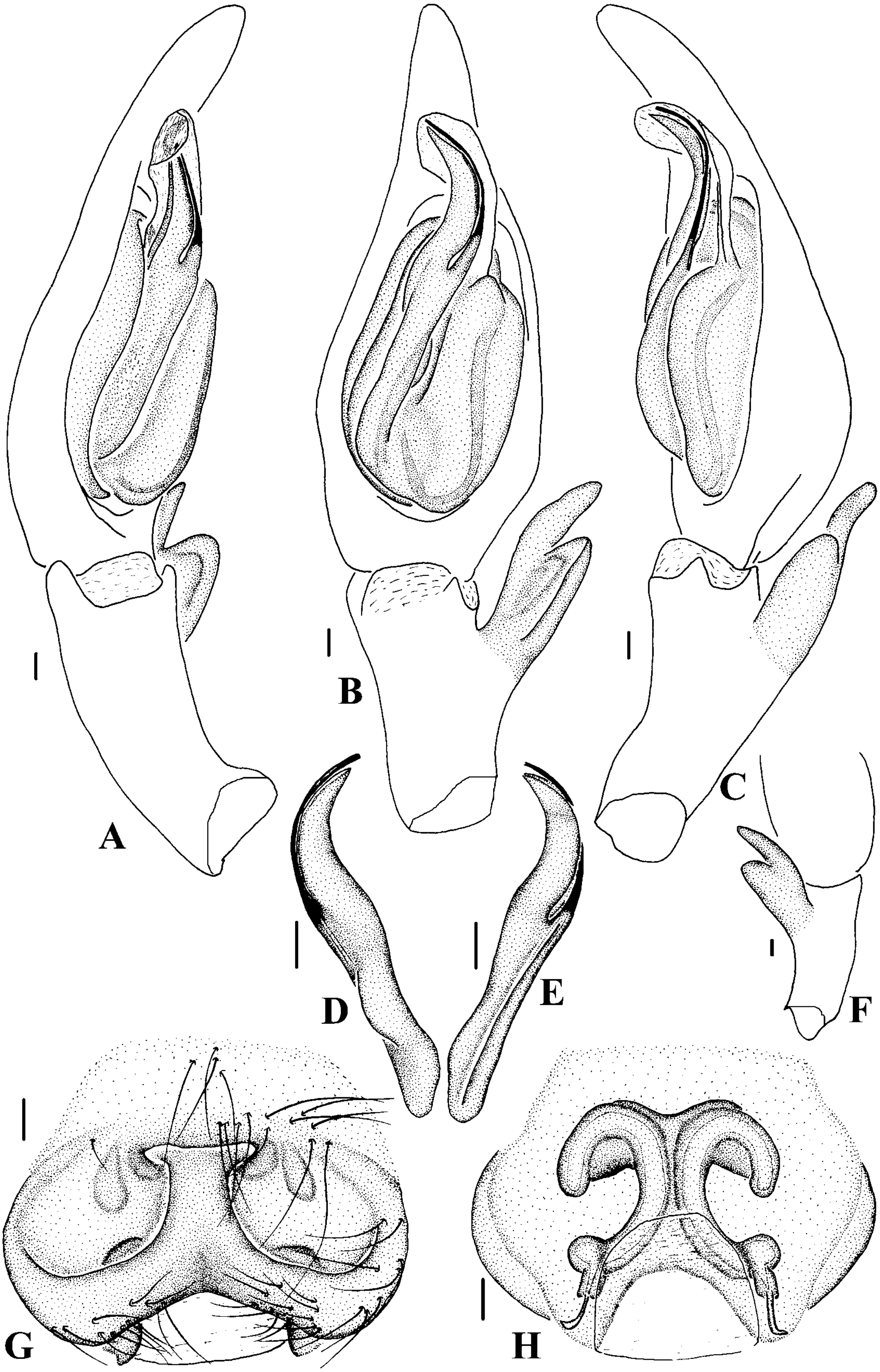
Copulatory organ as in diagnosis. Margins of lobal pockets running parallel to posterior margin of lateral lobes. Posterior margin of epigyne distinctly bilobate. Internal duct system with anterior part as wide as posterior part, anterior part bent at 180° (Figs 8G–H).

Distribution: China (Yunnan) (Fig. 12).

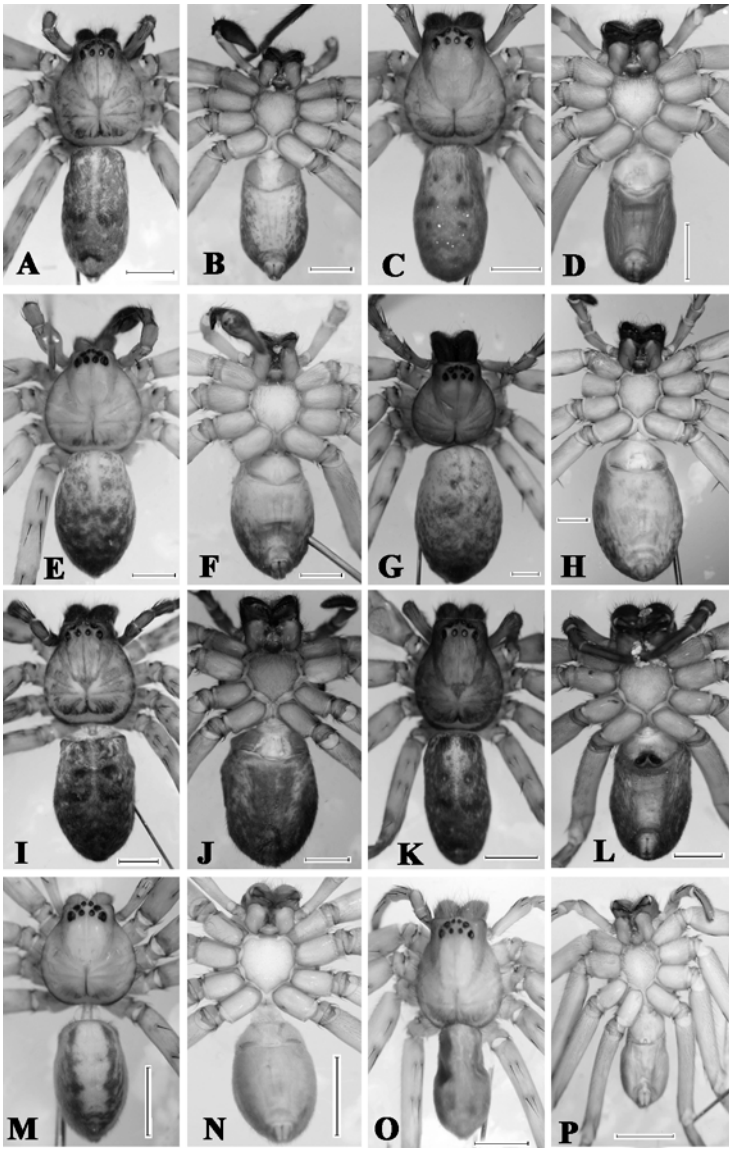
Sinopoda yaojingensis **sp. nov.**

Figs 2C–D, 9K–L and 12

Type material: Holotype female, 2 females (all IZCAS) and 1 female (SMF) paratypes, CHINA: Yunnan Province, Luoping County, Luoxiong Town, Yangzhewo Village, Yaojingdong Cave (24º50.284’N, 104º16.406’E, Alt: 1693m, T: 12°C, H: 80%), 20 March 2007, Yucheng Lin, Jie Liu leg.



FIGURES 8A–H. *Sinopoda undata* **sp. nov.**, holotype (A–F), paratype (G–H). A. Left male palp, prolateral view; B. Same, ventral view; C. Same, retrolateral view; D. Embolus and embolic apophysis, dorsal view; E. Same, ventral view; F. Left male palpal tibia, dorsal view; G. Epigyne, ventral view; H. Vulva, dorsal view. Scale lines: 0.2 mm.

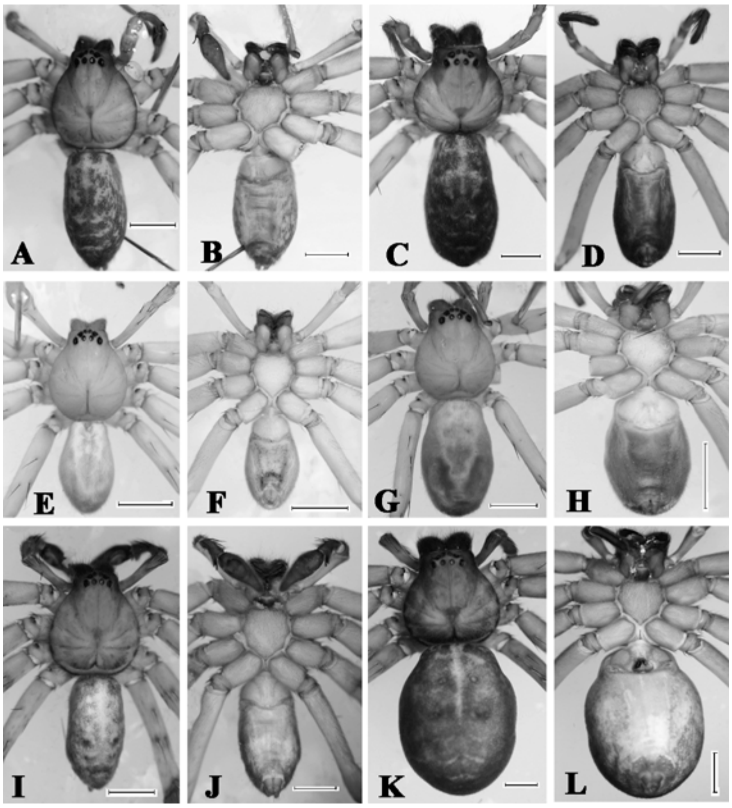


FIGURES 9A–P. A–B. *Sinopoda anguina* **sp. nov.**, male holotype; C–D. *Sinopoda crassa* **sp. nov.**, female holotype; E–H. *Sinopoda undata* **sp. nov.** (E–F. Male holotype, G–H. Female paratype); I–J. *Sinopoda fornicata* **sp. nov.**, female holotype; K–L. *Sinopoda yaojingensis* **sp. nov.**, female holotype; M–P. *Sinopoda grandispinosa* **sp. nov.** (M–N. Male holotype, O–P. Female paratype). (A, C, E, G, I, K, M, O, dorsal view; B, D, F, H, J, L, N, P, ventral view.). Scale lines: 3 mm.

Etymology: The specific name is a Latin adjective, referring to the type locality, the Yaojing Cave (Chinese: Yaojingdong).

Diagnosis: This new species may be recognised by the following combination of characters: 1. epigynal pockets distinctly curved, forming a narrow median part of epigyne; 2. posterior parts of internal duct system slightly swollen, distinctly narrower than anterior part; 3. anterior parts connected medially by a straight anterior rim (Figs 2C–D).

Description: Female (holotype). Measurements (in mm): PL 6.4, PW 5.5, AW 3.1, PH 5.2, OL 8.5, OW 6.7. Eyes: AME 0.31, ALE 0.41, PME 0.36, PLE 0.55, AME–AME 0.09, AME–ALE 0.14, PME–PME 0.32, PME–PLE 0.34, AME–PME 0.30, ALE–PLE 0.10, CH AME 0.33, CH ALE 0.42. Leg and palp measurements: Pp 8.2 (2.5, 1.2, 1.8, -, 2.7), I 21.7 (5.7, 2.9, 5.7, 5.6, 1.8), II 22.9 (6.6, 2.4, 5.8, 5.7, 2.4), III 18.8 (5.7, 2.2, 4.5, 4.5, 1.9), IV 21.2 (6.0, 2.2, 5.2, 5.2, 2.6). Leg formula: II-I-IV-III. Spination: Pp 131, 101, 2121, 1014; Fe I–III 323, IV 331; Pa I, IV 000, II–III 001; Ti I–III 2026, IV 2126; Mt I–II 1014, III 2026, IV 3036.



FIGURES 10A–L. A–D. *Sinopoda nuda* **sp. nov.** (A–B. Male holotype, C–D. Female paratype from Hejiaodong Cave); E–H. *Sinopoda semicirculata* **sp. nov.** (E–F. Male holotype, G–H. Female paratype); I–L. *Sinopoda triangula* **sp. nov.** (I–J. Male holotype, K–L. Female paratype) (A, C, E, G, I, K, dorsal view; B, D, F, H, J, L, ventral view.). Scale lines: 3 mm.

FIGURE 11. *Sinopoda undata* **sp. nov.** female paratype, habitus, dorsal view (taken in Yeniudong Cave, Mengyuan Village, Mengla County, Xishuangbana Dai Autonomous Prefecture, Yunnan Province, CHINA). (Photo by Dr Jinshuo Zhang).

Copulatory organ as in diagnosis. Median part of epigyne long, narrow and diverging posteriorly. Margins of lobal pockets running parallel to posterior margin of lateral lobes. Posterior margin of epigyne distinctly bilobate. Internal ducts diverging in their anterior and posterior part, anterior appendices long, slender, posterior parts of internal duct system small (Figs 2C–D).

Male. Unknown.

Distribution: China (Yunnan) (Fig. 12).

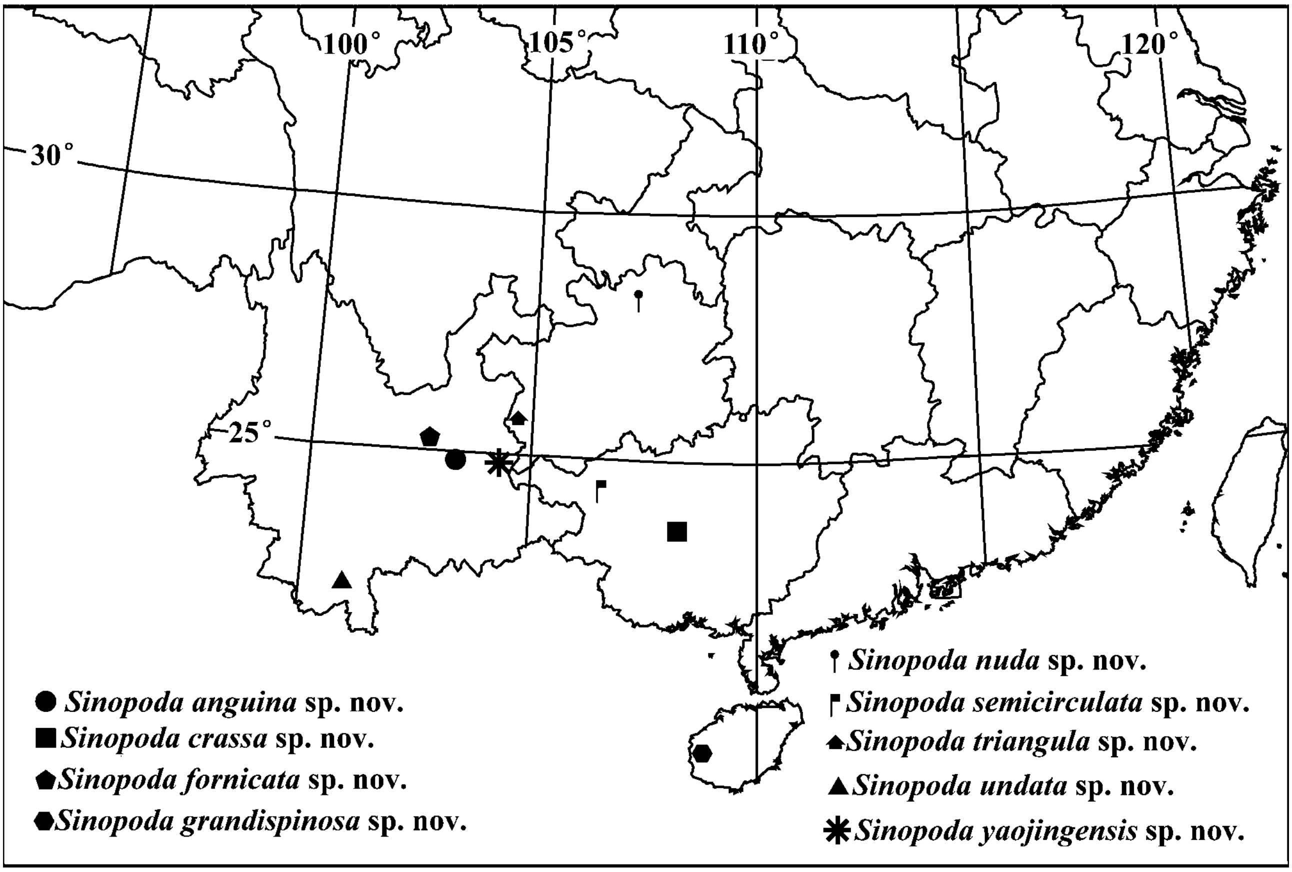


FIGURE 12. Collection localities of nine new *Sinopoda* species, described in this paper.

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Correspondence

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The true female of *Heteropoda squamacea* Wang, 1990 (Araneae: Sparassidae)

JIE LIU[1], SHUQIANG LI[1] & PETER JÄGER[2, 3]

[1]*Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China*
[2]*Research Institute Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, Germany*
[3]*Corresponding author. E-mail: Peter.Jaeger@Senckenberg.de*

Besides the genus *Olios* Walckenaer, 1837, *Heteropoda* Latreille, 1804 is the most diverse genus in the spider family Sparassidae. Currently, a total of 192 *Heteropoda* species are known, among them 13 from China (Platnick 2008). In the current paper, the female of *Heteropoda squamacea* Wang, 1990 is described for the first time. The previously proposed female of *H. squamacea* appeared to be a misidentification of *H. venatoria* (Linnaeus, 1767) (Jäger & Yin 2001). Another female paratype of *H. squamacea* falls into the variation scheme of *H. tetrica* Thorell, 1897 (Eusemann & Jäger, in press) and most likely belongs to this species. Due to congruence of palpal structure, especially the bifurcated tip of the conductor, *H. bifurcuta* Wang, Chen & Zhu, 2002 (not: *H. bifurcula*; contra Platnick 2008) is considered as a junior synonym of *H. squamacea*.

Specimens were examined and measured using an Olympus SZ40 stereomicroscope and an Olympus BX41 compound microscope. All illustrations were made using a drawing tube. Photos were taken with an Olympus C7070 wide zoom digital camera (7.1 megapixels) mounted on an Olympus SZX12 stereomicroscope. Male palps and female genitalia were examined and illustrated after they were dissected from the spiders' body. Vulvae of females were cleared in 90% lactic acid. The dissected parts were returned to ethanol and stored in a microvial with the body. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Number of spines are listed for each segment in the following order: prolateral, dorsal, retrolateral, ventral (in femora and patellae ventral spines are absent and fourth digit is omitted in the spination formula).

Abbreviations: ALE — anterior lateral eyes; AME — anterior median eyes; PLE — posterior lateral eyes; PME — posterior median eyes; RTA — retrolateral tibial apophysis; I, II, III, IV — legs I to IV. Collections: HNU — Hunan Normal University, Changsha, China; HUB — Hebei University, Baoding, China; IZCAS — Institute of Zoology, Academy of Sciences, Beijing, China.

This study was supported by the National Natural Sciences Foundation of China (NSFC-30670239/30770268), by the National Science Fund for Fostering Talents in Basic Research (Special Subjects in Animal Taxonomy, NSFC-J0630964/J0109), by the Knowledge Innovation Program of the Chinese Academy of Sciences (KSCX2-YW-Z-008/KSCX3-IOZ-0811), and partly also by the Ministry of Science and Technology of the People's Republic of China (MOST grant no. 2006FY120100/2006FY110500). Peter Jäger wishes to thank all colleagues from the Hunan Normal University, Changsha, for their kind help and support, furthermore the Deutscher Akademischer Austauschdienst (DAAD) and the National Natural Sciences Foundation of China (NSFC) for a travel grant to Beijing and Changsha.

Heteropoda squamacea Wang, 1990

Figs 1–8

Heteropoda squamacea Wang, 1990: 7, figs 6–10 (description of male, misidentification of female; Holotype male, China, Yunnan Province, Yuanjiang County, 8 March 1979, Jiafu Wang, HNU. 1 female paratype (misidentification; = *Heteropoda venatoria*), same data as for holotype. 1 female paratype (misidentification; = *Heteropoda tetrica*), 1 juvenile, China, Yunnan Province, Mengyang County, 10 March 1979, Jiafu Wang, HNU) all examined. Song, Zhu & Chen, 1999: 468, figs 268R, 269A (illustration of male, recognising presumable misidentification of female). Jäger, in press: figs. 340–349 (illustration of male and female).

Heteropoda bifurcuta Wang, Chen & Zhu, 2002: 19, figs 1–5 (description of male; Holotype: male, China, Guizhou Province, Libo County, Dongtang township, Baixian Mountain, 2 September 1998, Huiming Chen, HUB) examined. **New Synonymy.**

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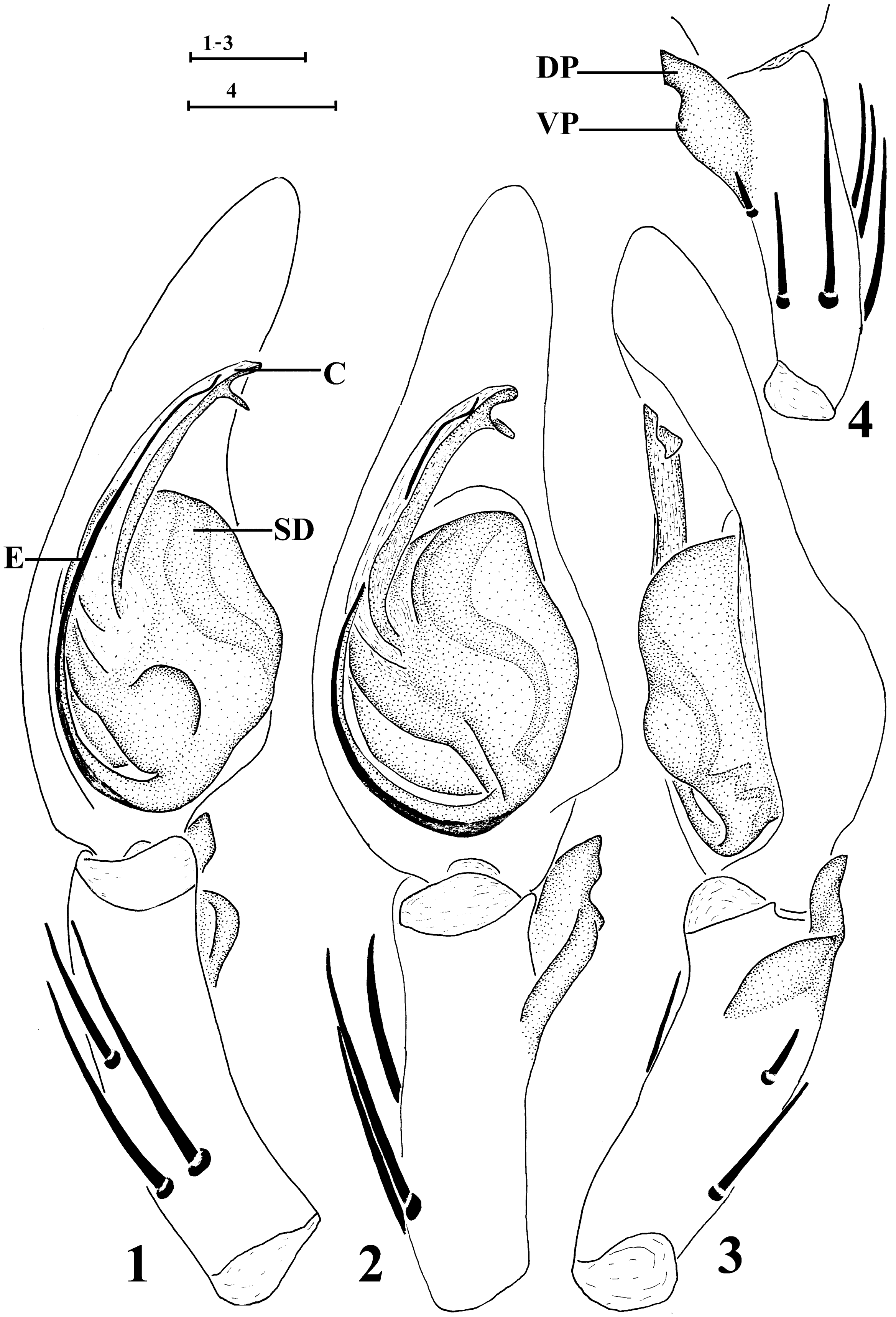
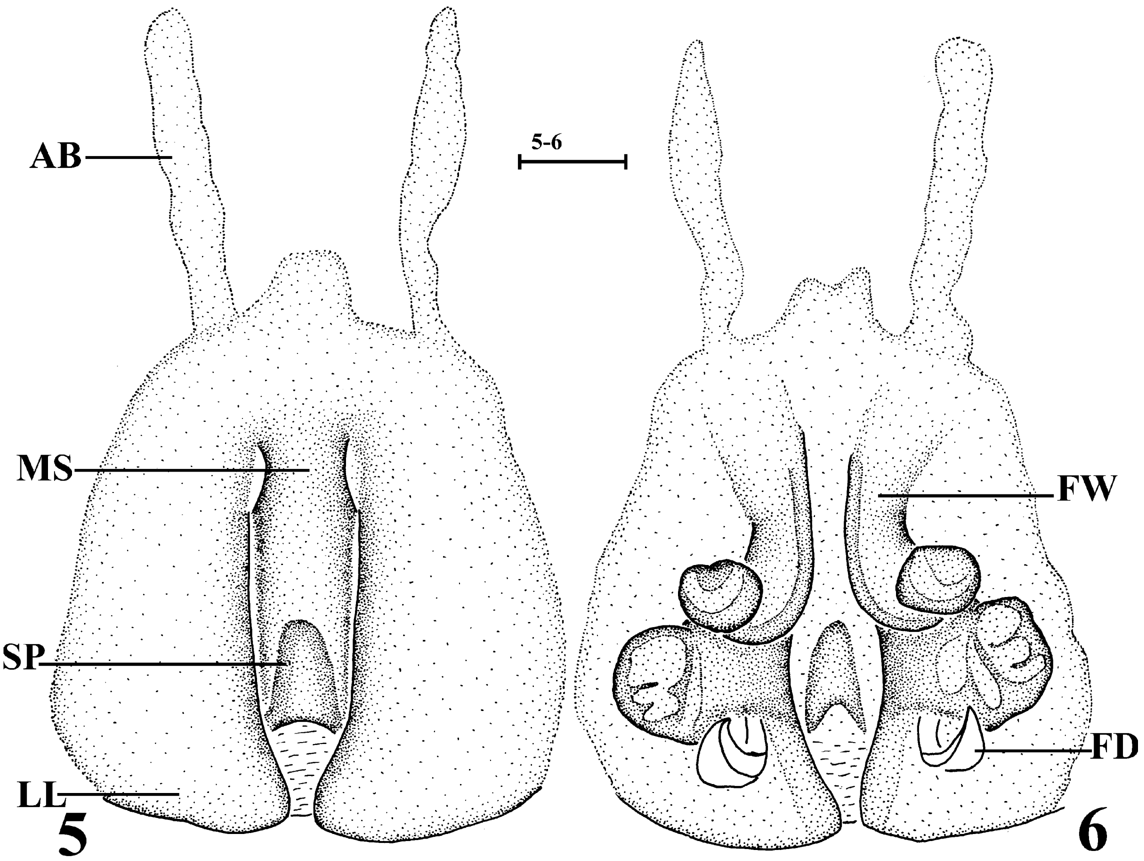
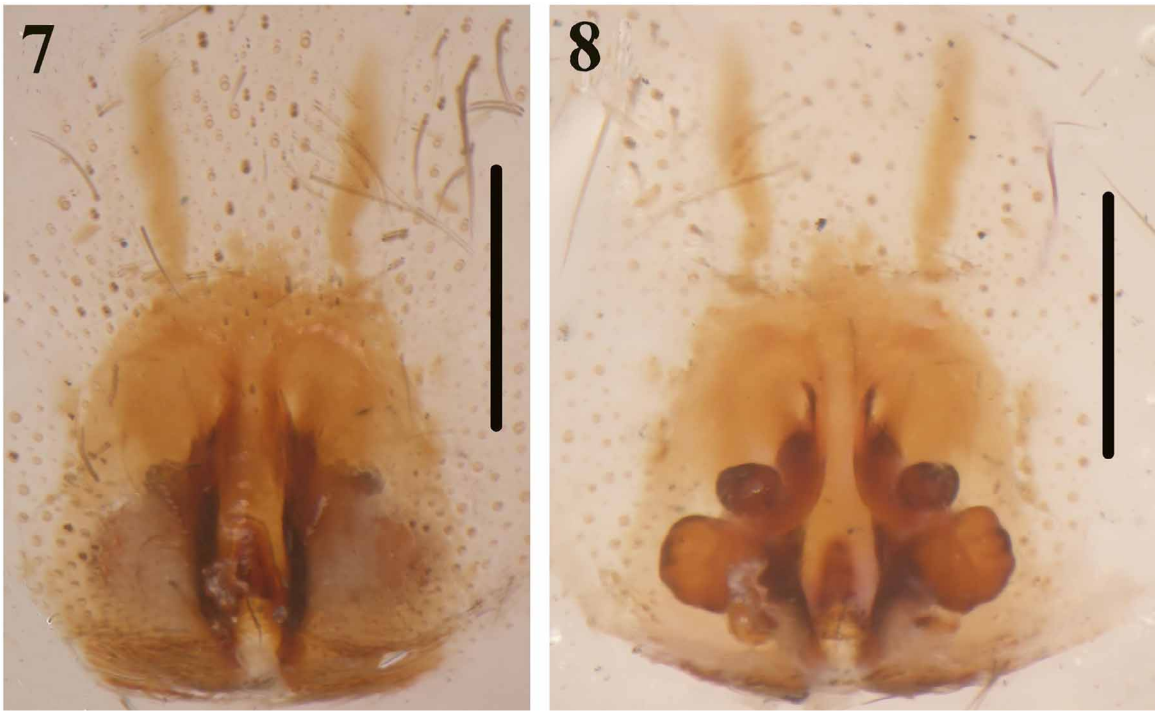


FIGURES 1–4. *Heteropoda squamacea*, male from Huangniudong Cave. 1–3 Left male palp (1 prolateral, 2 ventral, 3 retrolateral; 4 Palpal tibia, dorsal view. Scale bars: 1.0 mm. C — conductor, DP — dorsal part of RTA, E — embolus, SD — sperm duct, VP — ventral part of RTA.



FIGURES 5–6. *Heteropoda squamacea*, female from Huangniudong Cave. 5 Epigyne, ventral view; 6 vulva, dorsal view. Scale bar: 0.2 mm. FD — fertilisation duct, FW — first winding of the internal genital duct system, LL — lateral lobes, MS — median septum, SP — septal pocket.



FIGURES 7–8. *Heteropoda squamacea*, female from Huangniudong Cave. 7 Epigyne, ventral view; 8 Vulva, dorsal view. Scale bars: 7–8 = 0.5mm.

Additional material examined. CHINA: *Guangxi Zhuang Autonomous Region:* 1 male, 1 female, Dahua County, Jiangnan Town, Damo Village, Huangniudong Cave (23º55.120´N, 107º37.479´E), 15 May 2008, Fengxiang Liu & Jie Liu (IZCAS); 1 female, same locality as for preceding specimens, 8 March 2007, Yucheng Lin & Jie Liu (IZCAS); 1 male, Fengshan County, Fengcheng Town, Songren Village, Xi-Andong Cave (24º33.941´N, 107º02.465´E), 16 May 2008, Fengxiang Liu & Jie Liu (IZCAS).

Diagnosis. Males of *H. squamacea* can be distinguished from other *Heteropoda* species by the furcated distal tip of the conductor. Female copulatory organ is similar to that of *Heteropoda venatoria* (Linnaeus, 1767), but can be distinguished by the distinct median septum and the smaller anterior windings of the internal genital duct system (relatively larger in *H. venatoria* in comparison with posterior parts).

Redescription of male (from Huangniudong Cave): Measurements (in mm): Prosoma length 7.75, width 8.00, anterior width 3.50, height 3.50; opisthosoma length 9.00, width 5.00. Eyes: AME 0.35, ALE 0.58, PME 0.50, PLE 0.63, AME–AME 0.20, AME–ALE 0.02, PME–PME 0.25, PME–PLE 0.50, AME–PME 0.40, ALE–PLE 0.45, clypeus height at AME 0.58, clypeus height at ALE 0.38. Leg and palp measurements: Palp 14.25 (4.75, 2.00, 2.75, -, 4.75), I 55.00 (15.00, 4.75, 15.00, 16.00, 4.25), II 61.05 (15.50, 5.00, 18.50, 17.30, 4.75), III 43.25 (11.50, 4.50, 12.00, 12.00, 3.25), IV - (-, -, -, -, -). Spination: palp 131, 101, 2121; femur I–III 323; patella I–III 101; tibia I–II 2328, III 2126; metatarsus I–II 1014, III 2024.

Male palp as in diagnosis. Tip of cymbium as long as tegulum. Embolus arising in 5- to 5.30-o'clock-position on tegulum. Sperm duct 'S'-shaped. Conductor almost as long as tegulum, not reaching the cymbial margin in ventral view, with a furcated tip. RTA simple (Figs 1–4).

Description of female (from Huangniudong Cave): Measurements (in mm): Prosoma length 8.00, width 7.25, anterior width 3.75, height 3.00; opisthosoma length 12.50, width 7.50. Eyes: AME 0.25, ALE 0.53, PME 0.38, PLE 0.58, AME–AME 0.13, AME–ALE 0.05, PME–PME 0.25, PME–PLE 0.23, AME–PME 0.30, ALE–PLE 0.23, clypeus height at AME 0.63, clypeus height at ALE 0.50. Leg and palp measurements: Palp 13.95 (4.30, 2.15, 3.10, -, 4.40), I 42.10 (12.00, 4.50, 12.50, 10.50, 2.60), II 45.30 (13.00, 4.50, 14.00, 11.00, 2.80), III 38.00 (11.00, 4.00, 11.50, 8.80, 2.70), IV 41.70 (12.00, 3.80, 11.30, 12.00, 2.60). Leg formula: II-I-IV-III. Spination: palp 131, 101, 2121, 1014; femur I–III 323, IV 331; patella I 001, II–IV 000; tibia I–II 2026, III–IV 2126; metatarsus I–II 1014, III 2024, IV 3036.

Copulatory organ as in diagnosis. Anterior bands of epigynal field attached to the field, slightly more than half as long as the epigynal field, lateral lobes of epigyne not touching each other, median septum of epigyne clearly visible. Anterior part of first winding almost parallel to each other, looped apex spherical, situated at the margin of the first winding (Figs 5–8).

Distribution. China (Guangxi, Guizhou, Yunnan).

Remarks. Wang *et al.* (2002) distinguished *H. bifurcuta* from *H. squamacea* by the following characters: 1. distal end of embolus not covered by conductor in *H. bifurcuta* (the embolus is easy to move, so the relative position of the conductor is easy to change, and the embolus is shorter than conductor in both specimens); 2. conductor branched at the distal end with the lower branch needle-shaped in *H. bifurcuta* (in fact, the lower branch shows needle-shaped in a prolateral view, sheet-shaped in a retrolateral view in both specimens); 3. tip of tibial apophysis pointed, not strongly curved in *H. bifurcuta* (both species having the same shape of RTA after examining the type specimens). Therefore we place *H. bifurcuta* in the synonymy of *H. squamacea*.

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THE AMPHIPOD PILOT SPECIES PROJECT (AMPIS), A NOVEL DUTCH-CHINESE TAXONOMIC INITIATIVE (PERACARIDA, AMPHIPODA): A DESCRIPTION OF THE PROJECT

BY

DIRK PLATVOET[1,4]), ZHONG-E HOU[2]), SHUQIANG LI[2])
and GERARD VAN DER VELDE[3])

[1]) Zoological Museum, University of Amsterdam, Mauritskade 57, NL-1092 AD Amsterdam, The Netherlands
[2]) Institute of Zoology, Chinese Academy of Sciences, Du-Tun Road, Beijing 100101, P.R. China
[3]) Dept. of Animal Ecology and Ecophysiology, Institute for Wetland and Water Research, Radboud University Nijmegen, Toernooiveld 1, NL-6525 ED Nijmegen, The Netherlands

ABSTRACT

AMPIS is a comprehensive database of pictures and illustrations of the morphology of a collection of selected amphipod pilot species. All macro- and micro-characters of the entire body surface are systematically recorded. A pilot species in AMPIS is represented by a large number of illustrations and scanning electron micrographs accessible via a series of increasing magnification steps. Functional morphological interpretations will be made based on the inventories. Explanatory video recordings concerning specific behaviour will be added.

This unique vertical database, first of its kind, will be complementary to the many overlapping horizontal database projects that have been developed or are under construction. AMPIS will meet a demand for a framework of more detailed information of the highly complex morphology of amphipods. It is an entirely new approach towards taxonomic research.

AMPIS is the result of a cooperation between the Zoological Institute of the Chinese Academy of Sciences, the Radboud University of Nijmegen, and the University of Amsterdam, the last two partners from the Netherlands. The project is funded by the China Exchange Programme of the Royal Netherlands Academy of Sciences.

RÉSUMÉ

AMPIS est une base de données d'images et d'illustrations de la morphologie d'une collection d'espèces sélectionnées d'amphipodes. Tous les macro- et micro-caractères de la surface du corps dans son entier sont systématiquement enregistrés. Une espèce pilote dans AMPIS est représentée par un grand nombre d'illustrations et de microphotographies réalisées en microspopie électronique

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[4]) e-mail: platvoet@science.uva.nl

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à balayage via une série de grossissements successifs. Les interprétations en morphologie fonctionnelle seront réalisées à partir des inventaires. Des enregistrements vidéos explicatifs sur le comportement spécifique seront ajoutés.

Cette base de données unique, vertical, la première du genre, complètera les multiples projets de base de données horizontales, qui ont été développées ou sont en construction. AMPIS répondra à la demande pour une structure d'information plus détaillée sur la morphologie hautement complexe des amphipodes. C'est une approche entièrement nouvelle de la recherche taxonomique.

AMPIS est le résultat d'une coopération entre l'Institut de Zoologie de l'Académie des Sciences de Chine, l'Université Radboud de Nijmegen et l'Université d'Amsterdam, ces deux dernières des Pays-Bas. Le projet est financé par le «Programme d'échange avec la Chine» de l'Académie Royale des Sciences des Pays-Bas.

INTRODUCTION

From the time Linnaeus started modern taxonomy by introducing the binominal system, many species descriptions have one thing in common: they are produced arbitrarily. In the early days of taxonomy the reproduction of illustrations was a difficult and time-consuming process, resulting in primary emphasis on text. By the late nineteenth century printing techniques had improved so much that illustrations became more commonly used and their value for comparative research increasingly appreciated. However, illustrations in journals remain expensive, space limited, and therefore authors make selections, resulting in large differences in methods. This non-standardized approach has slowly undermined the status of taxonomy as a science. AMPIS tries to halt this process by systematically providing information of the entire morphology of species.

Horizontal taxonomic databases are in fashion (see website of Fauna Europaea: http://www.faunaeur.org/external_databases.php). Most initiatives cover groundwork, providing collections of names. Morphological information, if provided at all, is often presented in an unsatisfactory manner. Promising picture databases, such as MorphBank (http://morphbank.csit.fsu.edu/) are underway, but they are random in purpose, content, and form.

AMPIS provides as much information as possible of the entire body surface. Buttons give access to details (a few μm) and from there to publications highlighting these particular structures. This systematic and detailed overall visualization of amphipod morphology will be explanatory to those studying these important biota. Also, a series of publications is now being and will be produced, concerning specific (functional) morphological subjects (cf. Platvoet et al., 2005, 2006a; Platvoet et al., 2006b, 2007).

Structure of the database

The database will have a layered setup, in which a user can navigate to higher levels of magnification, allowing an easy access to details. The database will be fully compatible with other types of databases and with the internet, and will be based on the program Microsoft Power Point®.

Species choice

In fresh and brackish waters, gammaridean amphipods can make up to 90% of the total macrofaunal biomass (MacNeil, 1997). The important role of these animals in food chains becomes increasingly recognized. Identification of the animals is difficult, and limited to a decreasing number of specialists. AMPIS will provide information for the development of new (pictorial) keys for non-specialists. The large family Gammaridae is plesiomorphic in virtually all aspects compared to most of the other amphipod families (Barnard & Barnard, 1983), and therefore suitable as a starting point for this project.

In western Europe, the Ponto-Caspian species, *Dikerogammarus villosus* (Sowinsky, 1894) is rapidly extending its range at the expense of indigenous species and earlier invaders. The large body size of especially the males, in combination with the species' special adaptations to a predatory lifestyle, made us decide to choose this species as the first species to describe and, thus, set a standard for future descriptions in the course of the development of the project.

CONCLUSIONS

AMPIS is a unique initiative to assemble all available (functional) morphological information of amphipod 'pilot' species 'under one roof'.

AMPIS facilitates the identification and description of related species.

The accumulated knowledge developed by AMPIS, including genetic information, will form the basis of a highly sophisticated phylogenetic analysis of freshwater Amphipoda.

Our understanding of the behaviour of amphipods (and of crustaceans in general) will profit from this project. Behaviour and morphology go hand in hand.

Our understanding of invasive processes by exotic species will benefit from the knowledge of morphological pre-adaptations to new environments. AMPIS gives access to relevant, detailed information.

Nowadays, scientists in technical and other (i.e., pure) sciences become increasingly aware of the fact that lessons can be learned from the millions of years of evolutionary development in organisms. AMPIS can produce a link between these scientists and the highly complex (functional) morphology of amphipods.

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Four *Erigone* species (Araneae: Linyphiidae) from China

Yanjing SONG[1, 2] & Shuqiang LI[1, 3]
[1] Institute of Zoology, Chinese Academy of Sciences, Datun Road, Chaoyang District, Beijing 100101, P. R. China.
[2] Graduate University of Chinese Academy of Sciences, Yuquan Road, Shijingshan District, Beijing 100049, P. R. China.
[3] Corresponding author. E-mail: lisq@ioz.ac.cn

Four *Erigone* species (Araneae: Linyphiidae) from China. - *Erigone* species from China are reviewed and four of them, *E. lata* sp. n., *E. zheduoshanensis* sp. n., *E. atra* Blackwall, 1833 and *E. prominens* Bösenberg & Strand, 1906, are described. The name *E. ourania* Crosby & Bishop, 1928 is placed in the synonymy of *E. prominens*. *E. maculivulva* Strand, 1907, *E. noseki* Strand, 1907 and *E. subprominens* Saito, 1936 are treated as nomina dubia.

Keywords: Taxonomy - variation - type - new synonym - new species - nomina dubia.

INTRODUCTION

The linyphiid spider genus *Erigone* was established by Victor Audouin for *E. vagans* (Audouin, 1826), which was later transferred to the genus *Prinerigone* (Millidge, 1993). In order to conserve the name *Erigone* for the majority of species included in the genus, an application was made to the International Commission on Zoological Nomenclature which then substituted *E. longipalpis* (Sundevall, 1830) for *E. vagans* as the type species of *Erigone* (see Millidge, 1985).

The genus *Erigone* currently comprises 155 species, 11 of which have been reported from China (Platnick, 2008). Our examination of the holotype of *E. ourania* proved that it is a junior synonym of *E. prominens* and we found that the record for *E. longipalpis* from China is incorrect due to misidentification. Based on the fact that *E. maculivulva*, *E. noseki* and *E. subprominens* were described only from females, that no sufficient species diagnoses were provided, that the types of *E. maculivulva* and *E. noseki* were confirmed destroyed during World War II (Renner, 1988), and that the types for *E. subprominens* were also lost (Hirotsugu Ono, personal communication), we treat *E. maculivulva*, *E. noseki* and *E. subprominens* as nomina dubia.

Consequently only six *Erigone* species are confirmed for China. *E. dentipalpis* (Wider, 1834), *E. jägeri* Baehr, 1984, *E. koshiensis* Oi, 1960 and *E. sinensis* Schenkel, 1936 have already been described in detail (Wiehle, 1960; Baehr, 1984; Thaler, 1993; Tu *et al.*, 2005). Descriptions of the remaining two species, *E. atra* and *E. prominens*, as well as two new species are provided in the current paper. At present a total of eight *Erigone* species are known from China.

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MATERIAL AND METHODS

The material used for this study is deposited in the following institutions:

AMNH	American Museum of Natural History, New York, USA;
IZCAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, China;
JLU	Jilin University, Changchun, China;
MHNG	Muséum d'histoire naturelle, Genève, Switzerland.

For each species only the original description and new synonym are listed. Synonyms listed in the spider catalog of Platnick (2008) are not repeated here. Locality names and distribution data are given according to current Chinese standard (Peng *et al.*, 2003).

Specimens were examined using an Olympus-SZ11 stereomicroscope and illustrated using an Olympus-BX41 compound microscope equipped with a drawing tube. Left male palps and female epigyna were illustrated after being separated from the body. Embolic divisions were dissected from the palpal bulb using sharp pins and forceps. Genital organs were immersed in 75% alcohol and examined under a compound microscope; embolic divisions and vulvae were mounted in Hoyer's Solution and examined in strong transmitted light against a white background. In addition, the ventral tegument of epigyna was removed by sharp pins and forceps to study the duct system of the vulvae under a microscope.

Eye diameters were measured at their widest extent. Leg measurements are given as: Total length (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimeters. Terminology of genitalic structures follows Hormiga (2000) and Tanasevitch (2006).

The following abbreviations of somatic morphology and genitalic structures are used in the text and in the figures:

Somatic morphology: ALE, anterior lateral eye; AME, anterior median eye; PLE, posterior lateral eye; PME, posterior median eye; Tm I, position of trichobothrium on metatarsus I; Tm II, position of trichobothrium on metatarsus II; Tm IV, trichobothrium on metatarsus IV.

Male palp: ARP, anterior radical process; AT, anterior tooth; C, column; CTT, central tibial teeth; DSA, distal suprategular apophysis; E, embolus; EM, embolic membrane; MM, median membrane; MT, mesal tooth; PC, paracymbium; PRP, posterior radical process; PT, protegulum; PTA, prolateral tibial apophysis; R, radix; RTA, retrolateral tibial apophysis; SPT, suprategulum; ST, subtegulum; T, tegulum; TP, tailpiece of radix.

Epigynum: CD, copulatory duct; CO, copulatory opening; DP, dorsal plate; FD, fertilization duct; FO, fertilization opening; S, spermatheca; VP, ventral plate; VPD, ventral plate depression.

RESULTS

Erigone atra Blackwall, 1833 Figs 1-2

Erigone atra Blackwall, 1833: 195.

MATERIAL EXAMINED: GERMANY: 1♂1♀ (IZCAS), Baden-Württemberg, Lkr. Ravensburg, Wurzacher Ried, Haidgauer Torfgebiet, coll. S. Li, 15.X.1992; 1♂1♀ (IZCAS), Nordrhein-Westfalen, 20 km SE Köln, NSG Wahner Heide, Munitionsdepot, coll. T. Stumpf,

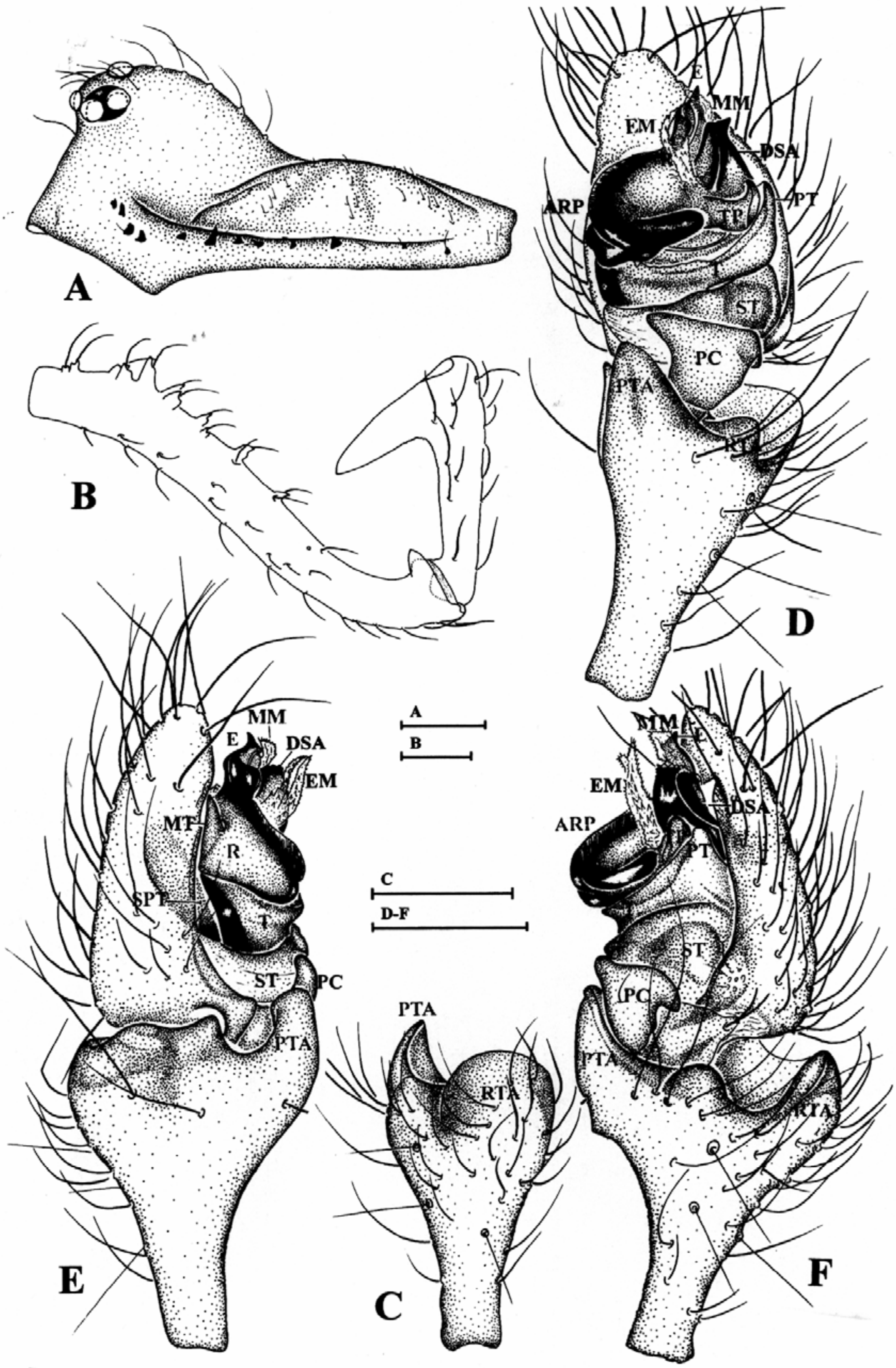

FIG. 1

Erigone atra. (A) Male carapace, lateral view. (B) Patella and femur of left male palp, retrolateral view. (C) Tibia of left male palp, dorsal view. (D) Distal part of left male palp, ventral view. (E) Same, prolateral view. (F) Same, retrolateral view. Drawings based on a specimen from Sichuan, China. Scale lines: 0.2 mm.

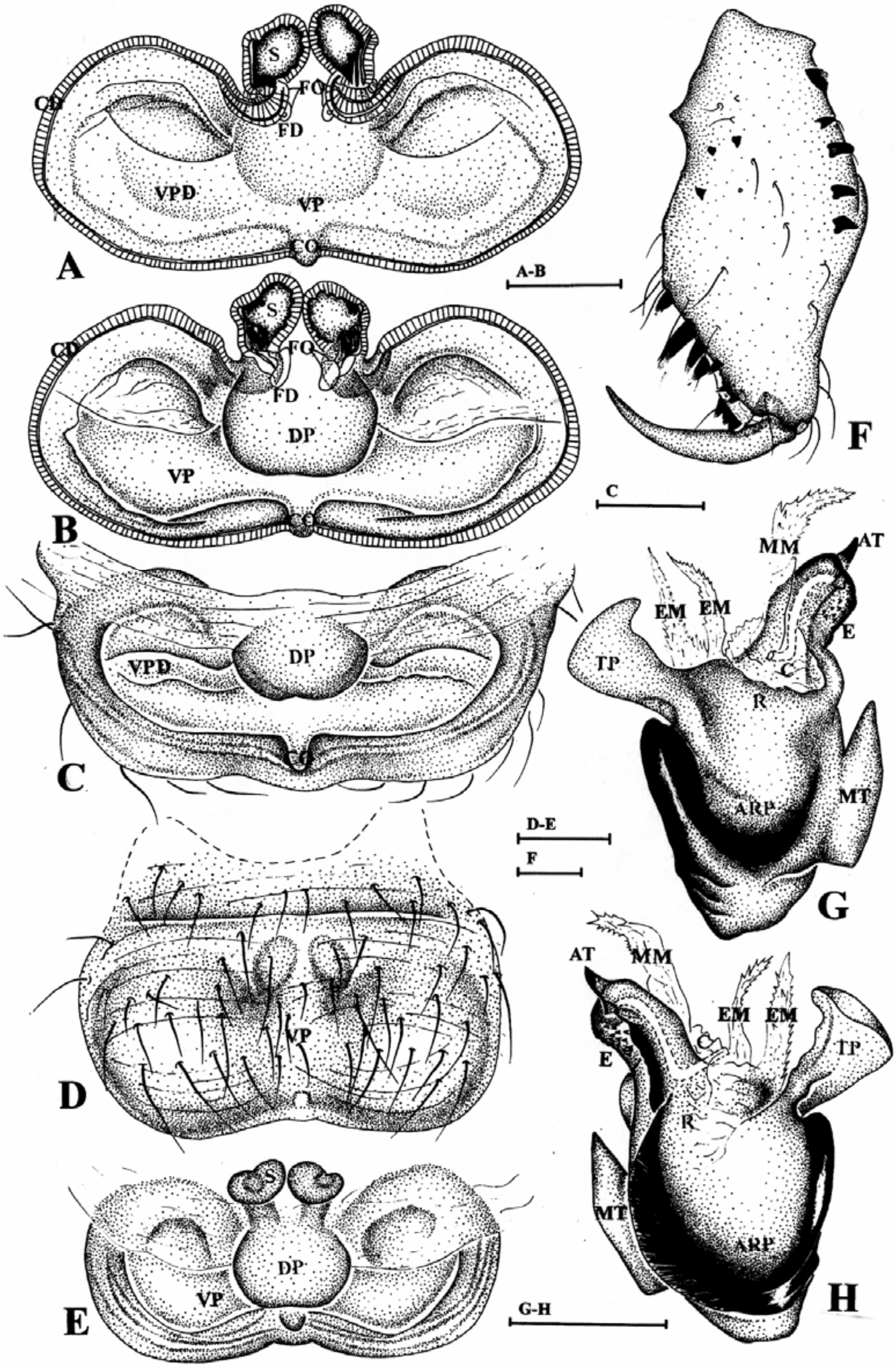

FIG. 2

Erigone atra. (A) Vulva, ventral view. (B) Same, dorsal view. (C) Epigynum, posterior view. (D) Same, ventral view. (E) Same, dorsal view. (F) Left male chelicera, frontal view. (G) Embolic division, dorsal view. (H) Same, ventral view. Drawings based on specimens from Sichuan, China. Scale lines: 0.1 mm.

27.XII.1990-7.I.1991, pitfall traps. – CHINA: 2♀2♂ (IZCAS), Xinyuan County (43.43°N, 83.27°E), Xinjiang Uygur Autonomous Region, coll. J. Chen, 3.VII.1991; 1♀ (IZCAS), Nyingchi County (29.53°N, 94.55°E), Tibet Autonomous Region, coll. M. Wu, 8-9.VII.1997; 18♀27♂ (MHNG), Mt Changbaishan (42.12°N, 128.35°E), Jilin Province, coll. J. Gao, 27.VII.1987; 5♀2♂ (IZCAS), Kouqian Town (43.68°N, 126.30°E), Yongji County, Jinlin Province, coll. Y. Tao, 28.VI.1989; 1♂ (IZCAS), Xining City (36.60°N, 101.70°E), alt. 2250-2330m, Qinghai Province, coll. M. Wu, 3.VI.1997; 14♀24♂ (JLU), 91-141, no detailed information; 1♂5♀ (MHNG), Fengtongzhai Town (30.37°N, 102.85°E), Baoxing County, Sichuan Province, China, coll. S. Li and L. Tu, 2-5.VII.2004.

DIAGNOSIS: Males of this species can be distinguished from those of similar species by the following combination characters: Anterior radical process bowl-shaped (Fig. 1F), mesal tooth robust (Fig. 2G-H), and tip of embolus clothed with numerous papillae (Fig. 2G-H). Females can be recognized by the bowknot-shaped course of their copulatory ducts (Fig. 2A-B).

DESCRIPTION: In addition to the characters given in the description of Crosby & Bishop (1928), two shallow depressions were found on the sclerotized capsule of the epigynum after the ventral tegument was removed (Fig. 2A).

DISTRIBUTION: Holarctic. In China this species was recorded in the provinces of Gansu, Jilin, Qinghai, Sichuan, Tibet and Xinjiang.

HABITAT: Found in wet moss, forest litter, under stones and among grass roots.

Erigone lata sp. n. Figs 3-5

MATERIAL EXAMINED: CHINA: ♂ holotype (IZCAS), Yakou Region (30.10°N, 101.75°E), Mt Zheduoshan, Kangding County, Sichuan Province, coll. S. Li and L. Tu, 17.VII.2004. – 8♂ 25♀ paratypes (IZCAS), same data as for holotype. – 1♂ 3♀ paratypes (IZCAS), Lhakang Town (30.27°N, 101.55°E), Kangding County, Sichuan Province, coll. Y. Song, 29.VII.2004. – 1♂ 4♀ paratypes (MHNG), Lhakang Town (30.27°N, 101.55°E), Kangding County, Sichuan Province, coll. Y. Song, 29.VII.2004.

DIAGNOSIS: The new species is similar to *E. arctica* (Holm, 1956), but the absence of a deep indentation mesally below the retrolateral tibial apophysis (Fig. 5K), the sharply pointed central tibial teeth (Fig. 5J), the broad, short tailpiece of the embolic division (Fig. 5E-F) and the oblate dorsal plate of the epigynum (Fig. 4B, E) of *E. lata* sp. n. show that it is distinct. The new species is also similar to *E. sinensis*, but males can be distinguished by the broad tailpiece and the short and slightly blunter anterior radical process of the embolic division, and by the smooth outer margin of the retrolateral tibial apophysis. Females can be distinguished by the broader posterior part of the ventral plate and rectangular capsule of the vulva (posterior part of the ventral plate narrow and capsule cordate in *E. sinensis*) and by the rounded spermathecae (oblong in *E. sinensis*).

DESCRIPTION OF MALE HOLOTYPE: Total length 2.70. Carapace 1.23 long, 0.97 wide, auburn, distinctly raised in the head region (Fig. 3A). Margins of carapace furnished with several small teeth (Fig. 3A). Clypeus 0.28 high. Abdomen dark brown. AME diameter 0.07, ALE 0.06, PME 0.07, PLE 0.07, AME interdistance 0.27 times their diameter, AME-ALE interdistance 0.68 times ALE diameter, PME interdistance 0.95 times their diameter, PME-PLE interdistance 1.05 times PLE diameter. Sternum 0.70 long, 0.70 wide, auburn. Coxa IV interdistance 0.97 times their width. Chelicera

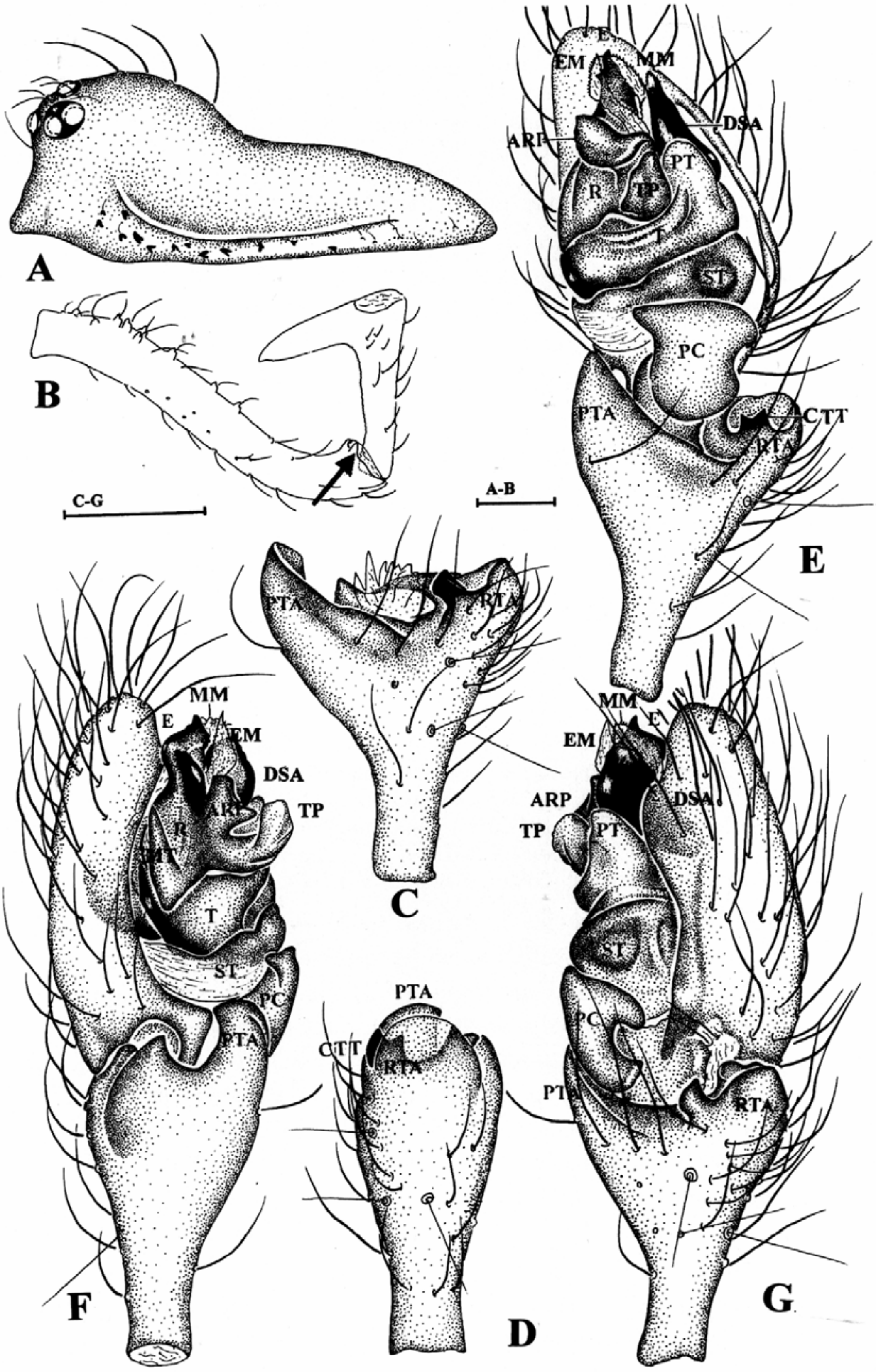

FIG. 3

Erigone lata sp. n. (A) Male carapace, lateral view. (B) Patella and femur of left male palp, retrolateral view (arrow indicates an extra tooth at the distal end). (C) Tibia of left male palp, retrolateral view. (D) Same, dorsal view. (E) Distal part of left male palp, ventral view. (F) Same, prolateral view. (G) Same, retrolateral view. Drawings based on the holotype. Scale lines: 0.2 mm.

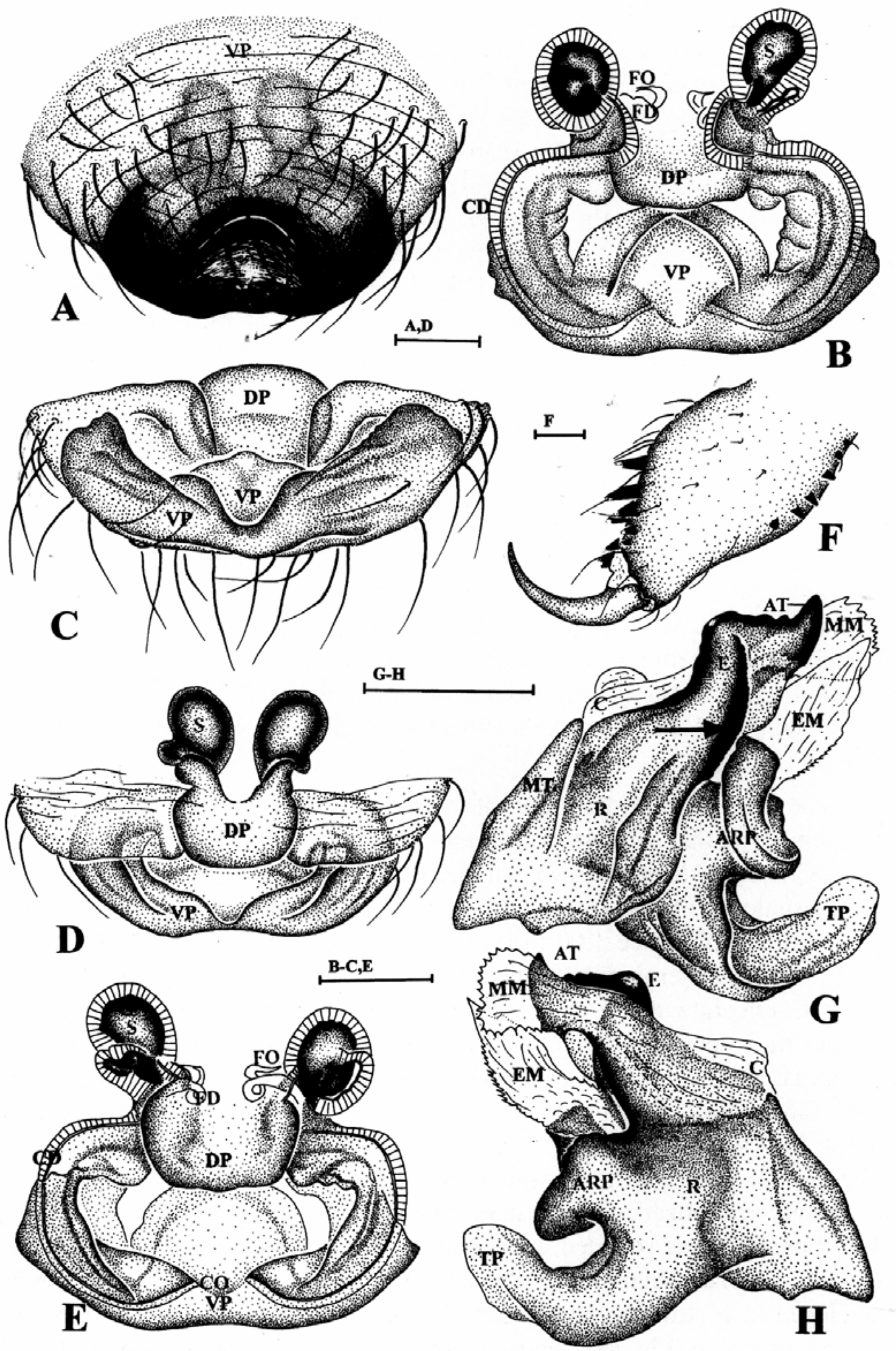

FIG. 4

Erigone lata sp. n. (A) Epigynum, ventral view. (B) Vulva, ventral view. (C) Epigynum, posterior view. (D) Same, dorsal view. (E) Vulva, dorsal view. (F) Left male chelicera, frontal view. (G) Embolic division, ventral view (arrow indicates the longitudinal ridge of the radix). (H) Same, dorsal view. Drawings based on paratype (A-E) and holotype (F-H). Scale lines: 0.1 mm.

grayish brown, anterolaterally furnished with a row of 6 small teeth; fang groove with 5 promarginal and 4 retromarginal teeth (Fig. 4F). Legs dusky yellow. Tibia of leg I 7.39 times longer than deep. Tm I 0.50, Tm IV absent. Dorsal spines on tibia of leg IV: 2-2-2-1; dorsal spine on patella of leg IV: 1-1-1-1. Leg measurements: I 3.17 (0.86, 0.36, 0.83, 0.66, 0.46); II 2.96 (0.81, 0.36, 0.74, 0.62, 0.43); III 2.55 (0.69, 0.35, 0.58, 0.54, 0.39); IV 3.22 (0.89, 0.32, 0.84, 0.71, 0.46).

Palp: Femur long, slightly curved, with 3 rows of small teeth (these usually furnished with weak hairs on top) and an extra tooth at its distal end (Fig. 3B). Patella slender, with tapering ventral apophysis (Fig. 3B). Tibia widened distally (Fig. 3C-G), without tooth on ventral side of widened part; blunt retrolateral apophysis without a deep indentation mesally; prolateral apophysis pointed, obliquely curved; 2 central teeth sharply pointed; 1 prolateral and 2 retrolateral trichobothria present. Paracymbium C-shaped, with hooked terminal part and 2 hairs on basal arm of paracymbium near junction with cymbium (Fig. 3G). Tegulum distal to subtegulum in unexpanded palp (Fig. 3E). Protegulum well-developed, covering base of strongly sclerotized distal suprategulum (Fig. 3E). Tailpiece of embolic division similar to that of *E. arctica* (see Holm, 1956), but a bit broader and shorter (Fig. 5F). Anterior radical process somewhat round when seen from distally (Fig. 5E), with outer margin expanded downwards. Mesal tooth tapering, directed distally (Fig. 3F). Embolus (Figs 3G, 5F) rather short, with distal end curved to form an anterior tooth; accompanied by a long embolic membrane arising from center of radix, and by a median membrane arising from column. Radix furnished with a longitudinal ridge, slightly indented at the outer margin (Fig. 4G).

DESCRIPTION OF FEMALE PARATYPE (collected at Mt Zheduoshan): Carapace unmodified, similar to that of male in coloration. Total length 2.65. Carapace 1.15 long, 0.92 wide. Clypeus 0.13 high. AME diameter 0.07, ALE 0.08, PME 0.06, PLE 0.07, AME interdistance 0.39 times their diameter, AME-ALE interdistance 0.41 times ALE diameter, PME interdistance 1.00 times their diameter, PME-PLE interdistance 1.00 times PLE diameter. Sternum 0.70 long, 0.70 wide. Coxa IV interdistance 0.83 times their width. Chelicera with 5 promarginal and 5 retromarginal teeth. Tibia of leg I 6.14 times longer than deep. Tm I 0.52, Tm IV absent. Dorsal spines on tibia of leg IV: 2-2-2-1; dorsal spine on patella of leg IV: 1-1-1-1. Leg measurements: I 3.25 (0.93, 0.38, 0.81, 0.65, 0.48); II 3.03 (0.86, 0.38, 0.74, 0.59, 0.46); III 2.69 (0.73, 0.33, 0.66, 0.56, 0.41); IV 3.40 (0.96, 0.36, 0.91, 0.71, 0.46).

Epigynum simple, with fine transversal striation (Fig. 4A). Posterior half of epigynum strongly sclerotized, concave in its center to form a crescent-shaped depression (Fig. 4A). Spermathecae rounded, separated by a distance of less than their diameter (Fig. 4D). Dorsal plate oblate (Fig. 4D), almost 1.5 times wider than long. Copulatory ducts enclosed in a strongly sclerotized oblong capsule, forming a 90° turn before entering spermathecae (Fig. 4B). Fertilization ducts short, mesally oriented (Fig. 4E).

ETYMOLOGY: The specific name is taken from the Latin adjective *latus* (=broad), referring to the broad tailpiece of the embolic division.

VARIATION: 11♂ and 32♀ were measured. Total length is 2.66-2.73 in males, 2.94-3.28 in females. Carapace length is 1.22-1.25 in males, 1.14-1.17 in females;

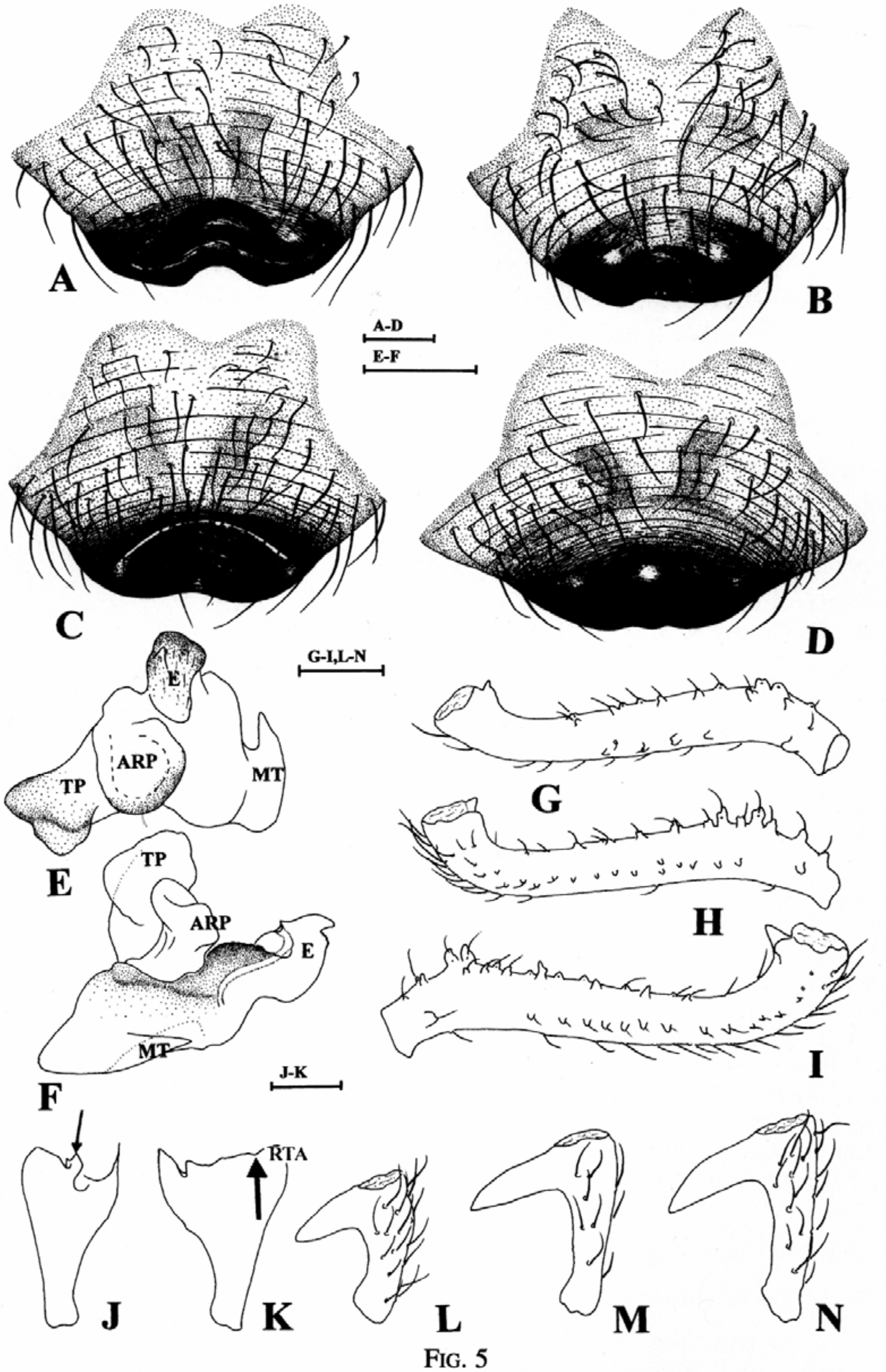

FIG. 5

Erigone lata sp. n. (A-D) Epigyna, ventral view. (E) Embolic division, anterior view. (F) Same, prolateral view. (G-H) Femora of left male palps, prolateral view. (I) Femur of right male palp, prolateral view. (J) Tibia of right male palp, dorsal view (small arrow indicates the sharply pointed central tibial teeth). (K) Same, prolateral view (large arrow points to the extremely shallow indentation mesally below the retrolateral tibial apophysis). (L-N) Patellae of left male palps, retrolateral view. Drawings based on holotype (E, F) and paratypes (A-D, G-N). A-D show variation in the shape of the epigynum; G-I show variation in the shape of palpal femur; L-N show variation in the shape of palpal tibia. Scale lines: A-F=0.1 mm, G-N=0.2 mm.

width 0.97-1.00 in males, 0.86-0.94 in females. The species shows considerable intraspecific variation in the length of male palpal femur and patella (Fig. 5G-I, L-N), number of teeth on the male palpal femur (Fig. 5G-I), shape of posterior margin of the epigynum (Fig. 5A-D), distance between spermathecae and overall size of the epigynum (Fig. 5A-D). The range of length of male palpal patellar apophysis (including the depth of the patella) is 0.31-0.43, average 0.38; the range of length of male palpal patella 0.36-0.51, average 0.46; the ratio of the former to the latter is 0.73-0.89, average 0.83. The range of width of epigynum is 0.33-0.38, average 0.35; the range of width of sternum 0.61-0.68, average 0.63; the ratio of the former to the latter is 0.50-0.64, average 0.55. The epigynum is posteriorly very slightly (Fig. 5C) or conspicuously (Fig. 5A) indented, and sometimes bent a little outward medially (Fig. 5D).

DISTRIBUTION: Mt Zheduoshan and Lhakang Town in Sichuan Province, China.

HABITAT: The spiders were found among grass roots on mountains in between 3700 and 4250 meters altitude.

Erigone prominens Bösenberg & Strand, 1906 Figs 6-8

Erigone prominens Bösenberg & Strand, 1906: 168, pl. 12, fig. 270.
Erigone ourania Crosby & Bishop, 1928: 35, figs 63-65. **Syn. n.**

MATERIAL EXAMINED (all China): 1♂ (AMNH), holotype of *E. ourania*, Yuanmingyuan Park, Beijing (40.00°N, 116.30°E), coll. P. W. Claassen, 11.X.1924. – 13♂ 51♀ (JLU), Erdaopao Village (42.85°N, 130.37°E), Hunchun City, Jilin Province, coll. J. Gao. – 1♂ 4♀ (IZCAS), Yakou Region (30.10°N, 101.75°E), Mt Zheduoshan, Kangding County, Sichuan Province, coll. S. Li and L. Tu, 17.VII.2004. – 4♀ (IZCAS), Yaoji Reservoir (30.37°N, 102.85°E), Baoxing County, Sichuan Province, coll. S. Li and L. Tu, 2.VII.2004. – 6♂ 5♀ (JLU), Yangri Town (31.75°N, 110.82°E), Shennongjia Forest Region, Hubei Province, coll. J. Gao, 11.VI.1986. – 2♂ 6♀ (IZCAS), Mt Wulingshan (40.47°N, 117.43°E), Xinglong County, Hebei Province, coll. S. Li, L. Tu and Y. Song, 23.VIII.2003. – 1♂ 1♀ (IZCAS), Zanhuang County (37.63°N, 114.42°E), Shijiazhuang City, Hebei Province, coll. S. Li, G. Zheng, Q. Wang and Y. Song, 12.IX.2005. – 48♂ 90♀ (IZCAS), 5♂5♀ (MHNG), Kongcun Village (36.70°N, 114.67°E), Yongnian County, Hebei Province, coll. S. Li, 25.VIII.1995. – 23♂ 31♀ (IZCAS), Mt Hengshan (27.22°N, 112.88°E), Hunan Province, coll. S. Li and L. Tu, 6.X.2003. – 1♂ (IZCAS), Mt Dinghushan (21.18°N, 110.38°E), Guangdong Province, coll. C. Liao. – 1♂ (IZCAS), Zhanjiang City (21.18°N, 110.38°E), Guangdong Province, 5.V.1977. – 3♂ (IZCAS), Hailing Island (21.63°N, 111.92°E), Yangjiang City, Guangdong Province, 31.III.1975. – 15♂ 36♀ (IZCAS), Mt Longqishan (26.25°N, 118.42°E), Jiangle County, Fujian Province, coll. S. Li, 20.VIII.1991. – 1♂ (IZCAS), Xiushan County (28.43°N, 108.93°E), Chongqing Municipality, 9.VI.1989. – 1♂ 1♀ (IZCAS), Tungdor District (29.04°N, 94.24°E), Tibet Autonomous Region, coll. Y. Chen, 5.IX.2004.

DIAGNOSIS: See remarks on *E. grandidens* Tu & Li, 2004 (see Tu & Li, 2004).

DESCRIPTION: This species was redescribed in detail by Holm (1977).

REMARKS: After the ventral tegument of the epigynum and tissue surrounding the vulva were removed, two black shallow depressions (in ventral view) disappeared and the vulva became much longer and more complicated (Fig. 7A, G-H). Both copulatory ducts are enclosed in a single slightly sclerotized capsule. In ventral view two broad, filmy, pocket-shaped accessorial structures (Fig. 7G) are visible at the position where the copulatory ducts are strongly curved. In dorsal view two additional small membranous structures (Fig. 7H) are seen at the other side of the pocket-shaped structures.

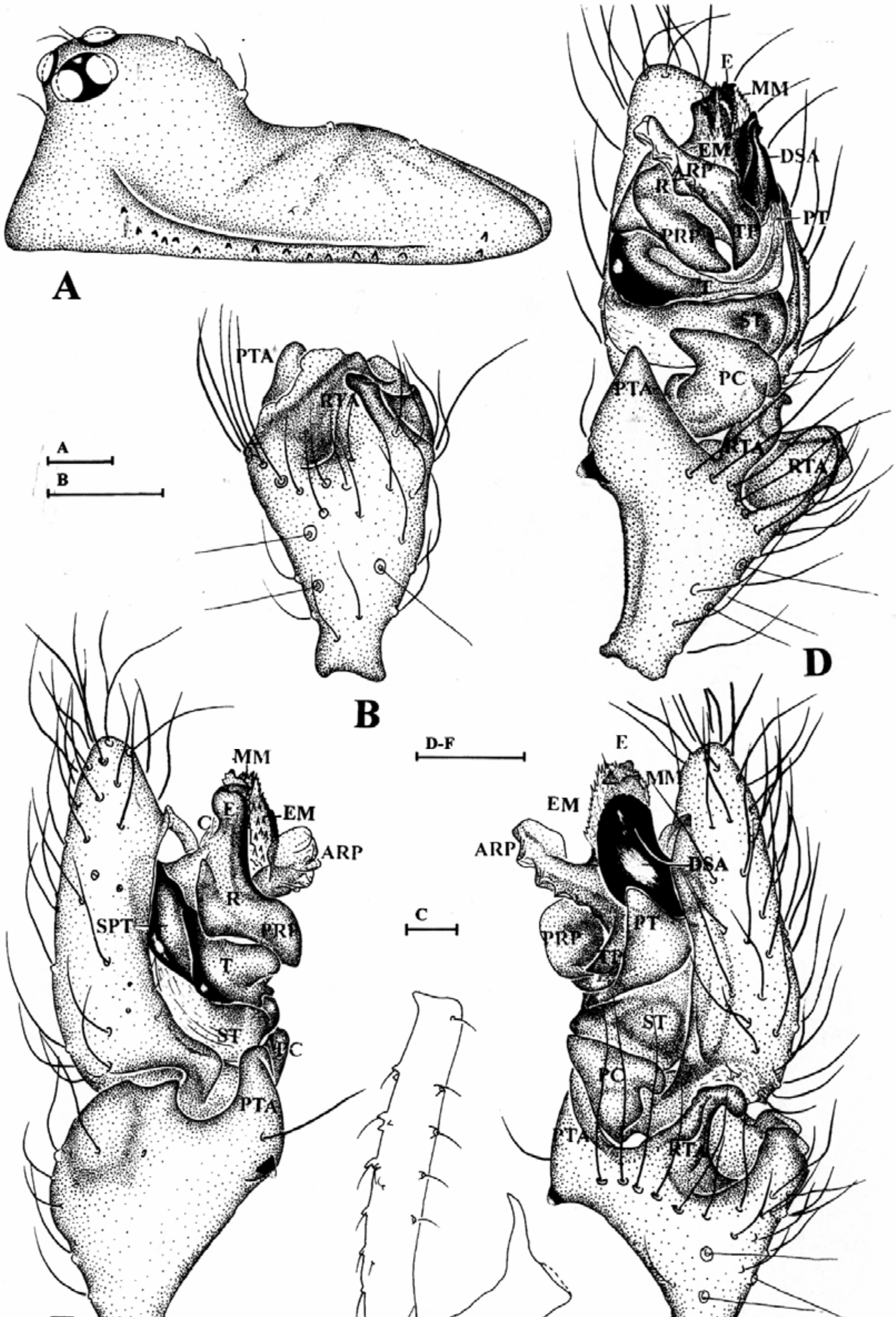

FIG. 6

Erigone prominens. (A) Male carapace, lateral view. (B) Tibia of left male palp, dorsal view. (C) Patella and femur of left male palp, retrolateral view. (D) Distal part of left male palp, ventral view. (E) Same, prolateral view. (F) Same, retrolateral view. Drawings based on a specimen from Hebei, China. Scale lines: 0.1 mm.

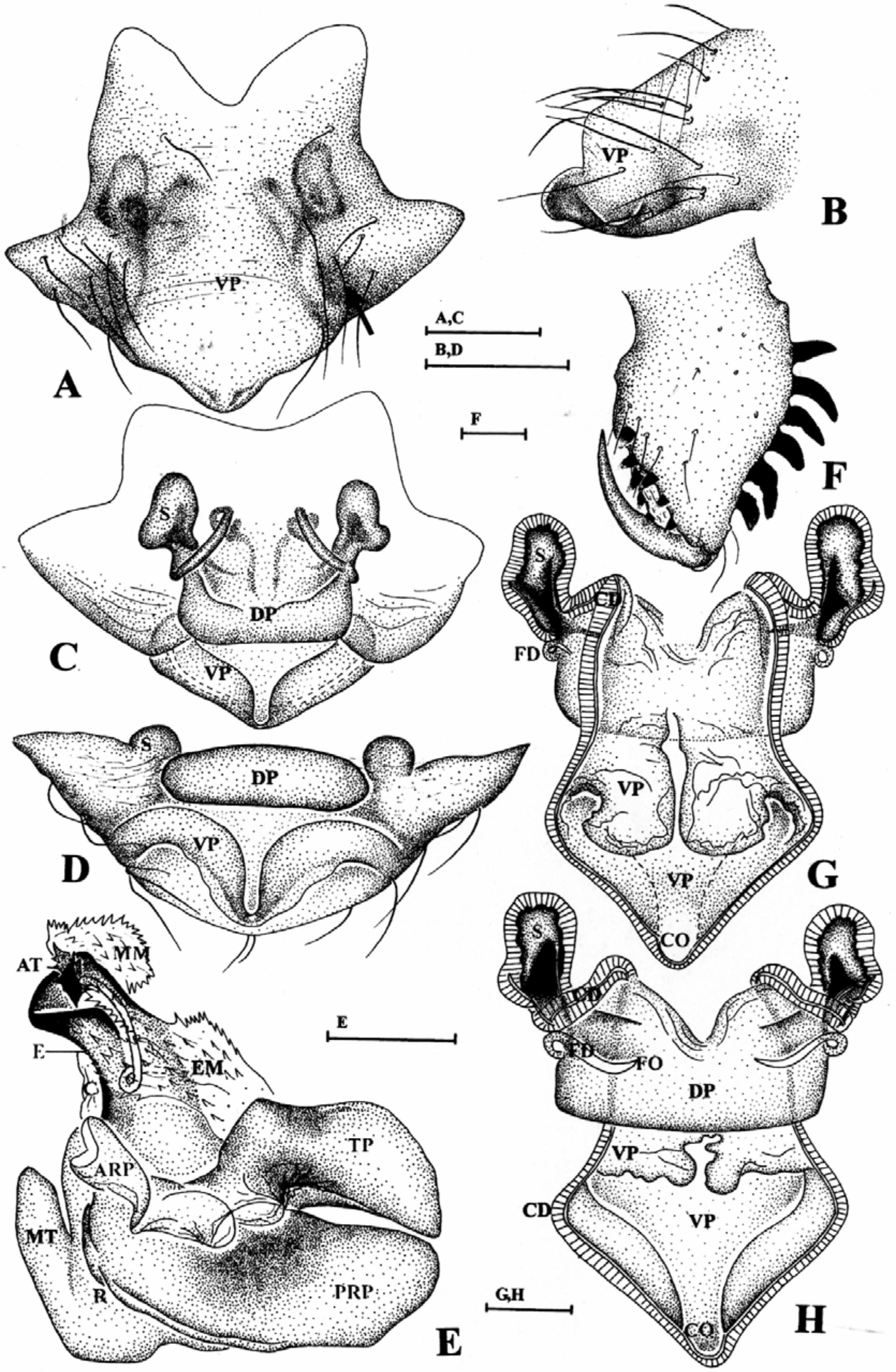

FIG. 7

Erigone prominens. (A) Epigynum, ventral view (arrow points to the shallow black depression). (B) Same, lateral view. (C) Same, dorsal view. (D) Same, posterior view. (E) Embolic division, ventral view. (F) Left male chelicera, frontal view. (G) Vulva, ventral view. (H) Same, dorsal view. Drawings based on specimens from Hebei, China. Scale lines: A-D, F=0.1 mm; E, G-H=0.05 mm.

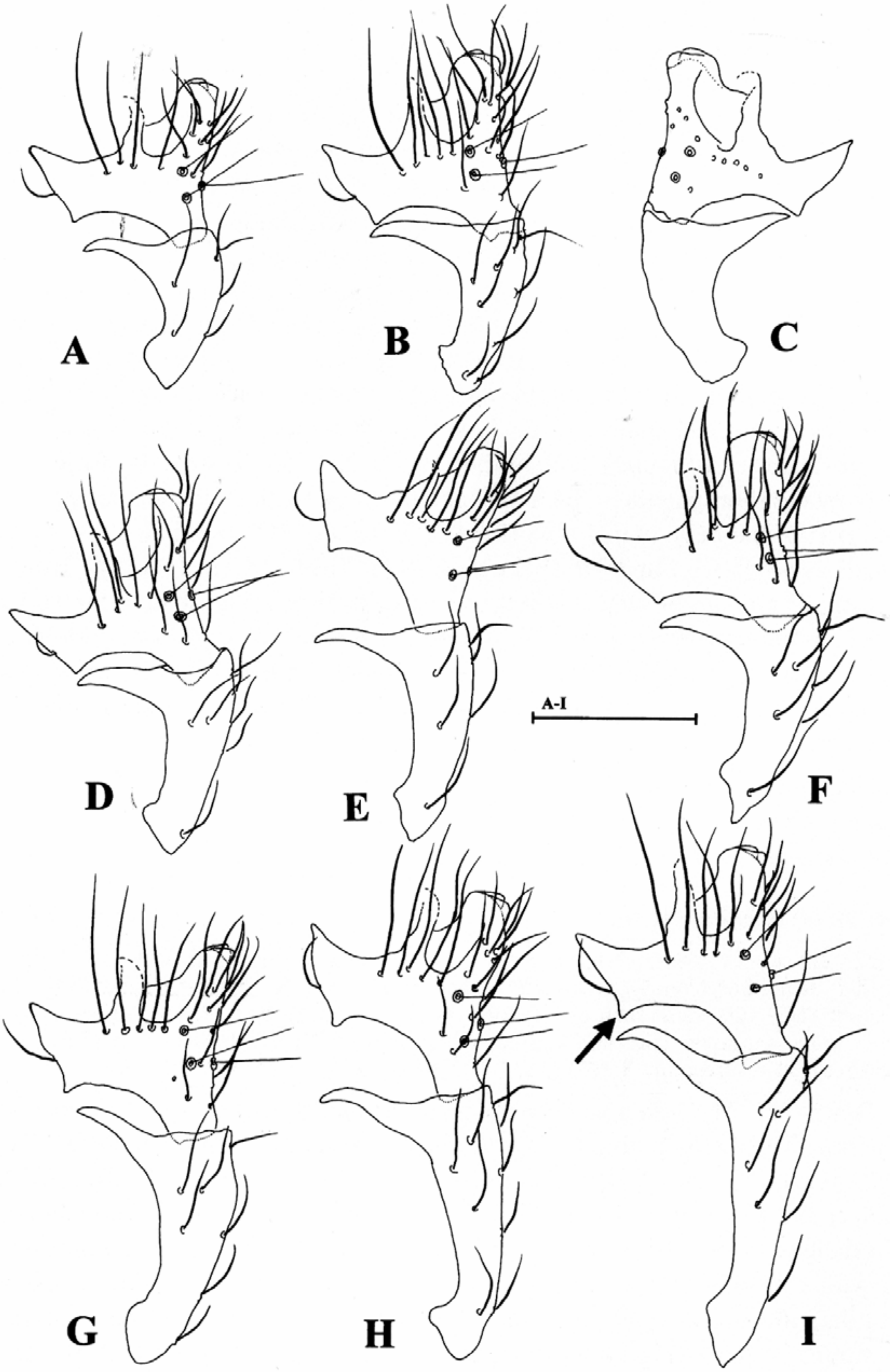

FIG. 8

Erigone prominens. (A-B, D-I) Tibiae and patellae of left male palps, retrolateral view (arrow points to the tooth on the ventral side of the widened part of the male palpal tibia). (C) Tibia and patella of right male palp, retrolateral view. Drawings based on specimens from the same population in Hebei, China (A, B, D-I) and on the holotype of *E. ourania* (C). Scale line: 0.2 mm.

E. prominens is a very widely distributed species. It shows considerable variation in epigynum and male palp. An investigation of palps, Tm I and Tm II of 50 *E. prominens* males collected from a population in a cotton field in Hebei Province, close to the type locality of *E. ourania* (Beijing), shows that length of palpal patella (Fig. 8), shape of palpal patellar apophysis (Fig. 8), development of the tooth on the ventral side of the widened part of the palpal tibia (Fig. 8) and value of Tm I and Tm II are variable. The range of Tm I and Tm II is 0.34-0.44, average 0.39 in males (n=50); 0.41-0.49, average 0.45 in females (n=50, from the same population as males). From our comparison of these 100 specimens we conclude that the species described by Crosby and Bishop (1928) under the name *E. ourania* (female unknown) corresponds to the widespread *E. prominens*. Locket (1973) examined the holotype of *E. ourania* and stated "it is difficult to bring out the differences in the sclerites of the palpal organs since their appearance changes so quickly with position, and dissection is not possible until more material is found". He further stated that "*E. ourania* is distinguished primarily by the short patella of the male palp, the large tooth on the ventral side of the widened part of the male palpal tibia (Locket, 1973: fig. 1C-D; see also Fig. 8C) and by a small value of Tm I and Tm II (Locket, 1973: Tm I and Tm II 0.35)". However, all these characters are of little taxonomical value as they all fall within the variation range of *E. prominens*. Specimens of *E. prominens* and the holotype of *E. ourania* were compared in our study and no differences in the embolic division and the apical margin of the palpal tibia were observed. Therefore we place *E. ourania* in the synonymy of *E. prominens*.

DISTRIBUTION: Cameroon to Japan, China (Anhui, Chongqing, Fujian, Guangdong, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shandong, Sichuan, Taiwan, Tibet and Zhejiang), Vietnam and New Zealand.

Erigone zheduoshanensis sp. n. Figs 9-10

MATERIAL EXAMINED: ♂ holotype (MHNG), Yakou Region (30.10°N, 101.75°E), Mt Zheduoshan, Kangding County, Sichuan Province, China, coll. S. Li and L. Tu, 17.VII.2004. – 1♀ paratype (MHNG), same data as for holotype. – 2♀ paratypes (IZCAS), same data as for holotype. – 1♀ paratype (IZCAS), Yushu Village (30.08°N, 101.95°E), Kangding County, Sichuan Province, China, coll. Y. Song, 13.VII.2004.

DIAGNOSIS: The new species belongs to Crosby & Bishop's (1928) *atra*-group of the genus *Erigone*, including *E. atra*, *E. arctica*, *E. arctophylacis* Crosby & Bishop, 1928, *E. alsaida* Crosby & Bishop, 1928, *E. dentigera* O. P.-Cambridge, 1874, *E. longipalpis* and *E. sinensis*. The male palp of all these species has a relatively simple anterior radical process, but the new species has a delicate anterior radical process furnished with conspicuous transversal membranous ridges on the outside. Copulatory ducts of the vulva have larger loops before entering into the spermathecae than in any of the similar species (Fig. 10E). Females can be further distinguished by the two additional extensions of the vulva that are visible in ventral view (Fig. 10D).

DESCRIPTION OF MALE HOLOTYPE: Total length 1.78. Carapace 0.95 long, 0.70 wide. Margins of carapace furnished with a row of small teeth (Fig. 9A). A distinct sulcus almost parallel to these teeth (Fig. 9A). Clypeus 0.16 high. AME diameter 0.05, ALE 0.07, PME 0.04, PLE 0.07, AME interdistance 0.50 times their diameter, AME-

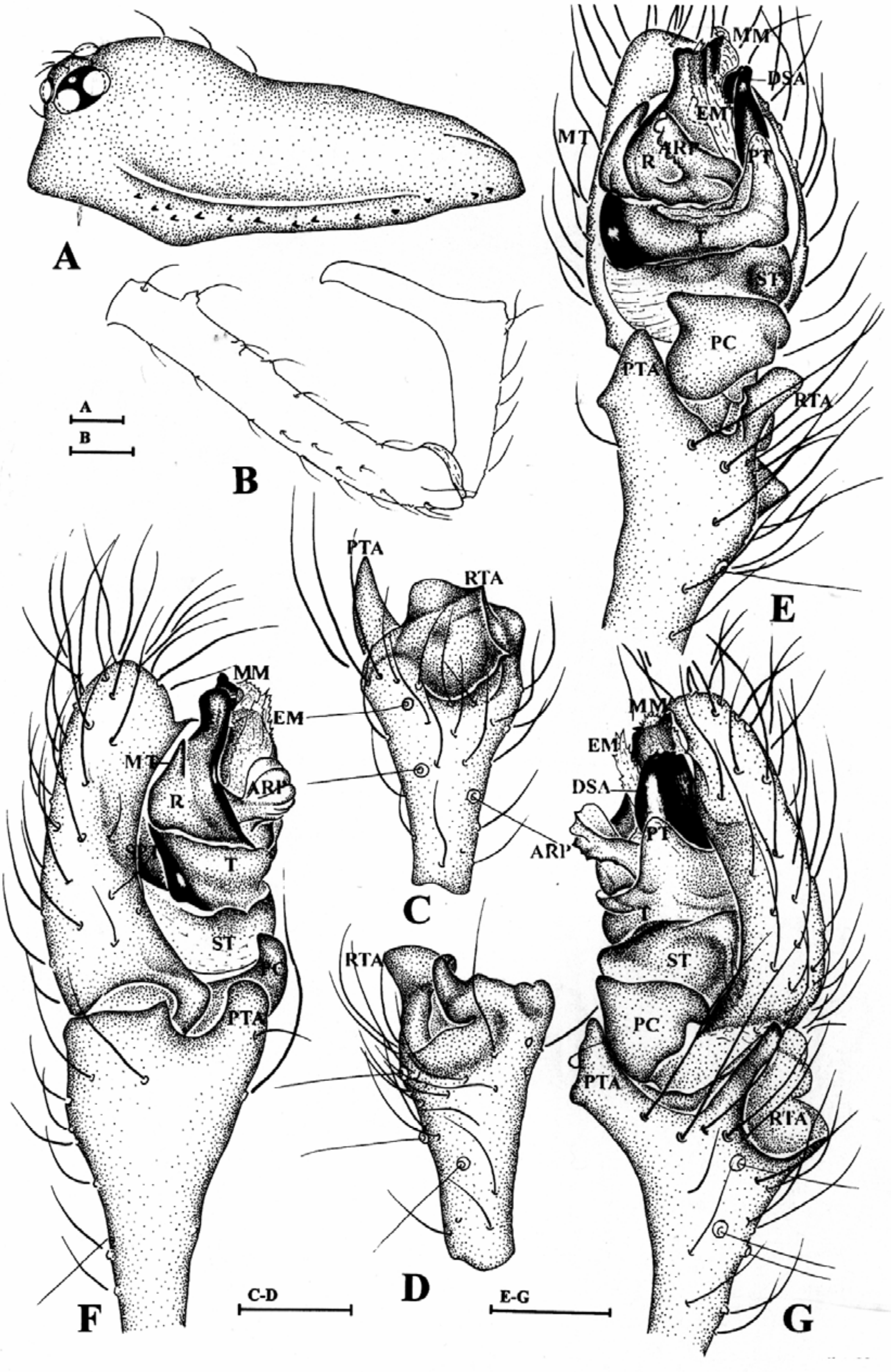

FIG. 9

Erigone zheduoshanensis sp. n. (A) Male carapace, lateral view. (B) Patella and femur of left male palp, retrolateral view. (C) Tibia of left male palp, dorsal view. (D) Same, dorsoectal view. (E) Distal part of left male palp, ventral view. (F) Same, prolateral view. (G) Same, retrolateral view. Drawings based on holotype. Scale lines: 0.1 mm.

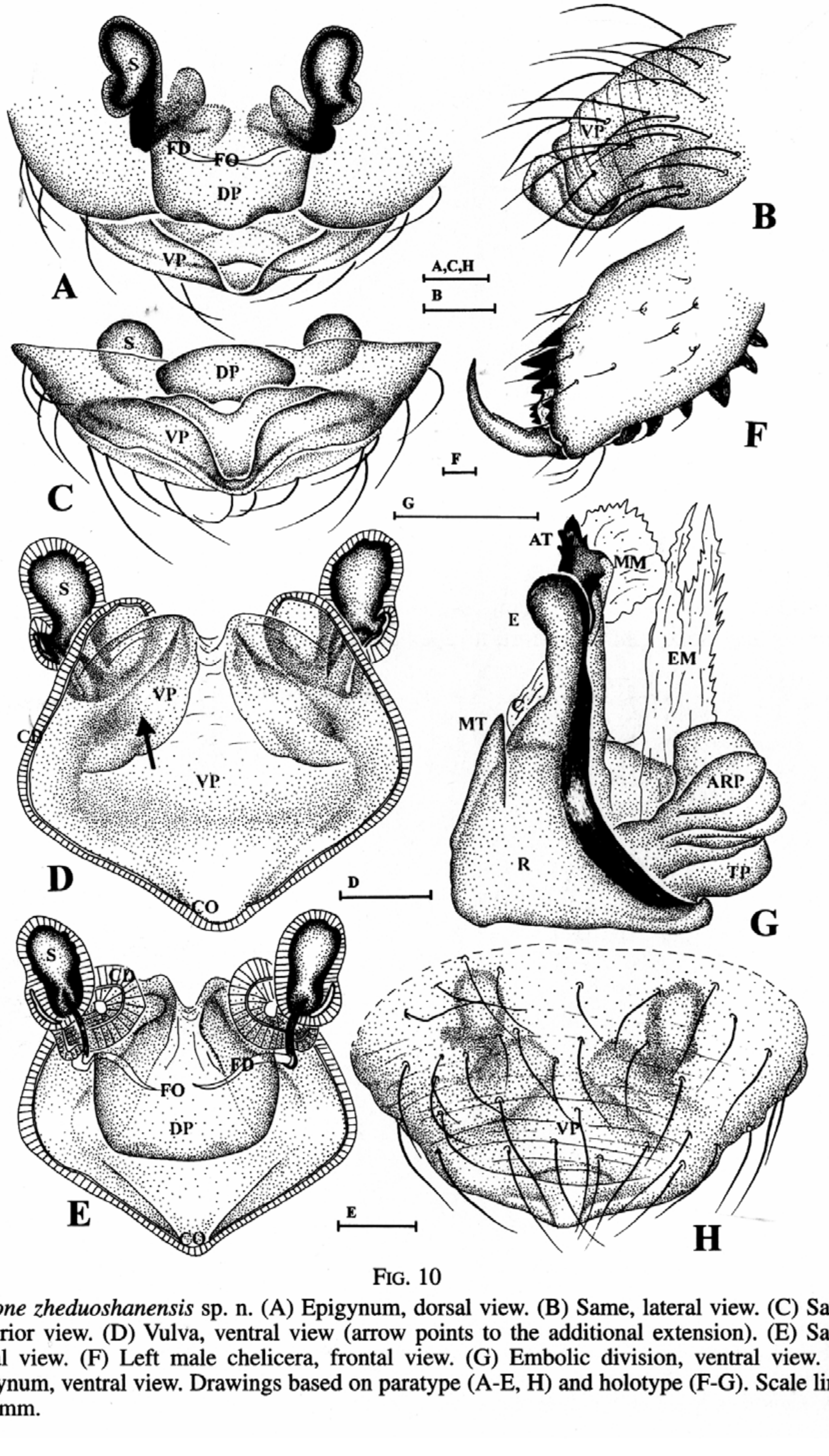

FIG. 10

Erigone zheduoshanensis sp. n. (A) Epigynum, dorsal view. (B) Same, lateral view. (C) Same, posterior view. (D) Vulva, ventral view (arrow points to the additional extension). (E) Same, dorsal view. (F) Left male chelicera, frontal view. (G) Embolic division, ventral view. (H) Epigynum, ventral view. Drawings based on paratype (A-E, H) and holotype (F-G). Scale lines: 0.05 mm.

ALE interdistance 0.48 times ALE diameter, PME interdistance 1.00 times their diameter, PME-PLE interdistance 1.00 times PLE diameter. Sternum 0.53 long, 0.52 wide. Coxa IV interdistance 0.91 times their width. Chelicera grayish brown, anterolaterally furnished with a row of 6 large teeth; fang groove with 5 promarginal and 5 retromarginal teeth (Fig. 10F). Tibia of leg I 6.54 times longer than deep. Tm I 0.49, Tm IV absent. Dorsal spines on tibia of leg IV: 2-2-2-1; dorsal spine on patella of leg IV: 1-1-1-1. Leg measurements: I 2.25 (0.64, 0.26, 0.53, 0.44, 0.38); II 2.06 (0.58, 0.27, 0.44, 0.41, 0.36); III 1.80 (0.54, 0.25, 0.35, 0.36, 0.30); IV 2.22 (0.63, 0.25, 0.53, 0.46, 0.35).

Palp: Femur armed with 3 robust ventral teeth in distal half (Fig. 9B). Patella longer than tibia, with long, evenly downward-curved ventral apophysis (Fig. 9B). Tibia (Fig. 9C-G) slender basally, strongly widened distally; provided with a retrolateral apophysis having an indented apical margin, with a stout prolateral apophysis and 1 prolateral and 2 retrolateral trichobothria. Tegulum distal to subtegulum in unexpanded palp (Fig. 9G). Protegulum well-developed. Distal suprategular apophysis of the usual form (Fig. 9E, G). Embolic division (Fig. 10G) is the most complicated in the atra-group: Anterior radical process with 6 conspicuous transversal membranous ridges on the outside; tailpiece undeveloped, with blunt tip; posterior radical process absent; mesal tooth of the usual form; median membrane arising from the column, meeting with tip of embolus ventrally; embolic membrane bifurcate distally, originating from center of the radix; embolus short, its apex armed with several small teeth.

DESCRIPTION OF FEMALE PARATYPE (collected at Mt Zheduoshan): Carapace unmodified, similar to that of male in coloration. Total length 2.19. Carapace 0.83 long, 0.64 wide. Clypeus 0.15 high. AME diameter 0.05, ALE 0.08, PME 0.06, PLE 0.07, AME interdistance 0.35 times their diameter, AME-ALE interdistance 0.50 times ALE diameter, PME interdistance 0.94 times their diameter, PME-PLE interdistance 0.57 times PLE diameter. Sternum 0.56 long, 0.50 wide. Coxa IV interdistace 0.96 times their width. Chelicera with 5 promarginal and 4 retromarginal teeth. Tibia of leg I 5 times longer than deep. Tm I 0.45, Tm IV absent. Dorsal spines on tibia of leg IV: 2-2-2-1; dorsal spine on patella of leg IV: 1-1-1-1. Leg measurements: I 2.42 (0.69, 0.28, 0.56, 0.51, 0.38); II 2.27 (0.64, 0.31, 0.48, 0.47, 0.37); III 1.95 (0.54, 0.27, 0.42, 0.41, 0.31); IV 2.48 (0.73, 0.26, 0.63, 0.53, 0.33).

Epigynum pale, with a slight notch on hind margin and a rounded tubercle in its center (Fig. 10B). Dorsal plate large, rectangular (Fig. 10A). Copulatory ducts embedded in outer margin of slightly sclerotized capsule with 2 additional extensions visible in ventral view (Fig. 10D). Copulatory ducts forming large oblong loops before entering into reniform spermathecae (Fig. 10E). Fertilization ducts mesally oriented, comparatively long for an Erigone species (Fig. 10E).

ETYMOLOGY: The specific name refers to the type locality.

VARIATION: The total length varies from 2.03 to 2.19, the carapace length from 0.83 to 0.92 and the carapace width from 0.64 to 0.70 in females (n=4).

DISTRIBUTION: Only known from two localities in Sichuan Province, China.

HABITAT: Under stones, in detritus and between roots of grass.

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Four new cave-dwelling species of *Telema* (Arachnida, Araneae, Telemidae) from Guizhou Province, China

Yanfeng TONG
Shuqiang LI
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101 (China)
lisq@ioz.ac.cn

Tong Y. & Li S. 2008. — Four new cave-dwelling *Telema* (Arachnida, Araneae, Telemidae) from Guizhou Province, China. *Zoosystema* 30 (2): 361-370.

ABSTRACT

Four new species of the spider genus *Telema* from caves in Guizhou Province, China, are diagnosed, described and illustrated. Three of these, *Telema circularis* n. sp., *T. claviformis* n. sp. and *T. grandidens* n. sp. are slightly troglomorphic species, with relatively long legs and without eyes. They differ from congeners and from each other in the male palpal structure, the female spermathecae, the shape of colulus, the distinctive large tooth at the middle of fang furrow (*T. grandidens* n. sp.) and the nearly rounded carapace (*T. circularis* n. sp.). A further species, *T. oculata* n. sp., has a clearly pigmented body, relatively shorter legs and distinctive eyes. It differs from congeners, except *T. nipponica* (Yaginuma, 1972), by the presence of eyes, and from *T. nipponica* by the different shape of sternum, the relatively long legs, the larger body size and the symmetric spermatheca.

KEY WORDS
Arachnida,
Araneae
Telemidae,
troglomorphy,
caves,
Yunnan-Guizhou
Plateau,
new species.

RÉSUMÉ

Quatre nouvelles espèces de Telema *(Arachnida, Araneae, Telemidae) provenant de grottes de la province de Guizhou, Chine.*

Quatre nouvelles espèces d'araignées du genre *Telema* sont décrites et illustrées à partir de spécimens provenant de grottes de la province de Guizhou en Chine. Trois d'entre elles, *Telema circularis* n. sp., *T. claviformis* n. sp. et *T. grandidens* n. sp., présentent quelques caractères cavernicoles comme des pattes relativement longues et la perte des yeux. Elles diffèrent légèrement de leurs congénères et les unes des autres quant à la structure du palpe mâle, la spermathèque femelle, la forme du colulus, la grande dent caractéristique au milieu de la marge des crochets (*T. grandidens* n. sp.) et la carapace presque arrondie (*T. circularis* n. sp.). L'autre espèce nouvelle, *T. oculata* n. sp., a un corps de couleur claire, des pattes relativement plus courtes et des yeux caractéristiques. Elle diffère de ses congénères, excepté *T. nipponica* (Yaginuma, 1972), par la présence d'yeux, et de *T. nipponica* par la forme du sternum, les pattes relativement plus longues, le corps plus grand et la spermathèque symétrique.

MOTS CLÉS
Arachnida,
Araneae
Telemidae,
troglomorphie,
grottes,
plateau du
Yunnan-Guizhou,
espèces nouvelles.

INTRODUCTION

Guizhou, with an area of more than 170 000 km^2, is located in the eastern part of Southwest China's Yunnan-Guizhou Plateau. The province is more than 1000 m above sea level, adding to its rich mountainous topography. Owing to folds, faults and erosion, the plateau is intersected with mountains, hills, basins and valleylands, giving it a very rugged topography. Indeed, in many areas of the province the world-famous karst rock is found with numerous caverns. However, research on cave spider fauna is not yet sufficiently developed, only a few species has been reported (Wang & Ran 1998; Wang *et al.* 1999; Zhu *et al.* 1999, 2001; Chen *et al.* 2000; Huang *et al.* 2002; Zhu & Chen 2002; Chen & Zhu 2004, 2005), whereas at least several times as more can be expected to occur in this area. Recently, an intensive survey to Guizhou Province with the objective of collecting cave spider fauna has been done. Several papers will be published to describe the spider fauna collected from this expedition, including four new *Telema* Simon, 1882 species (family Telemidae Fage, 1913) reported in the current paper.

The spider family Telemidae contains only seven genera and 22 species (Yaginuma 1972, 1973; Song & Zhu 1994; Platnick 2007), but is widely distributed from tropical Africa, Europe, East and South East Asia to North and Central America (Brignoli 1977). The spiders of this family are of small size (usually < 2 mm), and can be distinguished from other spiders by a transverse zigzag ridge located anterodorsally on the abdomen. They are usually found in moist conditions, such as in leaf litter, under rocks and in caves.

The genus *Telema* was erected by Simon in 1882, based on a tiny eyeless spider, *T. tenella* Simon, 1882. Up to the present, six species were described under *Telema*, all of them are known only from caves. All the specimens studied in this paper were caught in caves too. This suggests that *Telema* is likely to be an entirely troglobitic genus. Three of the four new *Telema* species (*T. circularis* n. sp., *T. claviformis* n. sp. and *T. grandidens* n. sp.) have slightly troglomorphic characters, with relatively long legs and without eyes. A further species, *T. oculata* n. sp., is however not troglomorphic, with clearly pigmented body, relatively short legs and large eyes.

The known *Telema* species has a disjunctive distribution pattern. The type species, *T. tenella,* is recorded in Europe (France and Spain), *T. mayana* occurs in South America (Guatemala), and the other species are all distributed in East Asia (China, Japan). This pattern is based on a poor taxonomic study of this group. However, if this is true, it suggests an ancestral widespread distribution, with subsequent extinction in the intervening area. Caves might have played the role of refuges during the extinction event. This is another interesting scientific question.

MATERIAL AND METHODS

Specimens were examined using an Olympus SZX12 stereomicroscope. Further details were studied under an Olympus BX51 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Photos were made with an Olympus C7070 wide zoom digital camera (7.1 megapixels) mounted on an Olympus SZX12 stereomicroscope. Male palps and female genitalia were examined and illustrated after they were dissected from the spider's bodies. Vulvae of female were cleared in lactic acid.

All measurements were made using an Olympus BX51 compound microscope and are given in millimeters. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus).

ABBREVIATIONS

AL	anterior lateral eyes;
AM	anterior median eyes;
IZCAS	Institute of Zoology, Chinese Academy of Sciences, Beijing;
MNHN	Muséum national d'Histoire naturelle, Paris.

SYSTEMATICS

Family TELEMIDAE Fage, 1913

Genus *Telema* Simon, 1882

Telema Simon, 1882: 205.

TYPE SPECIES. — *Telema tenella* Simon, 1882.

DIAGNOSIS. — Six eyes, anterior row nearly straight, laterals contiguous; or degenerate to eyeless. Labium wider than long. Cymbium usually with an apophysis prolaterally; bulb oval, embolus simple. Female genitalia simple, with a long unpaired tube-like spermatheca.

DISTRIBUTION. — East Asia (China, Japan), Central America (Guatemala), Europe (France, Spain).

KEY TO SPECIES OF *TELEMA* SIMON, 1882
(*T. mayana* Gertsch, 1973, only known from female, is not included)

1. Eyes present 2
— Eyes absent 3

2. Sternum outer margin triangular, obtusely inserted into coxae IV .... *T. nipponica*
— Sternum outer margin smooth, not inserted into coxae IV .... *T. oculata* n. sp.

3. Male cymbium without prolateral apophysis 4
— Male cymbium with prolateral apophysis 5

4. Embolus long, distal half strongly narrowed .... *T. wunderlichi*
— Embolus short and small, smoothly narrowed towards tip .... *T. tenella*

5. Chelicerae with tiny teeth, or without teeth 6
— Chelicerae at least with one distinct tooth 7

6. Male palpal embolus long; female spermatheca with distally swollen end .... *T. liangxi*
— Male palpal embolus short; female spermatheca with distal end spiral, curved posteriorly .... *T. dongbei*

7. Angle of embolus to the bulb smaller than 90°; female spermatheca strong, curved posteriorly .... *T. grandidens* n. sp.
— Embolus nearly straight to the bulb; female spermatheca otherwise 8

8. Embolus with acute tip; spermatheca boot-shaped in lateral view ...... *T. circularis* n. sp.
— Embolus with blunt tip; spermatheca narrow and long, stick-shaped ... *T. claviformis* n. sp.

Telema circularis n. sp.
(Figs 1A; 2)

TYPE MATERIAL. — Holotype: China, Guizhou Province, Guanling Bouyeizu Miaozu Autonomic County, Shangguan Town (25°48'N, 105°40'E), Gan-Zhi-Shu-Dong Cave, 8.V.2005, leg. Y. F. Tong & Y. C. Lin, ♂ (MNHN)
Paratypes: same data as holotype, 2 ♂♂, 16 ♀♀ (IZCAS); 1 ♂, 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name is from Latin *circularis*, round, and refers to the nearly round carapace.

DIAGNOSIS. — The new species is similar to *T. dongbei* Wang & Ran, 1998, but can be distinguished by the distinctive straight embolus of males (the angle of embolus to the bulb is smaller than 90° in *T. dongbei*), the different shapes of spermathecae of females (the spermatheca with distal end spiral in *T. dongbei*, but straight in the new species), the relatively distinctive promarginal teeth of fang furrow, the nearly rounded carapace and the relatively smaller body size.

DESCRIPTION
Male (n = 4)
Total length 1.33-1.36 (average: 1.34). Carapace 0.65-0.66 (average: 0.65) long, 0.59-0.61 (average: 0.60) wide; abdomen 0.64-0.70 (average: 0.68) long, 0.57-0.58 (average: 0.57) wide. Carapace, legs, sternum (Fig. 2A), labium, endites and chelicerae yellowish white. Carapace (Fig. 1A) nearly round, with a pair of setae on the clypeus, in the place of eyes and in the middle. No eyes. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles (Fig. 2H). Legs with a

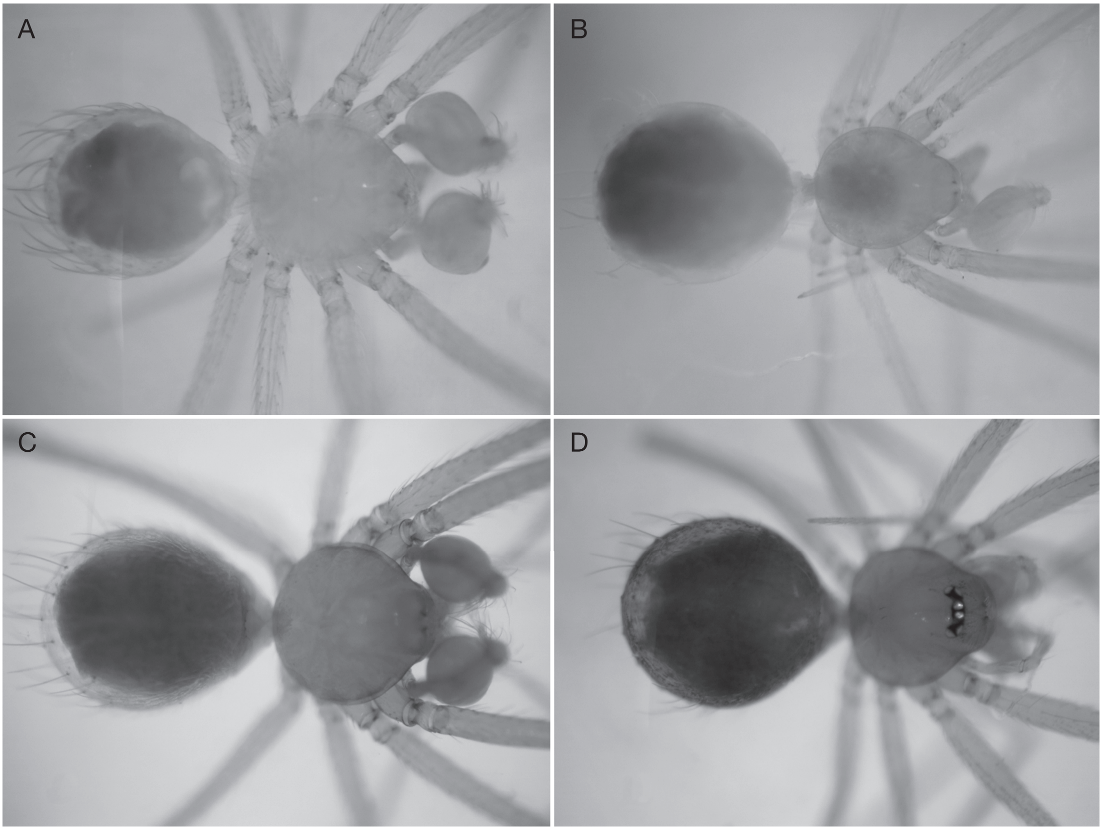

Fig. 1. — **A**, *Telema circularis* n. sp., dorsal view; **B**, *T. claviformis* n. sp., dorsal view; **C**, *T. grandidens* n. sp., dorsal view; **D**, *T. oculata* n. sp., dorsal view.

dorsal spine at the distal end of patella as well as in the middle of tibia. Leg measurements: I 5.44 (1.61, 0.23, 1.71, 1.16, 0.73); II 4.74 (1.48, 0.24, 1.44, 0.94, 0.64); III 3.39 (1.11, 0.22, 0.92, 0.63, 0.51); IV 4.03 (1.36, 0.22, 1.17, 0.71, 0.57). Leg formula: I-II-IV-III. Abdomen globular, gray; colulus as in Figure 2F. Palp with prolateral cymbial apophysis (Fig. 2C); bulb oval with one simple embolus (Fig. 2B).

Female (n = 18)
Total length 1.35-1.87 (average: 1.68). Carapace 0.61-0.82 (average: 0.75) long, 0.56-0.69 (average: 0.64) wide; abdomen 0.74-0.95 (average: 0.82) long, 0.72-0.88 (average: 0.79) wide. Eyes and chelicerae as in male. Leg measurements: I 5.50 (1.69, 0.25, 1.77, 1.12, 0.67); II 4.83 (1.52, 0.25, 1.54, 0.94, 0.58); III 3.55 (1.15, 0.23, 0.99, 0.69, 0.49); IV 4.43 (1.44, 0.24, 1.29, 0.90, 0.56). Leg formula: I-II-IV-III. Genital area with one row of hairs on epigynal plate, and another row behind epigastric furrow (Fig. 2G). Spermatheca boot-shaped in lateral view (Fig. 2D, E).

Telema claviformis n. sp.
(Figs 1B; 3)

Type material. — Holotype: China, Guizhou Province, Xingyi City, Malinghe Town (25°12'N, 104°53'E), Qiu-Xiang-Dong Cave, 12.V.2005, leg. Y. F. Tong & Y. C. Lin, ♂ (MNHN).
Paratypes: same data as holotype, 1 ♂, 10 ♀♀ (IZCAS); same data as holotype, 2 ♀♀ (MNHN).

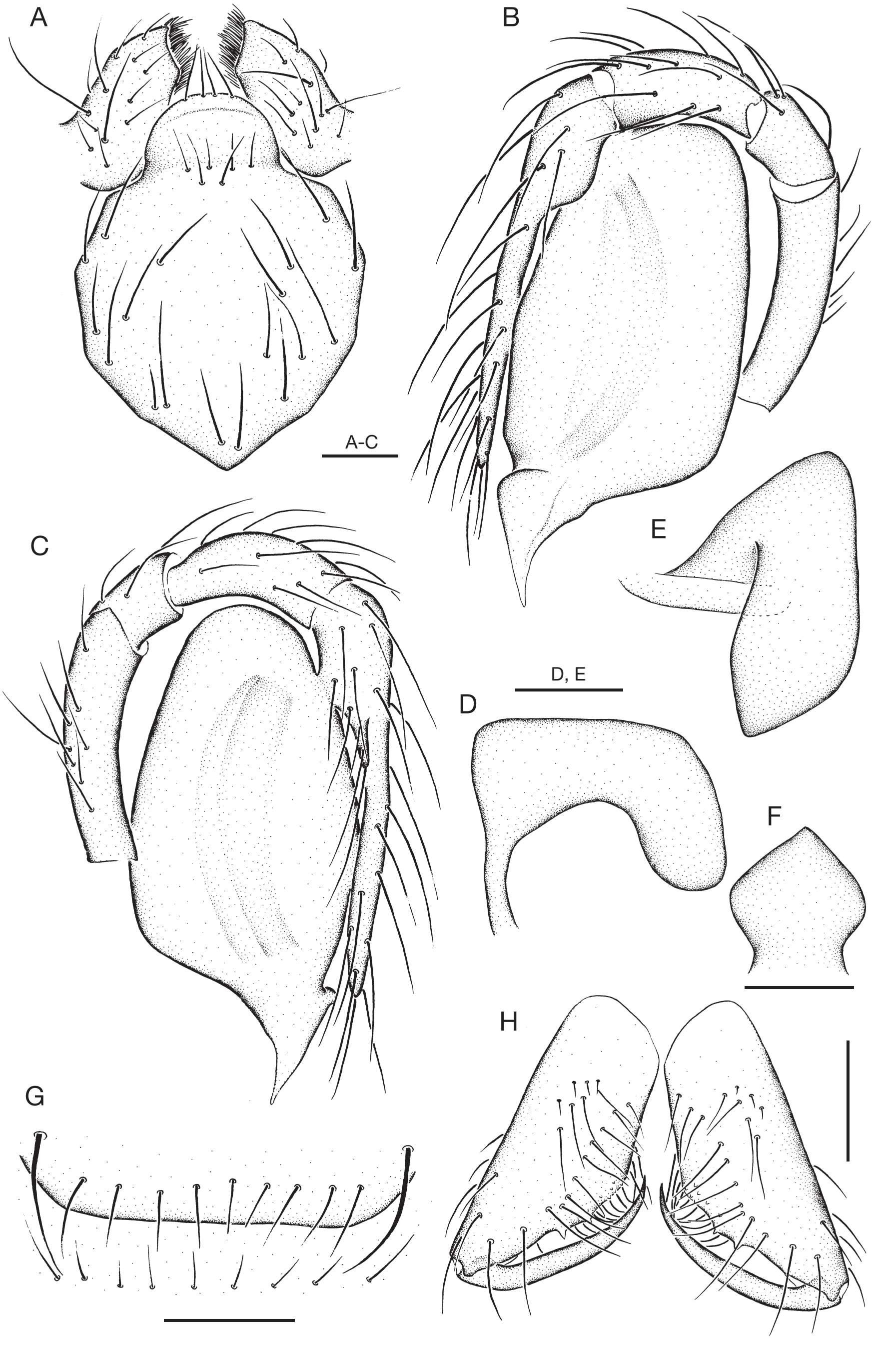

FIG. 2. — *Telema circularis* n. sp.: **A**, female endites, labium and sternum in ventral view; **B**, male left palp in retrolateral view; **C**, male left palp in prolateral view; **D**, spermatheca in lateral view; **E**, female genitalia in dorsal view; **F**, colulus; **G**, female genitalia in ventral view; **H**, chelicerae in ventral view. Scale bars: A-C, F, G, 0.1 mm; D, E, H, 0.2 mm.

ETYMOLOGY. — The specific name is from Latin *claviformis*, stick-shaped, indicates the narrow and long spermatheca of female.

DIAGNOSIS. — The new species is similar to *T. wunderlichi* Song & Zhu, 1994, but can be distinguished by the presence of a small prolateral cymbial apophysis on male palpal tarsus, the different shapes of embolus and the posteriorly curved spermatheca of female.

DESCRIPTION

Male (holotype)

Total length 1.67. Carapace 0.67 long, 0.56 wide; abdomen 0.88 long, 0.81 wide. Carapace, legs, sternum (Fig. 3A), labium, endites and chelicerae yellowish. Carapace (Fig. 1B) with pair of setae on the clypeus, in the place of eyes and in the middle. No eyes. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles, in which the one near the base of fang larger (Fig. 3H). Legs with a dorsal spine at the distal end of patella as well as in the middle of tibia. Leg measurements: I 5.53 (1.66, 0.23, 1.75, 1.19, 0.70); II 5.11 (1.48, 0.23, 1.51, 1.06, 0.83); III 3.55 (1.12, 0.22, 0.98, 0.71, 0.52); IV 4.33 (1.39, 0.22, 1.22, 0.93, 0.57). Leg formula: I-II-IV-III. Abdomen globular, yellowish-gray; colulus as in Figure 3F. Palp with prolateral cymbial apophysis (Fig. 3C); bulb oval with one simple embolus (Fig. 3B).

Female (n = 12)

Total length 1.42-1.85 (average: 1.75). Carapace 0.62-0.77 (average: 0.72) long, 0.55-0.65 (average: 0.61) wide; abdomen 0.93-1.05 (average: 0.98) long, 0.75-0.98 (average: 0.83) wide. Eyes and chelicerae as in male. Leg measurements: I 5.40 (1.66, 0.27, 1.67, 1.13, 0.67); II 4.82 (1.49, 0.24, 1.47, 1.00, 0.62); III 3.41 (1.09, 0.22, 0.94, 0.68, 0.48); IV 4.26 (1.39, 0.23, 1.20, 0.90, 0.54). Leg formula: I-II-IV-III. Genital area with one row of hairs on epigynal plate, and another row behind epigastric furrow (Fig. 3G). Spermatheca narrow and long, with distal end curved posteriorly (Fig. 3D, E).

Telema grandidens n. sp.
(Figs 1C; 4)

TYPE MATERIAL. — Holotype: China, Guizhou Province, Duyun City, Dushan County, Xiasi Town (25°26'N, 107°25'E), Ba-You-Dong Cave, 21.V.2005, Leg. Y. F. Tong & Y. C. Lin, ♂ (MNHN).
Paratypes: same data as holotype, 13 ♂♂, 16 ♀♀ (IZCAS); same data as holotype, 2 ♂♂, 2 ♀♀ (MNHN).

ETYMOLOGY. — The species name is from Latin *grand*, large and *dens*, tooth and refers to the large tooth present at the middle of fang furrow.

DIAGNOSIS. — The new species is similar to *T. dongbei* Wang & Ran, 1998, but can be distinguished by the slightly broader apical part of palpal embolus, the different shapes of spermathecae of females and the distinctive large tooth at the middle of fang furrow.

DESCRIPTION

Male (n = 16)

Total length 1.65-1.76 (average: 1.71). Carapace 0.72-0.77 (average: 0.75) long, 0.67-0.71 (average: 0.69) wide; abdomen 0.86-0.95 (average: 0.92) long, 0.77-0.82 (average: 0.79) wide. Carapace, legs, sternum (Fig. 4A), labium, endites and chelicerae yellow. Carapace (Fig. 1C) with pair of setae on the clypeus, in place of eyes and in the middle. No eyes. Promargin of fang furrow with one distinctive large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles (Fig. 4H). Legs with a dorsal spine at the distal end of patella as well as in the middle of tibia. Leg measurements: I 6.18 (1.85, 0.26, 2.00, 1.34, 0.73); II 5.26 (1.64, 0.26, 1.60, 1.10, 0.66); III 3.85 (1.25, 0.22, 1.10, 0.74, 0.54); IV 4.59 (1.53, 0.21, 1.32, 0.95, 0.58). Leg formula: I-II-IV-III. Abdomen globular, gray; colulus as in Figure 4F. Palp with prolateral cymbial apophysis (Fig. 4C); bulb oval with one simple embolus (Fig. 4B).

Female (n = 18)

Total length 1.70-2.05 (average: 1.92). Carapace 0.72-0.82 (average: 0.78) long, 0.65-0.74 (average: 0.71) wide; abdomen 0.86-1.09 long, 0.82-1.05 wide. Eyes and chelicerae as in male. Leg measurements: I 6.68 (2.10, 0.28, 2.13, 1.41, 0.76); II 5.69 (1.80, 0.27, 1.76, 1.17, 0.69); III 4.16 (1.38, 0.25, 1.18, 0.81, 0.54); IV 5.09 (1.70, 0.25, 1.49, 1.04, 0.61). Leg formula: I-II-IV-III. Genital area with one row of hairs on epigynal plate and another row behind epigastric furrow (Fig. 4G). Spermatheca strong, curved posteriorly (Fig. 4D, E).

FIG. 3. — *Telema claviformis* n. sp.: **A**, female endites, labium and sternum in ventral view; **B**, male left palp in retrolateral view; **C**, male left palp in prolateral view; **D**, spermatheca in lateral view; **E**, female genitalia in dorsal view; **F**, colulus; **G**, female genitalia in ventral view; **H**, chelicerae in ventral view. Scale bars: A-E, H, 0.2 mm; F, G, 0.1 mm.

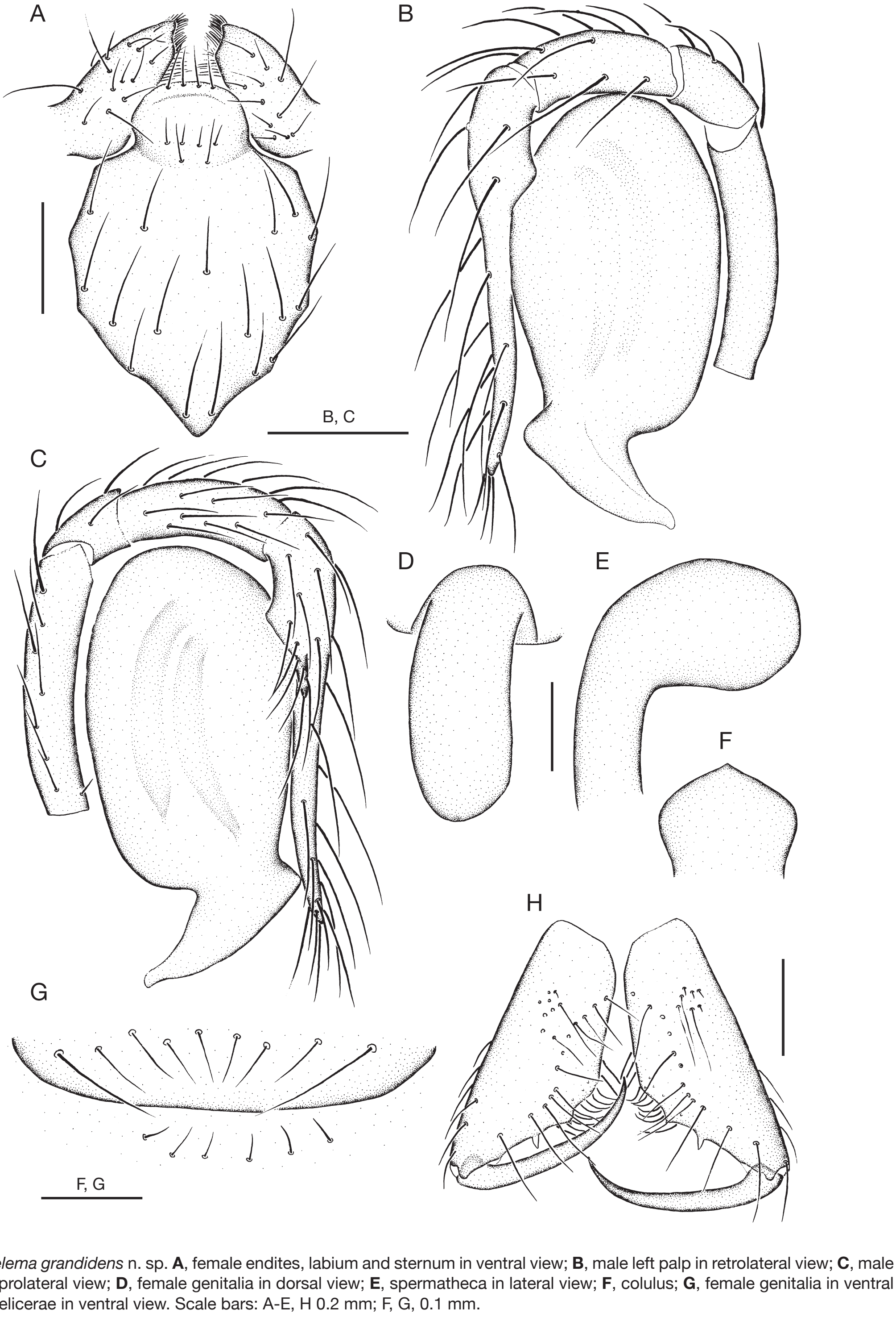

FIG. 4. — *Telema grandidens* n. sp. **A**, female endites, labium and sternum in ventral view; **B**, male left palp in retrolateral view; **C**, male left palp in prolateral view; **D**, female genitalia in dorsal view; **E**, spermatheca in lateral view; **F**, colulus; **G**, female genitalia in ventral view; **H**, chelicerae in ventral view. Scale bars: A-E, H 0.2 mm; F, G, 0.1 mm.

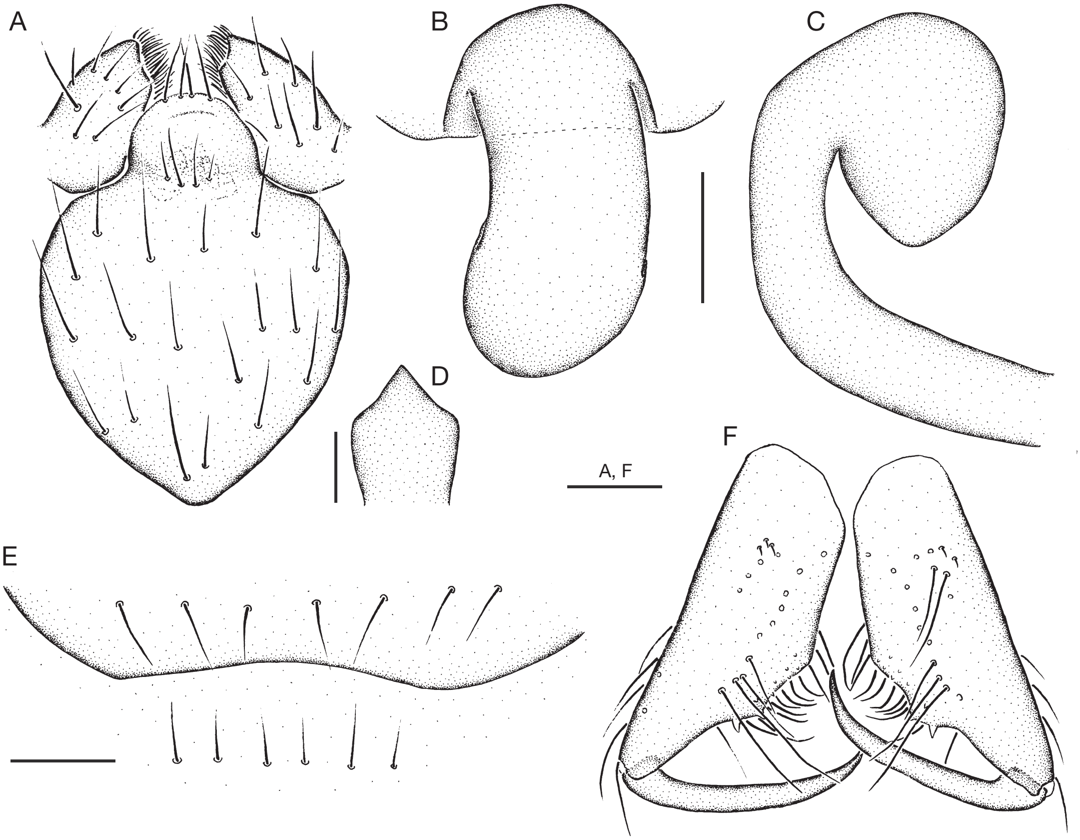

FIG. 5. — *Telema oculata* n. sp.: **A**, female endites, labium and sternum in ventral view; **B**, female genitalia in dorsal view; **C**, spermatheca in lateral view; **D**, colulus; **E**, female genitalia in ventral view; **F**, chelicerae in ventral view. Scale bars: A-C, F 0.1 mm; D, E, 0.05 mm.

Telema oculata n. sp.
(Figs 1D; 5)

TYPE MATERIAL. — Holotype: China, Guizhou Province, Duyun City, Dushan County, Xiasi Town (25°29'N, 107°27'E), Guo-Jia-Fen-Dong Cave, 24.V.2005, Leg. Y. F. Tong & Y. C. Lin, ♀ (MNHN).

Paratypes: same data as holotype, 3 ♀♀ (IZCAS), 2 ♀♀ (MNHN); same locality and collector as holotype, Liang-Shui-Jing-Dong Cave, 21.V.2005, 3 ♀♀ (IZCAS), 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name is from Latin oculata, with eyes and refers to the presence of eyes in this species, for all recorded telema species from Guizhou are eyeless.

DIAGNOSIS. — The new species is closely similar to the female of *T. nipponica* (Yaginuma, 1972), distributed in Japan. However, in *T. nipponica* the sternum is triangular, and obtusely inserted into coxae IV, but this new species with a smoothly outer margin. This new species also has relatively longer legs (the shortest leg of the new species is nearly as long as the longest leg of *T. nipponica*), the body size is larger, and the spermatheca is symmetrical in the new species (the spermatheca of *T. nipponica* is without figure, but described as asymmetrical thick curved tube [Yaginuma 1973]).

DESCRIPTION

Female (n = 11)

Total length 1.40-1.45 (average: 1.42). Carapace 0.57-0.61 (average: 0.59) long, 0.51-0.53 (average: 0.52) wide; abdomen 0.79-0.83 (average: 0.81) long, 0.71-0.73 (average: 0.72) wide. Carapace, legs, labium, endites and chelicerae yellow. Sternum (Fig. 5A) deep brown. Carapace (Fig. 1D) nearly round, with pair of setae on the clypeus, behind eyes and at middle. Six eyes, anterior row of four eyes nearly straight, AM close together, nearly touching, separated from AL by 1/2 diameter of AL, lateral eyes contiguous. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles (Fig. 5F). Legs with a dorsal spine at the distal end of patella as well as in the middle of tibia. Leg measurements: I 3.57 (1.12, 0.19, 1.10, 0.68, 0.48); II 3.12 (0.97, 0.18, 0.91, 0.58, 0.48); III 2.28 (0.72, 0.17, 0.60, 0.41, 0.38); IV 2.85 (0.92, 0.17, 0.81, 0.54, 0.41). Leg formula: I-II-IV-III. Abdomen globular, bluish-gray, the ventral surface being purplish-brown; colulus as in Figure 5D. Genital area with one row of hairs on epigynal plate, and another row behind epigastric furrow (Fig. 5E). Spermatheca distal end swollen, curved downwards (Fig. 5B, C).

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FOUR NEW SPECIES OF SIX-EYED PHOLCID SPIDERS (ARANEAE: PHOLCIDAE) FROM HAINAN ISLAND, CHINA

Yanfeng Tong
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China

Shuqiang Li
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China
Email: lisq@ioz.ac.cn (Corresponding author)

ABSTRACT. – Four new six-eyed pholcid spiders belonging to two genera are reported from Hainan Island, China. They are: *Belisana aliformis* (female, male), *B. huberi* (female, male), *B. lamellaris* (female, male) and *Khorata diaoluoshanensis* (female, male). The genus *Khorata* Huber, 2005, is newly recorded from China. All the species are diagnosed, described and illustrated.

KEY WORDS. – Hainan Island, Pholcidae, *Belisana*, *Khorata*, new species, new record, China.

INTRODUCTION

Spiders of the family Pholcidae are small- to medium-sized, haplogyne spiders, having six or eight eyes. They can be easily distinguished from other families by the following characters: prosoma about as long as wide; clypeus about as high as chelicerae; male palp with prominent retrolateral paracymbium (procursus), which is rarely reduced; male chelicerae usually with sexual modifications; and tarsi usually pseudosegmented (Huber, 2000). Pholcids occupy a wide range of ecosystems and habitats, ranging from deserts to rainforests, from sea level to over 3,500 m altitude, and from leaf litter to the canopy (Huber, 2005a). At present, a total of 81 genera and 967 species are recorded worldwide. In terms of the described species number, the family is the ninth among spiders (Platnick, 2007). However, considering some recent revisions of pholcids, it is reasonable to deduce that only a small percentage of species have been described (Huber, 2005a).

Six-eyed pholcids are usually tiny, leaf-litter dwelling spiders. Traditionally, almost any small pholcid with six eyes had been assigned to *Spermophora*. As a result, it is probably the most chaotic genus in the family. Recently, some revisions (Wunderlich, 1992; Huber, 2000, 2001, 2003a, 2003b, 2003c, 2005a, 2005b; Senglet, 2001) have greatly alleviated the situation. Now it is clear that most Chinese six-eyed pholcid species belong to the genus *Belisana* (Song et al., 1999; Huber, 2005a; Zhang et al., 2006). Exceptions are the synanthropic *Spermophora senoculata* and *S. elongata* which are probably representatives of the genus *Pholcus* (Huber, 2001).

Hainan Island, situated at the southernmost part of China, is considered as a tropical-biodiversity-rich region. No six-eyed pholcid spiders have previously been reported from the Island. In an expedition to Hainan Island from March to April 2005 with the objective of collecting spiders, we collected some six-eyed pholcids. Four new species belonging to two genera, including the first record of the genus *Khorata* from China, are reported in the present paper.

MATERIALS AND METHODS

Taxonomic descriptions and terminology followed Huber (2000, 2005a). Specimens were examined using an Olympus® SZX12 stereomicroscope [Olympus Corporation, Tokyo, Japan]. Further details were studied under an Olympus® BX51 compound microscope [Olympus Corporation, Tokyo, Japan]. All illustrations were made using a drawing tube [Olympus Corporation, Tokyo, Japan] and inked on ink jet plotter paper [Canson, Arjowiggins group, Qingdao, China]. Photos were made with an Olympus® C7070 wide zoom digital camera (7.1 megapixels) mounted on an Olympus® SZX12 dissecting scope. Vulvae of females were cleared in lactic acid. All measurements given are in milimetres (mm).

The following abbreviations are used in the illustrations: ba = bulbal apophysis; e = embolus; ep = epigynal pocket; f = membranous flap on procursus; pr = procursus; used in the text: ALE = anterior lateral eyes; AME = anterior median eyes; PME = posterior median eyes.

The specimens studied here are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

TAXONOMY

Pholcidae C. L. Koch, 1850

Belisana Thorell, 1898

Belisana Thorell, 1898: 278; Simon, 1903: 988; Simon, 1909: 81; Deeleman-Reinhold, 1986: 46–48; Huber, 2001: 124–126; Huber, 2005a: 1–126. Type species: *Belisana tauricornis* Thorell, 1898.

Belisana aliformis, new species
(Figs. 1A–C, 2A–H)

***Material examined.* –** Holotype: male (IZCAS), Wuzhishan Natural Reserve (18°49'N 109°39'E), Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 16 Apr.2005.

Paratypes: 8 males and 17 females (IZCAS), same data as holotype; 3 males and 7 females (IZCAS), Jianfengling Natural Reserve, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 5 Apr.2005.

***Diagnosis.* –** The new species is similar to *B. nujiang* Huber, 2005, and *B. pianma* Huber, 2005, but can be distinguished by the unpaired modification of the male clypeus, the less widely spaced cheliceral apophyses, the shapes of procursus and embolus, and the different female vulval structure.

***Description.* – Male** (holotype). Total length 2.95 (3.15 with clypeus), carapace width 1.28. Leg 1: 28.95 (6.99+0.44+7.14+12.28+2.1), tibia 2: 4.57, tibia 3: 2.99, tibia 4: 4.14; tibia 1 L/d: 64. Habitus as in Figs. 1A and 1B. Carapace ochre-yellow, brown margins laterally, sternum whitish, Legs ochre-yellow except brown on patella and joints of tibia to metatarsus, without darker rings. Opisthosoma whitish gray, with two pairs of darker spots dorsolaterally. Ocular area not elevated, thoracic furrow absent; distance PME-PME 0.23; diameter PME 0.10; distance PME-ALE 0.02; AME absent. Clypeus with duck-beak shaped apophysis

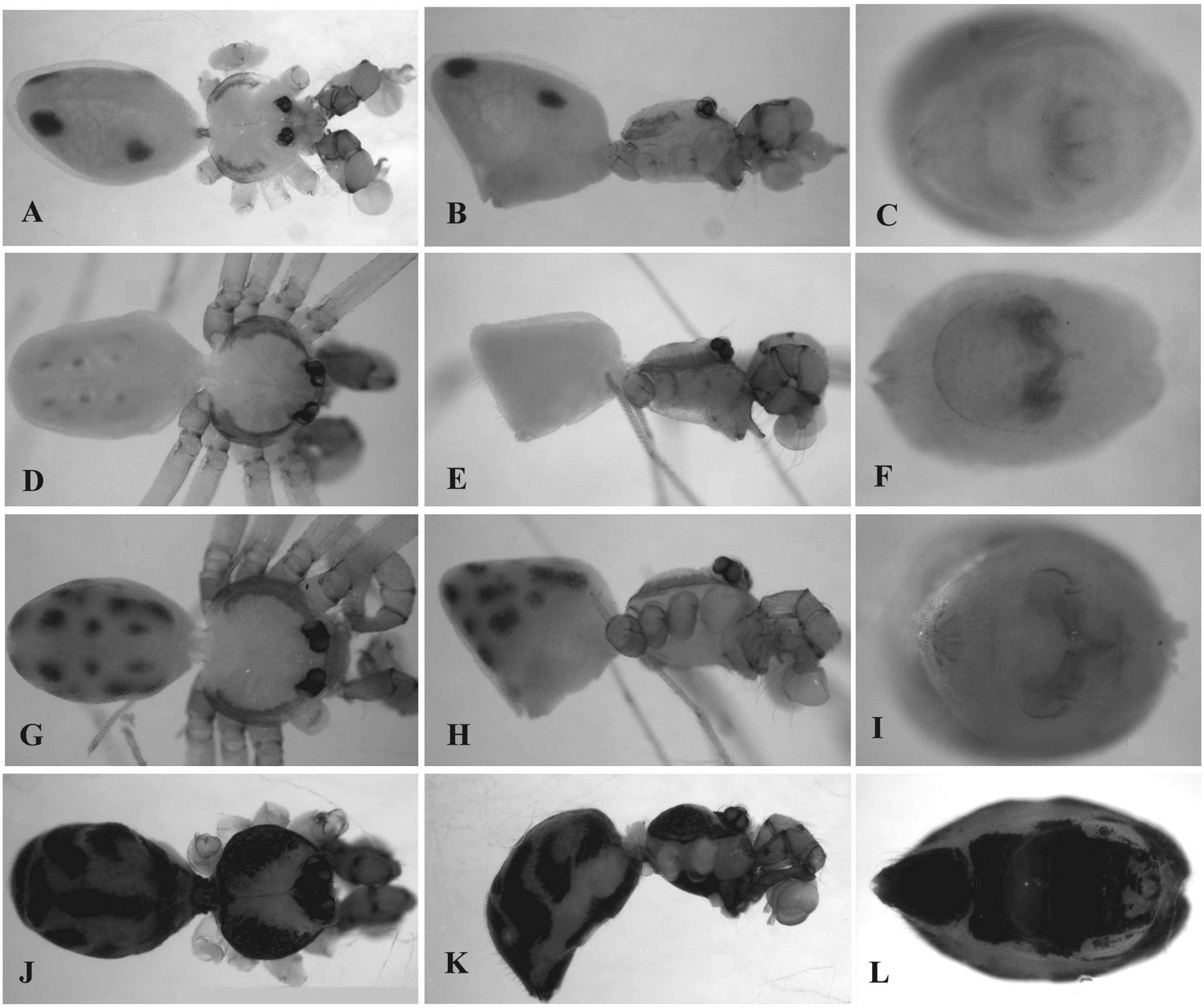

Fig. 1. A–C, *Belisana aliformis*, new species; D–F, *Belisana huberi*, new species; G–I, *Belisana lamellaris*, new species; J–L, *Khorata diaoluoshanensis*, new species. A, D, G, J, male habitus, dorsal view; B, E, H, K, male habitus, lateral view; C, F, I, L, female abdomen, ventral view.

on anterior margin. Sternum slightly wider than long (0.75/0.62). Chelicerae as in Fig. 2F, with pair of curved apophyses, tips with cuticular ridges laterally, 0.36 apart. Palps as in Figs. 2B, 2C and 2D; trochanter with short retrolateral apophysis, femur with indistinct hump proximo-dorsally, procursus complicated distally, with ventral membranous flap, bulb with hooked apophysis and complicated embolus. Retrolateral trichobothrium of tibia 1 at 7%; legs without spines, vertical hairs, and curved hairs; tarsus 1 apparently with > 20 pseudosegments, but only about 15 quite distinct distally.

Variation. Tibia 1 in other males (n = 8) from Wuzhishan: 6.28–7.18 (mean: 6.68); in the males from Jianfengling (n = 3): 6.81, 7.12, 7.52. Distance between tips of distal cheliceral apophyses in other males from Wuzhishan (n = 8): 0.31–0.37 (mean: 0.33); in the males from Jianfengling (n = 3): 0.29, 0.32, 0.33.

Females. In general, similar to male. Body colour lighter than male's; dorsal spots on opisthosoma indistinct (nearly invisible in some specimens from Jianfengling). Tibia 1 in females from Wuzhishan (n = 17): 5.04–6.08 (mean: 5.45); in females from Jianfengling (n = 7): 5.44–6.02 (mean: 5.72). Epigynum simple and flat externally, with distinctive internal dark structures visible through cuticle (Figs. 1C and 2G), pockets 0.19 apart. Dorsal view as in Fig. 2H.

***Etymology.* –** The specific name is an adjective from Latin, in reference to the wing-shaped dark structure visible through the epigynal cuticle.

***Distribution.* –** Hainan, China (present study).

Belisana huberi, new species

(Figs. 1D–F, 3A–G)

***Material examined.* –** Holotype: male (IZCAS), Bawangling National Natural Reserve (19°04'N 109°08'E), Changjiang County, Hainan Island, China, coll. G. Deng, 22 Mar.2005.

Paratypes: 2 males and 7 females (IZCAS), same data as holotype.

***Diagnosis.* –** The new species can be easily distinguished from known congeners by the modifications of chelicerae (pair of upward-directed proximal apophyses), the shape of procursus, and the unique female vulval structures.

***Description.* – Male** (holotype). Total length 1.75 (1.86 with clypeus), carapace width 0.75. Leg 1: 11.87 (3.05+0.27+2.95+4.5+1.1), tibia 2: 1.92, tibia 3: 1.3, tibia 4: 1.87; tibia 1 L/d: 39. Habitus as in Fig. 2D and 2E. Carapace yellowish, brown margins laterally, sternum whitish. Legs yellow except brown on patella and joints of tibia to metatarsus, without darker rings. Opisthosoma whitish-grey, with some indistinct darker spots dorsally. Ocular area not elevated, thoracic furrow absent; distance PME-PME 0.12; diameter PME 0.08; distance PME-ALE 0.03; AME absent. Clypeus unmodified. Sternum slightly wider than long (0.51/0.47). Chelicerae as in Fig. 3B and 3C, with pair of curved frontal apophyses, tips with cuticular ridges laterally, 0.14 apart; with pair of upward-directed proximal apophyses and pair of proximolateral apophyses. Palps as in Fig. 3A, 3D and 3E; trochanter with short retrolateral apophysis, femur with distinctive hump proximo-dorsally, procursus complicated distally, with ventral membranous flap, bulb with hooked apophysis and complicated embolus. Retrolateral trichobothrium of tibia 1 at 16%; legs without spines, vertical hairs, and curved hairs; tarsus 1 with about 15 quite distinct pseudosegments distally.

Variation. Tibia 1 in other males (n = 2): 3.05, 3.07. Distance between tips of distal cheliceral apophyses in other males (n = 2): 0.09, 0.13. One male with obscure moustache-like marks on median of carapace; dorsal spots on opisthosoma nearly invisible.

Females. In general, similar to male. Some specimens with distinctive moustache-like marks on median of carapace. Tibia 1 in females (n = 7): 2.27–2.87 (mean: 2.58). Epigynum simple and flat externally, with distinctive internal dark structures visible through cuticle (Figs. 1F and 3F); with pair of posterior pockets, 0.09 apart. Dorsal view as in Fig. 3G.

***Etymology.* –** Named for Dr. Bernhard A. Huber from the Alexander Koenig Zoological Research Museum who contributed to our understanding of the taxonomy of this genus.

***Distribution.* –** Hainan, China (present study).

Belisana lamellaris, new species

(Figs. 1G–I, 4A–F)

***Material examined.* –** Holotype: male (IZCAS), Diaoluoshan Natural Reserve, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 19 Apr.2005.

Paratypes: 2 males and 7 females (IZCAS), same data as holotype.

***Diagnosis.* –** The new species is similar to *B. phurua* Huber, 2005, but can be distinguished by the absence of distal spine on procursus, the shape of bulbal apophyses, and the different female vulval structure.

***Description.* – Male** (holotype). Total length 1.85 (1.94 with clypeus), carapace width 0.78. Leg 1: 13.48 (3.28+0.30+3.30+5.07+1.53), tibia 2: 1.87, tibia 3: 1.27, tibia 4: 1.90; tibia 1 L/d: 42. Habitus as in Fig. 1G and 1H. Carapace ochre-yellow, light brown margins laterally, sternum yellowish, Legs ochre-yellow except brown patella, without darker rings. Opisthosoma ochre-gray, with some dorsal darker spots. Ocular area not elevated, thoracic furrow absent; distance PME-PME 0.10; diameter PME 0.11; distance PME-ALE 0.02; AME absent. Clypeus unmodified. sternum slightly wider than long (0.57/0.53). Chelicerae as in Fig. 4B, with pair of curved apophyses, tips unmodified, 0.4 apart. Palps as in Fig. 4A, 4C and 4D; trochanter with small retrolateral apophysis, femur with indistinct hump

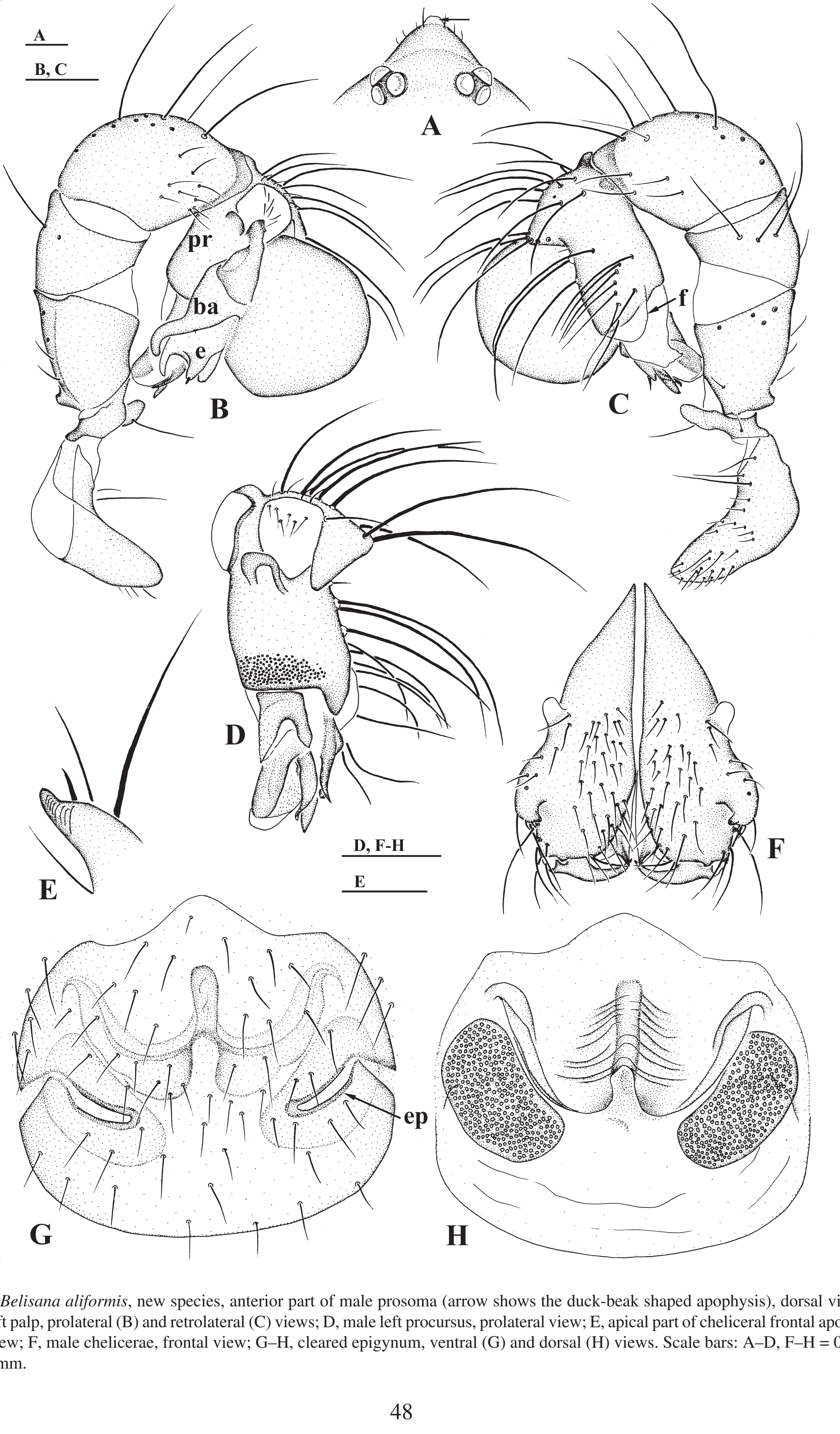

Fig. 2. A, *Belisana aliformis*, new species, anterior part of male prosoma (arrow shows the duck-beak shaped apophysis), dorsal view; B–C, male left palp, prolateral (B) and retrolateral (C) views; D, male left procursus, prolateral view; E, apical part of cheliceral frontal apophysis, internal view; F, male chelicerae, frontal view; G–H, cleared epigynum, ventral (G) and dorsal (H) views. Scale bars: A–D, F–H = 0.2 mm; E = 0.05 mm.

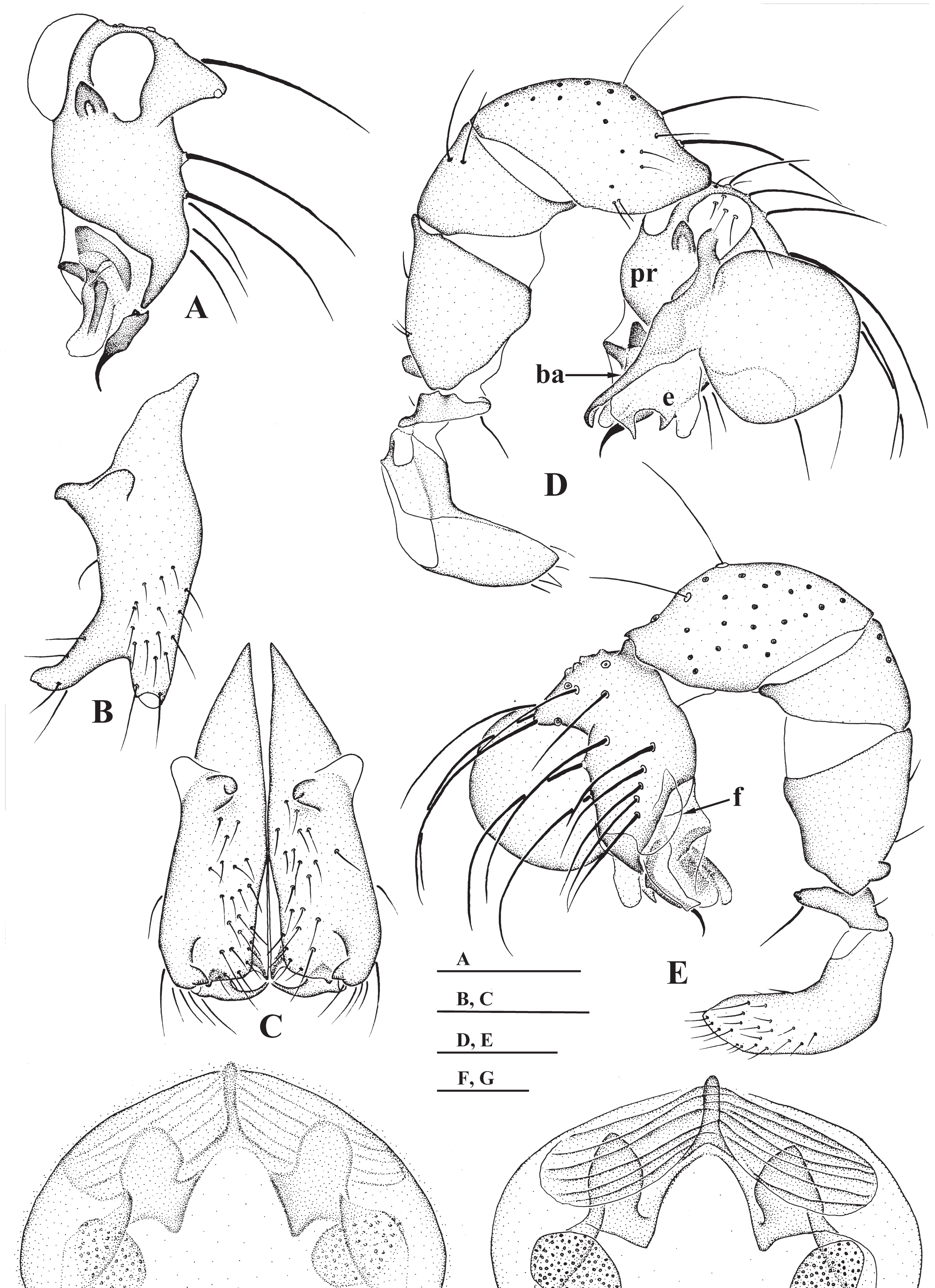

Fig. 3. A, *Belisana huberi*, new species, male left procursus, prolateral view; B, male chelicerae, lateral view; C, male chelicerae, frontal view; D–E, male left palp, prolateral (D) and retrolateral (E) views; F–G, cleared epigynum, ventral (F) and dorsal (G) views. Scale bars: A–E = 0.2 mm; F, G = 0.1 mm.

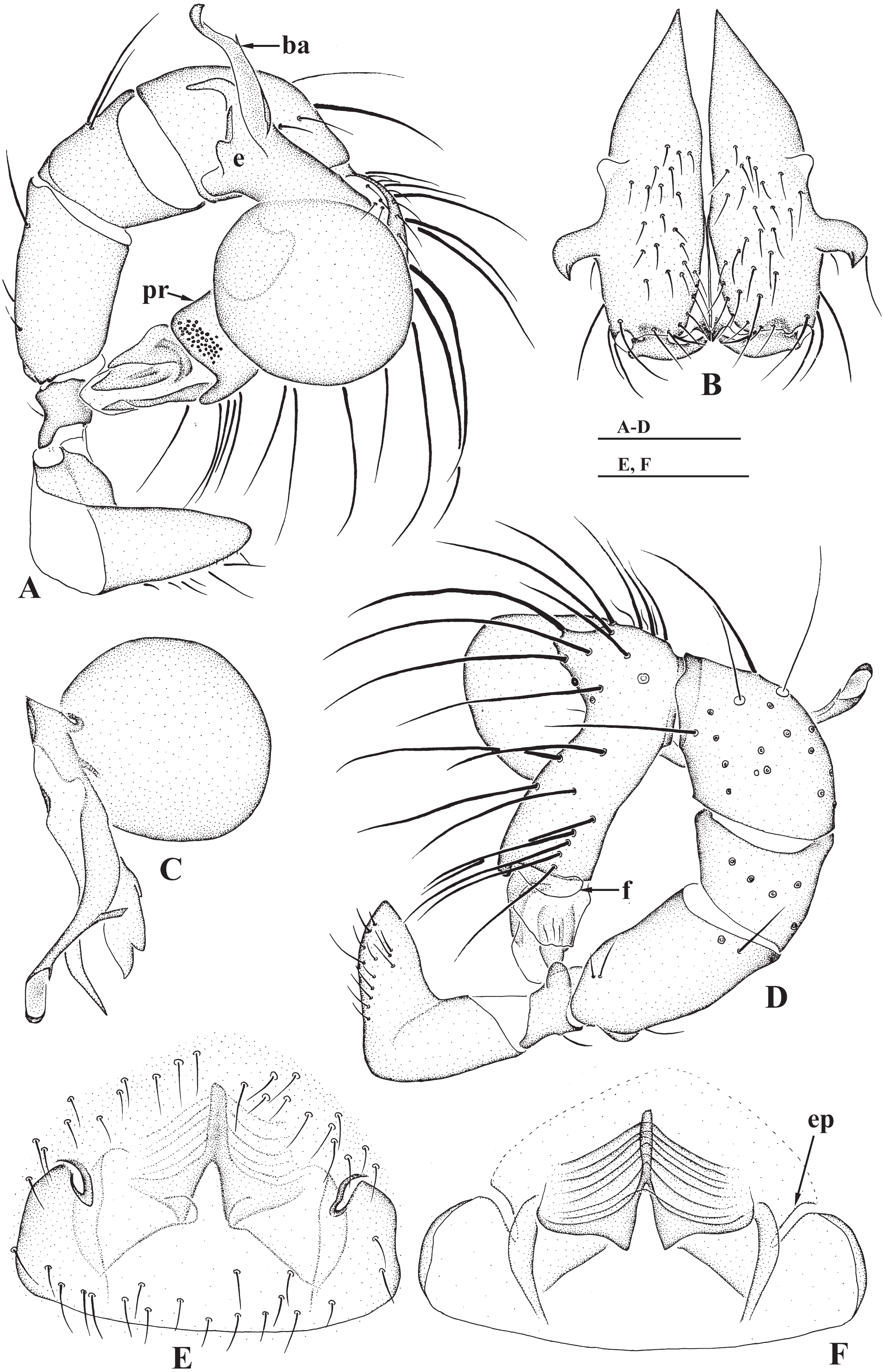

Fig. 4. A, *Belisana lamellaris*, new species, male left palp, prolateral view; B, male chelicerae, frontal view; C, male bulb with bulbal apophysis and embolus, laterodorsal view; D, male left palp, retrolateral view; E–F, cleared epigynum, ventral (E) and dorsal (F) views. Scale bars = 0.2 mm.

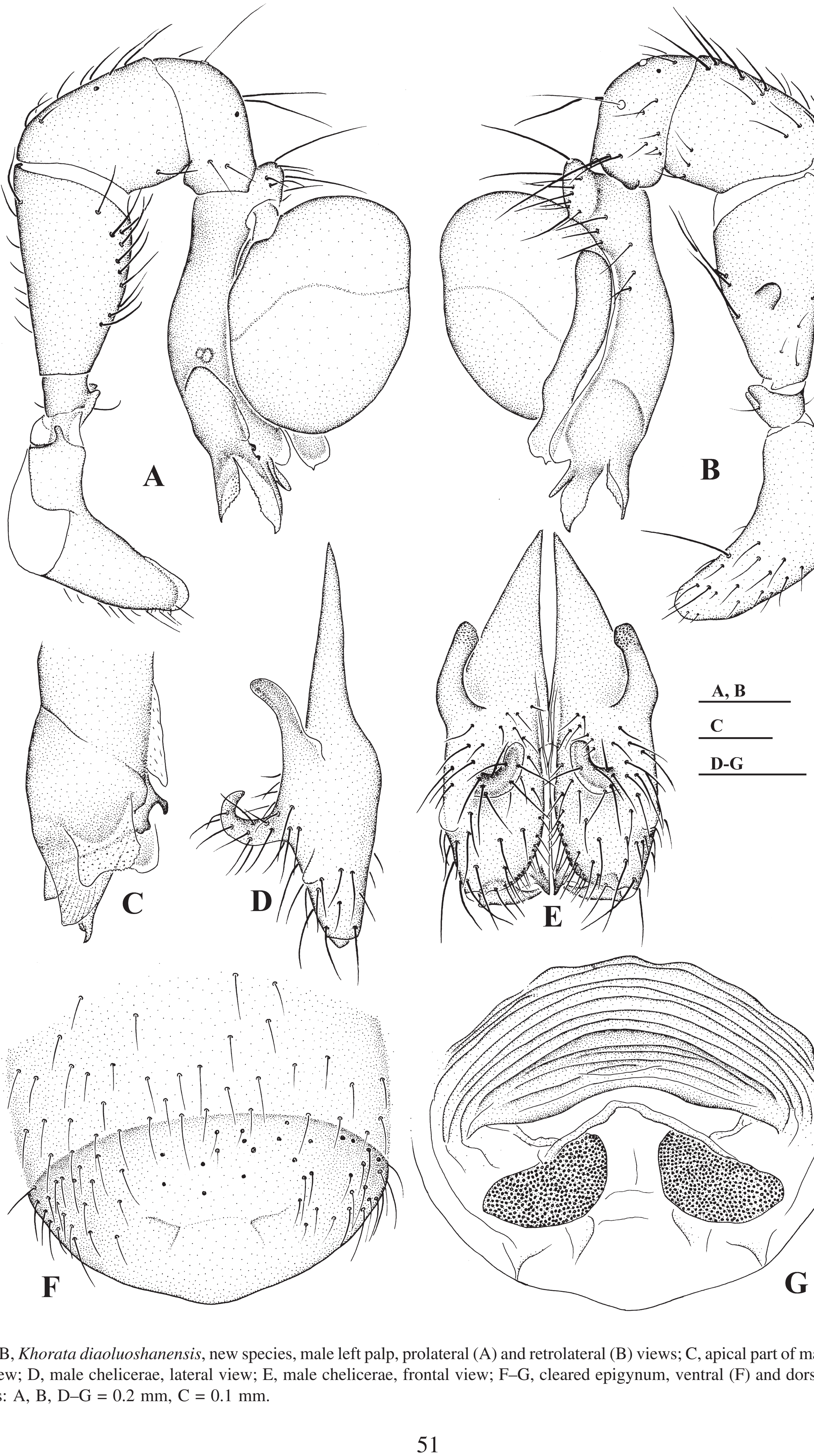

Fig. 5. A–B, *Khorata diaoluoshanensis*, new species, male left palp, prolateral (A) and retrolateral (B) views; C, apical part of male procursus, ventral view; D, male chelicerae, lateral view; E, male chelicerae, frontal view; F–G, cleared epigynum, ventral (F) and dorsal (G) views. Scale bars: A, B, D–G = 0.2 mm, C = 0.1 mm.

proximo-dorsally, procursus with ventral membranous flap, bulb with hooked apophysis and complicated embolus. Retrolateral trichobothrium of tibia 1 at 14%; legs without spines, vertical hairs, and curved hairs; tarsus 1 apparently with > 20 pseudosegments, only about 15 quite distinct distally.

Variation. Tibia 1 in other males (n = 2): 3.37, 3.5. Distance between tips of distal cheliceral apophyses in other males (n = 2): 0.45, 0.38. Dorsal darker spots on opisthosoma indistinctive in one male.

Females. In general, similar to male. Tibia 1 in females (n = 7): 2.22–2.65 (mean: 2.48). Epigynum simple and flat externally, with distinctive internal dark structures visible through cuticle (Figs. 1I and 4E), pockets 0.33 apart. Dorsal view as in Fig. 4F.

***Etymology.* –** The specific name is an adjective from Latin, and refers to the narrow sheet-like elongation on the bulbal apophysis of the male palp.

***Distribution.* –** Hainan, China (present study).

Khorata Huber, 2005

Khorata Huber, 2005b: 79–83. Type species: *K. khammouan* Huber, 2005.

Khorata diaoluoshanensis, new species

(Figs. 1J–L, 5A–G)

***Material examined.* –** Holotype: male (IZCAS), Diaoluoshan Natural Reserve, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 19 Apr.2005.

Paratypes: 7 males and 14 females (IZCAS), same data as holotype.

***Diagnosis.* –** The new species is similar to *K. schwendingeri* Huber, 2005, and *K. bangkok* Huber, 2005, but can be easily distinguished by the longer proximal apophyses of the male chelicerae, and by the shape of the distal elements of the procursus; from the other two species of this genus, *K. khammouan* Huber, 2005, and *K. jaegeri* Huber, 2005, by the male chelicerae (distal apophyses close together), the male palpal bulb (absence of hump or projection retrolaterally), and by the distal elements of the procursus.

***Description.* – Male** (holotype). Total length 2.25 (2.4 with clypeus), carapace width 1.12. Leg 1: 22.28 (5.67+0.42+5.37+8.35+2.47), tibia 2: 3.3, tibia 3: 2.4, tibia 4: 3.17; tibia 1 L/d: 54. Habitus as in Fig. 1J and 1K. Carapace ochre with black margins and dark mark behind ocular area; sternum black. Legs ochre, with slightly darker rings on femora (subdistally) and tibiae (proximally and subdistally). Opisthosoma gray with large black spots, also ventrally. Ocular area slightly elevated and separated from carapace, thoracic furrow shallow but distinct; distance PME-PME 0.14; diameter PME 0.14; distance PME-ALE 0.02; AME absent. Clypeus unmodified. Sternum slightly wider than long (0.67/0.58). Chelicerae as in Fig. 5D and 5E, with pair of long frontal apophyses (distance between tips: 0.1), strong proximal apophyses provided with scales, and pair of small, nearly transparent apophyses at frontolateral surface and basal part of proximal apophyses, respectively, without modified hairs. Palps as in Fig. 5A, 5B and 5C; trochanter with retrolateral apophysis and small ventral projection, femur with retrolateral apophysis, patella very large, procursus relatively simple except distally, bulb very simple, no projection apart from embolus. Retrolateral trichobothrium of tibia 1 at 7%; legs without spines, vertical hairs, and curved hairs; tarsus 1 with barely visible pseudosegments, only about 10 distinct distally.

Variation. Tibia 1 in other males (n = 7): 5.25–5.92 (mean: 5.59).

Females. In general similar to male. Tibia 1 in females (n = 14): 4.82–5.53 (mean: 5.12). Epigynum simple brown plate, with internal structures nearly invisible through cuticle (Figs. 1L and 5F), apparently without pockets. Dorsal view as in Fig. 5G.

***Etymology.* –** The specific name refers to the type locality.

***Distribution.* –** Hainan, China (present study).

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THE OONOPID SPIDERS (ARANEAE: OONOPIDAE) FROM HAINAN ISLAND, CHINA

Yanfeng Tong
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China

Shuqiang Li
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China
Email: lisq@ioz.ac.cn (Corresponding author)

ABSTRACT. **–** Nine species of oonopid spiders belonging to four genera are reported from Hainan Island, China, including six new species, *Ischnothyreus campanaceus* (female, male), *I. falcatus* (female, male), *I. hanae* (female), *I. qianlongae* (male), *Oonopinus corneus* (male) and *Opopaea gibbifera* (female, male). Three other species, *Gamasomorpha anhuiensis*, *I. narutomii* and *I. peltifer*, are newly recorded. All the species except *G. anhuiensis* and *I. peltifer*, are diagnosed, described and illustrated.

KEY WORDS. **–** Hainan Island, taxonomy, Oonopidae, new species, new record, China.

INTRODUCTION

Oonopids are small (1–4 mm) haplogyne spiders. They are mostly yellowish, orange or reddish-brown, sometimes whitish or even pink in colour (Saaristo & van Harten, 2006). They can be distinguished from other haplogynes by having six eyes which are usually closely grouped and touching, sternum usually with 3 pairs of radial furrows, abdomen usually covered by scuta, tracheal spiracles which are paired and anteriorly positioned, and tarsus with onychium bearing two claws. Oonopids are usually found in shaded but dry conditions, e.g., in leaf litter, under rocks and under bark (Xu, 1996).

The Oonopidae is a relatively small family with 68 genera and 472 species (Platnick, 2007). Eight genera and 19 species are distributed in China (Hu, 2001; Song et al., 1999). However, the taxonomy of the family is still poorly known even on the generic level, and only a small fraction of the species of this family has apparently been discovered and described (Saaristo, 2001).

Hainan Island, a province situated at the southernmost part of China, is considered as a tropical biodiversity rich region (Anonymous, 2006). However, the taxonomy on the oonopids has not been done until recently. Only one species, *Opopaea cornuta*, was formerly recorded in Ledong County (Song et al., 2002). In an expedition to Hainan Island with the objective of collecting cave fauna, some oonopids were collected. A total of 4 genera and 9 species are reported in the present paper, six of them are new to science, and all are new to Hainan Island.

MATERIALS AND METHODS

Specimens were examined using an Olympus SZX12 stereomicroscope. Further details were studied under an Olympus BX51 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Male palps and female genitalia were examined and illustrated. Vulvae of female were cleared in lactic acid. All measurements were measured using an Olympus BX51 compound microscope and given in millimeters (mm). Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Legs segments were measured on their dorsal side. Taxonomic descriptions partly follow the format of Saaristo (2001) and Saaristo & van Harten (2006). All type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

TAXONOMY

Oonopidae Simon, 1890

Gamasomorpha Karsch, 1881

Gamasomorpha anhuiensis Song & Xu, 1984

Material examined. **–** 1 male (IZCAS), Mountain Wuzhishan (18°49'N 109°39'E), Wuzhishan City, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 16 Apr.2005; male holotype and 1 male paratype (IZCAS).

Distribution. **–** China (new to Hainan, Anhui).

Ischnothyreus Simon, 1893

Ischnothyreus campanaceus, new species

(Fig. 1A–I)

Holotype. **–** Male (IZCAS), Mountain Wuzhishan (18°49'N 109°39'E), Wuzhishan City, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 16 Apr.2005.

Paratypes. **–** 2 males, 4 females (IZCAS), same data as holotype.

Diagnosis. **–** The female of the new species is similar to *I. linzhiensis* Hu, 2001 (male unknown), but can be distinguished by the distinctly short and clearly winding tube in the middle line of the postepigastric scutum, and the distinctly long abdominal dorsal scutum; the male is similar to *I. shillongensis* Tikader, 1968 (Brignoli, 1978), but can be distinguished by the modifications on base of cheliceral fang and the outgrowths on apical part of embolus.

Description. **– Male.** Body length 1.47; carapace 0.80 length, 0.64 width; abdomen 0.70 length, 0.44 width. Sides of carapace yellowish-brown, dorsally yellow, scutum yellow, chelicerae, sternum, legs and ventral scutum light yellow. Carapace with pair of dark brown, egg-shaped patches behind eyes; dorsally with three rows of short hairs. Eyes six in two rows, quite compactly arranged; ALE slightly separated; posterior eyes in a straight row, touching each other. Base of fang with prominent processes; retromargin of fang furrow with a small tooth. Labium wider than long, endites with pointed tip. Leg I: femur with 2 prolateral and 1 small retrolateral spine, patella spineless, tibia with 4 pairs, metatarsus with 2 pairs of long ventral spines. Leg II spinatoin is similar to leg I except that femur with only one prolateral spine. Legs III and IV spineless. Measurements of legs: I 1.89 (0.56, 0.25, 0.47, 0.39, 0.22); II 1.83 (0.55, 0.24, 0.44, 0.39, 0.21); III 1.61 (0.49, 0.23, 0.26, 0.39, 0.24); IV 2.33 (0.67, 0.32, 0.49, 0.56, 0.29). Leg formula: 4 > 1 > 2 > 3. Dorsal scutum of abdomen oval-shaped, covering nearly entirely abdominal length. Bulbus of palp elongated, gradually tapering apically, obtusely bent before apex. Embolic part not divided into distinct lobes, bearing some membranous outgrowths.

Female. Similar to male, but sides of carapace deeper in colour, without dorsal egg-shaped patches, base of fang unmodified, tip of endites truncated, dorsal scutum of abdomen shorter, about five-sixths abdominal length. Body length 1.52–1.57; carapace 0.70–0.78 length, 0.62–0.65 width; abdomen 0.85–0.94 length, 0.55–0.57 width. Measurements of legs: I 2.04 (0.61, 0.27, 0.54, 0.41, 0.21); II 2.04 (0.61, 0.27, 0.51, 0.43, 0.22); III 1.74 (0.49, 0.26, 0.35, 0.42, 0.22); IV 2.48 (0.69, 0.40, 0.54, 0.56, 0.29). Postepigastric scutum elongated hexagonal. A strongly winding tube visible through cuticle, originated from near the middle of epigastric sulcus and running posteriorly into the bell-shaped atrium. Internal course of tube explicit, same as the course when see from ventral view.

Etymology. **–** Specific name comes from the Latin "*campanaceus* = bell-shaped", in reference to the bell-shaped atrium in female.

Ischnothyreus falcatus, new species

(Fig. 2A–K)

Holotype. **–** Male (IZCAS)**,** Bawangling National Natural Reserve (19°04'N 109°08'E), Changjiang County, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 22 Mar.2005.

Paratypes. **–** 1 female (IZCAS), same data as holotype; 1 male (IZCAS), Xianren Cave (19°57'N 110°12'E), Shishan Town, Haikou City, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 16 Mar.2005.

Diagnosis. **–** The male of this new species can be easily recognized by the sickle-shaped process on laterodorsal surface of chelicerae, a similar structure can also be found in *I. flagellichelis* Xu, 1989 (Xu, 1989), but in *I. flagellichelis* the process is flagelliform, with two segments and a claw on the tip; the female of this new species is characterized by the trapezoid-shaped atrium.

Description. **– Male.** Body length 1.28; carapace 0.72 length, 0.56 width; abdomen 0.67 length, 0.40 width. Carapace deep orange, chelicerae, sternum, legs, dorsal and ventral scutum light yellow. Carapace with pair of dark-brown, egg-shaped patches behind eyes; with three rows of short hairs. Eyes six in two rows, large, nearly equally sized, compactly arranged; ALE slightly separated; posterior eyes in a straight row, touching each other. Chelicerae with a sickle-shaped process on median of laterodorsal surface, which straight upwards, slowly curved mesially, then abruptly turned outwards; retromargin of fang furrow with a small tooth, promargin with some tiny indistinct teeth; base of cheliceral fang modified. Labium wider than long, endites with pointed tip. Leg I: femur with 2 prolateral and 1 small retrolateral spine, patella spineless, tibia with 4 pairs, metatarsus with 2 pairs of very long ventral spines. Leg II is similar to leg I except femur with only one prolateral spine. Legs III and IV spineless. Measurements of legs: I 1.72 (0.53, 0.21, 0.44, 0.35, 0.19); II 1.70 (0.52, 0.22, 0.41, 0.36, 0.19); III 1.43 (0.44, 0.19, 0.29, 0.33, 0.18); IV 2.12 (0.63, 0.28, 0.48, 0.49, 0.24). Leg formula: 4 > 1 = 2 > 3. Abdomen with small dorsal scutum, about two-seconds abdominal length. Bulbus of palp elongated, gradually tapering apically, obtusely bent before apex. Embolic part not divided into distinct lobes, bearing some membranous outgrowths.

Female. Similar to male, but chelicerae without sickle-shaped process, base of cheliceral fang unmodified, tip of endites truncated. Body length 1.21; carapace 0.67 length, 0.59 width; abdomen 0.68 length, 0.42 width. Measurements of legs: I 1.80 (0.56, 0.22, 0.48, 0.35, 0.19); II 1.79 (0.53, 0.23, 0.46, 0.38, 0.19); III 1.57 (0.47, 0.22, 0.29, 0.36, 0.23); IV 2.22 (0.63, 0.34, 0.50, 0.51, 0.24). Postepigastric scutum rectangular, with straight posterior margin. A strongly winding tube visible through cuticle, originated from near the middle of epigastric sulcus and running posteriorly into the trapezoid-shaped atrium.

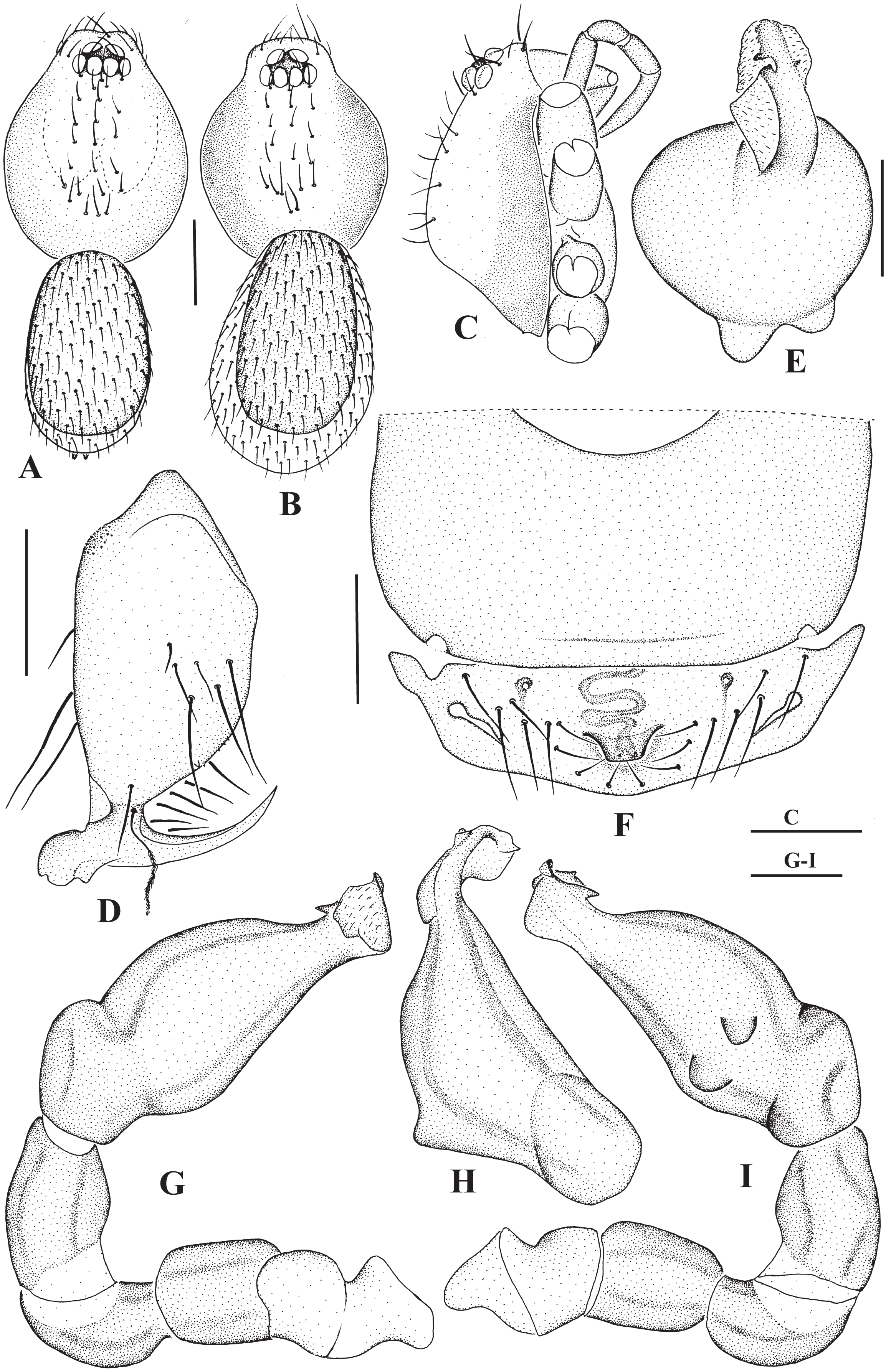

Fig. 1. *Ischnothyreus campanaceus*, new species: A, male, dorsal view; B, female, dorsal view; C, carapace of female, lateral view; D, left male chelicera, posterior view; E, left male palpal bulb, apical view; F, ventral scutum of female, ventral view; G, H, I, left male palp in prolateral, dorsal and retrolateral view. Scales: A-C = 0.3 mm, D, F = 0.1 mm, E, G-I = 0.05 mm.

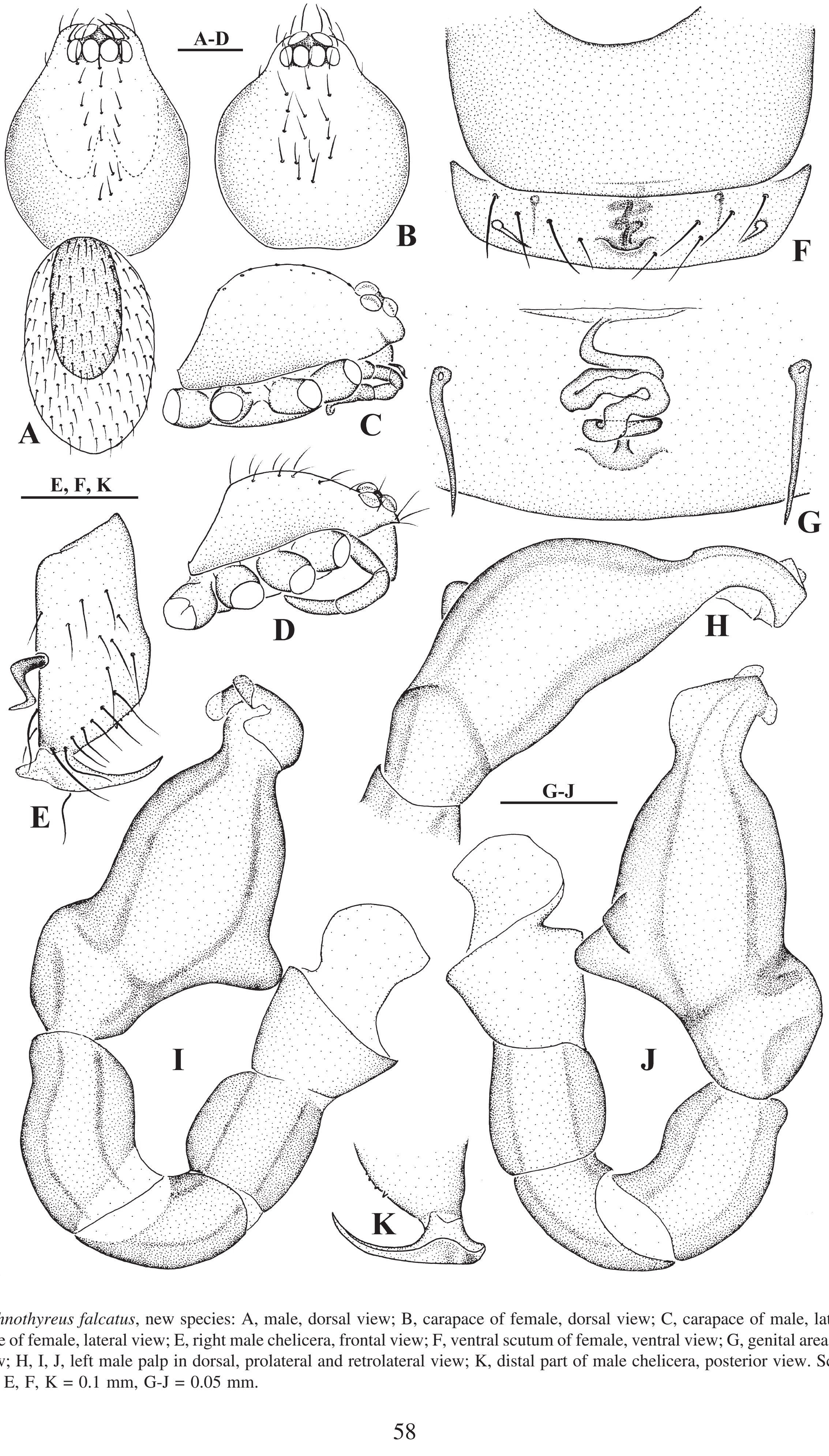

Fig. 2. *Ischnothyreus falcatus*, new species: A, male, dorsal view; B, carapace of female, dorsal view; C, carapace of male, lateral view; D, carapace of female, lateral view; E, right male chelicera, frontal view; F, ventral scutum of female, ventral view; G, genital area of female, dorsal view; H, I, J, left male palp in dorsal, prolateral and retrolateral view; K, distal part of male chelicera, posterior view. Scales: A-D = 0.2 mm, E, F, K = 0.1 mm, G-J = 0.05 mm.

***Etymology.* –** Specific name comes from the Latin "*falcatus* = sickle-shaped", and refers to the sickle-shaped process on laterodorsal surface of male chelicerae.

Ischnothyreus hanae, new species

(Fig. 3A–D)

***Holotype.* –** Female (IZCAS), Bawangling National Natural Reserve (19°04'N, 109°08'E), Changjiang County, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 22 Mar.2005.

***Paratypes.* –** 1 female (IZCAS), same data as holotype.

***Diagnosis.* –** The female of this new species (male unknown) is similar to the widely distributed species *I. peltifer* (Simon, 1891) (Saaristo, 2001), but can be distinguished by the distinctly longer abdominal dorsal scutum, the shape of ventral postepigastric scutum and the goblet like atrium of female.

***Description.* – Female**. Body length 1.18–1.29; carapace 0.61–0.62 length, 0.50–0.52 width; abdomen 0.60–0.69 length, 0.32–0.35 width. Carapace and dorsal scutum brown; chelicerae, sternum, legs and ventral scuta yellow. Carapace with three rows of short hairs dorsally. Eyes six in two rows, quite compactly arranged; eyes sizes relatively smaller than

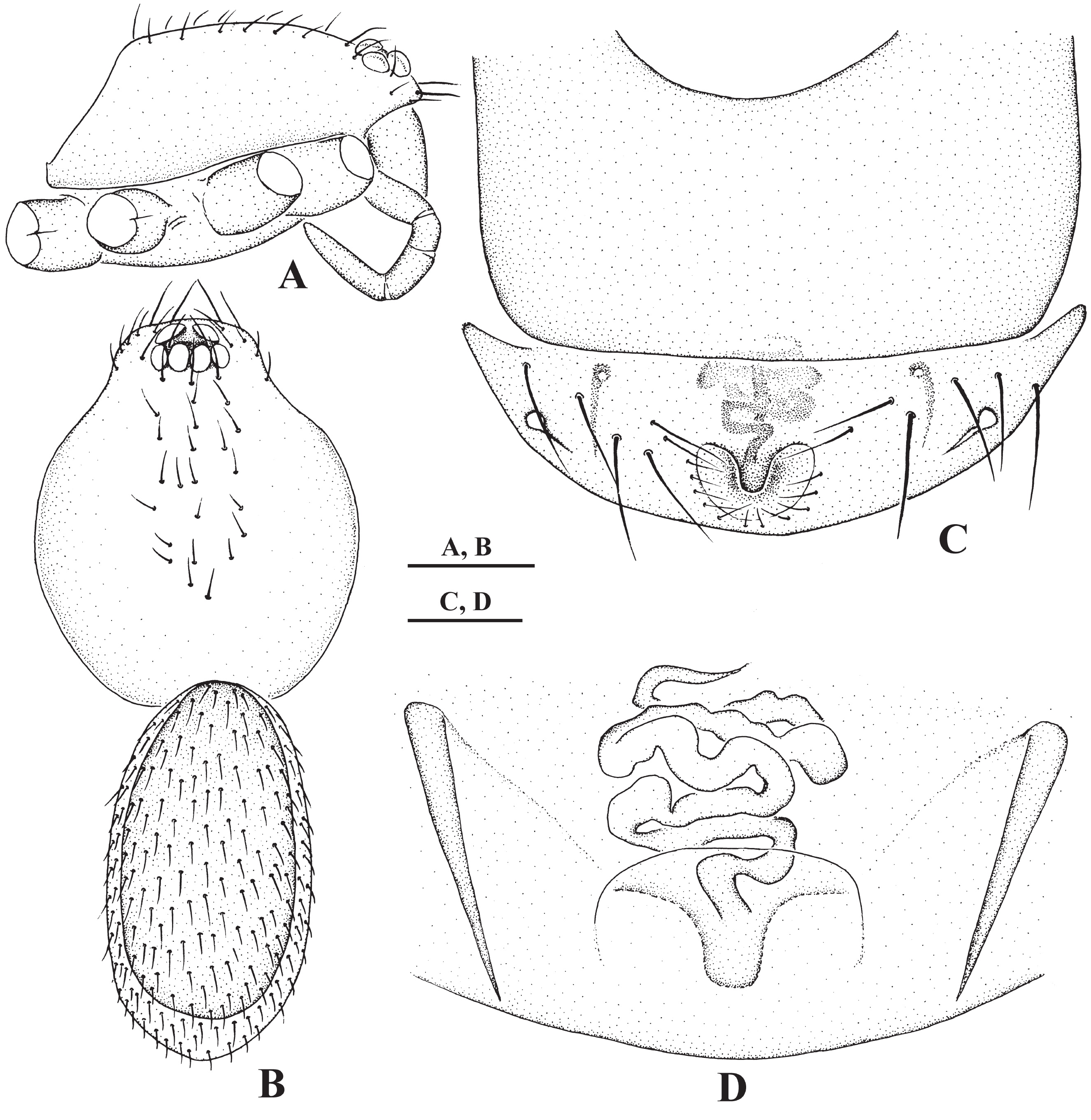

Fig. 3. *Ischnothyreus hanae*, new species: A, carapace of female, lateral view; B, female, dorsal view; C, ventral scutum of female, ventral view; D, genital area of female, dorsal view. Scales: A, B = 0.2 mm, C = 0.05 mm, D = 0.025 mm.

those of *I. falcatus*, new species; ALE about one-fourth of their diameter apart; posterior eyes in a slightly procurved row, touching each other. Labium wider than long, tip of endites truncated. Leg I: femur with 2 prolateral spines, patella spineless, tibia with 4 pairs, metatarsus with 2 pairs of very long ventral spines. Leg II is similar to leg I except femur with only one prolateral spine. Legs III and IV spineless. Measurements of legs: I 1.47 (0.43, 0.21, 0.37, 0.29, 0.17); II 1.46 (0.40, 0.22, 0.36, 0.30, 0.18); III 1.22 (0.36, 0.15, 0.24, 0.28, 0.19); IV 1.78 (0.51, 0.25, 0.39, 0.39, 0.24). Leg formula: 4 > 1 = 2 > 3. Dorsal scutum long oval-shaped, about four-fifths to five-sixths abdominal length. Postepigastric scutum elongated triangular. A strongly winding tube visible through cuticle, originated from near the middle of epigastric sulcus and running posteriorly into the goblet like atrium.

Male. Unknown.

***Discussion.* –** The species *I. falcatus*, new species and *I. hanae*, new species (male unknown) are collected in the same locality, but the females of these two species can be easily distinguished by the length of abdominal scutum and the shape of atrium. Based on the similarity of the shorter abdominal scutum (most species of *Ischnothyreus* with longer abdominal dorsal scutum in male than that in female (Chickering, 1968), but the female of *I. hanae*, new species has a distinctly longer abdominal dorsal scutum than the male of *I. falcatus*, new species. This suggests that they might not be the same species), the steeper lateral view of carapace, the larger sizes of eyes, and the body colour, it will be able to help match the male and female.

***Etymology.* –** This species is named after the collector Mrs. Xu Han.

Ischnothyreus qianlongae, new species

(Fig. 4A–G)

***Holotype.* –** Male (IZCAS), Qianlong Cave (18°35'N 109°25'E), Maogan Town, Baoting County, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 13 Apr.2005.

***Diagnosis.* –** The male of this new species (female unknown) is similar to *I. narutomii* (Nakatsudi, 1942) (Oi, 1958; Lee, 1964), but can be distinguished by the modifications on base of cheliceral fang, the complicated membranous outgrowths on apical part of embolus, and the blackish brown sides of carapace.

***Description.* – Male.** Body length 1.51; carapace 0.84 length, 0.65 width; abdomen 0.67 length, 0.42 width. Sides of carapace blackish brown, dorsally yellow, dorsal scutum brown, chelicerae, sternum and ventral scutum light yellow, legs yellow. Carapace with pair of dark brown, egg-shaped patches behind eyes; dorsally with three rows of short hairs. Eyes six in two rows, quite compactly arranged; ALE separated only by a line; posterior eyes in a straight row, touching each other. Base of cheliceral fang with prominent processes; retromargin of fang furrow with a small tooth. Labium wider than long; endites with pointed tip. Leg I: femur with 2 prolateral and 1 small retrolateral spine, patella spineless, tibia with 4 pairs, metatarsus with 2 pairs of very long ventral spines. Leg II is similar to leg I except femur with only one prolateral spine. Measurements of legs: I 2.13 (0.62, 0.27, 0.56, 0.43, 0.25); II 2.15 (0.63, 0.28, 0.52, 0.47, 0.25); III 1.85 (0.56, 0.25, 0.35, 0.44, 0.25); IV 2.65 (0.75, 0.36, 0.55, 0.64, 0.35). Leg formula: 4 > 1 = 2 > 3. Dorsal scutum about covering five-sixths abdominal length. Bulbus of palp elongated, gradually tapering apically, obtusely bent before apex. Embolic part not divided into distinct lobes, bearing complicated membranous outgrowths.

Female. Unknown.

***Etymology.* –** Specific name comes from the type locality.

Ischnothyreus narutomii (Nakatsudi, 1942)

(Fig. 5A–D)

***Material examined.* –** 2 males (IZCAS), Baoyou Cave (19°06'N 109°01'E), Baoyou Village, Qicha Town, Changjiang County, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 3 Apr.2005.

***Diagnosis.* –** The male of this species (female unexamined) can be distinguished from the other congeners by the distinctly lobes on apical part of embolus, connected by developed membranous outgrowths.

***Redescription.* – Male.** Body length 1.88; carapace 0.97 length, 0.74 width; abdomen 0.89 length, 0.52 width. Sides of carapace yellowish brown to gray, dorsally yellow, chelicerae, sternum, legs, dorsal and ventral scutum light yellow. Carapace with pair of dark brown, egg-shaped patches behind eyes; dorsally with three rows of short hairs. Eyes six in two rows, quite compactly arranged; ALE separated only by a line; posterior eyes in a straight row, touching each other. Base of cheliceral fang unmodified. Labium wider than long; endites with pointed tip. Leg I: femur with 2 prolateral and 1 small retrolateral spine, patella spineless, tibia with 4 pairs, metatarsus with 2 pairs of very long ventral spines. Leg II is similar to leg I except femur with only one prolateral spine. Measurements of legs: I 2.97 (0.85, 0.37, 0.83, 0.64, 0.28); II 3.19 (0.91, 0.39, 0.82, 0.74, 0.33); III 2.65 (0.79, 0.35, 0.56, 0.67, 0.28); IV 3.73 (1.07, 0.50, 0.87, 0.93, 0.36). Leg formula: 4 > 2 > 1 > 3. Abdomen oval-shaped, dorsal scutum about three-fourths abdominal length. Bulbus of palp elongated, gradually tapering apically, obtusely bent before apex. Embolic part divided into distinct lobes, connected by some membranous outgrowths.

Female. Unexamined.

***Distribution.* –** China (new to Hainan, Taiwan), Japan.

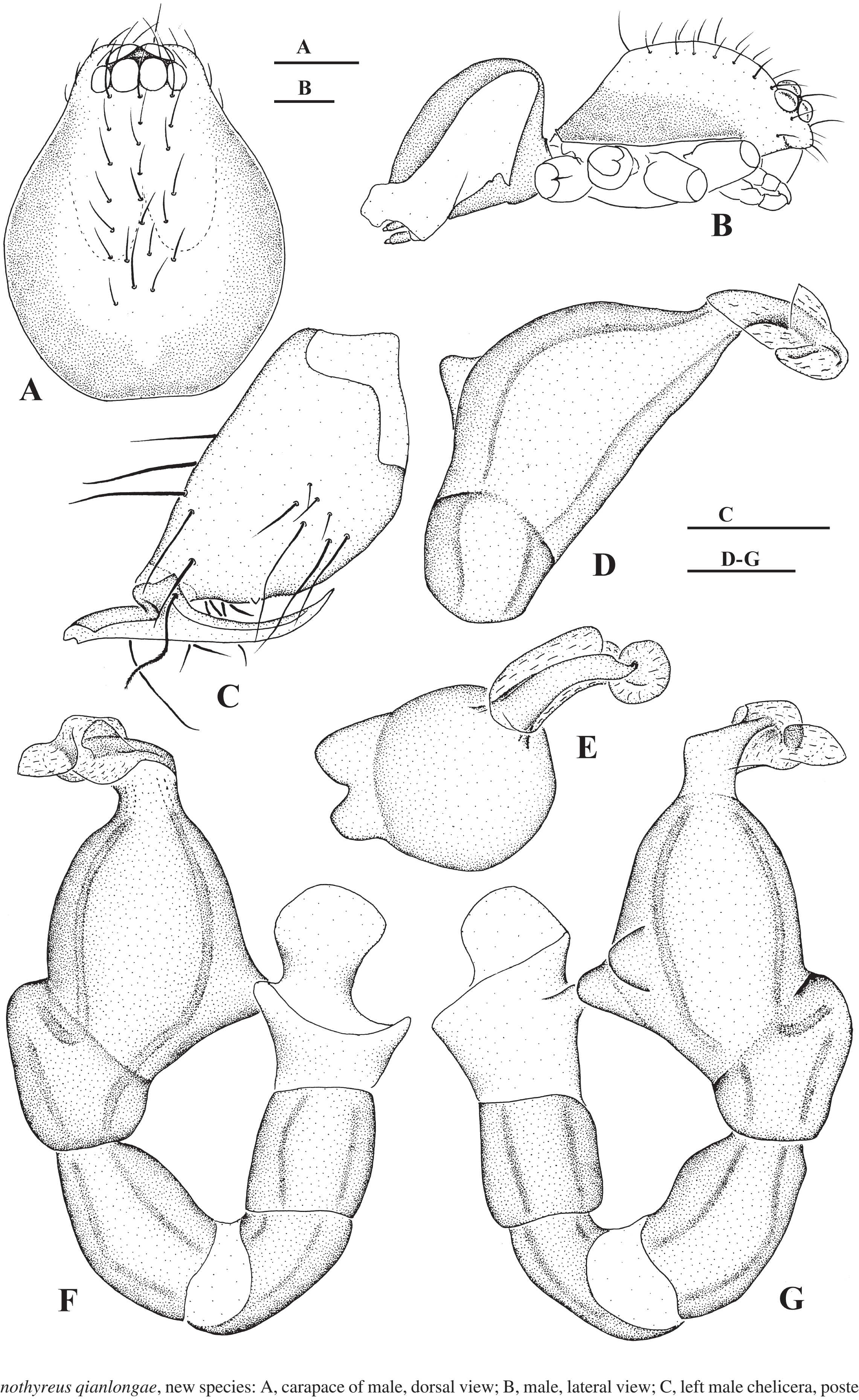

Fig. 4. *Ischnothyreus qianlongae*, new species: A, carapace of male, dorsal view; B, male, lateral view; C, left male chelicera, posterior view; D, left male palp, dorsal view; E, left male palpal bulb, apical view; F, left male palp, prolateral view; G, left male palp, retrolateral view. Scales: A, B = 0.2 mm, C = 0.1 mm, D-G = 0.05 mm.

Ischnothyreus peltifer (Simon, 1891)

Material examined. – 1 female (IZCAS), Mountain Wuzhishan (18°49'N 109°39'E), Wuzhishan City, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong,, 16 Apr.2005.

Remarks. – This species has been well described by Saaristo (2001).

Distribution. – New record for Hainan, although it appears to be widely distributed in southern China. According to Saaristo (2001), this species is easily transported by man and maybe widely distributed in the tropics.

Oonopinus Simon, 1893

Oonopinus corneus, new species
(Fig. 6A–D)

Holotype. – Male (IZCAS), cave without name (18°59'N 108°53'E), Yalong Village, Donghe Town, Dongfang City, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 31 Mar.2005.

Diagnosis. – The male of this new species (female unknown) is similar to *Oonopinus kilikus* Suman, 1965 from Hawaii and Seychelles (Saaristo, 2001), but can be distinguished by the cone-shaped protuberance on inner side of posterior

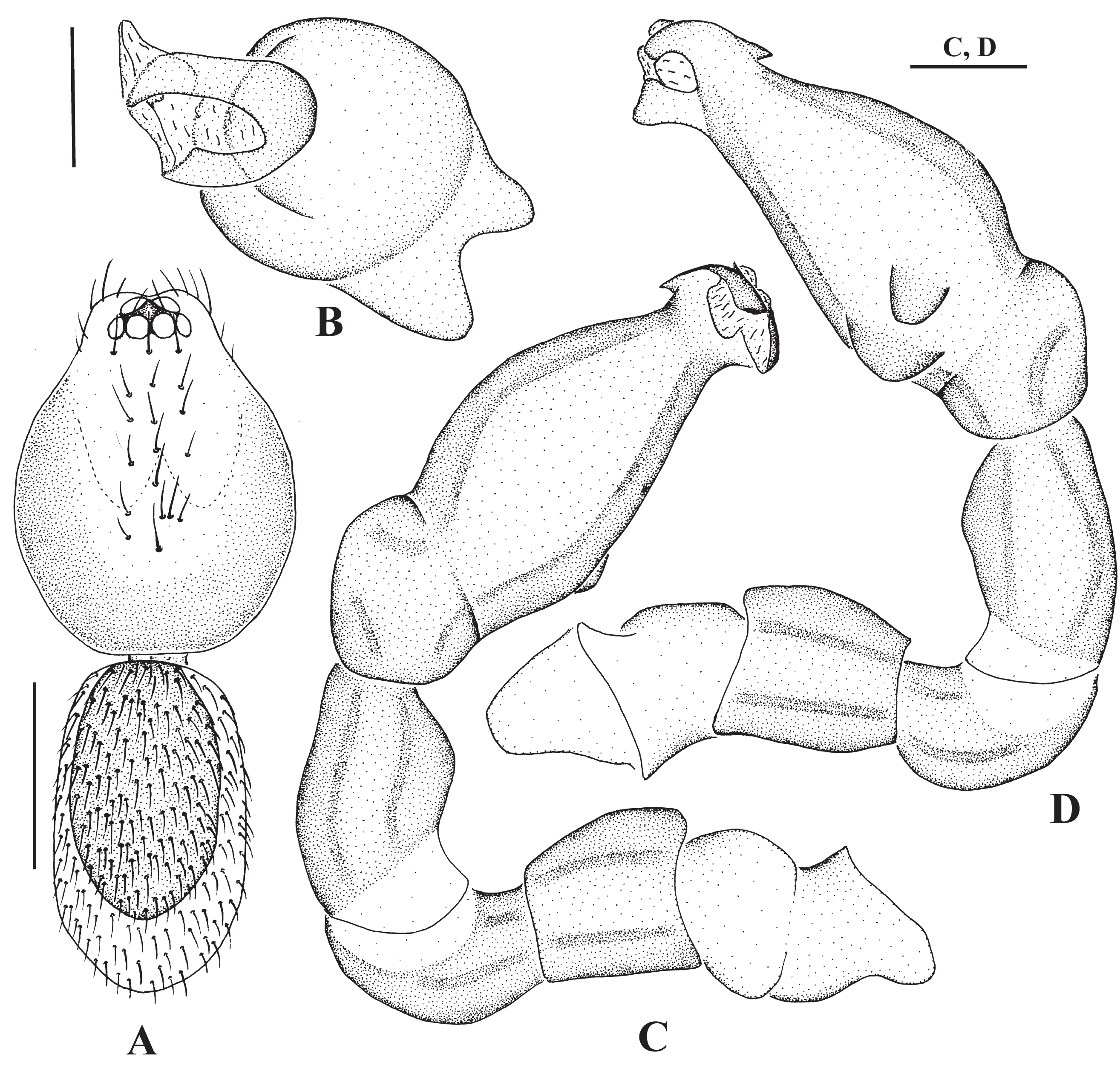

Fig. 5. *Ischnothyreus narutomii* (Nakatsudi, 1942): A, male, dorsal view; B, left male palpal bulb, apical view; C, left male palp, prolateral view; D, left male palp, retrolateral view. Scales: A = 0.5 mm, B-D = 0.05 mm.

surface of chelicerae, the higher height of clypeus, the dense hairs on dorsal and lateral surfaces of carapace, and the short, thick and upstanding hairs on cymbium of palp.

***Description.* – Male.** Body length 1.44; carapace 0.69 length, 0.48 width; abdomen 0.76 length, 0.50 width. Carapace, sternum pale, legs still paler, abdomen white. Carapace smooth, with densely hairs on dorsal and lateral surfaces. Eyes large, forming almost H-shaped figure. Height of clypeus nearly equally to diameter of ALE. Chelicerae with a cone-shaped protuberance on inner sides of posterior surface. Legs with some scattered spines on tibia and metatarsi of leg III and IV. Legs Measurements: I 1.67 (0.53, 0.25, 0.39, 0.33, 0.17); II 1.65 (0.50, 0.25, 0.39, 0.33, 0.18); III 1.32 (0.42, 0.20, 0.25, 0.28, 0.17); IV 1.99 (0.58, 0.27, 0.48, 0.47, 0.19). Leg formula: 4 > 1 = 2 > 3. Abdomen egg-shaped, without scutum. Colulus indiscernible.

Male palp white except dark brown embolus. Embolus long, thread-like, slightly curved, at base abruptly mesially. Narrow, highly translucent ‘conductor’ running pressed tightly against embolus and up to apex of it. No other accessories at base of embolus. Tibia, especially cymbium with short, thick and upstanding hairs.

Female. Unknown.

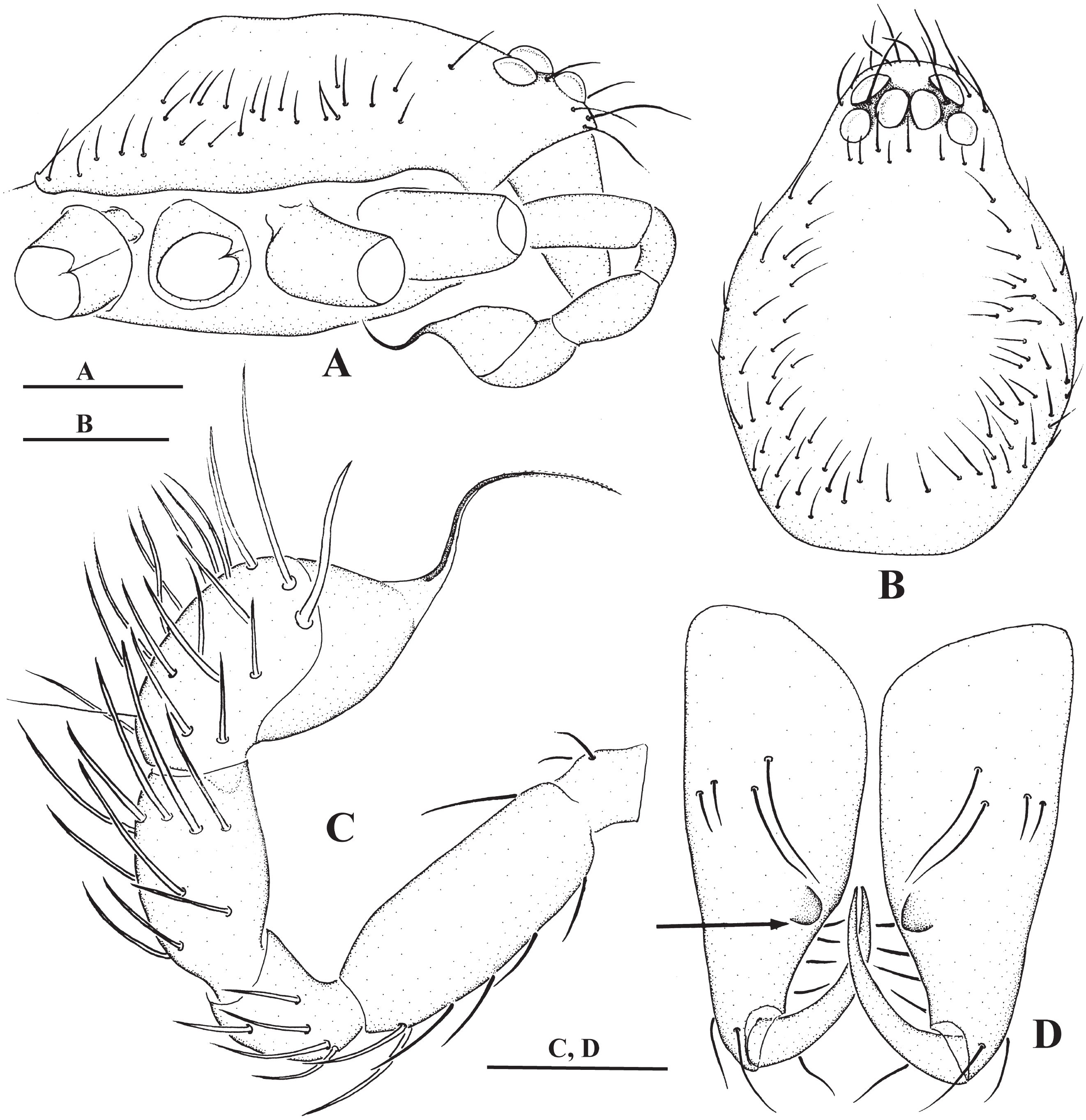

Fig. 6. *Oonopinus corneus*, new species: A, carapace of male, lateral view; B, carapace of male, dorsal view; C, left male palp, prolateral view; D, male chelicerae, posterior view (the arrow refers to the protuberance). Scales: A, B = 0.2 mm, C, D = 0.1 mm.

***Etymology.* –** Specific name from the Greece "*corn-* = horn-shaped", and refers to the cone-shaped protuberance on inner sides of posterior surface of chelicerae.

Opopaea Simon, 1891

Opopaea gibbifera, new species
(Fig. 7A–G)

***Holotype.* –** Male (IZCAS), Mountain Wuzhishan (18°49'N 109°39'E), Wuzhishan City, Hainan Island, China, coll. Y. Song, X. Han and Y. Tong, 16 Apr.2005.

***Paratypes.* –** 2 males, 9 females (IZCAS), same data as holotype.

***Diagnosis.* –** The new species is similar to *Opopaea cornuta* Yin & Wang, 1984 (Yin & Wang, 1984), in having cone-shaped tubercles on posterior corners of carapace, but can be distinguished in male by the bulge on posterior part of sternum between coxae IV, the pointed projection on anterior end of endites, the slender palpal femur, the relatively longer palpal patella, and the long extension on the border of bulbus and embolus; in female by the presence of a small triangular parmula in genital area; and in both sexes by the finely longitudinal striae on sides of carapace.

***Description.* – Male.** Reddish-brown species with yellowish-brown legs. Body length 1.39–1.42; carapace 0.61–0.67 length, 0.51–0.54 width; abdomen 0.84–0.89 length, 0.62–0.64 width. Posterior margin of carapace concaved; sides with finely longitudinal striae; dorsal area smooth with some mesially pointing hairs at lateral edges and pair of cone-shaped tubercles on posterior corners, one larger and one very small, both bearing up-standing long hairs. Eyes rather large, PLE relatively smaller; AME about half their diameter apart, touching posterior lateral eyes; posterior eyes in a slightly retro-curved row, touching each other. Height of clypeus about one and half diameters of AME. Sternum smooth, with distinguished radial furrows; posterior part between coxae IV strongly bulged, cone-shaped in lateral view. Anterior end of endites with a small, sharply pointed projection. Legs short, thick and spineless. Measurements of legs: I 1.26 (0.42, 0.22, 0.27, 0.22, 0.13); II 1.30 (0.44, 0.21, 0.27, 0.24, 0.14); III 1.10 (0.36, 0.17, 0.22, 0.21, 0.14); IV 1.54 (0.47, 0.24, 0.35, 0.29, 0.19). Leg formula: 4 > 1 = 2 > 3. Abdominal dorsal scutum oval-shaped, sparsely covered with short hairs. Lobes on anterolateral corners of petiolar tube distinct, ridges developed, but without forming a scutal cove; opercula small, oval-shaped. Sperm pore clearly discernible, transverse. Patella of palp significantly larger than cymbiobulbus; fenestra rather large; cymbiobulbus with a long extension on the border of bulbus and embolus.

Female. Body length 1.39–1.67; carapace 0.65–0.68 length, 0.52–0.56 width; abdomen 1.04–1.06 length, 0.76–0.79 width. Height of clypeus equal to or nearly shorter than one diameter of AME. Sternum without cone-shaped tubercle like in male. Endites without projections. Measurements of legs: I 1.33 (0.42, 0.24, 0.28, 0.25, 0.14); II 1.31 (0.42, 0.24, 0.27, 0.24, 0.14); III 1.09 (0.36, 0.18, 0.21, 0.21, 0.13); IV 1.57 (0.47, 0.24, 0.41, 0.28, 0.17). Postgynal depression of epigastric area shallow; parmula black, small.

***Etymology.* –** Specific name from the Latin "*gibbifer* = with tuber", in reference to the cone-shaped bulge on posterior part of sternum between coxae IV in male.

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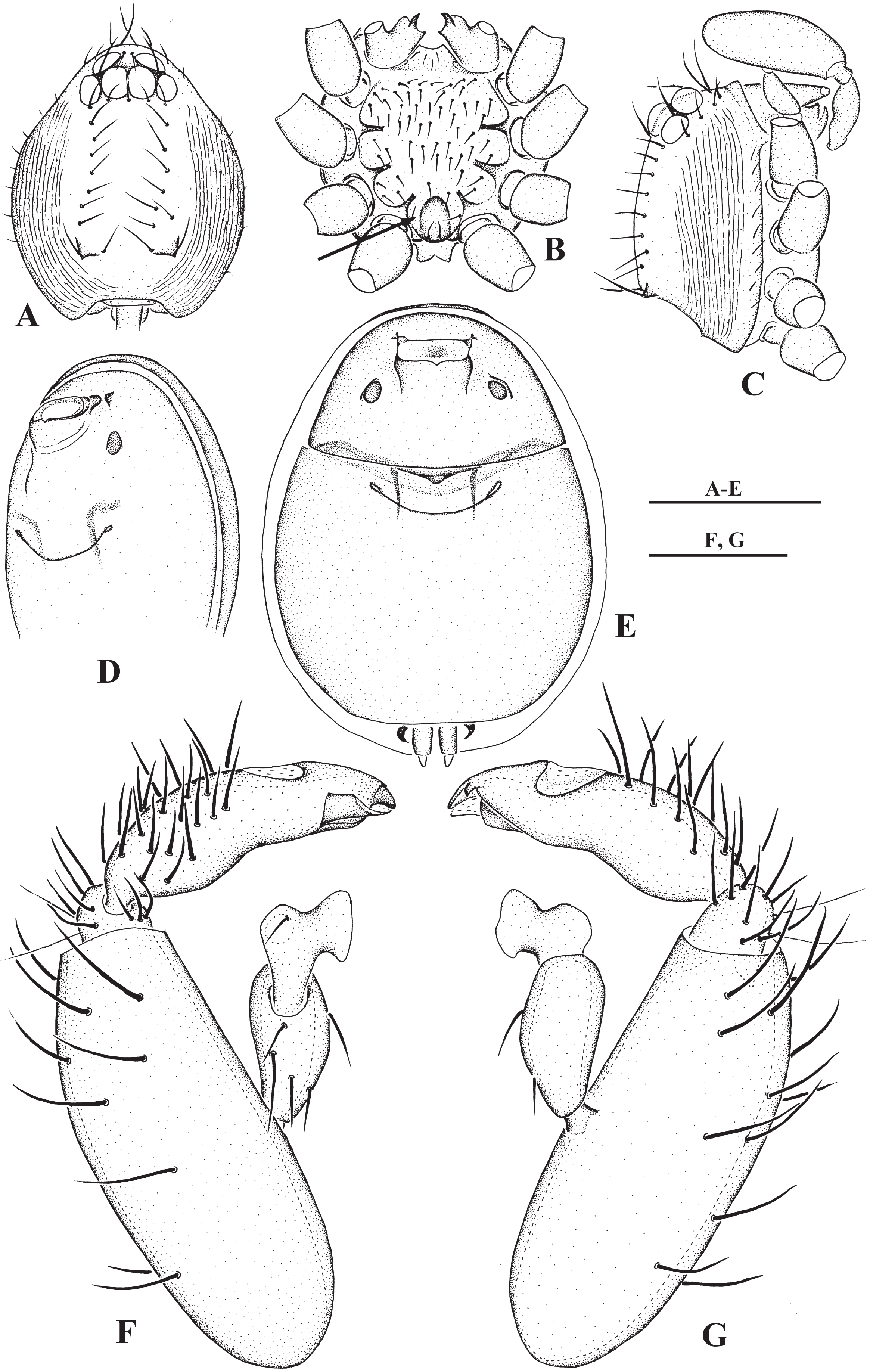

Fig. 7. *Opopaea gibbifera*, new species: A, carapace of male, dorsal view; B, sternum of male, ventral view (the arrow refers to the bulge between coxae IV); C, carapace of male, lateral view; D, anterior part of male abdomen, obliquely ventral view; E, abdomen of female, ventral view; F, left male palp, prolateral view; G, left male palp, retrolateral view. Scales: A-E = 0.4 mm, F, G = 0.1 mm.

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THE SPIDERS OF THE GENUS *TELEMA* (ARANEAE: TELEMIDAE) FROM HAINAN ISLAND, CHINA

Yanfeng Tong
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China.

Shuqiang Li
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China
Email: lisq@ioz.ac.cn (Corresponding author)

ABSTRACT. – Four new species of the genus *Telema*, collected from Hainan Island, China, are diagnosed, described and illustrated: *Telema bella* (male, female), *T. breviseta* (male, female), *T. dengi* (male, female) and *T. spina* (male). *T. spina*, was collected from Mountain Wuzhishan, and the other three species were from caves. The type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

KEY WORDS. – Taxonomy, Telemidae, new species, cave, endemic species.

INTRODUCTION

The spiders of family Telemidae are small (usually < 2 mm), three-clawed, ecribellate haplogyne spiders. They can be distinguished from other spiders by a transverse zigzag ridge anterodorsally on abdomen and, in females, a dorsal brush of distinctive short, stout and abruptly tapered macrosetae on the palpal tarsus. They are usually found in moist conditions, for example, in leaf litter, under rocks, and in caves (Song et al., 1999). Telemidae is a small family with 7 genera and 22 recognized species (Platnick, 2007), and widely distributed from tropical Africa, Europe, East and Southeast Asia to North and Central America (Brignoli, 1977).

The genus *Telema* was erected by Simon in 1882, with *T. tenella* as the type species. To date, only six species have been described under *Telema* (Gertsch, 1973; Song & Zhu, 1994; Wang & Ran, 1998; Yaginuma, 1972, 1973, 1974; Zhu & Chen, 2002) including *T. tenella* Simon, 1882, from Spain and France, *T. dongbei* Wang & Ran, 1998, and *T. liangxi* Zhu & Chen, 2002, from Guizhou, China, *T. mayana* Gertsch, 1973, from Guatemala, *T. nipponica* (Yaginuma, 1972) from Japan, and *T. wunderlichi* Song & Zhu, 1994, from Hunan, China. Whether the East Asian telemids actually belong to the genus *Telema* still await further testing (Wang & Ran, 1998). No *Telema* species has been reported from Hainan Province, a tropical island.

Hainan Island is situated at the southernmost part of China and has an area of 34,000 sq km, an average temperature between 22ºC and 26ºC and an annual rainfall of 1,600 to 2,000 mm. More than 4,000 species of plants are recorded from Hainan Island, which account for 15% of the country's total, and among them 600 are endemic to the island (Anonymous, 2006a). Meanwhile, 344 species of birds and 82 species mammals dwell on Hainan, including gibbons (*Hylobates concolor hainanus*) and Hainan Eld's Deer (*Cervus eldi hainanus*), of which 11 species (or subspecies) birds and 16 mammals are endemic to Hainan (Anonymous, 2006b). The high ratio of endemic species is thought to be a result of active speciation on the island.

During expeditions to Hainan, some telemids specimens were collected. Four new species are recognized and accommodated to genus *Telema* in this paper.

MATERIAL AND METHODS

Specimens were examined using an Olympus SZX12 stereomicroscope. Further details were studied under an Olympus® BX51 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Photos were made with an Olympus® digital camera (C7070, 7.1 megapixels) mounted on an Olympus® SZX12 stereomicroscope. Male palps and female genitalia were examined and illustrated after they were dissected from the spiders' bodies. Vulvae of female were cleared in lactic acid.

All measurements were measured using an Olympus® BX51 compound microscope and given in millimeters (mm). Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus).

The abbreviations used are: AM, anterior median eyes and AL, anterior lateral eyes. The specimens studied here are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

TAXONOMY

Telema Simon, 1882

Type species. – *Telema tenella* Simon, 1882: 205.

Telema bella, new species
(Figs. 1A, 2A–G, 6)

Holotype. – Male (IZCAS), Mihou Cave (18°56'N 109°04'E), Datian National Natural Reserve, Dongfang City, Hainan Island, China, coll. Y. Song, X. Han, Y. Tong and G. Deng, 28 Mar.2005.

Paratypes. – 22 females, 28 males (IZCAS), same data as holotype.

Diagnosis. – The new species is similar to *T. dongbei* and *T. liangxi* but can be distinguished from *T. dongbei* by the presence of eyes, the distinctive cheliceral promarginal teeth and the shape of spermathecae of female, from *T. liangxi* by the presence of eyes, the presence of cheliceral teeth, the distinctive shape of palpal bulb of males, and the shape of spermathecae of female.

Description. – **Males**. Total length 0.98–1.07. Carapace 0.48–0.51 long, 0.39–0.47 wide; abdomen 0.53–0.62 long, 0.41–0.53 wide. Carapace, legs, sternum, labium, endites and chelicerae yellow. Abdomen usually blue, a few specimens gray. Carapace with pair of setae at clypeus behind eyes, and at middle. Six eyes, anterior row of four eyes nearly straight, AM close together, nearly touching, separated from AL by 2/3 diameter of AL, lateral eyes contiguous. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles. Legs with dorsal spine at distal end of patella as well as at middle of tibia. Leg measurements: I 2.92 (0.88, 0.16, 0.90, 0.54, 0.44); II 2.51 (0.77, 0.16, 0.75, 0.44, 0.39); III 1.85 (0.58, 0.15, 0.49, 0.33, 0.30); IV 2.23 (0.72, 0.16, 0.60, 0.39, 0.36). Leg formula: I-II-IV-III. Palp with prolateral cymbial apophysis; bulb oval with one simple apophysis.

Females. Total length 1.05–1.10. Carapace 0.47–0.52 long, 0.42–0.48 wide; abdomen 0.59–0.65 long, 0.48–0.55 wide. Eyes and chelicerae as in male. Leg measurements: I 2.79 (0.85, 0.17, 0.85, 0.47, 0.45); II 2.46 (0.75, 0.16, 0.72, 0.44, 0.39); III 1.84 (0.57, 0.14, 0.49, 0.32, 0.32); IV 2.28 (0.72,

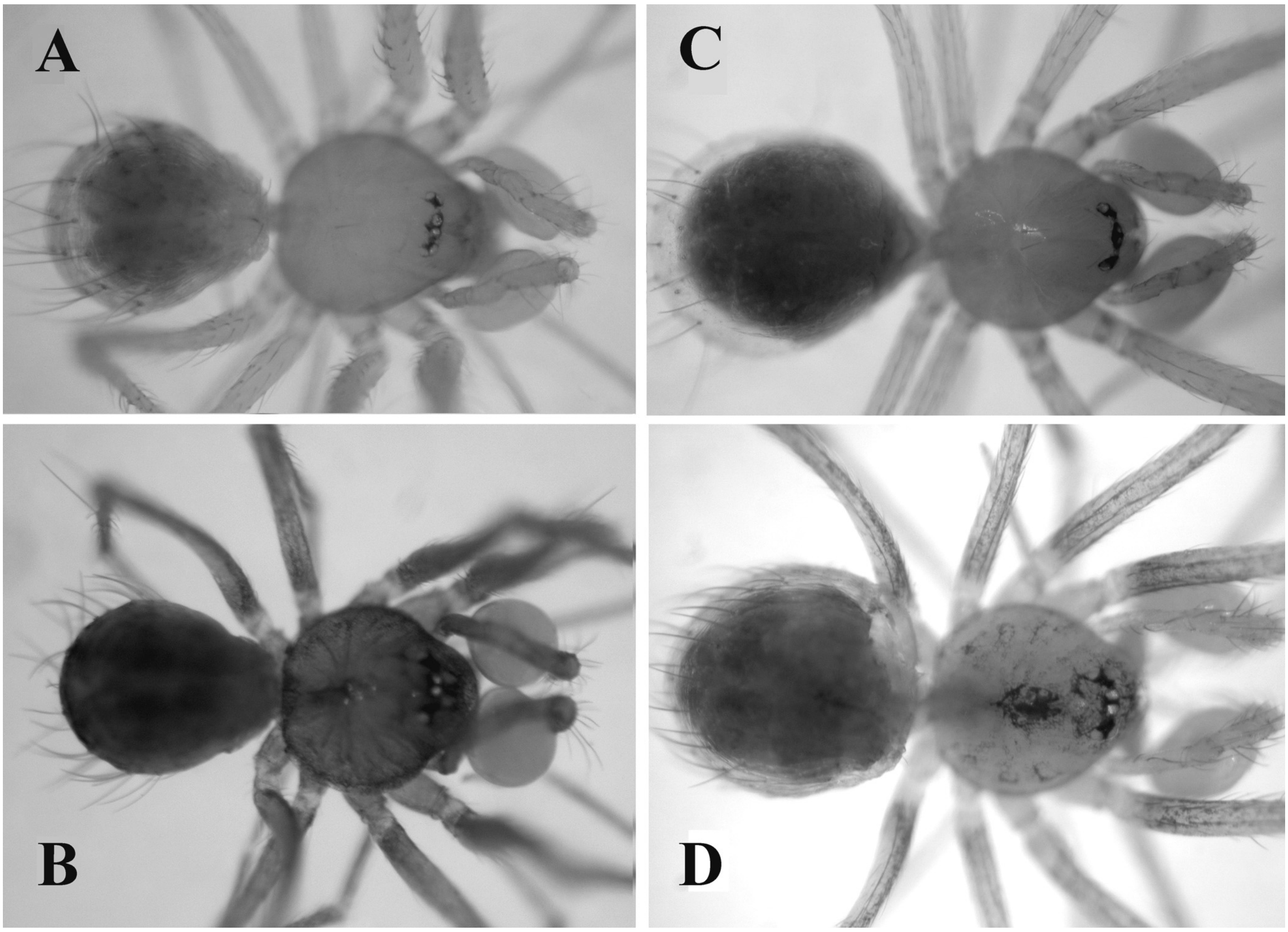

Fig. 1. Dorsal views of *Telema* spiders: A, *T. bella*, new species, dorsal view; B, *T. breviseta*, new species, dorsal view; C, *T. dengi*, new species, dorsal view; D, *T. spina*, new species, dorsal view.

0.15, 0.62, 0.44, 0.35). Leg formula: I-II-IV-III. Epigynum with one row of hairs on epigynal plate. Spermatheca narrow, long, with distal end curved posteriorly.

Etymology. **–** The specific name is from Latin "*bella* = beautiful", indicates the beautiful color of abdomen of the species.

Telema breviseta, new species

(Figs. 1B, 3A–I, 6)

Holotype. **–** Male (IZCAS), Yalong Cave (18°59'N 108°53'E), Yalong Village, Donghe Town, Dongfang City, Hainan Island, China, coll. Y. Song, X. Han, G. Deng and Y. Tong, 1 Apr.2005.

Paratypes. **–** 8 females, 6 males (IZCAS), same data as holotype; 2 females, 1 male (IZCAS), a cave (not named) (19°01'N 109°04'E), Nanlang village, Donghe town, Dongfang city, Hainan Island, China, same collectors as holotype, 30 Mar.2005.

Diagnosis. **–** The new species is similar to *T. nipponica* (Yaginuma, 1972) and can be distinguished by the presence of a small prolateral cymbial apophysis, the distinctive shape of papal bulb of males, the presence of a row of short setae on anteroventral surface of femur I, the shape of sternum, and the presence of two large promarginal teeth on fang furrow.

Description. **– Males.** Total length 0.98–1.09. Carapace 0.51–0.53 long, 0.47–0.50 wide; abdomen 0.58–0.61 long, 0.44–0.46 wide. Carapace yellowish brown with brownish margin; at center a dark suffused area from which ill-defined striae diverge; area before AM with two light yellow rings, indistinct in some specimens. Legs, labium, endites and chelicerae yellowish brown. Sternum dark brown. Abdomen gray, blackened on posterior area; spinnerets light yellow, colulus blackened. Carapace with pair of setae at clypeus, behind eyes, and at middle. Six eyes, anterior row of four eyes nearly straight, AM close together, nearly touching, separated from AL by 1/2 diameter of AL, lateral eyes contiguous. Promargin of fang furrow with two large tooth, and three small denticles, retromargin with four barely visible denticles. Legs with dorsal spine at distal end of patella as well as at middle of tibia. Leg measurements: I 2.90 (0.86, 0.18, 0.87, 0.56, 0.43); II 2.55 (0.77, 0.17, 0.74, 0.46, 0.41); III 1.93 (0.62, 0.17, 0.48, 0.34, 0.32); IV 2.44 (0.77, 0.17, 0.66, 0.47, 0.37). Leg formula: I-II-IV-III. Femur I with characteristic row of short setae on anteroventral surface (also present in femur II on specimens of Nanlang). Palp with prolateral slender cymbial apophysis; bulb oval with one simple apophysis.

Females. Total length 1.05–1.12. Carapace 0.51–0.58 long, 0.48–0.54 wide; abdomen 0.62–0.67 long, 0.47–0.51 wide. Eyes and chelicerae as in male. Leg measurements: I 2.84 (0.85, 0.18, 0.82, 0.52, 0.47); II 2.46 (0.76, 0.17, 0.69, 0.45, 0.39); III 1.88 (0.57, 0.17, 0.48, 0.34, 0.32); IV 2.41 (0.76, 0.17, 0.66, 0.45, 0.37). Leg formula: I-II-IV-III. Femur I without special setae. Epigynum with sparse hairs on epigynal plate, and another row behind epigastric furrow. Spermatheca strong, with distal end swollen and curved downwards.

Etymology. **–** The specific name is from Latin "*brevi* = short, and *seta* = bristle", and refers to the row of short setae on anteroventral surface of femur I.

Telema dengi, new species

(Figs. 1C, 4A–H, 6)

Holotype. **–** Male (IZCAS), Luobi Cave (18°20'N 109°33'E), Lizhigou Town, Sanya City, Hainan Island, China, coll. X. Han, Y. Song, G. Deng and Y. Tong, 10–11 Apr.2005.

Paratypes. **–** 26 females, 23 males (IZCAS), same data as holotype; 4 females, 14 males (IZCAS), a cave (not named), Lizhigou Town, Sanya City, Hainan Island, China, same collectors as holotype, 11 Apr.2005.

Diagnosis. **–** This new species is similar to *T. dongbei* and can be distinguished from *T. dongbei* and all the congeneric species by the presence of eyes, the distinctive shape of palpal bulb of males, and the shape of spermathecae of females.

Description. **– Males.** Total length 1.20–1.49. Carapace 0.60–0.70 long, 0.56–0.62 wide; abdomen 0.66–0.82 long, 0.60–0.73 wide. Carapace, legs, labium, endites and chelicerae yellow; sternum yellow, with margins dark colour. Abdomen grayish; spinnerets and colulus white. Carapace without patterns, with pair of setae at clypeus, behind eyes, and at middle. Six eyes, anterior row of four eyes nearly straight, AM close together, nearly touching, separated from AL by one diameter of AL, lateral eyes contiguous. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles, in which the one near base of fang larger. Legs with dorsal spine at distal end of patella as well as at middle of tibia. Leg measurements: I 4.58 (1.41, 0.21, 1.44, 0.90, 0.62); II 3.97 (1.26, 0.21, 1.22, 0.75, 0.53); III 2.81 (0.93, 0.19, 0.72, 0.54, 0.43); IV 3.50 (1.15, 0.19, 0.97, 0.70, 0.49). Leg formula: I-II-IV-III. Palp with prolateral cymbial apophysis; bulb oval with one relatively complex apophysis.

Females. Total length 1.26–1.52. Carapace 0.70–0.73 long, 0.61–0.63 wide; abdomen 0.65–0.83 long, 0.63–0.76 wide. Eyes and chelicerae as in male. Leg measurements: I 4.95 (1.57, 0.23, 1.59, 0.93, 0.63); II 4.27 (1.41, 0.22, 1.32, 0.79, 0.53); III 3.12 (1.03, 0.21, 0.87, 0.56, 0.45); IV 3.84 (1.29, 0.21, 1.11, 0.71, 0.52). Leg formula: I-II-IV-III. Epigynum with one row of hairs on epigynal plate, and another row behind epigastric furrow. Spermatheca narrow basally and strongly swollen at distal end.

Etymology. **–** The species is named after the collector Mr. Gaoyun Deng, a colleague at Hainan Normal University, China.

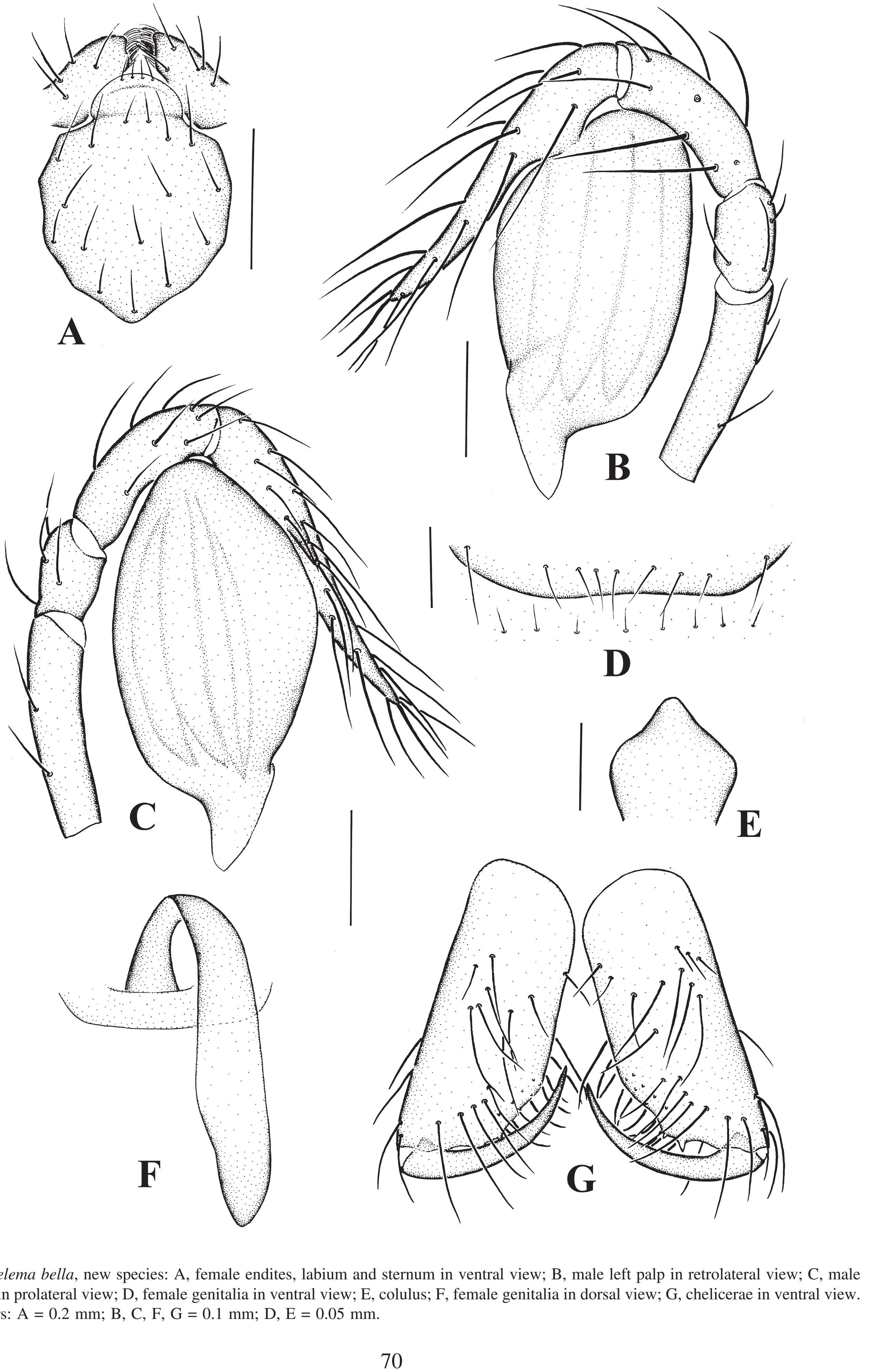

Fig. 2. *Telema bella*, new species: A, female endites, labium and sternum in ventral view; B, male left palp in retrolateral view; C, male left palp in prolateral view; D, female genitalia in ventral view; E, colulus; F, female genitalia in dorsal view; G, chelicerae in ventral view. Scale bars: A = 0.2 mm; B, C, F, G = 0.1 mm; D, E = 0.05 mm.

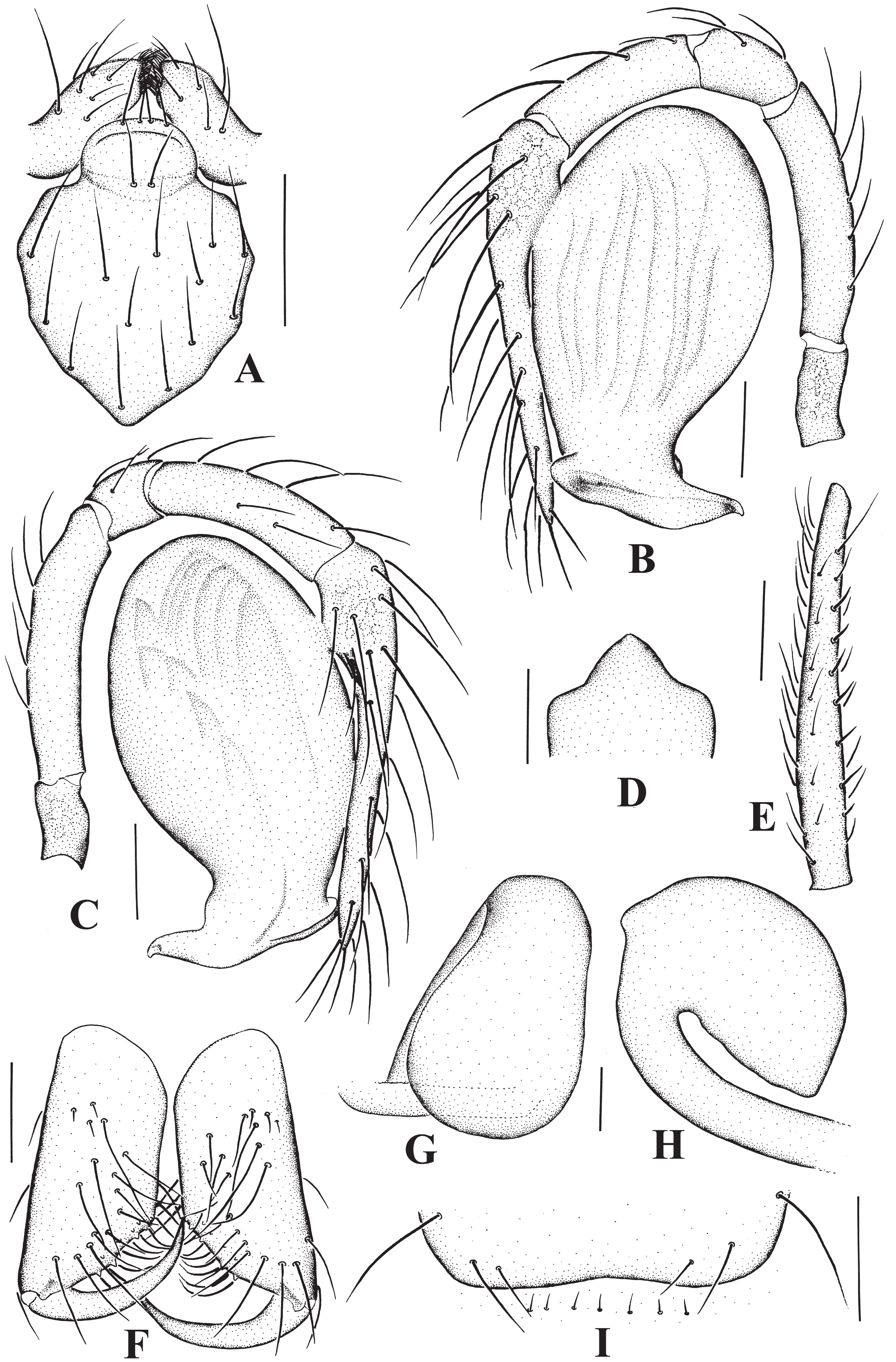

Fig. 3. *Telema breviseta*, new species: A, female endites, labium and sternum in ventral view; B, male left palp in retrolateral view; C, male left palp in prolateral view; D, colulus; E, male femur I in prolateral view; F, chelicerae in ventral view; G, female genitalia in dorsal view; H, spermatheca in lateral view; I, female genitalia in ventral view. Scale bars: A, E = 0.2 mm; B, C, F–I = 0.1 mm, D = 0.05 mm.

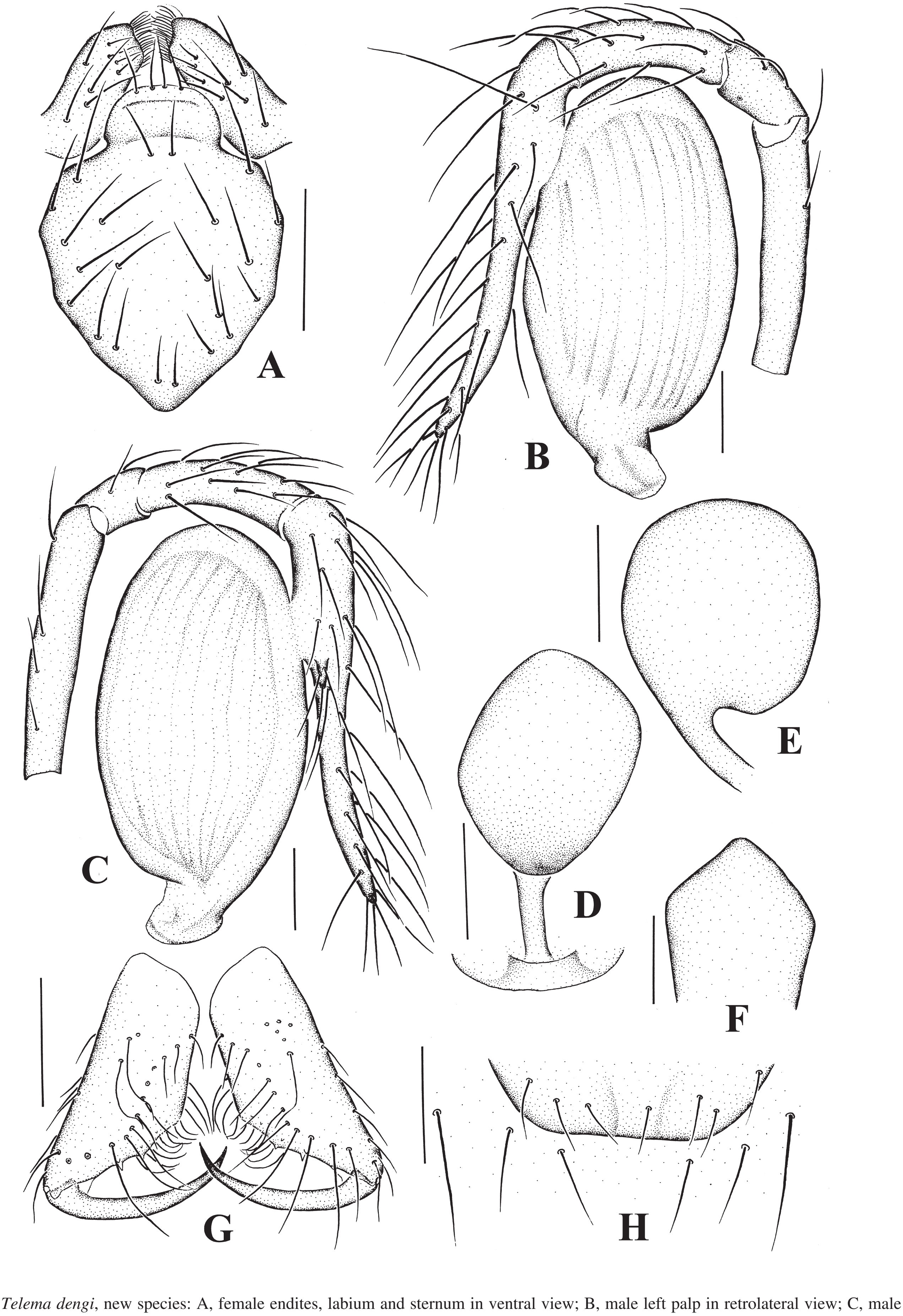

Fig. 4. *Telema dengi*, new species: A, female endites, labium and sternum in ventral view; B, male left palp in retrolateral view; C, male left palp in prolateral view; D, female genitalia in dorsal view; E, Spermatheca in lateral view; F, colulus; G, chelicerae in ventral view; H, female genitalia in ventral view. Scale bars: A, D, E, G, H = 0.2 mm; B, C = 0.1 mm; F = 0.05 mm.

Telema spina, new species

(Figs. 1D, 5A–C, 6)

Holotype. – Male (IZCAS), Mountain Wuzhishan (18°49'N 109°39'E), Wuzhishan City, Hainan Island, China, coll. Y. Song, 16 Apr.2005.

Diagnosis. – The new species is similar to the male of *T. dongbei* Wang & Ran, 1998, and can be distinguished by the distinctive straight bulb apophysis (the angle of bulbal apophysis to the bulb is smaller than 90° in *T. dongbei*), the strong spine present on distal end of palpal tarsus, the presence of eyes, the presence of dark area on carapace, the distinctive cheliceral promarginal teeth, the distinctive shorter legs (the longest legs of *T. dongbei* are more than twice those of the counterpart of the new species, the shortest legs of *T. dongbei* are distinctly longer than the longest legs of the new species), and the smaller body size.

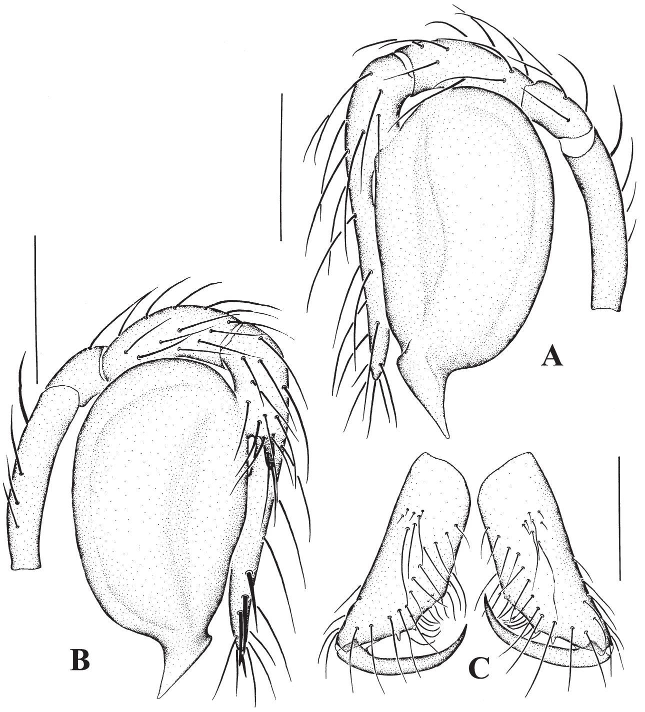

Fig.5. *Telema spina*, new species: A, male left palp in retrolateral view; B, male left palp in prolateral view; C, chelicerae in ventral view. Scale bars: 0.2 mm.

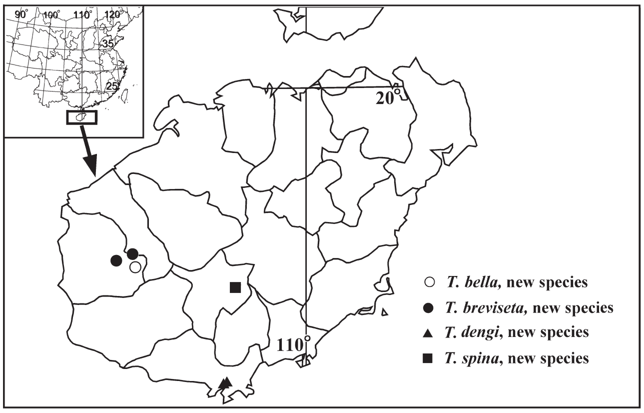

Fig. 6. Collection localities of *Telema* spiders in Hainan, China.

Description. – **Males.** Total length 1.22. Carapace 0.56 long, 0.49 wide; abdomen 0.66 long, 0.55 wide. Carapace yellow, with dark patterns. Middle area of clypeus, area behind eyes and center of carapace blackened. Legs, labium, endites and chelicerae yellowish brown. Sternum blackish brown. Abdomen gray; spinnerets yellow, colulus brown. Carapace with pair of setae at clypeus, and behind eyes. Six eyes, anterior row of four eyes nearly straight, AM close together, nearly touching, separated from AL by 1/3 diameter of AL, lateral eyes contiguous. Promargin of fang furrow with one large tooth, one relatively small tooth and three barely visible granulous denticles, retromargin with four barely visible denticles. Legs with dorsal spine at distal end of patella as well as at middle of tibia. Leg measurements: I 3.13 (0.92, 0.18, 0.93, 0.59, 0.51); II 2.70 (0.81, 0.18, 0.77, 0.49, 0.45); III 1.93 (0.56, 0.17, 0.51, 0.36, 0.33); IV 2.50 (0.80, 0.17, 0.67, 0.47, 0.39). Leg formula: I-II-IV-III. Palp with prolateral cymbial apophysis; palpal tarsus with 3-4 strong spines on distal end; bulb oval with one simple apophysis.

Female. Unknown.

Etymology. – The specific name is from Latin "*spina*", refers to the strong spine present on distal end of palpal tarsus.

ACKNOWLEDGMENTS

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Six new cave-dwelling species of *Leptoneta* (Arachnida, Araneae, Leptonetidae) from Beijing and adjacent regions, China

Yanfeng TONG
Shuqiang LI
Institute of Zoology, Chinese Academy of Sciences,
Beijing 100101 (China)
lisq@ioz.ac.cn

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ABSTRACT

Six new leptonetid spiders of the genus *Leptoneta* from caves of Beijing, Hebei, and Henan, China are diagnosed, described and illustrated. They are: *L. cornea* n. sp., *L. exilocula* n. sp., *L. foliiformis* n. sp., *L. setulifera* n. sp., *L. tianxinensis* n. sp. and *L. wangae* n. sp. All the new species described in this study can be distinguished from other congener species by the spines on male palpal femur and tibia, the number of cheliceral teeth and the details of genitalia of both sexes. An identification key to currently known 25 Chinese *Leptoneta* species, except for *L. arquata* Song & Kim, 1991, is provided.

KEY WORDS
Arachnida,
Araneae,
Leptonetidae,
Leptoneta,
caves,
China,
new species.

RÉSUMÉ

Six nouvelles espèces de Leptoneta *(Arachnida, Araneae, Leptonetidae) de Pékin et ses environs, Chine.*

Six espèces d'araignées Leptonetidae du *Leptoneta* sont nouvellement décrites et illustrées de grottes de Pékin, Hebei et Henan en Chine. Il s'agit de : *L. cornea* n. sp., *L. exilocula* n. sp., *L. foliiformis* n. sp., *L. setulifera* n. sp., *L. tianxinensis* n. sp. et *L. wangae* n. sp. Ces nouvelles espèces se distinguent de leurs congénères par les épines du fémur palpal et du tibia mâles, le nombre de dents des chélicères et des détails des génitalia des deux sexes. Une clé d'identification des 25 espèces de *Leptoneta* actuellement connue de Chine, excepté *L. arquata* Song & Kim, 1991, est incluse.

MOTS CLÉS
Arachnida,
Araneae,
Leptonetidae,
Leptoneta,
grottes,
Chine,
espèces nouvelles.

INTRODUCTION

Leptonetidae are small (1.0-3.0 mm), 3-clawed, haplogyne spiders, characterized by a distinctive 6-eyed pattern with the PME separated from the strongly recurved ALE and PLE; rarely with eyes continuous, or degenerate to four, two or even none (Song *et al.* 1999). They are cryptozoic spiders, construct irregular sheet webs in damp situations, under rocks, in leaf litter and may be common in caves (Yaginuma 1986). A total of 14 valid genera and 200 species have been recorded worldwide, of which 71 species belonging to the genus *Leptoneta* (Platnick 2007). To date, only the genus *Leptoneta* has been reported in China. Most of the recorded 19 Chinese species occur in caves or under leaf litter, showing a strong endemism (Chen *et al.* 1982, 1984, 1986, 2000; Xu & Song 1983; Yin *et al.* 1984; Song & Xu 1986; Song & Kim 1991; Chen & Zhang 1993; Zhu & Tso 2002). However, all the recorded species were from southern China, the most northern record was in Anhui Province (Xu & Song 1983; Song & Xu 1986).

This paper describes and illustrates six new leptonetids species from northern China, five of them (*Leptoneta cornea* n. sp., *L. exilocula* n. sp., *L. foliiformis* n. sp., *L. setulifera* n. sp. and *L. wangae* n. sp.) were collected from caves in Beijing, and one species, *L. tianxinensis* n. sp. was collected from cave in Henan Province. The lengthening of legs is usually considered as an adaptation to the cave environment, which is embodied in the present six species. *Leptoneta foliiformis* n. sp., which was collected from twilight zones of two different caves that are away from each other by more than 100 km, has the shortest legs, seems to be a troglophile, and may be also found in suitable habitats outside caves. Of the other five species, *L. exilocula* n. sp. and *L. wangae* n. sp., with longer legs and reduced eyes, are the most troglomorphic species.

MATERIAL AND METHODS

Specimens were collected from caves of Beijing, Hebei and Henan. A total of 89 caves are known in Beijing, and the authors have studied 75 of them. *Leptoneta* spiders are found in six caves in Beijing, one in Heibei, and one in Henan.

Specimens were examined using an Olympus SZX12 stereomicroscope. Further details were studied under an Olympus BX51 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Male palps and female genitalia were examined and illustrated after they were dissected from the spider's bodies. Vulvae of female were cleared in lactic acid.

All measurements were measured using an Olympus BX51 compound microscope and are given in mm. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Palp measurements are shown as: total length (femur, patella, tibia, –, tarsus). Legs segments were measured on their dorsal side.

The following abbreviations are used: ALE, PME, PLE for anterior lateral, posterior median and posterior lateral eyes; AER, PER for anterior and posterior eye rows (composed of ALE and PLE + PME, respectively); C, E, M for conductor, embolus and median apophysis of male palpal organ; IZCAS for Institute of Zoology, Chinese Academy of Sciences, Beijing; MNHN for Muséum national d'Histoire naturelle, Paris.

SYSTEMATICS

Family LEPTONETIDAE Simon, 1890

Genus *Leptoneta* Simon, 1872

Leptoneta Simon, 1872: 479.

TYPE SPECIES. — *Leptoneta convexa* Simon, 1872.

DIAGNOSIS. — Small sized species (body length 1.0-3.0 mm). Carapace usually with indistinct median groove. Six eyes with the PME separated from the strongly recurved ALE and PLE; rarely with eyes continuous, or degenerate to four, two or even none. Chelicerae with teeth on both promargin and retromargin. Legs slender, Leg formula usually I-IV-II-III. Male palp usually with strong spines on ventral surface of femur, and/or with strong spines or apophysis on tibia; bulb simple. Female with a pair of spermathecae; atrium oval to triangular in shape.

DISTRIBUTION. — Algeria, East Asia (China, Korea), North America (Mexico, USA), Western Europe (France, Italy, Portugal, Spain).

KEY TO CHINESE *LEPTONETA* SIMON, 1872
(*L. arquata* Song & Kim, 1991, only known from female, is not included)

1. Male palpal femur with strong spines ventrally, at least on distal half 2
— Male palpal femur without strong spines ventrally 10

2. Male palpal tibia without distal special spines or apophysis 3
— Male palpal tibia with distal special spines or apophysis 5

3. Male palpal patella without short stout spines on retrolateral surface; median apophysis leaf-shaped .... *L. foliiformis* n. sp.
— Male palpal patella with 3 short stout spines on retrolateral surface; median apophysis not leaf-shaped 4

4. Chelicerae with 10 teeth on promargin; abdomen with brown patches dorsally .... *L. maculosa*
— Chelicerae with 8 teeth on promargin; abdomen without patches dorsally ... *L. tunxiensis*

5. Male palpal tibia with row of long spines dorsally and ventrally, and 2 apophyses distally, one leaf-like, the other one hook-shaped .... *L. changlini*
— Male palpal tibia without above mentioned characters 6

6. Eyes absent; male palpal tibia with a short stick-shaped apophysis distally, with a hair on the tip of the apophysis .... *L. anocellata*
— Eyes present; male palpal tibia without above mentioned apophysis 7

7. Male palpal bulb with a horn-shaped projection ventrally .... *L. cornea* n. sp.
— Male palpal bulb without horn-shaped projection ventrally 8

8. Carapace with hairs on lateral margins .... *L. setulifera* n. sp.
— Carapace without hairs on lateral margins 9

9. Male palpal tibia with 1 strong short spine disto-laterally .... *L. exilocula* n. sp.
— Male palpal tibia with 2 strong short spines disto-laterally .... *L. wangae* n. sp.

10. Male palpal tibia with strong spines or apophysis distally 11
— Male palpal tibia without strong spines or apophysis distally 17

11. Male palpal tibia with 1 distally branched apophysis 12
— Male palpal tibia if with 1 apophysis, then not branched 13

12. The apophysis on male palpal tibia thick at base, just like prolongation of the tibia; with 2 long hairs and many short hairs on the apophysis; male chelicerae with 4 teeth on retromargin .... *L. huanglongensis*
— The apophysis on male palpal tibia not thick at base; without hairs on the apophysis; male chelicerae with 6 teeth on retromargin .... *L. lingqiensis*

13. Male palpal tibia with a single long straight apophysis distally 14
— Male palpal tibia with a hook-shaped apophysis distally 15

14. Apophysis on male palpal tibia spine-shaped; chelicerae with 8 teeth on promargin and 5 teeth on retromargin .... *L. taiwanensis*
— Apophysis on male palpal tibia finger-shaped; chelicerae with 5 teeth on promargin and without retromarginal teeth .... *L. monodactyla*

15. Eyes absent; male femur I incrassated on basal half part, distal half with dense long hairs ventrally .... *L. taizhensis*
— Eyes present; male femur I normal 16

16. Male palpal tibia with 1 single hook-shaped apophysis distally; cymbium distally branched .... *L. huisunica*
— Male palpal tibia with 2 apophyses distally, one hook-shaped and the other one spine-shaped; cymbium not distally branched .... *L. nigrabdomina*

17. Male palpal tibia with strong spines ventrally on basal half 18
— Male palpal tibia without strong spines ventrally on basal half 23

18. Male palpal tibia with 1 strong spine proximo-ventrally 19
— Male palpal tibia with 3 strong spines on basal half ventrally 21

19. Eyes reduced; chelicerae with 9 teeth on promargin, without teeth on retromargin ... *L. xui*
— Eyes present; chelicerae with 7 teeth on promargin and 3 or 4 teeth on retromargin ... 20

20. With a long slender spine near the strong spine on ventral surface of male palpal tibia; abdomen without distinct patches .... *L. tianxinensis* n. sp.
— Only with a single strong spine on ventral surface of male palpal tibia; abdomen with some blackish-brown transverse stripes .... *L. unispinosa*

21. Male palpal tibia with 1-3 long hairs proximo-ventrally and 2 long hairs disto-ventrally in addition to the 3 strong spines 22
— Male palpal tibia without long hairs in addition to the 3 strong spines ...... *L. trispinosa*

22. Chelicerae with 9 teeth on promargin and 6 teeth on retromargin in male, but with 8 teeth on promargin and 4 teeth on retromargin in female; sperm duct of female not twisted .... *L. hangzhouensis*
— Chelicerae with 8 teeth on promargin and 5 teeth on retromargin in both sexes; sperm duct of female twisted .... *L. microdonta*

23. With 2 eyes; male palpal femur with spine-like hairs ventrally and dorsally, palpal tibia with 2 long hairs ventrally; male cymbium without strong spine on the tip; female with slightly twisted sperm duct .... *L. miaoshiensis*
— With 6 eyes; male palpal femur and tibia without above mentioned hairs; male cymbium with a strong spine on the tip; female with strongly twisted sperm duct .... *L. falcata*

TAXONOMIC DISCUSSION

Leptoneta is a genus described from Western Europe (France). It is mainly distributed in Mediterranean region, East Asia, and a few in North America. However, all species from outside the Mediterranean region are probably misplaced (Platnick 1986, 2007). The Chinese *Leptoneta* species should probably be included in one or more new genera in a future revisional work. In this paper, all the Chinese *Leptoneta* species except *L. arquata* Song & Kim, 1991, which is only known from female, are arranged into the following four species groups mainly based on the characters of male palp.

1. *L. maculosa* group, including nine species: *L. maculosa*, *L. anocellata*, *L. changlini*, *L. cornea* n. sp., *L. exilocula* n. sp., *L. foliiformis* n. sp., *L. tunxiensis* n. sp., *L. setulifera* n. sp. and *L. wangae* n. sp. This group is characterized by the presence of strong spines at least on distal ventral half of male palpal femur, the distally situated apophysis on palpal tibia (missing in *L. foliiformis* n. sp., *L. maculosa* and *L. tunxiensis* n. sp.), and the absence of ventral spines on palpal tibia.

2. *L. huanglongensis* group, including seven species: *L. huanglongensis*, *L. huisunica*, *L. lingqiensis*, *L. monodactyla*, *L. nigrabdomina*, *L. taiwanensis* and *L. taizhensis*. This group is characterized by the absence of ventral strong spines on male palpal femur, the presence of apophyses on distal palpal tibia, and the absence of strong spines on ventral palpal tibia.
3. *L. microdonta* group, including six species: *L. microdonta*, *L. hangzhouensis*, *L.tianxinensis*, *L. trispinosa*, *L. unispinosa* and *L. xui*. This group is characterized by the presence of strong spines on ventral male palpal tibia.
4. *L. miaoshiensis* group, including two species: *L. miaoshiensis* and *L. falcata*. This group is characterized by the absence of any strong spines or apophysis on male palpal femur and tibia.

Leptoneta cornea n. sp.
(Fig. 1)

TYPE MATERIAL. — Holotype: China, Beijing City, Fangshan District, Shijiaying Town (39°52'N, 115°41'E), Shenxian Cave, 6.III.2005, leg. Q. Wang & Y. Bi, ♂ (MNHN).
Paratypes: same data as holotype, 1 ♂, 5 ♀♀ (IZCAS); 2 ♀♀ (MNHN). — Beijing City, Mentougou District (39°52'N, 116°04'E), Guanyin Cave (near Jietaishi Temple), 28.IV.2005, leg. H. Chen & X. Han, 1 ♂, 5 ♀♀ (IZCAS). — Beijing City, Mentougou District (39°52'N, 116°04'E), Guanyin Cave (near Jietaishi Temple), 28.IV.2005, leg. H. Chen & X. Han, 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name is from Greek, *corn*, horn-shaped, in reference to the horn-shaped projection presented on ventral surface of male palpal bulb.

DIAGNOSIS. — The new species can be distinguished from all the other congeners by the presence of a horn-shaped projection on ventral surface of male palpal bulb, the presence of two strong spines on apical part of male palpal tibia and the presence of many long spines on ventral surface of male palpal femur.

DESCRIPTION

Male (n = 3)
Body length 1.76-1.78 (average: 1.77). Carapace 0.79-0.81 (average: 0.80) long, 0.68-0.70 (average: 0.69) wide; abdomen 0.88-0.91 (average: 0.89) long, 0.69-0.71 (average: 0.70) wide. Carapace yellow, with a pair of setae at lateral area of PME. Median groove dark brown, needle-shaped. Cervical grooves and radial furrows evident and light brown. Clypeus 0.16 high, slightly sloped anteriorly. Six eyes. Eye sizes: ALE 0.06, PLE 0.05, PME 0.04. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.05, PLE-PME 0.04. AER 0.10, PER 0.14. Major axes of PLE convergent behind. PME continuous, axes parallel. Chelicera (Fig. 1F) light brown, with nine teeth on promargin of fang furrow and six small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 1D) and legs yellow. Measurements of palp and legs: palp 2.08 (0.84, 0.44, 0.42, –, 0.38); I 6.80 (1.83, 0.29, 2.16, 1.63, 0.89); II 5.02 (1.44, 0.27, 1.48, 1.13, 0.70); III 4.05 (1.15, 0.24, 1.08, 1.00, 0.58); IV 5.79 (1.64, 0.26, 1.77, 1.40, 0.72). Leg formula: I-IV-II-III. Femur I with some relatively thicker setae on middle part of anterior surface. Tibia I with row of fine hairs ventrally (Fig. 1C). Metatarsus II and III (Fig. 4H, I) as *L. setulifera* n. sp., with a cluster of hairs on basal part of ventral surface, respectively. Abdomen haired, pale yellow, and oval in shape, no distinct pattern on the dorsum. Palpal femur with many spines ventrally. Palpal tibia with three long trichobothria on the dorsal surface and with two strong spines on disto-lateral and disto-dorsal surfaces (Fig. 1A, B). Cymbium distally branched.

Female (n = 14)
Similar to male in coloration and general features, but body size larger and legs shorter. Body length 1.77-2.16 (average: 1.98). Carapace 0.76-0.80 (average: 0.79) long, 0.64-0.67 (average: 0.65) wide; abdomen 1.05-1.18 (average: 1.12) long, 0.91-1.18 (average: 0.99) wide. Clypeus 0.15 high. Eye sizes: ALE 0.05, PLE 0.04, PME 0.04. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.06, PLE-PME 0.03. AER 0.09, PER 0.12. Measurements of palp and legs: palp 1.49 (0.50, 0.17, 0.36, –, 0.46); I 5.25 (1.40, 0.25, 1.61, 1.24, 0.75); II 4.10 (1.17, 0.24, 1.16, 0.92, 0.61); III 3.47 (0.98, 0.23, 0.89, 0.85, 0.52); IV 4.81 (1.36, 0.23, 1.46, 1.14, 0.62). Leg I without special hairs as in male. Internal genitalia with a pair of spermatheca and sperm duct, atrium visible (Fig. 1E, G).

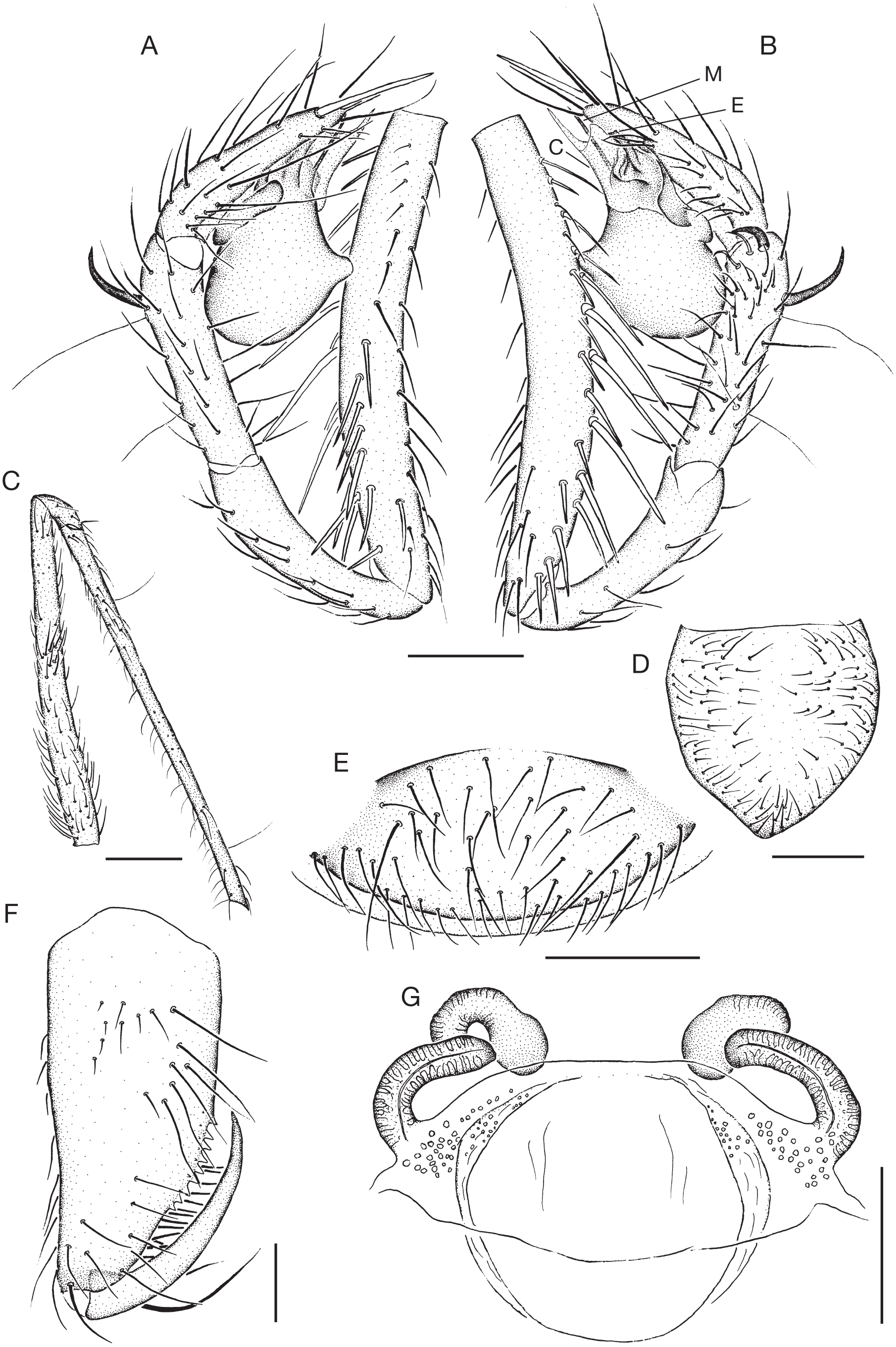

FIG. 1. — *Leptoneta cornea* n. sp.: **A**, male left palp in prolateral view; **B**, male left palp in retrolateral view; **C**, male left leg I in anterior view; **D**, female sternum in ventral view; **E**, female genitalia in ventral view; **F**, male chelicera in ventral view; **G**, female genitalia in dorsal view. Abbreviations: **C**, **E**, **M**, conductor, embolus and median apophysis of male palpal organ respectively. Scale bars: A, B, D, E, 0.2 mm; C, 0.4 mm; F, G, 0.1 mm.

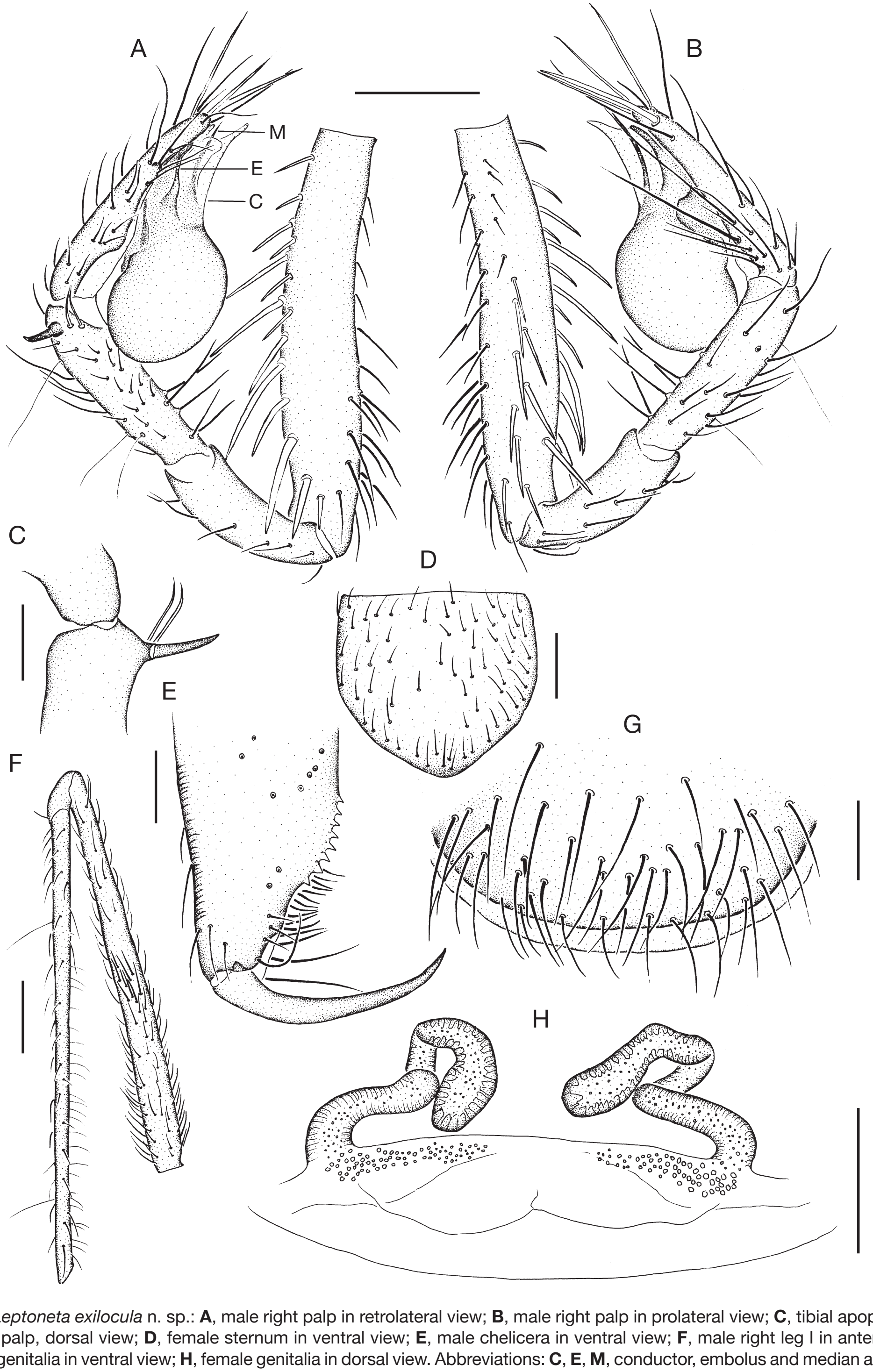

FIG. 2. — *Leptoneta exilocula* n. sp.: **A**, male right palp in retrolateral view; **B**, male right palp in prolateral view; **C**, tibial apophyses of male right palp, dorsal view; **D**, female sternum in ventral view; **E**, male chelicera in ventral view; **F**, male right leg I in anterior view; **G**, female genitalia in ventral view; **H**, female genitalia in dorsal view. Abbreviations: **C**, **E**, **M**, conductor, embolus and median apophysis of male palpal organ respectively. Scale bars: A, B, D, 0.2 mm; C, E, G, H, 0.1 mm; F, 0.4 mm.

Leptoneta exilocula n. sp.
(Fig. 2)

TYPE MATERIAL. — Holotype: China, Beijing City, Fangshan District, Hebeizhen Town (39°48'N, 115°54'E), Bianfu Cave, leg. H. Chen & Y. Tong, ♂ (MNHN).
Paratypes: same data as holotype, 2 ♂♂, 2 ♀♀ (IZCAS); 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name is from Latin, *exil*, small and *ocul*, eyes, in reference to the relatively smaller sized eyes of this species.

DIAGNOSIS. — The new species is similar to *L. miaoshiensis* Chen & Zhang, 1993, but can be distinguished by having six eyes, instead of two eyes as in *L. miaoshiensis*; carapace hairless, instead of with rows of hairs from eyes to median furrow as in *L. miaoshiensis*; male palpal tibia with a strong short spine disto-laterally, but without the two long hairs presented on ventral surface as in *L. miaoshiensis*; abdomen without patterns; and also by the different shape of lamina of palpal bulb.

DESCRIPTION

Male (holotype)

Body length 2.20. Carapace 0.92 long, 0.78 wide; abdomen 0.95 long, 0.89 wide. Carapace yellow, hairless. Cervical grooves and radial furrows evident and light brown. Median groove dark brown and needle-shaped. Clypeus 0.24 high. Eyes six. Eye sizes: ALE 0.03, PLE 0.03, PME 0.02. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.05, PLE-PME 0.06. AER 0.07, PER 0.10. Major axes of PLE convergent behind. PME continuous, axes parallel. Chelicera (Fig. 2E) light brown, with eight teeth on promargin of fang furrow and five small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 2D) and legs yellow. Measurements of palp and legs: palp 1.85 (0.72, 0.33, 0.37, –, 0.43); I 8.24 (2.28, 0.31, 2.51, 2.03, 1.11); II 6.13 (1.75, 0.30, 1.79, 1.40, 0.89); III 5.05 (1.43, 0.27, 1.38, 1.24, 0.73); IV 6.91 (2.03, 0.27, 2.10, 1.63, 0.88). Leg formula: I-IV-II-III. Femur I with some relatively thicker setae on middle part of anterior surface. Tibia I with rows of fine hairs on ventral surface (Fig. 2F). Abdomen haired, pale gray, and oval in shape, no distinct pattern on the dorsum. Palpal femur with many long spines. Palpal tibia with three long trichobothria on the dorsal surface and with a strong short spine disto-laterally (Fig. 2A-C). Cymbium distally branched.

Female

Similar to male in coloration and general features, but legs shorter. Body length 1.69. Carapace 0.75 long, 0.69 wide; abdomen 0.95 long, 0.74 wide. Clypeus 0.17 high. Eye sizes: ALE 0.04, PLE 0.04, PME 0.03. Distance between eyes: ALE-PME 0.07, PLE-PLE 0.05, PLE-PME 0.04. AER 0.06, PER 0.11. Measurements of palp and legs: palp 1.66 (0.58, 0.19, 0.39, –, 0.50); I 6.48 (1.77, 0.26, 1.97, 1.52, 0.96); II 4.98 (1.42, 0.25, 1.42, 1.11, 0.78); III 4.17 (1.19, 0.24, 1.08, 1.01, 0.65); IV 5.65 (1.62, 0.24, 1.68, 1.34, 0.77). Leg I without special hairs as in male. Internal genitalia with a pair of spermatheca and sperm duct, atrium visible (Fig. 2G, H).

Leptoneta foliiformis n. sp.
(Fig. 3)

TYPE MATERIAL. — Holotype: China, Beijing City, Fangshan District, Shangfangshan Mountain (39°39'N, 115°48'E), Yunshui Cave, 22.I.2005, leg. H. Chen & X. Han, ♂ (MNHN).
Paratypes: same data as holotype, 3 ♂♂, 4 ♀♀ (IZCAS); 2 ♂♂, 2 ♀♀ (MNHN). — Same locality as holotype, 1.IX.2005, Y. Tong & Q. Wang, 2 ♂♂, 1 ♀ (IZCAS). — Hebei Province, Mancheng County, Caojiayu Village, Caoxian Cave (39°03'N, 115°10'E), 9.VI.2005, leg. Y. Tong & Q. Wang, 7 ♂♂, 12 ♀♀ (IZCAS). — Hebei Province, Mancheng County, Caojiayu Village, Caoxian Cave (39°03'N, 115°10'E), 9.VI.2005, leg. Y. Tong & Q. Wang, 2 ♂♂, 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name comes from Latin, *foli*, leaf and *form*, shape, in reference to the leaf-shaped median apophysis of male palpal bulb.

DIAGNOSIS. — The new species is similar in female genitalia to *L. tunxiensis* Song & Xu, 1985, but can be distinguished by the presence of seven promarginal teeth on fang furrow, the absence of three short stout spines on retrolateral surface of male palpal patella, and the different shape of laminae of the palpal bulb.

DESCRIPTION

Male (n = 17)

Body length 1.42-1.99 (average: 1.79). Carapace 0.68-0.75 (average: 0.72) long, 0.66-0.71 (average: 0.69) wide; abdomen 0.84-1.15 (average: 1.03) long, 0.58-0.86 (average: 0.73) wide. Carapace

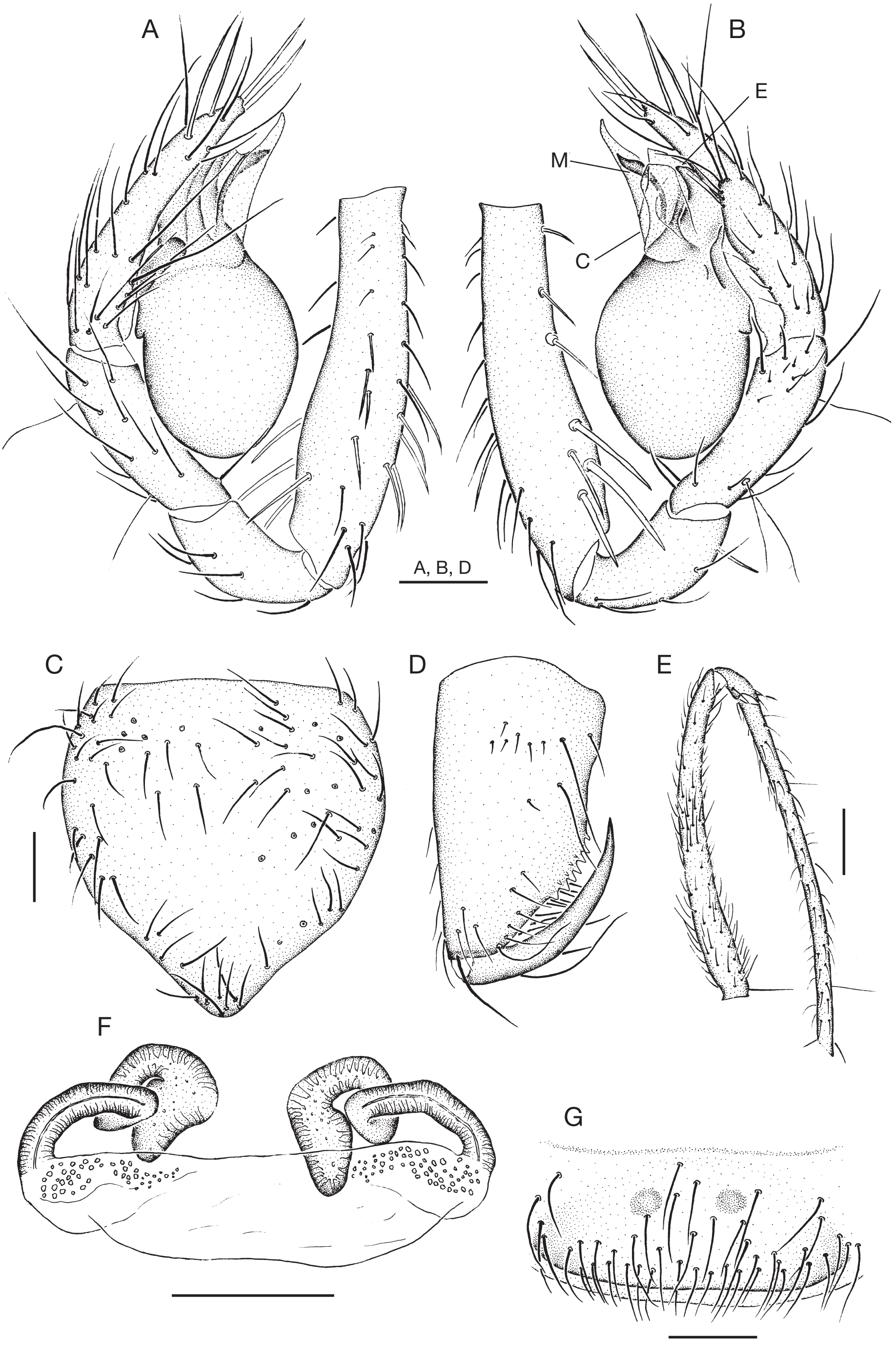

FIG. 3. — *Leptoneta foliiformis* n. sp.: **A**, male left palp in prolateral view; **B**, male left palp in retrolateral view; **C**, female sternum in ventral view; **D**, male chelicera in ventral view; **E**, male left leg I in anterior view; **F**, female genitalia in dorsal view; **G**, female genitalia in ventral view. Abbreviations: **C**, **E**, **M**, conductor, embolus and median apophysis of male palpal organ respectively. Scale bars: A-D, F, G, 0.1 mm; E, 0.3 mm.

yellow, with a small seta presented before middle of ALE, a pair of setae at antero-lateral area of PME, and with a long seta at the rear of median groove. Median groove dark brown, needle-shaped. Cervical grooves and radial furrows light brown. Clypeus 0.13-0.19 (average: 0.16) high. Six eyes. Eye sizes: ALE 0.05, PLE 0.04, PME 0.04. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.06, PLE-PME 0.03. AER 0.11, PER 0.14. Major axes of PLE convergent behind. PME continuous, axes parallel. Chelicera (Fig. 3D) light brown, with seven teeth on promargin of fang furrow and four small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 3C) and legs yellow. Measurements of palp and legs: palp 2.01 (0.76, 0.33, 0.36, –, 0.56); I 4.98 (1.45, 0.25, 1.56, 1.13, 0.59); II 4.13 (1.20, 0.26, 1.14, 0.92, 0.61); III 3.48 (0.97, 0.24, 0.92, 0.83, 0.52); IV 4.70 (1.35, 0.24, 1.42, 1.08, 0.61). Leg formula: I-IV-II-III. Femur I with some relatively thicker setae on middle part of anterior surface. Tibia I with row of finely hairs on distal half part of ventral surface (Fig. 3E). Metatarsus II and III (Fig. 4H, I) as *L. setulifera* n. sp., with a cluster of hairs on basal part of ventral surface, respectively. Abdomen haired, pale gray, and oval in shape, no distinct pattern on the dorsum. Palpal femur with some long spines ventrally. Palpal tibia with three long trichobothria on the dorsal surface and without special projection (Fig. 3A, B). Cymbium distally branched.

Female (n = 21)

Similar to male in coloration and general features, but legs shorter. Body length 1.65-1.95 (average: 1.76). Carapace 0.62-0.65 (average: 0.64) long, 0.61-0.63 (average: 0.62) wide; abdomen 1.00-1.37 (average: 1.19) long, 0.82-0.95 (average: 0.88) wide. Clypeus 0.13-0.15 (average: 0.14) high. Eye sizes: ALE 0.06, PLE 0.05, PME 0.04. Distance between eyes: ALE-PME 0.07, PLE-PLE 0.06, PLE-PME 0.03. AER 0.10, PER 0.13. Measurements of palp and legs: palp 1.27 (0.42, 0.15, 0.30, –, 0.40); I 4.53 (1.28, 0.23, 1.32, 1.02, 0.68); II 3.58 (1.02, 0.23, 1.00, 0.79, 0.54); III 3.06 (0.86, 0.22, 0.77, 0.72, 0.49); IV 4.24 (1.20, 0.22, 1.26, 0.97, 0.59). Leg I without special hairs as in male. Internal genitalia with a pair of spermatheca and sperm duct, atrium visible (Fig. 3F, G).

Leptoneta setulifera n. sp.
(Fig. 4)

TYPE MATERIAL. — Holotype: China, Beijing City, Fangshan District, Shidu Town (39°42'N, 115°37'E), Liuhe Village, Beipo Cave, 11.V.2005, leg. Q. Wang, ♂ (MNHN).

Paratypes: same locality as holotype, 5.IX.2006, leg. S. Li, Y. Lin & J. Liu, 6 ♂♂, 25 ♀♀ (IZCAS). — Same locality as holotype, 5.IX.2006, leg. S. Li, Y. Lin & J. Liu, 3 ♂♂, 3 ♀♀ (MNHN).

ETYMOLOGY. — The specific name comes from Latin, *set*, hairs, and combined with suffix *fera*, bearing, in reference to the hairs presented on carapace.

DIAGNOSIS. — The new species is similar to *L. handeulgulensis* Namkung, 2002 (Namkung 2003), but can be distinguished by the presence of many long spines on ventral surface of male palpal femur, and the presence of hook-like projection on male palpal tibia.

DESCRIPTION

Male (n = 10)

Body length 1.62-1.96 (average: 1.83). Carapace 0.73-0.87 (average: 0.78) long, 0.66-0.71 (average: 0.69) wide; abdomen 0.88-1.08 (average: 0.98) long, 0.72-0.84 (average: 0.77) wide. Carapace yellow, with hairs on anterior margin of clypeus and lateral margins, with a pair of setae at lateral area of PME, and with two setae at median groove. Median groove dark brown, needle-shaped. Cervical grooves and radial furrows indistinct. Clypeus 0.13-0.16 (average: 0.15) high, slightly sloped anteriorly. Six eyes. Eye sizes: ALE 0.05, PLE 0.04, PME 0.04. Distance between eyes: ALE-PME 0.09, PLE-PLE 0.07, PLE-PME 0.04. AER 0.10, PER 0.13. Major axes of PLE convergent behind. PME also touching one another, axes parallel. Chelicera (Fig. 4F) light brown, with seven teeth on promargin of fang furrow and five small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 4E) and legs yellow. Measurements of palp and legs: palp 2.31 (0.91, 0.45, 0.55, –, 0.40); I 6.10 (1.69, 0.25, 1.92, 1.47, 0.77); II 4.56 (1.31, 0.25, 1.29, 1.06, 0.65); III 3.85 (1.08, 0.24, 1.00, 0.95, 0.58); IV 5.32 (1.48, 0.25, 1.63, 1.28, 0.68). Leg formula: I-IV-II-III. Tibia I with row of finely hairs ventrally (Fig. 4D). Metatarsus II and III (Fig. 4H, I) with a cluster of hairs on

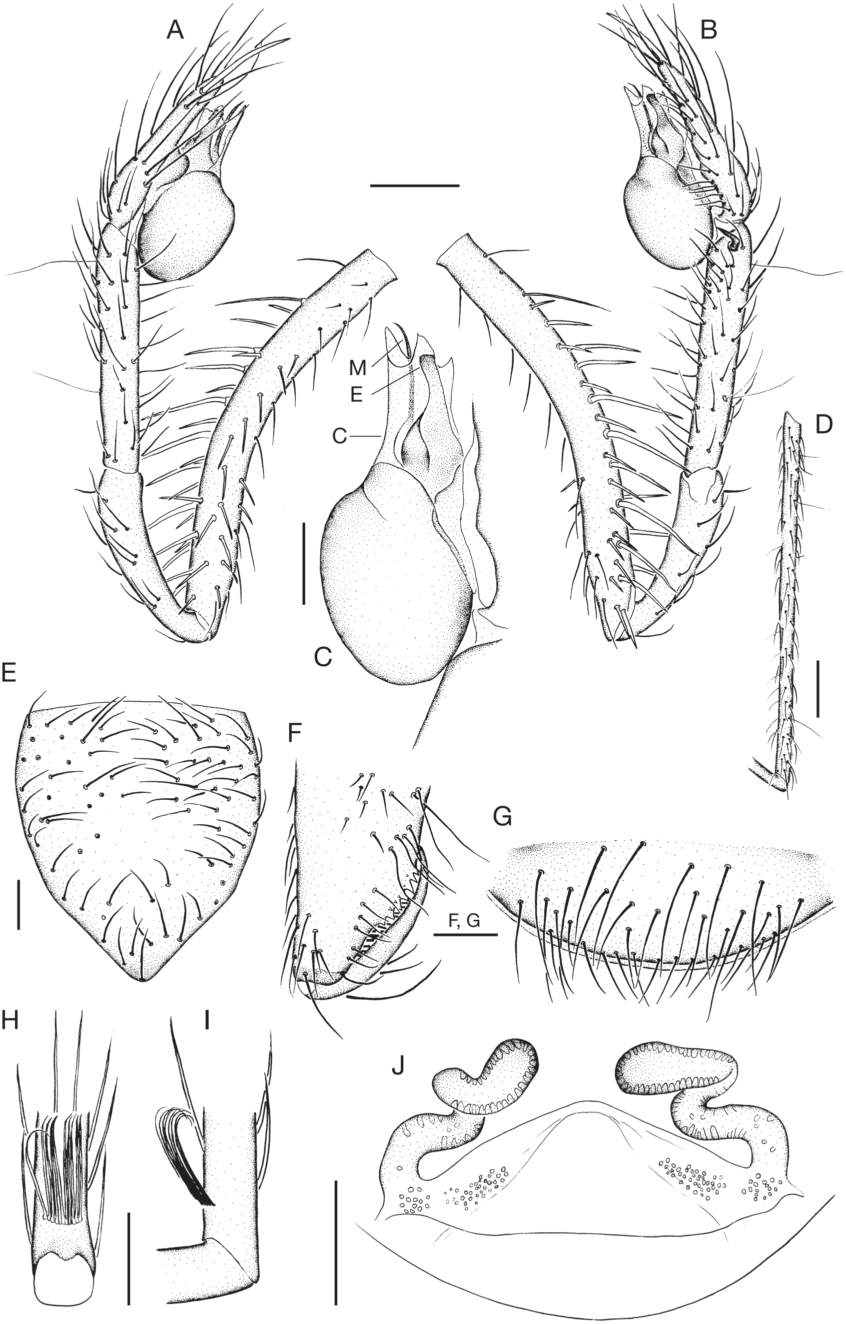

FIG. 4. — *Leptoneta setulifera* n. sp.: **A**, male left palp in prolateral view; **B**, male left palp in retrolateral view; **C**, male left palpal bulb in retrolateral view; **D**, tibia I of male left leg in anterior view; **E**, male sternum in ventral view; **F**, male chelicera in ventral view; **G**, female genitalia in ventral view; **H**, proximally of metatarsus of male leg III, ventral view; **I**, proximally of metatarsus of male leg III, lateral view; **J**, female genitalia in dorsal view. Abbreviations: **C**, **E**, **M**, conductor, embolus and median apophysis of male palpal organ respectively. Scale bars: A, B, 0.2 mm; C, E-J, 0.1 mm; D, 0.3 mm.

basal part of ventral surface. Abdomen haired, brown on dorsum and dark brown on lateral and ventral surfaces, and oval in shape, dorsum with black brown transverse stripes posteriorly, forming three to four folds. Palpal femur with many spines ventrally. Palpal tibia with three long trichobothria on the dorsal surface and with a single hook-like projection disto-laterally (Fig. 4A-C). Cymbium distally branched.

Female (n = 28)

Similar to male in coloration and general features, but legs shorter. Body length 1.55-2.16 (average: 1.97). Carapace 0.73-0.81 (average: 0.76) long, 0.63-0.70 (average: 0.67) wide; abdomen 0.86-1.24 (average: 1.09) long, 0.61-1.02 (average: 0.88) wide. Clypeus 0.13-0.14 (average: 0.14) high. Eye sizes: ALE 0.05, PLE 0.05, PME 0.04. Distance between eyes: ALE-PME 0.07, PLE-PLE 0.05, PLE-PME 0.03. AER 0.10, PER 0.14. Measurements of palp and legs: palp 1.57 (0.54, 0.19, 0.38, –, 0.46); I 5.03 (1.43, 0.25, 1.51, 1.18, 0.66); II 3.93 (1.13, 0.25, 1.09, 0.87, 0.59); III 3.36 (0.97, 0.24, 0.86, 0.78, 0.51); IV 4.69 (1.37, 0.24, 1.40, 1.07, 0.61). Leg I without special hairs as in male. Internal genitalia with a pair of spermatheca and sperm duct, atrium visible (Fig. 4G, J).

Leptoneta tianxinensis n. sp.

(Fig. 5)

TYPE MATERIAL. — Holotype: China, Henan Province, Neixiang County, Qiliping Town, Sandaohe Village, Tianxin Cave (33°21'N, 111°53'E), 24.VI.2005, leg. Q. Wang & Y. Tong, ♂ (MNHN). Paratypes: same data as holotype, 12 ♂♂, 6 ♀♀ (IZCAS); 2 ♂♂, 2 ♀♀ (MNHN).

ETYMOLOGY. — The specific name is derived from the type locality.

DIAGNOSIS. — The new species is similar to *L. xui* Chen, Gao & Zhu, 2000, distributed in Guizhou Province, but can be distinguished by having the chelicera with seven promarginal teeth, instead of nine as in *L. xui*; the eyes are normal-sized, but reduced in *L. xui*; the ventral long spines of male palpal tibia is two, one strong and one relatively slender; and also by the different shape of lamina of male palpal bulb.

DESCRIPTION

Male (n = 15)

Body length 1.83-1.87 (average: 1.85). Carapace 0.85-0.90 (average: 0.87) long, 0.74-0.76 (average: 0.75) wide; abdomen 0.92-0.98 (average: 0.96) long, 0.71-0.75 (average: 0.73) wide. Carapace yellow, with pair of hairs at antero-lateral area of PME. Median groove dark brown, needle-shaped. Cervical grooves and radial furrows evident and light brown. Clypeus 0.09-0.12 (average: 0.11) high. Six eyes. Eye sizes: ALE 0.06, PLE 0.06, PME 0.06. Distance between eyes: ALE-PME 0.10, PLE-PLE 0.08, PLE-PME 0.06. AER 0.11, PER 0.14. Major axes of PLE convergent behind. PME continuous, axes parallel. Chelicera (Fig. 5C) light brown, with seven teeth on promargin of fang furrow and four small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 5E) and legs yellow. Measurements of palp and legs: palp 2.12 (0.82, 0.31, 0.39, –, 0.60); I 6.71 (1.85, 0.31, 1.96, 1.60, 0.99); II 5.52 (1.57, 0.30, 1.53, 1.29, 0.83); III 4.44 (1.29, 0.27, 1.16, 1.05, 0.67); IV 5.96 (1.72, 0.29, 1.67, 1.45, 0.83). Leg formula: I-IV-II-III. Legs with several long and thin spines. Femur I with some stout setae at basal 1/3 of anterior surface. Tibia I with rows of finely hairs ventrally (Fig. 5F). Metatarsus II and III (Fig. 4H, I) as *L. setulifera* n. sp., with a cluster of hairs on basal part of ventral surface, respectively. Abdomen haired, light gray, and oval in shape, no distinct pattern on the dorsum. Palpal femur without thick long spines ventrally. Palpal tibia with three long trichobothria on the dorsal surface and with two long spines ventrally, one is very thick and inserted a finely hair on apical part, the other one relatively slender (Fig. 5A, B). Cymbium distally branched.

Female (n = 8)

Similar to male in coloration and general features, but legs shorter. Body length 1.88. Carapace 0.70-0.79 (average: 0.76) long, 0.59-0.69 (average: 0.64) wide; abdomen 1.08 long, 0.98 wide. Clypeus 0.10-0.12 (average: 0.11) high. Eye sizes: ALE 0.06, PLE 0.06, PME 0.05. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.07, PLE-PME 0.03. AER 0.10, PER 0.13. Measurements of palp and legs: palp 1.17 (0.38, 0.14, 0.24, –, 0.41); I 4.91

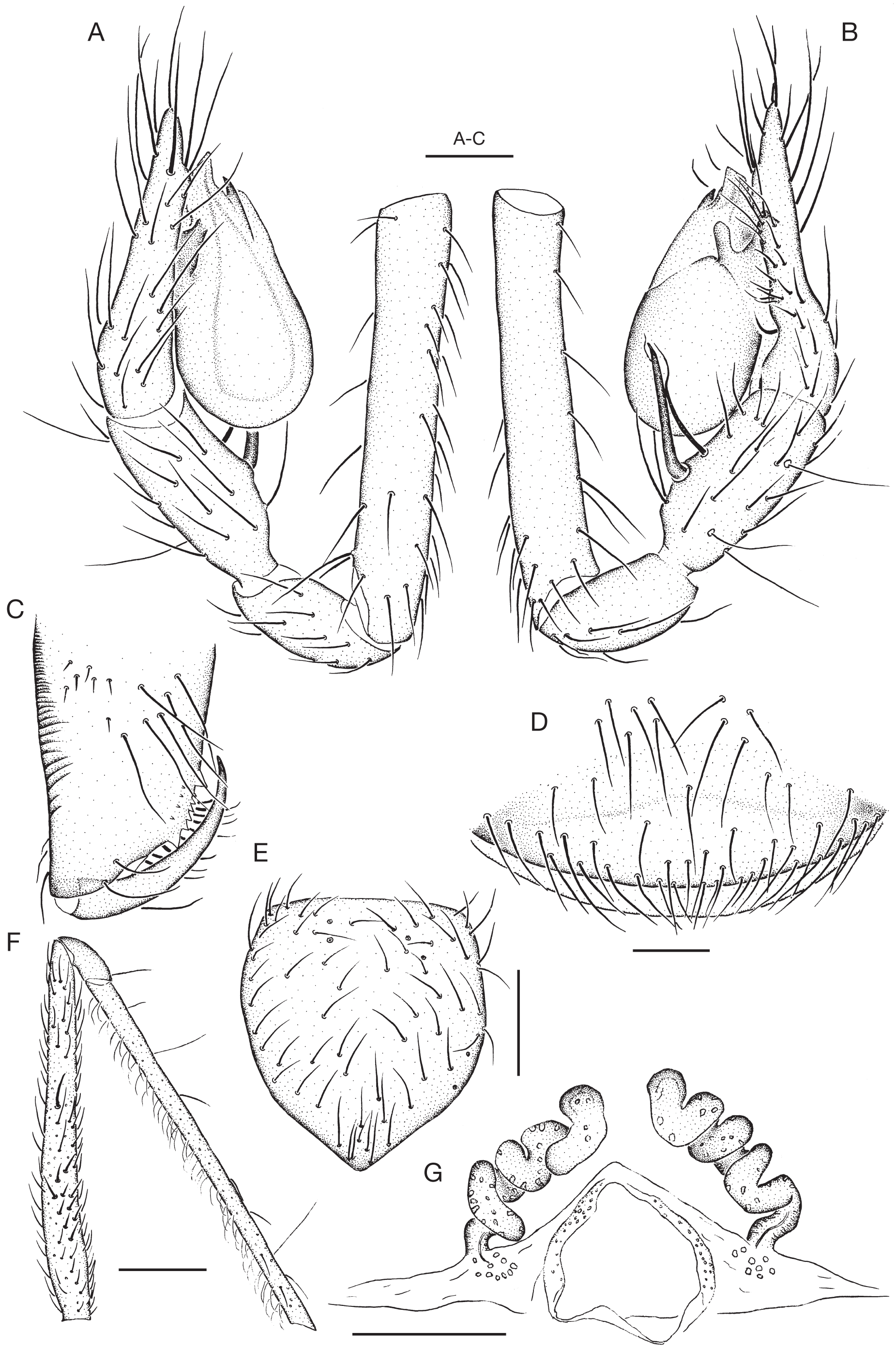

FIG. 5. — *Leptoneta tianxinensis* n. sp.: **A**, male left palp in prolateral view; **B**, male left palp in retrolateral view; **C**, male chelicera in ventral view; **D**, female genitalia in ventral view; **E**, female sternum in ventral view; **F**, male left leg I in anterior view; **G**, female genitalia in dorsal view. Scale bars: A-D, G, 0.1 mm; E, 0.2 mm; F, 0.4 mm.

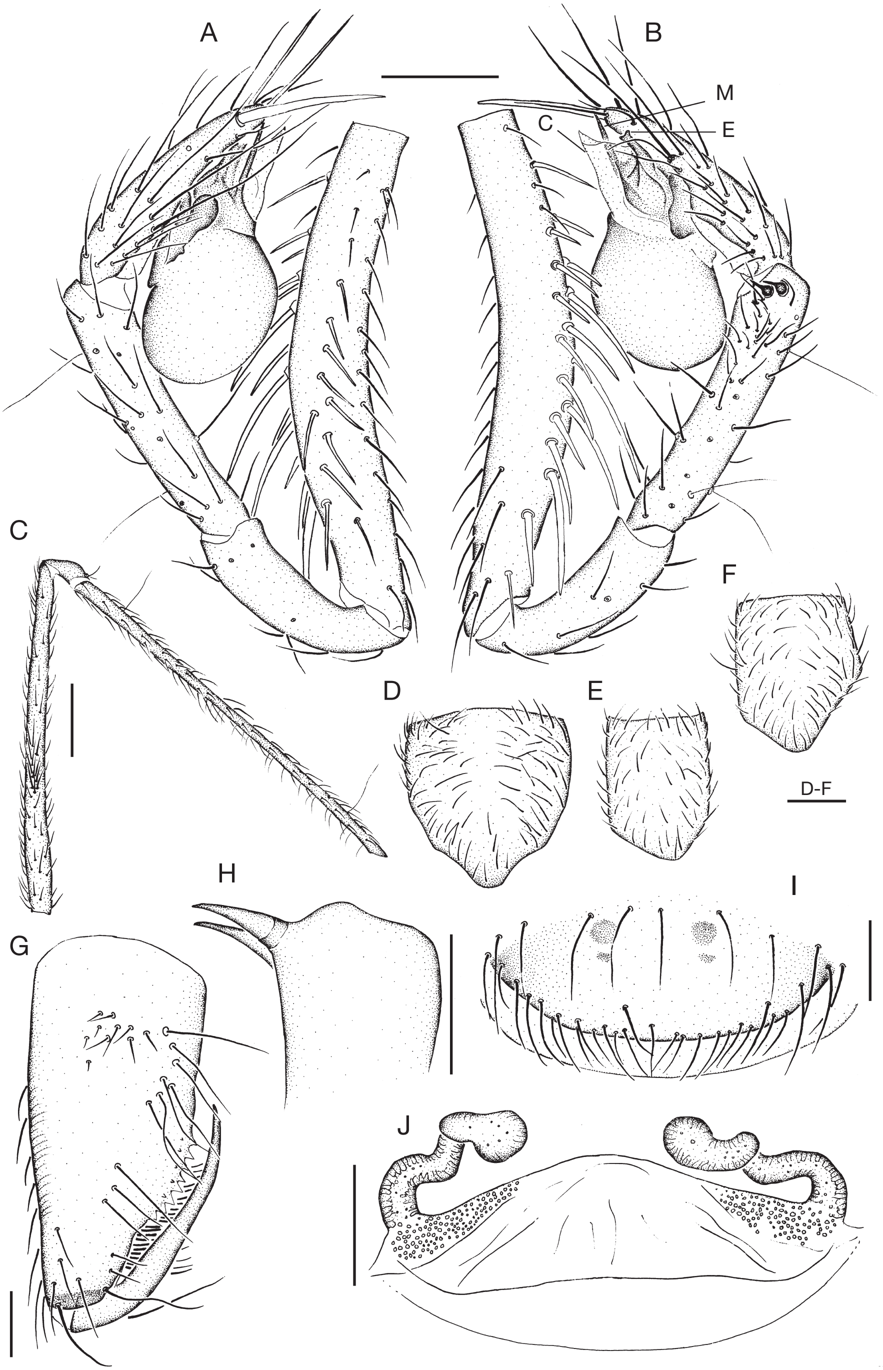

FIG. 6. — *Leptoneta wangae* n. sp.: **A**, male left palp in prolateral view; **B**, male left palp in retrolateral view; **C**, male left leg I in anterior view; **D**-**F**, female sternum in ventral view; **G**, male chelicera in ventral view; **H**, tibial apophyses of male left palp, dorsal view; **I**, female genitalia in ventral view; **J**, female genitalia in dorsal view. Abbreviations: **C**, **E**, **M**, conductor, embolus and median apophysis of male palpal organ respectively. Scale bars: A, B, D-F, 0.2 mm; C, 0.5 mm; G-J, 0.1 mm.

(1.37, 0.26, 1.36, 1.11, 0.81); II 4.07 (1.16, 0.24, 1.06, 0.91, 0.70); III 3.47 (1.00, 0.23, 0.87, 0.79, 0.58); IV 4.64 (1.33, 0.23, 1.26, 1.09, 0.73). Leg I without special hairs as in male. Internal genitalia with a pair of spermatheca and sperm duct, atrium visible (Fig. 5D, G).

Leptoneta wangae n. sp.
(Fig. 6)

TYPE MATERIAL. — Holotype: China, Beijing City, Fangshan District, Xiayunling Town (39°42'N, 115°44'E), Beizhihe Village, Zhizhu Cave, 8.III.2005, leg. Q. Wang & Y. Tong, ♂ (MNHN).
Paratypes: same data as holotype, 10 ♂♂, 8 ♀♀ (IZCAS); 2 ♂♂, 2 ♀♀ (MNHN).

ETYMOLOGY. — The species is named after the collector Dr Qian Wang (Shanghai Institute for Biological Sciences, Chinese Academy of Sciences).

DIAGNOSIS. — The new species is similar to *L. yongdamgulensis* Paik & Namkung, 1969 (Paik *et al.* 1969), but can be easily distinguished by the presence of eight teeth on promargin of fang furrow and five small denticles on retromargin, the presence of many long spines on ventral surface of male palpal femur, and the presence of two small strong spines on disto-lateral surface of male palpal tibia, instead of a single long spine on middle part of retrolateral surface as in *L. yongdamgulensis*.

DESCRIPTION
Male (n = 13)
Body length 1.76-1.99 (average: 1.87). Carapace 0.81-0.87 (average: 0.84) long, 0.70-0.76 (average: 0.73) wide; abdomen 0.95-1.16 (average: 1.04) long, 0.70-0.79 (average: 0.75) wide. Carapace yellow, with a pair of setae at lateral area of PME. Median groove dark brown, needle-shaped. Cervical grooves and radial furrows evident and light brown. Clypeus 0.20 high. Eyes six, but the PME strongly reduced or only one of the PME can be discernable or both absent. Eye sizes: ALE 0.04, PLE 0.04, PME 0-0.03. Distance between eyes: ALE-PME 0.08, PLE-PLE 0.04, PLE-PME 0.04. AER 0.08, PER 0.10. Major axes of PLE convergent behind. PME, if both present, separated from each other by one time of their diameter. Chelicera (Fig. 6G) light brown, with eight teeth on promargin of fang furrow and five small teeth on retromargin. Endites and labium light brown. Sternum (Fig. 6D-F) usually shield-shaped, but varying greatly, some narrowed and lateral margins parallel and some asymmetrical at outer margins, especially in the part along the coxae III and IV. Legs yellow. Measurements of palp and legs: palp 2.24 (0.90, 0.39, 0.50, –, 0.45); I 8.93 (2.47, 0.30, 2.73, 2.22, 1.21); II 6.52 (1.87, 0.28, 1.90, 1.48, 0.99); III 5.21 (1.51, 0.21, 1.45, 1.28, 0.76); IV 7.27 (2.08, 0.28, 2.24, 1.75, 0.92). Leg formula: I-IV-II-III. Femur I with some relatively thicker setae on middle part of anterior surface. Tibia I with row of fine hairs on distal half of ventral surface (Fig. 6C). Abdomen haired, pale yellow, venter brownish, and oval in shape, no distinct pattern on the dorsum. Palpal femur with many long spines ventrally. Palpal tibia with three long trichobothria on the dorsal surface and with two strong short spines disto-laterally (Fig. 6A, B, H). Cymbium distally branched.

Female (n = 10)
Similar to male in coloration and general features, but legs shorter. Body length 1.65-2.01 (average: 1.89). Carapace 0.75-0.81 (average: 0.78) long, 0.69-0.73 (average: 0.71) wide; abdomen 0.90-1.21 (average: 1.12) long, 0.62-0.91 (average: 0.79) wide. Clypeus 0.19-0.20 (average: 0.19) high. Eyes usually four, PME more strongly reduced than in male, in a few specimens, the PLE even slightly reduced. Eye sizes: ALE 0.04, PLE 0.04. Distance between eyes: ALE-PME 0.10, PLE-PLE 0.05, PLE-PME 0.07. AER 0.08, PER 0.12. PME, if both discernable, separated from each other by at least one time of their diameter. Measurements of palp and legs: palp 1.80 (0.62, 0.21, 0.45, –, 0.52); I 7.35 (1.95, 0.30, 2.19, 1.75, 1.16); II 5.58 (1.57, 0.26, 1.60, 1.27, 0.88); III 4.62 (1.30, 0.25, 1.23, 1.12, 0.72); IV 6.39 (1.85, 0.26, 1.91, 1.51, 0.86). Leg I without special hairs as in male. Internal genitalia with a pair of spermathecae and sperm duct, atrium visible (Fig. 6I, J).

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Notiocoelotes, a new genus of the spider subfamily Coelotinae from Southeast Asia (Araneae, Amaurobiidae)

XIN-PING WANG [1], XIANG XU[2] & SHUQIANG LI[3, 4]

[1] *College of Life Sciences, Hebei University, Baoding 071002, Hebei, China*
[2] *College of Life Sciences, Hunan Normal University, Changsha 410081, Hunan, China*
[3] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China*
[4] *Corresponding author. E-mail: lisq@ioz.ac.cn*

Abstract

Notiocoelotes gen. nov. is described from China, Laos, Thailand and Vietnam. The type species is *N. palinitropus* (Zhu & Wang 1994) **comb. nov.** from Hainan Island, China, and is transferred from *Coelotes* Blackwall 1841. Other species included in this new genus are: *N. laosensis* **sp. nov.** from Khammouan, Laos; *N. lingulatus* **sp. nov.** from Hainan Island, China; *N. sparus* (Dankittipakul, Chami-Kranon & Wang 2005) **comb. nov.** from Nakhon Ratchasima, Thailand transferred from *Iwogumoa* Kishida 1955, and *N. vietnamensis* **sp. nov.** from Huong Son, Vietnam. Females of *Notiocoelotes* gen. nov. can be recognized from other Coelotinae species by the absence of epigynal teeth and the presence of a tongue-shaped atrial scape on the posterior atrium, and males by the presence of a strongly bifurcated lateral tibial apophysis and the long, coiled conductor. The species of *Notiocoelotes* gen. nov. are similar to the basal clade genera, i.e., *Coronilla* Wang 2004, *Femoracoelotes* Wang 2002, *Alloclubionoides* Paik 1992, and *Robusticoelotes* Wang 2002 in lacking epigynal teeth and having a simple or reduced median apophysis, but the long conductor and the absence of a conductor dorsal apophysis are similar to the genera *Pireneitega* Kishida 1955 and *Iwogumoa* Kishida 1955.

Key words: Taxonomy, transfer, new species, China, Laos, Thailand, Vietnam

Introduction

With 422 described species (Platnick 2008; Wang 2008), the Holarctic spider subfamily Coelotinae F.O.P.-Cambridge 1893 is one of the most diverse spider groups and shows a continuous distribution pattern from North America (west to the Rocky Mountains and north to southern Canada), Europe (north to southern Sweden and Finland), Middle Asia, East Asia, Himalayan region (Nepal, Bhutan, Pakistan) to Southeast Asia (south to northern Vietnam and central Thailand) (Muma 1946; Blauwe 1973; Bennett 1987; Nishikawa 1995; Wang 2002; Ovtchnnikov & Inayatullah 2005; Dankittipakul *et al.* 2006). Many Coelotinae species are rather endemic, particularly to the islands (Shimojana 1982, 1989, 2000a, 2000b). In addition to the revisionary work of some genera by Wang (2002, 2003), a series of papers dealing with Coelotine fauna have been published since, including at least twenty papers published in the last two years (Chami-Kranon *et al.* 2006; Dankittipakul *et al.* 2006; Kim & Lee 2006a, 2006b, 2007; Kim *et al.* 2007; Okumura & Ono 2006; Wang & Jäger 2007; Xu & Li 2006a–e; Xu *et al.* 2006; Xu & Li 2007a–c; Zhang *et al.* 2006; Zhang & Zhu 2007; Zhang *et al.* 2007). The research results reveal even richer species diversity in East Asia, the Himalayan region, and northern Southeast Asia.

Among the coelotines described from East Asia and Southeast Asia, a group of five species was recognized and a new genus, *Notiocoelotes* gen. nov., is proposed to accommodate them. One of the species

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included in this new genus is *Coelotes palinitropus* Zhu & Wang 1994 which was described from Hainan Island, southern China based on two males. It did not receive much attention despite the unique genitalic modifications, e.g., the strongly bifurcated lateral tibial apophysis, the long coiled conductor, the absence of a conductor dorsal apophysis, and the simple median apophysis. Xu & Li (2006a) described the female of the species, characterized by the absence of epigynal teeth, the presence of a small but distinct atrium, and the presence of a tongue-shaped protrusion on the posterior atrium, which we call an atrial scape here. A second species from Thailand found to belong to this new genus is *Iwogumoa sparus* (Dankittipakul, Chami-Kranon & Wang 2005) which was described as a member of the genus *Asiacoelotes* Wang 2002 (=*Iwogumoa* Kishida 1955) because of the absence of a conductor dorsal apophysis and the presence of a similar long conductor (Dankittipakul *et al.* 2005). Further study indicates that rather than congeneric with the type species of *Iwogumoa*, *I. sparus* is in fact a member of *Notiocoelotes* gen. nov. due to the absence of a patellar apophysis, the presence of a strongly bifurcated lateral tibial apophysis, the strongly elongated, coiled conductor, and the simple median apophysis. In addition, three new species, collected separately from Hainan Island, Vietnam, and Laos, were found to share the male and female morphological features with *Notiocoelotes* gen. nov. A cladistic analysis is not included in this study but will be prepared in the near future to identify its phylogenetic relationship within the subfamily Coelotinae and to test the monophyly of its species.

Material and methods

All measurements are in millimeters. Scale lines are 0.2 mm long, except where indicated. The eye diameter is taken at the widest point. The total body length excludes the length of the chelicerae or spinnerets. The terminology used in the text and figures follows Wang (2002). Specimens studied in the current paper are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS), the American Museum of Natural History, New York (AMNH), and Senckenberg Museum, Frankfurt (SMF). Type specimens from the former Norman Bethune University of Medical Sciences, Changchun, China (NBUMS) were not found and may be lost. The distribution map was generated using ArcView GIS software and the .dbf files of the studied species are downloadable from Wang (2008). More photos of the type specimens can be viewed at Li & Wang (2008).

Two new species (*N. laosensis* **sp. nov.** and *N. lingulatus* **sp. nov.**) are described only from female specimens. The lack of males could be caused either by under sampling of specimens or by inappropriate collecting time of the year. A study by Wang *et al.* (2001) using year-round pitfall trap collection indicated that both adult male and female coelotines demonstrated highly seasonal variations. Males are only abundant in Taiwan from October to December, although females can be found year-around.

Abbreviations:

ALE — anterior lateral eyes, ALS — anterior lateral spinnerets; AME — anterior median eyes; PLE — posterior lateral eyes; PLS — posterior lateral spinnerets; PME — posterior median eyes; PMS — posterior median spinnerets.

Phylogenetic relationships

The monophyly of *Notiocoelotes* gen. nov. is supported by at least two putative synapomorphies: the presence of a tongue-shaped atrial scape on posterior atrium and the large, strongly bifurcated lateral tibial apophysis. The absence of epigynal teeth, the small, longitudinally elongated atrium, the large copulatory ducts, the absence of a patellar apophysis, the strongly elongated coiled conductor, the absence of a conductor dorsal apophysis, and the reduced or simple median apophysis might provide additional support for this hypothesis.

The sister group of *Notiocoelotes* gen. nov. is unknown. The absence of epigynal teeth, the absence of a patellar apophysis, and the reduced, simple median apophysis are the characteristics of some basal clade Coelotinae genera, i.e., *Coronilla* Wang 2004, *Femoracoelotes* Wang 2002, *Alloclubionoides* Paik 1992 (=*Ambanus* Ovtchinnikov 1999), and *Robusticoelotes* Wang 2002, but the presence of a long, coiled conductor and the absence of a conductor dorsal apophysis in *Notiocoelotes* gen. nov. are similar to the genus *Pireneitega* Kishida 1955 (=*Paracoelotes* Brignoli 1982) which is known from Europe, Central Asia, and East Asia. The absence of a conductor dorsal apophysis in *Notiocoelotes* gen. nov. is also similar to the genus *Iwogumoa* Kishida 1955 (=*Asiacoelotes* Wang 2002) from East Asia.

Biogeography

Although the Coelotinae genera *Coronilla* Wang 1994 and *Draconarius* Ovtchinnikov 1999 have been found widespread in East Asia and northern Southeast Asia (northern Vietnam and northern Thailand), species of *Notiocoelotes* gen. nov. are uniquely restricted only to northern regions of Southeast Asia (Huong Son in northern Vietnam, Khammouan in central Laos, Nakhon Ratchasima in central Thailand), in addition to Hainan Island of southern China (Fig. 44). This discontinuous distribution is probably an undersampling artifact. Coelotines from these and nearby regions, that is, Guangdong and Guangxi, China, northern Vietname, Laos, Thailand, are understudied. The origin and patterns of distribution of *Notiocoelotes* gen. nov. species still need to be further studied. It is possible that the northern regions of Southeast Asia consist of fragments broken off from the Australian plate, which rifted northwards, collided with the Eurasian plate, and became populated by East Asian Coelotinae. It is also possible that the northern regions of Southeast Asia are in fact part of the Eurasian plate and *Notiocoelotes* gen. nov. species either originated from this region and dispersed to Hainan island via continental China or originated from southern China and dispersed to both Hainan Island and southeast Asia. Hainan Island, situated south of mainland China and separated from the Leizhou Peninsula on the mainland by the Qiongzhou Strait only 15 km wide with an average depth of 60m, was separated and became islands during the late Tertiary (Duellman 1999, Hsu 1983). Under those hypotheses and the fact of disjunction distribution from Thailand, Laos, Vietnam, to Hainan, there might be more *Notiocoelotes* gen. nov. species waiting to be discovered from southern China and northern Laos, Vietnam and Thailand, particularly from Guangdong and Guangxi coastal regions, if they have not become extinct due to environment change. The Figure 44 shows the current distribution range of the five *Notiocoelotes* gen. nov. species.

Taxonomy

Amaurobiidae Thorell 1870

Coelotinae F.O.P.-Cambridge 1893

Notiocoelotes gen. nov.

Type species. – *Coelotes palinitropus* Zhu and Wang 1994

Etymology: The generic name is a compound word with the Greek word "notio" and the generic name *Coelotes*. "Notio" means "southern", referring to the southern distribution of this genus compared to other Coelotinae. Masculine in gender.

Diagnosis: Members of *Notiocoelotes* gen. nov. can be separated from other Coelotinae by the absence of epigynal teeth, the presence of a tongue-shaped atrial scape, and the large copulatory ducts in females, and by the absence of a patellar apophysis, the large, strongly bifurcated lateral tibial apophysis, the absence of a conductor dorsal apophysis, the strongly elongated, coiled conductor, and the reduced or simple median apophysis in males.

Description: Small to medium sized ecribellate spiders, total length 3.20–9.40. Somatic morphology is similar to other Coelotinae (Figs 3, 6, 14–16, 27–29, 36–37). From dorsal view, anterior eye row slightly procurved, posterior row procurved; AME smallest, less than or approximately half the size of ALE; ALE, PLE, and PME subequal (Figs 13, 26, 35); *N. laosensis* without AME (Figs 4, 7). Chilum divided, hairless. Chelicerae with 3 promarginal teeth and 2 retromarginal teeth (N. sparus with 3 retromarginal teeth). Trichobothria, tarsal organ and spinnerets of *N. vietnamensis* **sp. nov.** were examined under SEM. Tibiae with about four rows of trichobothria; metatarsi and tarsi with one row of trichobothria; trichobothria with large hood transversely striated and small hoods smooth (Figs 41–43). Tarsal organ with simple opening (Fig. 42). Leg length and spination similar to other Coelotinae, except *N. laosensis* **sp. nov.** which has relatively longer and slender legs due to its cave life habitat. Trachea not examined. Colulus represented by two clusters of hairs, each with 3 hairs on the examined specimen; ALS short; PMS short, approximately 11 aciniform gland spigots, 2 cylindrical gland spigots, 1 minor ampullate gland spigot; PLS second segment long, with approximately 11–12 aciniform gland spigots, and 2 cylindrical gland spigots (Figs 38–40).

Female epigynum simple, without teeth; atrium small, more or less elongated, reaching posteriorly epigastric furrow, with a tongue-shaped, posteriorly directed atrial scape; copulatory ducts broad, covering part of spermathecae and spermathecal heads from dorsal view; spermathecae with bases widely separated (Figs 1–2, 9–12, 17–18, 23–25, 30–31). Male palpus without patellar apophysis; RTA long, extending along most of tibial length; cymbial furrow longer than half of cymbial length; without conductor dorsal apophysis; conductor long, coiling; median apophysis either simple or absent, not spoon-shaped; embolus filiform, relatively strong, proximal in origin, with distal part coiled (Figs 19–22, 32–34).

Natural history: Species of *Notiocoelotes* gen. nov. were collected by searching under tree bark, under stone and other objects, inside a cave entrance, sifting leaf litter and were collected from pitfall traps.

Composition: Five species: *Notiocoelotes laosensis* **sp. nov.**(♀), *N. lingulatus* **sp. nov.** (♀), *N. palinitropus* (Zhu & Wang, 1994) **comb. nov.** (♀♂), *N. sparus* (Dankittipakul, Chami-Kranon & Wang, 2005) **comb. nov.** (♂), and *N. vietnamensis* **sp. nov.** (♀♂).

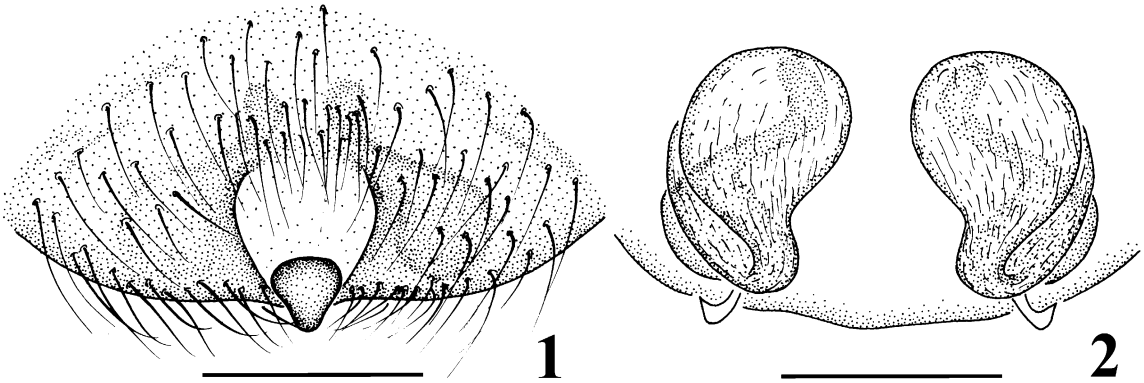
Distribution: China (Hainan Island), Laos (Khammouan), Thailand (Nakhon Ratchasima), and Vietnam (Huong Son) (Fig. 44).

Key to species

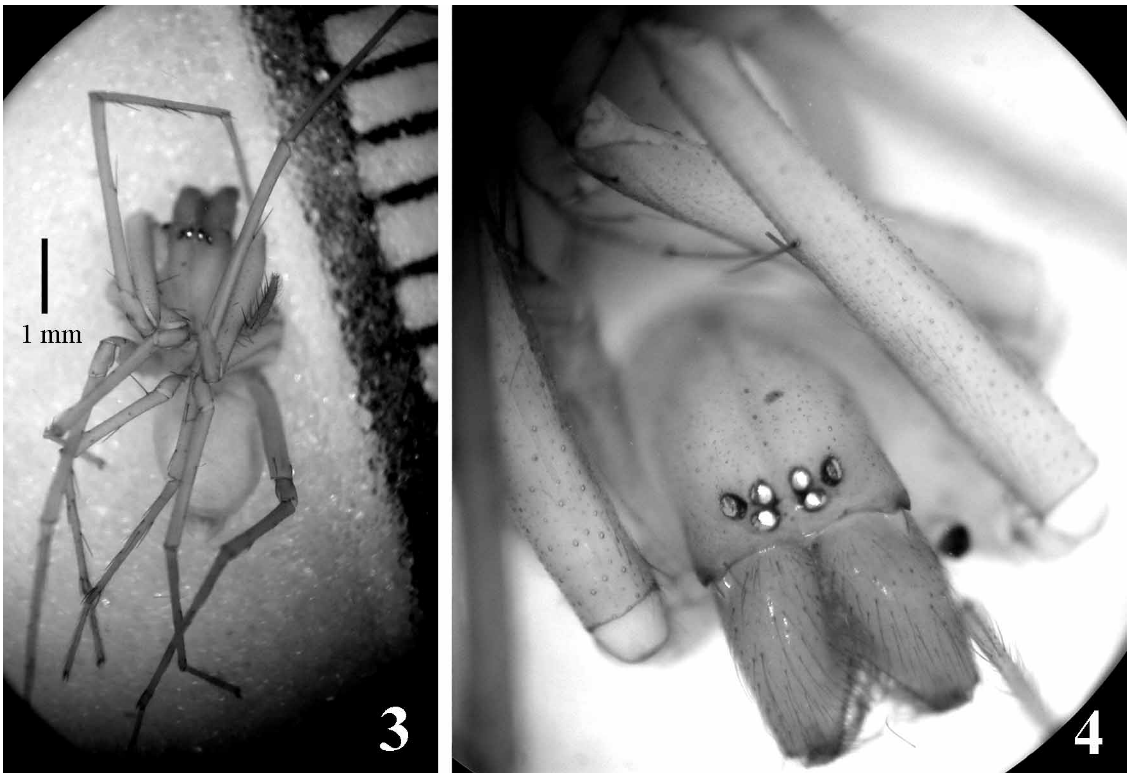
1. Males (those of *N. laosensis* **sp. nov.** and *N. lingulatus* **sp. nov.** unknown) 2
- Females (those of *N. sparus* unknown) 4
2. Median apophysis absent (Figs 19–22) 3
- Median apophysis present, simple (Figs 32–34) .... *vietnamensis* **sp. nov.**
3. Conductor strongly coiled, semi-circular (Figs. 19, 21–22) .... *palinitropus*
- Conductor slightly coiled, proximally extending, not semi-circular .... *sparus*
4. Atrium longitudinally extended, copulatory ducts at least partly fused together (Figs 17–18, 23–25, 30–31)..5
- Atrium circular-shaped, copulatory ducts distinctly separated over their entire length (Figs 1–2, 9–12)...6
5. Atrium length at least four times width, copulatory ducts strongly folded posteriorly (Figs 17–18, 23–25) .... *palinitropus*
- Atrium with length at most two times its width, copulatory ducts with slightly folded posterior edges (Figs 30–31) .... *vietnamensis* **sp. nov.**

6. Copulatory ducts posteriorly adjacent; spermathecal heads small, extending posteriorly (Figs 9–12).........
.... *lingulatus* **sp. nov.**

\- Copulatory ducts posteriorly separated; spermathecal heads large, extending anteriorly (Figs 1–2) ....
.... *laosensis* **sp. nov.**



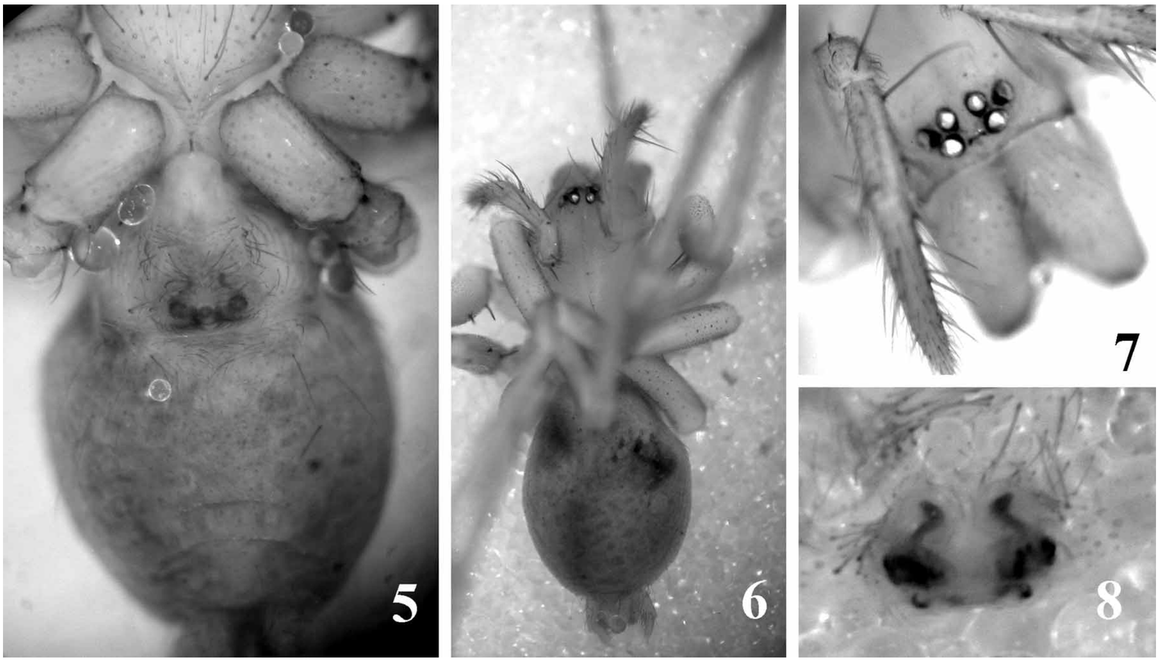
FIGURES 1–2. *Notiocoelotes laosensis* **sp. nov.**, holotype female from Khammouan, Laos. **1** Epigynum, ventral view; **2** Vulva, dorsal view.



FIGURES 3–4. *Notiocoelotes laosensis* **sp. nov.**, holotype female from Khammouan, Laos. **3** Habitus, dorsal view; **4** Prosoma, fronto-dorsal view (Scale line is not available).

Notiocoelotes laosensis sp. nov.
Figs 1–8, 44

Type material: Holotype female and 1 female paratype from Laos, Khammouan Province, 2.5 km WNW Ban (=village) Tathot, entrance N17°37.897', E105°07.502', exit N17°37.994', E105°07.195', ca. 200 m alt., entrance area and in the karst cave Tham Kamouk, February 19, 2003, P. Jäger leg. (SMF). 1 female paratype from Laos, Khammouan Province, 2.5 km WNW Ban Tathot, entrance N17°37.897', E105°07.502', exit N17°37.994', E105°07.195', ca. 200 m alt., entrance area and in the Karst cave Tham Kamouk, February 19, 2003, P. Jäger leg. (SMF). 1 female paratype from Laos, Khammouan, 2.5 km WNW Ban Tathot, entrance N17°37.897', E105°07.502', exit N17°37.994', E105°07.195', ca. 200 m alt., entrance area and in the karst cave Tham Kamouk, February 19, 2003, H. Steiner leg. (SMF).



FIGURES 5–8. *Notiocoelotes laosensis* **sp. nov.**, female paratype from Khammouan, Laos. **5** Opisthosoma, ventral view; **6** Habitus, dorsal view; **7** Eyes, fronto-dorsal view; **8** Vulva, dorsal view (Scale lines are not available).

Additional material examined: 1 juvenile male and 1 juvenile female, in same vial as holotype (SMF); 3 juvenile females from Laos, Khammouan Province, 2.5 km WNW Ban Tathot, entrance N17°37.897', E105°07.502', exit N17°37.994', E105°07.195', ca. 200 m alt., entrance area and in the karst cave Tham Kamouk, February 19, 2003, H. Steiner leg. (SMF).

Etymology: The specific name refers to the type locality of the species, Laos; adjective.

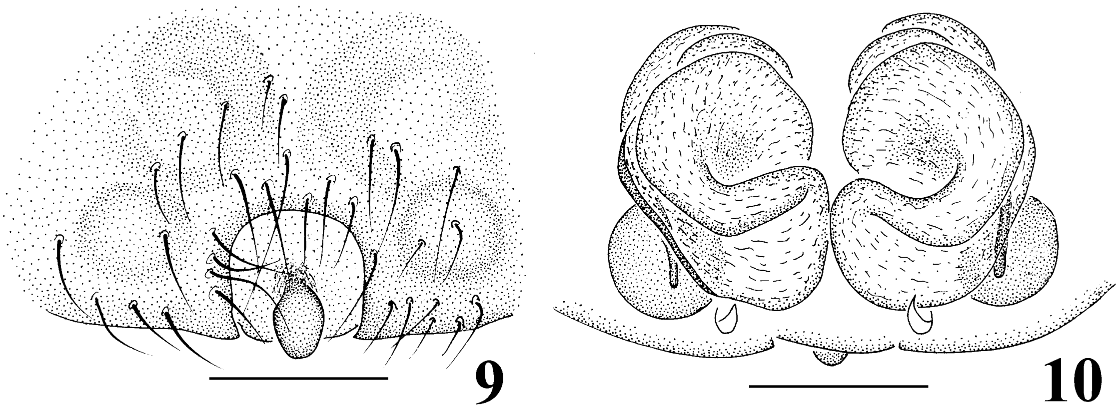
Diagnosis: *Notiocoelotes laosensis* **sp. nov.** resembles *N. vietnamensis* **sp. nov.** from Vietnam in having distinct, long spermathecal heads but can be easily distinguished by the relatively small, distinctly separated copulatory ducts (Figs 1–2, 8), whereas *N. vietnamensis* **sp. nov.** has large, medially adjacent copulatory ducts.

Description: Female holotype: Small sized coelotine, total length 4.32. Dorsal shield of prosoma 1.92 long, 1.44 wide; opisthosoma 2.40 long, 1.60 wide. Body pale, without distinct color pattern (Figs 3, 6). Eye sizes and interdistances: anterior row with only two eyes, AME absent, other eyes subequal (AME missing, ALE 0.10, PME 0.08, PLE 0.10); ALE and PME slightly separated, other eyes distinctly separated (ALE–ALE 0.12, ALE–PLE 0.04, PME–PME 0.06, PME–PLE 0.04) (Figs 4, 7). Chelicera with 3 promarginal and 2 retromarginal teeth. Legs slightly long and slender comparing to other coelotines, with length of first leg about 5.67 times dorsal shield of prosoma length (I 10.88; II 8.48; III 7.52; IV 10.56). Epigynum without teeth; atrium small, length subequal to width, with distinct scape on posterior edge; copulatory ducts large, rounded, folded posterolaterally; spermathecae small, widely separated; spermathecal heads long, strong, extending anteriorly and covered by copulatory ducts from dorsal view (Figs 1–2, 8).

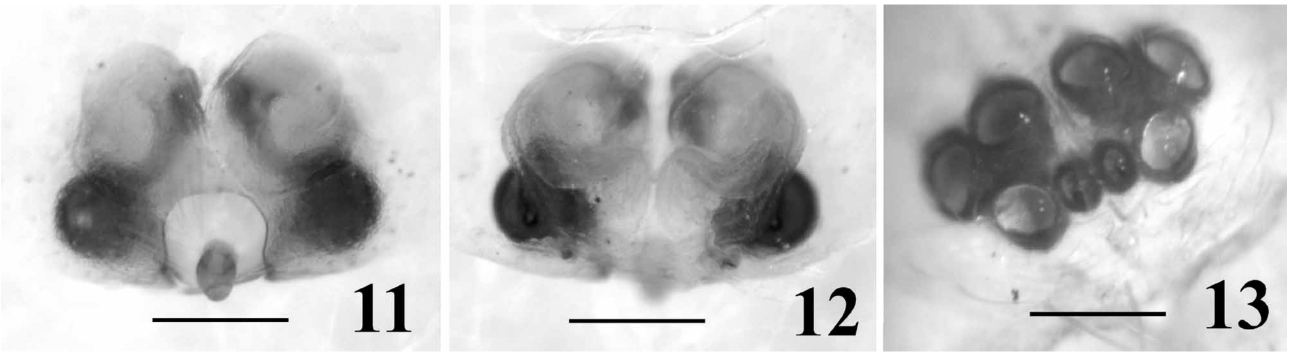
Male: Only immatures were collected, adults are unknown.

Habitat: The spider was collected from a limestone cave in a Karstic region.

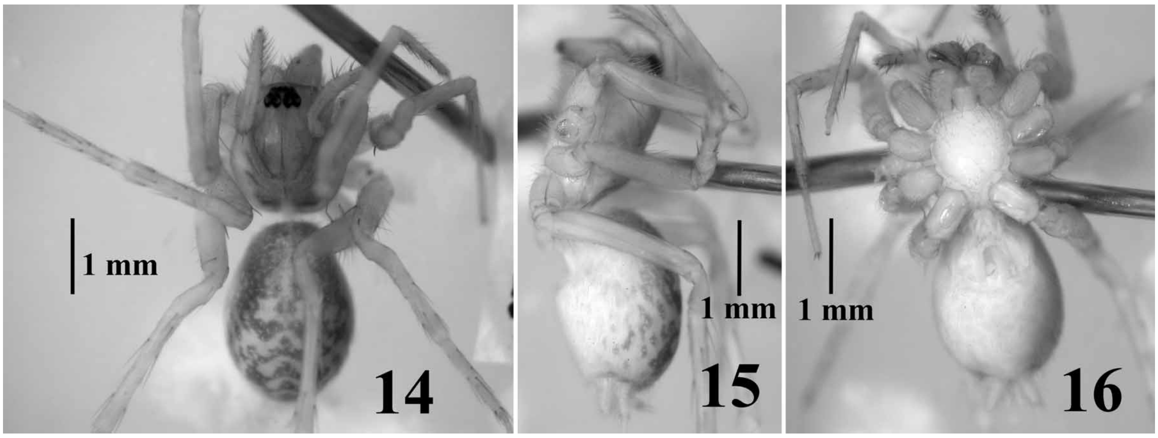
Distribution: Laos (Khammouan) (Fig. 44).



FIGURES 9–10. *Notiocoelotes lingulatus* **sp. nov.**, holotype female from Diaoluoshan Mt., Hainan, China. **9** Epigynum, ventral view; **10** Vulva, dorsal view.



FIGURES 11–13. *Notiocoelotes lingulatus* **sp. nov.**, holotype female from Diaoluoshan Mt., Hainan, China. **11** Epigynum, ventral view; **12** Vulva, dorsal view; **13** Eyes, fronto-dorsal view.



FIGURES 14–16. *Notiocoelotes lingulatus* **sp. nov.**, holotype female from Diaoluoshan Mt., Hainan, China, habitus (14 dorsal, 15 lateral, 16 ventral view).

Notiocoelotes lingulatus sp. nov.

Figs 9–16, 44

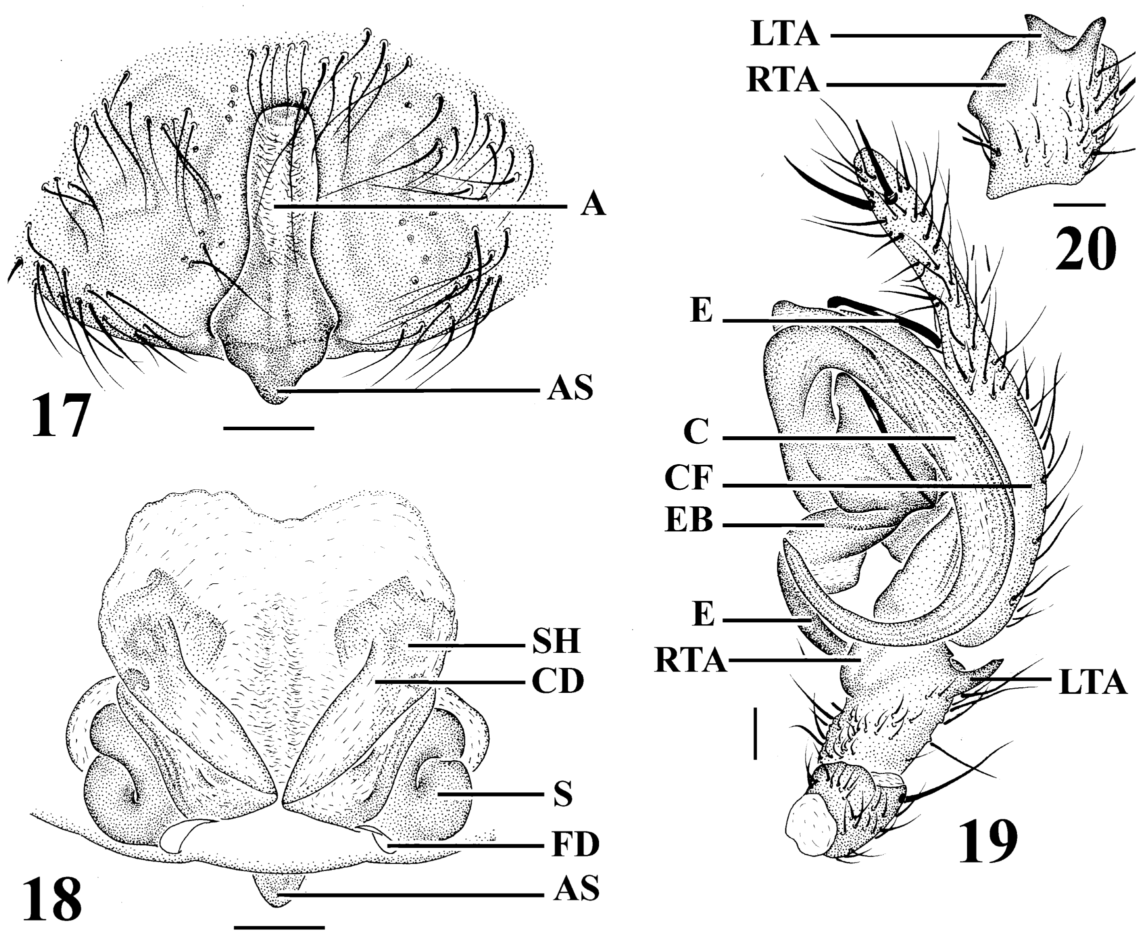
Type material: Holotype female: China, Hainan Province, Diaoluoshan Mt., N18.7º, E109.8º, December 23, 1989 (IZCAS).

Etymology: The species name is derived from the Latin “lingulatus”, meaning tongue-shaped, and refers to the tongue-shaped atrial scape; adjective.

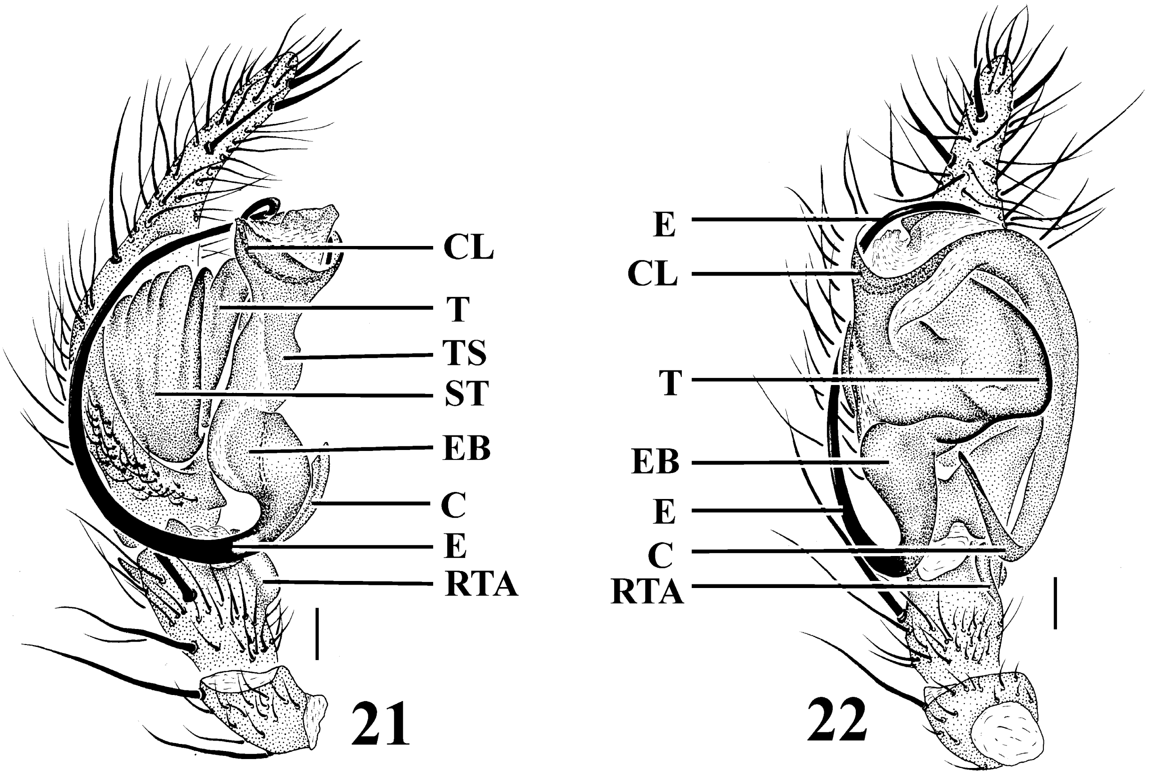
Diagnosis: *Notiocoelotes lingulatus* **sp. nov.** resembles *N. palinitropus* from Hainan, China in having the strongly folded copulatory ducts and the small spermathecal heads but can be easily distinguished by the short, square-shaped atrium and the distinctly separated, semi-circular copulatory ducts (Figs 9–12), whereas *N. palinitropus* has a strongly elongated atrium and large, fused, anteriorly extending copulatory ducts.

Description: Female holotype: Small sized coelotine, total length 4.20. Dorsal shield of prosoma 1.90 long, 1.40 wide; opisthosoma 2.30 long, 1.65 wide (Figs 14–16). Eye sizes and interdistances: AME smallest, approximately half the size of other eyes which are subequal and clustered (AME 0.06, ALE 0.10, PLE 0.12, PME 0.12); AME–PME separated by approximately PME diameter (Fig. 13). Chelicera with 3 promarginal and 2 retromarginal teeth. Legs normal length (I 5.50; II 4.80; III 4.50; IV 5.95) (1st leg/dorsal shield of prosoma = 2.90). Epigynum without teeth; atrium small, length and width subequal; atrial scape distinct, situated on posterior atrial edge; copulatory ducts large, anteriorly originating, extending and folding posteriorly semi-circular; spermathecae small, widely separated; spermathecal heads long, extending posteriorly, covered mostly by copulatory ducts and only their distal parts visible from dorsal view (Figs 9–12).

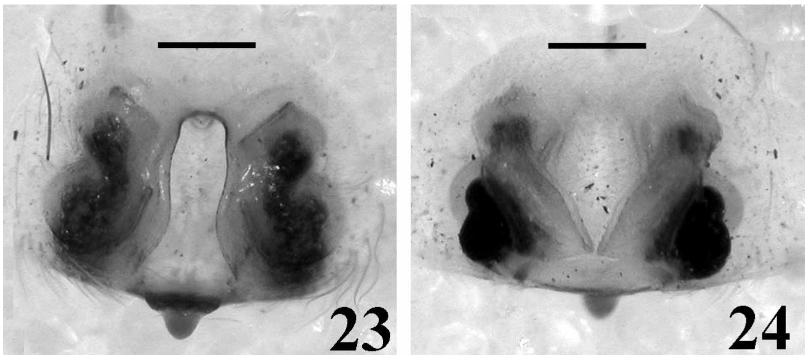
Distribution: China (Hainan) (Fig. 44).



FIGURES 17–20. *Notiocoelotes palinitropus* (Zhu & Wang, 1994), female (17–18) and male (19–20) from Jianfengling Nature Reserve, Hainan, China. **17** Epigynum, ventral view; **18** Vulva, dorsal view; **19** Left palp, retrolateral view; **20** Left palp, tibia, retrolateral view, showing the bifurcated LTA. A=atrium; AS = atrial scape; C = conductor; CD = copulatory duct; CF = cymbial furrow; E = embolus; EB = embolic base; FD = fertilization duct; S = spermathecae; SH = spermathecal head; LTA = lateral tibial apophysis; RTA = retrolateral tibial apophysis.



FIGURES 21–22. *Notiocoelotes palinitropus* (Zhu & Wang, 1994), male from Jianfengling Nature Reserve, Hainan, China, left palpus (21 prolateral, 22 ventral view). C = conductor; CL = conductor lamella; E = embolus; EB = embolic base; RTA = retrolateral tibial apophysis; ST = subtegulum; T = tegulum; TS = tegular sclerite.



FIGURES 23–24. *Notiocoelotes palinitropus* (Zhu & Wang, 1994), female from Jianfengling Nature Reserve, Hainan, China. **23** Epigynum, ventral view; **24** Vulva, dorsal view.

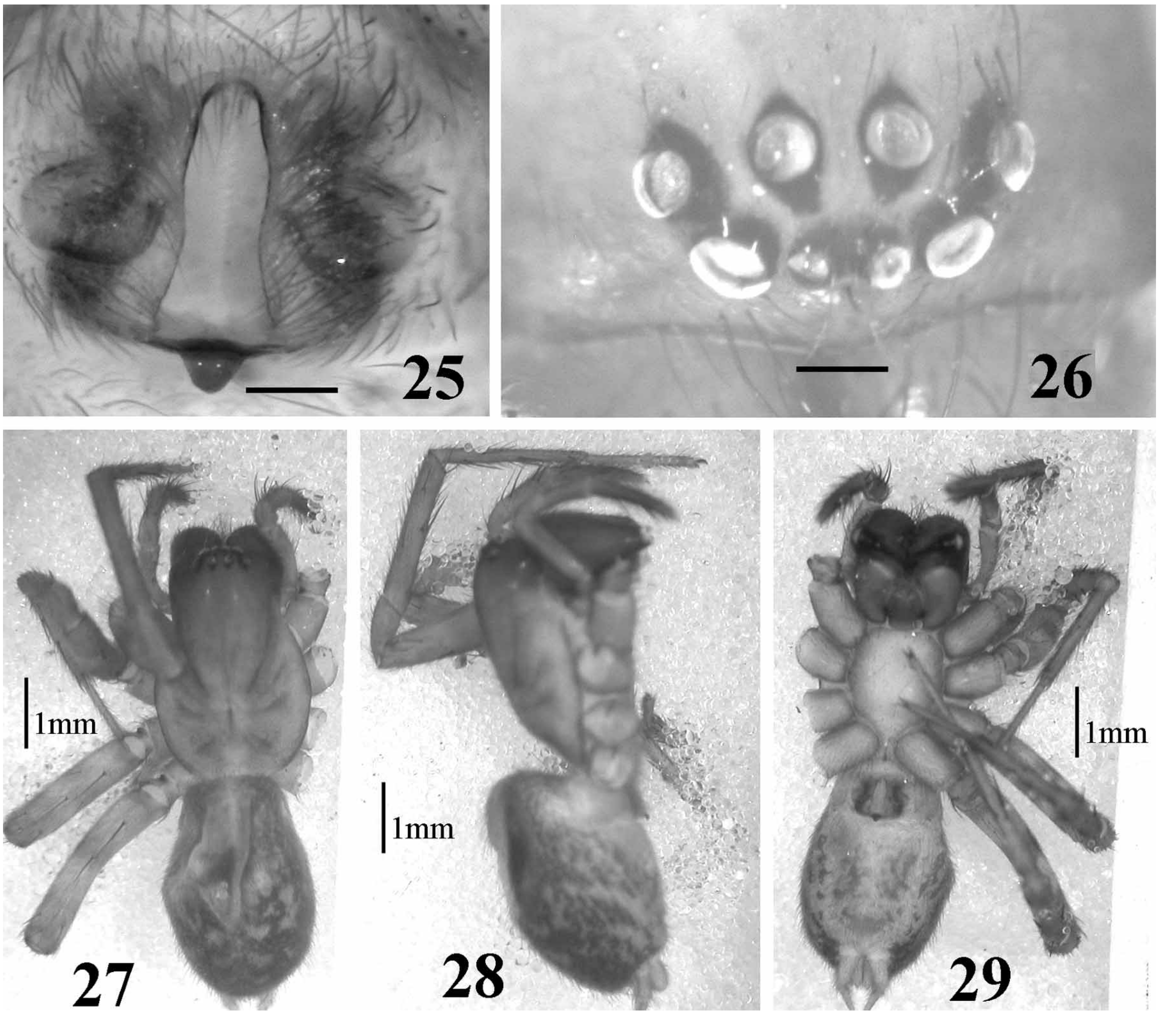
Notiocoelotes palinitropus (Zhu and Wang 1994) comb. nov.

Figs 17–29, 44

Coelotes palinitropus Zhu and Wang 1994: 42, figs 19–21 (holotype male, 1 male paratype from Jianfengling, Hainan, China, in NBUMS, not examined). —Song *et al.* 1999: 377, figs 220O, 224C; Xu and Li 2006a: 337, figs 8–13, 35–37.

Material examined: 6 females, 2 males: China, Hainan, Jianfengling Nature Reserve, N18.7°, E108.8°, December 14, 1989 (IZCAS); 1 female: China, Hainan, Wuzhishan Mt., N18.8°, E109.5°, April 16, 2005, Y.J. Song leg. (IZCAS); 1 female: Hainan, Diaoluoshan Nature Reserve, N18.7°, E109.8°, April 19, 2005, Y.J.

Song leg. (IZCAS); 1 female: China, Hainan, Baoting County, Maogan Xiang, Xian An, Shilin cave, N18.7º, E109.8º, March 2005, Y.F. Tong leg. (IZCAS).



FIGURES 25–29. *Notiocoelotes palinitropus* (Zhu & Wang, 1994), female from Dianyushan, Hainan, China. **25** Epigynum, ventral view; **26** Eyes, fronto-dorsal view; **27–29** Habitus (27 dorsal, 28 lateral, 29 ventral view).

Diagnosis: Females of *N. palinitropus* can be easily distinguished by the elongated atrium which is 4–5 times longer than wide (Figs 17, 23, 25). Males can be easily distinguished from *N. vietnamensis* **sp. nov.** by the reduced median apophysis (large in *N. vietnamensis*), and from *N. sparus* by the semi-circular conductor (proximally extended and only slightly coiled in *N. sparsus*) (Figs 19–22).

Description: Females: Described by Xu and Li (2006a). Medium sized coelotine, total length 8.26–9.40. One female from Hainan, Jianfengling Nature Reserve: Total length 8.26. Dorsal shield of prosoma 3.91 long, 2.61 wide; opisthosoma 4.35 long, 3.04 wide. Eye sizes and interdistances: AME smallest, slightly more than half the size of other eyes which are subequal (AME 0.09, ALE 0.15, PLE 0.15, PME 0.14); AME separated by approximately their diameter; AME and ALE slightly separated, other eyes distinctly separated (ALE–PLE 0.06, PME–PME 0.09, PME–PLE 0.12, AME–PME 0.12) (Fig. 26). Chelicerae with 3 promarginal and 2 retromarginal teeth. Legs normal length (I 11.30; II 9.45; III 7.60; IV 12.28) (1^{st} leg/dorsal shield of prosoma = 2.90). Epigynum without teeth; atrium strongly elongated, with length 4–5 times longer than width; posterior margin of atrium with a tongue-shaped, posteriorly directed atrial scape; copulatory ducts large, anteriorly originated, posteriorly folded, covering anterior part of spermathecae; spermathecal bases broad, widely separated by copulatory ducts; spermathecal heads covered by copulatory ducts (Figs 17–18, 23–25).

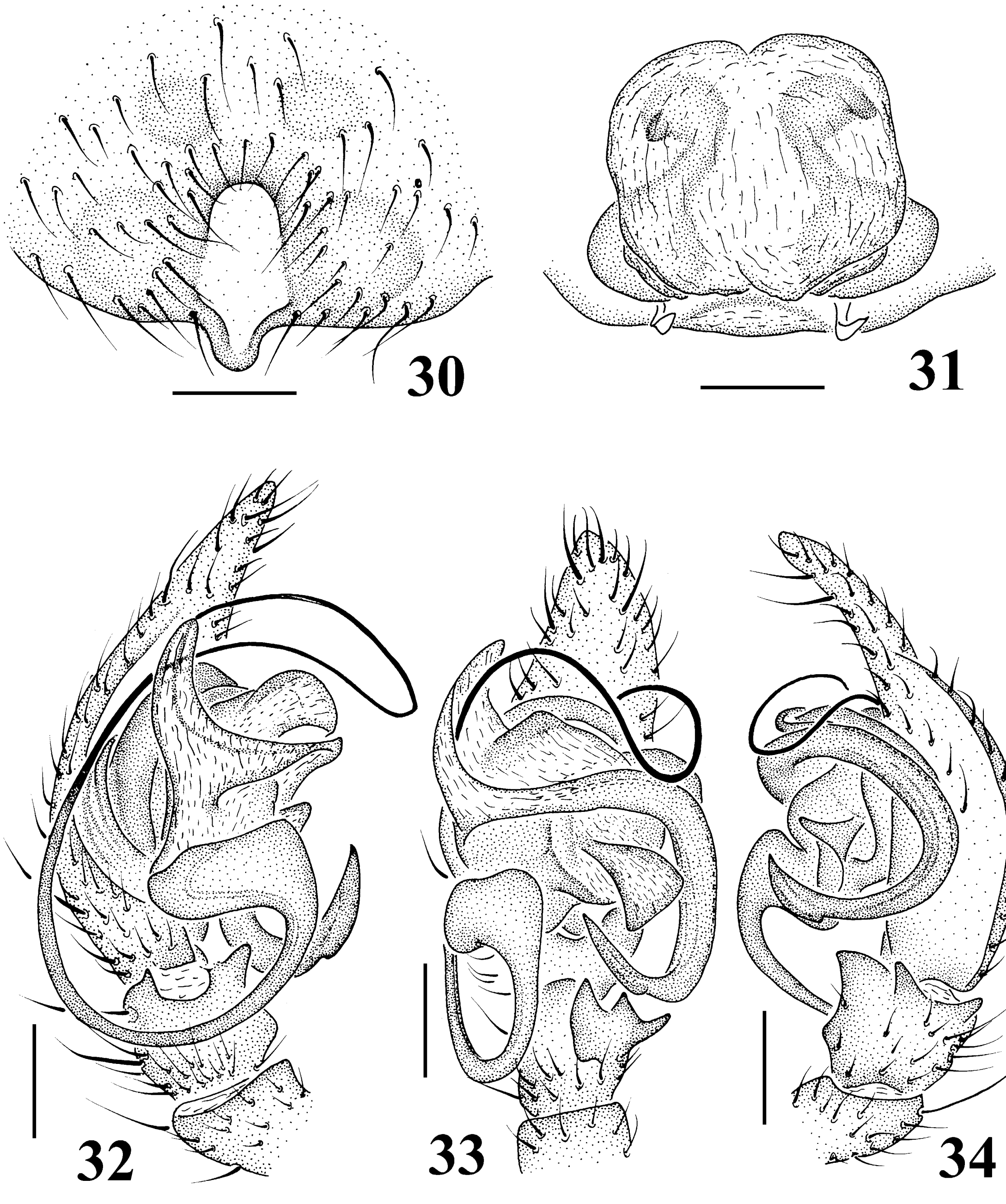
Males: Described by Zhu and Wang (1994). Medium sized coelotine, total length 6.70–7.70. Eyes and chelicerae similar to female. Palpus without patellar apophysis; RTA small; lateral tibial apophysis strongly bifurcated; cymbial furrow about half of cymbial length or slightly longer; conductor long, extending proximally, coiling and forming a semi-circular shape; conductor dorsal apophysis absent; conductor lamella large; median apophysis reduced; embolus filiform, proximal in origin, with narrow base (Figs 19–22).

Distribution: China (Hainan) (Fig. 44).

Notiocoelotes sparus (Dankittipakul, Chami-Kranon & Wang 2005) comb. nov.

Fig. 44

Asiacoelotes sparus Dankittipakul *et al.* 2005: 3, figs 1–3 (holotype male from Nakhon Ratchasima Province, Pak Chong District, Khao Yai National Park, Khao Khieo, central Thailand, deposited in MHNG, examined).



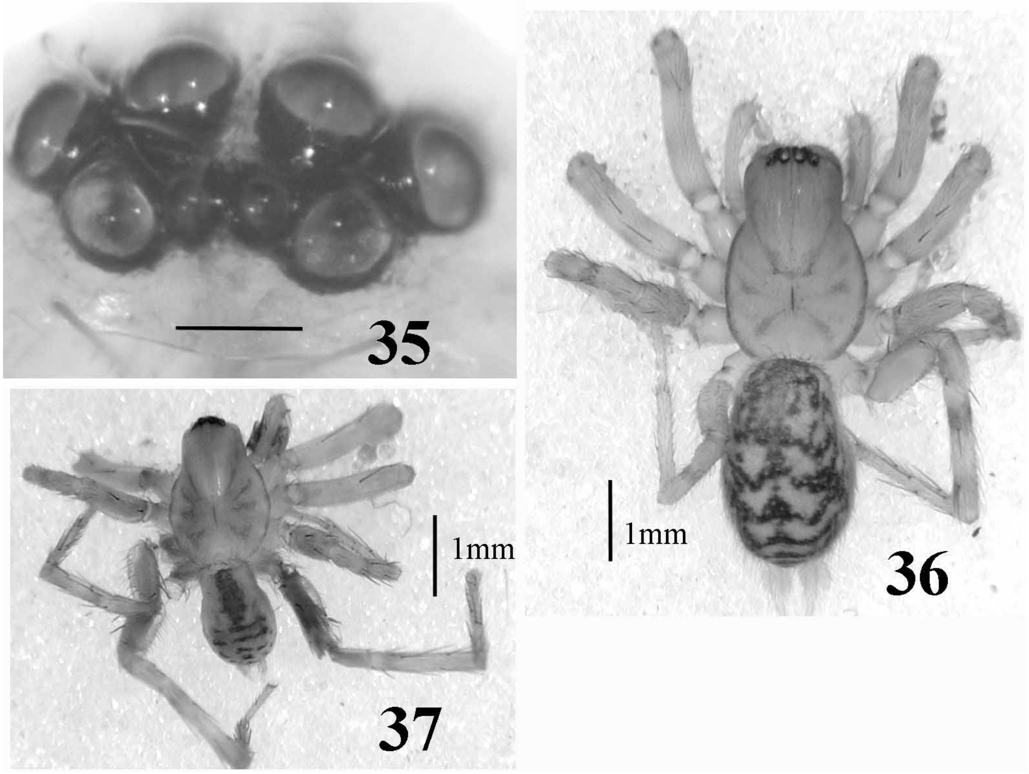
FIGURES 30–34. *Notiocoelotes vietnamensis* **sp. nov.**, holotype female (30–31) and male paratype (32–34) from Huong Son, Vietnam. **30** Epigynum, ventral view; **31** Vulva, dorsal view; **32–34** Left palpus (32 prolateral, 33 ventral, 34 retrolateral view).

Diagnosis: Males can be easily distinguished from *N. palinitropus* (Zhu & Wang, 1994) and *N. vietnamensis* **sp. nov.** by the less coiled conductor (Dankittipakul et al 2005: figures 1–3).

Description: Males: Described by Dankittipakul *et al.* (2005). Small sized coelotine, total length 3.45. AME smallest, half size of other eyes; ALE, PLE, PME subequal; PME and PLE distinctly separated by two times of their size, other eyes equal separated by slightly more than AME diameter. Chelicerae with 3 promarginal and 3 retromarginal teeth. Legs long (1st leg/dorsal shield of prosoma = 4.35). Palpus without patellar apophysis; RTA small, about half of tibial length; lateral tibial apophysis strongly bifurcated, situated close to RTA; cymbial furrow slightly more than half of cymbial length; conductor long, extending proximally, with slender apex, only slightly coiled comparing to other *Notiocoelotes* species; conductor dorsal apophysis absent; conductor lamella moderately large; median apophysis reduced; embolus filiform, originating proximally.

Habitats: The spiders were collected by sifting leaf litter and humus in a lower montane rain forest just above the semi-evergreen forest below (Dankittipakul *et al.* 2005).

Distribution: Thailand (Nakhon Ratchasima) (Fig. 44).



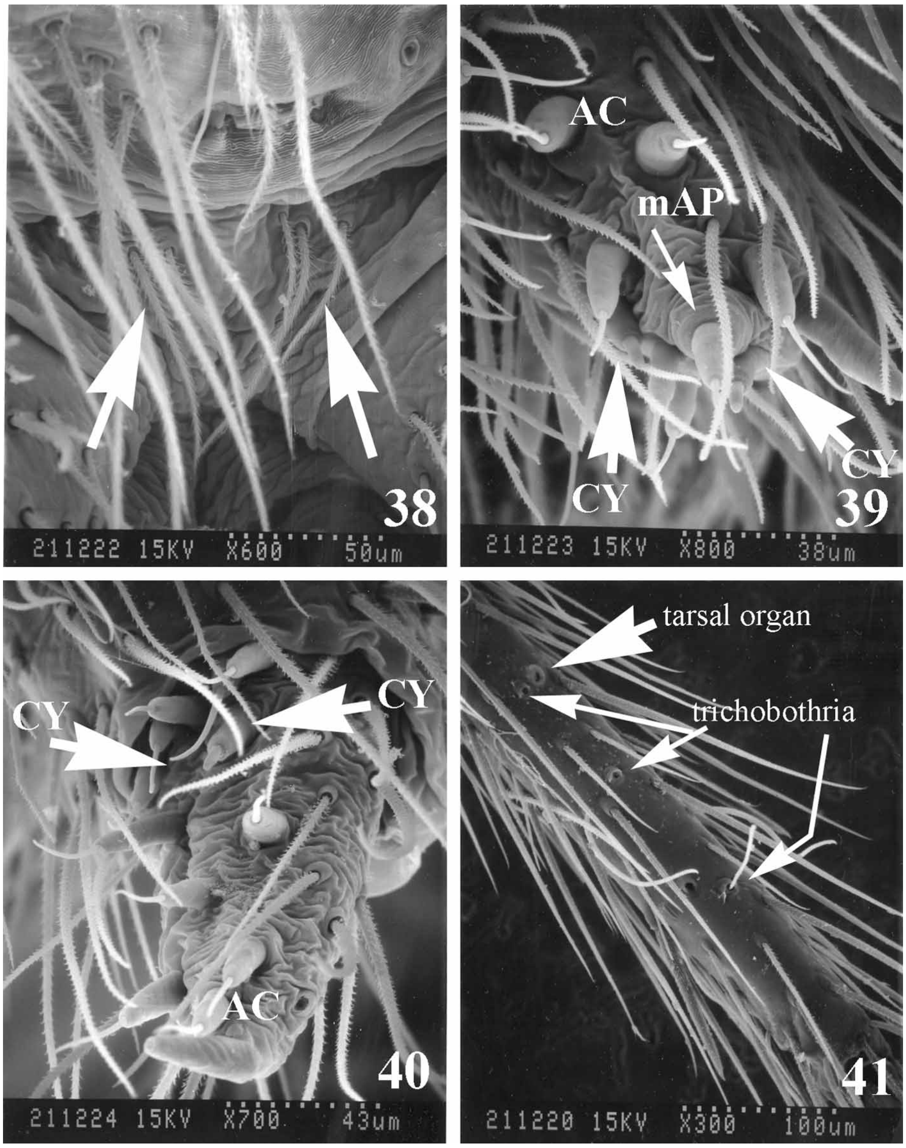
FIGURES 35–37. *Notiocoelotes vietnamensis* **sp. nov.**, holotype female (35–36) and male paratype (37) from Huong Son, Vietnam. **35** Eyes, fronto-dorsal view; **36–37** Habitus, dorsal view.

Notiocoelotes vietnamensis sp. nov.

Figs 30–43, 44

Type material: Holotype female: Vietnam, Huong Son, leaf litter, 1000m, May 9, 1998, D. Silva leg. (AMNH); 1 male paratype: Vietnam, Rao An River, 13 km W Huong Son, Route 8, Hatinh Tinh, 1100m, N18°20'50", E105°14'41", pitfall trap, May 21, 1998, D. Silva leg. (AMNH); 1 female paratype: Vietnam, Rao An River, 13 km W Huong Son, Route 8, Hatinh Tinh, 940m, N18°20'52", E105°14'41"E, May 15, 1998, D. Silva leg. (AMNH); 1 female paratype: Vietnam, Huong Son, pitfall trap, 680m, May 12, 1998, D. Silva (AMNH).

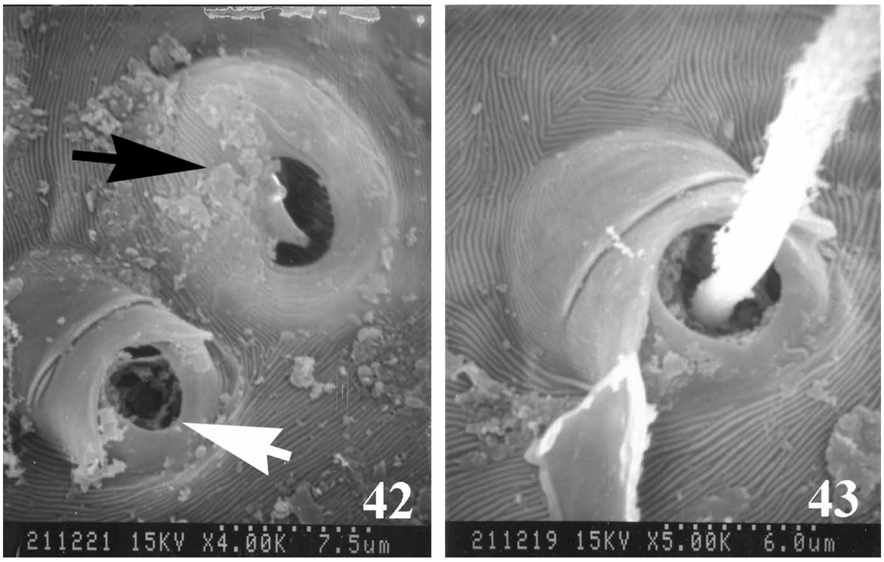
Etymology: The specific name refers to its type locality; adjective.



FIGURES 38–41. Notiocoelotes *vietnamensis* **sp. nov.**, female paratype from Huong Son, Vietnam. **38** Colulus, represented by setae (indicated by arrows); **39** PMS; **40** PLS; **41** Tarsus of the fourth leg, showing position of tarsal organ and trichobothria. AC = aciniform gland spigots; CY = cylindrical gland spigots; mAP = minor ampullate gland spigot.

Diagnosis: Males of this new species are similar to *N. palinitropus* in having a long, coiled conductor but can be distinguished by the presence of a large median apophysis and the presence of an indentation on the distal conductor (Figs 32–34). Females are similar to *N. palinitropus* in having an elongated atrium, but this being much shorter than in *N. palinitropus*.

Description: Female holotype: Medium sized coelotine, total length 5.20. Dorsal shield of prosoma 2.60 long, 1.77 wide; opisthosoma 2.60 long, 1.69 wide (Fig. 36). Eye arrangements of *N. vietnamensis* **sp. nov.** is similar to that of *N. lingulatus* **sp. nov.** AME smallest, approximately half the size of other eyes which are subequal and clustered (AME 0.08, ALE 0.16, PME 0.16, PLE 0.16); AME–PME separated by approximately PME diameter (Fig. 35). Chelicerae with 3 promarginal and 2 retromarginal teeth. Legs normal length (I 7.28; II 6.06; III 5.54; IV 7.82) (1st leg/ dorsal shield of prosoma = 2.79). Spinnerets with ALS short; PMS small, approximately 11 aciniform gland spigots, 2 cylindrical gland spigots, minor ampullate gland spigots not observed on the specimen examined; PLS second segment long, with approximately 11–12 aciniform gland spigots, and 2 cylindrical gland spigots (Figs 38–40). Epigynal teeth absent; atrium small, elongated, with a tongue-shaped posterior extension; copulatory ducts broad, covering most of spermathecae; spermathecae small, rounded, widely separated; spermathecal heads extended anteriorly, with distinct stalks (Figs 30–31).



FIGURES 42–43. *Notiocoelotes vietnamensis* **sp. nov.**, female paratype from Huong Son, Vietnam. **42** Tarsal organ (indicated by black arrow) and the third trichobothrium (indicated by white arrow, the hair itself is absent); **43** Trichobothrium, base, from the tarsus of the fourth leg.

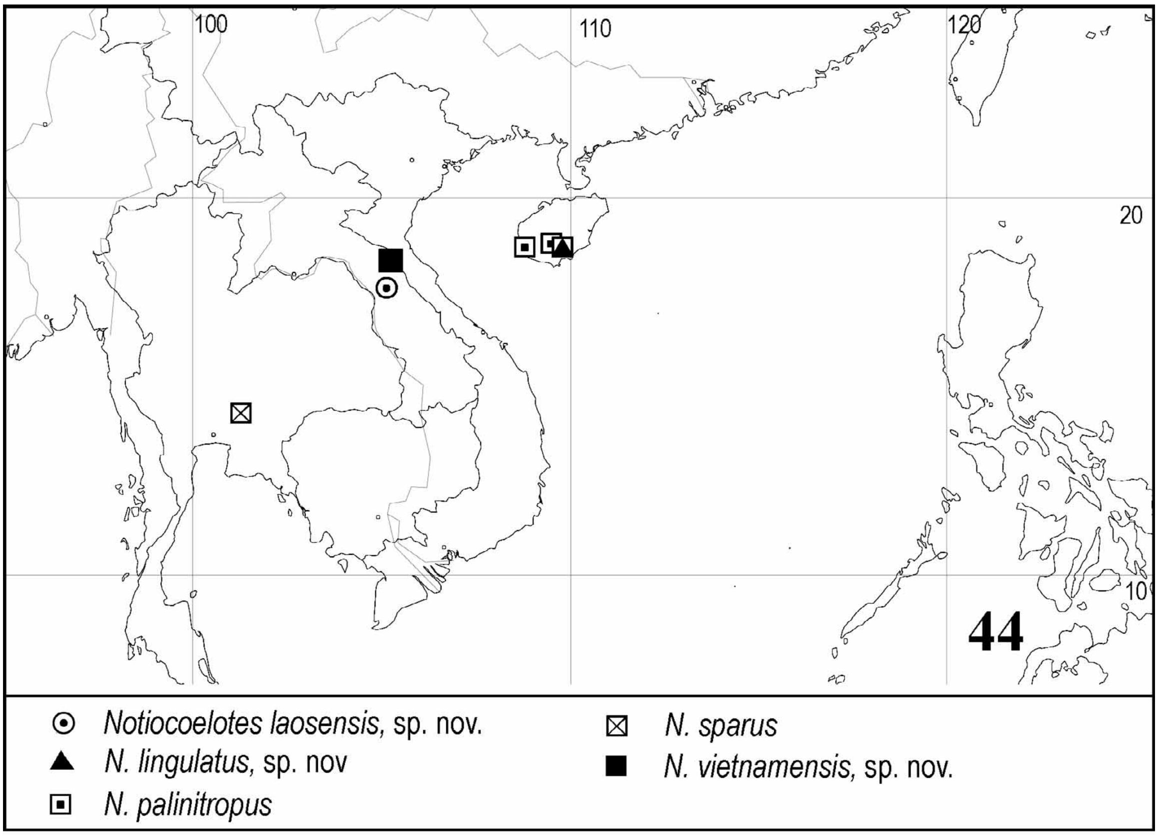


FIGURE 44. Records of species of *Notiocoelotes* gen. nov.

Male paratype: Small sized coelotine, total length 3.20. Dorsal shield of prosoma 1.80 long, 1.75 wide; opisthosoma 1.40 long, 0.90 wide (Fig. 37). Eye sizes and interdistances: AME smallest, approximately half the size of other eyes which are approximately same size and clustered (AME 0.04, ALE 0.10, PME 0.09, PLE 0.10); AME–PME separated by approximately PME diameter. Chelicerae with 3 promarginal and 2 retromarginal teeth. Legs normal length (I 5.84; II 4.80; III 4.70; IV 6.12) (1st leg/ dorsal shield of prosoma = 3.24). Palpus without patellar apophysis; RTA occupying most of tibial length; lateral tibial apophysis large, strongly bifurcated; cymbial furrow long, slightly more than half of cymbial length; conductor long, extending proximally, coiling, semi-circular; conductor dorsal apophysis absent; conductor lamella large; median apophysis large, simple, not spoon-shaped; embolus filiform, originating proximally (Figs 32–34).

Habitats. The spiders were collected by sifting leaf litter and by pitfall trapping in montane rain forest between 700–1100 meters elevation.

Distribution. Vietnam (Huong Son) (Fig. 44).

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New species of the spider genus *Platocoelotes* Wang, 2002 (Araneae: Amaurobiidae)

Xiang XU[1, 2] & Shuqiang LI[1, 3]
[1] Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China.
[2] College of Life Science, Hunan Normal University, Changsha 410081, P. R. China.
[3] Corresponding author. E-mail: lisq@ioz.ac.cn

New species of the spider genus *Platocoelotes* Wang, 2002 (Araneae: Amaurobiidae). - Nine species from China, including four new species described in the current paper, are placed in the spider genus *Platocoelotes*. The new species are: *Platocoelotes daweishanensis* sp. n., *Platocoelotes globosus* sp. n., *Platocoelotes latus* sp. n. and *Platocoelotes paralatus* sp. n. A key and a distribution map for all nine species in this genus are provided.

Keywords: Taxonomy - morphology - cave adaptation - China.

INTRODUCTION

The spider genus *Platocoelotes* was established and revised by Wang in 2002 and 2003, respectively. Five valid *Platocoelotes* species were so far known, i.e. *P. impletus* (Peng & Wang, 1997), *P. icohamatoides* (Peng & Wang, 1997) and *P. polyptychus* Xu & Li, 2007 from Hunan, *P. kailiensis* Wang, 2003 from Guizhou, *P. lichuanensis* (Chen & Zhao, 1998) from Hubei (see Platnick, 2007). All these species are distributed in central and southwest China, which lie in the transition zone between the Palaearctic and the Oriental realms.

The current paper provides descriptions of four new *Platocoelotes* species, three of which were collected in caves, i.e. *P. globosus* sp. n., *P. latus* sp. n. and *P. paralatus* sp. n. These three new cave species all have simple and more or less rounded spermathecae, indistinct copulatory ducts, mesally situated epigynal hoods, a short cymbial furrow, and a single patellar apophysis. However, the presence of a ventral conductor apophysis on the male palp and the broad, shallow atrium in the female epigynum indicate that they are congeneric with the type species of *Platocoelotes*.

METHODS

Specimens were examined with an Olympus SZ40 stereomicroscope; details were studied with an Olympus BX41 compound microscope. All illustrations were made using an Olympus drawing tube. Male palps and female epigyna were examined and illustrated after being dissected from the spider bodies.

All measurements were obtained using an Olympus SZ40 stereomicroscope and are given in millimeters. Leg measurements are given as: Total length (femur, patella

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+ tibia, metatarsus, tarsus). Only structures (e.g., palp, legs) of the left body side were described and measured. The terminology used in text and figure legends follows Wang (2002). Abbreviations used in text and legends: A = atrium; ALE = anterior lateral eye; AME = anterior median eye; AME-ALE = distance between AME and ALE; AME-AME = distance between AME and AME; ALE-PLE = distance between ALE and PLE; C = conductor; CD = copulatory duct; CDA = dorsal conductor apophysis; CF = cymbial furrow; E = embolus; FD = fertilization duct; H = epigynal hood; LTA = lateral tibial apophysis; PA = patellar apophysis; PLE = posterior lateral eye; PME = posterior median eye; PME-PLE = distance between PME and PLE; PME-PME = distance between PME and PME; RTA = retrolateral tibial apophysis; S = spermatheca; SB = spermathecal base; SST = spermathecal stalk; ST = subtegulum; T = tegulum; TS = tegular sclerite. All types of the new species are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS), and in the Muséum d'histoire naturelle de Genève, Switzerland (MHNG).

TAXONOMY

Platocoelotes Wang, 2002

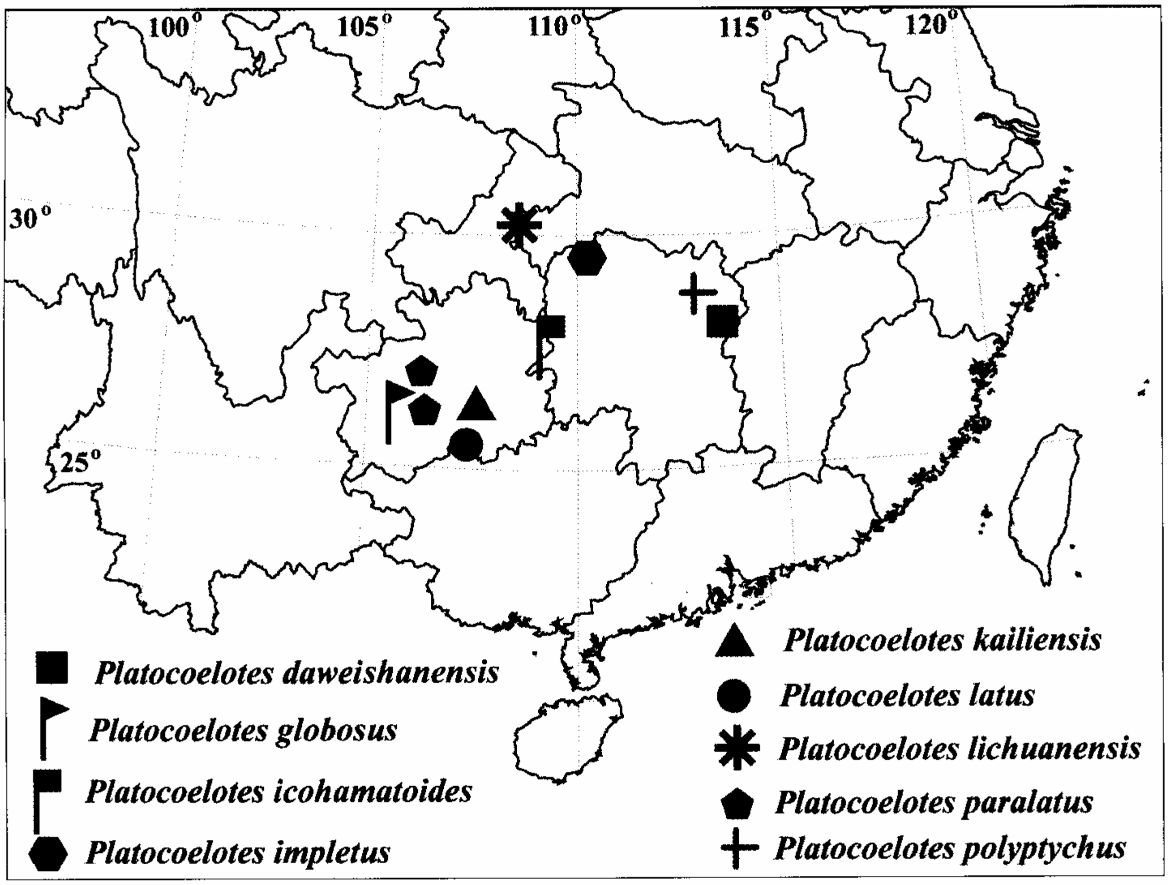
Platocoelotes Wang, 2002: 119. – Wang, 2003: 561.

DIAGNOSIS: Male palpal organ without median apophysis and with ventral conductor apophysis; two patellar apophyses and a dorsal conductor apophysis present in most species; cymbial furrow length varying from less than one third to more than two thirds of cymbium length. Epigynum without epigynal teeth; epigynal hoods distinct, situated close to or widely apart from epigastric furrow; genital atrium large and shallow; spermathecae strongly convoluted or simple and globose; spermathecal heads and copulatory ducts small in most species.

DISTRIBUTION: China (Guizhou, Hubei, Hunan, Sichuan) (Map 1).

KEY TO THE SPECIES OF THE GENUS *PLATOCOELOTES*:

1a Males (those of *P. globosus* and *P. icohamatoides* unknown) 2
1b Females (those of *P. lichuanensis* unknown) 8
2a Conductor strongly modified and forming a large cavity 3
2b Conductor not forming a large cavity 4
3a Ventral conductor apophysis short and blunt . . . . *paralatus* sp. n.
3b Ventral conductor apophysis long and slender . . . . *latus* sp. n.
4a Conductor deeply bifid . . . . *polyptychus*
4b Conductor not bifid 5
5a Apical conductor apophysis present 6
5b Apical conductor apophysis absent . . . . *daweishanensis* sp. n.
6a Apical conductor apophysis large . . . . *lichuanensis*
6b Apical conductor apophysis small 7
7a Embolus with base extending posteriorly . . . . *kailiensis*
7b Embolus with base extending prolaterally . . . . *impletus*
8a Atrium with atrial septum . . . . *polyptychus*
8b Atrium without atrial septum 9



MAP 1

Records of nine *Platocoelotes* species in southern China.

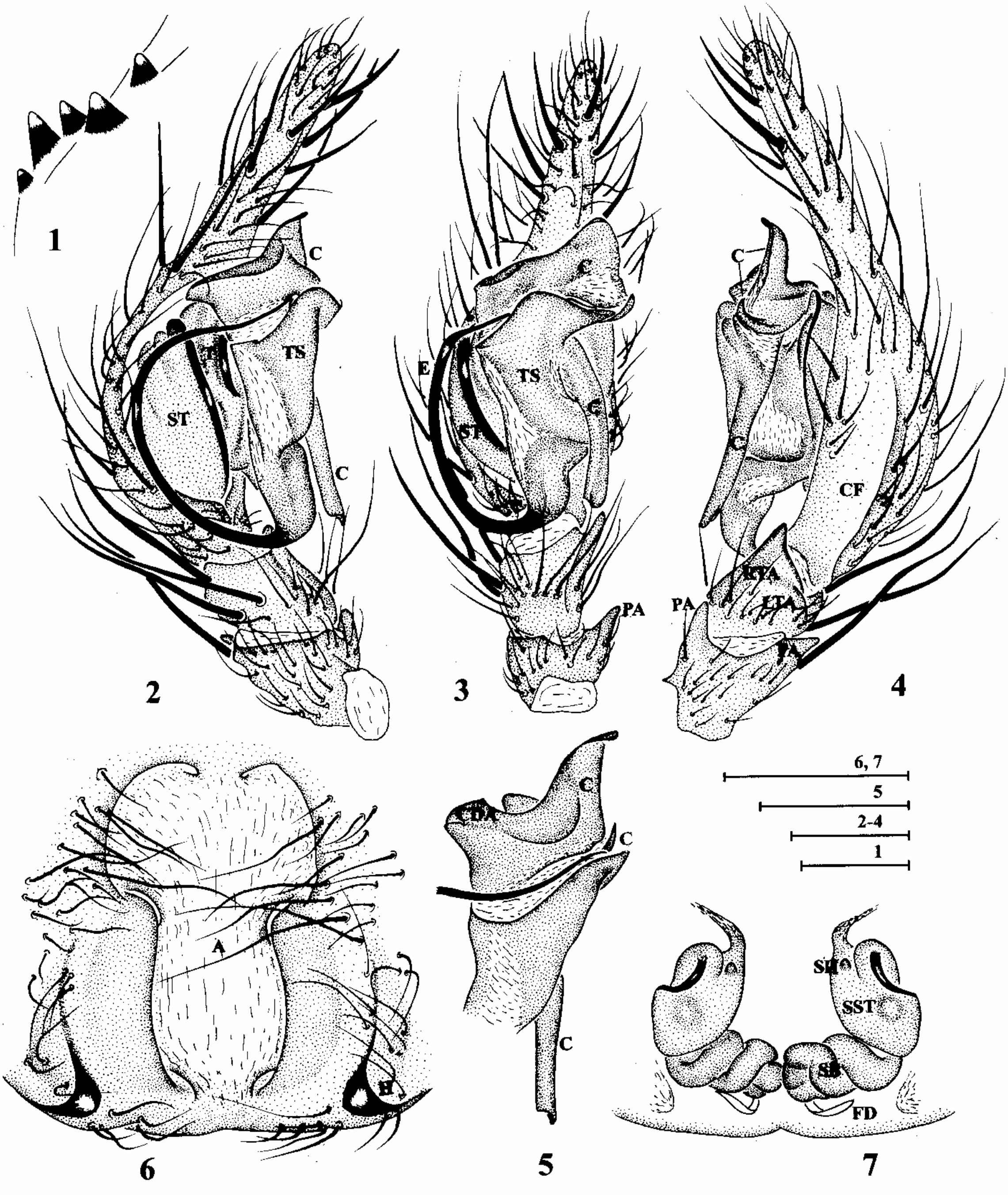
9a Epigynal hoods close to the epigastric furrow 10
9b Epigynal hoods situated mesally and widely separated from the epigastric furrow 12
10a Posterior atrium broad . . . . *daweishanensis* sp. n.
10b Posterior atrium narrow 11
11a Spermathecal stalks extremely long, with at least five loops . . . . *kailiensis*
11b Spermathecal stalks moderately long, with three or four loops . . *icohamatoides*
12a Lateral atrial margins anteriorly diverging and posteriorly converging . . . . *globosus* sp. n.
12b Lateral atrial margins parallel or slightly diverging posteriorly 13
13a Spermathecal heads situated laterally . . . . *latus* sp. n.
13b Spermathecal heads situated posteriorly . . . . *paralatus* sp. n.

Platocoelotes daweishanensis sp. n. Figs 1-7

HOLOTYPE ♂ (IZCAS): Mt Daweishan, Liuyang County (28.1°N, 113.6°E), Hunan Province, China, collected by Xiang Xu, October 6, 2005.

PARATYPES: 1 ♀ (IZCAS) and 1 ♀ (MHNG), same locality as for the holotype, collected by Xiang Xu and Yufa Luo, October 7, 2005.

ETYMOLOGY: The specific name is an adjective derived from the name of the type locality.



FIGS 1-7

Platocoelotes daweishanensis sp. n., male holotype (1-5), female (6-7). (1) Cheliceral teeth, posterior view. (2) Palp, prolateral view. (3) Palp, ventral view. (4) Palp, retrolateral view. (5) Conductor, prolateral view. (6) Epigynum, ventral view. (7) Vulva, dorsal view. Scale lines: 1 = 0.2 mm; 2-7 = 0.5 mm.

DIAGNOSIS: The new species can be distinguished from all other *Platocoelotes* by the flat distal margin of its conductor and by the longitudinally extended spermathecal stalks which are abruptly turning back distally.

DESCRIPTION: Male (holotype). Total length 8.3. Carapace length 4.2, width 2.8; abdomen length 4.1, width 2.2. Eye measurements: AME 0.15; ALE 0.23; PME 0.18;

PLE 0.23; AME-AME 0.08; AME-ALE 0.03; ALE-PLE 0; PME-PME 0.13; PME-PLE 0.15. Clypeus height 0.13. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 18.5 (4.8, 6.0, 4.8, 2.9); II: 16.3 (4.5, 5.2, 4.1, 2.5); III: 14.5 (4.0, 4.3, 4.0, 2.2); IV: 19.6 (5.2, 6.1, 5.8, 2.5). ALE in contact with PLE. Chelicerae with three promarginal and two retromarginal teeth (Fig. 1). Palp with two widely separated patellar apophyses (Fig. 4); RTA with its distal end extending beyond the distal margin of the tibia; LTA wide; cymbial furrow less than half of cymbium length (Fig. 4); distal margin of conductor flat (Fig. 3); dorsal conductor apophysis situated prolaterally (Fig. 5); ventral conductor apophysis long, strongly extended proximally and almost reaching the distal end of the RTA (Figs 2-4); median apophysis absent; embolus long, proximal in origin (Fig. 3).

Female. A specimen of total length 6.1 measures: Carapace length 2.9, width 1.9; abdomen length 3.2, width 1.9. Eye measurements: AME 0.10; ALE 0.18; PME 0.15; PLE 0.17; AME-AME 0.08; AME-ALE 0.03; ALE-PLE 0; PME-PME 0.10; PME-PLE 0.10. Clypeus height 0.10. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 9.8 (2.7, 3.4, 2.2, 1.5); II: 8.4 (2.4, 2.8, 1.9, 1.3); III: 7.8 (2.1, 2.5, 2.0, 1.2); IV: 10.7 (2.8, 3.4, 3.0, 1.5). Genital atrium large, becoming slightly narrower posteriorly; epigynal hoods distinct, situated close to the epigastric furrow and widely separated from the lateral atrial margins (Fig. 6); copulatory ducts small, originating anteriorly in the genital atrium; spermathecal bases situated close to each other, twisted and elongated horizontally; spermathecal stalks elongated longitudinally and abruptly turning back distally; spermathecal heads small (Fig. 7).

VARIATION: The total lengths of the two females examined are 6.1 and 9.4.

DISTRIBUTION: China (Hunan) (Map 1).

***Platocoelotes globosus* sp. n.** Figs 8-10

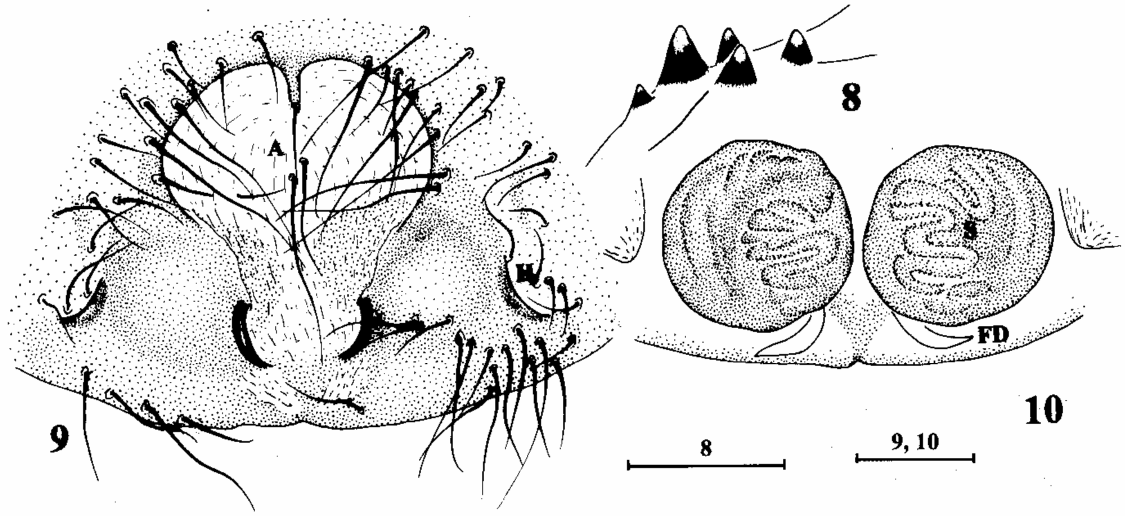
HOLOTYPE ♀ (IZCAS): Xianglushandong Cave, Caiguan Town, Anshun County (26.3°N, 106.0°E), Guizhou Province, China, collected by Yanfeng Tong, April 29, 2005.

PARATYPE: 2 ♀ (IZCAS) and 2 ♀ (MHNG), same data as for the holotype.

ETYMOLOGY: The specific name is taken from the Latin adjective *globosus* and refers to the globular spermathecae of this species.

DIAGNOSIS: Females of this new species can be distinguished from other *Platocoelotes* by their rounded spermathecae and indistinct spermathecal heads.

DESCRIPTION: Female (holotype). Total length 6.4. Carapace length 3.2, width 2.1; abdomen length 3.2, width 2.2. Eye measurements: AME 0.18; ALE 0.23; PME 0.18; PLE 0.18; AME-AME 0.08; AME-ALE 0.04; ALE-PLE 0; PME-PME 0.10; PME-PLE 0.15. Clypeus height 0.15. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 10.7 (2.9, 3.6, 2.6, 1.6); II: 9.6 (2.6, 3.1, 2.4, 1.5); III: 8.5 (2.3, 2.6, 2.3, 1.3); IV: 11.2 (2.9, 3.5, 3.3, 1.5). ALE in contact with PLE. Chelicerae with three promarginal and two retromarginal teeth (Fig. 8). Genital atrium large, anterior margin two times as wide as posterior margin; epigynal hoods widely separated from lateral atrial margin and slightly separated from the epigastric furrow (Fig. 9); spermathecae simple, globose; spermathecal heads absent; copulatory ducts not visible (Fig. 10).



FIGS 8-10
Platocoelotes globosus sp. n., female holotype. (8) Cheliceral teeth, posterior view. (9) Epigynum, ventral view. (10) Vulva, dorsal view. Scale lines: 8-10 = 0.2 mm.

Male. Unknown.

VARIATION: The total length varies from 6.4 to 6.9 in the five females examined.

DISTRIBUTION: China (Guizhou) (Map 1).

Platocoelotes latus **sp. n.** Figs 11-16

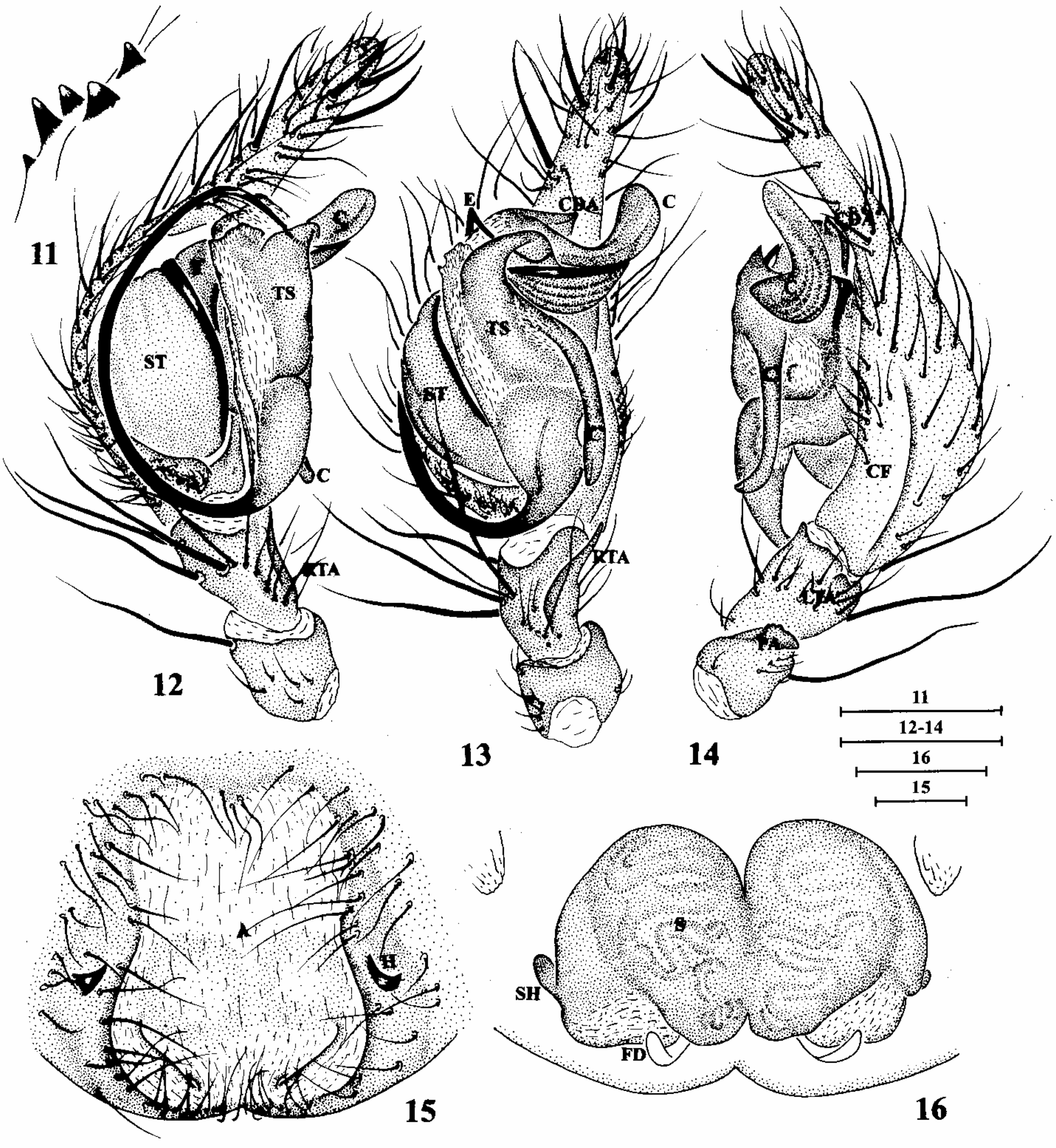
HOLOTYPE ♂ (IZCAS): Huoyaodong Cave, Xiasi Town, Dushan County (25.5°N, 107.4°E), Guizhou Province, China, collected by Yanfeng Tong, May 20, 2005.

PARATYPES: 3 ♀ (IZCAS), same data as for the holotype. – 1 ♂ (MHNG), Shenxiandong Cave, Bajing Village, Xiasi Town, Dushan County, Guizhou Province, China, collected by Yanfeng Tong, May 20, 2005. – 1 ♀ (MHNG), a cave without name, Yangjiao Village, Xiasi Town, Dushan County, Guizhou Province, China, collected by Yanfeng Tong, May 24, 2005.

ETYMOLOGY: The specific name is taken from the Latin adjective *latus*, meaning broad; it refers to the broad female genital atrium of this species.

DIAGNOSIS: The new species is similar to *Platocoelotes daweishanensis* sp. n. in having a long ventral conductor apophysis and a large genital atrium, but males can be distinguished by the presence of a single patellar apophysis and by the modified and unique conductor which possesses a large cavity; females are distinguished by the epigynal hoods that are situated close to the lateral atrial margin and widely separated from the epigastric furrow, by the anterior margin of the genital atrium that is almost equal in width to the posterior margin, by the simple and fused spermathecae and by the large spermathecal heads.

DESCRIPTION: Male (holotype). Total length 5.9. Carapace length 2.9, width 2.0; abdomen length 3.0, width 2.0. Eye measurements: AME 0.13; ALE 0.17; PME 0.15; PLE 0.17; AME-AME 0.06; AME-ALE 0; ALE-PLE 0; PME-PME 0.06; PME-PLE 0.08. Clypeus height 0.05. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 12.0 (3.1, 3.9, 3.0, 2.0); II: 10.3 (2.8, 3.2, 2.6, 1.7); III: 9.8 (2.5, 3.0, 2.8, 1.5); IV: 13.2 (3.4, 3.9, 4.0, 1.9). AME and PLE in contact with ALE. Chelicerae with



FIGS 11-16

Platocoelotes latus sp. n., male holotype (11-14), female (15, 16). (11) Cheliceral teeth, posterior view. (12) Palp, prolateral view. (13) Palp, ventral view. (14) Palp, retrolateral view. (15) Epigynum, ventral view. (16) Vulva, dorsal view. Scale lines: 11, 15, 16 = 0.2 mm; 12-14 = 0.5 mm.

three promarginal and two retromarginal teeth (Fig. 11). Patellar apophysis thumb-shaped (Fig. 14); RTA with its distal end sharp and extending beyond distal margin of tibia; LTA small, widely separated from RTA (Fig. 14); cymbial furrow less than half of cymbium length (Figs 13, 14); conductor modified, forming a large medio-distal cavity and slight terminal extension (Figs 12, 13); dorsal conductor apophysis small (Fig. 14); ventral conductor apophysis long and strongly extended posteriorly (Figs 13, 14); median apophysis strongly reduced, vestige visible (Fig. 14); embolus long, proximal in origin (Figs 12, 13).

Female. A specimen of total length 6.1 measures. Carapace length 3.2, width 2.2; abdomen length 2.9, width 1.8. Eye measurements: AME 0.13; ALE 0.15; PME 0.15; PLE 0.18; AME-AME 0.09; AME-ALE 0.04; ALE-PLE 0; PME-PME 0.11; PME-PLE 0.06. Clypeus height 0.15. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 11.1 (2.9, 3.8, 2.7, 1.7); II: 9.5 (2.6, 3.1, 2.3, 1.5); III: 8.9 (2.4, 2.8, 2.4, 1.3); IV: 11.8 (3.1, 3.8, 3.2, 1.7). Genital atrium large, occupying two thirds of epigynum; epigynal hoods situated mesally, close to the lateral atrial margin (Fig. 15); spermathecae simple and medially fused to each other; spermathecal heads situated laterally, widely separated from each other; copulatory ducts small; fertilization ducts widely separated (Fig. 16).

VARIATION: The total length in the two males examined is 5.7 and 5.9, and it varies from 5.5 to 7.3 in the four females examined.

DISTRIBUTION: China (Guizhou) (Map 1).

***Platocoelotes paralatus* sp. n.** Figs 17-22

HOLOTYPE ♂ (IZCAS): Guanyin Cave, Jinbi Town, Qianxi County (26.9°N, 106.0°E), Guizhou Province, China, collected by Yanfeng Tong, May 18, 2005.

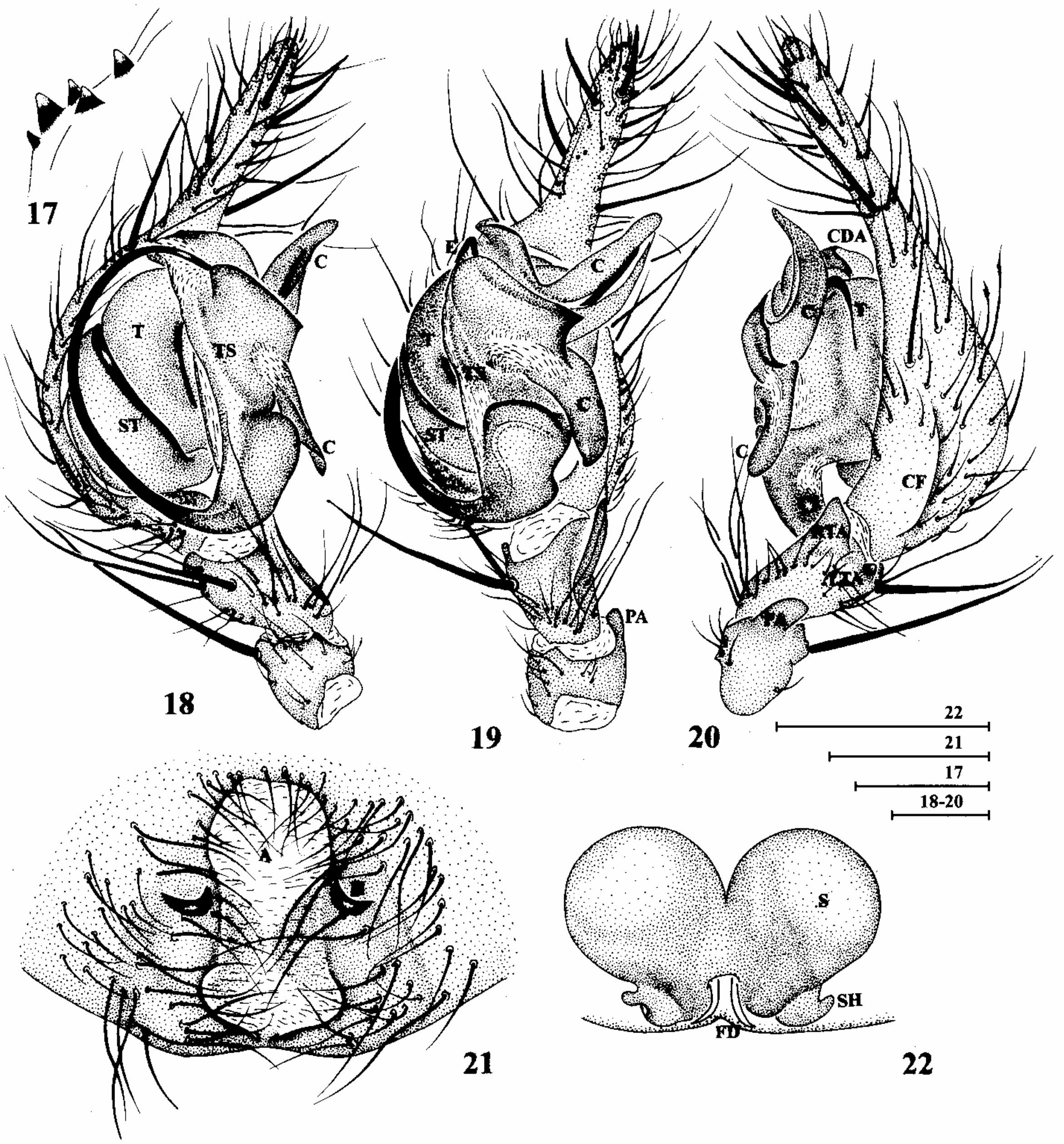
PARATYPES: 4 ♀ (MHNG), same data as for the holotype; 8 ♀ (IZCAS), Xianglushan Cave, Caiguan Town, Anshun County (26.3°N, 106.0°E), Guizhou Province, China, collected by Yanfeng Tong, April 29, 2005.

ETYMOLOGY: The specific name is a compound word of the Greek prefix "*para*" and the Latin adjective "*latus*", referring to similarities with *Platocoelotes latus* sp. n.

DIAGNOSIS: The new species is similar to *Platocoelotes latus* sp. n. in the shape of its conductor, the presence of a large genital atrium and simple, fused spermathecae, but can be distinguished by its narrower atrium, short and blunt ventral conductor apophysis and fertilization ducts situated close to each other.

DESCRIPTION: Male (holotype). Total length 5.5. Carapace length 2.6, width 2.2; abdomen length 2.9, width 1.9. Eye measurements: AME 0.15; ALE 0.20; PME 0.15; PLE 0.18; AME-AME 0.03; AME-ALE 0; ALE-PLE 0; PME-PME 0.05; PME-PLE 0.08. Clypeus height 0.13. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 13.2 (3.4, 4.3, 3.4, 2.1); II: 11.5 (3.1, 3.6, 3.0, 1.8); III: 10.6 (2.8, 3.2, 3.0, 1.6); IV: 13.6 (3.6, 4.0, 3.9, 2.1). AME and PLE in contact with ALE. Chelicerae with three promarginal teeth and two retromarginal teeth (Fig. 17). Patellar apophysis large (Fig. 20); RTA with its distal end slightly extending beyond distal margin of tibia; LTA small (Fig. 20); cymbial furrow about one third of cymbium length (Fig. 20); conductor modified, forming a long medio-distal cavity (Fig. 19); proximal conductor margin with a sharp tooth (Fig. 19); dorsal conductor apophysis small (Fig. 20); ventral conductor apophysis short and blunt; tegular sclerite small (Fig. 19); embolus long, proximal in origin (Figs 18, 19).

Female. A specimen of total length 5.5 measures: Carapace length 2.3, width 1.6; abdomen length 3.2, width 2.6. Eye measurements: AME 0.10; ALE 0.15; PME 0.13; PLE 0.15; AME-AME 0.03; AME-ALE 0; ALE-PLE 0; PME-PME 0.04; PME-PLE 0.09. Clypeus height 0.10. Leg IV longest; leg formula: IV, I, II, III; leg measurements as follows: I: 9.4 (2.6, 3.1, 2.2, 1.5); II: 7.9 (2.3, 2.5, 1.9, 1.2); III: 7.0



FIGS 17-22

Platocoelotes paralatus sp. n., male holotype (17-20), female (21, 22). (17) Cheliceral teeth, posterior view. (18) Palp, prolateral view. (19) Palp, ventral view. (20) Palp, retrolateral view. (21) Epigynum, ventral view. (22) Vulva, dorsal view. Scale lines: 17-20 = 0.2 mm; 21-22 = 0.5 mm.

(1.9, 2.1, 1.9, 1.1); IV: 9.8 (2.6, 3.0, 2.8, 1.4). Genital atrium large, occupying half of epigynum; epigynal hoods situated mesally, close to the lateral atrial margin (Fig. 21); copulatory ducts not visible; spermathecae simple and medially fused to each other; spermathecal heads small, situated posteriorly and widely separated from each other; fertilization ducts situated close to each other (Fig. 22).

VARIATION: The total length varies from 3.6 to 5.5 in the twelve female examined.

DISTRIBUTION: China (Guizhou) (Map 1).

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Ten new species of the genus *Draconarius* (Araneae: Amaurobiidae) from China

XIANG XU[1] & SHUQIANG LI[2, 3]

[1]*College of Life Science, Hunan Normal University, Changsha 410081, P. R. China*
[2]*Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China*
[3]*Corresponding author. E–mail: lisq@ioz.ac.cn*

Abstract

Ten new *Draconarius* species are described: *D. acutus* **spec. nov.**, *D. complanatus* **spec. nov.**, *D. expansus* **spec. nov.**, *D. magnarcuatus* **spec. nov.**, *D. pseudocoreanus* **spec. nov.**, *D. subabsentis* **spec. nov.**, *D. sublutulentus* **spec. nov.**, *D. tensus* **spec. nov.**, *D. ventrifurcatus* **spec. nov.** and *D. zonalis* **spec. nov.** Detailed descriptions and illustrations of these new species are provided.

Key words: Taxonomy, biodiversity, spiders, Sichuan, Yunnan, Hunan

Introduction

Draconarius Ovtchinnikov 1999 is a large genus of Coelotinae that comprises more than 100 species. Eighty of them are recorded from China (Platnick 2008). In recent years, a lot of new Coelotinae spiders species have been reported from the southwestern provinces of China, especially from Sichuan and Yunnan (Wang 2003, Wang & Jäger 2007). Of the ten new *Draconarius* species described in this study, five were also collected from this region. This result confirmed our hypothesis that southwestern China has an extremely high spider biodiversity (Xu & Li 2006).

Typical *Draconarius* has two retrolateral cheliceral teeth. In combination, *Draconarius* males have usually a dorsal apophysis of the conductor, a long and posteriorly extending embolus, a long cymbial furrow and an elongated median apophysis. Females exhibit large copulatory ducts and long spermathecae (Wang 2003). Among the ten new species described in this paper two are clearly *Draconarius*: *D. sublutulentus* **spec. nov.** and *D. pseudocoreanus* **spec. nov.** Others differ from the typical *Draconarius* in the origin of embolus, the shape of median apophysis and spermathecae or the length of cymbial furrow. However, they are also named as *Draconarius* species based on the presence of two retrolateral teeth and a conductoral dorsal apophysis.

Material and methods

All the specimens used in the current study are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS). Specimens were examined with an Olympus SZ40 stereomicroscope. Further details were studied with an Olympus BX41 compound microscope. All illustrations were made using an Olympus drawing tube and inked on ink jet plotter paper.

Measurements are given in millimeters. Eye diameters are taken at the widest point. The measurements of legs are shown as: total length (femur, patella, tibia, metatarsus, tarsus). In males, left structures are described,

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illustrated and measured except the pedipalpus of the holotype of *Draconarius expansus* **spec. nov.** whose left pedipalpus is lost. However, clock-position of tegular appendices are always described for the left pedipalpus in ventral view. The terminology used in the text and in the figure legends mainly follows Wang (2002). Abbreviations used in the text and figures are: A = atrium; ALE = anterior lateral eye; AME = anterior median eye; AME–ALE = distance between AME and ALE; AME–AME = distance between AME and AME; ALE–PLE = distance between ALE and PLE; C = conductor; CD = copulatory duct; CDA = dorsal apophysis of the conductor; CF = cymbial furrow; E = embolus; FD = fertilization duct; LTA = lateral tibial apophysis; MA = median apophysis; PA = patellar apophysis; PLE = posterior lateral eye; PLS = posterior lateral spinneret; PME = posterior median eye; PME–PLE = distance between PME and PLE; PME–PME = distance between PME and PME; RTA = retrolateral tibial apophysis; S = spermathecae; SH = spermathecal head; T = tegulum; TS = tegular sclerite; TSA = apophysis of tegular sclerite.

Taxonomy

Amaurobiidae Thorell 1870

Draconarius Ovtchinnikov 1999

Draconarius acutus spec. nov.

Figs 1– 4, 49

Type material. Holotype male, CHINA: Sichuan, Lushan County (30.3° N, 103.0° E), Weita Village, near Shuiluodong Cave, 15 October 2005, Shuqiang Li leg. (IZCAS)

Etymology. The species name is derived from the Latin *acutus*, *-a -um*, meaning “sharp” and referring to the sharply pointed distal tip of the conductor; adjective.

Diagnosis. This species is similar to *Draconarius aspinatus* (Wang, Yin, Peng & Xie 1990) in having the simple and sharply pointed conductor, but can be easily distinguished by the short cymbial furrow and short median apophysis, the narrow dorsal margin of conductor and the basally originating embolus.

Description. Holotype male. Total length 5.6, prosoma 2.9 long, 2.0 wide; opisthosoma 2.7 long, 1.6 wide. Eye measurements: AME 0.06; ALE 0.18; PME 0.15; PLE 0.15; AME–AME 0.06; AME–ALE 0.03; PME–PME 0.06; PME–PLE 0.10; clypeus 0.10. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 1). Legs with brown annulations; leg formula: IV, I, II, III; measurements of legs: I: 8.8 (2.4, 3.0, 2.0, 1.4); II: 7.7 (2.2, 2.5, 1.9, 1.1); III: 7.4 (2.1, 2.2, 2.0, 1.1); IV: 10.0 (2.8, 3.0, 2.9, 1.3). PLS with distal segment almost half length of basal one.

Patella with two small apophyses; RTA large, and with distal end distinctly extending beyond tibia; lateral tibial apophysis flat; cymbial furrow about half of cymbium length; tegulum strong; conductor simple, with a short and sharp distal end; dorsal apophysis of conductor large; median apophysis spoon–shaped; embolus moderately long, originating basally (Figs 2–4).

Female. Unknown.

Distribution. China (Sichuan) (Fig. 49).

Draconarius complanatus spec. nov.

Figs 5–8, 49

Type material. Holotype male, CHINA: Hunan, Liuyang County (28.1° N, 113.6° E), Dawei Mt., near Yuquan Lake, 6 October 2003, Xiang Xu leg. (IZCAS)

Etymology. The species name is derived from the Latin *complanatus, -a, -um*, meaning “flattened” and referring to the broad, flat conductor; adjective.

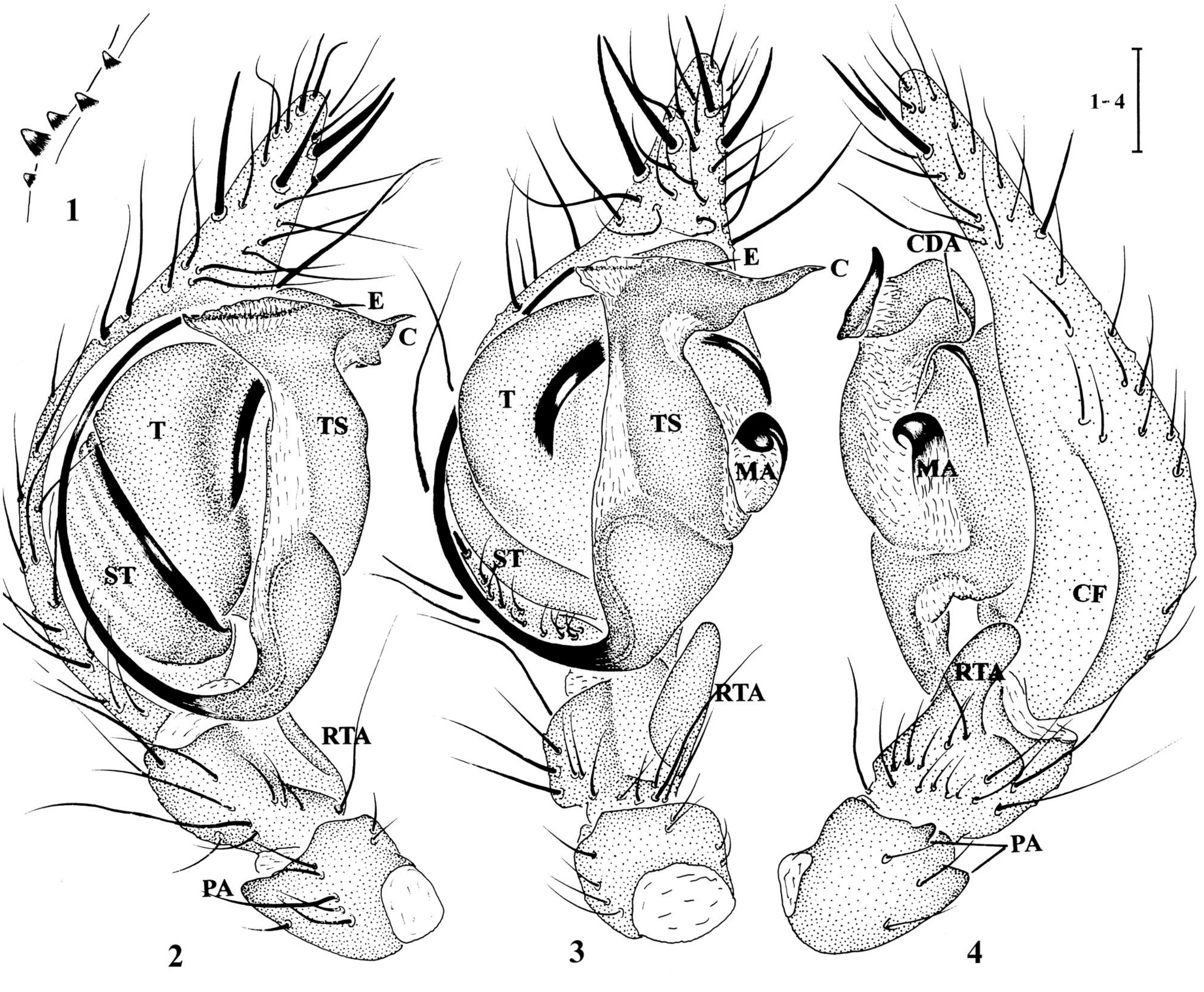
Diagnosis. This species can be distinguished from all other *Draconarius* by the broad and flat conductor, the broad embolus arising at approximately 7–o’clock–position, and the absence of a patellar apophysis.

Description. Holotype male. Total length 10.5, prosoma 5.1 long, 3.6 wide; opisthosoma 5.4 long, 3.1 wide. Eye measurements: AME 0.14; ALE 0.20; PME 0.18; PLE 0.20; AME–AME 0.10; AME–ALE 0.05; PME–PME 0.09; PME–PLE 0.22; clypeus 0.20. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 5). Leg formula: IV, I, II, III; measurements of legs: I: 15.0 (4.1, 5.2, 3.6, 2.1); II: 13.3 (3.7, 4.3, 3.3, 2.0); III: 10.4 (1.4, 3.8, 3.3, 1.9); IV: 16.1 (4.2, 5.2, 4.6, 2.1). PLS with the distal segment slightly longer than the basal one.

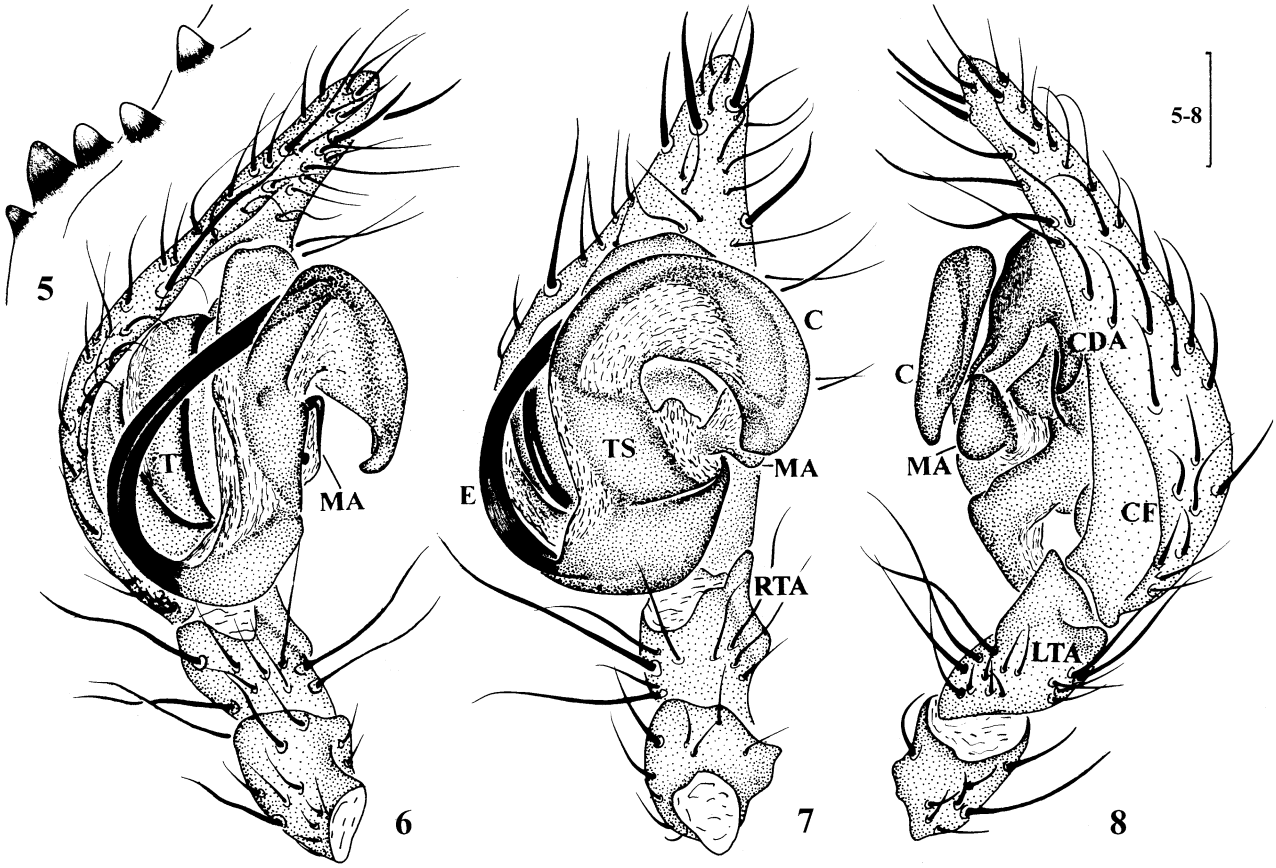
Patellar apophysis absent; RTA about half length of tibia, and with distal end extending beyond tibia; lateral tibial apophysis large; cymbial furrow about half of cymbium length; conductor broad, slightly curved basal, and with horned dorsal apophysis; median apophysis triangular in retrolateral view; embolus broad, almost equably wide from base to end, arising at approximately 7–o’clock–position (Figs 6–8).

Female. Unknown.

Distribution. China (Hunan) (Fig. 49).



FIGURES 1–4. *Draconarius acutus* **spec. nov.** male, 1. Cheliceral teeth, ventral view; 2. Pedipalpus, prolateral view; 3. *Ditto*, ventral view; 4. *Ditto*, retrolateral view. Scale bar: 0.2 mm.



FIGURES 5–8. *Draconarius complanatus* **spec. nov.** male, 5. Cheliceral teeth, ventral view; 6. Pedipalpus, prolateral view; 7. *Ditto*, ventral view; 8. *Ditto*, retrolateral view. Scale bar: 0.2 mm.

Draconarius expansus spec. nov.

Figs 9–12

Type material. Holotype male, CHINA: Hunan Province (lacking detailed collection data), 2 March 1975, Qiliang Huang leg. (IZCAS).

Etymology. The species name is derived from the from past participle *expansus*, *-a*, *-um* of the Latin verb *expandere*, means "expanded" and refers to the expanded conductor, median apophysis and the distal end of embolus; adjective.

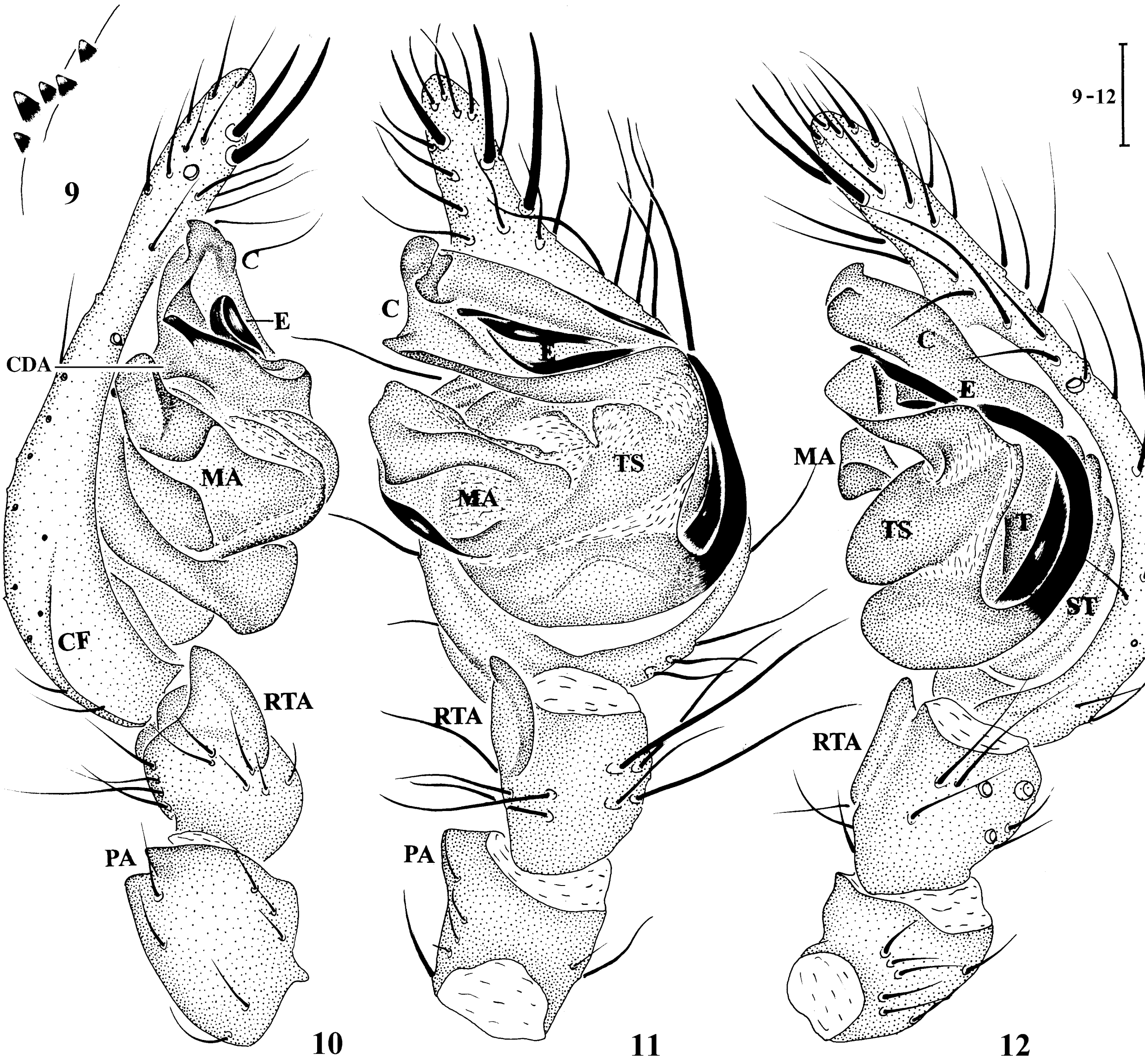
Diagnosis. This species can be easily distinguished from all other *Draconarius* by the extraordinarily expanded median apophysis.

Description. Holotype male. Prosoma 3.0 long, 2.1 wide; opisthosoma absent. Eye measurements: AME 0.08; ALE 0.15; PME 0.15; PLE 0.15; AME–AME 0.04; AME–ALE 0.05; PME–PME 0.10; PME–PLE 0.10; clypeus 0.10. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 9). Leg formula unknown; measurements of legs: I: 8.4 (2.4, 2.8, 2.0, 1.2); II: absent; III: absent; IV: 9.8 (2.6, 3.0, 2.9, 1.3).

Patellar apophysis short and stour; RTA broad, with distal end extending beyond tibia; lateral tibial apophysis absent; cymbial furrow extremely short; conductor broad, slightly modified into a shallow groove holding the embolus; dorsal apophysis of conductor sharp, and hidden by median apophysis from prolateral view; median apophysis extraordinarily expanded, and with distal margin thickened; embolus short, arising at approximately 4.30–o'clock–position, and with the distal end slightly modified into a shallow groove (Figs 10–12).

Female. Unknown.

Distribution. China (Hunan).



FIGURES 9–12. *Draconarius expansus* **spec. nov.** male, 9. Cheliceral teeth, ventral view; 10. Pedipalpus, retrolateral view; 11. *Ditto*, ventral view; 12. *Ditto*, prolateral view. Scale bar: 0.2 mm.

Draconarius magnarcuatus spec. nov.

Figs 13–17, 49

Type material. Holotype male, CHINA: Jiangsu Province, Nanjing City (32.0° N, 118.5° E), lacking detailed collecting data. (IZCAS)

Etymology. The species name is a compound word of the Latin *magnus, -a, -um* and the Latin *arcuatus*, meaning “large” and “arcuated” respectively, and refering to the shape of the embolus; adjective.

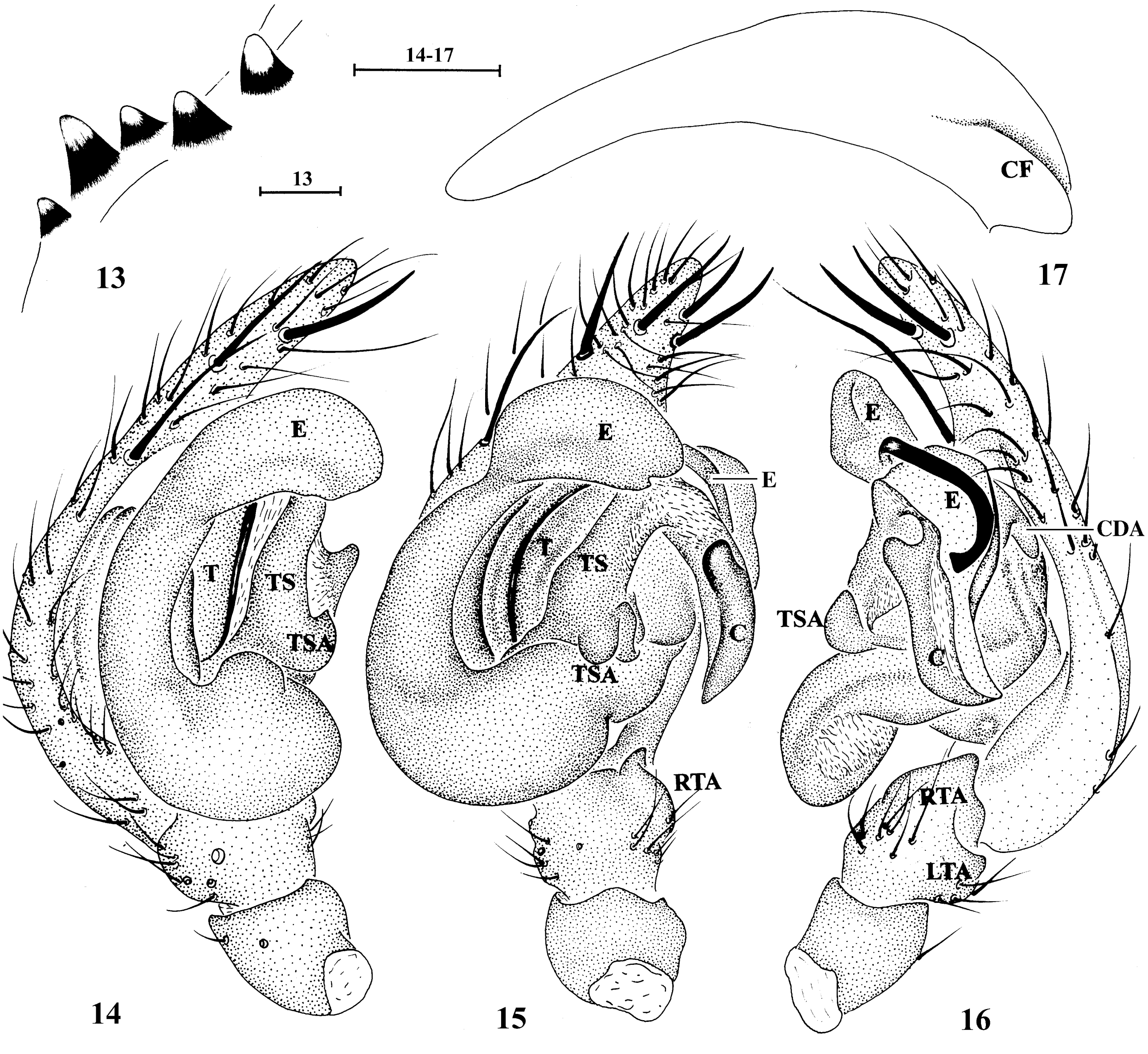
Diagnosis. This species is similar to *Draconarius rufulus* (Wang, Yin, Peng & Xie 1990) in having the distal embolus abruptly becoming narrow and lacking the patellar apophysis, but can be distinguished by the absence of a median apophysis and the presence of an apophysis on the tegular sclerite and the extraordinarily strong embolus.

Description. Holotype male. Total length 7.8, prosoma 4.3 long, 2.9 wide; opisthosoma (decayed) 3.5 long, 2.3 wide. Eye measurements: AME 0.15; ALE 0.25; PME 0.18; PLE 0.18; AME–AME 0.08; AME–ALE 0.05; PME–PME 0.10; PME–PLE 0.20; clypeus 0.06. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 13). Leg formula: IV, I, II, III; measurements of legs: I: 11.2 (3.1, 3.8, 2.7, 1.6); II: 9.7 (2.7, 3.2, 2.4, 1.4); III: 9.0 (2.5, 2.9, 2.4, 1.2); IV: 12.2 (3.3, 3.9, 3.5, 1.5).

Patellar apophysis absent; RTA shorter than tibia; lateral tibial apophysis distinct and widely separated from RTA; cymbial furrow about one third of cymbium length; conductor strongly curved basally, strongly modified into a groove holding the distal end of embolus, and with a process on the ventral margin of conductor; median apophysis absent; embolus strong at the basal two thirds and abruptly becoming slender at the distal one third, arising at approximately 6–o'clock–position (Figs 14–16).

Female. Unknown.

Distribution. China (Jiangsu) (Fig. 49).



FIGURES 13–17. *Draconarius magnarcuatus* **spec. nov.** male, 13. Cheliceral teeth, ventral view; 14. Pedipalpus, prolateral view; 15. *Ditto*, ventral view; 16. *Ditto*, retrolateral view; 17. Cymbium, retrolateral view. Scale bars: 13 = 0.1mm; 14–17 = 0.5 mm.

Draconarius pseudocoreanus spec. nov.

Figs 18–23, 49

Type material. Holotype male, 6 female paratypes, CHINA: Sichuan Province, Mianning County (29.6° N, 102.0° E), Yele Nature Reserve, 24 July 2004, Xiang Xu leg.; 6 male and 3 female paratypes, same locality as for holotype, 21 October 2005, Xiufeng Zhang and Xiang Xu leg. (IZCAS)

Etymology. The species name is a compound word from the Greek prefix *pseudo*– and the specific name of *Draconarius coreanus* (Paik & Yaginuma 1969), pointing to the similarities in epigyna and male pedipalpi of both species; to be interpreted as a noun in apposition.

Diagnosis. This species is similar to *D. coreanus* in having short epigynal teeth, a shallow atrium, spiraled spermathecae in females, and having a broad conductor lamella, a long embolus, and a long cymbial furrow in males, but can be distinguished by the long, posteriorly originated spermathecal heads in females, and by the conductor with two sharp apexes in males.

Description. Holotype male. Total length 10.8, prosoma 5.8 long, 3.8 wide; opisthosoma 5.0 long, 3.3 wide. Eye measurements: AME 0.15; ALE 0.20; PME 0.20; PLE 0.25; AME–AME 0.13; AME–ALE 0.10; PME–PME 0.10; PME–PLE 0.26; clypeus 0.15. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 18). Leg formula: IV, I, II, III; measurements of legs: I: 14.8 (3.8, 5.2, 3.7, 2.1); II: 12.9 (3.4, 4.5, 3.0, 2.0); III: 11.4 (3.2, 3.9, 2.8, 1.5); IV: 15.1 (4.1, 5.0, 4.1, 1.9). PLS with distal segment almost equal to length of basal one.

Patellar apophysis long, slender; RTA with distal end not extending beyond tibia in retrolateral view; lateral tibial apophysis present; cymbial furrow slightly less than cymbium length; conductor lamella broad; conductor with two sharp apices; dorsal apophysis of conductor stout; median apophysis rounded; embolus extremely long, arising at approximately 5.30 to 6–o'clock–position (Figs 19–21).

Female paratype. Total length 8.7. Prosoma 4.1 long, 2.7 wide; opisthosoma 4.6 long, 3.2 wide. Eye measurements: AME 0.13; ALE 0.25; PME 0.20; PLE 0.20; AME–AME 0.11; AME–ALE 0.10; PME–PME 0.10; PME–PLE 0.20; clypeus 0.18. Chelicerae with 3 promarginal and 2 retromarginal teeth. Leg IV formula: IV, I, II, III; measurements of legs: I: 10.3 (3.0, 3.5, 2.4, 1.4); II: 9.1 (2.7, 3.0, 2.1, 1.3); III: 7.5 (2.3, 2.2, 2.0, 1.0); IV: 10.5 (3.0, 3.4, 2.8, 1.3).

Epigynal teeth short, widely separated; atrium shallow, with the anterior margin extended medially; a shallow median concavity situated near to epigastric furrow; copulatory ducts indistinct; spermathecae separated posteriorly and overlapped anteriorly; spermathecal heads long, originating posteriorly (Figs 22–23).

Distribution. China (Sichuan) (Fig. 49).

Draconarius subabsentis spec. nov.

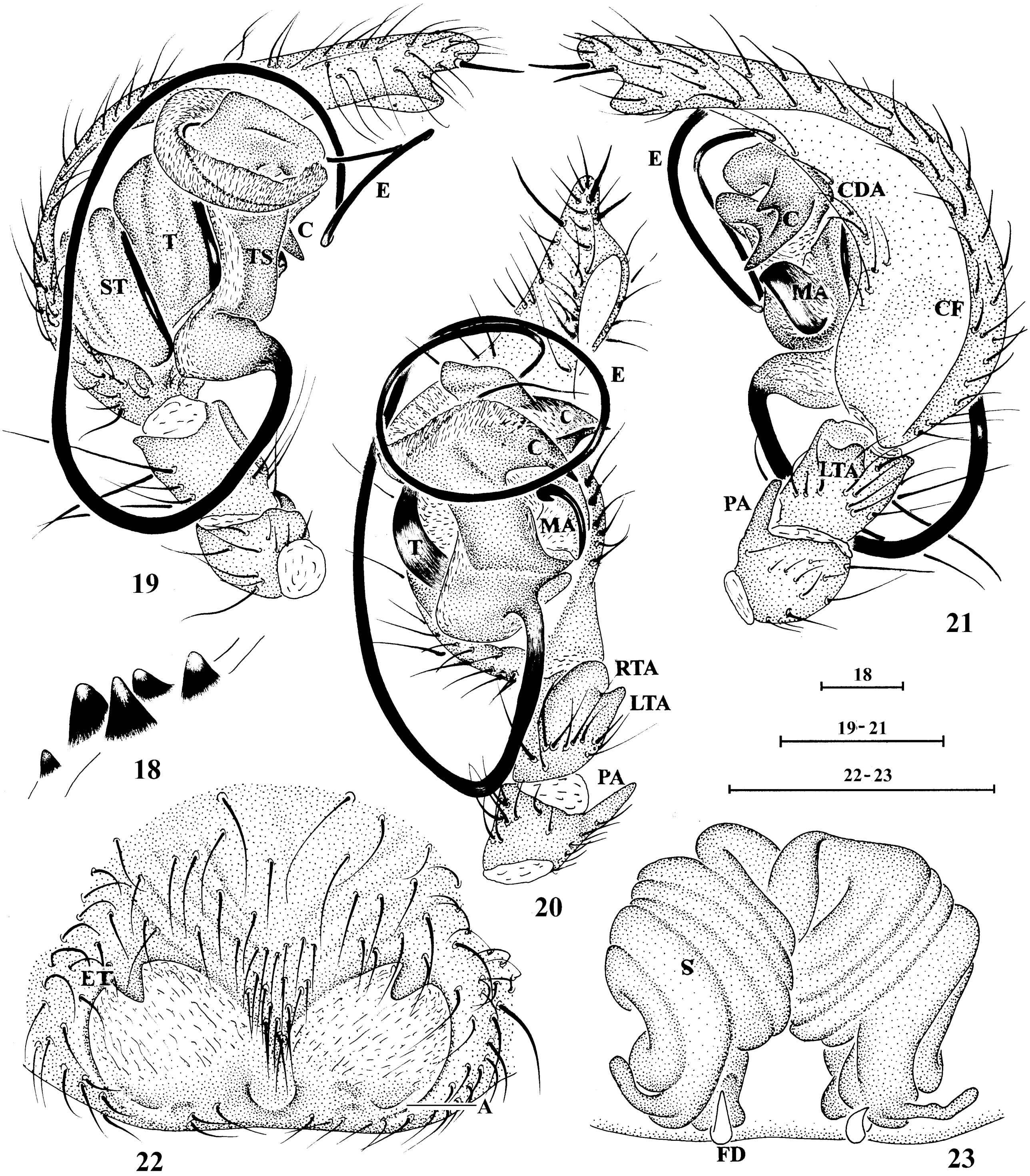
Figs 24–27, 49

Type material: Holotype male, 16 male paratypes, CHINA: Hubei Province, Shennongjia Nature Reserve (31.7° N, 110.6° E), Watchtower, 27 July to 8 August 1998, Hongzhang Zhou and Xiaodong Yu leg.; 65 male paratypes, CHINA: Hubei Province, Shennongjia Nature Reserve, Jinhouling, 27 July to 8 August 1998, Hongzhang Zhou and Xiaodong Yu leg. (IZCAS)

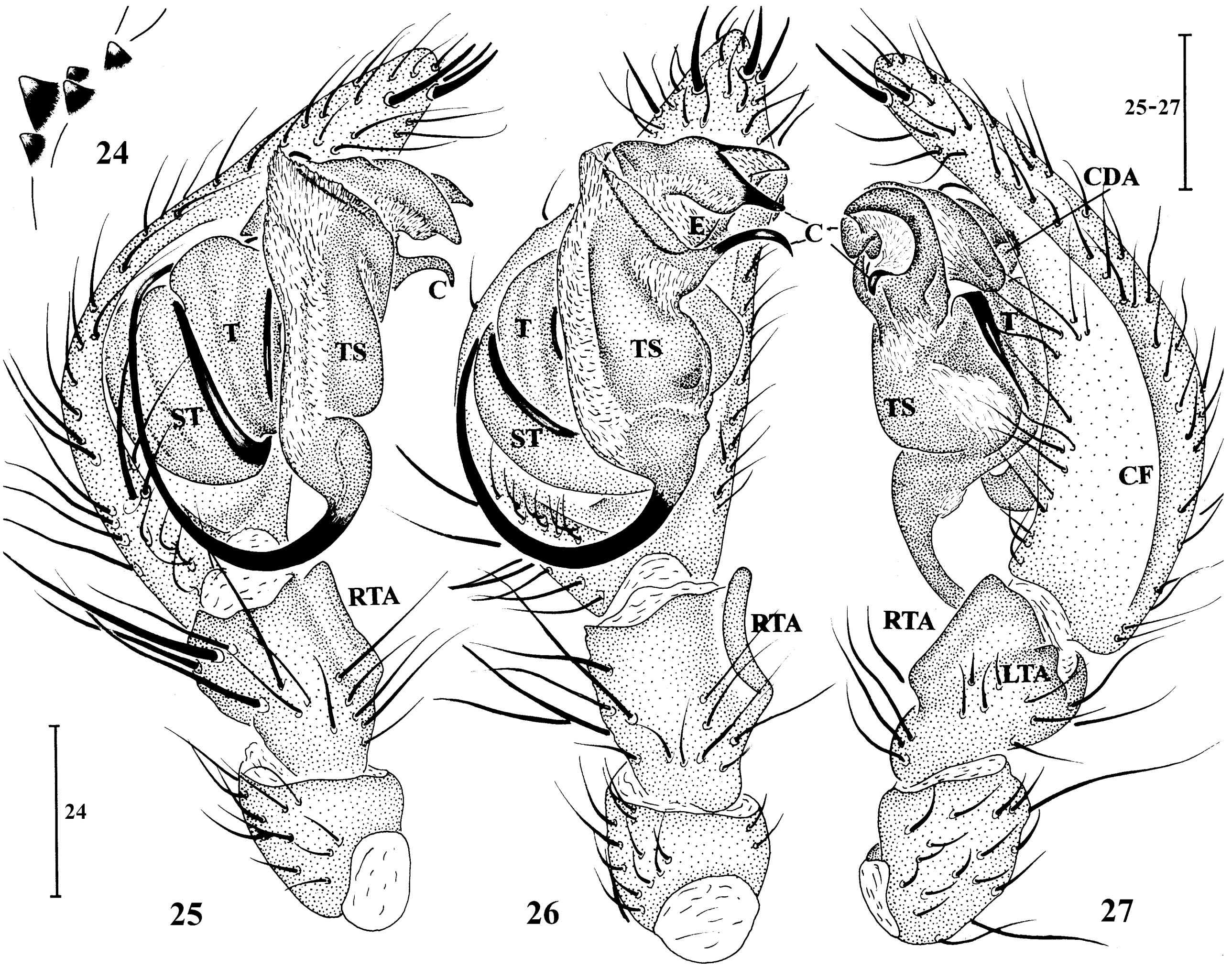
Etymology. The species name is a compound word of the Latin prefix *sub*– and the specific name of *Draconarius absentis* Wang 2003, pointing to the similarity of conductors in both species; to be interpreted as a noun in apposition.

Diagnosis. This new species is similar to *D. absentis* in having the trifid conductor and lacking the median apophysis, but can be distinguished by the embolus arising at approximately 6–o'clock–position, the slender and sharp ventral apex of conductor and the absence of a patellar apophysis.

Description. Holotype male. Total length 9.1, prosoma 4.8 long, 3.2 wide; opisthosoma 4.3 long, 2.8 wide. Eye measurements: AME 0.19; ALE 0.20; PME 0.17; PLE 0.25; AME–AME 0.09; AME–ALE 0.10; PME–PME 0.08; PME–PLE 0.25; clypeus 0.11. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 24). Leg formula: IV, I, II, III; measurements of legs: I: 12.4 (3.5, 4.3, 2.9, 1.7); II: 11.1 (3.1, 3.7, 2.6, 1.7); III: 9.2 (2.5, 2.9, 2.4, 1.4); IV: 12.5 (3.7, 4.0, 3.2, 1.6). PLS with the distal segment shorter than the basal one.



FIGURES 18–23. *Draconarius pseudocoreanus* **spec. nov.** male: 18–21, female: 22–23, 18. Cheliceral teeth, ventral view; 19. Pedipalpus, prolateral view; 20. *Ditto*, ventral view; 21. *Ditto*, retrolateral view; 22. Epigynum, ventral view; 23. Vulva, dorsal view. Scale bars: 18 = 0.2 mm; 19–23 = 1.0 mm.



FIGURES 24–27. *Draconarius subabsentis* **spec. nov.** male, 24. Cheliceral teeth, ventral view; 25. Pedipalpus, prolateral view; 26. *Ditto*, ventral view; 27. *Ditto*, retrolateral view. Scale bars: 0.5 mm.

Patellar apophysis absent; the distal end of RTA slightly extending beyond tibia; lateral tibial apophysis distinct; cymbial furrow longer than half of cymbium length; conductor with trifid apex and the ventral apex slender and sharp; dorsal apophysis of conductor large; median apophysis absent; embolus originating at approximately 6–o’clock–position (Figs 25–27).

Female. Unknown.

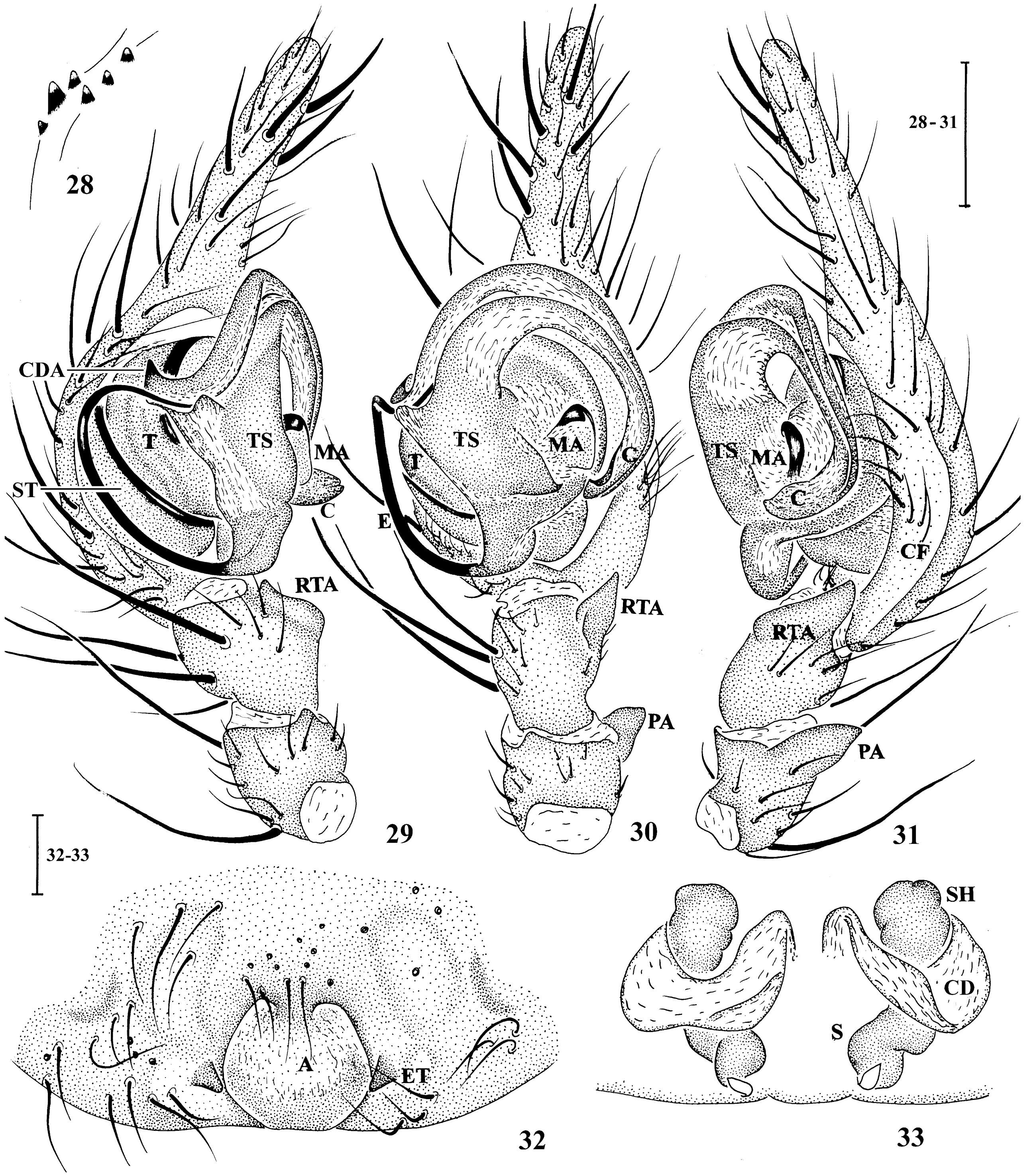
Distribution. China (Sichuan) (Fig. 49).

Draconarius sublutulentus spec. nov.

Figs 28–33, 49

Type material: Holotype male, 1 female paratype, CHINA: Sichuan Province, Baoxing County (30.3° N, 102.8° E), Yaoji Village, 5 July 2004, Xiang Xu leg.; 2 female paratypes, CHINA: Sichuan Province, Baoxing County, Fengtongzhai Natural Reserve, 1 July 2004, Fengxiang Liu leg.; 3 male and 9 female paratypes, CHINA: Sichuan, Danba County (30.8° N, 101.9° E), Geshizha Town, 30 July 2004, Xiang Xu leg.; 1 female paratype, CHINA: Sichuan, Kangding County (30.0° N, 101.9° E), Liangshui Well, 12 July 2004, Xiang Xu leg.; 1 female paratype, CHINA: Sichuan, Tianquan County (30.1° N, 102.7° E), Qingshi Tower, Yunshi Valley, 11 July 2004, Qian Wang leg. (IZCAS)

Etymology. The species name is a compound word of the Latin prefix *sub*– and the specific name of *Draconarius lutulentus* (Wang, Yin, Peng & Xie 1990), pointing to the similar conductors of both species; to be interpreted as a noun in apposition.



FIGURES 28–33. *Draconarius sublutulentus* **spec. nov.** male: 28–31; female: 32–33, 28. Cheliceral teeth, ventral view; 29. Pedipalpus, prolateral view; 30. *Ditto*, ventral view; 31. *Ditto*, retrolateral view; 32. Epigynum, ventral view; 33. Vulva, dorsal view. Scale bars: 28–31 = 0.5 mm; 32–33 = 0.20 mm.

Diagnosis. This species is similar to *D. lutulentus* in having a long conductor and a longitudinally elongated spermathecae, but can be distinguished by the broad patellar apophysis and the broad conductor apex in males, and by the laterally situated epigynal teeth, the widely separated spermathecae, and the small, anteriorly originating spermathecal heads in females.

Description. Holotype male. Total length 7.5, prosoma 4.1 long, 2.7 wide; opisthosoma 3.4 long, 2.0 wide. Eye measurements: AME 0.10; ALE 0.20; PME 0.18; PLE 0.20; AME–AME 0.06; AME–ALE 0.06; PME–PME 0.15; PME–PLE 0.18; clypeus 0.20. Chelicerae with 3 promarginal and 3 retromarginal teeth (Fig. 28). Leg slender and long, hairy; leg formula: IV, I, II, III; measurements of legs: I: 16.5 (4.2, 5.7, 4.4, 2.2); II: 14.8 (3.8, 4.9, 4.0, 2.1); III: 13.1 (3.4, 4.3, 3.8, 1.6); IV: 17.1 (4.4, 5.5, 5.2, 2.0). PLS with the distal segment longer than the basal one.

Patellar apophysis strong; RTA shorter than tibia, with distal end extending beyond tibia; lateral tibial apophysis absent; cymbial furrow less than half of cymbium length; conductor lamella small; conductor extremely extended basal; dorsal apophysis of conductor small, situated prolaterally; median apophysis rounded; embolus moderately long, arising at approximately 6–o’clock–position (Figs 29–31).

Female paratype. Total length 8.2, prosoma 4.0 long, 2.7 wide; opisthosoma 4.2 long, 2.7 wide. Eye measurements: AME 0.15; ALE 0.20; PME 0.20; PLE 0.23; AME–AME 0.12; AME–ALE 0.05; PME–PME 0.12; PME–PLE 0.20; clypeus 0.15. Chelicerae with 3 promarginal and 2 retromarginal teeth. Leg IV formula: IV, I, II, III; measurements of legs: I: 13.6 (3.8, 4.8, 3.4, 1.6); II: 12.0 (3.3, 4.1, 3.1, 1.5); III: 10.0 (3.0, 3.0, 2.8, 1.2); IV: 14.5 (3.7, 4.9, 4.2, 1.7).

Epigynal teeth short, situated on the lateral margin of the atrium; copulatory ducts encircling spermathecae; spermathecae widely separated; spermathecal heads small, originating anteriorly (Figs 32–33).

Distribution. China (Sichuan) (Fig. 49).

Draconarius tensus spec. nov.

Figs 34–37, 49

Type material: Holotype male, CHINA: Anhui, Huangshan Mt., Huangshan City (30.1°N, 118.1°E), 18 October 1990, Yinfang Chen leg. (IZCAS)

Etymology. The species name is a participle of the Latin verb *tendere*, meaning “stretched” and referring to the stretched cymbium; adjective.

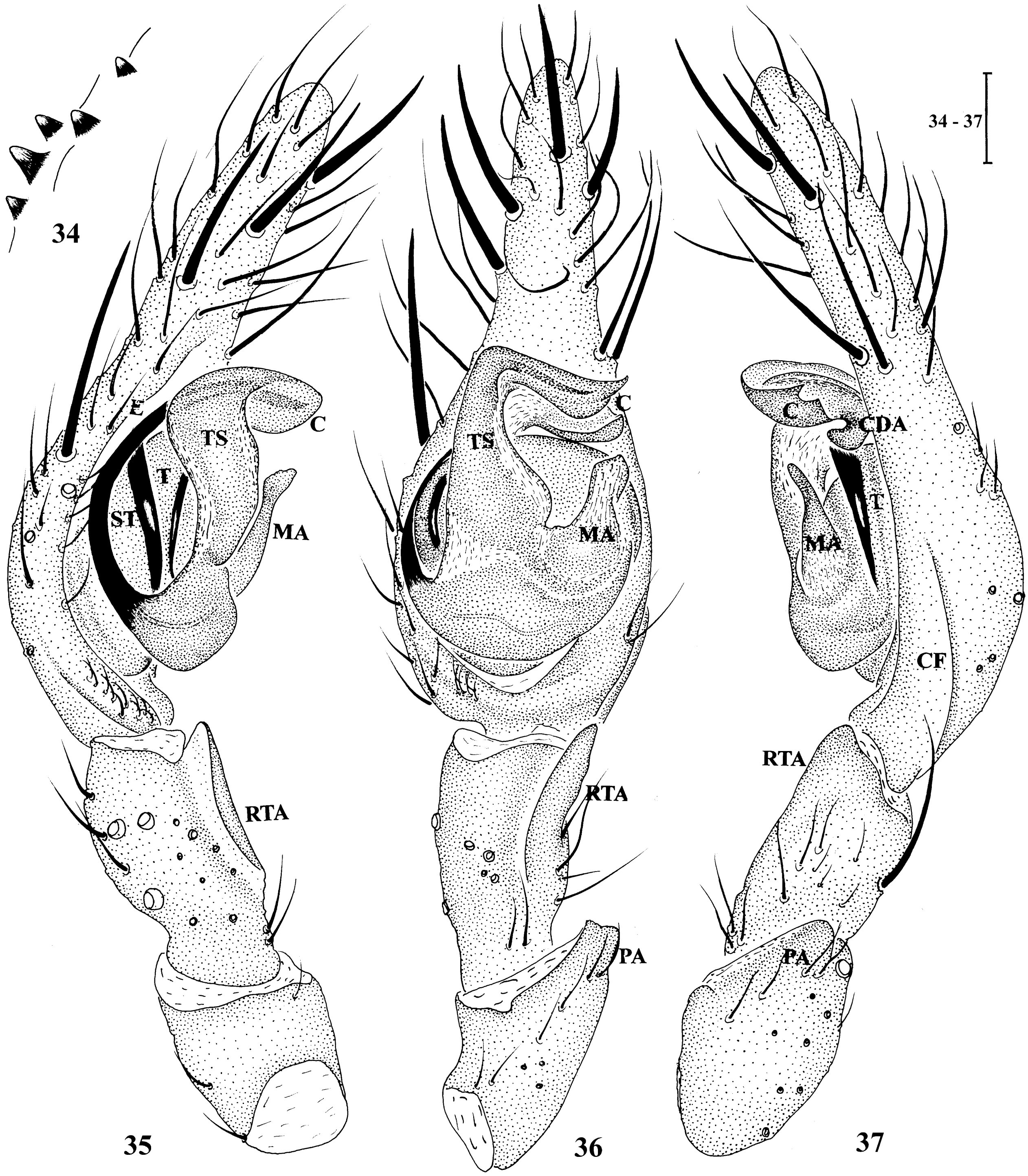
Diagnosis. This species is similar to *D. expansus* **spec. nov.** in having a broad conductor and a short embolus, but can be distinguished by the simple median apophysis and the hooked dorsal apophysis of conductor.

Description. Holotype male. Total length 7.4, prosoma 3.7 long, 2.7 wide; opisthosoma 3.7 long, 2.3 wide. Eye measurements: AME 0.18; ALE 0.20; PME 0.20; PLE 0.20; AME–AME 0.10; AME–ALE 0.05; PME–PME 0.10; PME–PLE 0.18; clypeus 0.18. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 34). Leg formula: IV, I, II, III; measurements of legs: I: 15.2 (3.9, 5.2, 4.0, 2.1); II: 14.1 (3.8, 4.7, 3.7, 1.9); III: 12.9 (3.4, 4.1, 3.7, 1.7); IV: 16.4 (4.2, 5.1, 5.1, 2.0). PLS with the distal segment distinctly shorter than the basal one.

Patellar apophysis stout; RTA long, with distal end slightly extending beyond tibia; lateral tibial apophysis absent; cymbial furrow about one third of cymbium length; conductor simple, modified into a deep groove hiding the distal end of embolus; dorsal apophysis of conductor hooked; median apophysis longer than wide; embolus short, arising at approximately 8.30–o’clock–position (Figs 35–37).

Female. Unknown.

Distribution. China (Anhui) (Fig. 49).



FIGURES 34–37. *Draconarius tensus* **spec. nov.** male, 34. Cheliceral teeth, ventral view; 35. Pedipalpus, prolateral view; 36. *Ditto*, ventral view; 37. *Ditto*, retrolateral view. Scale bar: 0.2 mm.

Draconarius ventrifurcatus **spec. nov.**

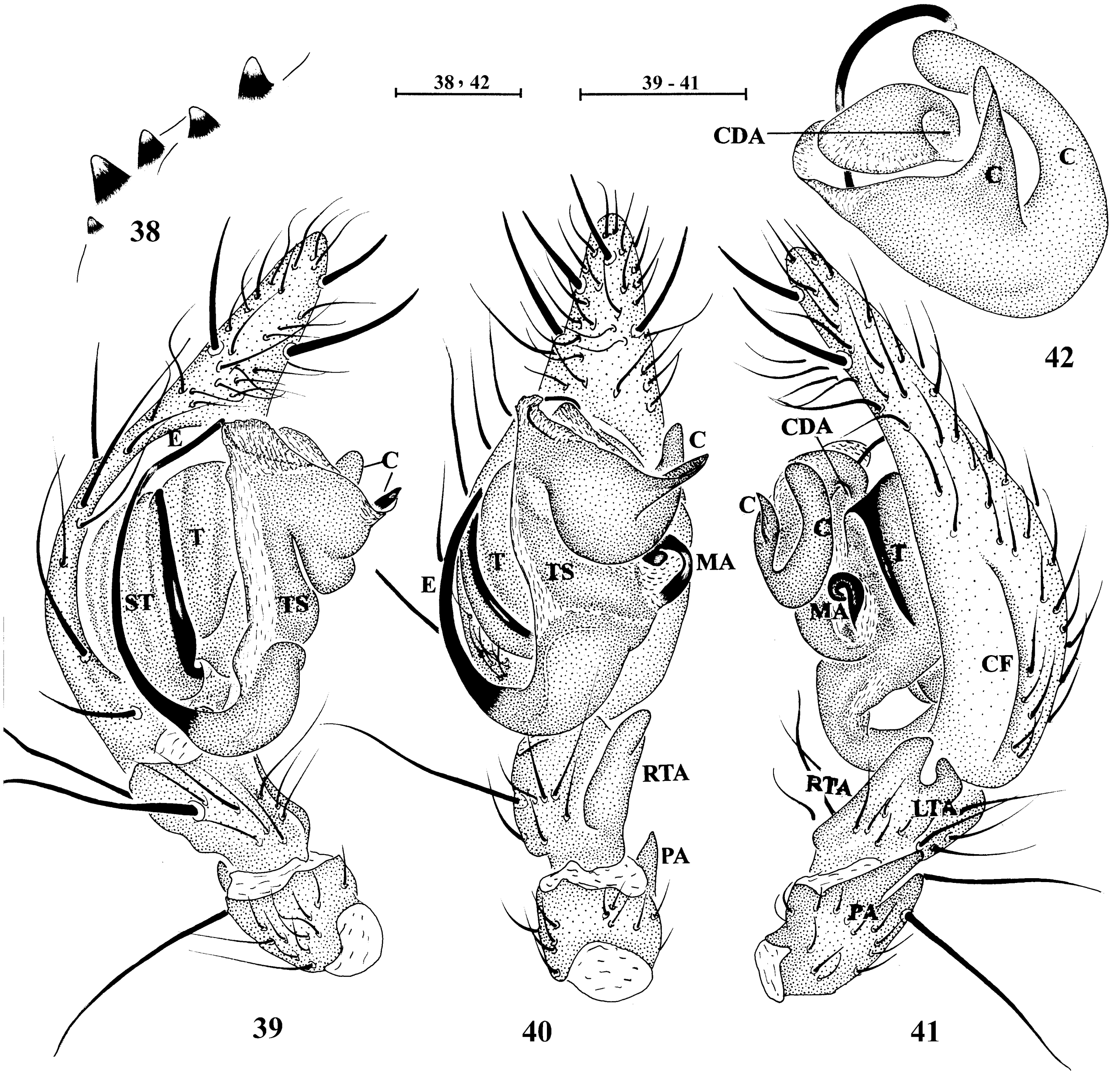
Figs 38–42, 49

Type material: Holotype male, 1 male paratype, CHINA: Sichuan, Luding County (29.8°N, 102.1°E), the road from Moxi Town to Yajiageng, 10 October 2005, Xiang Xu and Xiufeng Zhang leg. (IZCAS)

Etymology. The species name is a compound word of the Latin noun *venter* and the Latin adjective *furcatus*, meaning “venter” and “forked” respectively, and referring to the shape of the conductor; adjective.

Diagnosis. This species is similar to *D. calcariformis* (Wang 1994) in having a bifid conductor and a small median apophysis, but can be distinguished by the presence of two patellar apophyses, the hooked lateral tibial apophysis and the different shape of conductor.

Description. Holotype male. Total length 7.7, prosoma 4.1 long, 2.6 wide; opisthosoma 3.6 long, 2.2 wide. Eye measurements: AME 0.10; ALE 0.20; PME 0.09; PLE 0.20; AME–AME 0.05; AME–ALE 0.04; PME–PME 0.09; PME–PLE 0.15; clypeus 0.10. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 38). Leg formula: IV, I, II, III; measurements of legs: I: 10.6 (2.8, 3.6, 2.6, 1.6); II: 9.1 (2.5, 3.0, 2.3, 1.3); III: 8.5 (2.3, 2.6, 2.4, 1.2); IV: 11.4 (3.1, 3.7, 3.1, 1.5). PLS with the distal segment almost equal to the length of the basal one.

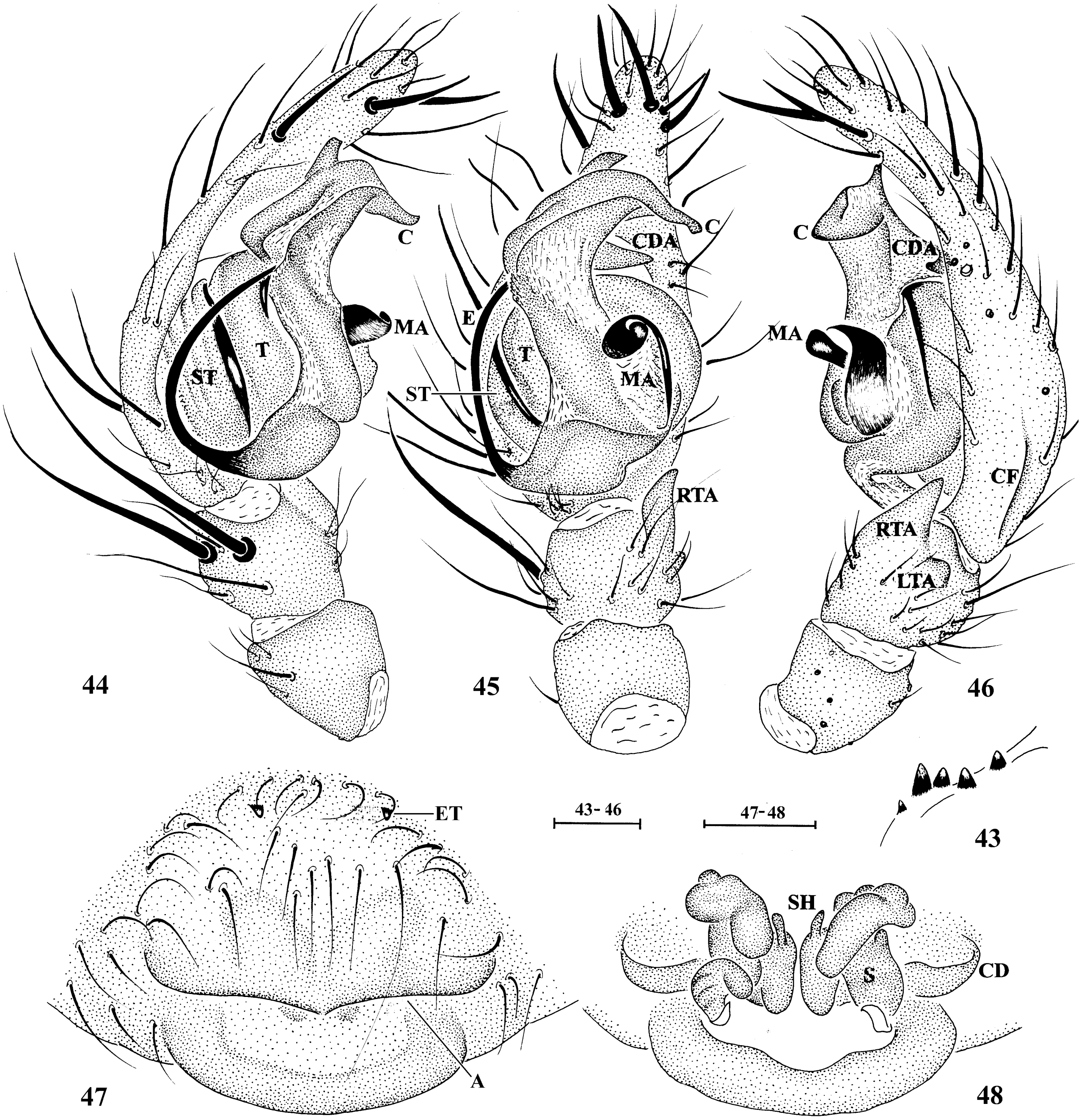


FIGURES 38–42. *Draconarius ventrifurcatus* **spec. nov.** male, 38. Cheliceral teeth, ventral view; 39. Pedipalpus, prolateral view; 40. *Ditto*, ventral view; 41. *Ditto*, retrolateral view; 42. Conductor, enlarged, retrolatero- to ventrodistal view. Scale bars: 38, 42 = 0.2 mm; 39–41 = 0.5 mm.

Patella with two apophyses; RTA almost equal to the length of tibia, with distal end extending beyond tibia; lateral tibial apophysis hooked; cymbial furrow less than half of cymbium length; conductor lamella moderately large; conductor with two apexes; dorsal apophysis of conductor indistinct; median apophysis small and rounded (Figs 39–42).

Female. Unknown.

Distribution. China (Sichuan) (Fig. 49).



FIGURES 43–48. *Draconarius zonalis* **spec. nov.** male: 43–46; female: 47–48, 43. Cheliceral teeth, ventral view; 44. Pedipalpus, prolateral view; 45. *Ditto*, ventral view; 46. *Ditto*, retrolateral view; 47. Epigynum, ventral view; 48. Vulva, dorsal view. Scale bars: 0.2 mm.

Draconarius zonalis spec. nov.

Figs 43–49

Type material: Holotype female, 1 male paratype, CHINA: Hunan Province, Hengshan County (30.3°N, 102.8°E), Nanyue Mt., 6 October 2003, Xiang Xu leg. (IZCAS)

Etymology. The species name *zonalis, -is, -e* is derived from the Latin noun *zona*, meaning “belt” and referring to the copulatory ducts resembling a waistbelt; adjective.

Diagnosis. This species is similar to *D. neixiangensis* (Hu, Wang & Wang, 1991) in having short epigynal teeth and missing a patellar apophysis, but can be distinguished by the presence of a strongly curved median apophysis, the embolus having a sharp distal end and the conductor exhibiting an apophysis on the distal margin in males (Figs 44–46), and by the strongly sclerotised copulatory ducts and the strongly contorted spermathecae (Fig. 48).

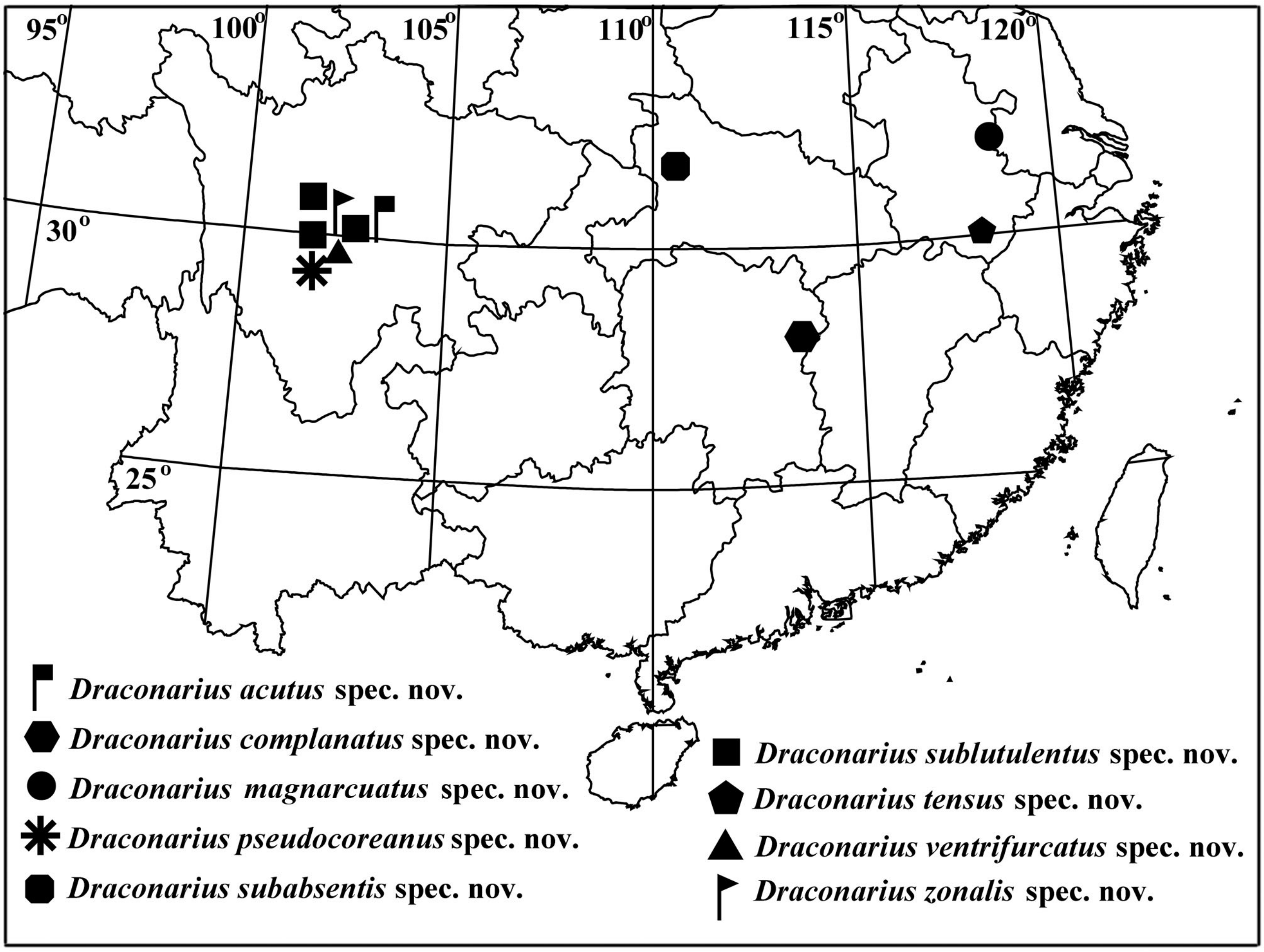


FIGURE 49. Known distribution range of nine new *Draconarius* species in China.

Description. Holotype male. Total length 4.6 (specimen dried), prosoma 3.0 long, 2.0 wide; opisthosoma 1.6 long, 1.0 wide. Eye measurements: AME 0.10; ALE 0.18; PME 0.15; PLE 0.15; AME–AME 0.03; AME–ALE 0.05; PME–PME 0.10; PME–PLE 0.13; clypeus 0.15. Chelicerae with 3 promarginal and 2 retromarginal teeth (Fig. 43). Leg formula: IV, I, II, III; measurements of legs: I: 8.3 (2.3, 2.9, 2.0, 1.1); II: 7.5 (2.1, 2.5, 1.9, 1.0); III: 6.8 (1.9, 2.2, 1.8, 0.9); IV: 9.3 (2.5, 3.1, 2.6, 1.1). PLS with the distal segment slightly longer than the basal one.

Patellar apophysis absent; RTA sharp, with distal end extending beyond tibia; lateral tibial apophysis present; cymbial furrow short, about one fourth of cymbium length; conductor with apophysis on distal margin; dorsal apophysis of conductor large; median apophysis strongly curved distally; embolus moderately long, arising at approximately 7.30–o'clock–position (Figs 44–46).

Female paratype. Total length 4.6 (specimen dried). Prosoma 2.8 long, 1.8 wide; opisthosoma 1.8 long, 1.5 wide. Eye measurements: AME 0.10; ALE 0.20; PME 0.20; PLE 0.20; AME–AME 0.03; AME–ALE 0.05; PME–PME 0.05; PME–PLE 0.15; clypeus 0.15. Chelicerae with 3 promarginal and 2 retromarginal teeth. Leg formula: IV, I, II, III; measurements of legs: I: 8.1 (2.1, 2.5, 1.7, 0.9); II: 6.3 (1.8, 2.2, 1.5, 0.8); III: 5.5 (1.5, 1.7, 1.6, 0.7); IV: 8.1 (2.1, 2.8, 2.3, 0.9).

Epigynal teeth small, situated on the anterior epigynum and widely separated from the atrium; atrium strongly reduced and with posterior margin strongly sclerotised; copulatory ducts zonal, originating laterally; spermathecae complex, separated not far from each other (Figs 47–48).

Distribution. China (Hunan) (Fig. 49).

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Lineacoelotes, a new genus of Coelotinae from China (Araneae: Amaurobiidae)

XIANG XU[1, 2], SHUQIANG LI[1, 5] & XIN-PING WANG [3, 4]
[1] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China*
[2] *College of Life Sciences, Hunan Normal University, Changsha 410081, Hunan, China*
[3] *College of Life Sciences, Hebei University, Baoding 071002, Hebei, China*
[4] *College of Medicine, University of Florida, Gainesville, Florida 32610, USA. E-mail: wang@amaurobiidae.com*
[5] *Corresponding author. E-mail: lisq@ioz.ac.cn*

Abstract

A new genus of Coelotinae, *Lineacoelotes* gen. nov., is described. *Lineacoelotes* includes five species from central and western China. The females of *L. bicultratus* (Chen, Zhao & Wang, 1991) comb. nov. from Hubei (transferred from *Coelotes*), the males and females of *L. funiushanensis* (Hu, Wang & Wang, 1991) comb. nov. from Henan (transferred from *Draconarius*), the females of *L. nitidus* (Li & Zhang, 2002) comb. nov. from Hubei (transferred from *Coelotes*) are redescribed, the males of *L. nitidus* are described for the first time. Two new species from both males and females, *L. longicephalus* sp. nov. from Sichuan and *L. strenuus* sp. nov. from Hubei, are described. The females of this new genus have distinct, unusually long spermathecal heads, and the males have a broad, long patellar apophysis and a strongly modified conductor but lack a lateral tibial apophysis and a conductor dorsal apophysis. Comparison of male palps of *Lineacoelotes* gen. nov. suggests that none of the modified apophyses on the dorsal edge of the conductor is homologous to the conductor dorsal apophysis found in many other Coelotinae, but this assumption should be tested in a future phylogenetic analysis. As in other Coelotinae, spinnerets of representatives of *Lineacoelotes* gen. nov. have PMS with 2 cylindrical spigots on the lateral sides and 2 minor ampullate spigots on the middle, and PLS long with 1–2 cylindrical spigots on its base, and the trichobothrium has a transversely striped large hood and a smooth small hood.

Key words: new species, taxonomy, phylogenetic relationships, biogeography, Holarctic

Introduction

The spider subfamily Coelotinae F.O.P.-Cambridge, 1893 is well known for its species richness in Asia, particularly East Asian regions, including China, Japan, and Korea (Platnick 2007). Recent studies also show an abundant distribution of Coelotinae in the Himalayas and Thailand. Based on the specimens from the Himalayan expeditions of J. Martens (Mainz, Germany), Wang (2002) found a new genus (*Himalcoelotes* Wang, 2002) and 10 related species from Bhutan, Nepal and Tibet. Thirty-eight more species belonging to other genera are awaiting description. A series of four papers have been published on the discovery of 24 new endemic Coelotinae from Thailand (Dankittipakul & Wang 2003, 2004; Dankittipakul *et al.* 2005; Chami-Kranon *et al.* 2006). Coelotinae show both high species richness and great variation in their genitalic morphology, particularly that of the male palp. Genitalia of Coelotinae are so diversified that people often find it difficult to assign some species to any of the existing genera (Wang & Jäger, 2007). In fact, many species have been lumped into the genera *Coelotes* Blackwall, 1841 and *Draconarius* Ovtchinnikov, 1999. Wang (2003) tentatively assigned some of the *Draconarius* species to 7 species groups and more groups were recognized subsequently (Dankittipakul & Wang 2004; Zhang *et al.* 2005; Xu & Li 2006a). Obviously many species listed in both *Draconarius* and *Coelotes* are only arbitrarily assigned (Wang & Jäger 2007; Xu & Li 2006b; Xu *et al.* 2006). A compara-

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tive study of worldwide Coelotinae is needed in the near future, especially if thorough collections of specimens can be obtained from some critical regions, such as southern and southwestern China, northern Vietnam, etc.

Among the highly diversified Coelotinae species, one species, *Coelotes bicultratus* Chen, Zhao & Wang, 1991, which was based only on females from Hubei, is particularly interesting because of its unusually long spermathecal heads. The same long spermathecal heads appear to be also present in another species, *Coelotes funiushanensis* Hu, Wang & Wang, 1991 from Henan. *C. funiushanensis* was described from both males and females but unfortunately the types are not available for study and the original illustrations are not clear enough to portray the detailed genitalic structures, particularly the male palp. The finding of a third similar species, *Coelotes nitidus* Li & Zhang, 2002 from Hubei, also described from females only, convinced the authors that these species do form a distinct group, but lack of males prohibits us from further conclusions. In order to understand these spiders in detail, further collecting trips were arranged to the type localities, focused on collecting both sexes. We successfully collected not only males and females of the two described species, but also another undescribed species, with both males and females. With one more undescribed species from the collections of the American Museum of Natural History (donated by C. Deeleman), five species are recognized to belong to this distinct group. We here define this group of five species as a new genus, *Lineacoelotes* gen. nov. A cladistic analysis is not included in this study but will be arranged in the near future to identify its phylogenetic relationship within the subfamily Coelotinae. In addition to the long spermathecal heads, all the species of *Lineacoelotes* gen. nov. have a pair of relatively long, anteriorly originating epigynal teeth in females, and a long patellar apophysis and a strongly modified conductor in males, but none of them have a lateral tibial apophysis or a conductor dorsal apophysis in males.

Material and methods

All measurements are in millimeters. All the scale lines are 0.2 mm long except where indicated otherwise. Eye diameters are taken at the widest point. The total body length does not include the length of the chelicerae or spinnerets. Leg measurements are given as: Total length (femur, patella + tibia, metatarsus, tarsus). The terminology used in the text and figures follows Wang (2002). Specimens studied in the current paper are deposited in the American Museum of Natural History in New York (AMNH), Hubei University in Wuhan (HUW) and Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS). The distribution map was generated using GIS ArcView software and the .dbf files of the studied species are downloadable from http://www.amaurobiidae.com, which is published and maintained by Xin-Ping Wang (Wang 2007).

Abbreviations

A	atrium
AC	aciniform gland spigots
ALE	anterior lateral eyes
ALS	anterior lateral spinnerets
AME	anterior median eyes
C	conductor
C1	conductor ventral edge
C2	conductor dorsal edge: distal apophysis
C3	conductor dorsal edge: ventral side apophysis
CD	copulatory duct
CF	cymbial furrow

CL	conductor lamella
CY	cylindrical gland spigots
E	embolus
EB	embolic base
ET	epigynal tooth
FD	fertilization duct
LTA	lateral tibial apophysis
MA	median apophysis
mAP	minor ampullate gland spigots
MAP	major ampullate gland spigots
PA	patellar apophysis
PI	piriform gland spigots
PLE	posterior lateral eyes
PLS	posterior lateral spinnerets
PME	posterior median eyes
PMS	posterior median spinnerets
RTA	retrolateral tibial apophysis
S	spermathecae
SH	spermathecal head
ST	subtegulum
T	tegulum
TS	tegulum sclerite

Phylogenetic relationships

The monophyly of the new genus *Lineacoelotes* is supported by at least two putative synapomorphies: the strongly elongated, looped spermathecal heads and the modified conductor (particularly the presence of a ventral apophysis on the dorsal edge of the conductor). The long, strong, anteriorly situated epigynal teeth, the large copulatory ducts, and the large patellar apophysis might provide additional support for this hypothesis.

The sister group of *Lineacoelotes* gen. nov. is unknown. The long epigynal teeth, the large copulatory ducts, and the absence of a conductor dorsal apophysis might relate *Lineacoelotes* gen. nov. to the genus *Pireneitega* Kishida, 1955 (=*Paracoelotes* Brignoli, 1982) which is known from Europe, Central Asia, and East Asia. The presence of a large patellar apophysis is shared with the true *Coelotes* species, including the *atropos* group from Europe and Middle Asia, the *charitonovi* group from Middle Asia, the *pseudoterrestris* group from Yunnan, China, and the *exitialis* group from Japan. Another distinct feature of *Lineacoelotes* gen. nov. is the absence of a lateral tibial apophysis, which corresponds to the species of two basal genera (*Coronilla* Wang, 1994 and *Femoracoelotes* Wang, 2002). The lack of a lateral tibial apophysis might be associated with the presence of a large patellar apophysis. The dorsal edge of the conductor of *Lineacoelotes* gen. nov. is highly modified into several apophyses and none of which seem homologous with the conductor dorsal apophysis presented in most Coelotinae except the genus *Pireneitega* Kishida 1955 and genus *Iwogumoa* Kishida 1955 (= *Asiacoelotes* Wang, 2002) (Nishikawa & Ono 2004; Wang & Jäger 2007). In fact, the palps of all four species (another species is known only by females) are so similar that they can only be separated by the apophyses on the dorsal edge of conductor.

Within *Lineacoelotes* gen. nov., one distinct clade might include *L. bicultratus, L. funiushanensis* and *L. nitidus*, supported by the anteriorly extending spermathecal heads and the similar modification of the conductor dorsal edge, while both *L. longicephalus* sp. nov. and *L. strenuus* sp. nov. have their own unique characteristics.

Biogeography

The Holarctic spider subfamily Coelotinae includes some of the most common spider taxa in North America (at least west to the Rocky Mountains and north to southern Canada), in Europe north to southern Sweden and Finland, and in Asia north to far eastern Russia and south to Nepal, northern and central Thailand, and northern Vietnam (Wang 2002; Wang 2003; Chami-Kranon *et al.* 2006), and is best represented in East Asia, followed by the Mediterranean (Ubick 2005: Map 2). The relationship of the three western Nearctic cribellate Zanomyinae (Ubick 2005) with the "true" Coelotinae is still awaiting cladistic testing based on either morphological or molecular evidence. But the similarity of the male palps might be not enough to support their sister group relationship. Although they have similar cymbial furrows and emboli, in Coelotinae the RTA is long and extends along the more or less elongated tibia rather than being a small, short apophysis on distal tibia, the Coelotinae conductor originates prolaterally from the distal tegulum and forms the "embolus, tegular sclerite, conductor complex" rather than just an isolated, retrolaterally and distally originated apophysis, and the large hood of Coelotinae trichobothria has 3–5 large transverse stripes rather than numerous fine longitudinal or transverse stripes. The possible lack of Coelotinae in the western Nearctic is still a mystery, perhaps the Rocky Mountains serve as a barrier, as suggested by Ubick (2005).

All five *Lineacoelotes* species are recorded in central (Henan, Hubei) and western (Sichuan) China. The species *L. bicultratus* and *L. strenuus* sp. nov. were collected from the same mountain range which adjoins Mt. Baotianman where *L. funiushanensis* was collected, while *L. nititus* is from far south and *L. longicephalus* sp. nov. from far west (Fig. 39).

Taxonomy

Amaurobiidae Thorell, 1870

Coelotinae F.O.P.-Cambridge, 1893

Lineacoelotes gen. nov.

Type species: *Lineacoelotes longicephalus* sp. nov.

Etymology: The generic name is a compound word with the prefix "linea" and the generic name of *Coelotes*. "Linea" means a thread, referring to the long, coiled spermathecal head and is masculine in gender.

Diagnosis: Members of this genus can be separated from other Coelotinae by their unusually long, coiled spermathecal heads (Figs 2, 4, 6, 12, 26, 38), the large patellar apophysis, the absence of a lateral tibial apophysis (a small apophysis situated on retrolateral side of tibia in most Coelotinae and separated slightly from RTA dorsal side, see Wang 2002: Fig 73), the strongly modified short conductor (Figs 8, 9, 14, 15, 31, 32, 34, 35), and the absence of a conductor dorsal apophysis.

Description: Medium sized ecribellate spiders, with total length 6.40–8.39. Somatic morphology is similar to other Coelotinae (Fig 16). From dorsal view, anterior eye row straight or slightly procurved, posterior row procurved; AME smallest, ALE and PLE largest and subequal, PME can be slightly larger than AME or as large as ALE and PLE (Fig 17); chilum undivided, hairless. Chelicerae with 3 promarginal teeth and 2 retromarginal teeth; tibiae with about four rows of trichobothria; metatarsi and tarsi with one row of trichobothria; trichobothria with large hood transversely striated and small hood smooth, (Fig 24). Tarsal organ with simple opening (Fig 22). Leg spination also similar to other Coelotinae. Trachea not examined. Colulus represented by clusters of hairs (Fig 23); ALS short, apex of ALS with 2 major ampullate gland spigots (MAP) and approximately 15–20 piriform gland spigots (PI); PMS small, with 2 minor ampullate gland spigots (mAP), approximately 15 aciniform gland spigots (AC), 2 cylindrical gland spigots (CY); PLS second segment long, with approximately 30 aciniform gland spigots, and only 1 cylindrical gland spigot visible from the examined spinneret (Figs 19–21). Female epigynum simple, atrium large, situated anteriorly, distinctly separated from epigastric furrow; copulatory ducts broad; spermathecae with bases relatively small, situated close together (except *L. strenuus* sp. nov.); spermathecal heads extremely long, strong looped and extended anteriorly or laterally (Figs 11–12). Male palp with large patellar apophysis which can be as long as patellar length; RTA, which is the only apophysis on retrolateral side of tibia, extending along most of tibial length (in most Coelotinae, there is another small apophysis called lateral tibial apophysis by Wang, 2002. Lateral tibial apophysis is usually slightly separated from RTA); cymbial furrow can be shorter, as long as, or longer than cymbial length; conductor short (Figs 14, C1), conductor dorsal edge strongly modified to a retrolaterally directed distal apophysis (Figs 14, C2) and another apophysis (C3) that is directed either prolaterally (Figs 14) or retrolaterally (Figs 8–10); median apophysis spoon-shaped, rounded; embolus filiform, with base directed proximally and then curved distally (Figs 13–15).

Natural history: Species of *Lineacoelotes* gen. nov. build small funnel webs, usually close to the ground. The spiders can be found under objects, such as logs and stones. Some of them are found in caves. *L. funiushanensis*, for example, has been collected both inside and outside caves, whereas *L. nitidus* is known exclusively from caves. Judging from the somatic appearance, neither presents particular adaptations to cavernicolous life.

Adults of *Lineacoelotes* gen. nov. have been collected from early May to late November, but our collecting experience shows that adults of *Lineacoelotes* gen. nov., particularly the adult males, are only abundant in October and November, which is also observed by Wang et al. (2001) in their year-round pitfall trap sampling.

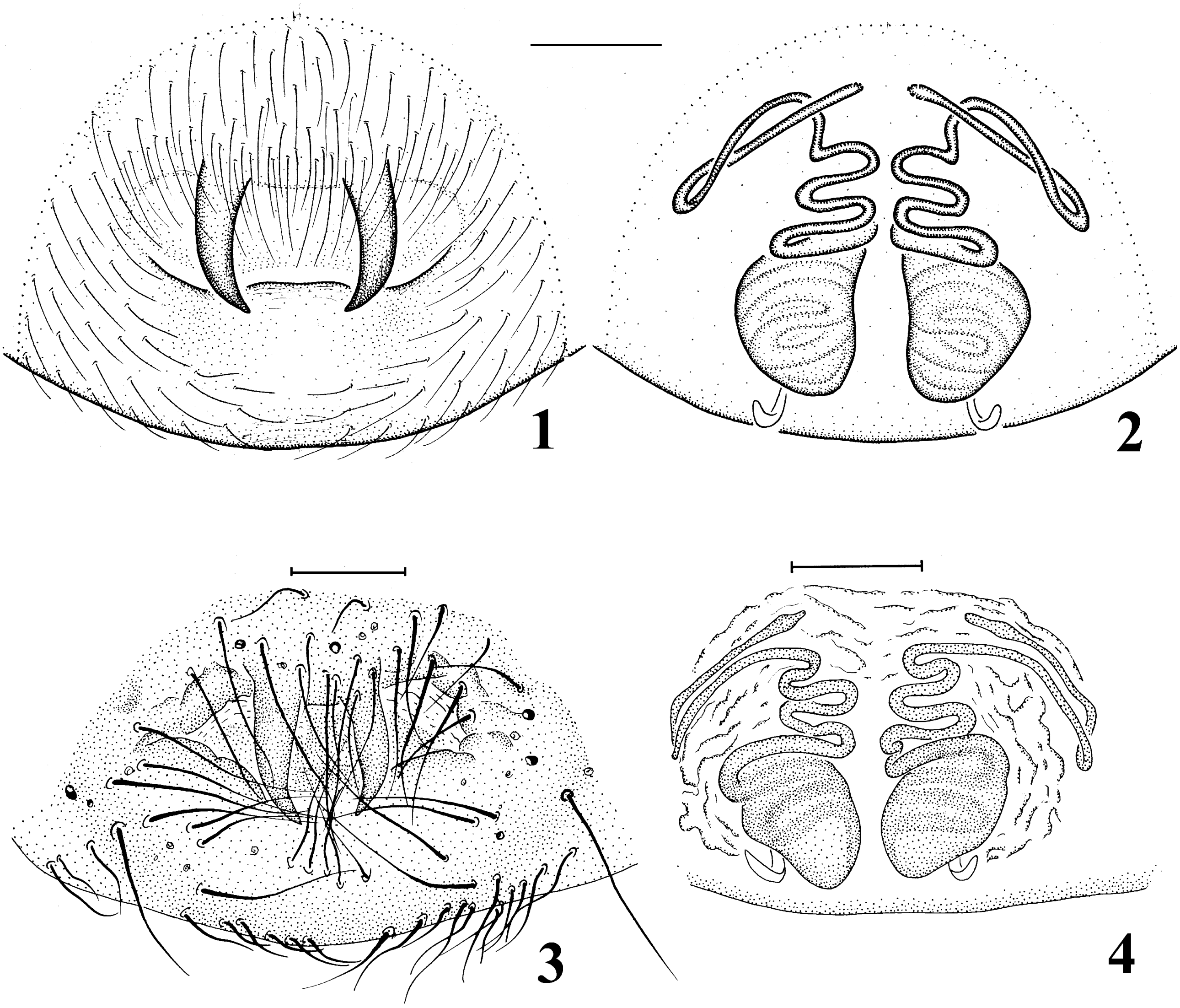
Compositon: Five species: *Lineacoelotes bicultratus* (Chen, Zhao & Wang, 1991), *L. funiushanensis* (Hu, Wang & Wang, 1991), *L. longicephalus* sp. nov., *L. nitidus* (Li & Zhang, 2002), and *L. strenuus* sp. nov.

Distribution: China (Henan, Hubei, Sichuan) (Fig 39).

Key to species

1. Male 2
   Female..5
2. Dorsal edge of conductor with distal apophysis strongly spiraled (C2 in Figs 13–15, 33–36) 3
   Dorsal edge of conductor with distal apophysis broad, not spiraled (C2 in Figs 7–10, 27–32).................4
3. Dorsal edge of conductor, with large prolaterally extending apophysis on its ventral side (C3 in Figs 13–14) ....*longicephalus* sp. nov.
   Dorsal edge of conductor, with a small retrolaterally extending bifurcated apophysis on its ventral side (C3 in Figs 33–36) ....*strenuus* sp. nov
4. Dorsal edge of conductor, with a small, blunt, relatively broad, prolaterally extending apophysis on its ventral side, and without a tooth on top of that apophysis (C3 in Figs 27–32) ....*nitidus*
   Dorsal edge of conductor, with a small, blunt, relatively slender, retrolaterally extending apophysis on its ventral side, and with a sharp tooth on top of that apophysis (C3 in Figs 7–10) ....*funiushanensis*
5. Spermathecal heads extending posteriorly, laterally, and then curving back anteriorly (Figs 12, 38) 6
   Spermathecal heads extending anteriorly only (Figs 2, 4, 6, 26)...7
6. Epigynal teeth with narrow base (approximately as wide as its distal half); atrium simple; spermathecal heads extending on lateral side and then on ventral side of copulatory ducts, toward each other in the middle (Fig. 11–12)..*longicephalus* sp. nov.
   Epigynal teeth with broad base (at least two times wider than its distal half); atrium complex, with lateral margins strongly modified to several ridges; spermathecal heads extending on ventral side of copulatory ducts, toward each other in the middle (Fig. 37–38)...*strenuus* sp. nov.

7. Atrium small, separated from epigastric furrow by at least its length; spermathecal heads originating from marginal area of spermathecae (Figs 1–4, 5–6) 8
   Atrium large, separated from epigastric furrow by less than its length; spermathecal heads originating from middle area of spermathecae (Figs 25, 26) .... *nitidus*
8. Atrium separated from epigastric furrow by at least 1.5 times its length; spermathecal heads zigzagged relatively medially (Figs 1–4) .... *bicultratus*
   Atrium separated from epigastric furrow by approximately its length; spermathecal heads zigzagged relatively laterally (Figs 5–6) .... *funiushanensis*



FIGURES 1–4. *Lineacoelotes bicultratus* (Chen, Zhao & Wang, 1991), females from Mt. Wudangshan, Hubei, China, epigynum (1, 3 ventral view; 2, 4 dorsal view; 1–2 Holotype; 3–4. Non-type).

Lineacoelotes bicultratus (Chen, Zhao & Wang, 1991) comb. nov.
Figs 1–4, 39

Coelotes bicultratus Chen, Zhao & Wang 1991: 9, figs 1–2 (female holotype and paratype from Mt. Wudangshan, Hubei, China, deposited in HUW, examined). —Song *et al.* 1999: 374, figs 216R–S.

Additional material examined: China, Hubei, Mt. Wudangshan, 2 females (HUW).

Diagnosis: Females of this species similar to those of *L. funiushanensis* and *L. nitidus* in having anteriorly extending spermathecal heads but the epigynal teeth of *L. bicultratus* separated by 1–1.5 times their width (Figs 1, 3), while in the other two species they are separated by at least twice their width. The atrium of *L. bicultratus* is separated from the epigastric furrow by approximately 1.5 times its length (Figs 1, 3) but they are separated by about the atrium length in *L. funiushanensis* and less than the atrium length in *L. nitidus*.

Description: See Chen *et al.* (1991) for detailed somatic description.

Female. Eye measurements (one non–type female): AME 0.13; ALE 0.20; PME 0.15; PLE 0.20; AME-AME 0.08; PME-PME 0.13; PME-PLE 0.13. Chelicerae with 3 promarginal and 2 retromarginal teeth. Epigynum with two long, strong, closely situated teeth originating from anterior margin of atrium, separated by 1.5 times their basal width in examined types (Fig. 1) (in two other specimens collected from the same mountain, the epigynal teeth situated close together and separated by only about their basal width, Fig. 3); atrium narrow, extending transversely, widely separated from epigastric furrow by approximately 1.5 times its length; epigynal teeth reaching posterior margin of atrium; atrium extending into epigynum, forming broad copulatory duct that connects to spermathecae; spermathecal heads originating anterior of spermathecae, zigzag anteriorly, forming 3–4 loops, then extending laterally, curving back medially; spermathecae simple, oval-shaped, slightly separated (Figs 1–4).

Male. Unknown.

Distribution: China (Hubei) (Fig. 39).

Lineacoelotes funiushanensis (Hu, Wang & Wang, 1991) comb. nov.

Figs 5–10, 39

Coelotes funiushanensis Hu, Wang & Wang 1991: 41, figs 14–17 (female holotype, 2 female and 4 male paratypes from Yaochanggou, Neixiang, Henan, China, deposited in Shandong University, not examined). —Song *et al.* 1999: 375, figs 217Q–R, 222B, 223G.

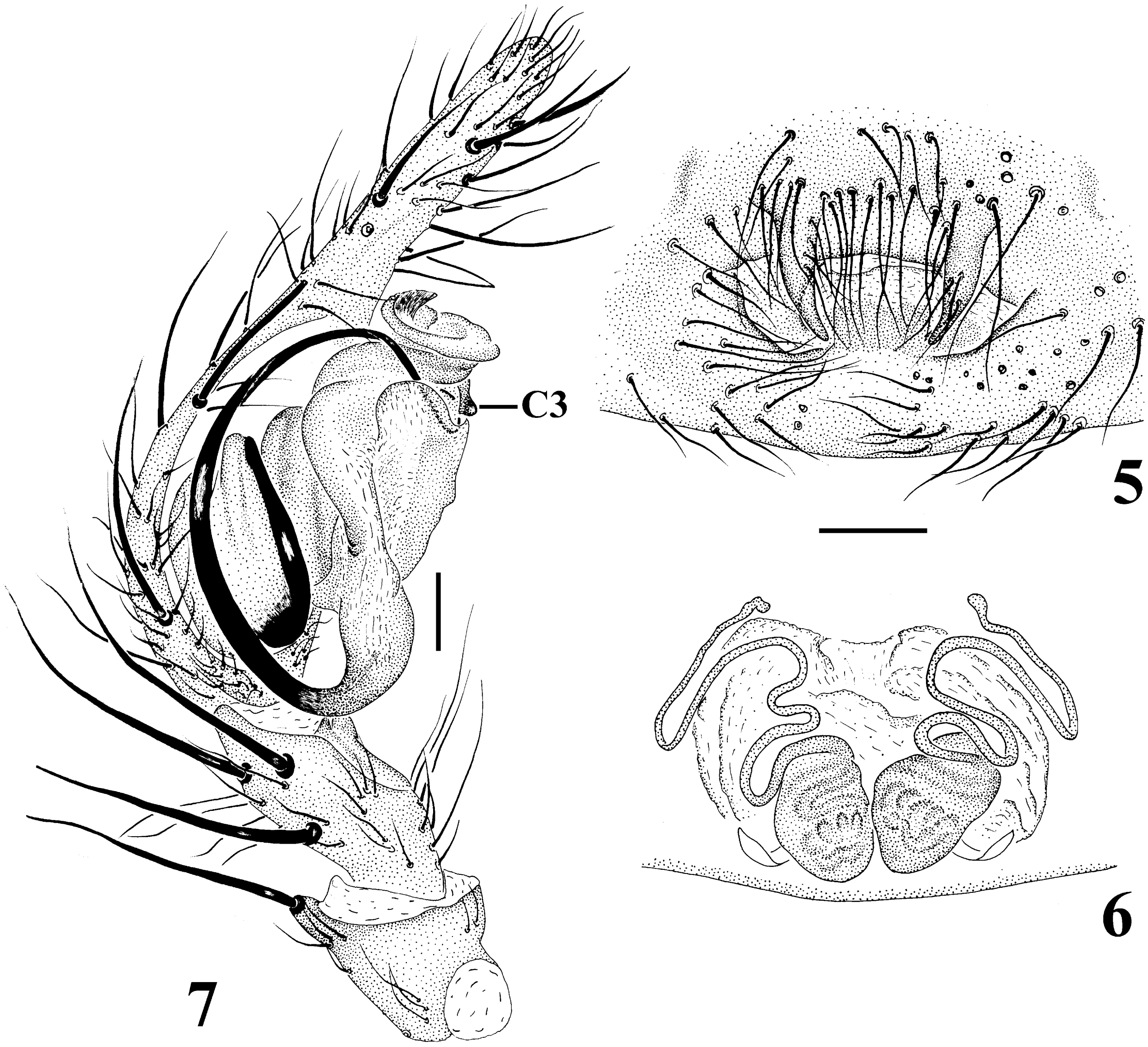
Draconarius funiushanensis Wang 2003: 532.

Additional material examined: China: Henan: Neixiang County, Qiliping Town (33.3°N, 111.8°E), Yaochanggou, November 12, 2005, 16 females and 7 males (Xxiang Xu and Qian Wang, IZCAS); Neixiang County, Baotianman Nature Reserve (33.5°N, 111.9°E), November 12, 2005, 5 females (Xiang Xu and Qian Wang, IZCAS); Xixia County, Wuliqiao Village, Yunhuabianfudong Cave (33.3°N, 111.4°E), June 20, 2005, 5 females (Xiang Xu and Qian Wang, IZCAS).

Diagnosis: The females of this species are similar to those of *L. bicultratus* and *L. nitidus* in spermathecal shape and in having anteriorly extending spermathecal heads. The widely separated epigynal teeth (Fig. 5) easily distinguish them from *L. bicultratus*, but they can only be separated from *L. nitidus* by the relatively narrow atrium which is separated from the epigastric furrow by approximately its length (Fig. 5), whereas *L. nitidus* has a large atrium that is separated from the epigastric furrow by less than its length. Another character that may distinguish *L. funiushanensis* from *L. nitidus* is the distally originating spermathecal heads, but there might be variation and this difference may not be reliable. The males are also similar to those of *L. nitidus* and can only be distinguished by the modification of the conductor dorsal edge (Fig. 10). Regarding the conductor dorsal edge, *L. funiushanensis* has a slightly large distal apophysis (C2) and a retrolaterally extended apophysis on the ventral side and a sharp tooth on top (C3) (Figs 7–10), whereas *L. nitidus* has a relatively small distal apophysis and a prolaterally extending apophysis and without a sharp tooth on top (Figs 29–32).

Description: See Hu *et al.* (1991) for detailed somatic description.

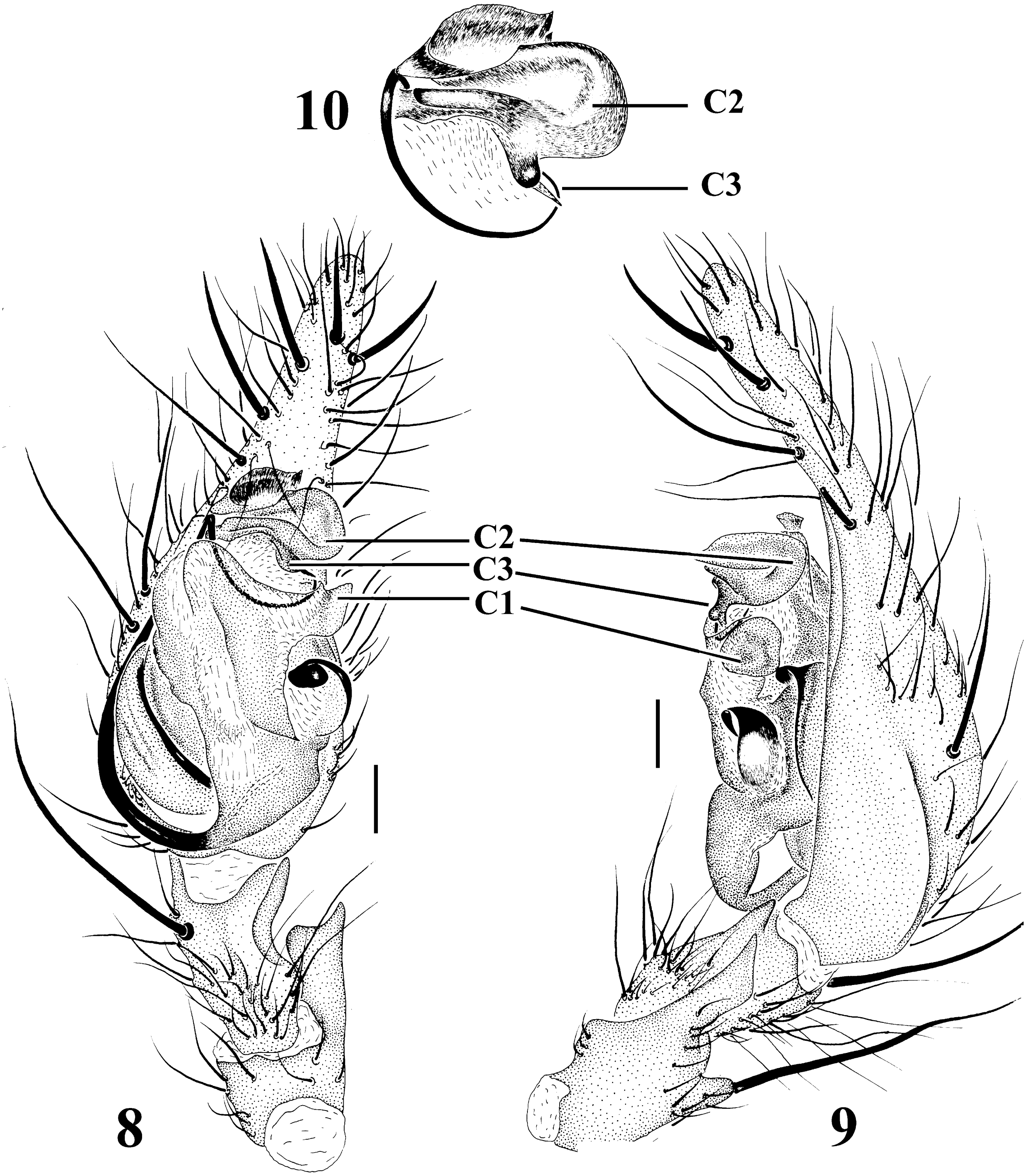
Female: Eye measurements (one female from Neixiang County, Qiliping Town, Yaochanggou): AME 0.15; ALE 0.20; PME 0.18; PLE 0.20; AME-AME 0.08; PME-PME 0.13; PME-PLE 0.18. Chelicera with 3 promarginal and 2 retromarginal teeth. Epigynum with two long, strong teeth originating from anterior margin of atrium, widely separated by twice their basal width; atrium narrow, transversely extended, separated from epigastric furrow by approximately its height; epigynal teeth reaching almost posterior margin of atrium; atrium extending into epigynum, forming broad copulatory duct; spermathecal heads originating on distal spermathecae, zigzag anteriorly, forming 2–3 loops, then extending laterally, curving back medially; spermathecae simple, oval-shaped, close together (Figs 5–6).



FIGURES 5–7. *Lineacoelotes funiushanensis* (Hu, Wang & Wang, 1991), male and female from Qiliping, Neixiang, Henan, China. 5–6 Female, epigynum (5 ventral view; 6 dorsal view). 7 Male palp, prolateral view.

Male: Eye measurements (one male from Neixiang County, Qiliping Town, Yaochanggou): AME 0.15; ALE 0.20; PME 0.18; PLE 0.20; AME-AME 0.05; PME-PME 0.10; PME-PLE 0.15. Chelicera with 3 promarginal and 2 retromarginal teeth. Palpal patellar apophysis long, with more or less sharp distal end; RTA extending along most of tibial length, with pointed distal end; cymbial furrow short, extending up to 1/3 of cymbial length; conductor distinctly separated into broad, short ventral apophysis (C1) and strongly modified dorsal edge; in addition to broad distal apophysis (C2) on retrolateral side of conductor dorsal edge, another small, retrolaterally directed apophysis (C3) being situated on ventral side of conductor dorsal edge, with sharp tooth situated on top; median apophysis spoon-shaped, rounded; embolic base originating more or less proximally, extending distally; embolus moderately long, filiform (Figs 7–10).

Distribution: China (Hubei) (Fig. 39).

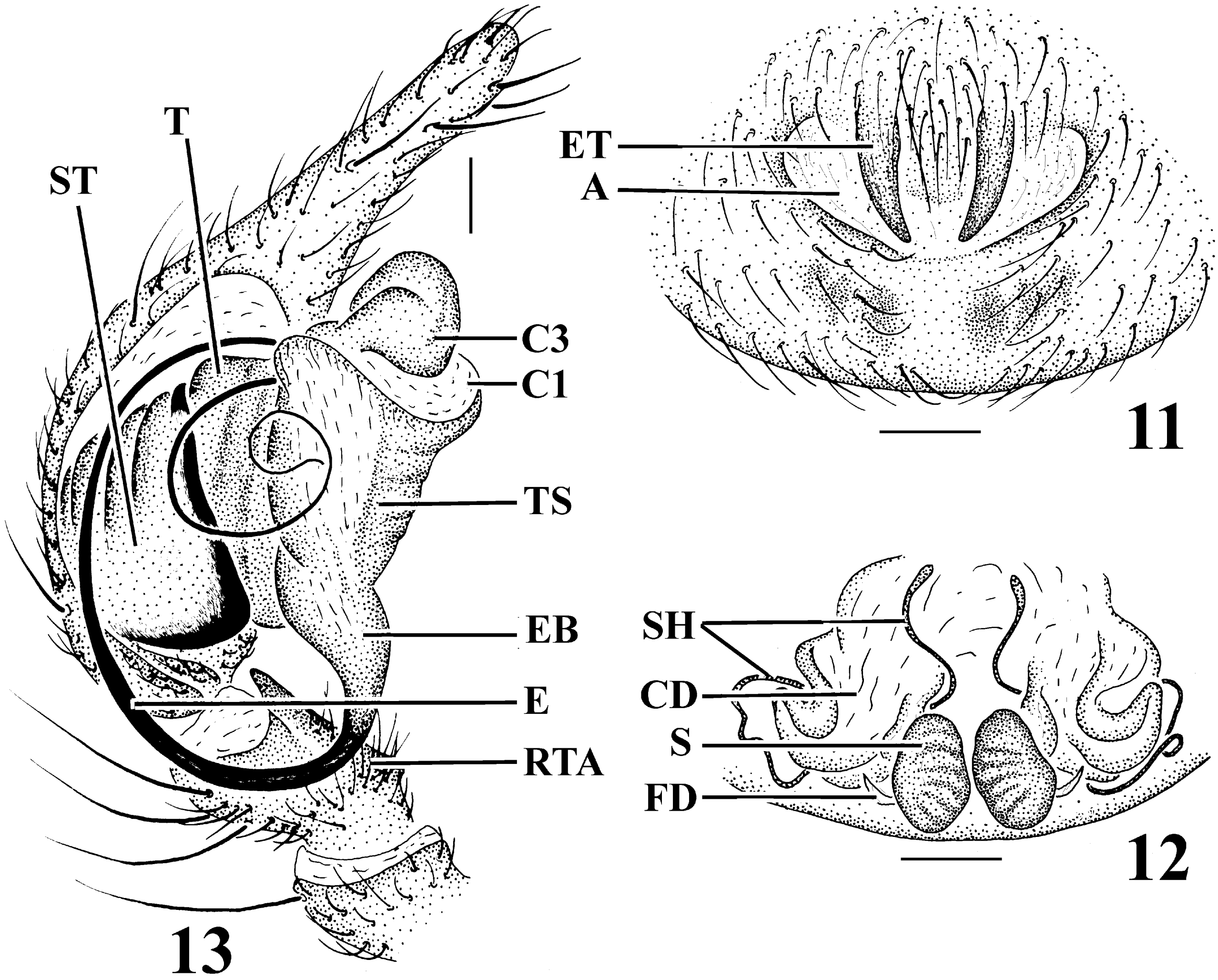


FIGURES 8–10. *Lineacoelotes funiushanensis* (Hu, Wang & Wang, 1991), male from Qiliping, Neixiang, Henan, China, palp (8 ventral view; 9 retrolateral view; 10 conductor dorsal edge, ventral view).

Lineacoelotes longicephalus **sp. nov.**
Figs 11–24, 39

Type material: Holotype female, 3 female and 4 male paratypes from Bao-guang monastery, Chengdu (30.8°N, 104.1°E), Sichuan, China, May 21, 1989, P. Beron, deposited in AMNH.

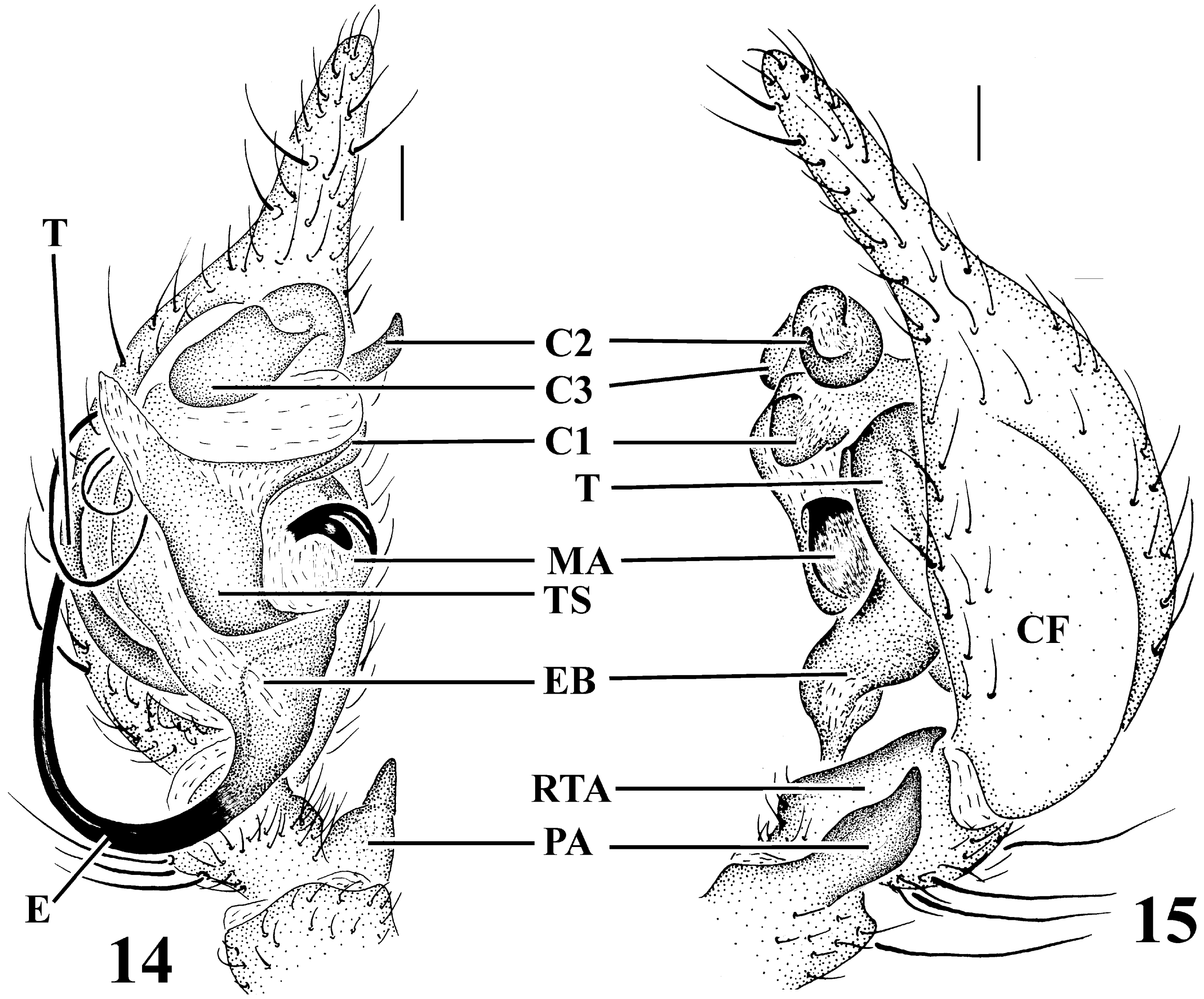
Etymology: The specific name refers to the strongly elongated spermathecal heads (Latin: longus=long, Greek: cephalon=head); noun in apposition.



FIGURES 11–13. *Lineacoelotes longicephalus* sp. nov., female holotype and male paratype from Xindu, Sichuan, China. 11 Female epigynum, ventral view. 12 Female epigynum, dorsal view. 13 Male palp, prolateral view.

Diagnosis: Females of this species can be easily distinguished from those of other species of *Lineacoelotes* gen. nov. by the unique spermathecal heads, which originating ventrally from spermathecae (with basal part covered by spermathecae and copulatory ducts, in dorsal view), extending laterally, running anteriorly on the ventral and lateral sides of the copulatory ducts, and then converging medially and anteriorly (Fig. 12). Males can also be easily distinguished from those of other species of *Lineacoelotes* gen. nov. by the large, prolaterally extending apophysis of conductor dorsal edge (Fig. 14).

Description: Female holotype: Total length 8.17 (Fig. 16). Prosoma 3.17 long, 2.31 wide; opisthosoma 5.00 long, 3.35 wide. Eye measurements: AME 0.12, ALE 0.19, PME 0.16, PLE 0.16; AME-AME 0.09, PME-PME 0.13, PME-PLE 0.14 (Fig. 17). Chelicera with 3 promarginal and 2 retromarginal teeth (Fig. 18). Leg formula: IV, I, II, III; leg measurements: I: 11.0 (3.0, 3.8, 2.5, 1.7); II: 9.3 (2.7, 3.0, 2.1, 1.5); III: 8.9 (2.5, 2.8, 2.3, 1.3); IV: 11.6 (3.2, 3.6, 3.3, 1.5). Epigynum with two long, strong teeth which originate from anterior margin of atrium, separated by approximately 1.5 times their basal width; atrium narrow, transversely extended, separated from epigastric furrow by approximately 1.5 times its length; epigynal teeth reaching almost the posterior margin of atrium; copulatory ducts distinct, large, originating anteriorly, extending laterally and posteriorly; spermathecal heads originating from ventral side of spermathecae, with basal part invisible from dorsal view; spermathecal heads extending to lateral sides of copulatory ducts, curving anteriorly, and then converging medially and anteriorly; spermathecae small, oval, close together (Figs 11–12).

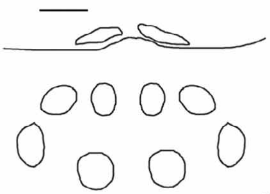


FIGURES 14–15. *Lineacoelotes longicephalus* sp. nov., male paratype from Xindu, Sichuan, China, palp (**14.** Ventral view; **15.** Retrolateral view).

Male (one paratype): Total length 8.39. Prosoma 3.92 long, 2.70 wide; opisthosoma 4.47 long, 2.69 wide. Eye measurements: AME 0.12, ALE 0.18, PME 0.17, PLE 0.19; AME-AME 0.08, PME-PME 0.09, PME-PLE 0.13. Chelicera with 3 promarginal and 2 retromarginal teeth. Leg formula: IV, I, II, III; leg measurements: I: 14.7 (3.8, 4.9, 3.6, 2.4); II: 12.4 (3.5, 4.1, 2.9, 1.9); III: 11.9 (3.2, 3.6, 3.2, 1.9); IV: 15.8 (4.1, 4.8, 4.6, 2.3). Palpal patellar apophysis long, with more or less sharp distal end; RTA extending along most of tibial length, with pointed distal end; cymbial furrow approximately half of cymbial length; conductor distinctly separated into broad, short ventral apophysis (C1) and strongly modified dorsal edge; in addition to slender, strongly spiral distal apophysis (C2) on retrolateral side of conductor dorsal edge, another large, prolaterally directed apophysis (C3) being situated on conductor dorsal edge; median apophysis spoon-shaped, rounded; embolic base originating more or less proximally from tegulum, extending distally; embolus moderately long, filiform (Figs 13–15).

Distribution: China (Sichuan) (Fig. 39).

16



17

18

FIGURES 16–18. *Lineacoelotes longicephalus* sp. nov., female holotype from Xindu, Sichuan, China. 16 Habitus. 17 Eyes, dorsal view. 18. Chelicerae, ventral view.

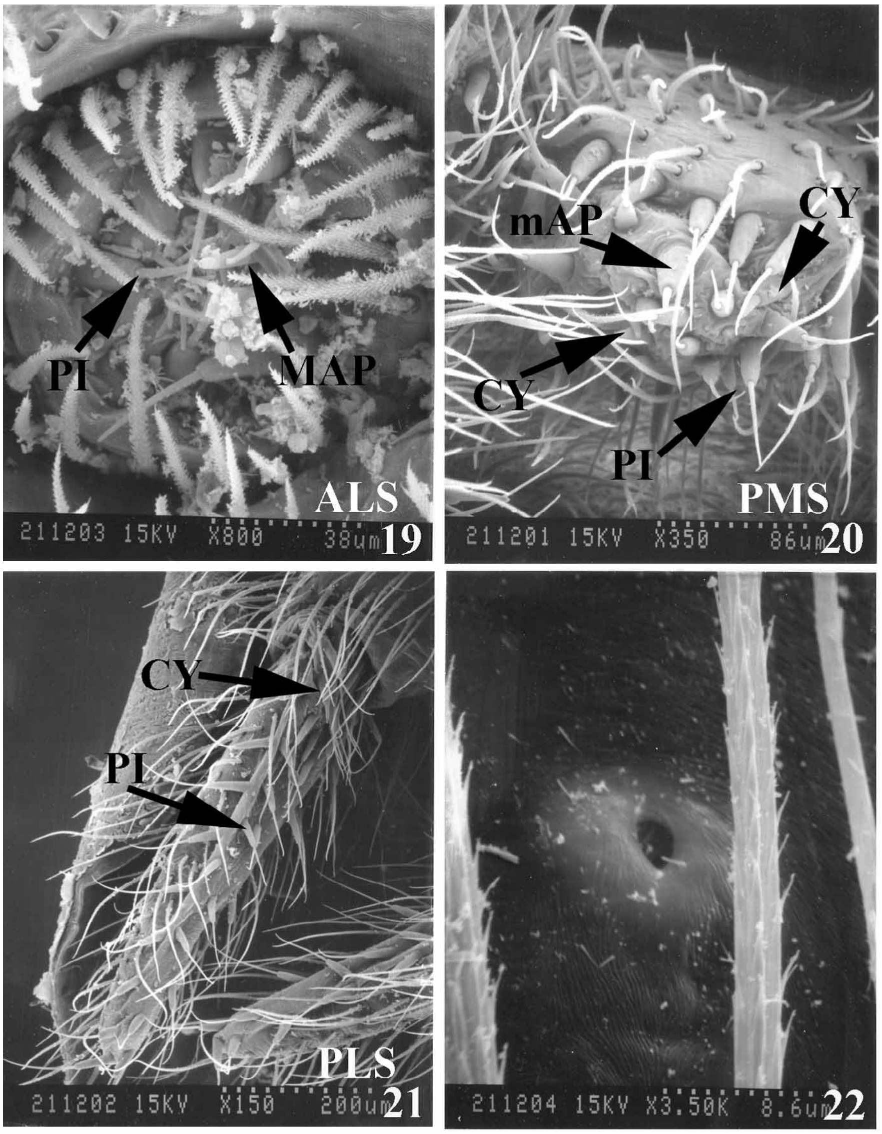
Lineacoelotes nitidus (Li & Zhang, 2002) comb. nov.

Figs 25–32, 39

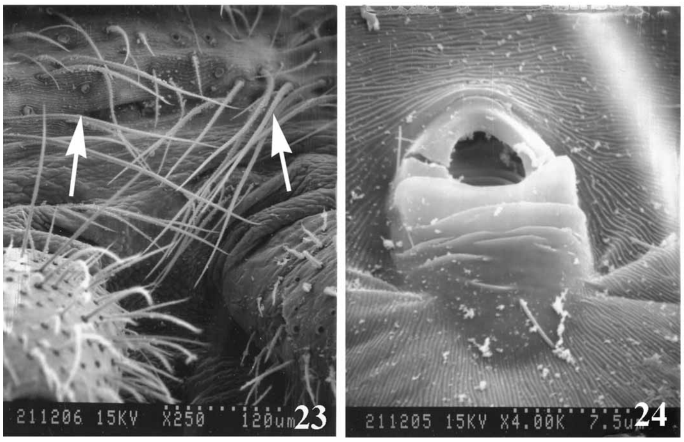
Coelotes nitidus Li & Zhang 2002: 466, figs 1–4 (female holotype from Lichuan, Hubei, China, deposited in IZCAS, examined).

Additional material examined: **China: Hubei:** Lichuan County (30.2°N, 108.6°E), Tenglongdong Cave, October 26, 2005, 8 females and 7 males (Xiang Xu & Xiufeng Zhang, IZCAS).

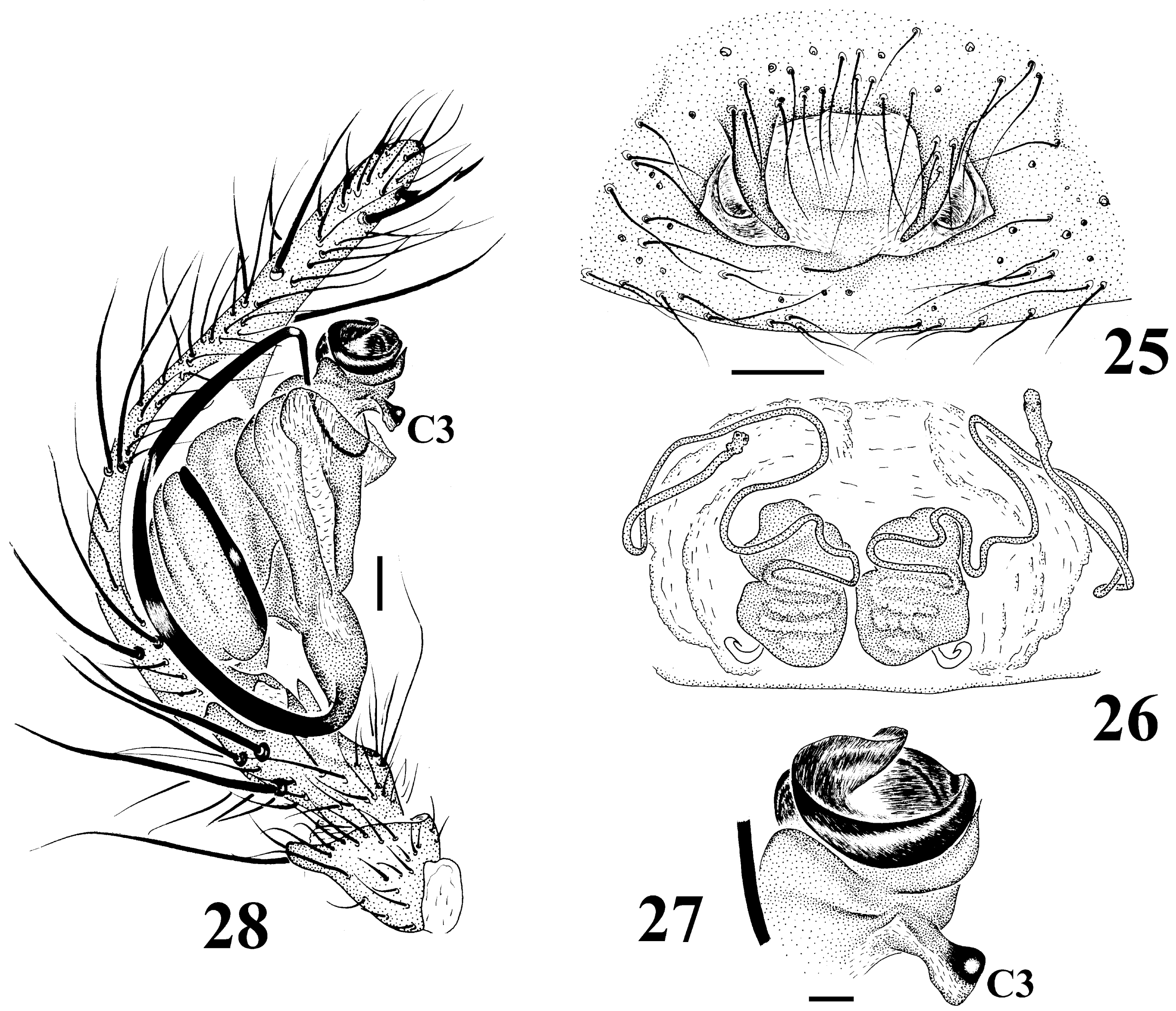
Diagnosis: The females of this species are similar to those of *L. bicultratus* and *L. funiushanensis* in spermathecal shape and in having anteriorly extending spermathecal heads. The widely separated epigynal teeth (Fig. 25) easily distinguish them from *L. bicultratus*, but can be separated from *L. funiushanensis* by the relatively large atrium, which is separated from the epigastric furrow by less than its length (Fig. 25), whereas *L. funiushanensis* has a narrow atrium that is separated from the epigastric furrow by approximately its length (Fig. 5). Males of *L. nitidus* are also similar to those of *L. funiushanensis* and can be distinguished by the modifications of the conductor dorsal edge. The conductor dorsal edge of *L. nitidus* has a relatively small distal apophysis (C2) and a prolaterally extending apophysis and without a sharp tooth on top (C3) (Figs 29, 31), whereas *L. funiushanensis* has slightly large distal apophysis (C2) and retrolaterally extending apophysis (c3) and a sharp tooth on top (Figs 8, 10).



FIGURES 19–22. *Lineacoelotes longicephalus* sp. nov., female paratype from Xindu, Sichuan, China. 19 Anterior lateral spinneret. 20 Posterior median spinneret. 21 Posterior lateral spinneret. 22 Tarsal organ.



FIGURES 23–24. *Lineacoelotes longicephalus* sp. nov., female paratype from Xindu, Sichuan, China. 23 Colulus, represented by two clusters of setae (indicated by two arrows). 24 Trichobothrium base, tarsus of leg 4 (hair is absent).

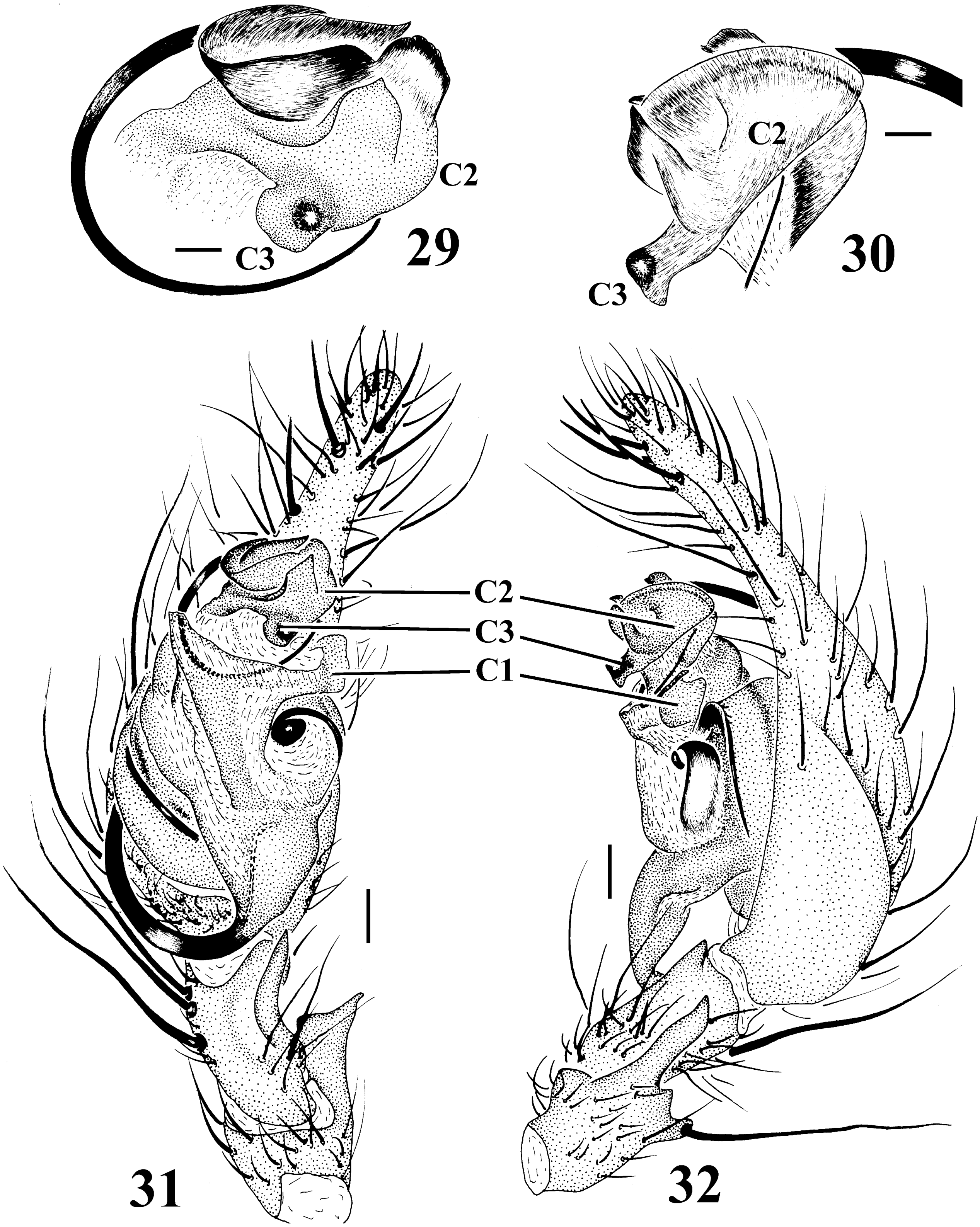


FIGURES 25–28. *Lineacoelotes nitidus* (Li & Zhang, 2002), male and female from Tenglongdong Cave, Lichuan, Hubei, China. 25 Epigynum, ventral view. 26 Epigynum, dorsal view. 27 Palp, conductor dorsal edge, prolateral view. 28 Palp, prolateral view.

Description: See Li and Zhang (2002) for detailed somatic description.

Female: Eye measurements (one female from Tenglongdong Cave): AME 0.18; ALE 0.20; PME 0.18; PLE 0.20; AME-AME 0.10; ALE-PLE 0; PME-PME 0.10; PME-PLE 0.15. Chelicera with 3 promarginal and 2 retromarginal teeth. Epigynum with two long, strong, widely separated teeth, originating from anterior margin of atrium, separated by at least twice their basal width; atrium large, transversely extended, separated from epigastric furrow by approximately half its length; epigynal teeth reaching almost posterior margin of atrium; atrium extending into epigynum, forming broad copulatory duct; spermathecal heads long, originating medially on spermathecae, extending anteriorly and laterally; spermathecae small, oval-shaped, close together (Figs 25, 26).

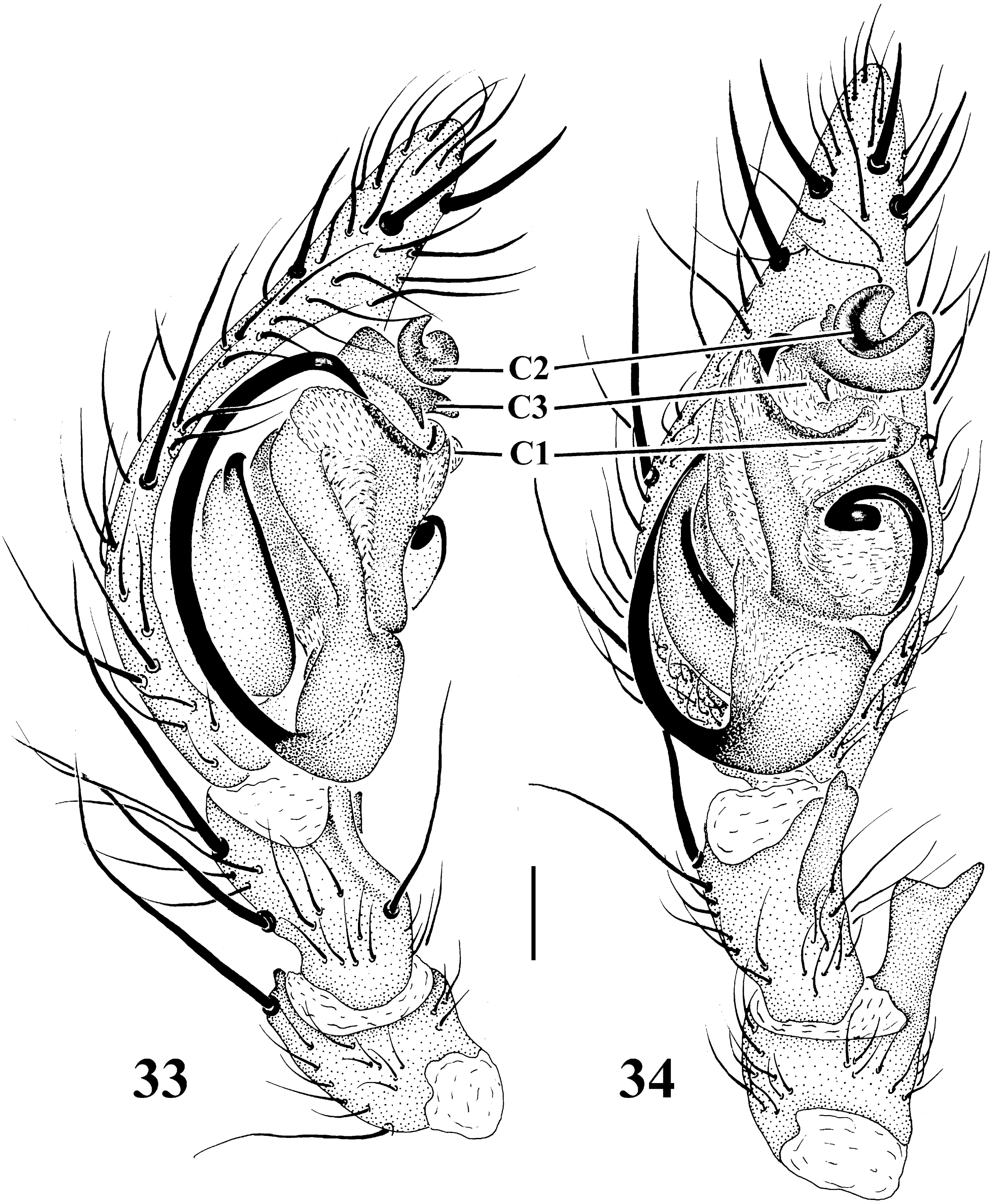
First description of male (one male from Tenglongdong Cave in Lichuan County): Total length 8.40. Prosoma length 4.40, width 3.05; opisthosoma length 4.00, width 2.70. Eye measurements: AME 0.23; ALE 0.23; PME 0.18; PLE 0.23; AME-AME 0.08; ALE-PLE 0; PME-PME 0.10; PME-PLE 0.14. Chelicera with 3 promarginal and 2 retromarginal teeth. Leg formula: IV, I, II, III; leg measurements: I: 16.0 (4.1 + 5.3 + 4.2 + 2.4); II: 14.2 (3.8 + 4.6 + 3.7 + 2.1); III: 13.3 (3.2 + 4.2 + 3.9 + 2.0); IV: 17.6 (4.3 + 5.6 + 5.3 + 2.4). Palpal



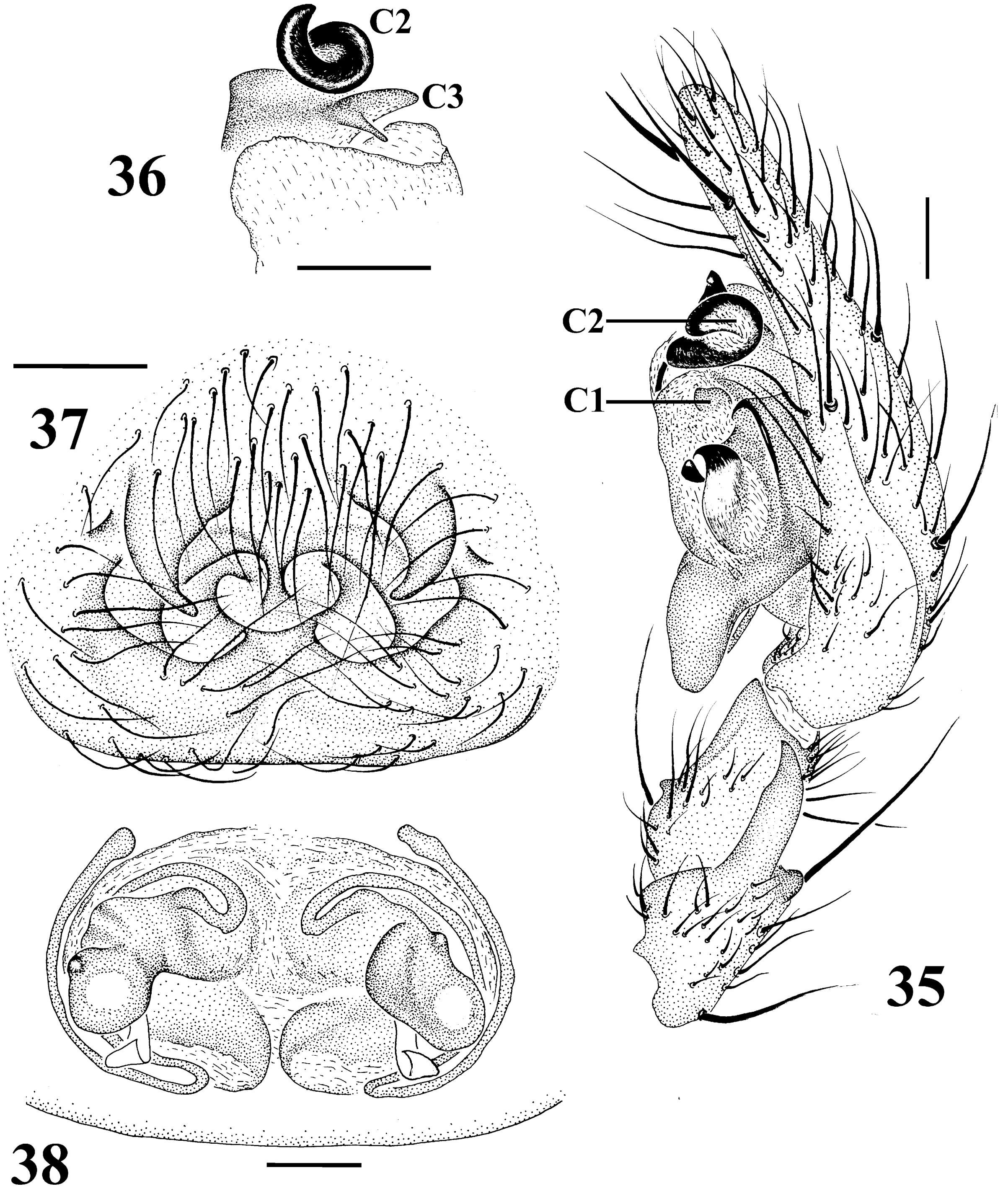
FIGURES 29–32. *Lineacoelotes nitidus* (Li & Zhang, 2002), male from Tenglongdong Cave, Lichuan, Hubei, China, palp (29 Showing conductor dorsal edge, ventral view; 30 Showing conductor dorsal edge, retrolateral view; 31 Ventral view; 32 Retrolateral view).

patellar apophysis long, with more or less sharp distal end; RTA occupies most of tibial length, with distal end pointed; cymbial furrow slightly less than half of cymbial length; conductor distinctly separated into broad, short ventral apophysis (C1) and strongly modified dorsal edge; in addition to small, indistinct distal apophysis (C2) on retrolateral side of conductor dorsal edge, another small, prolaterally directed apophysis (C3) being situated on conductor dorsal edge; median apophysis spoon-shaped, rounded; embolic base originating more or less proximally, immediately extending distally; embolus moderately long, filiform (Figs 27–32).

Distribution: China (Hubei) (Fig. 39).



FIGURES 33–34. *Lineacoelotes strenuus* sp. nov., male holotype from Shennongjia, Hubei, China, palp (33 Prolateral view; 34 Ventral view).



FIGURES 35–38. *Lineacoelotes strenuus* sp. nov., male holotype and female paratype from Shenlongjia, Hubei, China. 35 Palp, retrolateral view. 36 Palp, conductor dorsal edge, prolateral view. 37 Epigynum, ventral view. 38 Epigynum, dorsal view.

Lineacoelotes strenuus **sp. nov.**
Figs 33–38, 39

Type material: Holotype male, 1 female and 5 male paratypes from Shennongjia Nature Reserve (31.5°N, 110.4°E), July 23, 1998 to August 10, 1998, Hubei, China (Hongzhang Zhou, IZCAS).

Etymology: The specific name is taken from the Latin "strenuus", meaning strong and referring to the strong epigynal teeth; adjective.

Diagnosis: The females of this new species are very distinctive and can be easily distinguished from other species of *Lineacoelotes* gen. nov. Atrium broad, with relatively complicated atrial margins, the bases of epigynal teeth broad, and the spermathecal heads originating anteriorly, extending posteriorly and reaching almost epigastric furrow, then curving back laterally to the anterior side of spermathecae (Figs 37, 38). The males are similar to those of *L. longicephalus* sp. nov. in having the spiral distal apophysis at the conductor dorsal edge but the distal apophysis is broad and anteriorly extending (Figs 33–36), whereas in *L. longicephalus* sp. nov. it is narrow and retrolaterally extending (Figs 13–15).

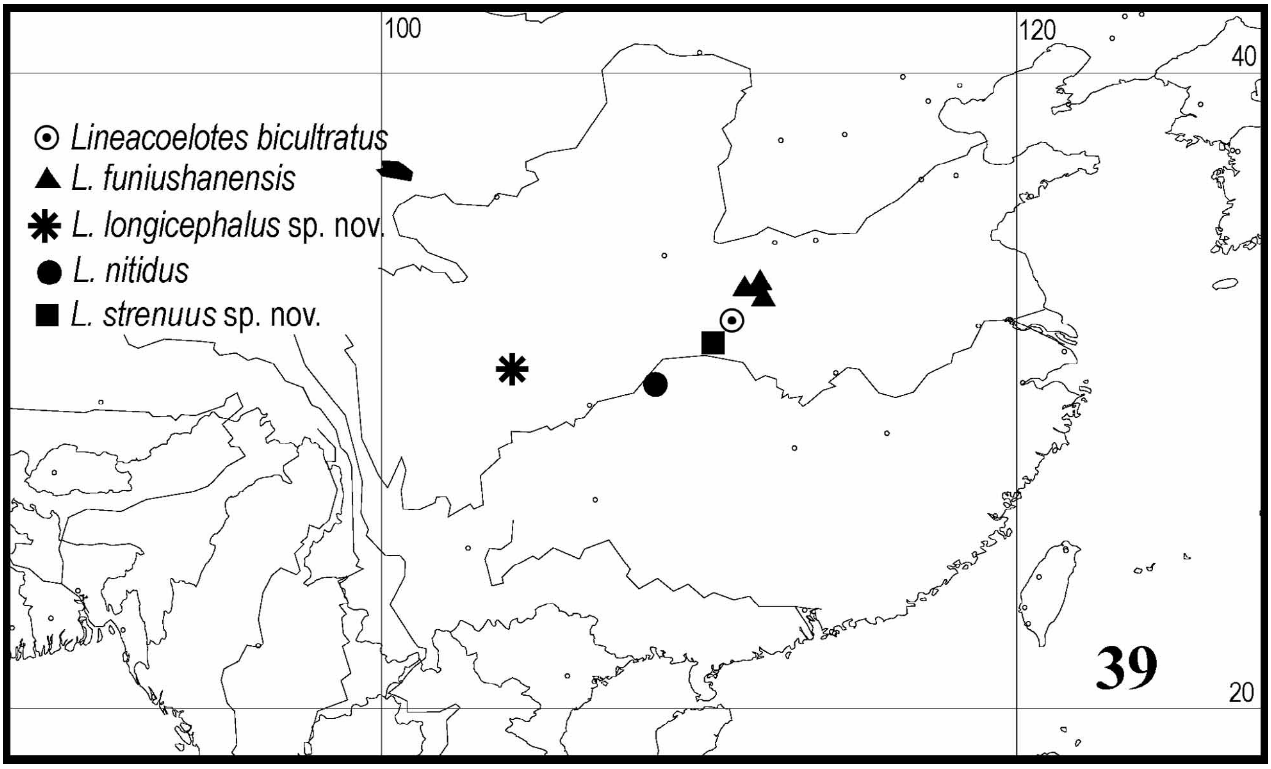


FIGURE 39. Records of species of *Lineacoelotes* gen. nov.

Description, male holotype: Total length 6.40. Prosoma 3.20 long, 2.30 wide; opisthosoma 3.20 long, 1.90 wide. Eye measurements: AME 0.11, ALE 0.18, PME 0.15, PLE 0.20; AME-AME 0.10, PME-PME 0.12, PME-PLE 0.10. Chelicera with 3 promarginal and 2 retromarginal teeth. Leg formula: IV, I, II, III; leg measurements: I: 12.4 (3.1 + 4.2 + 3.1 + 2.0); II: 11.1 (2.8 + 3.7 + 2.8 + 1.8); III: 10.4 (2.5 + 3.2 + 3.0 + 1.7); IV: 13.7 (3.0 + 4.4 + 4.2 + 2.1). Palpal patellar apophysis long, with more or less sharp distal end; RTA occupying most of tibial length, with distal end pointed; cymbial furrow less than half of cymbial length; conductor distinctly separated into broad, short ventral apophysis (C1) and strongly modified dorsal edge; in addition to broad, anteriorly spiral distal apophysis (C2) on retrolateral side of conductor dorsal edge, another small, bifurcated, retrolaterally directed apophysis (C3) being situated on conductor dorsal edge; median apophysis spoon-shaped, rounded; embolic base originating more or less proximally and extending distally; embolus moderately long, filiform (Figs 33–36).

Female paratype: Prosoma 4.10 long, 2.60 wide. opisthosoma is damaged. Eye measurements: AME 0.13, ALE 0.18, PME 0.15, PLE 0.19; AME-AME 0.08, PME-PME 0.18, PME-PLE 0.18. Chelicera with 3 promarginal and 2 retromarginal teeth. Leg formula: IV, I, II, III; leg measurements: I: 11.0 (3.0 + 3.7 + 2.8 + 1.5); II: 9.6 (2.7 + 3.2 + 2.2 + 1.5); III: 9.0 (2.5 + 2.9 + 2.3 + 1.3); IV: 11.95 (3.2 + 3.85 + 3.3 + 1.6). Epigynal teeth relatively short, separated by their basal width, originating on anterior margin of atrium; atrium large, much more complex than other species of *Lineacoelotes* gen. nov., separated from epigastric furrow by slight less than its length; epigynal teeth not reaching posterior margin of atrium; atrium extending into epigynum, forming broad copulatory duct; spermathecal heads long, originating distally on spermathecae, extending laterally and posteriorly posterior of spermathecae, close to epigastric furrow, then curving back anteriorly; spermathecae small, oval-shaped, widely separated (Figs 37, 38).

Distribution: China (Hubei) (Fig. 39).

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Three new spider species of the family Thomisidae from Hong Kong (Arachnida: Araneae)

Xiang Xu, Xu Han & Shuqiang Li

Xu, X., Han, X. & Li, S. 2008: Three new spider species of the family Thomisidae from Hong Kong (Arachnida: Araneae). — Entomol. Fennica 19: 13–17.

Three new species of spiders from farmland and nearby non-crop fields at Tai Lung Experimental Station (TLES), Hong Kong, were discovered. All three new species occurred in the family Thomisidae, they are *Diaea simplex* Xu, Han & Li sp. n., *Massuria bellula* Xu, Han & Li sp. n. and *Mastira tegularis* Xu, Han & Li sp. n. Descriptions and illustrations of the new species are provided.

X. Xu, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China; sansanxu@163.com
X. Han, Department of Integrative Biology, University of Guelph, Guelph, Ontario N1G 2W1, Canada; hanx@uoguelph.ca
S. Li, Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China; corresponding author's e-mail: lisq@ioz.ac.cn

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1. Introduction

Hong Kong is located in a wide transition zone between the Palaearctic and Oriental regions. Xu & Li (2006) reported that Palaearctic species comprise 30% of the spider fauna in Hong Kong. Although Platnick (2007) reported a total of 24 families and 148 species of spiders in this area, the biodiversity of spiders is not well known. Further study of the spiders of Hong Kong would facilitate construction of an accurate taxonomy, an exploration of biogeographic patterns and potentially a predictive framework for establishing priorities for conservation.

Recently, we examined a collection of spiders taken from farmland fields and nearby non-crop fields at the Tai Lung Experimental Station (TLES), Sheung Shui, Hong Kong. The only government farmland in Hong Kong, the TLES serves to help farmers with plant husbandry and protection. The station occupies 19.8 ha and primarily consists of established orchards, open fields and greenhouses for experimental use. Our examination of the collection revealed three new species of spiders.

2. Materials and methods

Spiders were collected by Mr. Ping-wing Chan and Mr. Chi-keung Johnny Pun, of the Agriculture, Fisheries and Conservation Department, Hong Kong and preserved in 70% alcohol. Specimens were examined and measured under an SZ11-Olympus stereomicroscope and an Olympus BX41 compound microscope. All illustrations were made using a camera lucida. Male palps and female epigyna were examined and illustrated after they were dissected from the spiders' bodies. Vulvae of female epigyna were cleared in boiling solution of KOH, which dissolved non-chitinous tissues. Male palps and epigyna were immersed in 75% alcohol for microscopic examination.

Anatomical nomenclature follows Platnick (2007). The leg measurements are given in the following sequence: Total (femur, patella, tibia, metatarsus, tarsus). All measurements are in millimeters. Terminology for the somatic morphology and genital structures follows Ono (1988). All the type material is deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing, China.

Abbreviations used in the description are as follows: AER – anterior eye row; ALE – anterior lateral eye; AME – anterior median eye; AME-ALE – distance between AME and ALE; AME-AME – distance between AMEs; ITA – intermediate tibial apophysis of male palp; MOA – median ocular area; MOA-L – length of MOA; MOA-WA – anterior width of MOA; MOA-WP – posterior width of MOA; PER – posterior eye row; PLE – posterior lateral eye; PME – posterior median eye; PME-PLE – distance between PME and PLE; PME-PME – distance between PMEs; RTA – retrolateral tibial apophysis of male palp; TL – total length; VTA – ventral tibial apophysis of male palp.

3. Taxonomy

3.1. *Diaea simplex* Xu, Han & Li sp. n. (Fig. 1)

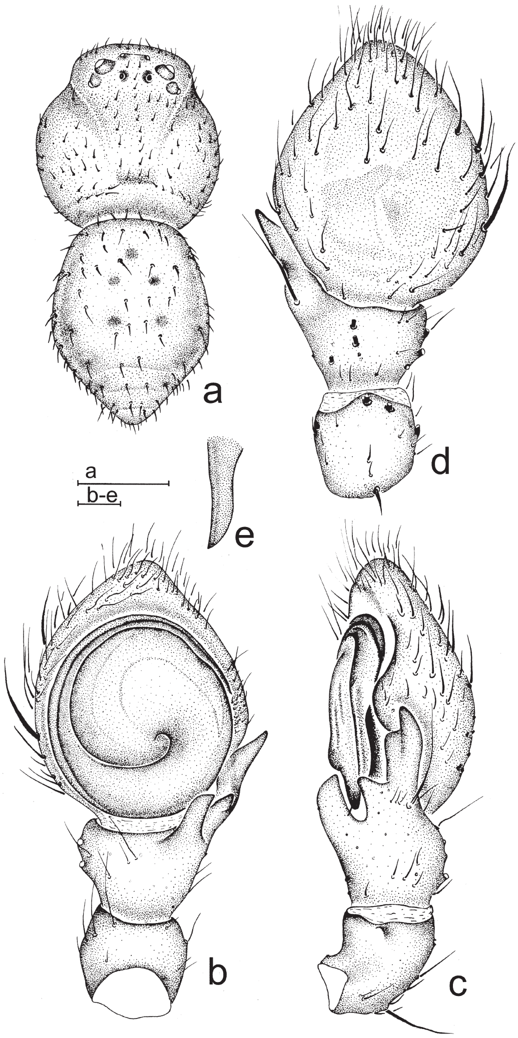

Fig. 1. *Diaea simplex* sp. n., holotype ♂. – a. Body, dorsal view. – b. Left male palp, ventral view. – c. Left male palp, retrolateral view. – d. Left male palp, dorsal view. – e. Distal end of embolus. Scale bars: a = 1.0; b–e = 0.1mm.

Material examined. Holotype ♂, China: on leaf, Tai Lung Experimental Station, Hong Kong, 7.VII.1999, Ping-wing Chan. Paratype: 1♂, collected together with the holotype.

Description. Total length: 4.37–4.53. TL of holotype 4.53. Prosoma: 2.13 long, 2.13 wide. Opisthosoma: 2.40 long, 1.90 wide. Prosoma (length/width 1.00) not flat but slightly raised, orange colored, covered with short setae (Fig. 1a). AER strongly recurved, PER recurved. Tubercles of ALE and PLE much developed and slightly separated. ALE > AME = PLE > PME, ALE/AME 1.47, PLE/PME 1.07, AME-AME/AME-ALE 1.43, PME-PME/PME-PLE 0.77, MOA-WA/WP 1.00, MOA- L/W 1.00, clypeus/AME-AME 1.30, clypeus nearly vertical. Chelicera toothless. Sternum (length/width 1.07) nearly as long as wide, labium (length/wide 1.67) much longer than wide. Setae of legs well developed. Lengths of legs: I 9.00 (2.67+ 1.20+ 2.13+ 2.00+ 1.00), II 8.96 (2.73+ 1.20+ 2.17+ 1.93+ 0.93), III 4.47 (1.47+ 0.67+ 1.00+ 0.80+ 0.53), IV 4.53 (1.47+ 0.63+ 1.00+ 0.83+ 0.60). Leg formula: I, II, IV, III. Opisthosoma (length/ width 1.26) weakly sclerotized, longer than wide, and the posterior half gradually becoming sharp. 5 distinct muscle markings located on the anterior

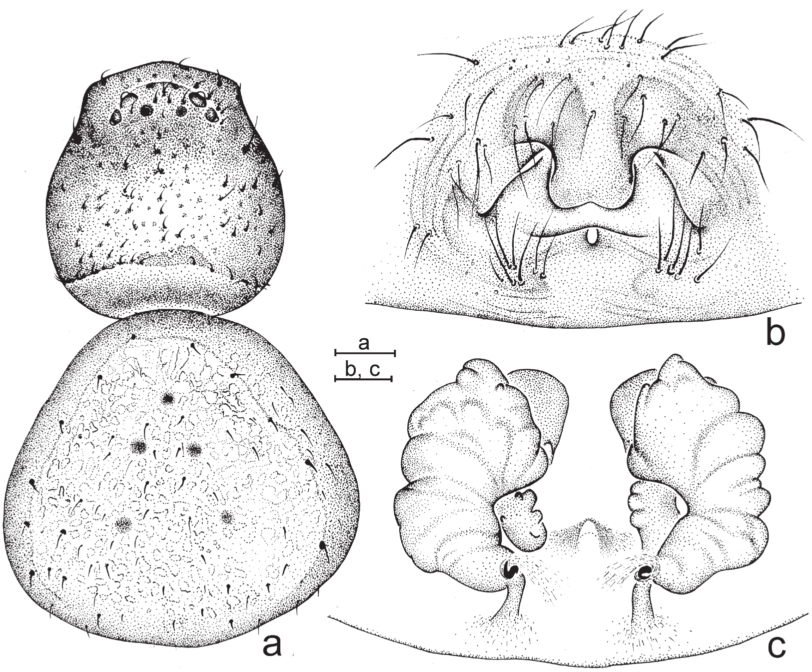

Fig. 2. *Massuria bellula* sp. n., holotype ♀. – a. Body, dorsal view. – b. Epigunum, ventral view. – c. Epigunum, dorsal view. Scale bars: a = 1.0; b, c = 0.1mm.

half of the dorsum (Fig. 1a). Ventral opisthosoma without pattern.

Spiniformation of legs of holotype. femur: I dorsal 1-1-2-2-1-1-0, II dorsal 1-1-1-1-0-1, III dorsal 0-1-1-0-0-1, IV dorsal 0-1-1; patella: I–III dorsal 1-0-1, IV dorsal 1-0-1, retrolateral 1; Tibia: I- II ventral 2-2, dorsal 1-1, III dorsal 1-1, IV dorsal 1-1, prolateral 0-1, retrolateral 0-1; Metatarsus: I ventral 0-1-2-0-2-2-2 ap, 1-1-2-0-2-2-2 ap (right leg), prolateral 1 ap, II ventral 0-2-2-0-1-2-2 (right leg), 0-0-2-0-2-2-0, prolateral 1 ap.

Male palp. Tibia with VTA, ITA and RTA. RTA with sharp distal end. ITA distinct. VTA strong (Fig. 1b–c). Bulb very simple, slightly convex (Fig. 1b). Embolus broad not only at the base but also in the distal end, winding less than 1.0 time around the tegulum (Fig. 1b–e).

Distribution. China (Hong Kong).

Diagnosis. This new species can be distinguished from *Diaea livens* Simon, 1876 by the slightly sclerotized opisthosomal dorsum, the distinct ITA and the short distance between RTA and ITA. This new species also differs from *Diaea subdola* O.P.-Cambridge, 1885 (Song *et al*. 1997) in having a strongly developed ITA and a large tip on the VTA (Fig. 1a–c).

Etymology. The specific name refers to the simple structure of the bulb of male palp (Latin: simplex – simple); adjective.

3.2. *Massuria bellula* Xu, Han & Li sp. n. (Fig. 2)

Material examined. Holotype ♀, China: on leaf, Tai Lung Experimental Station, Hong Kong, 30.VI.1999, Ping-wing Chan. Paratype: 1♀, collected together with the holotype.

Description. Total length: 9.55–12.84. TL of holotype 9.55. Prosoma: 4.03 long, 3.88 wide. Opisthosoma: 5.52 long, 5.67 wide. Prosoma (length/width 1.04) covered with many green dots except for eye region, each dot with one seta (Fig. 2a). AER strongly recurved, PER slightly recurved. Tubercles of all eyes white, tubercles of ALE and PLE strongly developed and distinctly separated. ALE> PLE> AME> PME, ALE/AME 1.45, PLE/PME 1.25, AME-AME/AME-ALE 1.55, PME-PME/PME-PLE 0.76, MOA-WA/WP 1.04, MOA- L/W 1.00, clypeus/AME-AME 1.39, clypeus nearly vertical. Chelicera toothless, with green dots on the dorsum as prosoma. Sternum (length/width 1.20) covered short white hairs. Labium (length/width 1.88) much longer than wide. Palpal tarsus, tibia and patella with many setae. Lengths of legs: I 11.44 (3.60+ 1.47+ 2.67+ 2.47+ 1.23), II 13.53 (4.13+ 2.00+ 3.20+ 2.80+ 1.40), III 7.99 (2.67+ 1.33+ 1.73+ 1.53+ 0.73), IV 8.28 (2.67+ 1.27+ 1.87+ 1.67+ 0.80). Leg formula: II, I, IV, III. Opisthosoma (length/width 0.97) pyriform. Dorsal opisthosoma yellow or yellowish white, covered with setae and many irregular silvery white patterns, and with 5 brown markings distinct (Fig. 2a). Ventral opisthosoma also covered with silvery white patterns.

Spiniformation of legs of holotype. femur: I dorsal 0-0-1-1-0, prolateral 1-1-1-1-0-0-0, II dorsal 1-0; patella: I–II dorsal 1-1 ap, III dorsal 1-1, IV dorsal 1-1 ap, prolateral 1; tibia: I ventral 0-0-2-2-2-3-2, II dorsal 1-1, ventral 0-2-0-2-2-0-2-2-1-2 ap, prolateral 0-0-1, retrolateral 0-0-1, III dorsal 1-1-2, ventral 1, IV dorsal 1-1; metatarsus: I ventral 0-2-2-0-2-2-2 ap, prolateral 0-1-1-1 ap, retrolateral 1-0-0, II ventral 0-2-1-2-2-1-2-2-2 ap, prolateral 0-1-1-1 ap, retrolateral 1-1.

Female genitalia. Epigynum with a nose-wing-shaped sclerotized plate. Central hood present under the sclerotized plate (Fig. 2b). Spermathecae slightly kidney-shaped, and with many small tubercles and shallow grooves. Intromittent duct broad and flat, hidden by the spermathecae and only partly visible (Fig. 2c).

Distribution. China (Hong Kong).

Diagnosis. This new species can be easily separated from *Massuria angulata* Thorell, 1887 by the sclerotized, nosewing-shaped epigynal plate (Fig. 2b) and the longitudinally extended spermathecae (Fig. 2c).

Etymology. The specific name is derived from the Latin “bellulus”, meaning “lovely”; adjective.

3.3. *Mastira tegularis* Xu, Han & Li sp. n. (Fig. 3)

Material examined. Holotype ♂, China: Tai Lung Experimental Station, Hong Kong, 12.X.1999, Ping-wing Chan. Paratype: 1♂, collected together with the holotype.

Description. Total length: 2.13–2.16. TL of holotype 2.16. Prosoma: 1.03 long, 1.07 wide. Opisthosoma: 1.13 long, 1.03 wide. Prosoma (length/width 0.96) orange colour. Head with strong setae and thoracic region with short setae (Fig. 3a). AER and PER recurved. Tubercles of all eyes black. Tubercles of ALE and PLE strongly developed, connate. ALE > PLE > AME = PME, ALE/AME 2.00, PLE/PME 1.50, AME-AME/AME-ALE 1.25, PME-PME/PME-PLE 1.14, MOA-WA/WP 0.79, MOA- L/W 1.20, clypeus/AME-AME 1.40. Chelicerae without any tooth, maxillae (length/width 1.00) and sternum (length/wide 1.13) light yellow. Setae of legs and claw tufts weakly developed. Legs without any annuli. The patellae, tibiae and metatarsusi of leg I– II reddish and other parts of legs I–IV yellow. Lengths of legs: I 4.55 (1.35+ 0.55+ 1.10+ 0.95+ 0.60), II 4.43 (1.25+ 0.55+ 1.15+ 0.90+ 0.58), III 2.05 (0.60+ 0.30+ 0.50+ 0.35+ 0.30), IV 2.20 (0.70+ 0.30+ 0.50+ 0.40). Leg formula: I, II, IV, III. Opisthosoma (length/width 1.10) widest

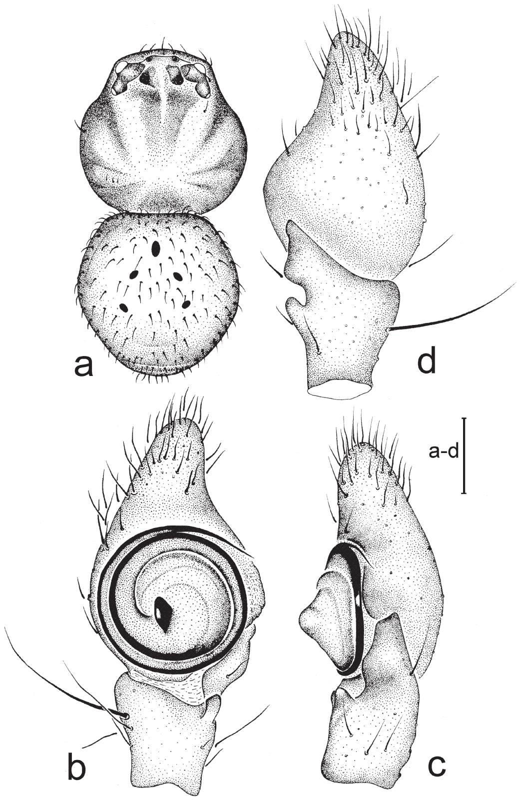

Fig. 3. *Mastira tegularis* sp. n., holotype ♂. – a. Body, dorsal view. – b. Left male palp, ventral view. – c. Left male palp, retrolateral view. – d. Left male palp, dorsal view. Scale bars: a = 0.5; b–d = 0.1mm.

in the middle. The dorsum of opisthosoma covered with short setae, and with 5 distinct muscle markings (Fig. 3a).

Spiniformation of legs of holotype. femur: I dorsal 2-2-1-1-0, II dorsal 1-1-1-0-0-1, III dorsal 0-1-1-0-0-1, IV dorsal 1; Tibia: I–II ventral 0-0-2, III dorsal 1-1; Metatarsus: I ventral 0-1-2-2 ap, II ventral 0-0-0-2-1.

Male palp. Tibia with VTA and RTA. VTA not much developed. RTA strong, with broad distal end (Fig. 3c–d). Bulb with median apophysis like a roof tile (Fig. 3b). Embolus very long, winding 1.5 times around the tegulum (Fig. 3b–c).

Distribution. China (Hong Kong).

Diagnosis. The species is similar to *M. bipunctata* Thorell, 1891, but can be easily distinguished by: 1) embolus of this new species is anteriorly origined (Fig. 3b), but in *M. bipunctata* it is posteriorly origined; 2) the differences in shape of their median apophysis (Fig. 3b). This new species can also distinguished from *M. flavens* (Thorell 1877) by the strong RTA and the roof-shaped median apophysis (Fig. 3b–c).

Etymology. The specific name is an adjective derived from the Latin noun “tegula”, meaning “roof tile”. It refers to the roof tile-like median apophysis of the male palp.

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A further study on the species of the spider family Agelenidae from China (Arachnida: Araneae)

Xiufeng ZHANG, Shuqiang LI* & Xiang XU
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China.
*Corresponding author. E-mail: lisq@ioz.ac.cn

A further study on the species of the spider family Agelenidae from China (Arachnida: Araneae). - Six agelenid spider species belonging to the genera *Agelena*, *Ageleradix* and *Benoitia* occurring in China are diagnosed, described and illustrated. The name *Agelena micropunctala* Wang, 1992 is placed in the synonymy of *Agelena poliosata* Wang, 1991; *Agelena otiforma* Wang, 1991 is transferred to the genus *Ageleradix*; *Benoitia agraulosa* (Wang & Wang, 1990) is newly reported from Xinjiang Province of China. Three new species are described: *Ageleradix schwendingeri* sp. n., *Ageleradix sternseptum* sp. n. and *Ageleradix zhishengi* sp. n.

Keywords: Taxonomy - new species - new synonymy - new combination - funnel-webs.

INTRODUCTION

Spiders of the family Agelenidae C. L. Koch, 1837, which construct conspicuous funnel-webs, are common inhabitants of the vegetation in China. According to Platnick's spider catalogue (2007), Agelenidae spiders are now represented by 41 genera and 508 species worldwide, and by 6 genera (*i.e.*, *Agelena* Walckenaer, 1805; *Ageleradix* Xu & Li, 2007; *Allagelena* Zhang, Zhu & Song, 2006; *Benoitia* Lehtinen, 1967; *Huangyuania* Song & Li, 1990; and *Tegenaria* Latreille, 1804) and 23 species occurring in China. A re-examination of the type material of the agelenid species known from China is becoming more and more important because some of the original descriptions do not provide sufficient information to meet the current requirements for species identification and phylogenetic evaluation. The current study aims to provide more information on type material of the known agelenid species in China, and it presents three new species.

MATERIAL AND METHODS

All specimens treated in the current paper are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZCAS), in the Hunan Biological Institute, Changsha, China (HBI) and in the Muséum d'histoire naturelle de la Ville de Genève, Switzerland (MHNG). Specimens were examined and measured under an SZ40-Olympus stereomicroscope; details were studied under an Olympus

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BX40 compound microscope. All illustrations were made using a drawing tube. Male palp and female epigynum were examined and illustrated after they were separated from the spider's body, the vulva was examined after being macerated in lactic acid for about 12 hours. For examination of the genital structures under transmitted light microscopy, male palp and female epigynum were immersed in 75% alcohol.

All measurements are given in millimeters. Leg measurements are shown as: Total length (femur, patella and tibia, metatarsus, tarsus). The terms used in the description of genitalia follow Wang (1997, 2002), Zhang, Zhu & Song (2006) and Xu & Li (2007). Abbreviations used in the text are: A = atrium; AER = anterior eye row; ALE = anterior lateral eye; ALS = anterior lateral spinneret; AME = anterior median eye; C = conductor; CB = copulatory bursa; D = diverticula; E = embolus; FD = fertilization duct; LTA = lateral tibial apophysis; MA = median apophysis; MOA = median ocular quadrangle; MOA-L = length of MOA; MOA-WA = anterior width of MOA; MOA-WP = posterior width of MOA; PA = patellar apophysis; PER = posterior eye row; PLE = posterior lateral eye; PLS = posterior lateral spinneret; PME = posterior median eye; PMS = posterior median spinneret; R = radix; RTA = retrolateral tibial apophysis; S = spermatheca; SA = spermathecal apophysis; ST = subtegulum; T = tegulum; TP = tegular process.

TAXONOMY

Agelena poliosata Wang, 1991 Figs 1-3

Agelena poliosata Wang, 1991: 411, figs 24-25. – Chen & Zhao, 1998: 3, figs 2.1-2. – Song, Zhu & Chen, 1999: 354, fig. 205O-P.

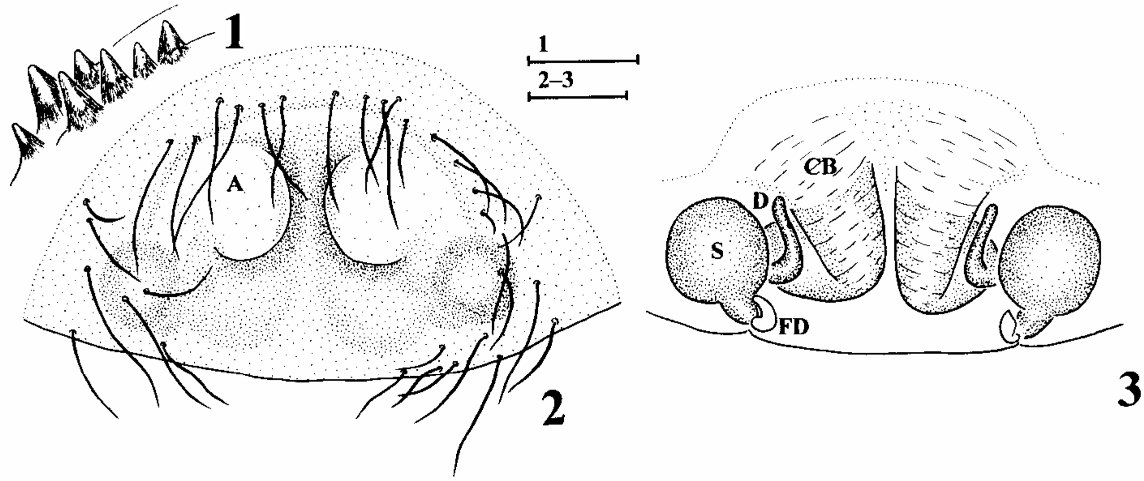
Agelena micropunctulata Wang, 1992: 288, figs 11-12, **syn. n.** – Song, Zhu & Chen, 1999: 354, fig. 205J-K.

TYPE MATERIAL EXAMINED: ♀ holotype (HBI) of *Agelena poliosata* Wang, 1991: Mt Tianmushan (30.4° N, 119.5° E), Zhejiang Province, China, collected by Jiafu Wang, October, 1979. ♀ holotype (HBI) of *A. micropunctulata* Wang, 1992: Sangang County (27.7° N, 117.6° E), Fujian Province, China, collected by Jiafu Wang, 20 July, 1986.

OTHER MATERIAL EXAMINED: 1 ♀ (IZCAS), Mt Tianmushan, Zhejiang Province, collector unknown, 12-17 October 1974. – 3 ♀ (MHNG), same locality as for the preceding, collector unknown, 12 October 1976. – 1 ♀ (IZCAS), Mt Huangshan (29.7° N, 118.3° E), Anhui Province, collector unknown, 27 October 1974. – 1 ♀ (IZCAS), Hongchunping Town, Mt Emeishan (29.6° N, 103.5° E), Sichuan Province, collector unknown, 24 September 1975.

DIAGNOSIS: Females of this species are similar to those of *A. limbata*, but can be distinguished by the different shape of their genital atrium and copulatory bursa (Figs 2-3).

DESCRIPTION: Female (holotype). Total length 10.00; carapace length 3.50, width 2.60; abdomen length 7.00, width 3.80. Anterior eye row and posterior eye row procurved in dorsal view. Eye measurements: AME 0.24; ALE 0.20; PME 0.20; PLE 0.21; AME-AME 0.12; AME-ALE 0.03; ALE-PLE 0.03; PME-PME 0.22; PME-PLE 0.17; MOA-L 0.60; MOA-WA 0.52; MOA-WP 0.58. Carapace yellow-brown; cervical groove and radial grooves black-brown; fovea short, slightly depressed. Each chelicera with 3 promarginal and 4 retromarginal teeth (Fig. 1). Maxillae and labium yellow-brown, labium wider than long. Sternum with slightly pointed posterior end only slightly inserted between coxae IV. Median and distal portion of leg femora and tibiae



FIGS 1-3

Agelena poliosata Wang, female. (1) Cheliceral teeth, left side. (2) Epigynum, ventral view. (3) Vulva, dorsal view. Scale bars: 0.2 mm.

with brown annulus. Leg formula (from longest to shortest): IV, I, II, III; leg measurements: I: 12.30 (3.50 + 4.10 + 3.00 + 1.70); II: 11.00 (3.10 + 3.70 + 2.60 + 1.60); III: 10.70 (3.20 + 3.40 + 2.60 + 1.50); IV: 13.60 (3.80 + 4.50 + 3.80 + 1.50). Abdomen ovoid. Dorsal side of abdomen gray; cardiac mark black; posterodorsal part of abdomen with several indistinct yellowish chevron-like markings; ventral side of abdomen without pattern. Apical segment of PLS about 1.8 times longer than basal segment. Epigynum (Figs 2-3) with median septum; atria separated by median septum and situated anteriorly on epigynum; copulatory bursa slightly shaped like the letter "L", with digitiform diverticula; spermathecae red-brown and round (Figs 2-3).

Male. Unknown.

VARIATION: The total length varies from 10.00 to 12.30 in females examined (n = 8).

DISTRIBUTION: China: Anhui, Fujian, Sichuan, Zhejiang (Map 1).

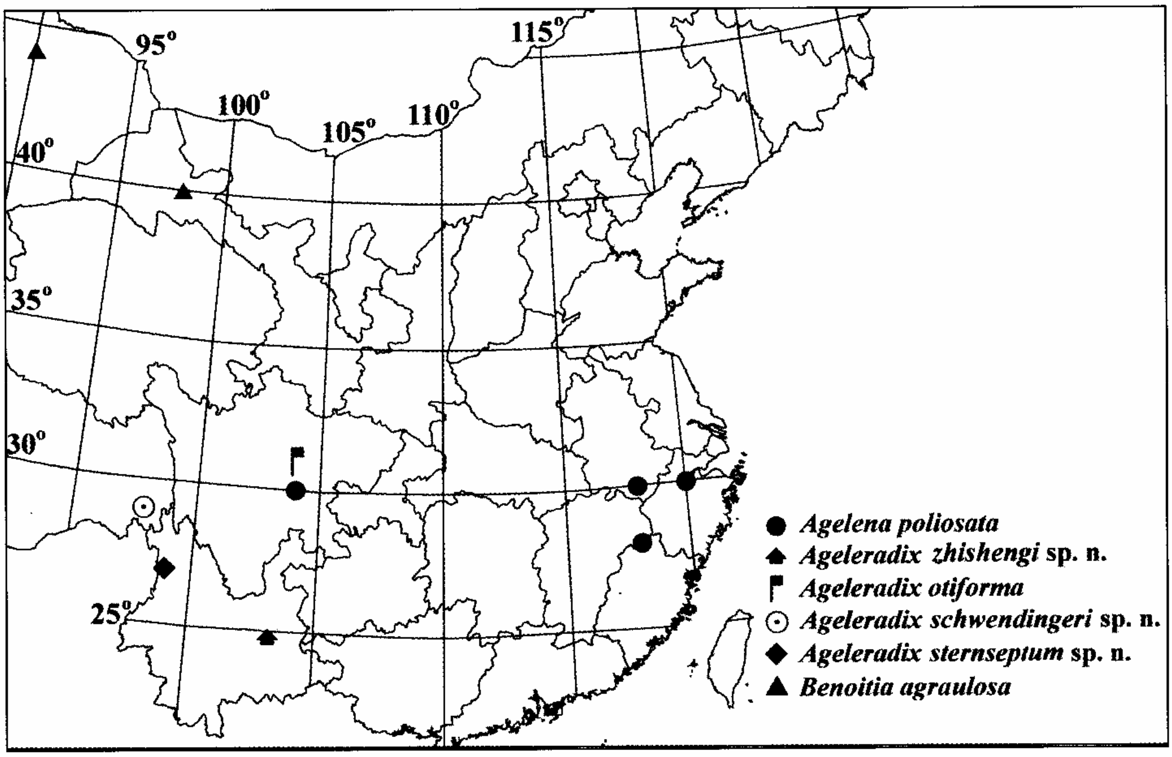
Ageleradix otiforma (Wang, 1991) comb. n. Figs 4-9

Agelena otiforma Wang, 1991: 409, figs 16-20. – Song, Zhu & Chen, 1999: 354, figs 205M-N, 206K, 207C.

TYPE MATERIAL EXAMINED: ♀ holotype (HBI); Sichuan Province, China, collected by Zhongming Luo, July 1981.– Paratypes; 2 ♂ (HBI), same data as for the holotype.

DIAGNOSIS: Females of this species can be recognized from those of other species by the tongue-shaped median septum, the strongly curved copulatory bursa, the shape of spermathecae and the position of the diverticulum (Fig. 9), and males by the brush-shaped distal end of the elongated conductor, the strongly modified radix (forming a cavity and with 2 apophyses), and the relatively long and slender embolus (Figs 4-6).

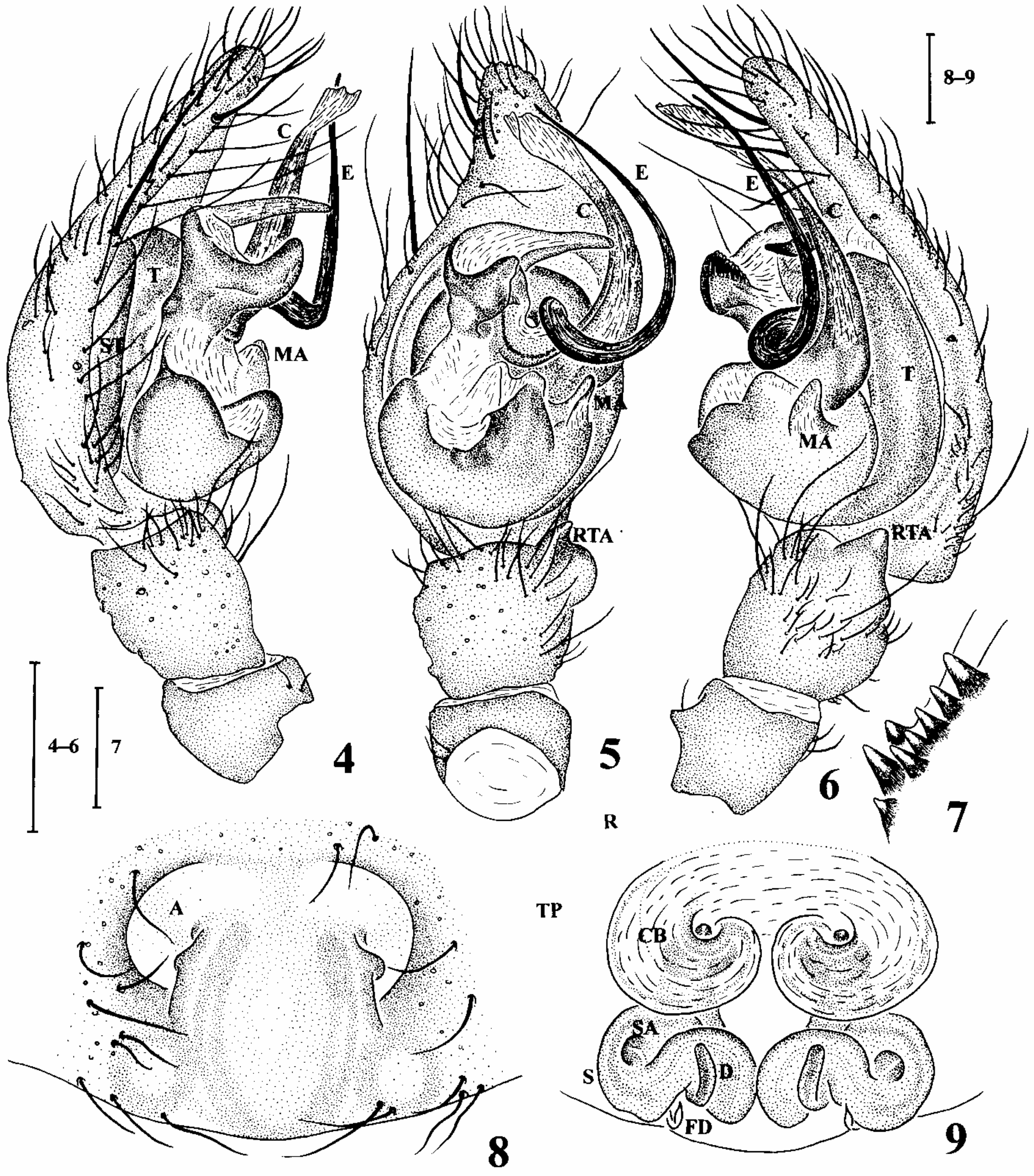
DESCRIPTION: Female (holotype). Total length 7.50. Carapace length 3.40, width 2.40; abdomen length 4.30, width 2.50. Anterior eye row and posterior eye row strongly procurved in dorsal view. Eye measurements: AME 0.20; ALE 0.18; PME 0.18; PLE 0.18; AME-AME 0.06; AME-ALE 0.03; ALE-PLE 0.03; PME-PME 0.17; PME-PLE 0.14; MOA-L 0.54; MOA-WA 0.46; MOA-WP 0.52. Carapace yellow-



MAP 1
Locality records for seven agelenid spider species in China.

brown, with brown margin. Each chelicera with 3 promarginal and 4 retromarginal teeth. Maxillae and labium light brown, labium wider than long. Sternum brown, covered with white fuzz and long brown hair. Basal and median portion of leg femora and tibiae with yellow-brown annulus. Leg formula (from longest to shortest): IV, I, II, III; leg measurements: I: 10.80 (2.50 + 3.90 + 2.70 + 1.70); II: 9.90 (2.50 + 3.60 + 2.30 + 1.50); III: 9.60 (2.60 + 3.30 + 2.50 + 1.30); IV: 13.60 (3.70 + 4.20 + 3.80 + 1.90). Dorsal side of abdomen brown, cardiac mark mauve and with white margin; posterodorsal part of abdomen with 5 yellowish chevron-like markings; ventral side of abdomen with 2 brown longitudinal markings between epigastric groove and spinnerets. Apical segment of PLS about 1.45 times longer than basal segment. Epigynum (Figs 8-9) with a tongue-shaped median septum; anterior part of vulva in the shape of two ears; spermathecae moderately large, copulatory bursa strongly curved, diverticula resting in a bend of the sigmoid spermathecae.

Male (paratype). Total length 7.30; carapace length 3.30, width 2.50; abdomen length 4.20, width 2.60. Eye measurements: AME 0.22; ALE 0.24; PME 0.17; PLE 0.24; AME-AME 0.03; AME-ALE 0.03; ALE-PLE 0.03; PME-PME 0.18; PME-PLE 0.12; MOA-L 0.54; MOA-WA 0.48; MOA-WP 0.54. Leg measurements: I: 14.88 (3.90 + 4.98 + 3.72 + 2.28); II: 13.74 (3.72 + 4.20 + 3.72 + 2.10); III: 13.50 (3.66 + 4.02 + 3.90 + 1.92); IV: 17.28 (4.56 + 4.74 + 5.40 + 2.58). Each chelicera with 3 promarginal and 5 retromarginal teeth (Fig. 7). Palp (Figs 4-6) without patellar apophysis; retrolateral tibial apophysis small, with distal end beak-shaped in ventral view; tegulum with processes; conductor slightly curved; embolus originating subapically, moderately long and slender; median apophysis small.



FIGS 4-9

Ageleradix otiforma (Wang). (4-6) Palp of male, left side. (4) Prolateral view. (5) Ventral view. (6) Retrolateral view. (7) Cheliceral teeth of male, left side. (8-9) Female genitalia. (8) Epigynum, ventral view. (9) Vulva, dorsal view. Scale bars: 4-6, 0.5 mm; 7-9, 0.2 mm.

VARIATION: The total length in the two males examined is 7.15 and 7.30.

DISTRIBUTION: China: Sichuan (Map 1).

Ageleradix schwendingeri sp. n. Figs 10-16

HOLOTYPE ♂ (MHNG): Xiazayü, Zayü County (28.6° N, 97.4° E), Tibet, China, collected by Xiaoen Chen and Junchuan Gao, 8 July 1981.

PARATYPE: 1♀ (MHNG), Kangga Town, Litang County (30.0°N, 100.2°E), Sichuan, China, 5 June 1982.

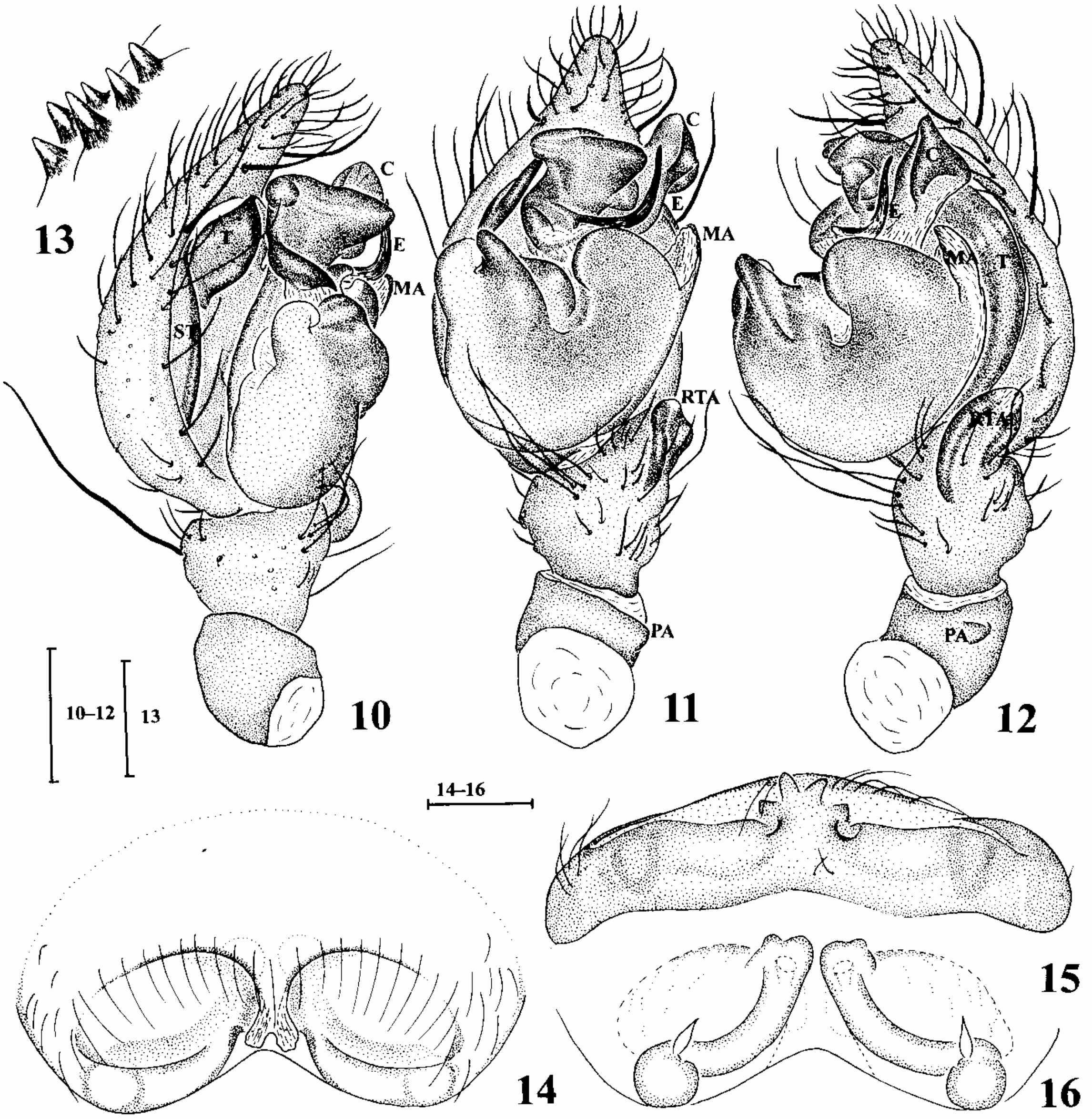
ETYMOLOGY: The new species is named in honor of Dr Peter J. Schwendinger (MHNG) for his contribution to arachnology.

DIAGNOSIS: The male of this species can be distinguished from those of other species by its short, anteriorly situated conductor, its slightly bifid tegulum process and its strong radix (Figs 10-12), and the female by the presence of an epigynal tooth, a deep cavity on the posterior edge of the epigynum and distinctive spermathecal stalks (Figs 14-16).

DESCRIPTION: Male (holotype). Total length 7.30; carapace length 3.60, width 2.60; abdomen length 3.70, width 2.00. Anterior eye row and posterior eye row procurved in dorsal view. Eye measurements: AME 0.18; ALE 0.23; PME 0.18; PLE 0.23; AME-AME 0.05; AME-ALE close to each other; ALE-PLE close to each other; PME-PME 0.10; PME-PLE 0.10; MOA-L 0.53; MOA-WA 0.33; MOA-WP 0.45. Carapace brown, with black margin and yellow-brown submargin. Head region clearly narrower than thorax region. Cervical groove and radial grooves black. Fovea longitudinal, long. Chelicerae red-brown, each with 3 promarginal and 3 retromarginal teeth (Fig. 13). Maxillae and labium brown, labium longer than wide. Sternum gray, with distal end slightly rounded, not very sharp. Leg brown, leg formula (from longest to shortest): IV, I, II, III; leg measurements: I: 14.85 (4.50 + 4.70 + 3.55 + 2.10); II: 13.45 (3.90 + 4.25 + 3.40 + 1.90); III: 12.40 (3.60 + 3.80 + 3.40 + 1.60); IV: 16.10 (4.10 + 5.00 + 4.80 + 2.20). Dorsal side of abdomen nut-brown, color of central region lighter than that of lateral region. Ventral side of abdomen with a line of light dots along each side. Colulus reduced to a tiny plate covered with several setae. ALS slightly longer than the basal segment of PLS. Apical segment of PLS about 1.3 times longer than that of basal segment. Palp (Figs 10-12) with small patellar apophysis; tegular process bifid, situated prolaterally on the tegulum; conductor strong and forming a moderate concavity; embolus short and sharp, originating subapically, in concavity of cunductor; stout radix with several blunt apophyses; median apophysis wide and situated retrolaterally on the bulb.

Female (paratype). Total length 7.00, carapace 3.00 long, 2.27 wide, abdomen 4.00 long, 2.53 wide. AER and PER strongly procurved. AME 0.13, ALE 0.20, PME 0.14, PLE 0.19; AME-AME 0.10, AME-ALE 0.08, PME-PME 0.13, PME-PLE 0.13, ALE-PLE 0.13; MOA-L 0.50, MOA-WA 0.33, MOA-WP 0.40. Carapace yellow-brown, with light yellow submargin and black margin. Cervical groove and radial grooves distinct, black-brown. Head region slightly narrower than thorax region. Fovea long and moderately deep. Chelicera with 3 promarginal and 3 retromarginal teeth. Legs yellow-brown, metatarsi and tarsi with trichobothria. Leg formula: IV, I, II, III; leg measurements: I: 10.03 (2.75, 3.25, 2.50, 1.53); II: 8.76 (2.50, 2.88, 2.13, 1.25); III: 8.63 (2.38, 2.75, 2.25, 1.25); IV: 11.76 (3.13, 3.63, 3.50, 1.50).

Abdomen dorsally with the indistinct cardiac pattern, a few scattered light dots and several chevrons. ALS strong, widely separated, about one third of the diameter of ALS. PLS about twice as long as ALS. Apical segment of PLS slender and sharp, about as long as basal segment. Epigynum in ventral view with a longitudinal septum, atrium divided into two inclined ellipses; posterior edge of the epigynum strongly indented; a single epigynal tooth with fishtail-shaped tip situated on the septum. Two small and



FIGS 10-16

Ageleradix schwendingeri sp. n. (10-12) Palp of male, left side. (10) Prolateral view. (11) Ventral view. (12) Retrolateral view. (13) Cheliceral teeth of male, left side. (14-16) Female genitalia. (14) Epigynum, ventral view. (15) Epigynum, posterior view. (16) Vulva, dorsal view. Scale bars: 10-12, 0.5 mm; 13, 0.2 mm; 14-16, 0.1 mm.

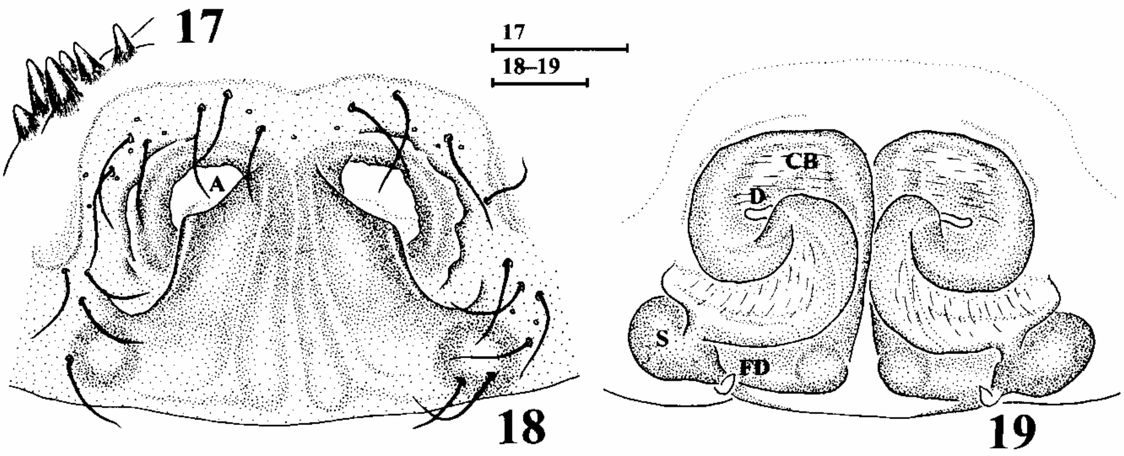
slightly pointed apophyses visible near the epigynal tooth in posterior view. Spermathecal heads in dorsal view small; spermathecae with round, widely separated bases and elongated, anteriorly converging stalks (Figs 14-16).

DISTRIBUTION: China: Tibet, Sichuan (Map 1).

Ageleradix sternseptum sp. n. Figs 17-19

HOLOTYPE ♀ (IZCAS): Judian Town, Lijiang County (27.2° N, 99.4° E), Yunnan Province, China, collected by Jinwen Shang, 13 July 1981.

ETYMOLOGY: This species name, a noun in apposition, refers to the shape of the median septum of the epigynum.



Figs 17-19
Ageleradix sternseptum sp. n. (17) Cheliceral teeth of female, left side. (18) Epigynum, ventral view. (19) Vulva, dorsal view. Scale bars: 0.2 mm.

Diagnosis: *A. sternseptum* can be distinguished from other *Ageleradix* species by the shape of its median epigynal septum (Fig. 18), the spermathecae and the twisted copulatory bursae (Fig. 19).

Description: Female (holotype). Total length 6.79. Carapace length 2.99, width 2.12; abdomen length 3.80, width 2.34. AER procurved and PER strongly procurved in dorsal view. Eye measurements: AME 0.14; ALE 0.17; PME 0.13; PLE 0.15; AME-AME 0.05; AME-ALE 0.03; ALE-PLE close to each other; PME-PME 0.11; PME-PLE 0.07; MOA-L 0.45; MOA-WA 0.31; MOA-WP 0.36. Carapace brown, covered with white and brown plumose hairs. Head region clearly narrower than thorax region. Cervical groove and radial grooves black. Fovea longitudinal, long. Chelicerae red-brown, with 3 promarginal and 3 retromarginal teeth (Fig. 24). Maxillae and labium brown, labium much longer than wide. Sternum gray, covered with white plumose hairs, its distal end slightly rounded, not very sharp. Legs yellow-brown, with annuli on femora, patellae, tibiae and distal end of metatarsi. Leg formula (from longest to shortest): IV, I, II = III; leg measurements: I: 8.00 (2.27 + 2.64 + 1.82 + 1.27); II: 7.81 (2.18 + 2.72 + 1.82 + 1.09); III: 7.81 (2.18 + 2.45 + 2.00 + 1.18); IV: 10.54 (2.91 + 3.27 + 2.91 + 1.45). Abdomen densely covered with white and brown plumose hairs. Middorsal region yellow, the rest brown. A broad brown pattern in the middle of the venter. Colulus reduced to a tiny plate covered with several setae. ALS about as long as basal segment of PLS; apical segment of PLS as long as basal segment. Epigynum (Figs 18-19) with large, shield-like median septum, posteriorly much wider than anteriorly, and with two posterior depressions. Genital atria situated anteriorly of median septum, giving the appearance of two nostrils. Spermathecae pear-shaped and widely separated from each other; copulatory bursae strongly twisted.

Male. Unknown.

Distribution: China: Yunnan (Map 1).

Ageleradix zhishengi sp. n. Figs 20-23

Agelena cymbiforma Wang, 1991: 408, figs 11-13 (misidentification of male). – Song, Zhu & Chen, 1999: 353, figs 206G, Q.

Ageleradix cymbiforma. – Xu & Li 2007: 60. (only male)

HOLOTYPE ♂ (HBI): Mt Xishan, Kunming City (25.0° N, 102.7° E), Yunnan Province, China, collected by Jiafu Wang, 30 July 1987 (male paratype of *Agelena cymbiforma* Wang, 1991).

ETYMOLOGY: The new species is named in honor of Dr Zhisheng Zhang for his contribution to the current paper. Specimens collected by his colleague made us aware of the incorrect match of male and female in the original description of *Agelena cymbiforma*. He also confirmed the match of male and female in *Ageleradix schwendingeri* sp. n.

DIAGNOSIS: This species can be recognized by a short, sharply pointed embolus, a strong, boat-shaped conductor, and a torch-like, distally serrated radix in males (Figs 20-22).

DESCRIPTION: Male (holotype). Total length 5.50; carapace length 2.70 width 2.10; abdomen length 3.00, width 1.60. Eye measurements: AME 0.11; ALE 0.18; PME 0.15; PLE 0.18; AME-AME 0.06; AME-ALE 0.06; ALE-PLE 0.04; PME-PME 0.12; PME-PLE 0.09; MOA-L 0.45; MOA-WA 0.32; MOA-WP 0.42. Leg measurements: I: 11.64 (2.94 + 3.78 + 3.00 + 1.92); II: 9.84 (2.52 + 3.36 + 2.64 + 1.32); III: 9.72 (2.70 + 3.00 + 2.82 + 1.20); IV: 14.64 (3.66 + 4.74 + 4.26 + 1.98). Promargin and retromargin of each chelicera with 3 teeth (Fig. 23). Palp (Figs 20-22) without patellar apophysis; retrolateral tibial apophysis relatively distinct; tegulum with 2 processes; conductor boat-shaped, long and strong; embolus originating subapically, needle-shaped; radix long and broad, torch-like, with a serrate membranous distal edge; median apophysis wide, membranous.

DISTRIBUTION: China: Yunnan (Map 1).

REMARK: 3 ♀ and 2 ♂ of this species, collected by Zizhong Yang at Xiaguan near Dali City, Yunnan Province, China on 28 March 2003, are deposited in the Dali University and were examined by Zhisheng Zhang. They show that the female holotype and the male paratype of *A. cymbiforma* are not conspecific. *Ageleradix zhishengi* sp. n. appears to be a common species in that area.

Benoitia agraulosa (Wang & Wang, 1990) Figs 24-29

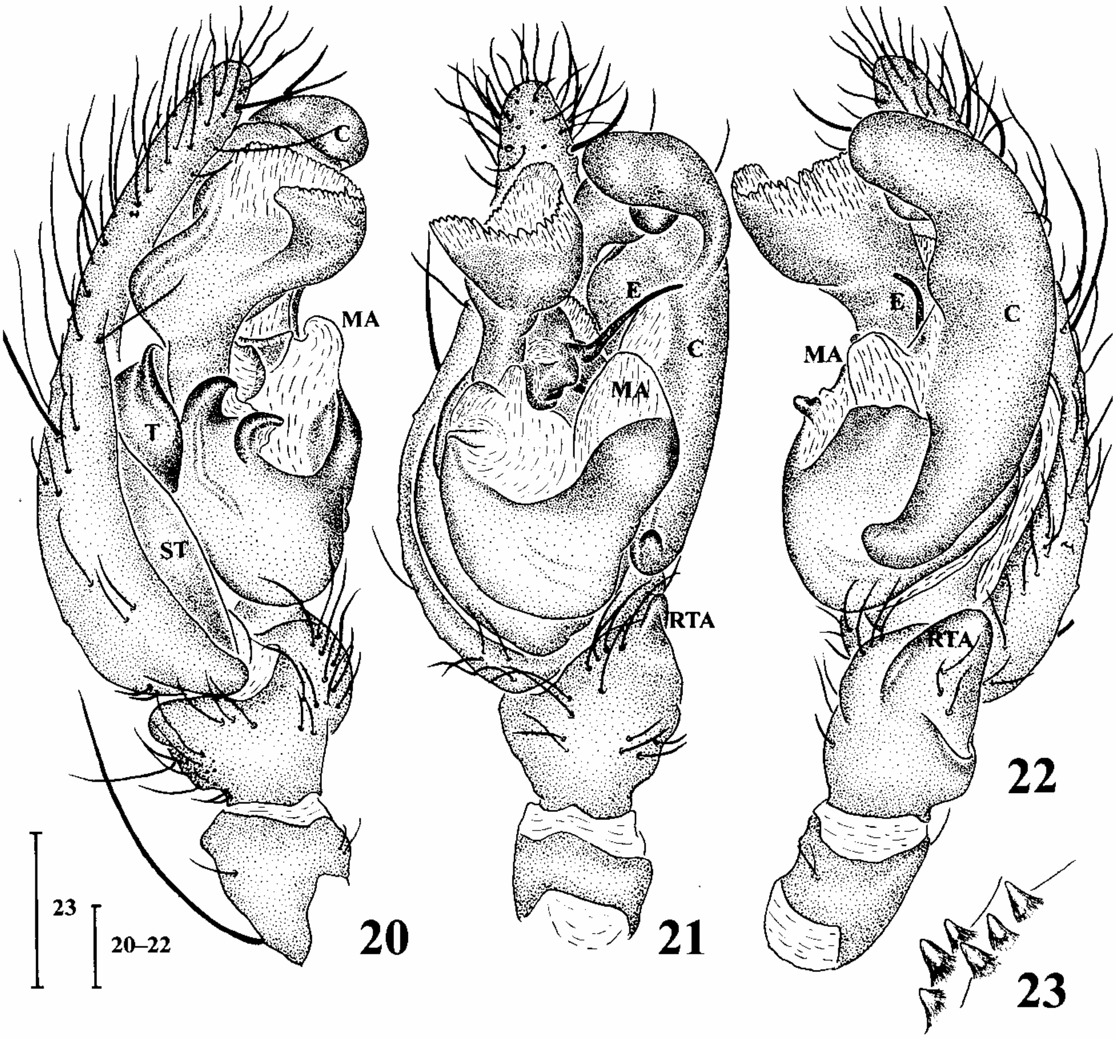
Agelena agraulosa Wang & Wang, 1990: 40, figs 1-5. – Wang, 1997: 254, figs 11-15;

Benoitia agraulosa. – Song, Zhu & Chen, 1999: 355, figs 207K-L, M-N (transferred from *Agelena*, following comments by Wang, 1997).

TYPE MATERIAL EXAMINED: ♀ holotype (IZCAS); Jiayuguan Great Wall, Jiayuguan City (39.8° N, 98.3° E), Gansu Province, China, collected by Xinping Wang and Xinai Hu, 26 July 1988. – Paratypes, 1 ♂ and 2 ♀ (IZCAS), same data as for the holotype.

OTHER MATERIAL EXAMINED: 1 ♀ (MHNG), Mt Baitashan, Qitai County (44.1° N, 89.8° E), Xinjiang, China, collector and date unknown.

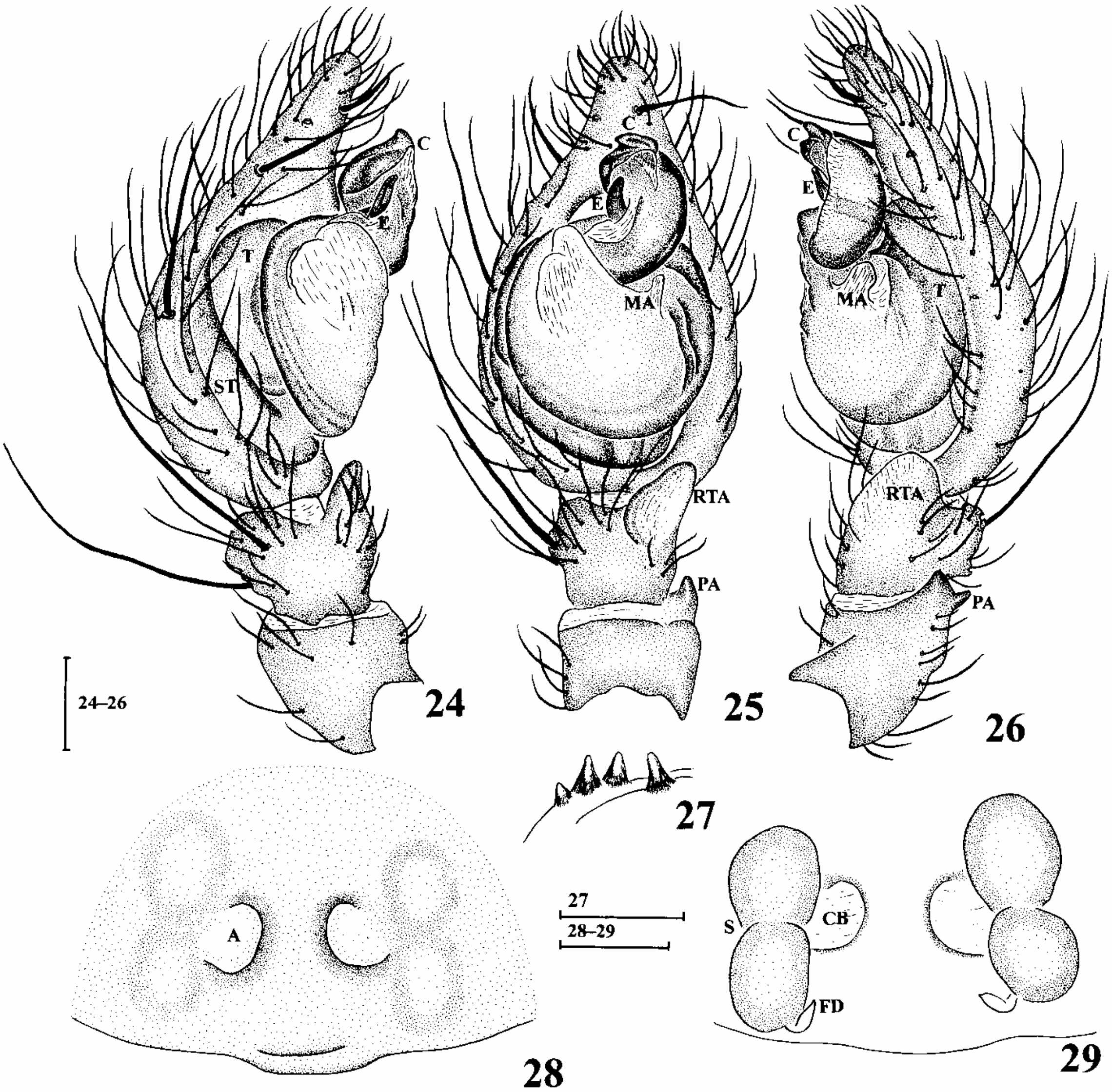
DIAGNOSIS: *B. agraulosa* can be distinguished from other *Benoitia* species by the shape of conductor and embolus in males (Figs 24-26), and by the small separated epigynal openings and medially constricted spermathecae in females (Figs 28-29).



Figs 20-23

Ageleradix zhishengi sp. n. (20-22) Palp of male, left side. (20) Prolateral view. (21) Ventral view. (22) Retrolateral view. (23) Cheliceral teeth of male, left side. Scale bars: 0.2 mm.

Description: Female (holotype). Total length 10.00; carapace length 4.19, width 2.58; abdomen length 5.97, width 3.55. AER and PER procurved in frontal view. Eye measurements: AME 0.18; ALE 0.12; PME 0.12; PLE 0.18; AME-AME 0.06; AME-ALE 0.06; ALE-PLE 0.06; PME-PME 0.12; PME-PLE 0.12; MOA-L 0.45; MOA-WA 0.42; MOA-WP 0.39. Carapace yellow-brown, with black-brown spots. Several long hairs in MOA and some between PME and thoratic groove. Clypeus covered with white plumose hairs. Chelicerae red-brown, each with 3 promarginal teeth and 1 retromarginal tooth. Maxillae, sternum and legs yellow-brown, maxillae much longer than wide. Labium brown. Sternum slightly longer than wide and covered with quite long hairs. Legs with a stripe on their ventral side. Leg formula (from longest to shortest): IV, I, III, II; leg measurements: I: 12.70 (3.17 + 4.92 + 2.86 + 1.75); II: 10.32 (2.86 + 3.93 + 2.54 + 1.59); III: 11.75 (2.86 + 4.76 + 2.38 + 1.75); IV: 13.81 (3.97 + 4.44 + 4.13 + 1.27). Dorsal side of abdomen brown, clothed with several pairs of black and silvery white spots. Lateral sides of abdomen brown. Epigynum with



FIGS 24-29

Benoitia agraulosa (Wang & Wang). (24-26) Palp of male, left side. (24) Prolateral view. (25) Ventral view. (26) Retrolateral view. (27) Cheliceral teeth of male, left side. (28-29) Female genitalia. (28) Epigynum, ventral view. (29) Vulva, dorsal view. Scale bars: 0.2 mm.

two relatively small openings, these clearly separated from each other. Wide, depressed septum lying between finely sclerotized rims of epigynal openings. Copulatory bursae bordered by long, medially constricted spermathecae (Figs 28-29).

Male (paratype). Total length 8.87; carapace length 4.03, width 2.10; abdomen length 5.00 width 2.26. Eye measurements: AME 0.15; ALE 0.18; PME 0.15; PLE 0.15; AME-AME 0.07; AME-ALE 0.03; ALE-PLE 0.06; PME-PME 0.15; PME-PLE 0.15; MOA-L 0.51; MOA-WA 0.42; MOA-WP 0.39. Leg measurements: I: 11.94 (3.00 + 3.54 + 3.72 + 1.68); II: 11.16 (2.88 + 3.60 + 3.06 + 1.62); III: 11.52 (3.00 + 3.78 + 3.06 + 1.68); IV: 14.54 (4.02 + 4.50 + 4.92 + 1.10). Each chelicera with 3 promarginal teeth and 1 retromarginal tooth (Fig. 27). Palp (Figs 24-26) with large retrolateral tibial apophysis; patellar apophysis with two distal ends; corkscrew-shaped conductor with sclerotised and membranaceous structures describing one whorl; embolus short, with blunt tip; median apophysis thumb-shaped.

VARIATION: The total length in females examined (n = 4) varies from 9.90 to 11.58.

DISTRIBUTION: China: Gansu, Xinjiang (Map 1).

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A review of the genus *Paratus* Simon (Araneae, Dionycha)

YURI M. MARUSIK[1,2,5], GUO ZHENG[3] & SHUQIANG LI[4]

[1] *Institute of Biological Problems of the North, RAS, Portovaya Str. 18, Magadan 685000, Russia*
[2] *Zoological Museum, University of Turku, FI-20014 Turku, Finland*
[3] *Shenyang Normal University, Shenyang 110034, P. R. China. E-mail: zhg1027@yahoo.com.cn*
[4] *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, P. R. China. Email: lisq@ioz.ac.cn*
[5] *Corresponding author. E-mail: yurmar@mail.ru*

Abstract

The spider genus *Paratus* Simon, 1898 was known for more than hundred years from a single female from Sri Lanka. A survey of spiders in south China and northern India reveals two new species: *P. sinensis* **sp. n.** and *P. indicus* **sp. n.** Both species are described based on males and females. The study of the copulatory organs and somatic morphology led us to conclude that *Paratus* cannot be placed in any described subfamily of Liocranidae, where it was placed originally, or in Corinnidae. Therefore, we describe a new subfamily Paratinae subfam. n. and retain this group within Liocranidae.

Key words: Taxonomy, morphology, palp, epigyne, Yunnan, Uttar Pradesh

Introduction

The spider genus *Paratus* Simon, 1898 was described based on a new species *P. reticulatus* from Sri Lanka, known from the female holotype only (Deeleman-Reinhold, 2001). Simon's (1898) description lacks figures, which could be the main reason why this genus and species remained forgotten for a long time. In addition to an inadequate description, the holotype of *P. reticulatus* was thought to be lost, because the specimen deposited in the Natural History Museum in Paris was labeled by Simon as *Saticula reticulata* (Deeleman-Reinhold, 2001). Recognition of this genus and species became possible when Deeleman-Reinhold (2001) provided a detailed, illustrated redescription of its somatic morphology.

Deeleman-Reinhold placed *Paratus* among "Liocraninae s.l. *incertae sedis*" because this genus lacks a retrocoxal window, which is typical of all European liocranid genera including *Liocranum* (Deeleman-Reinhold, 2001).

An extensive survey of spider fauna from Xishuangbanna rainforest in south Yunnan over a period of one year (June 2006–August 2007) using various collection techniques (fogging, pitfall traps, trunk traps and direct searching), brought abundant and diverse material. Among this material we recognized one undescribed species that undoubtedly belongs to *Paratus.* While comparing Chinese specimens with the habitually similar Indian liocranid specimens, we recognized that Indian specimens earlier identified by the first author as *Ceto* (= *Cetonana*) also belong to *Paratus*. The goal of this paper is the description of two new species based on both sexes and a discussion on the placement of *Paratus*.

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Methods

Specimens were photographed using an Olympus SZX12 stereomicroscope and Olympus Camedia C-5050 camera. Figures have been combined using “CombineZM” image stacking software. Internal structures of bulbus and epigyne were studied after exposing clarification in lactic acid for about 12 hours. All measurements are in mm. Abbreviations: AME = anterior median eyes, ALE = anterior lateral eyes, PME = posterior median eyes, PLE = posterior lateral eyes, *Bh* = bent setae, *Co* = conductor, *Di* = diverticula, *Em* = embolus, *Eo* = embolus opening, *Re* = receptaculum, *St* = stylus, *To* = tegular outgrowth. The type material derived from this study was deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS) and Senckenberg Museum, Frankfurt am Main (SMF).

Taxonomy

Paratus Simon, 1898

Paratus Simon, 1898: 209.
Paratus: Deeleman-Reinhold, 2001: 401.
Type species: *Paratus reticulatus* Simon, 1898 from Sri Lanka.

Diagnosis (after Deeleman-Reinhold, 2001): Squat spiders with high, almost round carapace which strongly narrows in front. Leg length uniform, anterior tibiae and metatarsi with several pairs of strong ventral spines and some lateral spines. Abdomen almost globular. *Paratus* is distinguished from European liocranid genera by the absence of the retrocoxal window on coxae I.

The following characters may also help diagnose the genus: Chelicera with an enlarged seta bent at a right angle (*Bh*, Fig. 4) originating near the base of fang. Male palp without distinct subtegulum, cymbium subequal in length to palpal femur, base of embolus continuous with tegulum, arising from the center of the tegulum, epigynal plate simple (without fovea, openings, grooves or outgrowths), epigyne with deep pocket, receptacula round. Abdomen with white guanine spots, carapace higher in thoracic part and very strong and long tibial and metatarsal spines.

Description. Medium sized spiders (2.60–4.60) with two claws, distinct pattern on carapace and abdomen, low clypeus, raised thoracic part of carapace, strong spines on legs I and II, white guanine spots on abdomen. Carapace width subequal to its length, light colored, with two pairs of dark bands (submedian and submarginal), lateral light band broken (Figs. 1, 5–6). Eyes subequal in size, clypeus low, about ½ of AME in height (Fig. 4). Thoracic part of carapace higher than cephalic area (Fig. 2). Chelicera with small teeth on both margins, with strong, characteristically bent near base of fang (Fig. 4). Maxillae relatively long (Fig. 3). Legs long, with distinct annulations (Figs. 1, 5), tibia I and II with 5 to 8 pairs of strong ventral spines (Figs. 2–3), metatarsi I and II with 3 pairs of long and strong spines. Abdomen with light cardiac spot and dark pattern on sides and venter, with irregular white guanine spots (Figs. 1–2, 5–6). Male palp with only one tibial (retrolateral) apophysis, long cymbium (about same length as femur), bulbus globular, without distinct subtegulum, without tegular (median) apophysis attached flexibly to tegulum. Conductor present in one species (*P. indicus* **sp. n.**) and absent in another (*P. sinensis* **sp. n.**). Embolus with long or very short stylus (*St*, extension of tip over embolic opening, *Eo*), seminal duct long, characteristically twisted near the base of embolus (Figs. 11, 13–14). Epigyne simple, represented by an undivided plate without any fovea or furrows. Receptacula round, insemination ducts short (Figs. 23–26, 28–29). *P. sinensis* **sp.n.** with pair of goffered diverticula. Diverticula became visible (expanded) after exposition of epigyne to lactic acid.

Composition. Three species, *P. reticulatus* Simon, 1898 (Sri Lanka), *P. sinensis* **sp. n.** (Yunnan, China), and *P. indicus* **sp. n.** (Uttar Pradesh, India).

Distribution. *Paratus* is known from three localities in South Asia: Sri Lanka, foothills of Indian Himalaya, and South China (Fig. 30). Its occurrence in Vietnam, Nepal, Burma, Bangladesh is very likely.

Paratus reticulatus Simon, 1898

P.r. Simon, 1898: 209 (♀).
P.r.: Deeleman-Reinhold, 2001: 401, figs. 628–632 (♀).

Diagnosis. It can be distinguished from congeners by having 5 pairs of ventral spines on tibia I.

Description. See Deeleman-Reinhold (2001).

Distribution. Known from single female found in Sri Lanka (Fig. 30).

Paratus sinensis sp. n.

Figs. 1–4, 12–18, 22–26

Material examined: Holotype ♂ and paratypes 1 ♂ 1 ♀ from China, Yunnan Province, Menglun Nature Reserve, 744 m, 21º57.699'N, 101º11.893'E; primary tropical seasonal rainforest, 790 m, trunk traps GBII-3-05, 16–31.03.2007 (G. Zheng). Paratypes: 1 ♂, same locality, sample GBII-5-041-15.03.2007 (G. Zheng); 1 ♂ 1 ♀ and 1 juv., same locality, sample GBII-5-05, 16–31.03.2007 (G. Zheng); 1 ♂, same locality, sample GBII-1-06, 1–15.04.2007 (G. Zheng). All deposited in IZCAS.

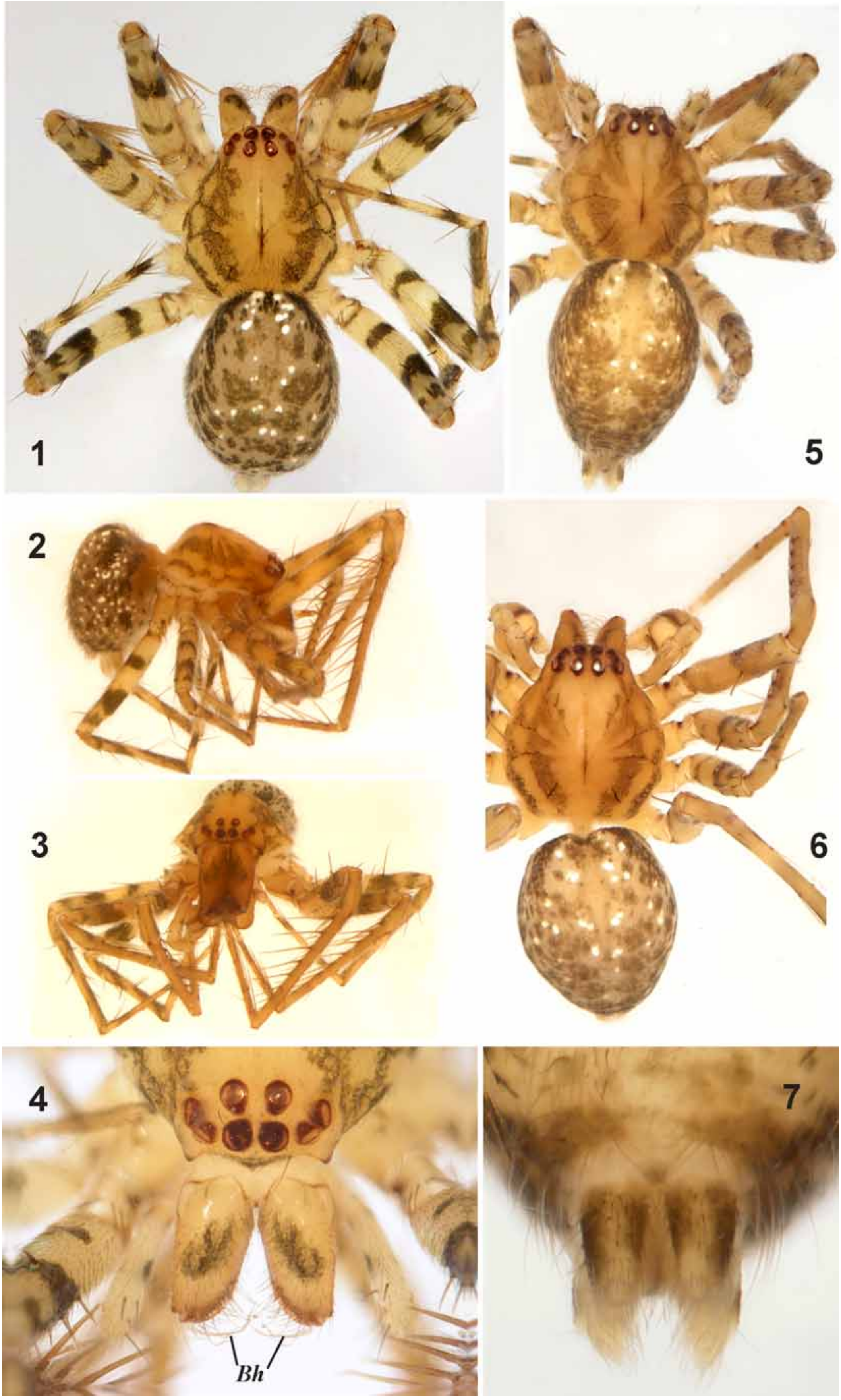
Etymology. The specific name refers to the type locality.

Diagnosis. *P. sinensis* **sp. n.** can be distinguished by the lack of conductor in male palp, presence of tegular outgrowth, long spine-like retrolateral tibial apophysis, cymbium shorter than femur, and goffered diverticula in vulva.

Description. Male. Total length 3.20–4.63. Carapace: 1.45–2.25 long, 1.50–2.00 wide, 0.80–1.10 high. Chelicera 0.70–1.43. Clypeus very low, 0.04, about 1/3 of AME diameter. Eyes sizes and interdistances: AME 0.14, ALE 0.13, PME 0.11, PLE 0.13 (AME > ALE = PLE > PME), AME–AME 0.13, AME–ALE 0.10, PME–PME 0.16, PME–PLE 0.19, ALE–PLE not spaced. Chelicera with 2 distinct promarginal and 4 retromarginal teeth. Carapace light brown with brown pattern: thin median stripe and two pairs of lateral bands. Submedian band wide, submarginal band about 3 times thinner, both bands connected by two radial stripes. Cephalic part without pattern. Thoracic groove long, well developed. Highest point of carapace in thoracic groove. Sternum light brown, without pattern. Chelicera colored as carapace, with dark median spot. Palpal coxae (0.50 long, 0.26 wide) with subparallel margins and parallel to each other, more than two times longer than labium (0.21 long). Abdomen darker than carapace, with distinct pattern formed by dark spots of different size and white guanine irregular dots. Posterior spinnerets longer than anteriors. Legs colored as carapace with distinct rings on femora and spots on tibia and metatarsus on legs III–IV. Rings on femora darker that carapace pattern, one ring on basal 1/3, two rings on apical 1/3. Tibiae I–II with 7 or 8 pairs of long ventral spines, longest spine (1.5 mm) 1/3 tibia length, 6 times longer than tibia diameter (0.17). Metatarsi I–II with 3 pairs of long ventral spines, longest spine almost ½ of metatarsus length.

Length of leg articles (large male with carapace 2.25 long):

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	2.63	0.75	3.15	2.03	0.73	9.29
II	2.25	0.70	2.43	1.63	0.67	7.68
III	2.13	0.57	1.83	1.65	0.83	7.01
IV	2.20	0.63	1.80	2.15	0.90	7.68



FIGURES 1–7. Somatic morphology of *Paratus sinensis* **sp. n.** (1–4) and *P. indicus* **sp. n.** (5–7). 1, 5—female, dorsal; 2—male, lateral, 3—male, frontal; 4—female, cephalic part and chelicera; 6—male, dorsal; 7—female spinnerets.

Palp as in Figs. 12–18. Femur long, 4.40, longer than wide, with dark promarginal dark spot, with 2 strong dorsal spines, strong retrolateral and smaller prolateral spine. Patella as long as tibia, about 2.6 times shorter than femur, with one dorsal and one prolateral spines (Figs. 17–18). Tibia with one spine-like dorso-retrolateral apophysis and two prolateral spines. Cymbium long, about 0.93 of femur length, spines absent. Bulbus globular, with bulbous tegulum, subtegulum seems to be absent. Tegulum with fine ridges/wrinkles (Figs. 13–14), and terminal retrolateral outgrowth. Embolus thick, C-shaped, longer than ½ of tegulum height, tip with very short stylus. Widest part of seminal duct thinner than embolus, makes one loop along base of tegulum, then thin part makes several turns and one twist near basal part of embolus (Figs. 13–14).

Female (collected with holotype). Total length 3.63. Carapace: 1.75 long, 1.63 wide, 0.75 high. Chelicera 0.70 long. Coloration and spination as in male, tibia I and II with 7 pairs of ventral spines.

Length of leg articles:

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1.50	0.57	1.63	1.00	0.53	5.23
II	1.50	0.55	1.57	1.00	0.55	5.17
III	1.55	0.55	1.45	1.25	0.70	5.50
IV	1.80	0.55	1.45	1.55	0.70	6.05

Epigyne as in Figs. 22–26. Epigynal plate weakly sclerotized, without fovea, pockets, furrows or outgrowths; at first look adult female can be considered as juvenile. Large, bell-shaped pocket below posterior margin of plate, upper part of pocket with two separate copulatory (insemination) openings leading to short, straight insemination ducts. Median part of insemination duct swollen. Receptacula round. Posterior part of vulva with pair of goffered diverticula (outgrowths) of unknown origin and function. Such outgrowths became visible (erected) after maceration in lactic acid.

Comments. Allometric growth. Large male specimen has carapace longer than wide, but small male has carapace wider than long. Larger male has 8 pairs of ventral tibial spines, and smaller one and female have only 7 pairs. Larger male has relatively longer first leg (carapace length/tibia I length ratio 0.67 in large specimen, 0.83 in small one). Chelicera of large male over ½ of carapace length, while in small male they are about 0.45 of carapace length.

Phenology and habitat. All adult specimens were found on tree trunks in primary seasonal rain forest in March and first half of April, although trunk trapping was made during the entire year. We have checked only part of the pitfall traps exposed for the entire year but did not find any adult *Paratus* specimens.

Distribution. Only known from type locality (Fig. 30).

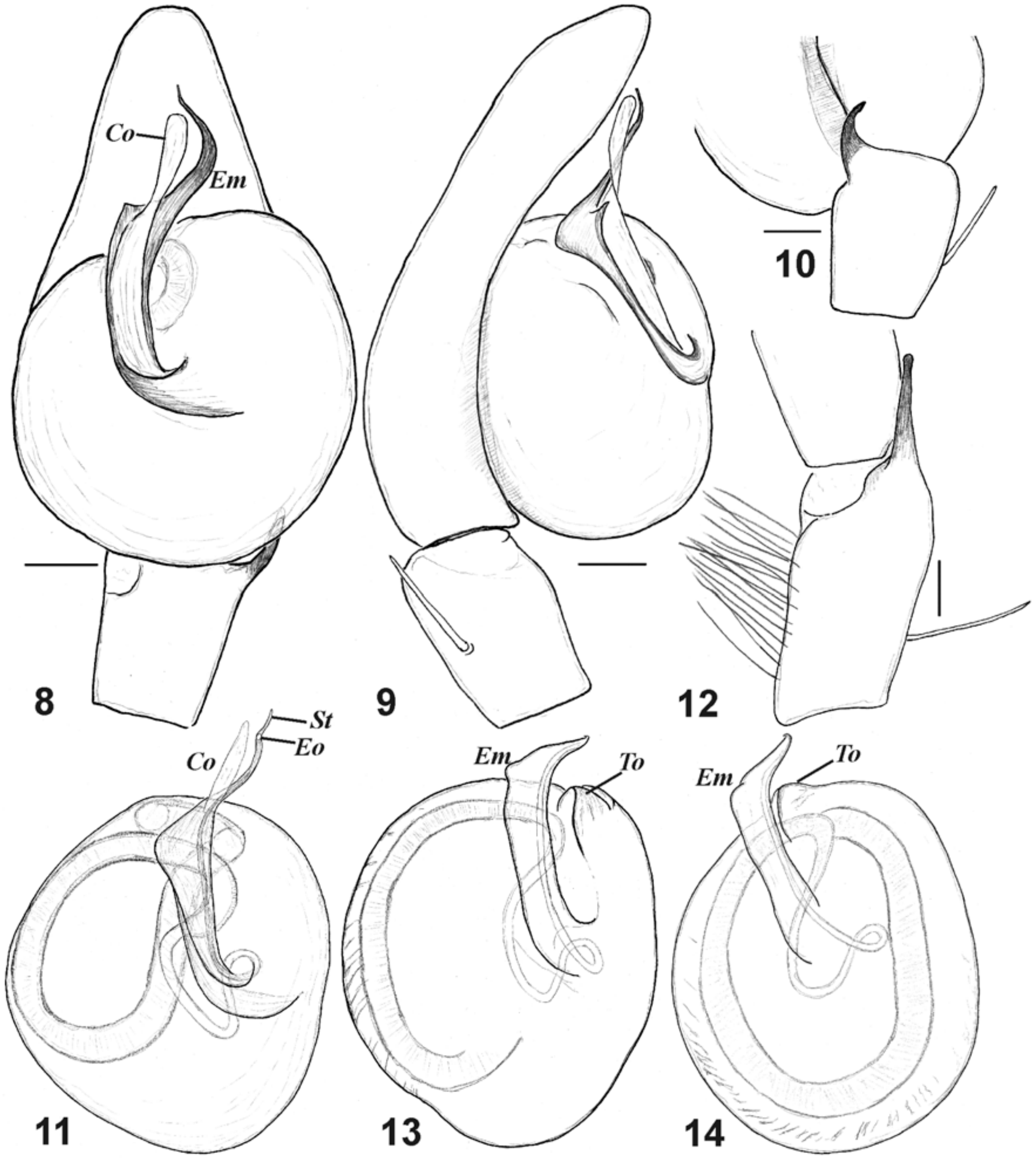
Paratus indicus sp. n.

Figs. 5–11, 19–21, 27–29

Material examined: Holotype ♂ and paratypes 1 ♂ and 5 ♀ from India, Uttar Pradesh, Gobind Ghat Vill., 30º37.5'N 79º33.5'E, 1750–1900m, 17–23.05.1999 (Yu. M. Marusik); ♂ paratype from Uttar Pradesh, Joshimath Town, 30º33.3'N 79º33.9'E, 1870m, 14.05.1999 (Yu. M. Marusik). All deposited in SMF.

Etymology. The specific name refers to the type locality.

Diagnosis. This species can be recognized by the presence of a conductor in the male palp, long embolus with distinct stylus, short slightly bent retrolateral apophysis, cymbium longer than femur, and lack of vulval diverticula. In comparison to *P. sinensis* **sp. n.**, the epigyne of this species has a more procurved (convex) posterior margin (Fig. 27).

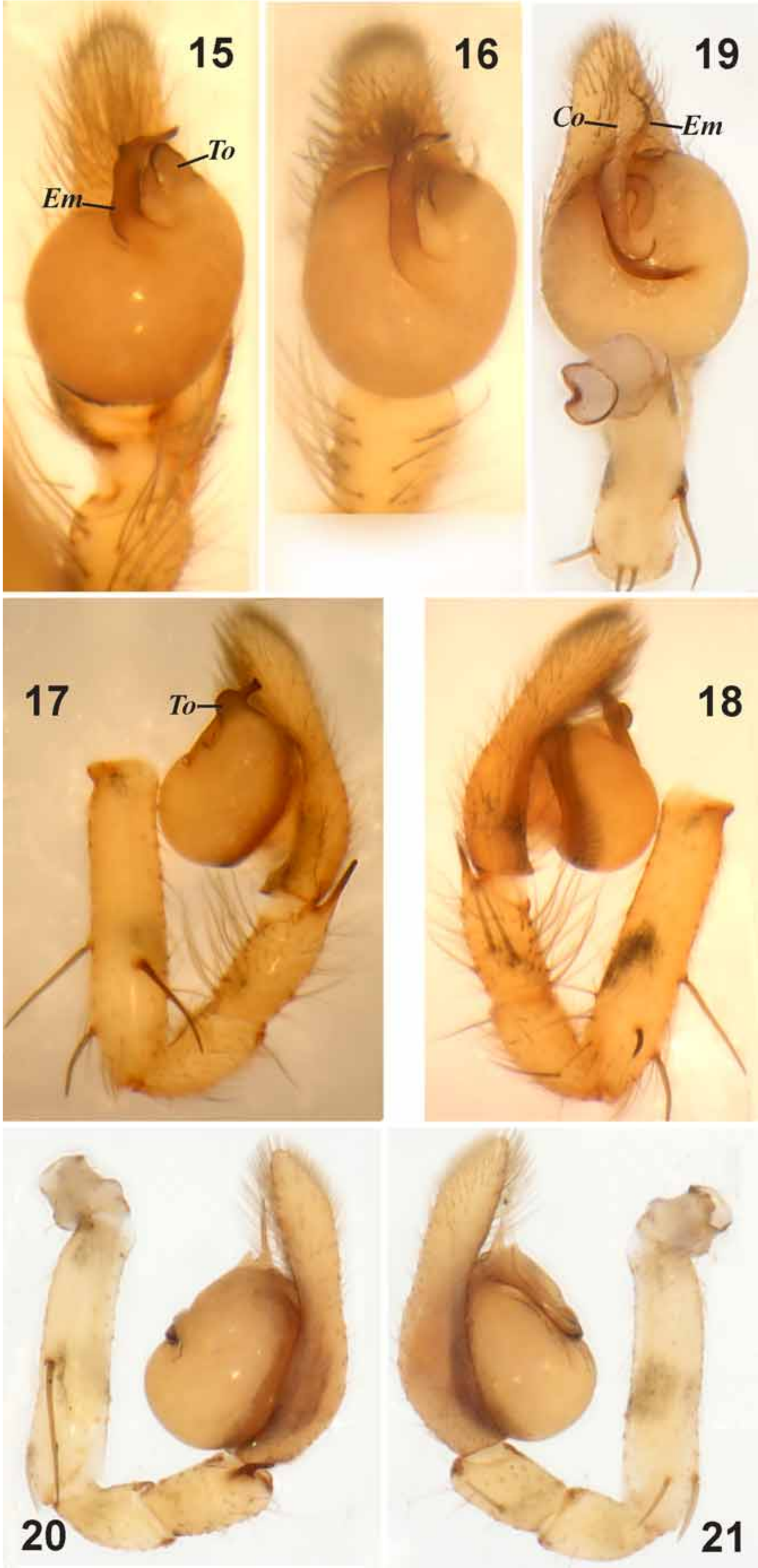


FIGURES 8–14. Male palp of *Paratus indicus* **sp. n.** (8–11) and *P. sinensis* **sp. n.** (12–14). 8—palp, ventral; 9—palp, prolateral; 10, 12—tibia, retrolateral; 11, 13–14—tegulum, ventral. Scale = 0.1 mm.

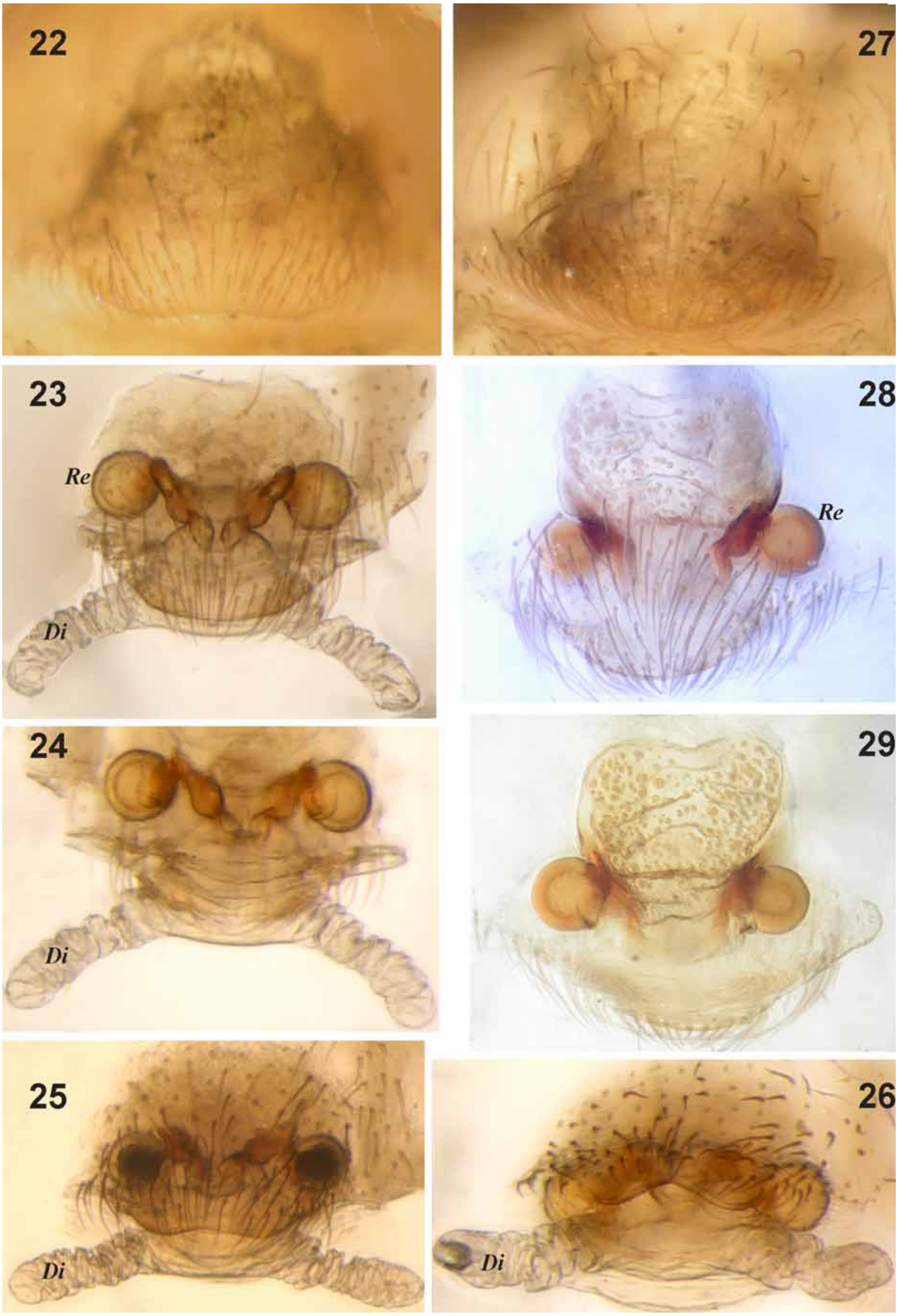
Description. Male. Total length 2.63–3.20. Carapace: 1.29–1.50 long, 1.23–1.37 wide, length/width ratio 1.05–1.09, coloration as in *P. sinensis* **sp. n.** Eyes sizes and interdistances: AME 0.08, ALE 0.09, PME 0.10, PLE 0.09, AME–AME 0.11, AME–ALE, AME–PME 0.13, ALE–PLE 0.06, PME–PME 0.11, PME–PLE 0.13. Tibia I with 7 pairs of ventral and one prolateral spine, tibia II with 6 pairs of ventral spines.

Length of leg articles:

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1.77	0.57	2.00	1.40	0.57	6.31
II	1.64	0.5	1.57	1.14	0.53	5.38
III	1.46	0.46	1.37	1.21	0.61	5.11
IV	1.63	0.40	1.36	1.58	0.69	5.66



FIGURES 15–21. Male palp of *Paratus sinensis* **sp. n.** (15–18) and *P. indicus* **sp. n.** (19–21). 15, 19—ventral; 16—ventral-apical; 17, 20—retrolateral; 18, 21—prolateral.



FIGURES 22–29. Epigyne of *Paratus sinensis* **sp. n.** (22–26) and *P. indicus* **sp. n.** (27–29). 22, 27—not detached epigyne, ventral; 23, 28—after maceration, ventral; 24–25—ditto, ventro-caudal; 26—ditto, caudal; 29—ditto, dorsal.

Palp as in Figs. 8–11, 19–21. Femur long and thin, slightly shorter than cymbium, middle part of femur with dark ring, prolateral side with long strong spine (1/2 of femur length), dorsal side with two small terminal spines, prolateral side with one small terminal spine as long as femur diameter. Patella and tibia subequal in size, and each more than 2 times shorter than femur. Tibia with one prolateral spine, tibial apophysis small, less than tibia diameter, claw-like, slightly bent backwards. Cymbium without spines, tegulum bulbous, round in frontal view. Tegulum bears embolus and conductor, both arising near center of tegulum. Conductor membranous, weakly sclerotized, lying on embolus base. Embolus gradually tapering, with distinct stylus (Fig. 11, *St*). Thick part of seminal duct makes closed loop, thin part makes a 360º loop near base of embolus.

Female. Total length 3.13–3.75. Carapace: 1.29–1.50 long, 1.23–1.37 wide, length/width 1.01–1.12, coloured as in *P. sinensis* **sp. n.** Eyes sizes and interdistances: AME 0.09, ALE 0.10, PME 0.11, PLE 0.11, AME–AME 0.07, AME–ALE 0.06, AME–PME 0.11, ALE–PLE 0.04, PME–PME 0.09, PME–PLE 0.11. Tibia I–II with 6 pairs of ventral spines, although some specimens have 7 retroventral spines on tibia I.

Length of leg articles:

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1.44	0.53	1.57	1.01	0.39	4.94
II	1.44	0.50	1.39	1.00	0.43	4.76
III	1.50	0.49	1.36	1.21	0.53	5.09
IV	1.58	0.49	1.36	1.57	0.69	5.69

Epigyne as in Figs. 27–29. Epigynal plate simple, without any fovea or furrows. Receptacula round, insemination ducts short, opening in common depression placed below plate. Dorsal wall of vulva with large plate (wall) (Figs. 28–29).

Habitat. All specimens were collected in leaf litter under 1.5–2 m high bushes.

Distribution. Only known from type locality (Fig. 30).

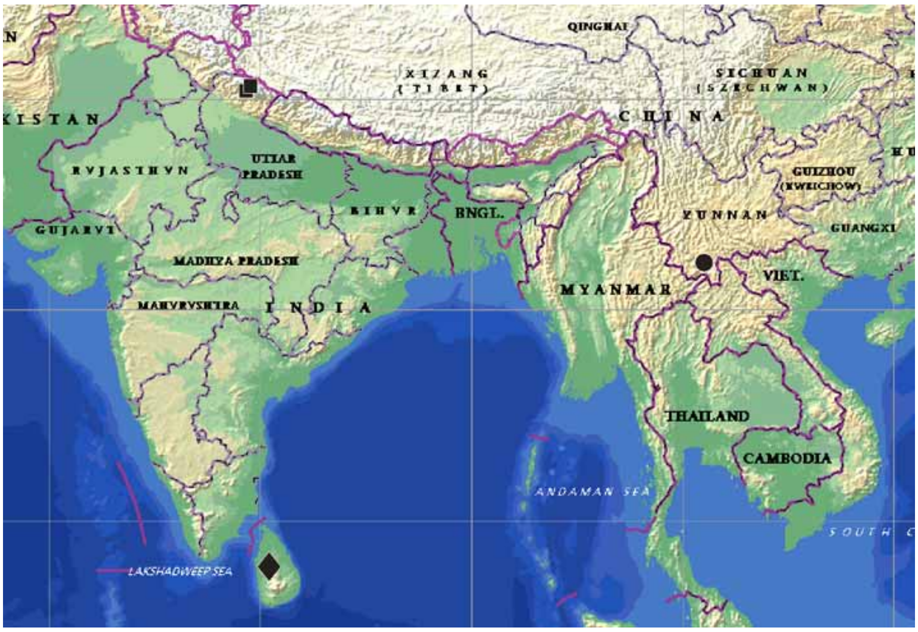


FIGURE 30. Distribution of *Paratus* spp.: diamond—*P. reticulatus*, square—*P. indicus* **sp. n.**, circle— *P. sinensis* **sp. n.**

Discussion

Liocranidae is a poorly diagnosed family, without known distinct synapomorphies (Platnick & Baptista, 1995; Deeleman-Reinhold, 2001; Jocqué & Dippenaar-Schoeman, 2006). Jocqué & Dippenaar-Schoeman (2006) list three subfamilies in Liocranidae: Cybaeodinae, Liocraninae and Phrurolithinae. However, according to Bosselaers and Jocqué (2002) and Platnick's catalogue (2008) *Phrurolithus* and related genera (Phrurolithinae) are members of Corinnidae. Ubick and Richman (2005) divide the Nearctic liocranids in two groups, Liocraninae and the "*Agroeca* complex".

A comparison of the copulatory organs of *Paratus* with those of *Liocranum* and other well described liocranid genera reveals very little similarity. First of all, the male palp of liocranids have a distinct subtegulum (lacking or indistinct in *Paratus*); in addition, the tegulum in *Liocranum* and most of other genera bears a tegular (= median) apophysis, lacking in *Paratus*. None of the liocranids have a simple epigynal plate, or round receptacula. A simple structure of bulbus is however common in Corinnidae. The entire subfamily Castianeirinae has simple bulbus without any outgrowth except the embolus, and, at any rate, the subtegulum in Castianerinae is distinct. Some corinnids have a simple epigynal plate (e.g., *Mazax* O.P.-Cambridge, 1898).

The length of legs in *Paratus* is intermediate between that of corinnids and liocranids. According to Deeleman-Reinhold (2001: 399), the leg IV in liocranids is longer than other legs, while in corinnids it is not so. In large specimens of *P. sinensis* **sp. n.** and *P. indicus* **sp. n.**, male legs I are the longest, while in females and small sized males, legs IV are longer than legs I. The thorax being higher than the cephalic area of carapace seems also to be unique for Liocranidae, and among the Corinnidae it is known only in enigmatic African genus *Hortipes* (see Bosselaers & Jocqué, 2000).

The two examined *Paratus* species display very similar habitus, pattern and epigyne, although their male palps and vulva differ significantly. *P. sinicus* **sp. n.** has no conductor, but the tegulum bears one outgrowth. *P. indicus* **sp. n.** has a distinct conductor but lacks any tegular outgrowth. The vulva of *P. sinicus* **sp. n.** has a unique goffered diverticula unknown in other spiders. Such significant differences indicate that these species may represent different genera. However, since the male of *P. reticulatus,* type species of the genus, is unknown, we cannot decide which of the two newly described species should be placed outside the genus.

While the Chinese and Indian species are rather different in their copulatory organs, they share several putative synapomorphies in the structure of the male palp: lack of subtegulum, a long seminal duct describing a characteristic loop near the basal part of embolus, embolus arising from the center of tegulum, without distinct articulation.

The somatic and genital apomorphies listed above indicate that *Paratus* cannot be easily placed in any known subfamily of Liocranidae or in Corinnidae. Therefore, we place it in a separate subfamily Paratinae **subfam. n.** within the Liocranidae, whose diagnosis, composition and distribution coincides with *Paratus*.

Acknowledgements

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SINOPIMOIDAE, A NEW SPIDER FAMILY FROM CHINA (ARACHNIDA, ARANEAE)

LI Shu-Qiang[1], WUNDERLICH Jörg[2]
1. *Institute of Zoology, Chinese Academy of Sciences, Beijing* 100101, *China*
2. *Oberer Häuselbergweg* 24, 69493 *Hirschberg, Germany*

Abstract The new spider family Sinopimoidae fam. nov. (Araneae, Araneoidea), with *Sinopimoa bicolor* gen. nov. *et* sp. nov., is described from a tropical rainforest in Southwest China.

Key words New taxa, rainforest, taxonomy, *Sinopimoa* gen. nov., *Sinopimoa bicolor* sp. nov.

1 Introduction

The highest number of suprageneric linyphoid taxa is known from Southeast Asia. The tropical Southwest China is the only region in which members of all three families of this araneoid branch are known to occur: Linyphiidae, Pimoidae and Sinopimoidae fam. nov.

The type material of the new taxa was collected by canopy fogging technique (Paarmann & Stork, 1987; Fig.15) within tropical wet or rainforests. The spiders of this new family may be restricted to rainforests, and may live in higher strata of the vegetation like many members of the related family Linyphiidae, in contrast to members of the family Pimoidae that usually occur on the ground, under stones and in caves.

2 Material and Methods

Specimens were examined using an Olympus-SZ11 stereomicroscope and illustrated using an Olympus-BX41 compound microscope equipped with a drawing tube. Male left pedipalpus and female epigynum were illustrated after being separated from the body. Embolic divisions were dissected from the palpal bulb using sharp pins and tweezers. Genital organs were immersed in 75% alcohol and examined under a compound microscope; embolic divisions and vulvae were mounted in Hoyer's Solution and examined in a strong transmitted light against a white background. Abbreviations used in the text and figures: A = sclerotized edge of the retromarginal pit of the cymbium, AT = apophysis of the pedipalpal tibia, E = embolus, L = labium, P = paracymbium, S = subtegulum, T = tegulum, TA = tegular apophysis, U = lumina (free sectors) within the sclerites of the bulbus.

All the types are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS) in Beijing. Type specimen photos of the species included in this paper can be viewed from website http://www.ChineseSpecies.com which was created and maintained by Li & Wang (2007).

3 Sinopimoidae fam. nov.

Etymology. See *Sinopimoa* gen. nov.

Diagnosis. ♂-pedipalpus (Figs.9-13). Tibia with a large and erect retrobasal outgrowth which is as long as the cymbium; cymbium with a retrolateral pit; paracymbium simple, pointed, only fairly bent, and fused to the cymbium; tegulum with a large and divided apophysis which reaches the pedipalpal patella. ♀. Claw of the pedipalpus absent; epigynum/vulva (Figs.4-7) strongly protruding, with a large and almost half-circled scapus. -Further characters. Dwarf spiders; see the nominate genus.

Relationships. Synapomorphies of the linyphoid branch are the cheliceral stridulatory files (Fig.8), the patella-tibia autotomy of the legs, the simple paracymbium which is fused to the cymbium, and the free labium which may be ancient characters of the superfamily Araneoidea. According to the combined existence of retrolateral cheliceral stridulatory files, a patellar-tibial kind of autotomy, and a well developed retrobasal paracymbium, Sinopimoidae fam. nov. is a member of the "linyphoid branch" of the superfamily Araneoidea and is related to Linyphiidae and Pimoidae, but it differs strongly from these families by the specialized structures of the ♂-pedipalpus, mainly of the bulbus. In the Linyphiidae the paracymbium is a free (movable) sclerite which is strongly bent and blunt. Remarks: 1) in *Linyphia mimonti* Simon, 1884 (Linyphiinae) the paracymbium is strongly reduced and fused to the cymbium; 2) in *Megalepthyphantes* Wunderlich, 1994 (Linyphiinae) a large and erect tibial apophysis of the ♂-pedipalpus evolved convergently to the Sinopimoidae fam. nov. which has also a basal position on the tibia.

In the Pimoidae, in contrast to the Sinopimoidae fam. nov., the cymbium bears cuspules, a "cymbial

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process", and a "pimoid cymbial sclerite", and the embolus bears a "pimoid embolic process". Pimoidae are larger spiders than the Sinopimoidae fam. nov., the fovea is well developed, the leg has more bristles, and the metatarsal bristles exist. The paracymbium is either fused to the cymbium (in *Pimoa* Chamberlin & Ivie, 1943) which is similar to the Sinopimoidae fam. nov. or can be a free sclerite which is attached to the cymbium by a membrane (in *Weintrauboa* Hormiga, 2003).

According to Hormiga (2003: 265) the paracymbium of *Pimoa* "may be secondarily integral", but in respect to its shape (pointed and only weakly bent) we regard the fused paracymbium of *Pimoa* and Sinopimoidae fam. nov. as a basal character of the "linyphoid branch", and the free paracymbium of *Weintrauboa* and Linyphiidae as convergently evolved apomorphic characters. The shape of the paracymbium as well as its connection to the cymbium may be hints that Pimoidae and Sinopimoidae fam. nov. are closely related and probable sister groups. Sinopimoidae fam. nov. is a remarkable mixture of plesiomorphic characters: the simple paracymbium which is fused to the cymbium, plus several other derived patterns: the existence of a free labium, the absence of a claw of the ♀-pedipalpus, the low number of leg bristles, the single pedipalpal stridulatory tooth (these patterns may be the result of dwarfism), the particular pedipalpal tibial apophysis, the retromarginal cymbial pit, and the highly specialized structures of the bulbus.

Biogeography. All the three families of the "linyphoid branch" of the superfamily Araneoidea are known from tropical and subtropical regions of Southeast Asia. Pimoidae and Sinopimoidae fam. nov. are completely absent in the Southern Hemisphere. The pattern of this distribution may indicate the origin of the "linyphoid branch" within a (sub) tropical region of Laurasia, most probably Southeast Asia.

Type genus: *Sinopimoa* gen. nov.

Etymology. "Sino" = Chinese; "pimoa" indicates to affinities of *Sinopimoa* gen. nov. to the family Pimoidae, especially to the similar paracymbium of its type genus *Pimoa* Chamberlin & Ivie 1943. The gender of the name is feminine.

Type species: *Sinopimoa bicolor* sp. nov.

Diagnosis. Bicoloured (Fig.14) and small spiders, fovea and trichobothrium of metatarsus Ⅳ absent, few leg bristles: metatarsi none, tibiae dorsally 2/2/1/1 and a lateral pair on Ⅰ, femora: only a single prolateral one on Ⅰ. Structures of the genital organs: see above, the family diagnosis.

Distribution. Southwestern China.

Sinopimoa bicolor gen. nov. _et_ sp. nov. (Figs.1-14)

Etymology. The specific name refers to the bicoloured spider (Latin: bicolor- of two colours); adjective.

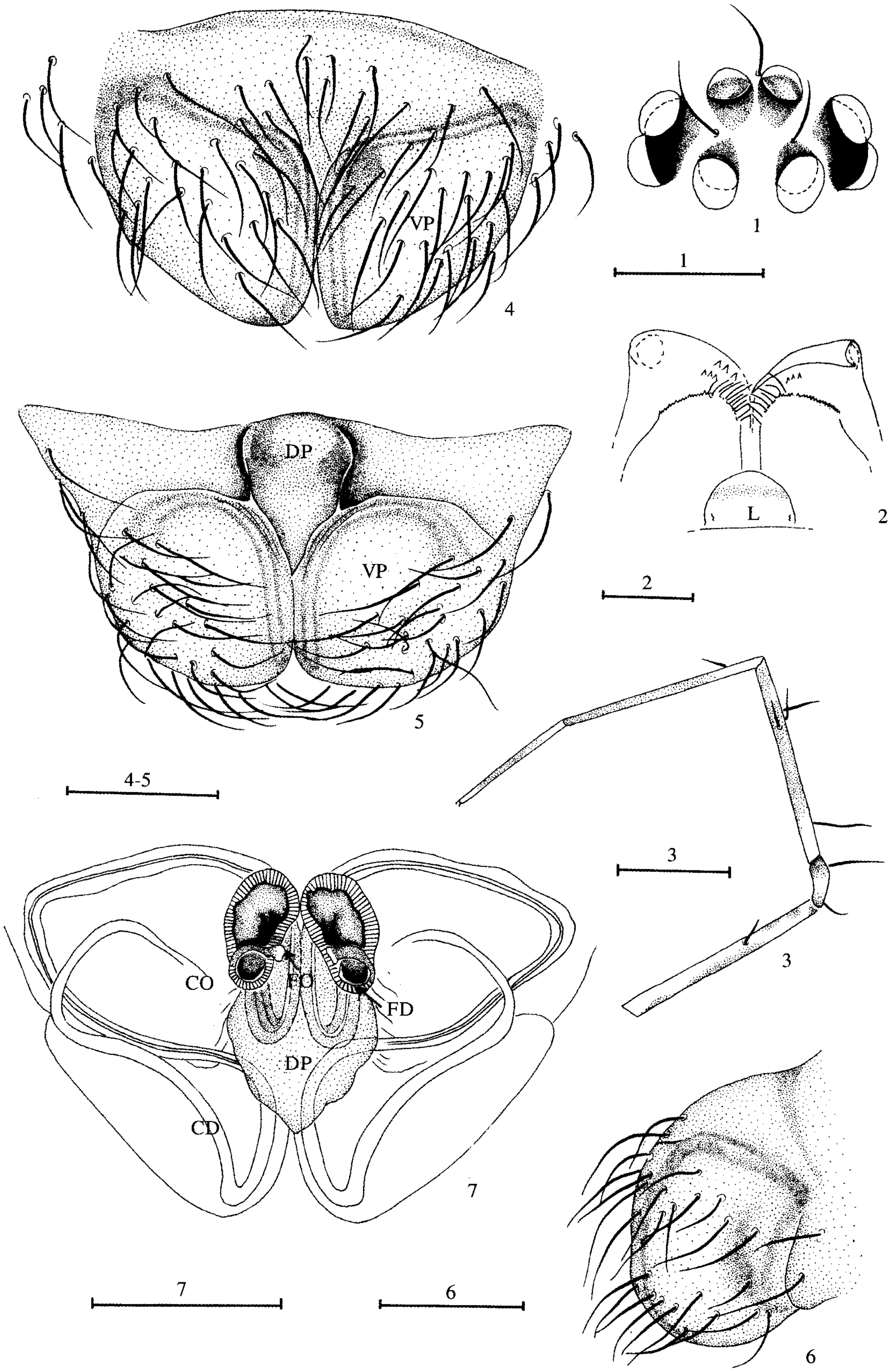
Material. Southwestern China, Yunnan Province, Menglun Nature Reserve. Holotype ♂ (21°55'N, 101°16'E), secondary tropical rainforest, alt. 598 m ± 17 m above sea-level, 22 July 2007. Paratype 1♀ (21°54'N, 101°16'E), secondary moist tropical forest, alt. 612 m ± 11 m, 10 Aug. 2007. leg. ZHENG Guo.

Diagnosis. Position of the trichobothrium on metatarsus Ⅰ-Ⅱ in 0.17-0.2, tibial apophysis of the ♂-pedipalpus flattened and widened distally (Fig.9), epigynum/vulva as in Figs.4-7.

Description. Measurements (in mm). Body length ♂ 1.2, ♀ 1.3, prosomal length ♂ 0.47, ♀ 0.5, prosomal width ♂ ♀ 0.43; legs: Ⅰ (♂/♀): femur 0.72/0.82, patella 0.15/0.18, tibia 0.66/0.8, metatarsus 0.70/0.84, tarsus 0.50/0.56, tibia Ⅱ 0.57/0.47 (the left ♀-tibia Ⅱ is lost), tibia Ⅲ 0.28/0.34, tibia Ⅳ 0.38/0.48, length of the basal tibial bristle Ⅰ 0.17-0.2, width of the eye field 0.25, length of the tibial apophysis of the ♂-pedipalpus 0.2.

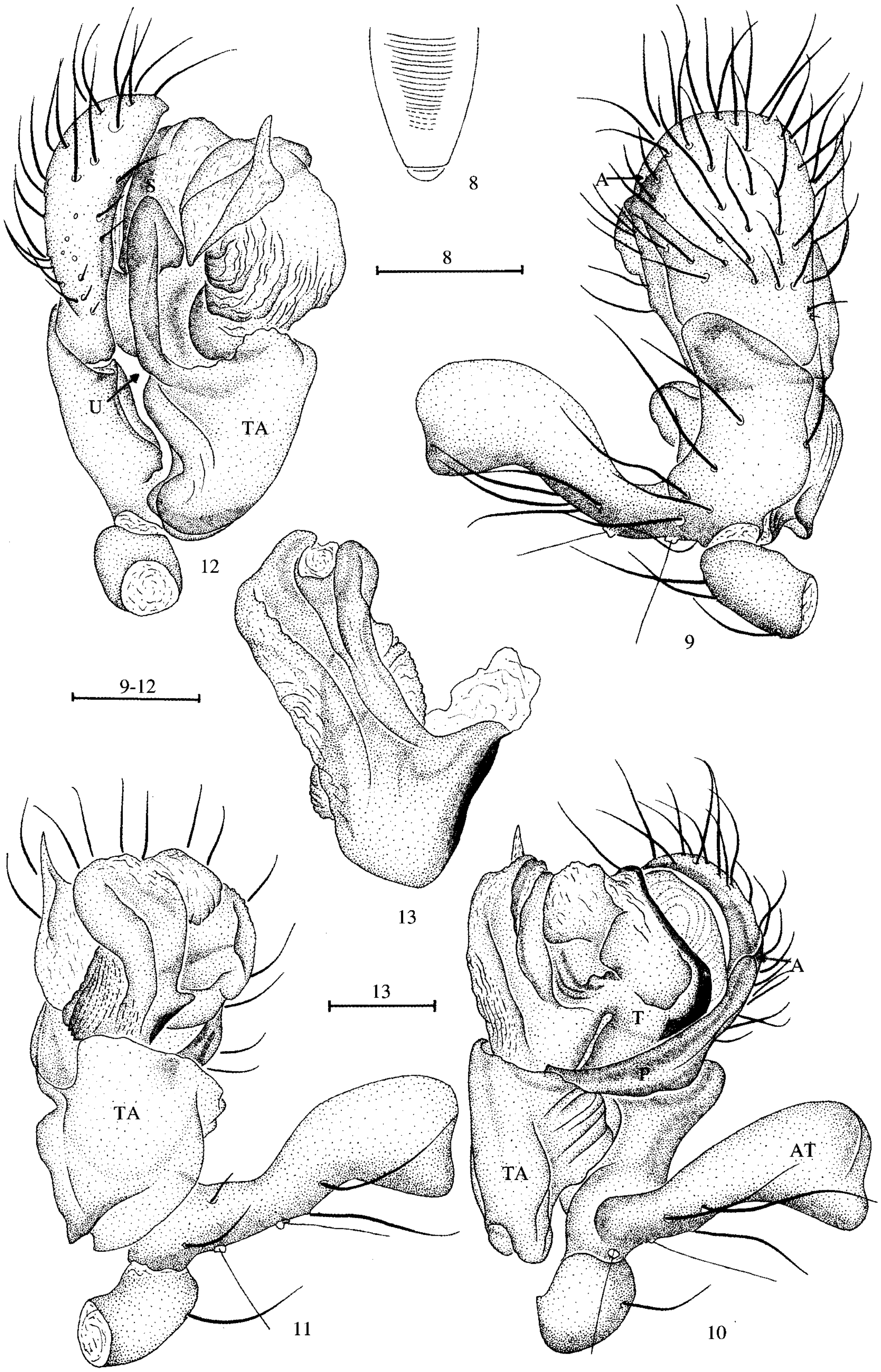
Colour (Fig.14) basicly light yellow, prosoma with a pair of wide longitudinal dark brown bands, eye field darkened, sternum medially with a narrow longitudinal stripe, legs partly distinctly darkened, e. g. tibia Ⅰ dark brown except basally, opisthosoma dorsally and laterally darkened like a net-web, ventrally yellow.

Prosoma (Figs.1-2, 8, 14) distinctly longer than wide, hairs short, fovea/thoracal ridge absent; eyes large, field almost as wide as the prosoma, posterior row straight, posterior median eyes separated by their diameter, lateral eyes contiguous, clypeus 1 1/2 times longer than the diameter of the anterior median eyes, basal cheliceral articles fairly large, the anterior margin of the cheliceral furrow bears 3 teeth (rarely 2), the posterior margin bears 3 tiny teeth, fangs slender. Numerous retrolateral stridulatory files exist in both sexes. Labium free, wider than long and rebordered, gnathocoxae in an almost parallel position, sternum as wide as tong, coxae Ⅳ separated by their diameter. ♀-pedipalpus with long bristles, femur with a single probasal stridulatory tooth, tarsal claw absent. -Legs (Fig.3) long and slender, order Ⅰ/Ⅱ/Ⅳ/Ⅲ, articles longer in the female except tibia Ⅱ, autotomy between patella and tibia (the left leg Ⅱ of the female is broken off in this position and lost), bristles are absent on tarsi and metatarsi, femora: only a single prolateral long bristle in the distal half on Ⅰ, sequence of the long dorsal tibial bristles 2/2/1/1, tibia Ⅰ bears an additional pair of long lateral bristles in the distal half. Trichobothria exist on metatarsi Ⅰ-Ⅲ, their position on Ⅰ-Ⅱ is in 0.17-0.20; the tarsi bear 3 small claws. -Opisthosoma 1.35 (♀) to 1.45 (♂) times longer than wide, oval, covered with short hairs, narrow posteriorly; tracheal spiracle small, its position near the spinnerets, the colulus bears 5 hairs in the female, the



Figs.1-7. *Sinopimoa bicolor* gen. nov. *et* sp. nov., female. 1. Eyes, dorsal view. 2. Mouth parts, ventral view, with the right fang removed to show the marginal teeth of the cheliceral furrow. 3. Right leg Ⅰ, prolateral view. 4-6. Ventral, lateral and posterior aspect of the epigynum. 7, Dorsal aspect of the vulva. Scale bars: 1, 2, 4-7 = 0.1 mm, 3 = 0.5 mm.

spinnerets are short. -♂ -pedipalpus (Figs.9-13): Femur slender, bearing a probasal stridulatory tooth, patella slightly longer than wide, bearing a long dorsal-distal bristle, tibia large, bearing a dorsal trichobothrium in a



Figs. 8-13. *Sinopimoa bicolor* gen. nov. *et* sp. nov., male. 8. Retrolateral aspect of the distal part of the left chelicera with stridulatory files. 9-12. Dorsal, retrolateral, ventral and prolateral aspect of the left pedipalpus. 13. Ventral aspect of the bulbus. Scale bars: 8-12 = 0.1 mm, 13 = 0.05 mm.

more basal position, and with a long erect retrobasal blunt and flattened apophysis which is widened distally, cymbium distally with a retromarginal pit which has a sclerotized margin, alveolus large, in a distal position

Fig. 14. *Sinopimoa bicolor* gen. nov. *et* sp. nov., ♂, habitus, dorsal view (Photo by LIN Yu-Cheng and LIU Jie). Fig. 15. Types were collected in Xishuangbanna Rainforest of Yunnan Province with canopy fogging technique (Photo by ZHENG Guo).

(Fig. 9). Strongly sclerotized structures of the bulbus are absent; the tegulum bears a large two-partite apophysis which extends up to the pedipalpal patella; embolus in an almost apical position, difficult to recognize. In the expanded bulbus the slender part of the tegular apophysis may fit as an "arresting apophysis" into the retromarginal pit of the cymbium. -Epigynum (Figs.4-6) large and distinctly protruding, not sclerotized, with a long and slender scapus which tip is hidden. Vulva Fig.7.

Relationships, distribution and ecology. See above.

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华模蛛科——采自中国的蜘蛛目一新科（蛛形纲，蜘蛛目）

李枢强[1] WUNDERLICH Jörg[2]

1. 中国科学院动物研究所 北京 100101
2. Oberer Haeuselbergweg 24, 69493 Hirschberg, Germany

摘 要 记述了采自我国云南西双版纳雨林的1新科，华模蛛科 Sinopimoidae fam. nov.，1新属，华模蛛属 *Sinopimoa* gen. nov.，1新种，双色华模蛛 *Sinopimoa bicolor* sp. nov.。模式标本保存在中国科学院动物研究所。

关键词 新阶元，雨林，分类，华模蛛属，双色华模蛛.

中图分类号 Q969.26

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A NEW SPECIES OF THE FAMILY TELEMIDAE (ARACHNIDA, ARANEAE) FROM XISHUANGBANNA RAINFOREST, CHINA

LIN Yu-Cheng, LI Shu-Qiang*
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, *China*

Abstract A new species, *Seychellia xinpingi* sp. nov., collected from rainforest of Xishuangbanna National Natural Reserve, Yunnan, China, is described and illustrated. Type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing. (IZCAS)

Key words Taxonomy, telemid, new species, rainforest, Yunnan.

1 Introduction

Telemids are minute (usually < 2 mm), three-clawed, ecribellate and haplogyne spiders (Tong & Li, 2008). The family is similar to Ochyroceratidae and Leptonetidae but can be distinguished by the presence of a transversely sclerotized zigzag ridge that arising anterodorsally on the pedicel. Although a small family with 7 genera and 26 species (Platnick, 2008), Telemidae are widely distributed from tropical Africa, Europe, East Asia, Southeast Asia to North and Central America (Brignoli, 1977). They are usually found under rocks bed, in leaf little, and especially abundant in caves (Song *et al.*, 1999).

In the current paper, a new *Seychellia* species is reported based on materials collected from Xishuangbanna rainforest, Yunnan, China.

2 Materials and Methods

The specimens used in this study are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS), Beijing, China. All specimens were examined and measured using an SZX12-Olympus stereomicroscope. Further details are studied under an Olympus BX51 compound microscope. All illustrations have been made using a drawing instrument attached to Olympus BX51 compound microscope, and then inked on ink jet plotter paper. The genitalia were examined and illustrated after they were dissected from the spiders' bodies. Vulvae of female were removed and treated in lactic acid before illustration. Left palpi of male spiders were illustrated. Type specimens were reserved in 80% ethanol solution. All measurements are made under an Olympus BX51 compound microscope and given in millimeters. Only holotype and a paratype are used in measurements. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus).

3 Taxonomy

***Seychellia xinpingi* sp. nov.** (Figs. 1-9)

Type material. Male holotype from primary tropical seasonal rainforest (21° 57′ N, 101° 11′ E), Menglun Town, Mengla County, Xishuangbanna National Natural Reserve, Yunnan Province, China, May-July 2005, collected by ZHENG Guo. Paratypes: 41 males and 86 females, same data as holotype; paratypes: 19 males and 26 females, secondary tropical seasonal moist forest (21°54′N, 101°16′E), Menglun Nature Reserve, Mengla County, Xishuangbanna, Yunnan, China, same date and collector as in holotype.

Etymology. The new species is named in honor of Dr WANG Xin-Ping (University of Florida, USA) for his work on Chinese spiders; noun in genitive case.

Diagnosis. The new species is similar to *Seychellia wiljoi* Saaristo, 1978, but can be distinguished by the more "complex" copulatory organ in male palp (with a crescent sclerotized conductor on the frontal surface of the bulb and a non-forked, horny embolus), the presence of an erect, club-shape spermatheca that arising from a long, sclerotized basal plate, the presence of darkish, modified pattern on the carapace.

Description. Male (holotype). Total length 1.14. Carapace 0.46 long, 0.42 wide. Clypeus 0.12 high. Sternum 0.26 long, 0.28 wide. Abdomen 0.54 long, 0.46 wide, 0.70 high. Carapace pale brown-yellow, pear-shaped, with modified net-shaped pattern, lateral margin brownish, with a central large nut-brown area mixed with blurry radial striae. A pair of small spots behind ocular area. Six eyes with black base. Chelicerae yellow brown, fang furrow with six promarginal teeth and five triangular retromarginal denticles (Fig. 5); eleven plumose hairs along cheliceral promargin. Endites, labium and sternum nigger-brown. Legs yellow. Each distal patella and middle tibia of legs bears a dorsal spine.

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* Corresponding author, E-mail: lisq@ioz.ac.cn

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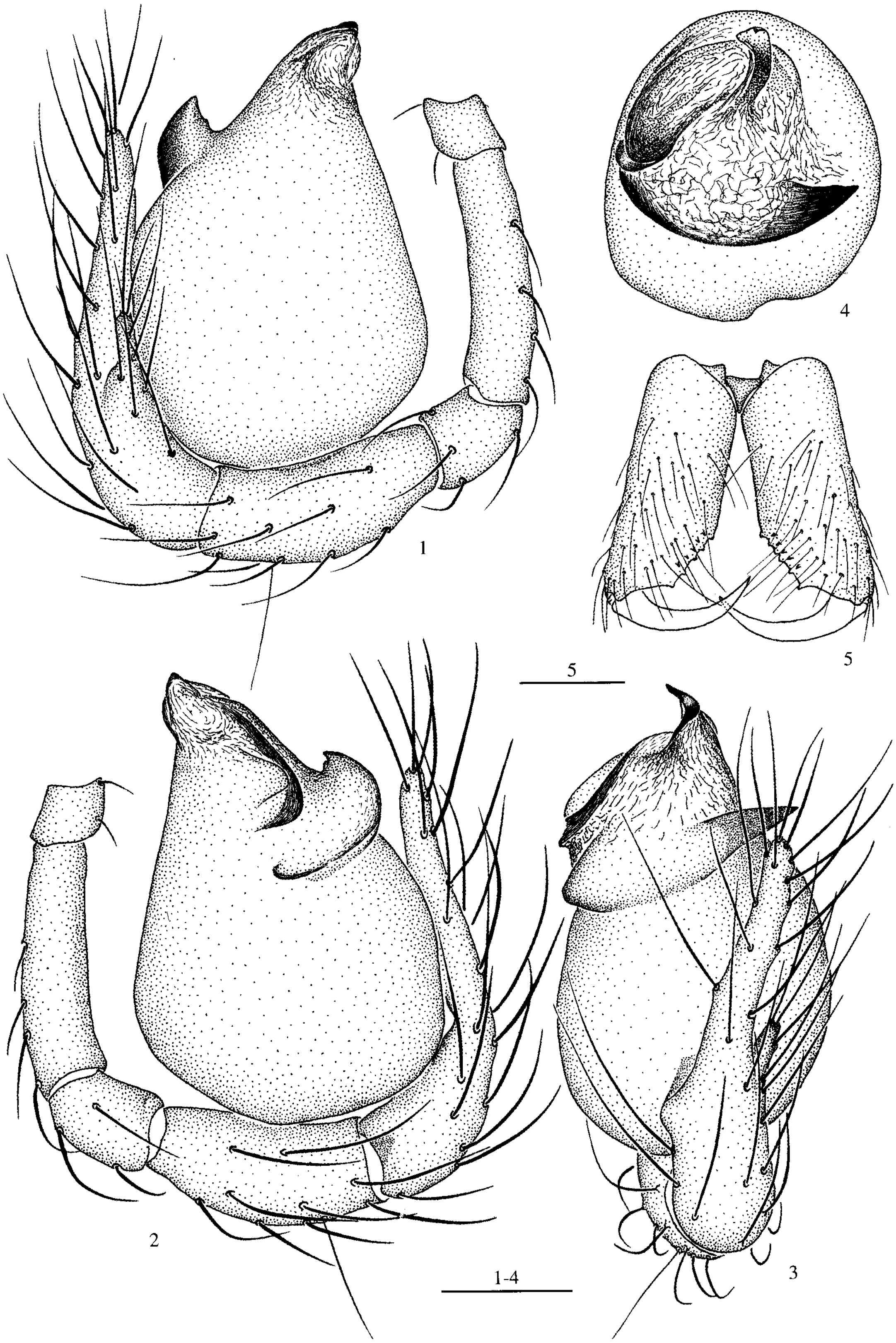
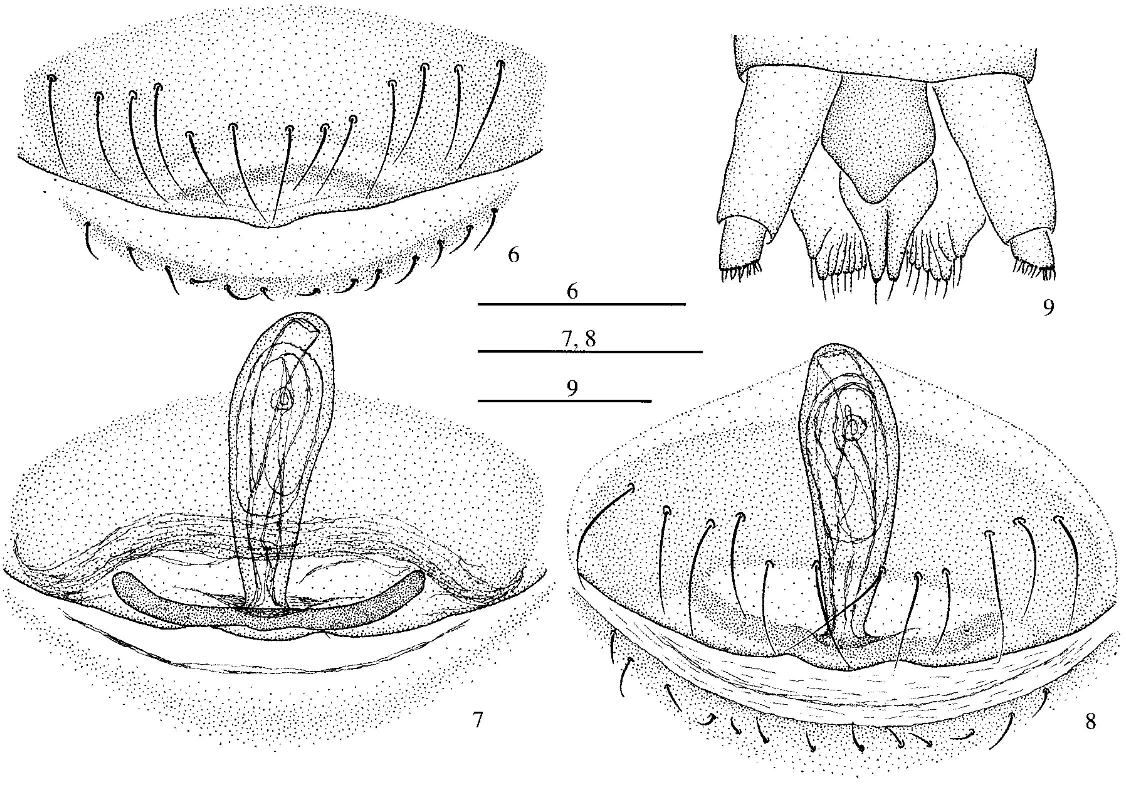


Figs. 1-5. *Seychellia xinpingi* sp. nov., holotype male. 1. Left palp, prolateral view. 2. Same, retrolateral view. 3. Same, anterior view. 4. Palpal bulb, apical view. 5. Chelicerae, posterior view. Scale bars = 0.1 mm.

Leg measurements: Ⅰ 2.40 (0.70, 0.16, 0.68, 0.48, 0.38); Ⅱ 2.16 (0.64, 0.14, 0.60, 0.44, 0.34); Ⅲ 1.67 (0.56, 0.11, 0.40, 0.34, 0.26); Ⅳ 2.07 (0.60, 0.13, 0.58, 0.46, 0.30). Leg formula: Ⅰ-Ⅱ-Ⅳ-Ⅲ. Dorsal abdomen blue, egg-shaped, with darkish pigmentation, ventral abdomen pale color at median area.

Palp relatively large (Figs.1-4); femur 2.2 times patellar length; tibia about 2 times patellar length, with a dorsal trichobothrium near one third of its distal end; tarsus with proximal swollen, narrow distal end, and a prolateral cymbial apophysis. Palpal bulb coniform. Conductor horn-shaped, sclerotized, attaches with anterior surface of bulb. Embolic apophysis tiny, horn-shaped, vertical with conductor, basally crinkled and distally curved.

Female (paratype). Total length 1.16. Carapace 0.48 long, 0.44 wide. Clypeus 0.12 high. Sternum 0.29 long, 0.28 wide. Abdomen 0.64 long, 0.60 wide, Abdomen 0.74 high. Same coloration and ornaments as in male. Leg measurements: Ⅰ 2.55 (0.74, 0.15, 0.73, 0.52, 0.41); Ⅱ 2.34 (0.70, 0.14, 0.66, 0.48, 0.36); Ⅲ 1.68 (0.50, 0.12, 0.44, 0.34, 0.28); Ⅳ 2.25 (0.68, 0.14, 0.62, 0.45, 0.36). Leg formula: Ⅰ-Ⅱ-Ⅳ-Ⅲ. Colulus elongate pentagon, blackish; spinnerets pale yellow (Fig.9).



Figs.6-9. *Seychellia xinpingi* sp. nov., paratype female. 6. Epigynial area, ventral view. 7. Cleared epigynum and spermatheca, dorsal view. 8. Same, ventral view. 9. Colulus and spinnerets, ventral view. Scale bars = 0.1 mm.

Genital area weakly sclerotized (Figs.6-8), a row of long hairs on epigynial shield, another row of short hairs arising below epigastric furrow. Two recurved small notches near lip at epigynial shield posteromargin. Spermatheca club-shaped, translucent, distally swollen and proximally narrowed, with base situated on a bar-shaped, strongly sclerotized basal plate.

Distribution. Known only from the type locality.

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西双版纳热带雨林泰莱蛛科一新种记述（蛛形纲，蜘蛛目）

林玉成　李枢强[*]
中国科学院动物研究所　北京　100101

摘　要　描述了采自云南西双版纳热带雨林的塞莱蛛属 1 新种：新平塞莱蛛 *Seychellia xinpingi* sp. nov.。模式标本保存在中国科学院动物研究所。

新平塞莱蛛，新种 *Seychellia xinpingi* sp. nov.（图 1～9）

正模♂，副模：60♂♂，112♀♀，云南省西双版纳国家自然保护区勐仑保护区原生热带季雨林，2005-05-07，郑国采集。

新种与威约塞莱蛛 *Seychellia wiljoi* Saaristo，1978 相近，但有以下区别：螯肢具 6 前齿 5 后齿；插入器短且呈弯角状，末梢不分叉；引导器呈月牙状，角质化明显，远端三角状游离，中部横向贴生于触肢球前表面；纳精囊棒状直立，基于一条形角质基板上；头胸甲具 1 棕色斑，放射沟可见，网格修饰。

关键词　分类学，泰莱蛛，新种，雨林，云南.
中图分类号　Q959.226

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[*] 通讯作者.

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动物分类学报

DESCRIPTION ON A NEW *PHILOPONELLA* SPECIES (ARANEAE, ULOBORIDAE), THE FIRST RECORD OF SOCIAL SPIDERS FROM CHINA

LIN Yu-Cheng[1,2], LI Shu-Qiang[1]*
1. *Institute of Zoology, Chinese Academy of Sciences, Beijing* 100101, *China*
2. *Graduate University of Chinese Academy of Science, Beijing* 100039, *China*

Abstract A new species of the family Uloboridae, *Philoponella alata* sp. nov., from Xishuangbanna tropical rainforest of Yunnan Province is described and illustrated. Type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

Key words *Philoponella*, morphology, social spiders, new species, China.

1 Introduction

Most spiders are solitary creatures, and social behavior is only known in a few dozen species (Buskerk, 1981; D' Andrea, 1987). Four categories of social behavior have been described for spiders: non-territorial permanent-social, territorial permanent-social, non-territorial periodic-social and territorial periodic-social (Avilés, 1997).

Several *Philoponella* species are well known territorial permanent-social spiders (Avilés, 1997; Masumoto, 1998). A total of seven *Philoponella* species are reported from China (Platnick, 2007): *P. cymbiformis* Xie *et al.*, 1997, *P. lingulata* Dong, Zhu & Yoshida, 2005, *P. nasuta* (Thorell, 1895), *P. nigromaculata* Yoshida, 1992, *P. pisiformis* Dong, Zhu & Yoshida, 2005, *P. prominens* (Bösenberg & Strand, 1906) and *P. wuyiensis* Xie *et al.*, 1997. However, none of them are reported to have social behavior. In the current paper, a new *Philoponella* spider is reported from the Xishuangbanna rainforest of Yunnan Province in southwestern China and its social behavior is characterized. This rainforest is one of the richest regions in biodiversity in China and was named biodiversity conservation centre in the world.

2 Material and Methods

Specimens were examined using an SZX12-Olympus stereomicroscope and illustrated using an Olympus-BX51 compound microscope equipped with a drawing tube. After being separated from the body, male palps and female epigyna were illustrated. Embolic divisions were dissected from the male palpal bulb using sharp pins and forceps. Vulvae of female were cleared in lactic acid.

Measurements are given in millimeters. Leg measurements are shown as: total length (femur, patella, tibia, metatarsus, tarsus). Terms used in the text and figure legends follow mainly Opell (1979) and partly Yoshida (1992). Abbreviations used in text and figures are: ALE-anterior lateral eye; AME-anterior median eye; C-conductor; E-embolus; FD-fertilization duct; MAB-median apophysis bulb; MAS-median apophysis spur; PLE-posterior lateral eye; PME-posterior median eye; S-spermatheca.

All type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS). Photos of the type specimens of the species included in this paper can be viewed from website http: //www. ChineseSpecies. com which was created and maintained by LI Shu-Qiang and WANG Xin-Ping (Li & Wang, 2007).

3 Taxonomy

Philoponella Mello-Leitão, 1917

Philoponella alata sp. nov. (Figs.1-9)

Type material. Male holotype from Xishuangbanna tropical rainforest (21.5° N, 101.2° E; alt. 569 m), Yunnan Province, China, 24 Dec. 2006, collected by LI Shu-Qiang. Paratypes: 32 males and 2 females, same collection data.

Other material studied. 140 larvae, same collection data.

Etymology. Specific epithet of *P. alata* sp. nov. derived from the Latin *alataus* (wing), referring to the wing-shaped basal lobe of conductor of male palp; adjective.

Diagnosis. *P. alata* sp. nov. is similar to *P. vittata* (Keyserling, 1881) but can be distinguished by having a wing-shaped conductor basal lobe in male and by the different shapes of crypt opening and fertilization duct in female.

Description. Male (holotype). Total length 4.25. Carapace 1.65 long, 1.40 wide. Sternum 0.95 long,

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* Corresponding author, E-mail: lisq@ioz.ac.cn

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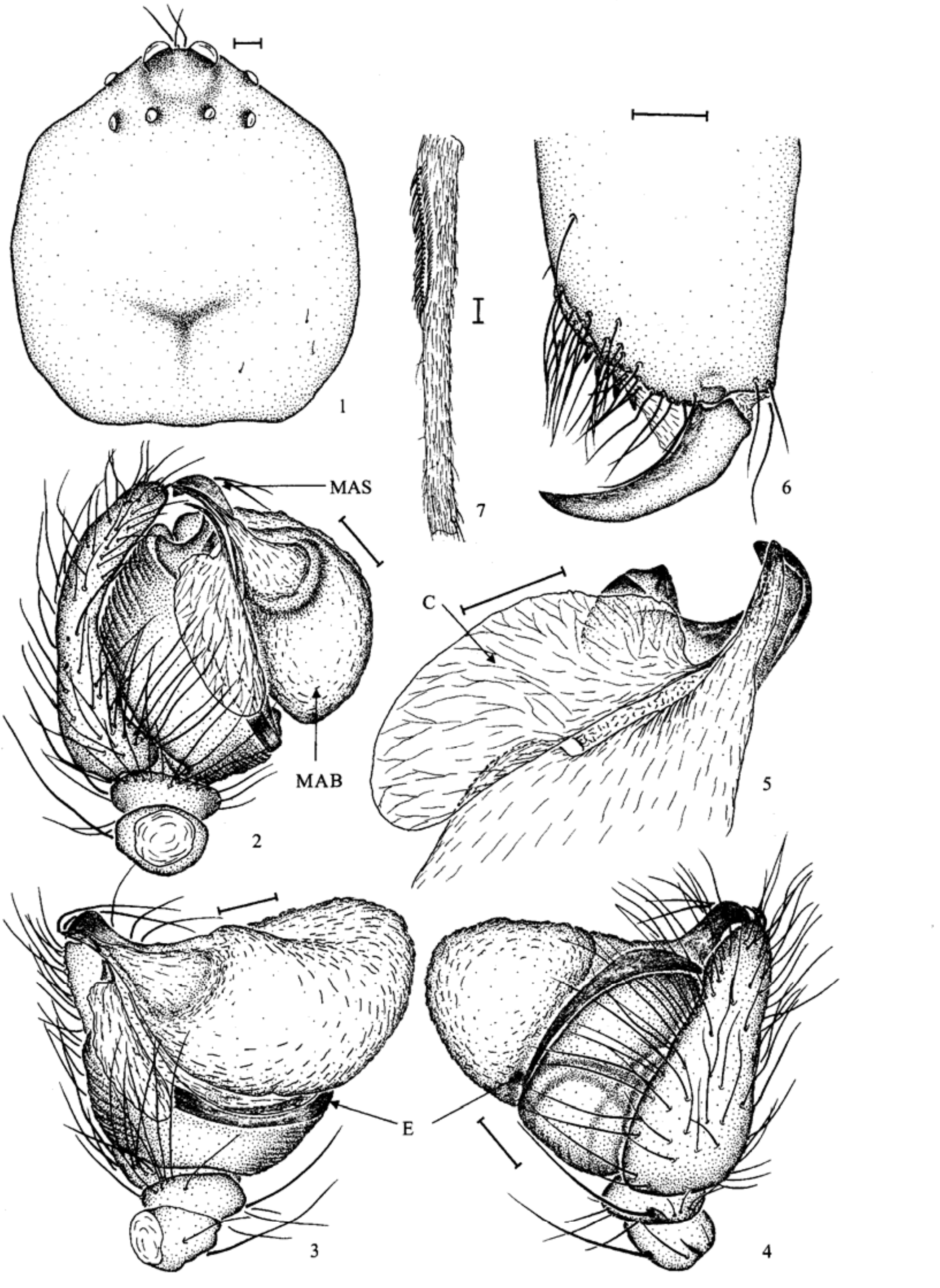
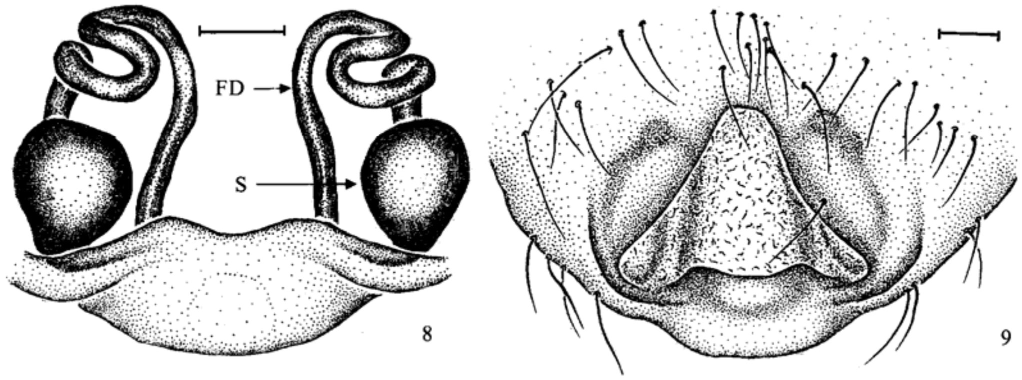
0.70 wide. Abdomen 2.75 long, 1.15 wide. Leg Ⅰ longest; leg formula: Ⅰ, Ⅳ, Ⅱ, Ⅲ. Leg measurements: Ⅰ: 8.90 (2.45 + 0.70 + 1.75 + 2.85 + 1.15); Ⅱ: 4.80 (1.40 + 0.45 + 0.90 + 1.30 + 0.75);



Figs.1-7. *Philoponella alata* sp. nov. 1. Male carapace, dorsal view. 2. Left male palp, prolateral view. 3. Same, ventral view. 4. Same, retrolateral view. 5. Male embolic division. 6. Male left chelicera, frontal view. 7. Female metatarsus Ⅳ. Scale bars = 0.1 mm.



Figs.8-9. *Philoponella alata* sp. nov., female paratype. 8. Vulva, dorsal view. 9. Epigynum, ventral view. Scale bar = 0.1 mm.

Ⅲ: 3.80 (1.20 + 0.35 + 0.65 + 1.00 + 0.60); Ⅳ: 6.20 (1.65 + 0.55 + 1.40 + 1.60 + 1.00).

Carapace circular, with a transverse thoracic groove and a somewhat projecting region of AMEs. AME largest, separated from each other by 3/4 its diameter, from ALE by 1.2 times its diameter. Other eyes are approximately same size and widely separated by at least twice their diameter, with PME slightly smaller than PLE. Median ocular area foursquare (Fig.1). Chlicerae longer than width, with 7 promarginal and 4 retromarginal teeth (Fig.6). Femur Ⅰ with one prolateral seta. Tibia Ⅰ with 3 dorsal, 4 prolateral and 4 retrolateral setae. Metatarsus Ⅰ with 14 dorsal and 4 retrolateral spines. Except for one dorsal seta, femur Ⅱ has 15 retrolateral trichobothria in a row. Tibia Ⅱ with 2 dorsal spines. Metatarsus Ⅱ with 2 prolateral and 3 retrolateral setae. Femur Ⅲ with 13 prolateral trichobothria in a row, one prolateral and one dorsal spine. Tibia Ⅲ with 2 dorsal spines. Metatarsus Ⅲ with 2 prolateral and 2 retrolateral spines. Femur Ⅳ bears 18 prolateral trichobothria, one prolateral and one dorsal spine. Tibia Ⅳ with 2 dorsal, 3 prolateral, one retrolateral and one ventral spines. Metatarsus Ⅳ with 4 prolateral, one retrolateral and 5 ventral spines. Palp orange, with basal lobe of conductor wing-shaped, similar to a dragonfly wing; its spike no longer than the apical part of MAS; MAS strongly bent as a rostriform tuber (Fig.5).

Carapace pale bisque with grey hairs on the rim, without any color pattern. Chelicerae, maxillae and labium light yellow. Sternum pyriform, pale red. Legs gray yellow. Abdomen reddish yellow, with dusky modified spot at lateral stern.

Female. Total length 5.90. Carapace 1.90 long, 1.60 wide. Sternum 1.10 long, 0.70 wide. Abdomen 4.15 long, 1.50 wide. Female calamistra composed of 29 setae (Fig.7). Leg Ⅰ longest; leg formula: Ⅰ, Ⅳ, Ⅱ, Ⅲ. Leg measurements: Ⅰ: 10.85 (2.95 + 0.85 + 1.90 + 3.75 + 1.40); Ⅱ: 6.20 (1.80 + 0.55 + 1.05 + 1.85 + 0.95); Ⅲ: 4.85 (1.50 + 0.45 + 0.80 + 1.30 + 0.80); Ⅳ: 8.90 (2.65 + 0.75 + 1.95 + 2.20 + 1.35).

Carapace pyriform, with a trapeziform thoracic groove. Diameters of AME larger than the others. Region of AMEs appreciably projecting. Clypeus about equal to diameter of AME. PLEs diameters wider than that of ALE and PME. Chlicerae with 7 promarginal and 5 retromarginal teeth. Femur Ⅰ with one dorsal spine. As male, tibia Ⅰ with three dorsal, four prolateral and four retrolateral setae. Metatarsus Ⅰ with 9 prolateral and 9 retrolateral spines. Except for one dorsal and one prolateral setae, femur Ⅱ, has 19 retrolateral trichobothria in a row. Tibia Ⅱ with 2 dorsal, one prolateral and one retrolateral spines. Metatarsus Ⅱ with 3 dorsal, one retrolateral and one ventral setae. Femur Ⅲ with 17 prolateral trichobothria in a row and one dorsal spine. Tibia Ⅲ with 2 dorsal spines. Metatarsus Ⅲ with 2 prolateral and one ventral spines. Femur Ⅳ bears 21 prolateral trichobothria, one prolateral spine. Tibia Ⅳ with 2 dorsal, 2 prolateral and 2 retrolateral spines. Metatarsus Ⅳ with 3 prolateral and 9 ventral spines. Tarsus Ⅳ bears 29 ventral spines. Epigynum as shown in Figs.8-9: in ventral view, the dusky epigynum looks like a triangular pocket with its opening amazedly. The depth of ventrally epigynal crypt about equals to the size of crypt opening. In dorsal view, each long straight fertilization duct loops thrice before linking up an inverted pyriform spermatheca located at the anterior of the epigynum.

Carapace light yellow, with some grey hairs on the rim. Chelicerae, maxillae and labium reddish yellow. Sternum upended enneagon, yellow; sternum setae needle-like, long, black and thick. Legs grey black. Abdomen pale yellow, with three white pigments belts at backside. In the ventral, coloration becomes dusky grey.

Variation. The total body length ranges from 4.16 to 4.32 in males ($n = 32$) and from 5.82 to 5.90 in females ($n = 2$). The carapace ranges in length from 1.62 to 1.68 in males ($n = 32$) and from 1.88 to 1.90 in females ($n = 2$); in width from 1.38 to 1.43 in males ($n = 32$) and from 1.58 to 1.60 in females ($n = 2$).

Distribution. Only known from the type locality.

Natural history. *P. alata* sp. nov. is a common species in Xishuangbanna tropical rainforest, Yunnan Province, China. It can be found in moist shrubbery on the forest floor. According to the criteria of Avilés (1997), *P. alata* sp. nov. belongs to territorial permanent-social spider. Juveniles first appear in June. Spiderlings persist until early February. Like other *Philoponella* species, several orb-webs were built close together within the same dense tangle of attachment lines. All of the specimens described in this study were collected in a single web cluster.

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中国妩蛛科一种社会性蜘蛛初报及新种记述（蜘蛛目，妩蛛科）

林玉成[1,2]　李枢强[1*]
1. 中国科学院动物研究所　北京　100101
2. 中国科学院研究生院　北京　100049

摘　要　报道并描述了一种隶属于蛛形纲蜘蛛目妩蛛科的社会性蜘蛛：翼状喜妩蛛 *Philoponella alata* sp. nov.。模式标本保存于中国科学院动物研究所。本种是中国第 1 次报道的社会性蜘蛛。

翼状喜妩蛛，新种 *Philoponella alata* sp. nov. (图 1～9)

正模♂，副模2♀♀，32♂♂，云南省西双版纳州勐腊县勐仑镇中国科学院西双版纳热带植物园，2006 年 12 月 24 日，李枢强采集。

新种与产自南美洲的条纹喜妩蛛 *P. vittata* (Keyserling, 1881) 相近，两者的主要区别：前者触肢引导器基片呈一完整的翼状，后者窄长；前者外雌器生殖孔为一近似等边三角形，后者圆形；前者受精管有 3 个弯结，然后变端直，后者则明显不同。

关键词　喜妩蛛属，分类学，社会性蜘蛛，新种，中国.
中图分类号　Q959.226

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* 通讯作者.

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IWOGUMOA XIEAE SP. NOV., ONE NEW CAVE-DWELLING SPECIES (ARANEAE, AMAUROBIIDAE) FROM HUNAN PROVINCE, CHINA

LIU Jie, LI Shu-Qiang*
Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, *China*

Abstract One new cave-dwelling *Iwogumoa* species from Hunan Province is reported: *Iwogumoa xieae* sp. nov. This new species differs from all other *Iwogumoa* by the absence of epigynal teeth and median apophysis, the presence of conductor dorsal apophysis, and the broad lateral tibial apophysis. The type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS).

Key words Coelotinae, cave, new species, Hunan, China.

The genus *Iwogumoa* Kishida, 1955 was retrieved as a senior synonym of *Asiacoelotes* Wang, 2002 by Nishikawa & Ono (2004). A total of 16 *Iwogumoa* species are known from Russian Far East, Japan, Korea, Thailand and China, among which 6 are recorded from Chinese fauna (Platnick, 2008). In the current paper, a new cave-dwelling *Iwogumoa* species is reported based on materials collected from Hunan Province of China. The presence of large conductor lamella, elongated cymbial furrow, slender embolus in male and strongly convoluted and closely situated spermathecae in female suggests that this new species may be a member of the genus *Iwogumoa* Kishida, 1955, but the absence of epigynal teeth and median apophysis, the broad lateral tibial apophysis, and the presence of conductor dorsal apophysis suggest that this placement may be incorrect. However, there is not an appropriate genus to accommodate this new species at present, here it is tentatively placed in this genus.

Specimens were examined with an Olympus SZ11 stereomicroscope; details were studied with an Olympus BX41 compound microscope. All illustrations were made using an Olympus drawing tube. Male palps and female epigyna were examined and illustrated after being dissected from the spider bodies. All measurements were obtained using an Olympus SZ11 stereomicroscope and are given in millimeters. All the scale lines are 0.2 mm long except where indicated otherwise. Eye diameters are taken at the widest point. The total body length does not include the length of the chelicerae or spinnerets. Leg measurements are given as: total length (femur, patella + tibia, metatarsus, tarsus). The terminology used in text and figure legends follows Wang (2002).

Abbreviations used in text and legends: ALE = anterior lateral eye; AME = anterior median eye; AME-ALE = distance between AME and ALE; AME-AME = distance between AME and AME; ALE-PLE = distance between ALE and PLE; C = conductor; CF = cymbial furrow; E = embolus; EB = embolic base; FD = fertilization duct; LTA = lateral tibial apophysis; PA = patellar apophysis; PLE = posterior lateral eye; PME = posterior median eye; PME-PLE = distance between PME and PLE; PME-PME = distance between PME and PME; RTA = retrolateral tibial apophysis; S = spermatheca; ST = subtegulum; T = tegulum; TS = tegulum sclerite.

All types are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS). Type specimen photos of the species included in this paper will be viewed from website http: //www. ChineseSpecies. com which was created and maintained by LI Shu-Qiang & WANG Xin-Ping (Li & Wang, 2008).

***Iwogumoa xieae* sp. nov.** (Figs. 1-6)

Type material. Holotype male, China, Hunan Province, Lengshuijiang City, Zhonglian Town, Boyue Cave (27°42′N, 111°27′E), 2 Dec. 2007, leg. LI Shu-Qiang, LIN Yu-Cheng and LIU Jie. Paratypes: 3 males and 7 females, data as holotype; 2 males and 12 females, China, Hunan Province, Lengshuijiang City, Zhadu Town, Zhadu Village, Jiumen Cave (27°44′N, 111°33′E), 1 Dec. 2007, leg. LI Shu-Qiang, LIN Yu-Cheng and LIU Jie; 12 males and 22 females, China, Hunan Province, Lengshuijiang City, Panqiao Town, Xianqi Cave (27°38′N, 111°24′E), 1 Dec. 2007, leg. LI Shu-Qiang, LIN Yu-Cheng and LIU Jie; 2 females, China, Hunan Province, Xinhua County, Youxi Town, Meishanlong Cave (27°56′N, 111°16′E), 30 Oct. 2007, leg. LI Shu-Qiang, LIN Yu-Cheng and LIU Jie.

Etymology. The specific name is dedicated to Miss XIE Li-Yan for her kind help on our cave collection in Hunan Province; noun (name) in apposition.

Diagnosis. Male of *I. xieae* sp. nov. can be easily

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* Corresponding author, E-mail: lisq@ioz.ac.cn

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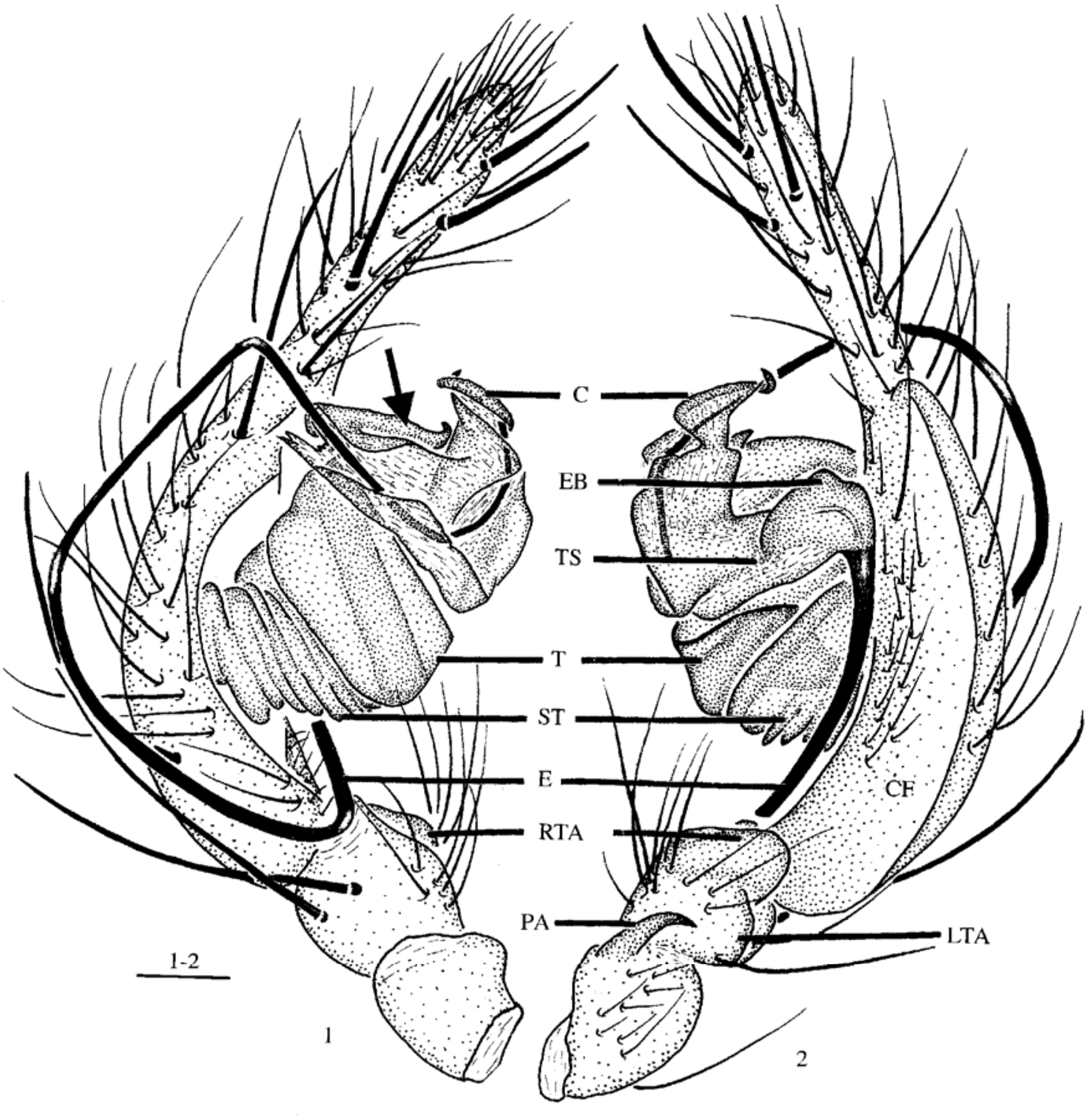
distinguished from other *Iwogumoa* species by the broad lateral tibial apophysis, the retrolaterally originating embolus, the absence of median apophysis and the presence of conductor dorsal apophysis. Female can be distinguished from other *Iwogumoa* species by the absence of epigynal teeth.

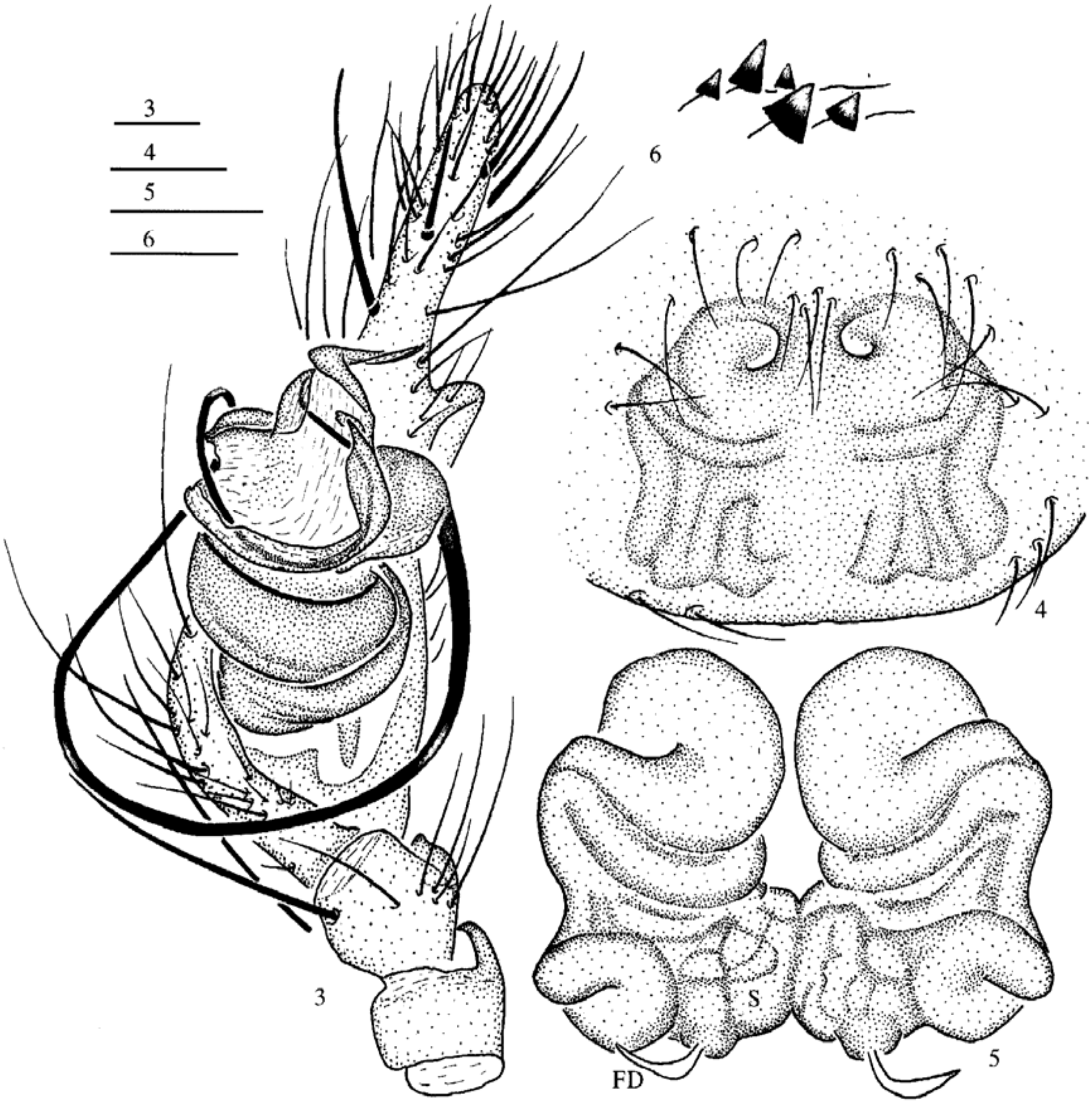
Description of male (holotype). Total length 6.45. Prosoma length 2.70, width 2.00; opisthosoma length 3.75, width 2.50. Eye measurements: AME 0.11; ALE 0.14; PME 0.15; PLE 0.15; AME-AME 0.03; AME-ALE 0.01; ALE-PLE 0; PME-PME 0.06; PME-PLE 0.05. PLE and ALE close together. Clypeus height 0.23. Leg formula: Ⅳ, Ⅰ, Ⅱ, Ⅲ; leg measurements: Ⅰ: 13.40 (3. 50, 4.25, 3.40, 2.25); Ⅱ: 12.30 (3.15, 3.90, 3.15, 2.10); Ⅲ: 11.80 (3.00, 3.60, 3.30, 1.90); Ⅳ: 15.45 (3.80, 4.60, 4.65, 2.40). Chelicerae with three promarginal and two retromarginal teeth. Patellar apophysis long, slender, with slightly curved apex; RTA almost as broad as tibia, extending about half of tibial length; lateral tibial apophysis broad; cymbial furrow longer than half of cymbial length, with the distal end widely separated from the cymbium; conductor large, wide proximally, slender and curved distally, conductor dorsal apophysis long, slender; median apophysis absent; tegulum sclerite small; embolus long, coiled, originating retrolaterally, from about 2 o'clock-position (Figs. 1-3, 6).

Female. Measurements (one of female paratypes). Total length 6.30. Prosoma length 3.00, width 2.15; Opisthosoma length 3.30, width 2.15. Eye measurements: AME 0.10; ALE 0.15; PME 0.14; PLE 0.15; AME-AME 0.05; AME-ALE 0.03; ALE-PLE 0.01; PME-PME 0.11; PME-PLE 0.09. Clypeus height 0.20. Leg formula: Ⅳ, Ⅰ, Ⅱ, Ⅲ; leg measurements:



Figs. 1-2. *Iwogumoa xieae* sp. nov. 1. Left male palp, prolateral view (arrow to the conductor dorsal apophysis). 2. Same, retrolateral view.

Ⅰ 12.55 (3.25, 4.10, 3.00, 2.20); Ⅱ 11.45 (3.25, 3.35, 2.85, 2.00); Ⅲ 11.00 (2.75, 3.50, 3.00, 1.75); Ⅳ 14.65 (3.75, 4.50, 4.25, 2.15). Chelicerae with three promarginal and two retromarginal teeth. Epigynal teeth absent; genital openings small, almost rounded, situated anteriorly, and separated by a moderately wide septum; copulatory ducts indistinct; spermathecal heads invisible; spermathecae long, broad, strongly convoluted, and situated close together (Figs.4-5).



Figs.3-6. *Iwogumoa xieae* sp. nov. 3. Left male palp, ventral view. 4. Female epigynum, ventral view. 5. Female vulva, dorsal view. 6. Male cheliceral teeth, ventral view.

Distribution. China (Hunan).

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中国湖南隙蛛亚科亚隙蛛属洞穴一新种记述（蜘蛛目，暗蛛科）

刘　杰　李枢强
中国科学院动物研究所　北京　100101

摘　要　描述了采自洞穴的隙蛛亚科蜘蛛1新种：*Iwogumoa xieae* sp. nov.，本种与同属其它种类的区别在于：生殖齿和中突缺失，具有明显的引导器背突，并且侧胫节突宽大。

谢氏亚隙蛛，新种 *Iwogumoa xieae* sp. nov.（图1~6）

正模♂，副模3♂♂，7♀♀，湖南省冷水江市中连乡波月洞，2007年11月2日，李枢强、林玉成和刘杰采；副模2♂♂，12♀♀，湖南省冷水江市渣渡镇渣渡村九门洞，2007年11月1日，李枢强、林玉成和刘杰采；副模12♂♂，22♀♀，湖南省冷水江市潘桥乡仙憩洞，2007年11月1日，李枢强、林玉成和刘杰采；副模2♀♀，湖南省新化县油溪乡高桥村梅山龙洞，2007年11月2日，李枢强、林玉成和刘杰采。

词源：新种种名取自谢立言女士的姓氏，感谢她对我们在湖南地区洞穴蜘蛛采集工作的大力支持。

关键词　隙蛛亚科，洞穴，新种，湖南，中国.
中图分类号　Q959.226

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动物分类学报

EIGHT NEW SPECIES OF SALTICIDS FROM CHINA (ARANEAE, SALTICIDAE)

PENG Xian-Jin[1, 2], TANG Guo[2], LI Shu-Qiang[1*]
1. *Institute of Zoology, Chinese Academy of Sciences, Beijing* 100101, *China*
2. *The College of Life Sciences, Hunan Normal University, Changsha, Hunan* 410081, *China*

Abstract The present paper deals with 8 new species of jumping spiders from China: *Langona atrata* Peng *et* Li, sp. nov., *Pancorius cheni* Peng *et* Li, sp. nov., *Plexippoides regiusoides* Peng *et* Li, sp. nov., *Rhene digitata* Peng *et* Li, sp. nov., *Synagelides hubeiensis* Peng *et* Li, sp. nov., *Synagelides zebrus* Peng *et* Li, sp. nov., *Synagelides zonatus* Peng *et* Li, sp. nov. and *Yaginumaella bulbosa* Peng, Li *et* Tang, sp. nov. Detailed morphological characteristics and illustrations of body and copulatory organs are presented.

Key words Salticidae, new species, taxonomy, China.

1 Introduction

Jumping spiders are the most diverse taxa in the Araneae. Currently, a total of 560 genera and 5 121 species of salticids are documented (Platnick, 2008). In recent years, due to large-scale habitat destruction and fragmentation, almost all ecosystems in China have experienced severe impact. Many species had become disappeared long before they could be collected and described because of such a rapid rate of habitat destruction. One of the ways to retrieve information on species that are currently difficult to find but were once quite abundant is to examine specimens collected when their natural habitats were more intact. Recently, during examining the specimens of jumping spiders deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS) eight new species are identified.

Specimens were examined with an Olympus SZ11 stereo dissecting microscope. Type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing. Measurements are given in millimeter (mm). Total leg length was measured as the sum of the lengths of femur, patella + tibia, metatarsus, and tarsus.

Abbreviations. AER-anterior eye row, AL-abdominal length, ALE-anterior lateral eye, AME-anterior median eye, AW-abdominal width, CL-carapace length, CLYH-clypeus height, CW-carapace width, EFL-length of eye field, PER-posterior eye row, PLE-posterior lateral eye, Pr-prolateral, rt-retrolateral, TL-total length.

2 Taxonomy

Langona atrata **Peng *et* Li, sp. nov.** (Figs.1-4)

Diagnosis. This new species is similar to *L. simoni* Heciak & Prozynski, 1983 (Heciak & Prószyn' ski, 1983: 227, Figs.24, 30-31), but differs in: 1) the epigynal hood as long as wide, with shallow depression (Fig.3) in the new species; longer than wide, anterior margin with deep depression, almost divided the hood in two parts in *L. simoni*; 2) copulatory openings far from hood in the new species, connected to hood in *L. simoni*; 3) the course of copulatory ducts. This new species is also similar to *L. biangular* Peng & Li, 2004 and *L. maculata* Peng & Li, 2004, but differs in: 1) atrium almost longitudinal versus diagonal in 45 degree angle with epigastric furrow in *L. biangular* and *L. maculate*; 2) the course of copulatory ducts; 3) abdominal patterns.

Measurements (holotype). TL 6.40. CL 3.20, CW 2.40; AL 3.60, AW 2.40. AER 1.70, PER 1.70, ELF1.00 long, AME 0.37, ALE 0.27, PLE 0.23. CLYH 0.33. Legs: Ⅰ 4.40 (1.60, 1.70, 0.60, 0.50), Ⅱ 4.30 (1.50, 1.70, 0.60, 0.50), Ⅲ 5.00 (2.00, 2.00, 0.90, 1.00), Ⅳ 6.20 (1.90, 2.10, 1.40, 6.20); formula 4, 3, 1, 2.

Female. Carapace blackish brown, margin and ocular area darken. Carapace with thin white and black hairs, and many long black hairs; the margin with a loop of white hairs. Anterior ocular area with short vertical claviform short hairs. Fovea, cervicle and radial grooves unclear. Sternum bottle-shaped, black, with thin white hairs. Clypeus brown, anterior rim black, bilaterally with black netted stripes, with white thin hairs and sparse black long hairs. Chelicerae blackish brown, prolateral with white thin hairs, 2 promarginal and 1 retromarginal teeth. Endites light brown, the distal light yellow with brown floss. Labium blackish brown, the distal with brown hairs. Palp and legs blackish brown, with distinct

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* Corresponding author, lisq@ioz.ac.cn

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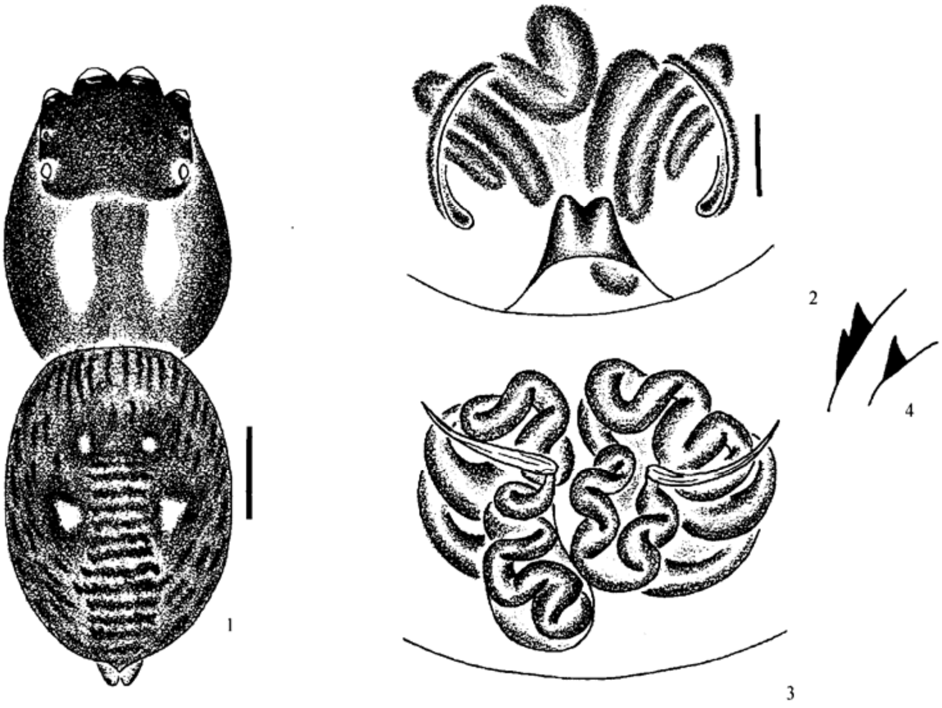
black annuli and brown ellipsoid markings; hairs long, white and brown; spines few and long, ventral of tibiae Ⅰ and Ⅱ with 1 prolateral spine on the distal and 3 retrolateral spines, metatarsi Ⅰ without pro-and retrolateral spine, metatarsi Ⅱ pr 1-1ap, rt 0-0, metatarsi Ⅰ and Ⅱ with 2 pairs of ventral spines. Abdomen quadrate, dorsum grayish black, furnished with gray and black hairs, 2 pairs of muscular depressions distinct, the mesal with many blackish brown transverse stripes, the bilateral with blackish brown longitudinal stripes. The venter yellowish brown, with 3 grayish black longitudinal stripes, the lateral with black oblique lines; spinnerets grayish black, with gray and black long hairs.



Figs. 1-4. *Langona atrata* Peng *et* Li, sp. nov. 1. Body, dorsal view. 2. Epigynum, ventral view. 3. Vulva, dorsal view. 4. Chelicerae teeth. Scale bars: 1 = 1.0, 2-4 = 0.5.

Epigyne (Figs. 2-4). epigyne hood posteriorly, as long as wide, anterior margin with shallow depression; copulatory openings bilaterally, far from hood; copulatory ducts twist multi-circles; spermathecae also twisted complicated.

Male. Unknown.

Etymology. The specific name refers to the dark color of the body.

Holotype ♀, China, Yunnan Province, Cangshan (25°58′N, 99°52′E), 9 June 1999.

Distribution. China (Yunnan).

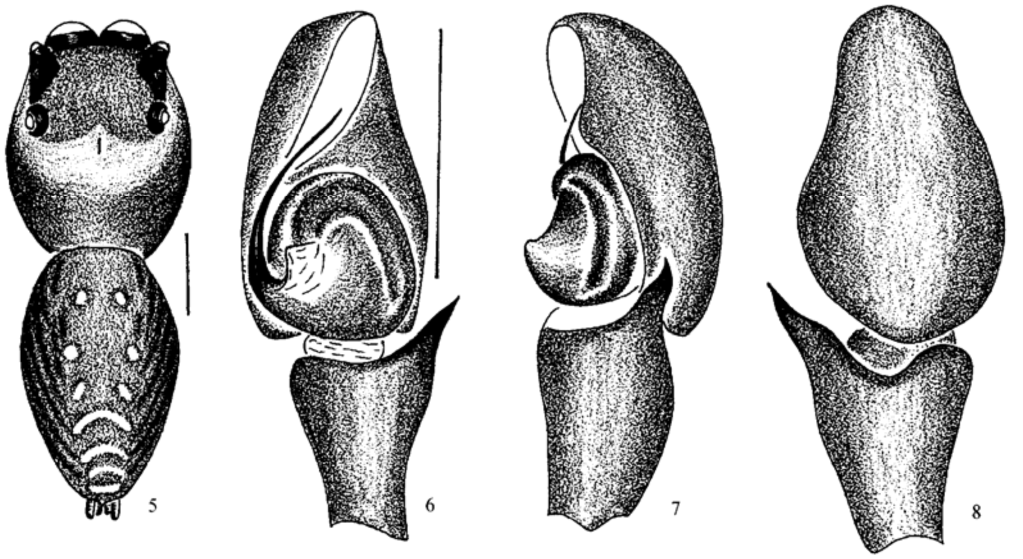
***Pancorius cheni* Peng *et* Li, sp. nov.** (Figs. 5-8)

Diagnosis. This new species is similar to *P. crassipes* (Karsch, 1881) (Logunov & Marusik, 2001: 150), but can be separated from the latter by: 1) embolus longer, originating at the position of 9: 00 o'clock (Fig. 6) in the new species; with a wide membrane on the base, originating at the position of 11: 00 in *P. crassipes*; 2) body markings.

Measurements. TL: 4.70-7.00. Holotype: TL 6.20. CL 3.00, CW 2.40; AL 3.20, AW 2.00. AER 1.70, PER 1.90, ELF 1.15, AME 0.55, ALE 0.30, PLE 0.30. CLYH 0.15. Legs: Ⅰ 7.30 (2.00, 3.10, 1.40, 0.80), Ⅱ 5.35 (1.70, 2.00, 1.00, 0.65), Ⅲ 5.55 (1.85, 2.00, 1.00, 0.70), Ⅳ 5.90 (1.85, 2.00, 1.35, 0.70); formula 1, 4, 3, 2.

Male. Cephalothorax swollen, wide-oval shaped, darken brown, bases of eyes black, one lunate reddish brown marking behind ocular area. Fovea short, black, longitudinal; cervicle and radial grooves unclear, with little short white hairs and brown long hairs. Sternum shield-shaped, clothed with white, brown long hairs, median area blackish brown, margin brown, blackish brown markings corresponding to coxae of legs. Clypeus brown, clothed with blackish brown long hairs. Inferior of AME with dense white long hairs. Chelicerae blackish brown, prolateral with sparse white long hairs, the base clothed with transverse wrinkles, 2 promarginal teeth combined basally, retromargin with 1 teeth. Endites and labium blackish brown, the distal yellowish brown with grayish brown floss. Legs blackish brown, with light brown annuli and dense blackish brown hairs, hairs on ventral of legs Ⅰ and Ⅱ brush-shaped, legs with little weak spines, tibiae Ⅰ and Ⅱ with 3 pairs of ventral spines, metatarsi of Ⅰ and Ⅱ with 2 pairs of ventral spines. Abdomen long oval, dorsum grayish black, with gray thin hairs, bilateral with many dark oblique stripes, anterior of dorsum with 3 pairs of muscular depressions, posterior with 4 light arc stripes; the venter grayish black, with 4 lines of dot-shaped spots, spinnerets grayish black, with black thin hairs.

Palpal organ. Tibial apophysis digitiform, distal sharp (Figs.6-8); bulb swollen posteriorly (Figs.6-7); embolus longer, originating at the position of 9: 00 o'clock (Fig.6).



Figs.5-8. *Pancorius cheni* Peng *et* Li, sp. nov. 5. Body, dorsal view. 6. Left palpal organ, ventral view. 7. Left palpal organ, retrolateral view. 8. Left palpal organ, dorsal view. Scale bars: 5 = 1.0, 6-8 = 0.5.

Female. Unknown.

Etymology. The specific name dedicates to CHEN Jun who collected the type specimens.

Holotype ♂, China, Guangxi Zhuang Autonomous Region, Napo County (23°44′N, 106°48′E), Defu Reserve, alt. 1 350 m, 19 June 2000, leg. CHEN Jun. Paratype 1 ♂, same data as holotype.

Distribution. China (Guangxi).

***Plexippoides regiusoides* Peng *et* Li, sp. nov.** (Figs.9-11)

Diagnosis. This new species is similar to *P. regius* Wesolowska, 1981 (Wesolowska, 1981: 73, Figs.85-93), but can be separated from the latter by: 1) the atrium wide and short (Fig.10) in the new species, rounded in *P. regius*; 2) the course of copulatory ducts; 3) markings on abdomen dorsum.

Measurements (holotype). TL 11.80. CL 5.50, CW 4.40; AL 6.30, AW 4.40. AER 2.90, PER 2.00, AME 0.95, ALE 0.45, PLE 0.45. CLYH 0.35. Legs: Ⅰ 9.50 (3.00, 4.00, 1.50, 1.00), Ⅱ 8.90 (3.00, 3.60, 1.40, 0.90), Ⅲ 9.80 (3.20, 3.50, 2.00, 1.10), Ⅳ 10.70 (3.20, 4.00, 2.30, 1.20); formula 4, 3, 1, 2.

Female. Carapace brown, with white and brown hairs, the bilateral with blackish brown longitudinal stripes; ocular area blackish brown, the anterior and the bilateral with brown long hairs; fovea long, reddish brown; cervicle and radial grooves dark. Sternum shield-shaped and brown, margin with dark brown spots corresponding to coxae of legs; hairs sparse and brown. Clypeus light brown, with white short hairs and sparse light brown long hairs. Chelicerae light brown, with long light brown hairs, 2 promarginal and 1 retromarginal teeth. Endites, labium brown, distal light brown, with grayish floss. Legs brown, coxae, trochanter, femur lighter, with blackish brown thin hairs; spines short, tibia Ⅰ with 3 pairs of ventral spines, tibia Ⅱ with 2 pro-and 3 retrolateral spines on the venter. Metatarsi Ⅰ and Ⅱ with 2 pairs of ventral spines. Abdomen (Fig.11) dark reddish brown, clothed with short brown hairs; 2 muscular depressions reddish brown; cardiac stripes short; median area of dorsum with a wide black longitudinal stripe clothed with black hairs, 2 rows of light small dots on the stripe; bilateral yellowish brown, with 4 pairs of light yellowish brown inclined striae and few brown irregular spots. Spinnerets yellowish brown, with grayish black thin hairs.

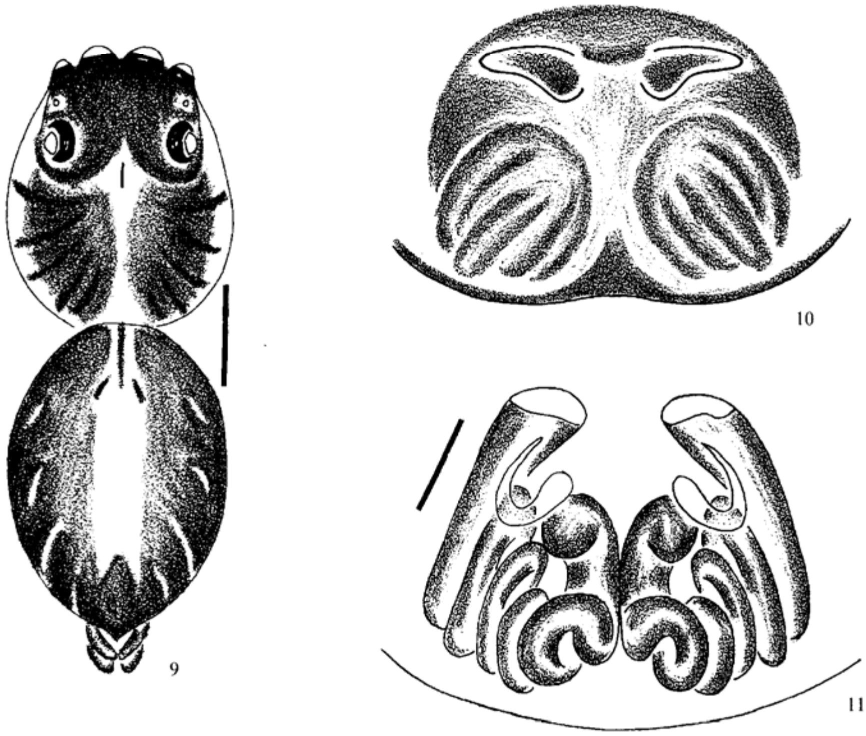
Epigyne. The atrium wide and short (Fig.11); copulatory openings bilaterally (Fig.10); copulatory ducts twisted helix-shaped, spermathecae thicker than ducts (Fig.11).

Male. Unknown.

Etymology. The specific name refers to its similarity to *P. regius* Wesolowska, 1981.

Holotype ♀, China, Hubei Province, Wudang, Nanyan (32°23′N, 110°56′E), 25 Aug. 1983.

Distribution. China (Hubei).



Figs.9-11. *Plexippoides regiusoides* Peng *et* Li, sp. nov. 9. Body, dorsal view. 10. Epigynum, ventral view. 11. Vulva, dorsal view. Scale bars: 9 = 1.0, 10-11 = 0.5.

Rhene digitata Peng *et* Li, sp. nov. (Figs.12-14)

Diagnosis. This new species is similar to *R. albigera* (C. L. Koch, 1848) (Peng *et al.*, 1993: 198, Figs.695-699), but can be separated from the latter by: 1) conductor longer, bow-shaped, distal portion needle-shaped (Fig.13) in the new species; blunt and digit form in *R. albigera*; 2) tibial apophysis longer.

Measurements (holotype). TL 4.60. CL 1.90, CW 1.90; AL 2.70, AW 1.90. AER 1.70, PER 1.80, ELF 1.10, AME 0.37, ALE 0.18, PLE 0.18. CLYH 0.07. Legs Ⅰ lost, Ⅱ 3.25 (1.10, 1.20, 0.55, 0.40), Ⅲ 3.00 (1.00, 1.00, 0.500, 0.50), Ⅳ 3.80 (1.25, 1.35, 0.70, 0.50).

Male. Carapace brown, ocular area dark brown, bases of eyes and the margin black, hairs white and brown; anterior and bilateral of ocular area clothed with white flat short hairs. Sternum ellipsoid and brown, the center somewhat swollen, grayish black; hairs short and blackish brown. Clypeus brown, anterior darker, with darken brown brush-shaped hairs. Chelicerae blackish brown, distal light, with brown hairs, 2 promarginal and 1 retromarginal teeth. Endites and labium blackish brown, distal light brown with floss, labium longer than wide. Legs brown with light spots, short hairs white, long hairs brown, spines weak and sparse. Abdomen oval, dorsum grayish brown, clothed white and brown short hairs; 3 pairs of muscular depressions; lateral area with 4 pairs of arc-shaped stripes formed by white hairs; the venter darken grayish brown. Spinnerets brown, with brown hairs.

Palpal organs (Figs.13-14). Distal portion of tibial apophysis sharp, curved inward; bulb swollen inferiorly, sperm ducts visible; conductor long, bow-shaped, distal portion sharp and needle-shaped; embolus short and digit form.

Female. Unknown.

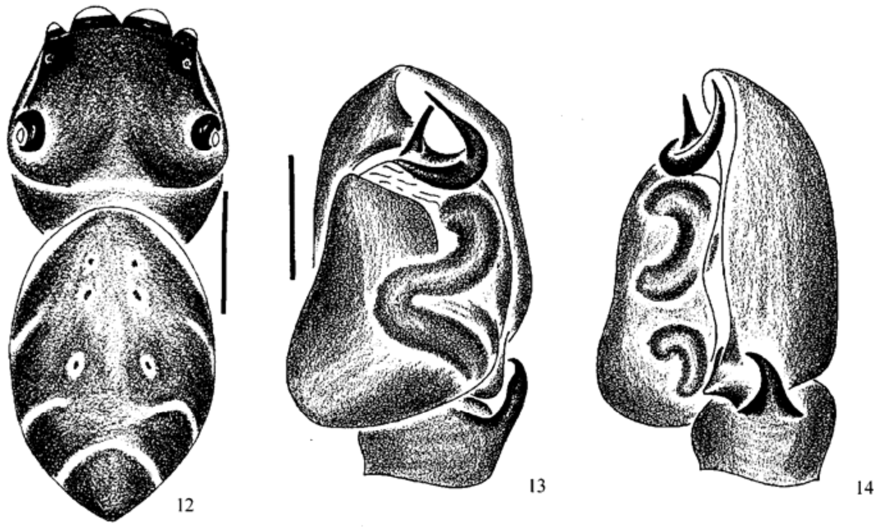
Etymology. The specific name refers to the digit form embolus of male papal organ.

Holotype ♂, China, Hubei Province, Wuxue City (29°51′N, 115°33′E), Wushi, 8 Dec. leg. unknown.

Distribution. China (Hubei).

Synagelides hubeiensis Peng *et* Li, sp. nov. (Figs.15-19)

Diagnosis. This new species is similar to *S. agoriformis* Strand, 1906 (Peng *et al.*, 1993: 222,



Figs. 12-14. *Rhene digitata* Peng *et* Li, sp. nov. 12. Body, dorsal view. 13. Left palpal organ, ventral view. 14. Left palpal organ, retrolateral view. Scale bars: 12 = 1.0, 13-14 = 0.5.

Figs. 787-794), but can be separated from the latter by: 1) the sclerotized plate beside the embolus complicated, with 3 angular apophyses in ventral view (Fig. 16) in the new species, absent in *S. agoriformis*; 2) cymbium with a cone-shaped dorsal apophysis in dorsal view (Fig. 18) in the new species, absent in *S. agoriformis*; 3) abdomen dorsum with distinct zebra-shaped transverse markings (Fig. 15) in the new species, absent in *S. agoriformis*.

Measurements (holotype). TL 2.70. CL 1.30, CW 0.95; AL 1.40, AW 0.95. AER 0.95, PER 1.00, EFL 0.75, AME 0.33, ALE 0.18, PLE 0.20. CLYH 0.07. Legs: Ⅰ 2.90 (0.90, 1.30, 0.45, 0.25), Ⅱ 2.10 (0.65, 0.75, 0.45, 0.25), Ⅲ 2.10 (0.65, 0.75, 0.50, 0.20). Ⅳ 2.15 (1.00, 1.10, 0.75, 0.30); formula: 1, 4, 3, 2.

Male. Carapace brown, with even granule-shaped small apophyses; only bases of eyes, anterior of ocular area and bilateral with white thin hairs; the bilateral almost parallel; the margin, bases of eyes, anterior of ocular area black; fovea dark brown, U-shaped; cervicle and radial grooves dark, the granule-shaped small apophyses arranged along with cervicle and radial grooves; sternum cordiform, anterior rim straight, much wider than posterior rim, light brown, the anterior half darken, the posterior half with 5 radial stripes. Clypeus brown, anterior rim black, with sparse brown and white hairs. Chelicerae thin, grayish brown, 2 promarginal and 1 retromargin teeth. Endites knife-shaped, grayish brown, inner rim light yellowish brown, with thin light brown hairs. Labium wider than long, darken brown, distal light yellowish brown with brown hairs. Legs light yellow, prolateral with gray longitudinal stripes; hairs sparse, short and thin, tibia Ⅰ with 3 pairs of long ventral spines, metatarsus Ⅰ with 2 pairs of long spines, others without spines. Abdomen (Fig. 15) oval, clothed with sparse hairs; Dorsum light yellowish brown, the anterior with 3 pairs of lighter circular patterns, the median with 2 grayish black arc-shaped transverse stripes; the posterior grayish brown, with 5 thin arc-shaped transverse stripes. The venter yellowish white, 2 wide grayish brown longitudinal stripes in the median. Spinnerets yellowish white, encircled with black loop patterns and sparse short hairs.

Palpal organ. The sclerotized plate beside the embolus complicated, with 3 angular apophyses in ventral view (Fig. 16); Cymbium with a cone-shaped dorsal apophysis in dorsal view (Fig. 18); Embolus long and thin (Figs. 16-17, 19), tibial apophysis invisible (Figs. 16-19).

Female. Unknown.

Holotype ♂, China, Hubei Province, no detailed information.

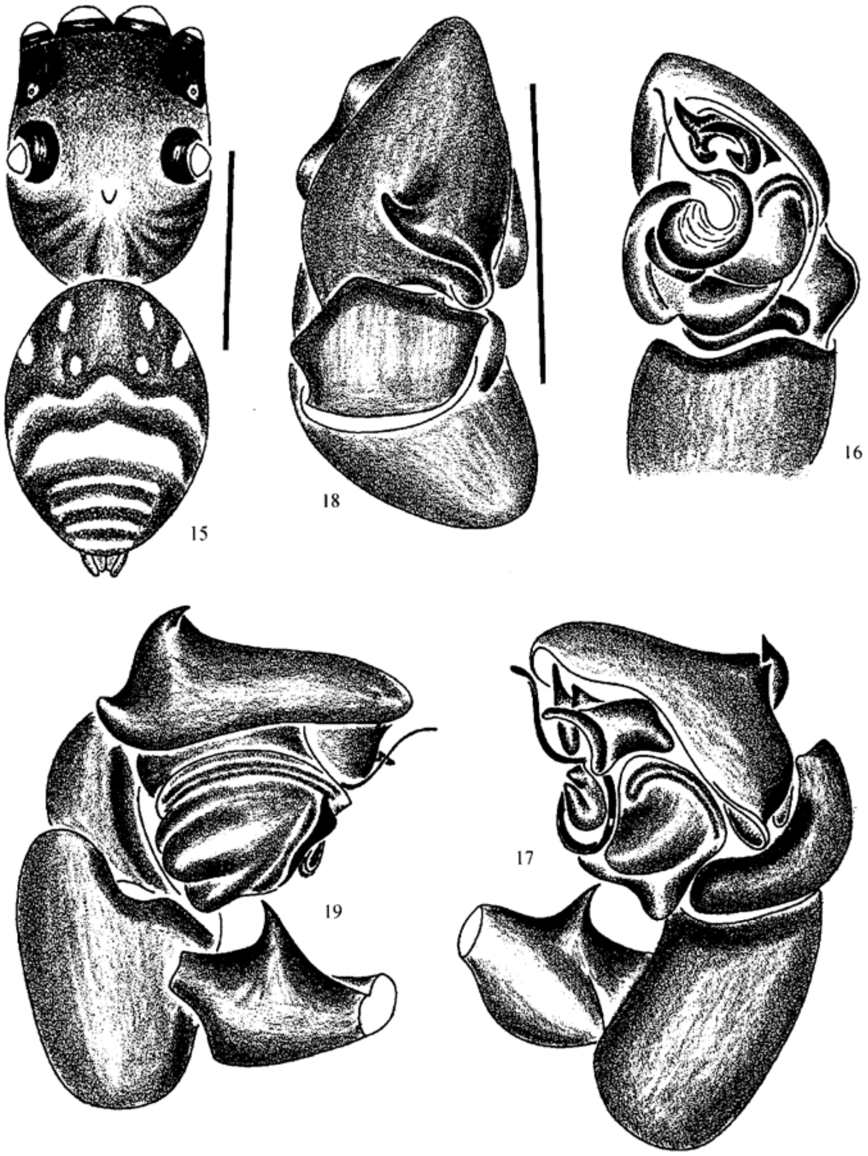
Etymology. The specific name refers to the type locality.

Distribution. China (Hubei).

Synagelides zebrus Peng _et_ Li, sp. nov. (Figs. 20-22)

Diagnosis. This new species is similar to *S. annae* Bohdanowicz, 1979 (Peng *et al.*, 1993: 224, Figs. 795-800), but can be separated from the latter by: 1) the spermathecae spherical, about as long as wide (Fig. 22) in the new species; oval, two times wider than long in *S. annae*; 2) the course of copulatory ducts much simpler (Fig. 22); 3) abdomen dorsum with distinct zebra-shaped stripes in the new species, absent in *S. annae* (Fig. 20).

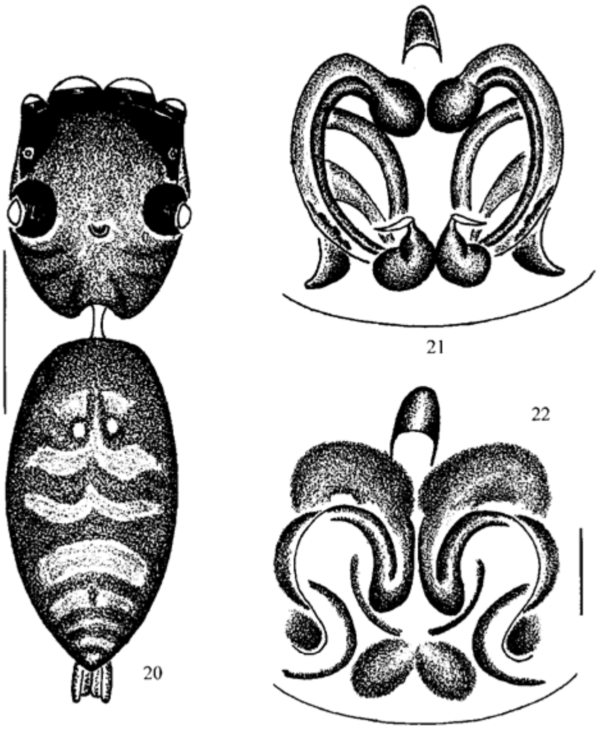
Measurements (holotype): TL 3.80. CL 1.50, CW 1.10; AL 2.10, AW 1.10. AER 1.10, PER 1.15,



Figs. 15-19. *Synagelides hubeiensis* Peng *et* Li, sp. nov. 15. Body, dorsal view. 16. Left palpal organ, ventral view. 17. Left palpal organ, retrolateral view. 18. Left palpal organ, dorsal view. 19. Left palpal organ, prolateral view. Scale bars: 15 = 1.0, 16-19 = 0.5.

EFL 0.90, AME 0.40, ALE 0.25, PLE 0.25. CLYH 0.05. Legs: Ⅰ 3.45 (1.05, 1.85, 0.30, 0.25), Ⅱ 2.25 (0.70, 0.80, 0.50, 0.25), Ⅲ 2.55 (0.70, 0.95, 0.60, 0.30), Ⅳ 3.55 (0.95, 1.30, 0.85, 0.45); formula 4, 1, 3, 2.

Female. Carapace brown, the bilaterally and posterior half dark brown; bases of eyes, the bilateral and anterior of ocular area black, with short white and brown hairs; carapace with small granules. Fovea small, precurved, black and deep; cervicle and radial grooves black, distinct. Sternum shield-shaped with smooth rim, yellowish brown with grayish black margin, hairs sparse and grayish black. Clypeus narrow and brown, anterior rim grayish black. Chelicerae yellowish brown with grayish black prolateral, 2 promarginal and 1 retromarginal teeth. Palp and legs light yellowish brown with grayish black longitudinal stripes; pro-and retrolateral of femur Ⅰ and ventral of patella Ⅰ grayish black; other legs with long grayish black longitudinal stripes (except tarsus and metatarsus), the bilaterally with long grayish black longitudinal stripes; tibia Ⅰ with 4 long ventral spines on the prolateral, 3 on the retrolateral; metatarsus Ⅰ with 2 pairs of ventral spines; other parts of legs no spines. Abdomen (Fig. 6A)



Figs.20-22. *Synagelides zebrus* Peng *et* Li, sp. nov. 20. Body, dorsal view. 21. Epigynum, ventral view. 22. Vulva, dorsal view. Scale bars: 20 = 1.0, 21-22 = 0.5.

cylindrical, dorsum light yellowish brown with dark gray bilaterally, the median with distinct grayish black transverse arc-shaped or sinuate stripes; the venter dark gray bilaterally, median yellowish gray, with 2 dark claviform stripes. Spinnerets grayish brown, with grayish black long hairs.

Epigyne (Figs.21-22). Epigynal hood anteriorly located; copulatory opening bilaterally located, copulatory ducts slender; the spermathecae spherical, about as long as wide.

Male. Unknown.

Etymology. The specific name refers to the distinct zebra-shaped stripes on the abdomen dorsum.

Holotype ♀, China, Guangxi Zhuang Autonomous Region, Napo County (23°44′N, 106°48′E), Defu Reserve, 1 350 m, 18 June 2000, CG065, leg. CHEN Jun.

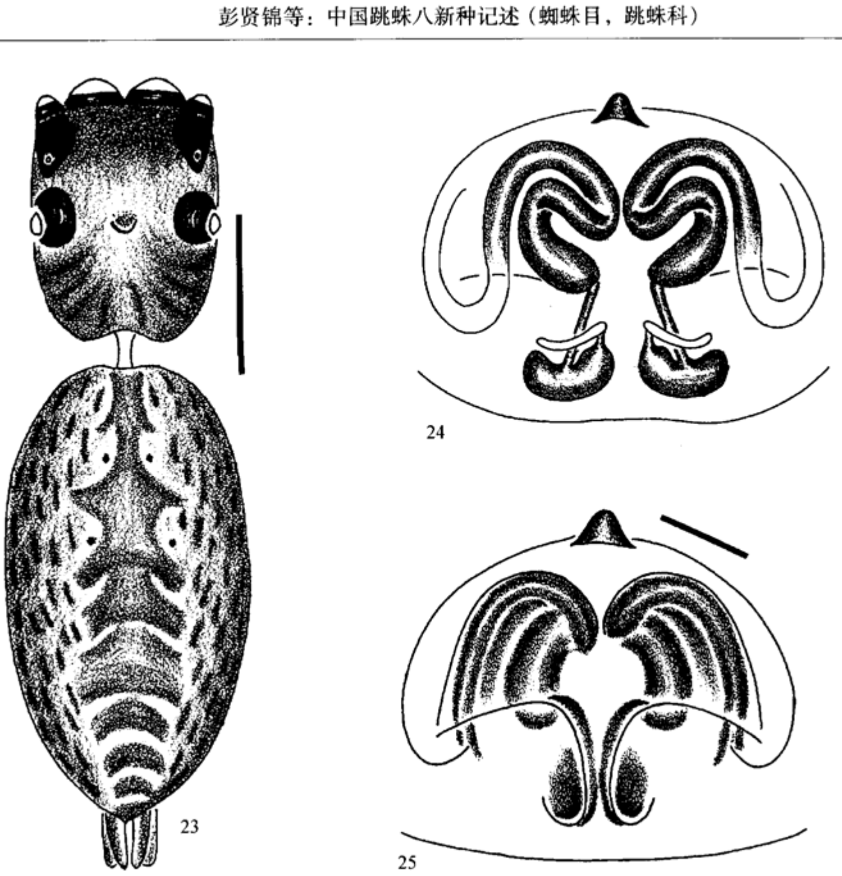
Distribution. China (Guangxi).

***Synagelides zonatus* Peng *et* Li, sp. nov.** (Figs.23-25)

Diagnosis. This new species is similar to *S. cavaleriei* (Schenkel, 1963) (Bohdanowicz, 1987: 66, Figs.1-4), but differs in: 1) spermathecae narrower (Fig.25); 2) copulatory ducts shorter, twisted in band-shaped (Fig.25); 3) median septum much shorter (Fig.24).

Measurements (holotype). TL 4.60. CL 1.60, CW 1.10; AL 2.80, AW 1.55. AER 1.10, PER 1.20, AME 0.37, ALE 0.20, PLE 0.20. CLYH 0.03. Legs: Ⅰ 3.75 (1.05, 1.60, 0.40, 0.25), Ⅱ 2.35 (0.70, 0.90, 0.45, 0.30), Ⅲ 2.50 (0.70, 0.90, 0.60, 0.30), Ⅳ 3.70 (1.00, 1.40, 0.90, 0.40); formula 1, 4, 3, 2.

Female. Carapace brown; margin, bases of eyes and anterior ocular area dark, posterior and median ocular area light brown; clothed with brown small granules; hairs short, white and brown; fovea blackish brown, arc-shaped; cervical and radial grooves clothed with granules and white short hairs. Sternum shield-shaped, light yellowish brown with dark margin; hairs brown, sparse and short. Clypeus brown, dark anteriorly; hairs sparse and darken brown. AER wide, with white short hairs subjacent. Chelicerae light brown, prolateral grayish brown, 2 promarginal and 1 retromarginal teeth small and slim. Endites and labium light brown, the distal lighter, with floss. Palp, legs brown, prolateral with grayish black longitudinal stripes; tibia Ⅰ with 4 pairs of long ventral spines, metatarsus Ⅰ with 2 pairs of long ventral spines, others parts of legs without spine. Abdomen long oval, hairs sparse and short. Dorsum light yellowish white, markings grayish black, 2 pairs of muscular depressions; cardiac pattern



Figs.23-25. *Synagelides zonatus* Peng *et* Li, sp. nov. 23. Body, dorsal view. 24. Epigynum, ventral view. 25. Vulva, dorsal view. Scale bars: 23 = 1.0, 24-25 = 0.5.

long stick-shaped; bilateral grayish black. Spinnerets brown with brown hairs.

Epigyne (Figs.24-25). Epigynal hood anteriorly located; copulatory openings bilaterally located; copulatory ducts slender, twisted and band-shaped; spermathecae small, transverse kidney-shaped.

Male. Unknown.

Etymology. The specific name refers to the form of copulatory ducts.

Holotype ♀, China, Hubei Province, Yingshan County (30°44′N, 115°40′E), 1 July 1984, leg. ZHAO Jin-Zhao.

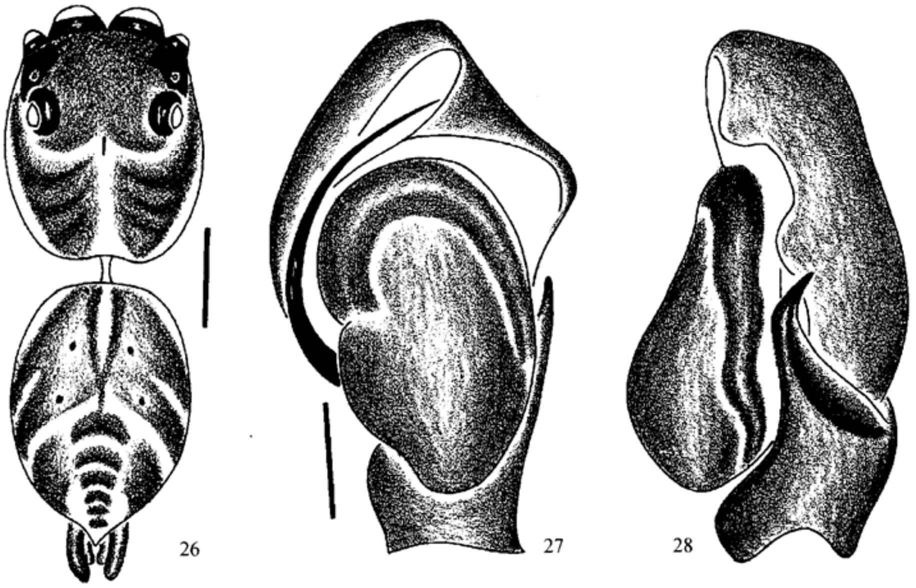
Distribution. China (Hubei).

Yaginumaella bulbosa Peng, Li _et_ Tang, sp. nov. (Figs.26-28)

Diagnosis. This new species is similar to *Y. tenzingi* Zabka, 1980 (Zabka, 1980: 377, Figs 2, 4, 6, 8, 11, 15, 18), but differs in: the distal portion of the tibial apophysis curved dorsally and digitiform in lateral view in the new species (Figs.27-28); straight and needlepoint-shaped in *Y. tenzingi*.

Measurements (holotype). TL 5.50. CL 2.50, CW 1.90; AL 2.70, AW 1.70. AER 1.70, PER 1.60, ELF 1.00, AME 0.56, ALE 0.30, PLE 0.30. CLYH 0.13. Legs: Ⅰ 5.50 (1.70, 2.20, 1.00, 0.60), Ⅱ 4.55 (1.50, 1.75, 0.80, 0.50), Ⅲ 5.05 (1.65, 1.70, 1.00, 0.70), Ⅳ 5.30 (1.70, 1.80, 1.20, 0.60); formula 1, 4, 3, 2.

Female. Carapace brown, bilateral and anterior of ocular area dark, with white and brown short hairs; fovea short and longitudinal, reddish brown; cervical and radial grooves darken. Sternum shield-shaped, light yellow, median area bulged, margin smooth, hairs brown; bilateral of clypeus light yellowish brown with white short hairs, median area dark brown with brown long hairs. Chelicerae brown, with brown long hairs, 2 promarginal and 1 retromarginal teeth. Endites with large and deep incision in exterior margin; endites and labium dark brown, distal yellowish brown, with brown floss. Legs light brown, with dark brown annuli and brown thin hairs; spines short, tibiae Ⅰ and Ⅱ with 3 pairs of ventral spines, metatarsi Ⅰ and Ⅱ with 2 pairs of ventral spines. Abdomen (Fig.26) oval, wider anteriorly; dorsum grayish brown, with sparse brown hairs; cardiac pattern stick-shaped; 2 pairs of muscular depressions visible, reddish brown; the bilateral with 3 pairs of large grayish black spots, the posterior with 6 arc-shaped stripes; venter grayish yellow, with darken grayish thin hairs, median area with dark gray longitudinal stripes,



Figs.26-28. *Yaginumaella bulbosa* Peng, Li *et* Tang, sp. nov. 26. Body, dorsal view. 27. Left palpal organ, ventral view. 28. Left palpal organ, retrolateral view. Scale bars: 26 = 1.0, 27-28 = 0.5.

lateral area with sparse grayish black dot spots. Spinnerets grayish brown, with grayish black hairs.

Palpal organ (Figs.27-28). Tibial apophysis long and narrow, distal portion curved dorsally, digitiform in lateral view; bulb swollen inferiorly, sperm ducts twist around the bulb, embolus slender, needle-shaped.

Female. Unknown.

Etymology. The specific name refers to the form of the bulb of male palpal organ.

Holotype ♂, China, Hubei Province, Wuchang City (30°32′N, 114°17′E), Dongyuan, 6 Nov. 1980, leg. ZHAO Jin-Zhao.

Distribution. China (Hubei).

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中国跳蛛八新种记述（蜘蛛目，跳蛛科）

彭贤锦[1,2]　唐　果[2]　李枢强[1*]
1. 中国科学院动物研究所　北京　100101
2. 湖南师范大学生命科学学院　长沙　410081

摘　要　记述了跳蛛科 8 新种，并提供了详细的描述。模式标本保存在中国科学院动物研究所。测量单位 mm。

暗色兰戈纳蛛，新种 *Langona atrata* Peng *et* Li, sp. nov.（图 1～4）

正模 ♀，云南苍山东坡，1999 年 6 月 9 日。

正模体长 6.4。头胸部长 3.2，宽 2.4；腹部长 3.6，宽 2.4。前眼列宽 1.7，后眼列宽 1.70，眼域长 1.0，前中眼直径 0.37，前侧眼直径 0.27，后侧眼直径 0.23，额高 0.33。背甲黑褐色，边缘及眼域色深，被有细的白色及黑色毛，此外尚有较多的黑色长毛；边缘有 1 圈白色毛，眼域前部有直立的棒状短毛，颈沟、放射沟及中窝不明显。胸甲瓶状，黑色，被有细长的白毛。额深褐色，前缘黑色，两侧有黑色网纹，被白色细毛及少许黑色长毛。螯肢暗褐色，前侧被有白色细毛，前齿堤 2 齿，后齿堤 1 齿。颚叶浅褐色，端部浅黄色，被褐色绒毛。下唇暗褐色，端部色浅具褐色毛。触肢、步足深褐色，具醒目的黑色环纹及浅色椭圆形斑，被白色及褐色长毛；足刺少而长，胫节Ⅰ、Ⅱ腹面前侧端部 1 刺、后侧 3 刺，后跗节Ⅰ无侧刺，后跗节Ⅱ pr 1-1ap，rt 0-0，后跗节Ⅰ、Ⅱ腹面具刺 2 对。各步足量度如下：Ⅰ 4.4（1.6，1.7，0.6，0.5），Ⅱ 4.3（1.5，1.7，0.6，0.5），Ⅲ 5.0（2.0，2.0，0.9，1.0），Ⅳ 6.2（1.9，2.1，1.4，0.8）。足式：4，3，1，2。腹部约呈方形，后端稍尖。背面灰黑色，密被灰色及黑色毛，肌痕 2 对，色浅，两侧为深色纵向皱纹，中央有许多深色横向皱纹。腹面黄褐色，中央有 3 条灰黑色纵纹，两侧有许多黑色斜纹。纺器灰黑色，被灰色及黑色长毛。

新种与 *L. simoni* Heciak & Prozynski，1983（219，figs. 24，30-31）相似，但有以下区别：1）外雌器兜长宽约相等，仅前缘有浅的凹陷；而后者宽远大于长，且明显分为 2 个兜，仅基部相连；2）交媾孔远离兜，而后者则与兜相连；3）交媾管走向不同。与 *L. biangula*，*L. maculata* 相比，本种交媾腔几乎纵向，后者与生殖沟呈 45 度角倾斜；交媾管走向及腹部背面斑纹也明显不同。

词源：新种因体色暗而得名。

分布：云南。

陈氏盘蛛，新种 *Pancorius cheni* Peng *et* Li, sp. nov.（图 5～8）

正模 ♂，副模1 ♂，广西那坡县德孚保护区，2000 年 6 月 19 日，CG063，海拔1 350 m，陈军采。

体长 4.70～6.00。正模体长 6.2。头胸部长 3.00，宽 2.40；腹部长 3.20，宽 2.00，前眼列宽 1.70，后眼列宽 1.90，眼域长 1.15，前中眼直径 0.55，前侧眼直径 0.30，后侧眼直径 0.30，额高 0.15。雄蛛背甲隆起较高，阔卵形，深褐色，各眼基部黑色，后中眼后方有 1 半月形赤褐色斑，向前延伸环绕眼域外侧；中窝很短，黑色，纵向；颈沟、放射沟不明显；被有少许短的白毛及褐色长毛。胸甲盾形，被有白色及褐色长毛，中央黑褐色，边缘褐色，有黑褐色斑点与各步足基节相对。额褐色，被黑褐色长毛，前中眼下方被有较密的白色长毛。螯肢黑褐色，前侧被有稀疏的白色长毛，螯基布满横向皱折，前齿堤 2 齿、基部相连，后齿堤 1 齿。颚叶、下唇深褐色，端部黄褐色，被灰褐色绒毛。步足黑褐色，有浅褐色环纹；被有较密的黑褐色毛，步足Ⅰ、Ⅱ腹面的毛呈刷状，足刺较弱而少，胫节Ⅰ、Ⅱ腹面各 3 对，后跗节Ⅰ、Ⅱ腹面各 2 对。各步足量度如下：Ⅰ 7.3（2.00，3.10，1.40，0.80），Ⅱ 5.35（1.70，2.00，1.00，0.65），Ⅲ 5.55（1.85，2.00，1.00，0.7），Ⅳ 5.9（1.85，2.00，1.35，0.70）。足式：1，4，3，2。腹部长卵形；背面灰黑色，被灰色细毛；两侧有许多深色斜纹，前端中央有 3 对浅色肌痕，后端中央有 4 条浅色弧纹。腹部腹面灰黑色，中央有 4 行浅色点状纹。纺器灰黑色，被黑色细毛。

新种与 *P. crassipes*（Karsch，1881）相似，但有以下区别：1）插入器远长于后者，起始于 9：00 处；而后者的则始于 11：00 处，且基部背面有 1 宽的膜质结构；2）身体上的斑纹不同。

新种以模式标本采集者的姓氏命名。

分布：广西。

类王拟蝇虎，新种 *Plexippoides regiusoides* Peng *et* Li, sp. nov.（图 9～11）

正模 ♀，湖北武当南岩，1983 年 8 月 25 日。

正模体长 11.8。头胸部长 5.5，宽 4.4；腹部长 6.3，宽 4.4。前眼列宽 2.9，后眼列宽 2.0，前中眼直径 0.95，前侧眼直径 0.45，后侧眼直径 0.45，额高 0.35。背甲褐色，被白色及褐色毛；眼域色深，呈黑褐色，两侧及前缘有褐色长毛；中窝长条状，赤褐色，颈沟、放射沟色深，胸区中央及背甲两侧为深褐色纵带。胸甲盾形，褐色，边缘有深色块斑与各步足基节相对；毛稀少，褐色。额浅褐色，被白色短毛及稀疏的浅褐色长毛。螯肢浅褐色，被浅褐色长毛，前齿堤 2 齿，后齿堤 1 齿。颚叶、下唇褐色，端部色浅，有灰褐色绒毛。步足褐色，基部 3 节色稍浅，被均匀的黑褐色细毛，足刺短而多，胫节Ⅰ腹面 3 对，胫节Ⅱ腹面前侧 2 根，后侧 3 根，后跗节Ⅰ、Ⅱ腹面各具 2 对。各步足量度如下：Ⅰ 9.5（3.0，4.0，1.5，1.0），Ⅱ 8.9（3.0，3.6，1.4，0.9），Ⅲ 9.8（3.2，3.5，2.0，1.1），Ⅳ 10.7（3.2，4.0，2.3，1.2）。足式：4，3，1，2。腹部深赤褐色，被褐色短毛；肌痕 1 对，赤褐色；心脏斑短，细条状；腹部正中有 1 宽的黄褐色纵带，两

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[*] 通讯作者.

侧有 4 对小的浅黄褐斑。腹面正中有 1 宽的黑色纵带，由黑色毛覆盖而成，其上有 2 列浅色小点；两侧黄褐色，散生少许褐色不规则斑。纺器浅黄褐色，被灰黑色细毛。

本种与 *P. regius* Wesolowska，1981 相似，但交媾腔宽而短，后者的约呈圆形；交媾管的走向差异明显，腹部背面的斑纹也明显不同。

词源：新种因与 *P. regius* Wesolowska，1981 相似，故名类王拟蝇虎。

分布：湖北。

指状宽胸蝇虎，新种 *Rhene digitata* Peng *et* Li，sp. nov.（图 12～14）

正模 ♂，湖北武穴市武师，12 月 8 日。

正模体长 4.6。头胸部长 1.9，宽 1.9；腹部长 2.7，宽 1.9。前眼列宽 1.7，后眼列宽 1.8，眼域长 1.1，额高 0.07，前中眼直径 0.37，前侧眼直径 0.18，后侧眼直径 0.18。背甲褐色，眼域色深，各眼基部、背甲边缘黑色；被白色及褐色细长毛，眼域两侧及前缘尚被有短的白色扁平状毛。胸甲椭圆状，褐色，中央稍隆起、灰黑色；被有黑褐色短毛。额褐色，前缘色深；被有暗褐色刷状毛。螯肢深褐色，端部色稍浅；被褐色毛；前齿堤 2 齿较短，后齿堤 1 齿。颚叶、下唇暗褐色，端部浅褐色具绒毛。下唇长条状，长明显大于宽。步足褐色，具浅色斑；足刺少，有少许白色短毛及褐色长毛。各步足量度如下：步足Ⅰ 缺，步足Ⅱ 3.25（1.1，1.2，0.55，0.4），步足Ⅲ 3.0（1.0，1.0，0.5，0.5），步足Ⅳ 3.8（1.25，1.35，0.7，0.5）。腹部卵形，背面灰褐色，被白色及褐色短毛；肌痕 3 对；两侧有 4 对由白毛覆盖而成的弧纹。腹部腹面深灰褐色。纺器褐色，被褐色毛。

新种与 *R. albigera*（C. L. Koch，1848）相似，但有以下区别：1）引导器长，弓状，远端尖细、呈针状；而后者的则粗短，指状；2）胫节突明显长于后者。

词源：新种种名来自其指状插入器。

分布：湖北。

湖北合跳蛛，新种 *Synagelides hubeiensis* Peng *et* Li，sp. nov.（图 15～19）

正模 ♂，P-295，湖北，地点不详。

正模体长 2.70。头胸部长 1.3，宽 0.95；腹部长 1.4，宽 0.95。后眼列宽 0.95，后眼列宽 1.00，眼域长 0.75，前中眼直径 0.33，前侧眼直径 0.18，后侧眼直径 0.2，额高 0.07。背甲褐色，覆盖有均匀的颗粒状小突起；毛稀少，仅各眼基部、眼域前部及两侧有白色细毛；背甲两侧几乎平行；背甲边缘、各眼基部、眼域两侧及前半黑色；中窝暗褐色，U 字状，凹陷深；颈沟、放射沟色深，颗粒状突起沿颈沟、放射沟呈辐射状排列。胸甲心形，前缘平截状、远宽于后缘，浅褐色，前半色稍深，后半边缘隐约可见 5 条深色放射状条纹。额褐色，前缘黑色，被稀疏的褐色及白色毛。螯肢细弱，灰褐色，前齿堤 2 小齿，后齿堤 1 齿。颚叶刀状，灰褐色，内缘浅黄褐色，被细的浅褐色毛。下唇宽大于长，深褐色，端部浅黄褐色，有褐色毛。步足浅黄色，前侧具有灰色纵条纹，毛稀少、短而细；胫节Ⅰ腹面有 3 对长刺，后跗节Ⅰ腹面有 2 对长刺，步足其余各节均无刺。各步足量度如下：步足Ⅰ 2.9（0.9，1.3，0.45，0.25），步足Ⅱ 2.1（0.65，0.75，0.45，0.25），步足Ⅲ 2.1（0.65，0.75，0.5，0.2），步足Ⅳ 2.15（1.0，1.1，0.75，0.3）。足式：1，4，3，2。腹部长卵形，毛极少而短。背面浅黄褐色，前端有 3 对浅色斑围以来黑边，中部有 2 条灰黑色弧形横纹；后端灰褐色，其上有 5 条细的浅色弧形横纹。腹部腹面黄白色，中央有 2 条宽的灰褐色纵带。纺器黄白色，围以黑色环纹，毛稀少而短。

新种与 *S. agoriformis* strand，1906 相似，但触肢器结构有以下区别：1）与插入器相伴的骨板结构复杂，腹面观可见多个角状突起，后者的未见明显的角状突；2）背面观新种跗舟背面中央有 1 锥状突；后者无；3）腹部背面的斑纹明显不同。

词源：新种的种名来自模式标本产地。

分布：湖北。

斑马合跳蛛，新种 *Synagelides zebrus* Peng *et* Li，sp. nov.（图 20～22）

正模 ♀，广西那坡县德孚保护区，海拔1 350 m，2000 年 6 月 18 日，CG065，陈军采。

正模体长 3.80。头胸部长 1.50，宽 1.10；腹部长 2.10，宽 1.10。前眼列宽 1.10，后眼列宽 1.15，眼域长 0.90，额高 0.05，前中眼直径 0.40，前侧眼直径 0.25，后侧眼直径 0.25。背甲褐色，两侧及后半部暗褐色，各眼基部、眼域两侧及前缘黑色；被有短的白色及褐色毛；整个背甲布满小颗粒状突起，中窝小，前凹，黑色，较深；颈沟，放射沟黑色，清晰可见。胸甲盾形，边缘光滑；黄褐色，边缘灰黑色，被有稀疏的灰黑色毛。额极狭，褐色，前缘灰黑色。螯肢黄褐色，前侧灰黑色，前齿堤 2 齿，后齿堤 1 齿。触肢、步足黄褐色，具灰黑色纵条纹；腿节Ⅰ的前、后侧、膝节的Ⅰ腹面灰黑色；其余步足各节（端部两节除外）两侧有长的灰黑色纵条纹；步足仅胫节Ⅰ及后跗节Ⅰ具刺，其中胫节Ⅰ腹面前侧具 4 根长刺，后侧 3 根，后跗节Ⅰ腹面 2 对；各步足量度如下：步足Ⅰ 3.45（1.05，1.85，0.30，0.25），步足Ⅱ 2.25（0.70，0.80，0.50，0.25），步足Ⅲ 2.55（0.70，0.95，0.60，0.30），步足Ⅳ 3.55（0.95，1.30，0.85，0.45）。足式：4，1，3，2。腹部筒状，背面浅黄褐色，两侧深灰色，中央有醒目的灰黑色横向弧形纹或波状纹；腹面两侧深灰色，中央黄灰色，具 2 条深色棒状纹。纺器灰褐色，被灰黑色长毛。

新种与 *S. annae* Bohdanowicz，1979 相似，但有以下区别：1）纳精囊近球形，长宽约相等；后者的则卵形，宽约为长的 2 倍；2）交媾管的缠绕方式远没有后者的复杂；3）腹部背面有醒目的斑马状横带。

词源：新种因腹部背面有醒目的斑马状横带而得名。

分布：广西。

带状合跳蛛，新种 *Synagelides zonatus* Peng *et* Li，sp. nov.（图 23～25）

正模 ♀，P-296，湖北应山溪丛，1984 年 7 月 1 日。

正模体长 4.6。头胸部长 1.6，宽 1.1；腹部长 2.8，宽 1.55。前眼列宽 1.1，后眼列宽 1.2，前中眼直径 0.37，前侧眼直径 0.2，后侧眼直径 0.2，眼域长 0.9，额高 0.03。背甲褐色，边缘、各眼基部及眼域前缘黑色，眼域后部及中央浅

褐色，布满褐色小颗粒状突起，被白色及褐色短毛；中窝黑褐色，弧状；颈沟、放射沟上覆盖有颗粒状突起及白色短毛。胸甲盾形，前缘宽而呈平截状；浅黄褐色，边缘深褐色；褐色毛稀少而短。额褐色，前缘色深；被稀疏的深褐色粗毛，前眼列宽、下方有白色短毛。螯肢浅褐色，前侧灰褐色；前齿堤2齿，后齿堤1齿，齿小而细弱。颚叶、下唇浅褐色，端部色浅有绒毛。触肢、步足褐色，前侧有灰黑色纵条纹；胫节Ⅰ腹面有4对长刺，后跗节Ⅰ腹面有2对长刺，步足其余各节均无刺。各步足量度如下：步足Ⅰ 3.75（1.05，1.6，0.4，0.25），步足Ⅱ 2.35（0.7，0.9，0.45，0.30），步足Ⅲ 2.5（0.7，0.9，0.6，0.3），步足Ⅳ 3.7（1.0，1.4，0.9，0.4）。足式：1，4，3，2。腹部长卵形，毛稀少而短。背面浅黄白色，斑纹灰黑色，肌痕2对；心脏斑长棒状；两侧灰黑色。纺器褐色，被褐色细毛。

新种与 *S. cavaleriei*（Schenkel，1963）相似，二者区别如下：1）纳精囊较狭；2）交媾管较短，缠绕简单，呈飘带状；3）生殖厣的中隔远短于后者。

词源：新种雌蛛交媾管较短，缠绕简单，呈飘带状，故名带状合跳蛛。

分布：湖北。

球状雅蛛，新种 ***Yaginumaella bulbosa*** **Peng，Li *et* Tang，sp. nov.**（图 26～28）

正模♂，P-294，湖北东园，1980年11月6日。

正模体长5.50。头胸部长2.5，宽1.90；腹部长2.7、宽1.70。前眼列宽1.7，后眼列宽1.6，眼域长1.0，前中眼直径0.56，前侧眼直径0.3，后侧眼直径0.3，额高0.13。背甲褐色，边缘、眼域两侧及前缘黑色；被白色及褐色短毛；中窝短、纵条状，赤褐色；颈沟、放射沟色深。胸甲盾形，中央隆起，边缘光滑；被褐色毛，中央浅黄褐色，边缘色深。额两侧浅黄褐色，被白色短毛；中央深褐色，被褐色长毛。螯肢褐色，被褐色长毛，前齿堤2齿，1大1小，后齿堤1大齿。颚叶外缘有大而深的缺刻。颚叶、下唇深褐色，端部黄褐色，有褐色绒毛。步足浅褐色，有深褐色轮纹，被褐色细毛；足刺短而多，胫节Ⅰ、Ⅱ腹面有刺3对，后跗节Ⅰ、Ⅱ腹面有刺2对。各步足量度如下：步足Ⅰ 5.5（1.7，2.2，1.0，0.6），步足Ⅱ 4.55（1.5，1.75，0.8，0.5），步足Ⅲ 5.05（1.65，1.7，1.0，0.7），步足Ⅳ 5.3（1.70，1.8，1.2，0.6）。足式：1，4，3，2。腹部卵形，前缘稍宽。背面灰褐色，被稀疏的褐色毛；心脏斑棒状；肌痕2对，赤褐色；两侧有3对大的灰黑斑，中央后端由6个弧形纹。腹面灰黄色，被深灰色细毛；中央隐约可见深灰色纵带，两侧散生灰黑色点状斑。纺器灰褐色，被灰黑色毛。

新种与 *Y. tenzingi* Zabka，1980相似，

但胫节突的形状明显不同，侧面观新种的胫节突端部弯向背侧、呈指状；后者则不弯曲，末端针尖状。

词源：新种因生殖球几乎呈球状。故名球状雅蛛。

分布：湖北。

关键词　跳蛛科，新种，分类学，中国.
中图分类号　Q959.226

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First description of the female of *Echinax panache* Deeleman-Reinhold, 2001 (Aranei: Corinnidae: Castianeirinae)

Первое описание самки *Echinax panache* Deeleman-Reinhold, 2001 (Aranei: Corinnidae: Castianeirinae)

Yuri M. Marusik[1], Guo Zheng[2] & Shuqiang Li[3]
Ю.М. Марусик[1], Г. Жень[2], Ш. Ли[3]

[1]Institute of Biological Problems of the North, RAS, Portovaya Str. 18, Magadan 685000 Russia. E-mail: yurmar@mail.ru
ИБПС ДВО РАН, Портовая 18, Магадан 685000 Россия.
[2]Shenyang Normal University, Shenyang 110034 P. R. China.
[3]Institute of Zoology, Chinese Academy of Sciences, Beijing 100101 P. R. China. E-mail: lisq@ioz.ac.cn

KEY WORDS: China, southeast Asia, spiders.
КЛЮЧЕВЫЕ СЛОВА: Китай, юго-восточная Азия, пауки.

ABSTRACT. The female of *Echinax panache* Deeleman-Reinhold, 2001 is described for the first time. Diagnostic figures for *E. panache* and sibling *E. oxyopoides* (Deeleman-Reinhold, 1995) are provided.

РЕЗЮМЕ. Приведено иллюстрированное описание ранее неизвестной самки *Echinax panache* Deeleman-Reinhold, 2001 и даны диагностические рисунки двух близких видов *E. panache* и *E. oxyopoides* (Deeleman-Reinhold, 1995).

Echinax Deeleman-Reinhold, 2001 is one of few non-ant mimicking Castianeirinae genera. It was recently established for *Copa oxyopodes* Deeleman-Reinhold, 1995 (Central Kalimantan and northern Sumatra) as the type species and three additional species *C. bosmansi* Deeleman-Reinhold, 1995 (northern Sulawesi), *C. javana* Deeleman-Reinhold, 1995 (East Java) and new species *E. panache* Deeleman-Reinhold, 2001 (northern Thailand) [Deeleman-Reinhold, 2001]. Soon after *E. oxyopoides* and *E. panache* were found in south China, Yunnan, as well as a new species, *E. anlongensis* Yang, Song & Zhu, 2004, from Guizhou Province [Yang et al., 2004]. Five species of *Echinax* now known [Platnick, 2008].

An extensive survey of spider fauna from Xishuangbanna rainforest in south Yunnan over a period of one year (June 2006 – August 2007) using various collection techniques, i.e., fogging, pitfall traps, trunk traps and direct searching, brought large and diverse material. Among the spiders collected were more than a dozen males and females of *Echinax.* Males were easily identified as *E. panache* because of a specific pattern, the characteristic shape of the male palp, and especially thick macrosetae (spines) on the cymbium. Because all the males belong to one species, and because the females have no variation in epigyne and are identical to the body pattern of males, we came to conclusion that these females belong to *E. panache,* whose females were not previously known. Therefore goals of this paper were first to describe the female female and to redescribe the male. When epigyne of this species was studied, we recognized that females illustrated by Yang et al. [2004] as *E. oxyopoides* in fact belong to *E. panache*. At present, only two species of *Echinax* are known in China.

Echinax panache Deeleman-Reinhold, 2001
Figs 1–9.

E. p. Deeleman-Reinhold, 2001: 365, f. 569–571 (D♂).
E. p.: Yang et al., 2004: 68, f. 2A–C (♂).
E. oxyopoides: Yang et al., 2004: 67, f. 1A–E (♀) [misidentification].

MATERIAL. Over 30 ♂♂ and ♀♀, China, Yunnan Province, Menglun Nature Reserve, 744 m, 21°57' N, 101°13' E; Xishuangbanna rainforest, 1 August, 2006 to 31 July, 2007 (G.Zheng and Z.Chen).

DESCRIPTION. Female. Total length 5.3. Carapace: 2.3 long, 1.88 wide. AME – 0.14. ALE – 0.10, PME – 0.11, PLE – 0.12. carapace yellow, with dark marginal stripes surrounded by light brown band formed by hairs, and dark long median stripe in posterior half. Two long light brown bands (formed by hairs) lying behind lateral eyes and two short coinciding light brown bands lying behind posterior median eyes. Width of light brown bands slightly thinner than submariginal light band. Abdomen yellow with brown — light brown pattern. Heart mark light, surrounded by dark band, heart mark is broken by transverse band. Anterior part of hear mark with most dark small spot. Legs yellow with

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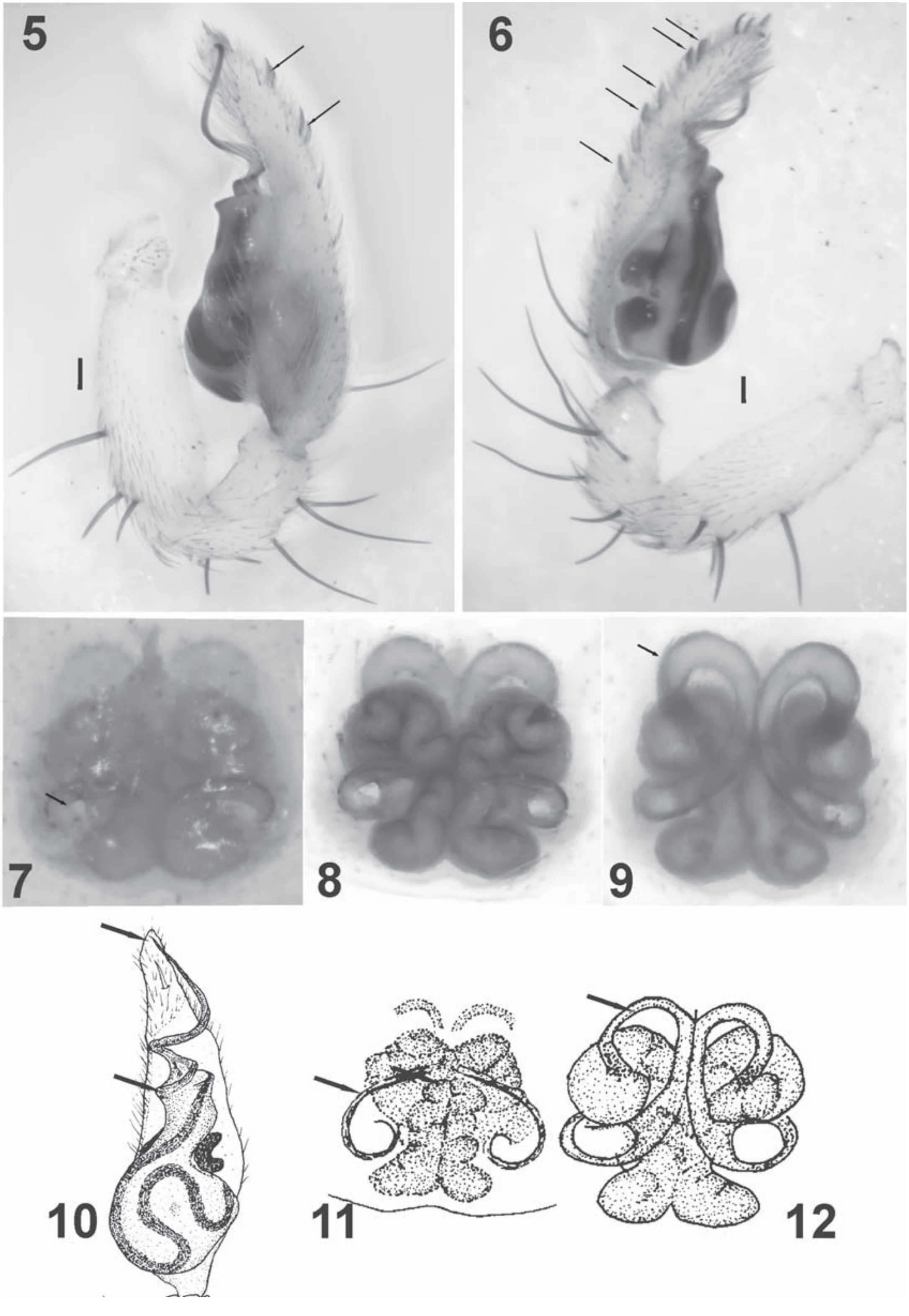
Figs 1–4. Male of *Echinax panache.* 1–2 — palp, ventral, different turns; 3 — habitus, dorsal; 4 — habitus, frontal. Scale: 1–2 — 0.1 mm, 3 — 1.0 mm. Arrows indicate differences between two species (cf. Figs 1–2 and 10).

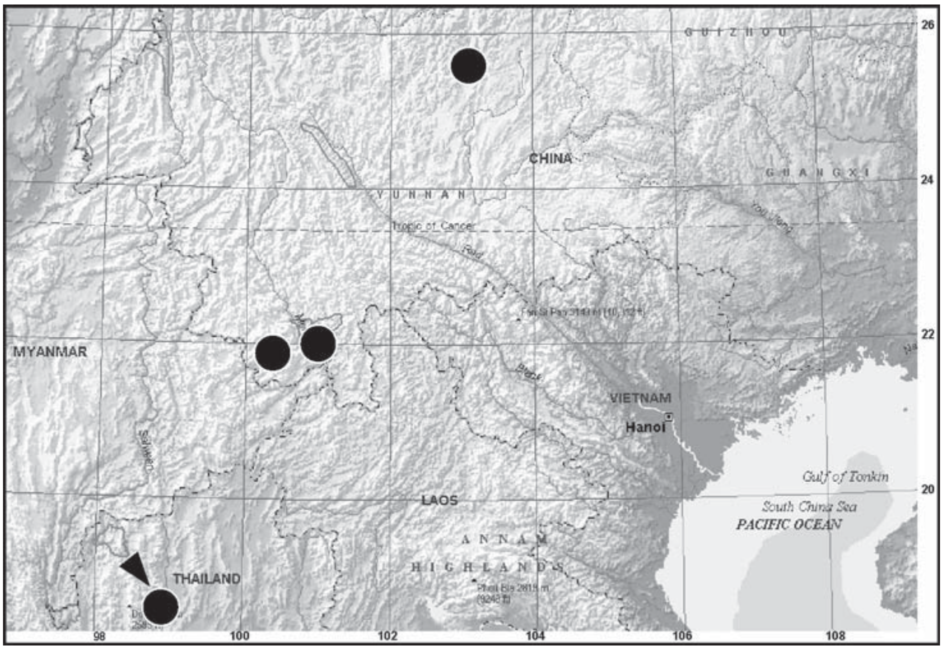
Рис. 1–4. Самец *Echinax panache.* 1–2 — пальпа, снизу, под разным углом; 3 — габитус, сверху; 4 — габитус, спереди. Масштаб: 1–2 — 0,1 мм, 3 — 1,0 мм. Стрелки указывают на отличительные признаки двух видов (ср. рис. 1–2 и 10).

few dorsal spots and rings Femora with 3 dorsal spines, femora I–III with 2prolateral and 2 retrolateral spines, femur IV with 2 prolateral and 1 retrolateral spines. Spines present on all legs joint except tarsi, their length exceed diameter of joints. Epigyne as in Figs 7–9, as long as wide, with two separate copulatory openings laced in basal 1/3of epigynal



Figs 5–12. Copulatory organs of *Echinax panache* (5–9) and *E. oxyopoides* (10–12). 5 — male palp, retrolateral; 6 — male palp, prolateral; 7, 11 — epigyne, ventral; 8 — epigyne after maceration, ventral; 9, 12 — epigyne, after maceration, dorsal. Scale in Figs 5–6 — 0.1 mm. Figs 10–12 after Deeleman-Reinhold (2001). Arrows indicate flattened spines on cymbium, and differences between two species.

Рис. 5–12. Копулятивные органы *Echinax panache* (5–9) и *E. oxyopoides* (10–12). 5 — пальпа самца, ретролатерально; 6 — пальпа самца, пролатерально; 7, 11 — эпигина, снизу; 8 — эпигина после мацерации, снизу; 9, 12 — эпигина после мацерации, сверху. Масштаб на рис. 5–6 — 0,1 мм. Рис. 10–12 по Deeleman-Reinhold (2001). Стрелки показывают уплощенные шипики цимбиума (5–6) и на отличительные признаки двух видов.



Map. Distribution records of *Echinax panache.* Triangle shows type locality.

Карта. Точки находок *Echinax panache.* Треугольник показывает типовое местообитание.

plate. Openings with sickle-shaped apical pocket. Edogyne formed by thin transparent insemination ducts and C-shaped receptacula, upper arm is larger than down. Receptaculum with long convoluted duct resembling a human brain's convolutions.

Leg joints length (♀).

	Femur	Patella	Tibia	Metatarsus	Tarsus
I	2.0	0.7	1.63	1.45	0.75
II	1.88	0.7	1.5	1.38	0.78
III	1.63	0.7	1.45	1.5	0.78
IV	2.25	0.8	2.83	2.3	0.8

Male. Total length 4.5. Carapace: 2.0 long, 1.58 wide. Coloration of male same as in female, but light-brown bands wider. Anterior half of abdomen with distinct lateral dark stripes.

Palp as in Figs 1–2, 5–6. Femur with 2 dorsal, 1 retro- and 1 prolateral spines, femur about 1.5 time shorter than cymbium. Patella short with 2 dorsal spines and 1 prolateral. Tibia short, equal in length to patella, with one dorsal and 2 prolateral spines. Tibial spines 2 times exceed diameter of tibia. Cymbium with one strong prolateral basal spine, and set of 7 dark flattened short dorsal spines arranged in 3 pars + one unpaired spine. Flattened spines easily lost. Bulbus typical for Castianeirinae, embolus makes two turns, apical turn two times higher than basal.

Leg joints length (♂).

	Femur	Patella	Tibia	Metatarsus	Tarsus
I	1.75	0.55	1.43	1.38	0.7
II	1.73	0.54	1.43	1.38	0.7
III	1.55	0.63	1.3	1.38	0.7
IV	1.88	0.6	1.75	1.88	0.78

DIAGNOSIS. *E. panache* is very similar to *E. oxyopoides* (Figs 10–12). Two species can be separated by body pattern and by the shape of copulatory organs. Male palp of *E. oxyopoides* has no flattened scales-spines on cymbium, has longer seminal duct, upper turn of which is not straight (straight in *E. panache*), and shorter apical turn of embolus. Upper turn of embolus of *E. panache* is round, while in *E. oxyopoides* it is straight. Female of *E. oxyopoides* has thinner and shorter insemination ducts and larger pockets.

COMMENTS. Because of similarity of females of two species, *E. oxyopoides* and *E. panache,* females of the latter species found in Yunnan were misidentified by Yang et al. [2004]. Specimens recorded by Yang et al. [2004] have been restudied.

DISTRIBUTION. So far this species is known from the northern Thailand and three localities in Yunnan Province of China (Map).

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北京幽灵蛛的附肢自残*

陈海峰[1,2]　陈　卫[3]　李枢强[1**]

1. 中国科学院动物研究所，北京 100101
2. 廊坊师范学院生命科学学院，河北 廊坊 065000
3. 首都师范大学生命科学院，北京 100037

摘　要　附肢自残是北京幽灵蛛（*Pholcus beijingensis* Zhu & Song, 1999）的习性之一。野外调查表明，约 20% 的个体至少失去 1 只步足；个体自残的发生率在 2 - 7 月间有显著的差异，同时第一对步足自残的比例最高（43.47%）；个体失去步足的比例随着年龄的增加而增加；左侧和右侧步足失去的比率接近（1.03:1）。野外调查发现，正在交配的个体与单独生活的个体相比，步足的完整性上并无显著差别。实验室研究表明，北京幽灵蛛附肢自残后没有再生现象。通过对自残幼体与非自残幼体的 3 龄与 4 龄龄期研究，发现各处理组间并无显著的差别。步足自残被认为是北京幽灵蛛在极端情况下的“避险策略”（Bet-hedging strategy）［动物学报 54（6）：998 - 1004，2008］。

关键词　北京幽灵蛛　附肢　自残　适合度　避险策略

Leg autotomy in *Pholcus beijingensis* (Araneae: Pholcidae)*

CHEN Hai-Feng[1,2], CHEN Wei[3], LI Shu-Qiang[1**]

1. Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China
2. College of Life Science, Langfang Teachers' College, Langfang 065000, Hebei, China
3. College of Life Science, Capital Normal University, Beijing 100037, China

Abstract　The occurrence and effects of appendage loss on fitness in spider *Pholcus beijingensis* (Araneae: Pholcidae) were studied. Leg loss was common in natural populations, with 20% of individuals surveyed were missing at least one leg, most commonly one of the anterior pair. The frequency of occurrence varied from month to month. Our results found that the first pair of legs may not be critical to the survival of pholcid spiders. In laboratory experiment, the individuals who lost leg (s) did not regenerate. Furthermore, juveniles with appendage loss had significantly reduced growth rates. Leg autotomy may reduce fitness of spiders, but it can avoid more significant loss of fitness such as death. Leg autotomy is likely a bet-hedging strategy for pholcid spiders [*Acta Zoologica Sinica* 54 (6): 998 - 1004, 2008].

Key words　*Pholcus beijingensis*, Appendage, Autotomy, Fitness, Bet-hedging strategy

附肢自残（Leg autotomy）是指个体在面临极端危险（例如逃脱捕食者）的情况下附肢与身体分离的现象。附肢自残不是附肢被外力“咬断”或“拉断”，而是自发的与身体分离的现象。实验表明，麻醉后的蜘蛛不能自残其附肢（Foelix，1982）。自残的部位一般是固定的，大多数蜘蛛位于基节和转节之间，也有在胫膝节或膝节上的。北京幽灵蛛自残的部位固定在基节和转节之间。

自残是动物界普遍的现象，两栖类（Wise and Jaeger，1998）、爬行类（Martin and Avery，1998）、软体动物（Louise，1989）等都有报道。节肢动物如昆虫纲动物（Carlberg，1994）、甲壳纲动物（Juanes and Smith，1995）和蛛形纲动物（Johnson and Jakob，1999；Roth and Roth，1984；Guffey，1998，1999）

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** 通讯作者（Corresponding author）.　E-mail：lisq@ioz.ac.cn

等，也有自残现象。步足自残在大部分蜘蛛种类中都是很普遍的现象（Roth and Roth，1984），步足的丧失率一般达到整个种群个体的5% - 20%（Foelix，1982）；而且因物种、年龄、性别和季节的不同而有很大差异，甚至达到30% - 40%（Brueseke et al.，2001；Dodson and Beck，1993）。如此高的丧失率暗示着自残引起的死亡率可能比较低，在强大的选择压力下迫使自残现象的发生。

附肢自残获得的益处是迅速且显而易见的，但付出的代价却长期且错综复杂。对于蜘蛛来说，自残对个体适合度的影响是益处（benefits）和代价（costs）的总和。益处包括分散捕食者的注意，在捕食者抓住身体的某部分时能够逃离（Arnold，1984），以及脱离网丝的缠绕（Johnson and Jakob，1999）等。代价则要扩展到很长的一个时期，包括移动性减弱和物理平衡性减弱，在以后面对捕食者时逃脱能力降低，在群体中的地位降低，需要耗费更多的能量用于再生失去的附肢，取食能力降低，交配的成功率降低，有时甚至会造成死亡等（Juanes and Smith，1995）。

自残在很多蜘蛛种类的高发生率暗示了其进化益处。在幽灵蛛科，步足长度相对其它科显著延长，是其体长的5 - 7倍；第一对步足显著长于其它3对步足，是最常用在触觉和感知上的附肢，在作用上近似于昆虫的触角，被认为是此类蜘蛛的重要感觉器官（Foelix，1982）。因此，幽灵蛛是研究自残现象的理想动物，本文对北京幽灵蛛（*Pholcus beijingensis*）的步足自残情况进行了6个月（2月至7月）的连续性调查，试图验证以下预测：（1）个体失去步足的比例将随着年龄的增加而增加；（2）由于第一对步足担任重要的感知功能，对蜘蛛来说，第一对步足最不愿意失去，因此失去的比例应该最小；（3）蜘蛛左右侧的步足在正常生活状态中没有对一侧的偏爱（比如右侧），因此左侧和右侧步足失去的比率应该是一样的；（4）自残可能带来生存能力的降低，因此野外调查正在交配的个体，应该比单独生活的个体具有8个步足的比例更大。

另外，为了验证北京幽灵蛛幼蛛自残的附肢能否再生，我们在室内分别进行了2 - 5龄蜘蛛步足再生和步足自残后生长情况的实验。

1 材料与方法

1.1 研究动物

北京幽灵蛛隶属于蜘蛛目幽灵蛛科，广泛分布于北京城郊及其临近的河北省部分地区（陈海峰、李枢强，2005）。北京幽灵蛛栖息在比较潮湿、阴暗的角落里，例如潮湿的石缝中以及洞穴的入口处等，捕食蝇蚊等昆虫。

1.2 研究方法

1.2.1 野外实验

2004年2月至7月对北京房山区和门头沟区的多处洞穴入口处进行标本采集和行为学观察，采集的蜘蛛分为成蛛、亚成蛛（4龄至6龄）和幼蛛（2龄至3龄），成蛛和亚成蛛按雌雄分别统计（亚成蛛室内饲养至成熟以后进一步验证雌雄）。所有蜘蛛做如下记录：采集日期、采集位点、步足数量、步足失去位置（按左、右侧以及第一、二、三、四对步足分类）。

采用Kruskal-Wallis H统计方法检验不同月份步足自残的个体数量是否有显著的不同。

因为蜘蛛有8条步足，验证步足的自残数目0，1，…，8的概率分布是否符合二项分布，如果服从二项分布，那么，可以认为不同步足的残缺事件之间是独立的，否则认为不同步足的残缺事件之间有关联。根据收集到的数据，可以通过加权平均求出蜘蛛的平均残缺步足数目E（X），令E（X）/ $n = p$，就可以用二项分布公式计算出p0，p1，…，p8，然后，用这些概率乘以总蜘蛛数 n，就得到相应的理论次数，然后用卡方分布进行拟合优度检验。

记录单独和正在交配中的个体的步足的数量。北京幽灵蛛的交配在网上进行，雄性用螯肢咬住雌性生殖器上方的突起部分，并同时将两触肢插入雌性的生殖腔。比较单独和交配的蜘蛛的步足数量，因为交配个体中步足发生过自残的样本数较少，我们将7足以及更少步足的个体编为一组，与八足的交配个体对比分析。采用Fisher精确检验分析分析单独（一个网上只有一头成熟的雄性或雌性）和正在交配的个体其步足自残情况是否不同。

1.2.2 室内实验

7个携卵的雌蛛在实验室饲养于长方体透明塑料盒内（130 mm × 85 mm × 50 mm），幼蛛孵化后，在雌蛛网上生活约3 - 6天，并蜕一次皮，成为二龄幼蛛。然后将二龄幼蛛分管饲养于玻璃指管内（直径40 mm，高120 mm），蜘蛛饲以黑腹果蝇（*Drosophila melanogaster*），一周两次，每次4 - 5只。实验室内温度22℃ ± 3℃，光周期15L:9D。在幼蛛第二次蜕皮，刚成为三龄幼蛛时，我们将幼蛛

分为三组：一组为早期自残组，一组为晚期自残组，一组为对照组。诱导自残参照 Johnson and Jakob（1999）的方法。早期自残组为幼蛛蜕皮后 3 天内诱导自残其第一步足的任意一个（$n = 32$），晚期自残组为幼蛛蜕皮后 6 - 8 天诱导自残其第一步足的任意一个（$n = 30$），对照组为完整附肢，在蜕皮 4 - 5 天后模拟进行上述诱导操作，没有发生自残（$n = 29$）。记录 3 龄和 4 龄的龄期。将这些幼蛛饲养至成体，以观察其再生情况。因为不同卵袋孵化的幼蛛生长率可能存在差别（Jakob and Dingle，1990），我们使用双因素方差分析（Two-way ANOVA）比较不同窝别（卵袋）和组在 3 龄和 4 龄龄期上的不同。

1.3 统计分析

数据在做进一步统计检验前，分别用 Kolmogorov-Smirnov 检验和 Bartlett 方法检验数据正态性和方差齐次性。统计分析方法前面已经叙述，由 SPSS 11.5 完成，显著性水平 $\alpha = 0.05$。文中的描述性统计值用平均值 ± 标准误表示。相关图表由 SPSS 或 Excel 绘制。

2 结 果

2.1 野外实验

调查显示大约 20% 的个体失去至少一条腿（表 1）。为了检验步足失去事件的独立性，零假设为步足失去事件是独立的，使用二项分布算出失去一个步足、两个步足等的期望概率（Johnson and Jakob，1999），进而算出期望数。由表 1 可以看出，低于 7 个步足的实际调查数要高于期望数，这说明步足失去事件不是独立的，个体可能一次不止失去一个步足，或者失去步足的个体比步足完整的个体更易于再次失去步足。雌雄个体发生特定数量的自残率没有显著的不同（卡方检验，$\chi^2 = 0.153$，$P = 0.997$），雄性与雌性的比例是 1.4∶1（$n = 305$）。

表 1 野外调查个体步足缺失情况

Table 1 Survey of missing legs in the field

	步足的数目 Number of legs					
	总计 Total	8	7	6	5	4
调查个体 Surveyed individuals	454	362（329.98）	56（107.41）	25（15.30）	8（1.24）	3（0.06）
百分比 Percentage（%）	100	79.74	12.33	5.51	1.76	0.66
雌 Female	127	101	14	8	3	1
雄 Male	178	140	20	11	5	2

括号内为期望值。

Expected values are in parentheses.

幼蛛自残率是 6.71%（$n = 149$），亚成体自残率是 14.3%（$n = 105$），成体自残率是 33.5%（$n = 200$），表明北京幽灵蛛随着年龄的增长个体失去附肢的比例越来越高（表 2）。各月调查的个体的步足数目有着显著的不同（Kruskal-Wallis H 检验，$\chi^2 = 22.778$，$P < 0.001$）（表 3）。

表 2 不同大小蜘蛛完整个体与缺足个体的比较

Table 2 Comparison of intact individuals and missing legs in different size

	蜘蛛大小 Spider size		
	成蛛 Adult	亚成蛛 Sub-adult	幼蛛 Larva
完整个体 Intact	133（159.5）	90（83.7）	139（118.8）
缺足个体 Mising legs	67（40.5）	15（21.3）	10（30.2）

括号内为期望值，卡方检验，$\chi^2 = 40.945$，$P < 0.001$。

Expected values are in parentheses, Chi-square Test, $\chi^2 = 40.945$, $P < 0.001$.

表 3 各个调查月份（2 - 7 月）的步足自残调查

Table 3 Leg number for *P. beijingensis* by month（Feb. to July）

月份 Month	数量 Number	平均值 Mean ± *SE*	百分比（%） Percentage
2	36	7.19（0.16）	25.3
3	104	7.65（0.08）	20.5
4	121	7.64（0.07）	20.1
5	68	7.68（0.09）	19.8
6	60	7.73（0.08）	18.9
7	65	7.80（0.07）	17.8

左侧步足和右侧步足的失去比例为 1.03∶1，没有显著差异（$\chi^2 = 0.028$，$P = 0.867$，$n = 142$）。北京幽灵蛛的 8 个步足失去的概率不等（$\chi^2 = 30.870$，$P < 0.001$），第一对步足更易于失去（图 1）。

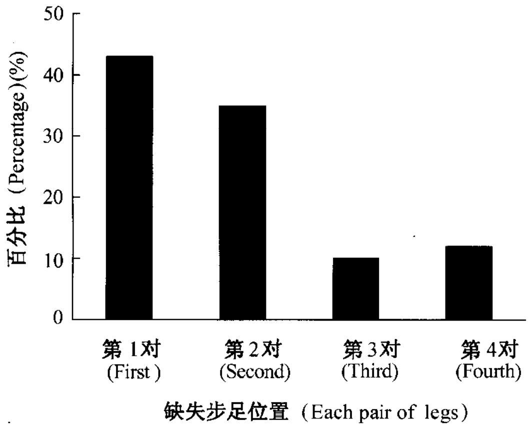

图1　野外调查北京幽灵蛛第1、2、3及4对步足自残的百分比

每一对步足的比率代表此对步足至少失去一个的个体比率。卡方检验，$\chi^2 = 30.870$，$P < 0.001$。

Fig.1　Percentage autotomy of four pairs of legs in *P. beijingensis* (Field observations)

The proportion of each pair of legs in *P. beijingensis* represents this pair missing at least one leg. Chi-square Test, $\chi^2 = 30.870$, $P < 0.001$.

交配姿势下的雄性与单独生活的雄性在步足缺失的数量上没有显著差异（Fisher精确检验，$P = 0.754$）；同样，交配姿势下的雌性与单独生活的雌性在步足缺失的数量上也没有显著差异（Fisher精确检验，$P = 0.296$）（表4）。交配姿势下的雌雄个体在步足缺失的数量上也没有显著差异（Fisher精确检验 $P = 1.000$）（表4）。

表4　野外正在交配的雌雄个体与单独的雌雄个体步足缺失情况比较

Table 4　A comparison of leg autotomy between mating and non-mating indivuduals of *P. beijingensis* (Field observations)

		步足数目 Number of legs		
		总计 Total	8足 Eight legs	<8足 < Eight legs
雄 Male	交配 Mating	14	10	5
	单独 Alone	38	27	11
雌 Female	交配 Mating	14	9	5
	单独 Alone	20	8	12

2.2　室内实验

对于3龄幼蛛来说，龄期有显著的组间效应（表5）。这个龄期也是诱导自残的龄期，多重比较表明，对照组的龄期显著短于早期自残组（Scheffe's $S = 1.477$，$P = 0.003$）或晚期自残组（Scheffe's $S = 1.35$，$P = 0.009$）（图2）。窝别之间没有显著的统计学意义，但组和窝别的交互作用有显著的统计学意义（表5）。

表5　三种不同处理及7个窝别的3龄、4龄以及3龄和4龄合并后的龄期分析

Table 5　The duration of the third and fourth instars and their combined duration for three treatments and seven families

龄期 Instar	效应 Effect	自由度 (*df*) Degree of freedom	*F*	*P*
3	组 Treatment	2	4.762	0.0115
	窝 Family	6	1.923	0.0890
	组×窝 Treatment × Family	12	1.999	0.0371
4	组 Treatment	2	3.456	0.0370
	窝 Family	6	3.548	0.0039
	组×窝 Treatment × Family	12	1.972	0.0400
3 – 4	组 Treatment	2	0.247	0.7818
	窝 Family	6	4.953	0.0003
	组×窝 Treatment × Family	12	1.813	0.0625

组为早期自残组，晚期自残组，对照组；窝为同一个卵袋孵出的幼蛛。数据来源于两因素方差分析结果。

Treatment include control, amputation early in third instar, amputation late in third instar, Family were Spiderlings hatched in a same clutche. The data based on Two-way of ANOVA.

对于4龄幼蛛来说，这个龄期也是诱导自残的下一个龄期，组间具有显著的统计学意义，对照组比其它两类自残组的龄期明显增长（图2），但多重比较没有显著的统计学意义（早期自残组：Scheffe's $S = 0.925$，$P = 0.117$；晚期自残组：Scheffe's $S = 0.874$，$P = 0.159$）。窝之间以及组与窝别的交互作用都有显著的统计学意义。

对3龄与4龄龄期之和做方差分析，结果表明组间没有显著的差别，但窝别之间有显著的统计学意义。

不管是早期自残组还是晚期自残组，所有人工诱导自残的幼蛛都没有显示再生其附肢的迹象，解剖镜下观察幼蛛的自残部位（基节末端）没有发现芽状物或者膨大现象，发生自残的个体直至其饲养到最后一次蜕皮即成熟后也没有再生。

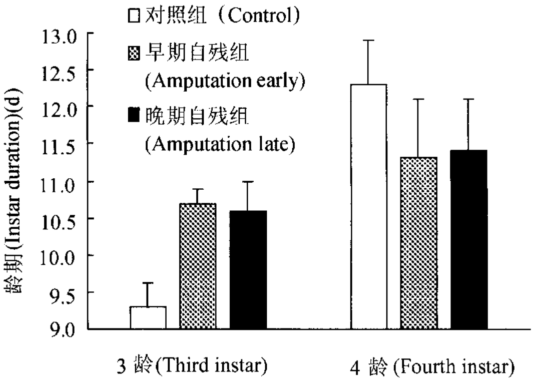

图2 北京幽灵蛛3龄和4龄的平均龄期（Mean ± *SE*）

Fig.2 Average duration（Mean ± *SE*）of the third and fourth instars in *P. beijingensis*

3 讨 论

3.1 几个预测的验证

针对第一个预测，野外调查表明，自然种群失去步足个体的比例随着年龄的增长而增长，这一方面由于随着个体年龄的增加，面对危险的机会增多，而且北京幽灵蛛的步足自残后不能再生，使自残的个体累积起来，导致自残步足的个体数越来越多；另一方面，据室内观察表明，北京幽灵蛛成体比幼体更为活跃，在群体生活中位于网的中央，常常为争夺食物和配偶而相互争斗，而幼体则较多处于静止状态，单独生活或群居生活中位于网的边缘，尽量避免与其它同种个体发生相互作用。因此，个体失去步足的比例随着年龄的增长而增加。

对于第二个预测，幽灵蛛的第一对步足是四对步足中最长的，也被认为包含着重要的感觉器官（Foelix，1982），在感知周围环境上起着重要的作用，在四对步足中应该是最重要的一对，因此北京幽灵蛛在自然选择的压力下应更不愿意失去这对步足。但野外调查表明，第一对步足反而最容易失去，当只有一只步足自残的情况下，失去的步足极可能是第一对步足中的一只。究其原因，主要是幽灵蛛最常使用第一对步足，又由于最长，在个体被干扰时这对步足最先伸出并移动，很容易被敌人（捕食者或种内竞争者）抓握或缠住，从而更容易失去。其它的蜘蛛种类以及一些甲壳类也有类似的现象（Juanes and Smith，1995；Dodson and Beck，1993；Uetz et al.，1996）。

对于第三个预测，虽然 Ades and Ramies（2002）对花皮蛛（*Scytodes globula*）的研究表明，这种蜘蛛在捕食和种内相互作用时偏爱使用左侧的步足，由于左侧使用频率较高，野外调查其步足自残率也是左侧步足高于右侧步足。不过，更多其它相关的研究则表明左侧和右侧自残的比率是相同的（Johnson and Jakob，1999；Brueseke et al.，2001；Guffey，1998），本文调查的结果表明左侧和右侧步足自残率没有显著差异。

对于第四个预测，我们认为野外调查中，正在交配的个体应比单独生活的个体更多地具有8个步足，并认为步足的数目在寻找配偶和性内竞争方面起着重要的作用。但结果表明交配个体和单独生活个体在步足数量上并没有显著的不同。由于例数太少，无法对失去两个步足以及多于两个步足的不同自残水平的个体做出比较分析（例如，8步足对6步足），但我们分析失去多个步足（≥2）的个体交配的概率很可能会降低，这些个体可能在如下的能力上减弱：(1) 由于移动性和感知能力的减弱，使其发现配偶的能力减弱；(2) 发现产卵和交配位点的能力减弱；(3) 性内冲突，特别是对配偶的竞争能力减弱。因此，步足自残现象对雌雄仍然可能使其潜在的适合度降低。

3.2 北京幽灵蛛附肢的再生及其对幼蛛发育时间的影响

北京幽灵蛛附肢自残后没有发现再生现象，这样就避免了用于再生的能量消耗。步足的失去可能影响捕捉猎物的能力，取食量减少会延缓发育（Jakob and Dingle，1990）。不过，第一对步足的一只自残后，同侧的第二对步足向前伸充当了第一步足的角色，北京幽灵蛛第二对步足的长度与第一对步足相似，都比第三和第四对步足显著延长，第二对步足的替代作用弥补了第一对步足的缺失。本实验研究的幼蛛是单独饲养的，未发现捕捉猎物（果蝇）的能力减弱。

在三龄幼蛛，无论是在该龄期的早期还是晚期诱导自残，都导致此龄期的延长（与对照组相比），不过在四龄时，自残的两组都比对照组的龄期短，导致两个龄期合并时三个组在生长率（两龄期之和）上没有显著的差别。自残的两组3龄的龄期比对照组长1.5天左右（图2）。北京幽灵蛛从二龄至最后一次蜕皮成熟的时间约在71天（食物丰富时）和98天（食物相对缺乏时）之间，相对于发育历期，虽然自残的两组在4龄龄期发育时间缩短以弥

补三龄的发育时间延长，自残对幼体发育时间上的效应仍然是相对较弱的。同样在野外，与步足自残相比，可以取食的猎物的多少将对个体发育时间的影响更大。因此，步足自残对个体发育时间延长的影响没有很强的选择效应。

3.3 自残的生态和理论上的进化意义

蜘蛛中的有些种类自残后会再生，但再生的附肢相对原先的附肢会短一些和细一些，步足上的一些感觉器官（如听毛，琴形器等）和修饰物常常没有再生（Foelix，1982；Vollrath，1995）。狼蛛（*Schizocosa ocreata*）雄性个体的第一步足有一毛刷似的第二性征，主要用于求偶和性内争斗时展示自己，但再生的步足上就没有，导致第一步足再生后的雄性向雌性求偶展示时，被雌性接受的可能性大为降低（Uetz et al.，1996）。由此可见，再生的步足能否完全代替原先的步足是值得怀疑的。北京幽灵蛛步足自残后没有再生的能力，与那些再生的种类相比孰优孰劣尚需进一步的研究，但至少不用将能量分配到附肢再生上，减少了额外的能量消耗。雄性成体的完整个体与自残个体之间对雌性的争斗在较低的水平上并没有显著的差异，在较为激烈的争斗中往往是完整个体取得胜利（Johnson and Jakob，1999），但竞争胜利者未必就一定增加了交配成功率。由于北京幽灵蛛营兼性群居生活，雌雄个体没有明显的领域性行为，经常从一个网上迁移到另一个网上，雌性个体的比例也没有很大的差别（1.4:1），幽灵蛛的雄性没有护雌行为（Blanchong et al.，1995），因此失败者可以寻找其它的雌性，或者呆在原先的网上等到胜利者交配完毕后再与雌性交配。雌性有多次交配的习性，对求偶的雄性的拒绝率非常低（只有4.18%）（陈海峰、李枢强，2005），因此失败者仍有极大的可能与其它雌性交配。从这一点来看，北京幽灵蛛自残的附肢不会再生有其进化上的适应意义。

生态上，避险策略（Bet-hedging strategy）是指通过降低个体的适合度来避免适合度的全部丧失（Boyce et al.，2002）。步足自残可能导致个体的感觉能力、运动能力以及遇到捕食者的逃脱能力降低，使个体适合度降低。北京幽灵蛛步足自残主要发生在种内对食物和空间的竞争以及反捕食的时候发生的，一方面避免了被捕食，短时间得到了求生的益处，但此后也要长期地为此付出代价。这正是避险策略在自残行为上的体现。

Guffey（1998）对盲蛛自残情况的研究中提出了“多余腿假说”（Spare legs hypothesis），指出盲蛛拥有足够多的腿，失去一个或少数几对并不会对个体的适合度产生影响。这个假说应用于北京幽灵蛛同样具有说服力。北京幽灵蛛自然情况下自残的高发生率、幼蛛自残一只第一步足后发育没有受到显著影响，说明完整步足的个体与失去一只或少数几只的个体之间没有显著的不同。但是，失去步足的数目超过一定数量后，自残个体的适合度可能会显著降低。由于野外失去多于2个步足的比例很小（2.42%），不会对整个种群产生大的选择压力。野外调查虽然有些数据很容易收集到（比如野外步足自残情况的频率），但这些结果又难于解释，如猎物的密度及其被捕食效率的影响、捕食者的密度及其捕食效率的影响、种群密度的影响等等（Medel et al.，1988）。因此，为了更好地定性自残对个体的影响，未来还需要进行更多的相关实验研究。

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