

A New Subgenus of *Rhithrogena* from China, with Description of a New Species (Ephemeroptera: Heptageniidae)

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Ann. Entomol. Soc. Am. 97(5): 898–902 (2004)

ABSTRACT Imagos of *Rhithrogena* (*Tumungula*) *unica* subgen. n., sp. n. from Yunnan and Guizhou provinces, China, have a series of unique characteristics. Male imagos have a hypertrophied foreclaw and a first tarsal segment ≈ 1.5 times the length of the second. The male styliger plate has two sharp projections, and the penis lobes are divergent without titillators but with spiny median lobes. Nymphal characters are those of the genus as presently defined: three caudal filaments and gills modified to form an adhesive disc.

KEY WORDS Ephemeroptera, Heptageniidae, *Rhithrogena*, new subgenus, China

THE FAMILY HEPTAGENIIDAE is the second largest family of Ephemeroptera in China, although You and Gui (1995) listed only 23 described species from this country. By comparison, 74 species are cited by Ishiwata (2001) in his revisionary checklist of mayflies of Japan, and Tshernova et al. (1986) keyed 45 species from the Russian Far East, a number that has declined slightly in recent years as new synonyms (Kluge 1995) outnumbered new species. Similarly, Soldán (2001) listed 114 species records from the Oriental Region with the caution that many of these are described from a single stage and may prove to be synonyms. The Chinese fauna is poorly known and only beginning to be studied seriously (Zhou and Zheng 2001, 2003, 2004). According to Soldán (2001) >120 species of *Rhithrogena* have been described, most from the Holarctic Region and only eight from the Oriental Region. There is a critical need for clear definitions of genera within the family Heptageniidae.

As presently defined, all heptageniid mayflies with three caudal filaments and nymphal gills modified to form an adhesive disc are included in the genus *Rhithrogena* Eaton (Edmunds and Waltz 1996, Tomka and Zurwerra 1985, Tshernova et al. 1986, Kluge 1988). In 2000 and 2001, 35 nymphs and 130 imagos and subimagos (95 males and 35 females) of a new species of Heptageniidae were collected from Yunnan and Guizhou provinces, China. Although fitting within the broad definition of *Rhithrogena*, several unique characters of the imago have prompted us to establish a new subgenus for the new species. The holotype and paratype specimens are deposited in Nanjing Normal University, China, except for two male and one female imagos, one female subimago, and two nymphal para-

types deposited in Florida A&M University, Tallahassee, FL.

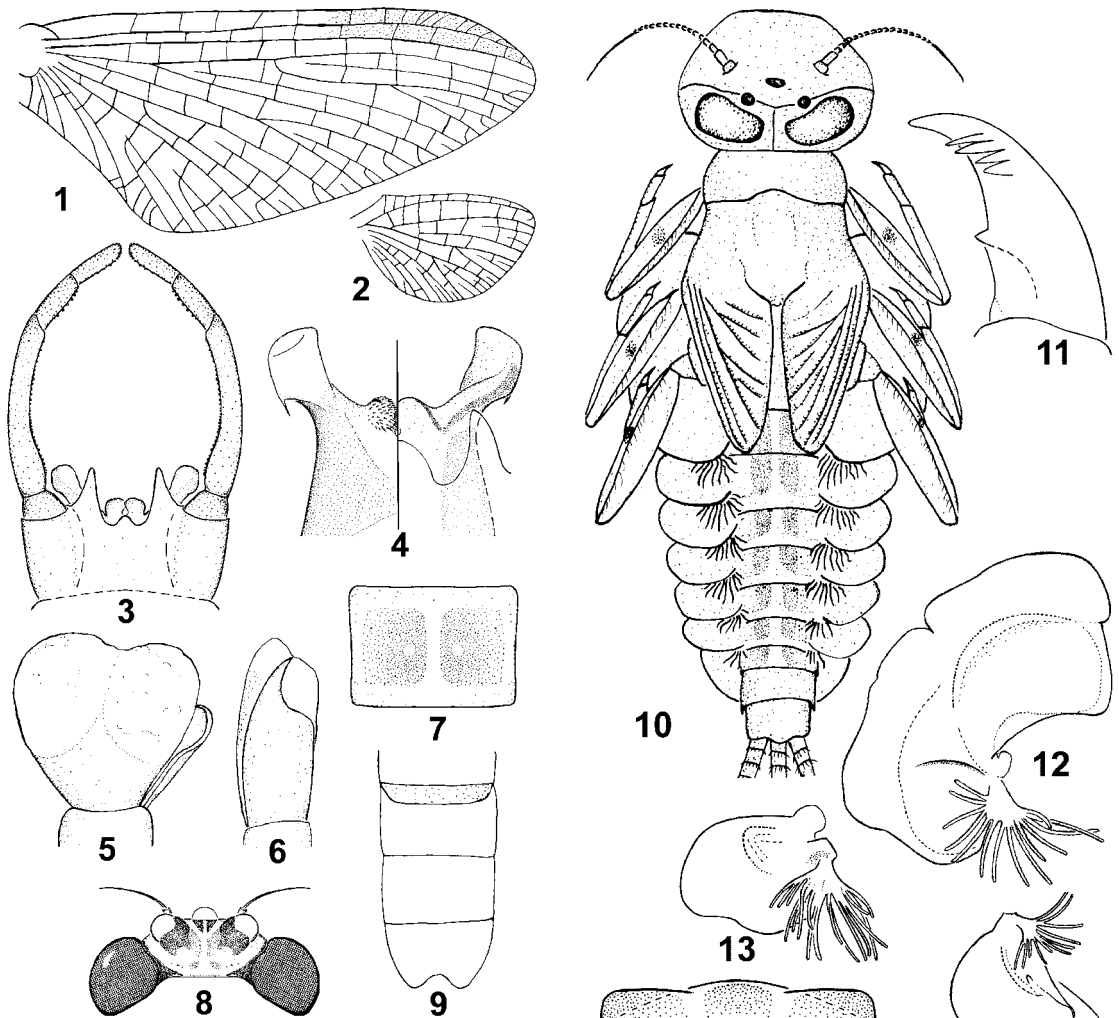
Rhithrogena (*Tumungula*) subgen. n. (Figs. 1–25)

Nymph. As in *Rhithrogena* (*Rhithrogena*) with three caudal filaments, gills modified to form adhesive disc, and other characters of the genus (Figs. 10–24); mandibles with lateral setae. Details given in the species description.

Imago. Compound eyes of male nearly contiguous dorsally, those of female separated by a distance about equal to width of an eye (Fig. 8). Mesonotum with transverse suture. Forelegs of male: femora shorter than tibiae, tibiae shorter than tarsi (ratios of femora: tibiae:tarsi, 1.0:1.6–1.7:2.4–2.5); first tarsal segment ≈ 1.5 times length of second and a little shorter than length of femur (ratios of foretarsal segments from basal to apical: 1.00:0.65–0.67: 0.53–0.56: 0.38–0.41: 0.13–0.17). Tibiae of mid- and hind legs of males and females with patella-tibial suture; tarsi much shorter than tibiae, ≈ 0.25 times length of tibiae. Male foreleg with unique two-part claw: one part hypertrophied, balloon-shaped with sclerotized base, the other small, blunt, plate-shaped (Figs. 5 and 25). Mid- and hind legs of male and all legs of female with pair of dissimilar claws, one acute and other blunt, pad-like (Fig. 6). Hind wing length ≈ 0.33 times forewing length; wing venation as in Figs. 1 and 2. Male genitalia: posterior margin of male styliger plate with a rounded median projection and acute sublateral projections (Figs. 3 and 4); forceps four-segmented, combined length of two apical segments slightly shorter than second segment (Fig. 3); penes sclerotized laterally; lobes divergent, without titillators, with dorsal spine at apex of each lobe; penes more membranous medially with pair of submedian lobes, each with small spines dorsally (Fig. 4). Sternum seven of female slightly expanded

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Figs. 1–9. *T. unica* sp. n., imagoes. (1) Male forewing. (2) Male hind wing. (3) Male genitalia, ventral view. (4) Male penes dorsal (left) and ventral (right). (5) Male foreclaw. (6) Claw of male middle leg. (7) Male tergum 2. (8) Female head. (9) Female sterna 7–9.

Fig. 10–15. *T. unica* sp. n., mature nymph. (10) Habitus. (11) Foreclaw. (12) Gill 1. (13) Gill 4. (14) Gill 7. (15) Abdominal sternum 1.

posteriorly; posterior extension of sternum 9 with median cleft (Fig. 9). Cerci of male a little more than twice length of body; those of female a little longer than body.

Etymology. Subgenus name *Tumungula* (feminine) from Latin prefix *tum* (expanded, swollen) and *ungula* (hoof), indicating the unique and hypertrophied foreclaws of the male.

Type Species. *Rhithrogena (Tumungula) unica* sp. n.

Diagnosis. Nymphs of *Rhithrogena (Tumungula)* subgen. n. cannot be distinguished from *Rhithrogena* (s.s.) as presently defined. Characters that may differentiate this subgenus include the combination of smooth gill margins with a small indentation and the presence of lateral setae on the mandibles. Tomka and Elpers (1991) erroneously considered the absence of lateral setae a defining character of the *Epeorus* and

Rhithrogena groups, but the character is so rarely described that its use for diagnosis of the genera and subgenera is unreliable. For example Ulmer (1940) (Fig. 467) illustrated lateral setae on the mandible of nymphal *Rhithrogena parva* (Ulmer 1912) from Sumatra (not associated with imagos), but setae were not mentioned by Kang and Yang (1994) for *Rhithrogena parva* from Taiwan. Also, marginal mandibular setae are present on some examined North American species [*Rhithrogena hageni* Eaton, 1885 and *Rhithrogena morrisoni* (Banks, 1924)].

The male imagoes of *Tumungula* subgen. n. can be distinguished from *Rhithrogena* s.s. by the following characters: 1) the basal segment of the foretarsus is ≈ 1.5 times longer than the second; 2) the foreclaw is

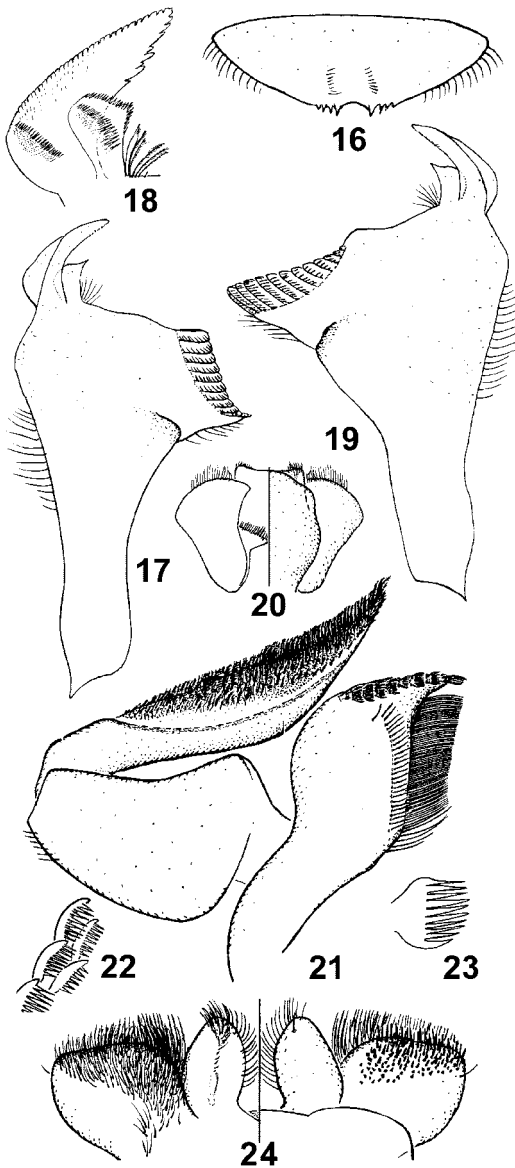


Fig. 16–24. *T. unica* sp. n., mature nymph. (16) Labrum. (17) Left mandible. (18) Ventral detail of incisors of right mandible. (19) Right mandible. (20) Hypopharynx dorsal (left) and ventral (right). (21) Maxilla. (22) Detail of setae on maxillary palp. (23) Detail of median seta from crown of maxilla. (24) Labial glossa and paraglossa dorsal (left) and ventral (right).

hypertrophied and balloon-shaped (Figs. 5 and 25); 3) the styliiger plate of the male possesses a rounded median projection and acute sublateral projections (Figs. 3 and 4); and 4) penes are divergent, without apparent titillators but with a pair of spiny median membranous lobes (Fig. 4). In species presently assigned to *Rhithrogena* s.s., the length of the basal tarsal segment ranges from 0.2 times to slightly shorter than

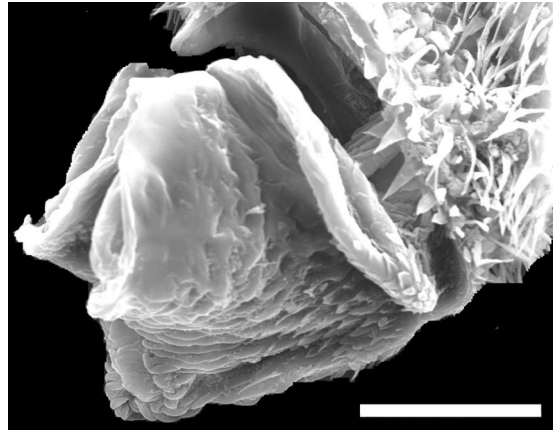


Fig. 25. Scanning electron micrograph of foreclaw of male imago. Bar, 30 μ m.

the second, and the foreclaws are variable but not hypertrophied (Kluge 1988). Compared with other species of *Rhithrogena* without titillators, the lateral lobes of the penes have a dorsal spine and are more expanded apically.

Discussion

Because of the long basal tarsal segment of the male forelegs and the lack of median titillators on the penes, *Tumungula* subgen. n. will key to *Epeorus* in many modern keys [Tomka and Zurwerra (1985), Edmunds and Waltz (1996) for North America; Bauernfeind and Humpesch (2001) for central Europe]. *Tumungula* will key to *Rhithrogena* in the key given by Kluge (1988) based on the presence of a transverse suture on the mesonotum and can be differentiated from *Rhithrogena* s.s. by all imaginal characters given in the diagnosis.

In the nonranking classification of Kluge (2004), the systematic position of *Tumungula* can be summarized as follows: *Rhithrogena*/fg1 (*Paegniodes* + *Epeorus*/fg1 + *Rhithrogena*/fg2 (*Cinygmula* + *Rhithrogena*/fg3 (*Rhithrogena*/fg4 + *Himalogena* + *Sibirigena* + *Epeiron*/g1 (*Epeiron*/g2 + *Tumungula*)))) (N. J. Kluge, personal communication).

The association between the nymph and male imago was based on the color pattern and details of external genitalia of two male subimagos dissected from two ultimate instar nymphs. Males and females were associated based on color pattern.

The illustrated male genitalia (Figs. 3 and 4) are taken from two paratype males to show variation, depending on the condition of the male and the angle of view. The male genitalia in Fig. 3 was drawn from a male that had apparently mated (sperm extruding from penis lobes), and the median lobes are more enlarged, the lateral lobes are more divergent, and the median lobe of the styliiger plate is curved dorsally. The male illustrated in Fig. 4 shows the more usual position of the penes from the dorsal and ventral

aspects with the outline of the margin of styliiger plate superimposed.

Tumungula subgen. n. has two unique characters for Heptageniidae. One is the presence of acute submedian projections on the styliiger plate (Figs. 3 and 4) that are substantially larger than those described for other any species in the family. The other is the hypertrophied foreclaw. Only males of the Australian genus *Coloburiscoides* (Coloburiscidae) have similar foreclaws (Peters and Campbell 1991), but their function is unknown. Because forelegs play important roles in mayfly mating flight (Brinck 1957), the hypertrophied foreclaws may be derived so that male legs cannot be detached easily from the wing bases of females.

Rhithrogena (*Tumungula*) *unica* sp. n.
(Figs. 1–25)

Mature Nymph (in Alcohol). Body length 7.0–9.0 mm, caudal filaments 6.5–8.5 mm. Head capsule gray dorsally with dark compound eyes, slightly wider than prothorax (Fig. 10). Antennae a little longer than width of head capsule. Entire margin of head capsule without setae. Mouthparts: labrum 0.3 times as wide as head capsule, with shallow median notch, short hair and spines on anterior margin, and two rows of submedian setae next to notch (Fig. 16). Mandibles: outer incisor much longer and stronger than inner incisor, margins serrated (Fig. 18), each with a row of bristles on inner surface (Figs. 17–19); protheca represented by approximately six to eight finely branched setae (Figs. 17–19). Maxillae (Fig. 21) with armature on crown of galea-lacinia consisting of eight to nine stout, pectinate, comb-like setae, median setae with up to 10 denticles (Fig. 23), lateral setae with only five to six; ventral surface of galea-lacinia with submedian row of setae, mesal margin with a row of dense setae; apical segment of maxillary palpi 1.7 times length of basal segment, basal segment expanded basally, apical segment pointed, covered ventrally with small, pectinate setae (Fig. 22). Labium with U-shaped separation between glossae, paraglossae moderately expanded laterally (Fig. 24); apical segment of palpi subequal in length to basal segment and with dorsal transverse row of bifurcate setae apically, palpi typical for *Rhithrogena* group (Kluge 1988). Hypopharynx with lingua truncate at apex, superlinguae slightly expanded laterally, row of short setae apically (Fig. 20). Thorax gray to brown. Femora of all legs with pale median area and a dark median macula (Fig. 10); surface with fine hairs and with scattered, mostly spatulate setae, a regular row of setae on outer margin. Claws of legs with large submedian denticle and three to four small apical denticles (Fig. 11). Terga of abdomen brown, with pale median line and posterior margins, submedian portions darker than others (Fig. 10); a row of strong and acute denticles on posterior margin of each tergum. Sternum one with anterior expansion to receive gills one (Fig. 15). Gills on abdominal segments 1–7, those on one and seven meet ventrally; gills one large, with smooth margins and few crenulations

(Fig. 12), gills seven folded with smooth margins (Fig. 14), gills 2–6 with oval lamellae and smooth margins with weak indentation (Fig. 13); all gills with well-developed fibrilliform portion (Figs. 10 and 12–14) and very small marginal setae. Three caudal filaments with whorls of minute spines at articulations, apical half of terminal filament with bilateral setae, cerci with mesal setae apically.

Male Imago (in Alcohol). Body length 9.0–10.0 mm, forewing 10.0 mm (Fig. 1), hind wing 3.0 mm (Fig. 2), cerci 24.0 mm. Vertex of head gray to brown, compound eyes gray to dark gray apically and darker basally. Pronotum with a pair of brown submedian longitudinal stripes; meso- and metanota uniformly yellowish brown to with a light brown wash on medioscutum, anterolateral margins of mesonotum dark brown; pleura and sterna of thorax pale. Forelegs 9.8 mm in length, femora yellowish to reddish brown, tibiae and tarsi pale, tibiae with brown apices. Tarsi of mid- and hind legs ≈ 0.25 times length of tibiae; the basal segment slightly longer than the second and about equal to the fifth, segments 2, 3, 4 subequal. Femora of all legs with distinct dark median macula somewhat basal to middle of femur. Terga 1–9 gray to pale brown, each tergum paler laterally and posteriorly with pale median line and pair of submedian brown to dark brown marks (Fig. 7); marks on terga 3–6 progressively smaller to sometimes indistinct, marks present on tergum seven and most extensive on tergum 8; each mark with a middle pale macula (Fig. 7); tergum nine with small median marks; tergum 10 pale, with indistinct submedian marks; spiracles and tracheae hyaline. Sterna pale. Male genitalia: basal segments of forceps light brown, apical segments a darker brown; penes brownish laterally, paler medially and apically, gonopore openings dorsal (Figs. 3 and 4). Cerci yellowish brown, with reddish line at articulations.

Female Imago (in Alcohol). Body length 7.0–9.0 mm, cerci 13.0 mm. Color pattern of head and thorax as in male. Median maculae of femora darker than those of male. Forelegs: ratios of femora:tibiae:tarsi, 1.8:2.7:1.2. Maculae and markings of abdominal terga 1–8 as in male but darker, tergum 9 with two small median brown maculae, tergum 10 pale.

Etymology. Adjective, *unicus*, Latin, referring to single, unique foreclaw of male.

Biology. Nymphs were collected with a hand net in strong current of streams and riffles of rivers with cobble substrates. Streams ranged in width from 2 m (Juhe River) to 10 m (Weiyuang River), and water depth was <50 cm at all collecting sites. The Jingsha River, located in a natural reserve, is in excellent condition, but the Changming River, located in an agricultural area, is somewhat impacted by agricultural runoff. Imagos and subimagos were attracted to blacklight (15-W fluorescent) at dusk.

Type Material. HOLOTYPE: 1 ♂, P. R. CHINA, YUNNAN PROV.: Jing-Gu Co., Weiyuang river, Feng-Shan (23.30° N, 100.41° E), 6-IV-2001, Chang-Fa Zhou (CFZ). PARATYPES: 17 ♂♂, 11 ♀♀, 2 ♂ subimagos, 2 ♀ subimagos, nine nymphs, same data as holotype,

6-IV/10-IV-2001; 1 ♂, 20 nymphs, Jing-Dong Co., Juhe river (24.26° N, 100.50° E), 12-IV-2001, CFZ; 15 ♂♂, 1 ♀, Jing-Dong Co., unnamed stream, Long-Jie, (24.26° N, 100.50° E), 12-IV-2001, CFZ. Except for one set of nymphal mouthparts and one foreclaw mounted on slides (Canada balsam) and the male foreclaw used for the scanning electron microscopy (Fig. 25), all specimens are in alcohol with associated, dissected parts in microvials.

Additional Material. 5 ♂♂, 8 ♀♀, Men-La Co., Nanla river, Men-Ban (21.29° N, 101.33° E), 28-III-2001, CFZ; 20 ♂♂, 10 ♀♀, Pu-Wen, Puwen river, Si-Mao City (22.48° N, 100.58° E), 4-IV-2001, CFZ; 30 ♂♂, 1 ♀, GHUIZHOU PROV.: Chishui Co., Jingsha river (altitude 250 m) (28.34° N, 105.42° E), 22-IX-2000, Chuan-Ren Li (CRL) and CFZ; 1 ♂, Guiding Co., Changming river, Changming village (altitude 1000 m), 9-IX-2000, CRL and CFZ; 3 ♂♂ and 2 ♀♀, Xishui Co., Tongming, unnamed river, Wuxing village, 28-IX-2000, Hai-Li Yu and CFZ.

Acknowledgments

We acknowledge N. J. Kluge (St. Petersburg State University, Russia) for advice and generous assistance. We also thank Gui Hong (Nanjing Normal University, China) and Zheng Le-Yi (Nankai University, China) for encouragement and comment on this study and the draft. We are indebted to M. D. Hubbard and B. A. Richard (Florida A&M University) for guidance and for critical review of the manuscript and to reviewers for the journal for very helpful comments. This work was supported by grant no. 30300037 awarded to C.-F.Z. from the National Natural Science Foundation of China.

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Received 9 January 2004; accepted 12 May 2004.