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Cladocera (Crustacea: Branchiopoda) of Vientiane province and municipality, Laos

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ABSTRACT

We present the first faunistic report on the Laotian Cladocera from diverse habitats in Vientiane province, Central Laos. We counted a total of 70 species, belonging to 37 genera, which is realistically close to an estimated 77 species. The five most common species were Diaphanosoma excisum*,* Ephemeroporus *cf.* barroisi*,* Anthalona harti*,* Macrothrix spinosa *and* Chydorus *cf.* eurynotus*. The fauna is typically Oriental/Southeast (SE) Asian, showing a strong similarity with neighbouring countries and especially Thailand. We discussed the current taxonomical status of the species and provided illustrations of the main taxa for future comparison. There are no surprising faunistic elements, except for a few new records for SE Asia* (Matralona freyi*,* Ilyocryptus thailandensis)*. Our data is preliminary, as the fauna of Laos remains insufficiently studied. As for SE Asia as a whole, a significant number of taxa is in need of taxonomical revision.*

Key words: Cladocera, Laos, SE Asia, diversity, taxonomy.

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INTRODUCTION

Taxonomy of the Cladocera (Crustacea: Branchiopoda) as well as many other groups of freshwater microscopic animals was in a very poor state during most of the 20th century, unjustly regarded by many hydrobiologists of that time as archaic and uninteresting (Korovchinsky, 1997). As a result, inadequate determinations compromised subsequent analysis of data dealing with studies at the species level (studies in ecology, biogeography, paleolimnology, *etc.*). Only in the 60-70s, the level of cladoceran taxonomy began to improve, following the pioneer efforts of David Frey and Nikolai N. Smirnov (Frey, 1959, 1973, 1982a, 1982b; Smirnov, 1966, 1971, 1976). As a result, we know about 700 valid species to date (Kotov, 2011), while at least 2/3-3/4 of the real cladoceran biodiversity is hidden (Adamowicz and Purvis, 2005; Forró *et al.,* 2008) and needs to be studied, *i.e.* formally described in a *descriptive* manner which is considered *irrelevant* by many recent journals. However, this work remains to be done and should be part of a large joint effort (*e.g.* Frey, 1987).

Groups in *tropical zooplankton* (including littoral animals), are now under intensive study by morphologists as well as geneticists. Studies of the biodiversity in the Western World almost exclusively concentrate on molecular methods, while the centres of the *traditional* morphological investigations have shifted to the developing countries, mainly Asia and Latin America. In taxonomical aspects, different tropical regions are studied to a very different extent. The best example is probably Mexico (Elías-Gutiérrez *et al*., 2006, 2008a, 2008b). At the same time, an insufficient level of study in the Oriental region leads to a situation where only 107 valid taxa have been reported, while in the Palaearctic the species number was estimated at about 2.5 times higher (Forró *et al*., 2008). The latter is unrealistic and it shows the need for continuous effort.

Among Southeast (SE) Asian countries, Thailand has been studied significantly better than others (Pholpunthin, 1997; Sanoamuang, 1998; Maiphae *et al.,* 2005, 2008). There were only a few publications concerning the Cladocera fauna of other countries (Tanaka and Ohtaka, 2010), sometimes outdated (Shirota, 1966; Thanh *et al.,* 1980). Korovchinsky (2013a) summarised the available information on the SE Asian cladocerans and concluded that among 297 formal species recorded from SE Asia, only 67 species could be regarded as *good*, while others are junior synonyms or taxa with unclear or/and unconfirmed status in SE Asia. We believe that the present volume (the FISA Proceedings), will significantly contribute to our knowledge on the SE Asian cladocerans, including new

papers by Korovchinsky (2013a) on the Cladocera of complete SE Asia, by Sinev and Korovchinsky (2013) about Vietnam, and by Van Damme *et al.* (2013) and Van Damme and Maiphae (2013) about new paludal chydorids of South Thailand. The focus of this particular work is situated in a country where faunistics of the cladocerans remained to be carried out.

Lao People's Democratic Republic (Laos) is a landlocked country in the centre of the Indochinese peninsula. The total human population is around 6.5 million, mostly distributed in the valleys of the Mekong river, where rice can be grown, because the dominant economy is represented by agriculture and subsistence farming with a few major urban centres (Wikipedia, 2013). The climate of Central Laos is tropical with a distinct wet season from June to October and a mostly dry season for the rest of year. In the hottest months of March and April, average temperature ranges from 30 to 38°C depending on location and altitude. Coolest temperature occurs between November and February and at higher elevations might average 15°C.

Not a single paper has been published that specifically focuses on the Cladocera of Laos. Heckman (1974) noted on the succession of zooplankton and other freshwater invertebrates in a rice field from Vientane province, Laos and included some cladocerans in his study; Silva-Briano *et al.* (2005) reported on 31 species in the central part of Laos, during a presentation of the 7th International Symposium on Cladocera; Ponthalith (2006) found 40 species in his Degree Thesis on Champasack province, but these results, or even lists, remained unpublished. Our aim is to make an inventory of the fauna of the cladocerans in Vientiane province, Central Laos.

METHODS

The main material for this study consists of 76 freshwater sample series (samples per water body on a particular date) collected qualitatively from 48 localities in the basin of Nam Ngum river and reservoir (about 250 km^2) in Viengkham (37 localities), Phohong (9 localities) and Keo Oudom (2 localities) districts of Vientiane province (Supplementary Tab. 1, Figs. 1-3). The samples were taken during dry (November to December, 2010) and rainy (June to July, 2011) seasons by SS (Fig. 3). The plankton net towed across the water over distances of 20 m or more for at least 20 times per sampling site; a dip net was used for collecting samples in the littoral zone, both nets have a mesh size of 60 μm. We tried to represent in the sampling different types of water bodies: swamps, lakes, ponds, roadside ditches, rice fields, rivers and dams (Fig. 2). Samples were preserved in 10% formalin and stored in 120 mL bottles.

We added 21 old samples to our material, previously collected in Vientiane municipality (3 samples), in Phohong (2 samples), Vangviang (2 samples) and Kasy (2 samples) districts (also Vientiane province) in 1999, and Vientiane municipality in 2004 (12 samples) sampled with a net of the same mesh size and preserved in formalin.

For determination, specimens were selected from samples under a binocular stereoscopic microscope, and studied under a compound optical microscope in a drop of a glycerol-formaldehyde mixture. Few females of each species (if possible) were dissected under a stereoscopic microscope for the study of appendages and postabdomen. Drawings were prepared using a camera lucida attached to a Olympus PM-10AD compound microscope (Olympus, Center Valley, PA, USA), and were made by MS-B and SS.

Some species were prepared for the scanning electron microscopic (SEM) study using the dehydration in a gradual series of alcohol (60, 70, 80, 90, 96, and 100%), changing the specimens in each concentration for 10 min, then kept in absolute alcohol for 24-48 h, then critical point dried in the TOUSIMIS chamber, mounted on aluminium stubs, coated with gold, and examined under a scanning electron microscope (JEOL LV-5900 and LEO 1450VP).

We used the computer package EstimateS (Colwell, 1997) to estimate species richness of the Cladocerans in the region. Separate tests were performed for all data, data of 2010-2011, and for rainy and dry seasons of 2010-2011.

RESULTS

Taxonomical account

We listed 70 taxa, belonging to 37 genera (Supplementary Tabs. 2-4). Comments on the taxa are represented below.

Order Ctenopoda Sars, 1865

Family Sididae Baird, 1850

Diaphanosoma Fischer, 1850. The three species that we identified here (*D. dubium*, *D. excisum* and *D. sarsi*) were expected in this country, as they are very characteristic of the SE Asian plankton (Korovchinsky, 2004, 2013a, 2013b). There were a few cases where we could not determine the exact species, because there were only a few juveniles in the sample. *Diaphanosoma excisum* and *D. sarsi* are species that are widely distributed in the Old World, while *D. dubium* is tropicopolitan, penetrating the North up to the Amur basin (Korovchinsky, 2004). Ponthalith (2006) also recorded *D. voltzi* Stingelin, 1905, *D. modigliani* Richard, 1894 and *D. senegal* Gauthier, 1951 in the Champasak province of Laos, 1951, but Korovchinsky (2013b), re-studying these samples, confirmed only the latter determination (as *D. senegal isanensis* Korovchinsky and Sanoamuang, 2008). While *D. voltzi* can be expected in Laos, considering its presence in neigh-

bouring Thailand, the occurrence of *D. modigliani* seems to be very dubious (Korovchinsky, 2013b). We also included a *Diaphanosoma* sp. in Supplementary Tabs. 2-4, which remains unidentified, and does not belong to previous species.

Latonopsis Sars, 1888. *Latonopsis australis* is a tropicopolitan, common and widely distributed species in SE Asia. In reality, it consists of a series of cryptic species (Korovchinsky, 2004), therefore the status of the Oriental populations needs to be revised.

Pseudosida Herrick, 1884. *Pseudosida szalayi* is a typical tropical taxon penetrating East Asia north up to

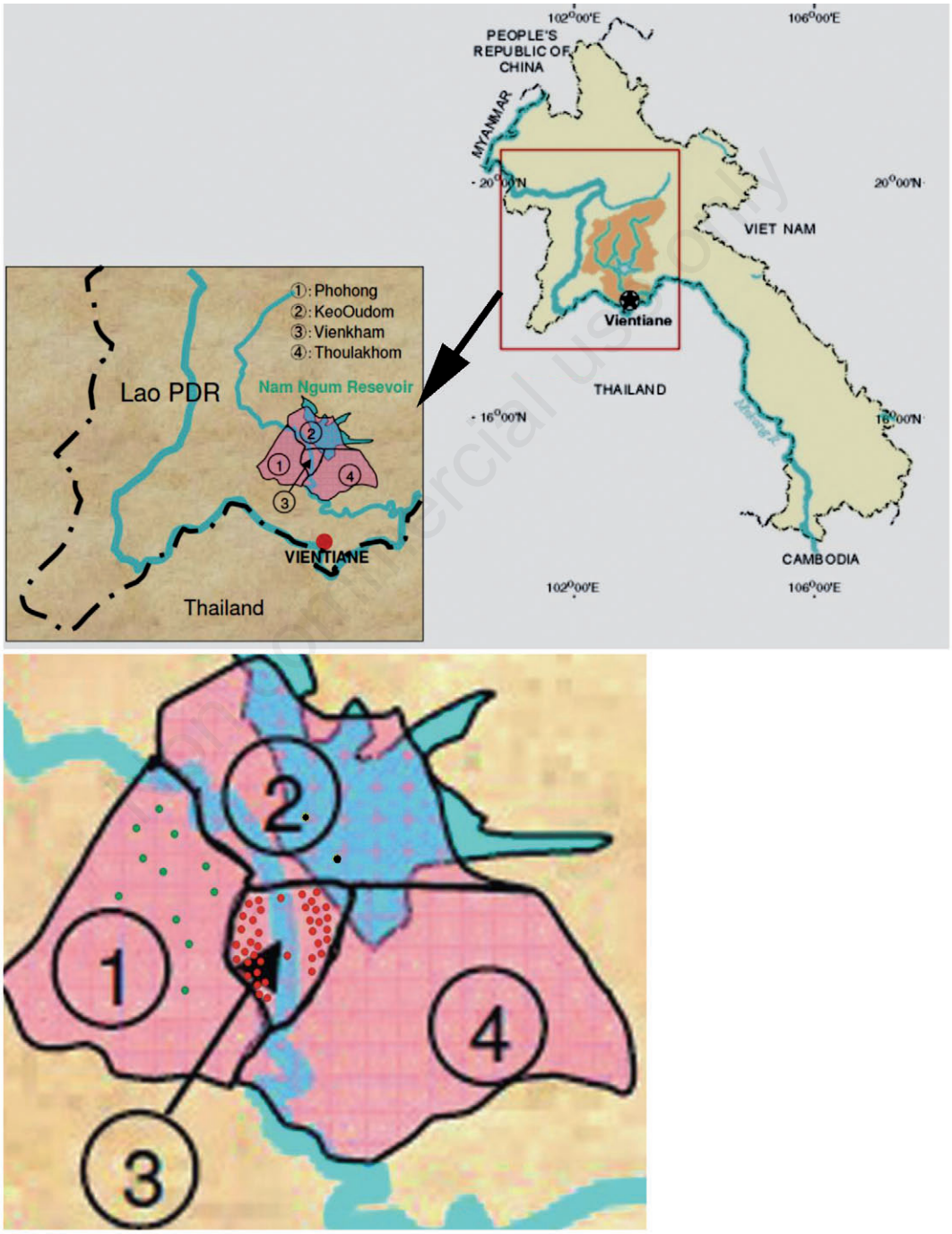

Fig. 1. Laos region where the main 76 samples were collected in 2010-2011: 9 sites in Phonhong district (1); 2 sites in Keo Oudom district (2); 37 sites in Viengkham district (3).

Korea and the Amur basin (Korovchinsky, 2010; Kotov *et al.*, 2012). It is present in all SE Asian countries (Korovchinsky, 2013a), sometimes misidentified as *P. bidentata* Herrick, 1888.

Order Anomopoda Sars, 1865

Family Daphniidae Straus, 1820

Ceriodaphnia Dana, 1853. Unfortunately, our species determinations (as most identifications of tropical *Ceriodaphnia*) can be regarded as preliminary, as the taxonomy of this genus is in a poor state. In particular with relation to *C. reticulata* and *C. laticaudata* (Kořínek, 2002), there are some difficulties. Korovchinsky (2013a) correctly concluded that there is not a single well-revised species of *Ceriodaphnia* in SE Asia. *Ceriodaphnia* cf. *cornuta* is a very common and widely distributed tropical-subtropical animal, however it is apparently a species group with significant (or complete) continental endemism (Berner, 1985; Elías-Gutiérrez *et al*., 2008a; Sharma and Kotov, 2013).

Daphnia O. F. Müller, 1785. We found only *D. lumholtzi* in Laos, which is also present in the surrounding countries. It is a tropical species of the Old World, aggressively occupying the New World (Havel and Hebert, 1993; Benzie, 2005). The taxon was described from Australia, and there is evidence that there are several species in this complex (Kořínek, 2002), an interesting question that could be addressed to in the future.

Scapholeberis Schödler, 1858. Only a single species, *S. kingi* was found, which is very common in East Asia, penetrating north up to Korea and the Amur basin (Kotov *et al.*, 2011, 2012).

Simocephalus Schödler, 1858. Among three species, *S. heilonjangensis* seems to be distributed in South Asia and Australia (Orlova-Bienkowskaja, 2001), while two others belong to widely distributed groups and need to be revised worldwide. Korovchinsky (2013a) listed also *S. mixtus* Sars, 1903 and *S. acutirostratus* (King, 1853) among the *good* SE Asian species, but we did not encounter them in our samples.

Family Moinidae Goulden, 1968

Moina Baird, 1850. The two species revealed here belong to widely distributed groups that need to be revised. *Moina dubia* was regarded by Smirnov (1976) as a subspecies of *M. micrura*. Indeed, *M. dubia* belongs to the *M. micrura* species group, and the tropical populations of the Old World normally bear somewhat larger teeth in the proximal pecten on the postabdominal claw when compared with the distal pecten, a diagnostic character. In reality, both species groups need to be revised worldwide.

Moinodaphnia Herrick, 1887. The genus is regarded as monotypical, although it is widely distributed in the tropics and subtropics of the Old and New World (Goulden, 1968), penetrating into non-tropical areas of Asia up to Korea (Kotov *et al.*, 2012). The genus needs to be revised worldwide.

Family Ilyocryptidae Smirnov, 1976* sensu *Smirnov, 1992

Ilyocryptus Sars, 1862. The two species revealed here are distributed in a very different manner. *Ilyocryptus spinifer* is a very characteristic and widely distributed tropicopolitan species (Kotov and Dumont, 2000) penetrating even very isolated archipelagoes (Schabetsberger *et al.*, 2009) and reaching the Amur basin and Korea (Kotov *et al.*, 2011, 2012) in the north. In contrast, *I. thailandensis* was previously known only from two close localities in North Thailand (Kotov and Sanoamuang, 2004b). Now we found the latter species in two localities about 300 km North East from the type locality and can say with confidence that i) this species is very rare and ii) it is more widely distributed in SE Asia than previously thought (with the initial information from the first description only).

Family Macrothricidae Norman & Brady, 1867

Grimaldina Richard, 1892. A monotypical genus, distributed in the tropics of Old and New World (Smirnov, 1976), originally described from D. R. Congo, Africa. It likely consists of a series of cryptic species but the SE Asian populations remain unrevised (H.J. Dumont, personal communication; Maiphae *et al.*, 2008).

Macrothrix Baird, 1843. We found four species, very characteristic for SE Asia. *Macrothrix odiosa* and *M. triserialis* are distributed in tropical and subtropical regions of Africa and Asia, including SE Asia (Dumont *et al*., 2002; Kotov *et al.,* 2005). While *M. odiosa* reaches Central Asia and even Armenia in the north, its penetration to the north is not so extensive in East Asia. In contrast, *M. triserialis* is present in Korea (Kotov *et al.,* 2012). Korovchinsky (2013a) places *M. flabelligera* Smirnov 1992 in the list of *good* species, but apparently these populations in SE Asia (not in Australia) belong to a special morphotype of *M. triserialis*, having additional spine-like setules on the segments of antenna II, in analogy with the South American *M. elegans* Sars, 1901 (Kotov *et al*., 2004). *Macrothrix vietnamensis* seems to be an endemic of the Oriental region. It was earlier misidentified as the Palaearctic *M. laticornis* (Jurine, 1820) (Silva-Briano *et al*., 1999). *Macrothrix spinosa* is a very common circumtropical taxon (Smirnov, 1976), occurring in isolated archipelagoes (Schabetsberger *et al.,* 2009) and likely forming a group of cryptic species.

Family Bosminidae Baird, 1845* sensu *Sars, 1865

Bosmina Baird, 1845. Only a single taxon of the sub-

Fig. 2. Different types of water bodies in Laos that were sampled during this study (dry season). A) Locality VTP01 - Nong Youp pond; B) locality VTP08 - Thaphoxay swamp 1; C) locality VTP11 - Phonekang South, pond; D) locality VTP14 - Nong Nork pond; E) locality 17 - Chenglong pond; F) locality 27 - Padook pond; G) locality 30 - North Napho rice field; H) locality 47 - Num Ngum dam 1.

genus *Bosmina* (*Liederobosmina*) Brtek, 1997 was found. It is traditionally determined as *B. meridionalis* (mainly present in Australia), although this is very superficial, considering the obvious problems in identifying liederobosminid females. Males are more informative (Kotov *et al.*, 2009), but they were never described for SE Asian populations. Only a global revision of the subgenus would make the identification of Asian liederobosminids more precise. *Bosmina* cf. *longirostris* (O. F. Müller, 1785) is recorded for other SE Asian countries (Korovchinsky, 2013a), and the same is true for *B.* (*Sinobosmina*) *fatalis* Burckhardt, 1924 (*e.g.* Maiphae *et al*., 2008), but we did not find these species in Laos.

Bosminopsis Richard, 1895. *Bosminopsis deitersi* is a tropicopolitan taxon, very common in tropics-subtropics of the Old and New World, yet penetrating north, even up to the Polar ring (Pirozhnikov, 1937). Preliminary molecular data suggest that this is a complex of species with a more restricted distribution, conforming to the non-cosmopolitanism concept (Frey, 1982a).

Family Chydoridae Dybowski & Grochowski, 1894 **emend.** ***Frey 1967***

Subfamily Aloninae Dybowski & Grochowski, 1894 **emend.** ***Frey, 1967***

Acroperus **Baird, 1843**

Acroperus cf. *harpae* (Baird, 1834). Representatives of the genus *Acroperus* are relatively rare in the tropics. Populations of the *A. harpae*-habitus are known from many regions, including some SE Asian countries (Korovchinsky, 2013a), but such populations need to be assessed as part of a worldwide revision. The presence of *A. harpae* s.str. in tropical regions is doubtful (Chatterjee *et al.*, 2013), yet according to Sinev (2009), the populations of neighbouring Thailand are phenotypically identical to the Palaearctic species.

Alona **Baird, 1843**

Alona cf. *affinis* Leydig, 1860. (Fig. 4A-C). Described from the Palaearctic, worldwide records of *A. affinis* in fact belong to a number of species, but the Oriental populations remain unrevised. Sinev (1997) evaluated the Australian populations, describing a number of new species (*e.g. A. elliptica* Sinev, 1997; Van Damme *et al*., 2011); still, SE Asian populations should be compared with both Palaearctic and Australian species in detail since SE Asian forms can represent other taxa. The Laos specimens do belong to the *A. affinis* complex, but the limb morphology remains to be analysed. Notes on the SE Asian populations shown in Maiphae's PhD thesis (2005), suggest that this is not *A. affinis sensu stricto*, but a revision is necessary.

Alona cambouei de Guerne & Richard, 1893 (Fig. 5). This is a species originally described from Madagascar (de Guerne & Richard, 1893), but with a wide distribution in Africa and Asia (Sinev, 2001). It is very close to *A. pulchella*, which is an Australian species, but *A. cambouei* has disconnected head pores (Sinev, 2001). Both are on record in SE Asia yet *A. pulchella* and *A. cambouei* are often mentioned and also often confused (*e.g.* Maiphae *et al.*, 2008; Korovchinsky, 2013a). In fact, it remains to be sorted out in detail whether the SE Asian *A. cambouei* is truly identical to the populations from Madagascar.

Alona cf. *costata* Sars, 1862 (Fig. 4D-G). Species complex, with *A. costata* – a Palaearctic species (Sinev, 2008) –, yet with a number of siblings worldwide. Records in SE Asia need to be revised, but the SE boundary of the distribution of genuine *A. costata* is unknown. In southern China, it seems that real *A. costata* is present (Van Damme, personal observation). Close, similar species in the Australasian region, such as *A. setigera* or *A. cheni* (Sinev, 1999), could be confused with *A. costata*. However, Laotian populations are closer to *A. costata* (yet not necessarily conspecific) instead of showing affinities to *A. setigera* or *A. cheni*.

Alona cf. *guttata* Sars, 1862 (Fig. 4H-J). Originally a Palaearctic species, and populations outside the region should be revised (Van Damme and Dumont, 2008a). In SE Asia, this should be done especially in comparison to *Alona clathrata* Sars, 1888, which is the yet unrevised Australian member of the *A. guttata* species complex, as well as in comparison to the real *A. guttata* from the Palaearctic.

Alona kotovi Sinev, 2012. Described from Vietnam as the SE Asian sibling species of *A. quadrangularis* (O. F. Müller, 1776); most *A. quadrangularis* records from the region likely refer to *A. kotovi,* yet these populations need to be revised in detail and compared to both *A. quadrangularis* s. str., which is a Palaearctic species (Van Damme and Dumont, 2008a) and *A. kotovi*, its SE Asian sibling (Sinev, 2012).

Alona sarasinorum Stingelin, 1900. A peculiar euryhaline species that is endemic to the Oriental region and only sporadically mentioned from the neighbouring areas (*e.g*. Thailand: Maiphae *et al.*, 2008). The taxon is revised in a separate study in this special volume (Van Damme and Maiphae, 2013).

Alona siamensis Sinev & Sanoamuang, 2007. A species described from Thailand to replace the SE Asian records of *Alona dentifera* (Sars, 1901) (Sinev and Sanoamuang, 2007); it is actually a *Coronatella* (Van Damme and Dumont, 2008a), but the species still needs to be formally removed from *Alona.* It is a species that can be expected in Laos, as it occurs in the neighbouring countries, and the former Oriental records of *A. dentifera* now refer to *A. siamensis*.

Fig. 3. Differences between some localities in Laos during the dry (left) and wet (right) season. A,B) Locality VTP05 - Nong Khouy Lake 1; C,D) locality VTP21 - Nong Someseng swamp; E,F) locality VTP43 - South Napho river; G,H) locality VTP44 - Nam Cheng river.

Anthalona Van Damme, Sinev & Dumont, 2011

Anthalona harti harti Van Damme, Sinev & Dumont, 2011 (Figs. 4K, 4L and 6) This species was originally described from South Africa and it was supposed that *distribution most likely extends to East Africa and Mediterranean* (Van Damme *et al.,* 2011). Shortly after, *A. harti* was also found in SE Asia: Thailand, Vietnam and Cambodia (Sinev and Kotov, 2012; Van Damme *et al.*, 2013). The species seems to be widely distributed, common in the tropics and subtropics of Africa and Asia. In Indochina, *A. harti* is the most common species of the genus (Sinev and Kotov, 2012). At the same time, earlier

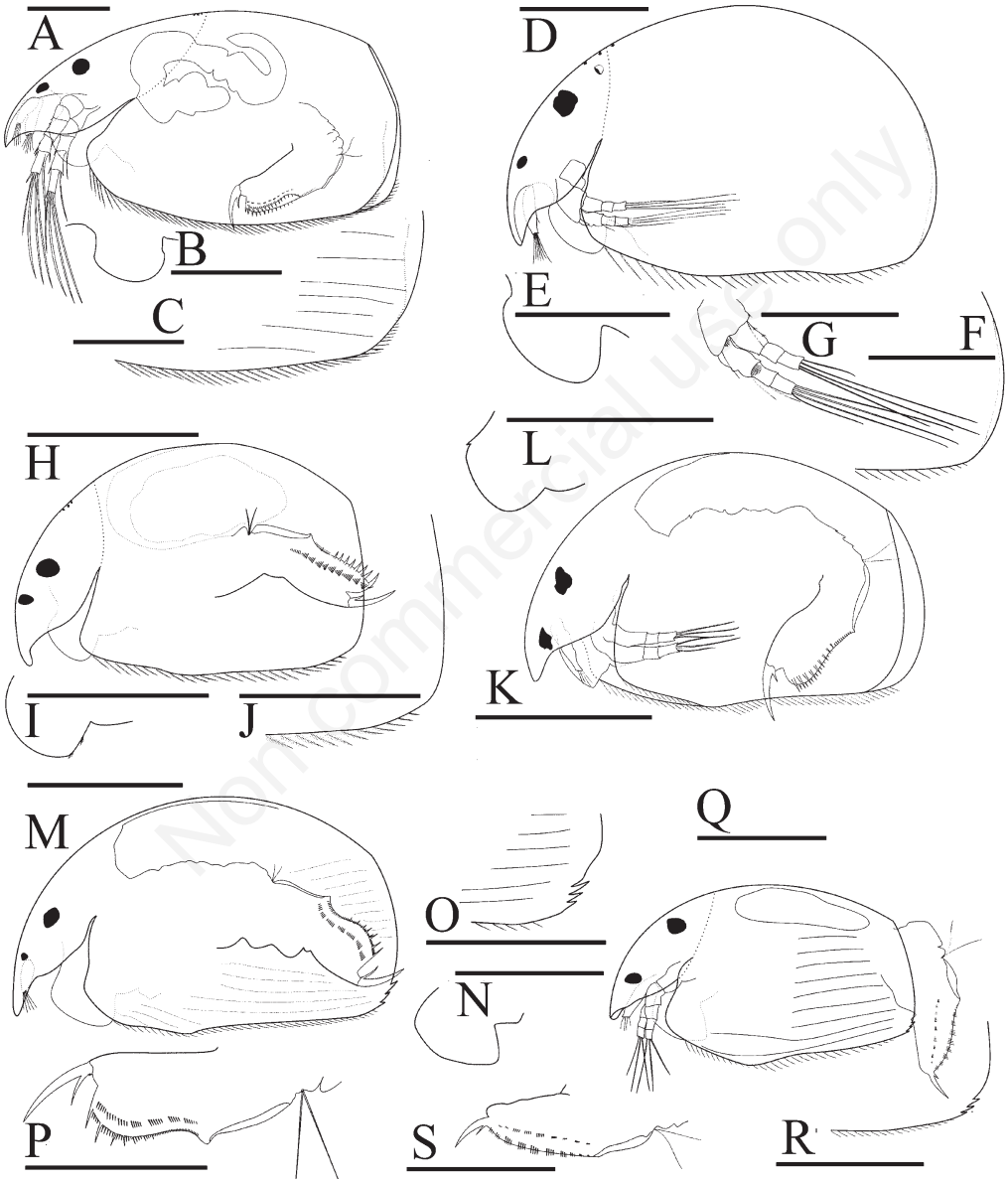

Fig. 4. Aloninae from Vientiane province, Laos. A-C) *Alona* cf. *affinis* from Nam Cheng in Napho village, adult in general view, labrum and postero-ventral valve portion; D-G) *Alona* cf. *costata* from Hongkang (South Napho village), adult in general view; labral keel, postero-ventral valve portion and antenna II; H-J) *Alona* cf. *guttata* from Nong Samkha in Viengkham district, lateral view of adult, labral keel and postero-ventral portion of valve; K-L) *Anthalona harti* from Houyphai (roadside channel) in Viengkham district, adult in general view and labral keel; M-P) *Coronatella* cf. *monacantha* from Nam Ngum dam, adult female in general view, labral keel, postabdomen and postero-ventral portion of valve; Q-S) *Coronatella* cf. *monacantha* from rice field at Phonehong village, adult male, labral keel, postero-ventral valve portion and postabdomen. Scale bars: 0.1 mm.

determinations of *A. verrucosa* (Sars, 1901) from SE Asia can be regarded as misidentifications.

Anthalona sanoamuangae Sinev and Kotov, 2012. Described from the Mekong river basin in Thailand and South Vietnam (Sinev and Kotov, 2012). The presence of this rare SE Asian species in Laos was expected. At this moment, the taxon seems to be restricted to the Indochina peninsula.

Camptocercus Baird, 1843

Camptocercus vietnamensis Thanh, 1980. This species was previously known from North and South Vietnam (Thanh *et al*., 1980; Sinev, 2011), yet it was later shown to have a wider distribution in East Asia, occuring up to South Korea (Kotov *et al.,* 2012). Previous records of *C. australis* Sars, 1896 and *C. uncinatus* Smirnov, 1971 (Korovchinsky, 2013a) in SE Asia can be at least partially attributed to this species.

Celsinotum Frey, 1991

Celsinotum macronyx (Daday, 1898). It is the only Oriental species in this predominantly Australian genus. *Celsinotum macronyx* was originally described from Sri

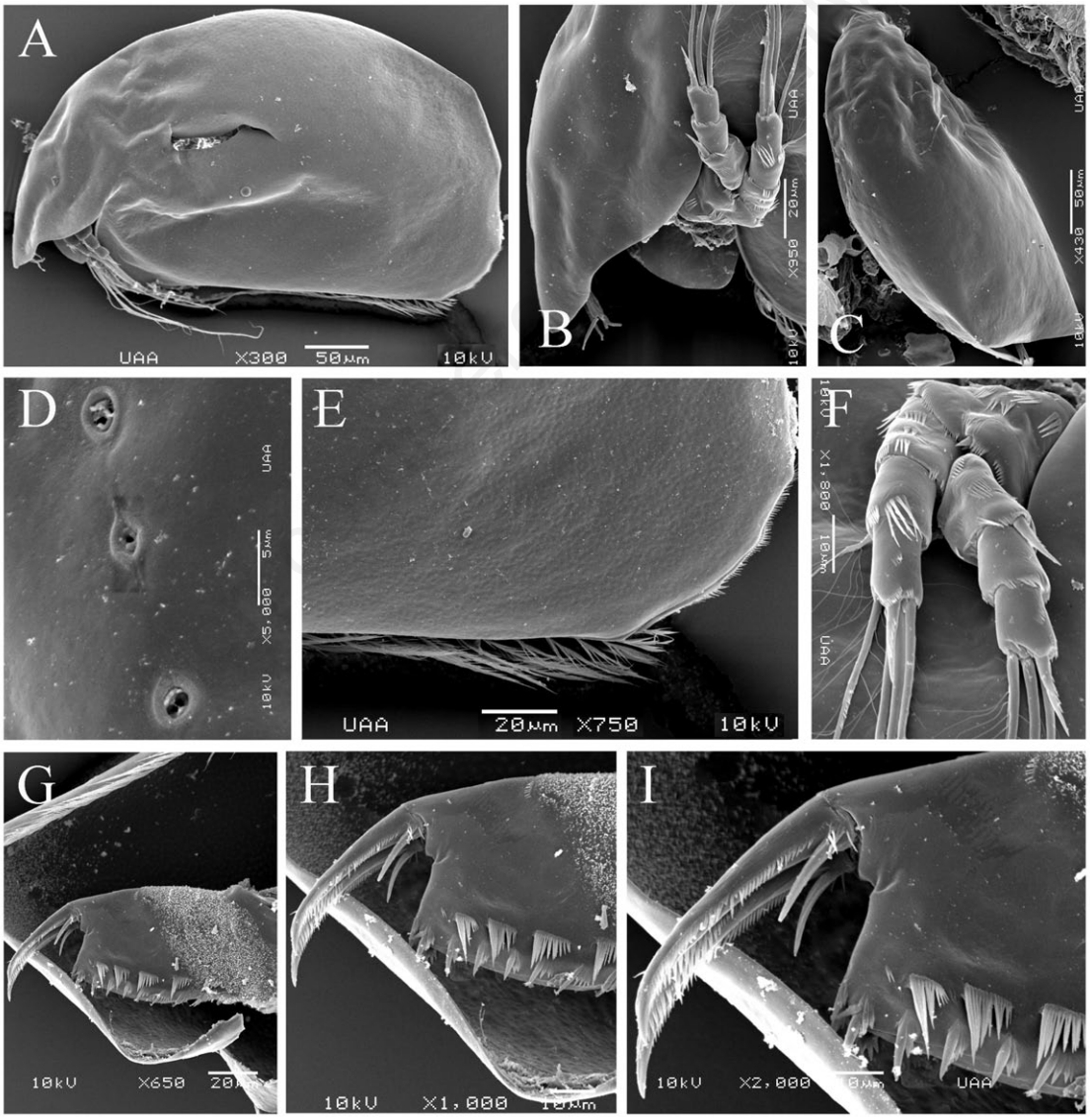

Fig. 5. Scanning electron microscopy of *Alona cambouei*, parthenogenetic female from LV09 - Ban Hua Chang roadside canal, Vientiane municipality, Laos. A) General view; B) head, lateral view; C) dorsal view; D) head pores; E) postero-ventral valve portion; F) antenna II; G-I) postabdomen.

Lanka and allocated to the genus *Alona* (Daday, 1898), subsequently placed in *Indialona* (Smirnov, 1971), then returned to *Alona* (Rajapaksa and Fernando, 1985, 1987a), and now moved to *Celsinotum* (Sinev and Kotov, 2012). It occurs in the surrounding regions, yet it is not common (Sinev and Kotov, 2012; Van Damme *et al*., 2013).

Coronatella Dybowski & Grochowski, 1894

Coronatella cf. *monacantha* (Sars, 1901) (Fig. 4M-S). It was described from South America (Sars, 1901), and placed in the genus *Alona,* and then moved to *Coronatella* (Van Damme and Dumont, 2008a). *Coronatella monacantha* s.str. most likely is an exclusively Neotropical taxon. Some authors (Sinev, 2004; Van Damme *et al*., 2010, 2013) have suggested that the SE Asian *C.* cf. *monacantha* likely is *C. acuticostata* (Sars, 1903), the taxonomic status of which should be clarified in future revisions.

Coronatella cf. *rectangula* (Sars, 1862). The *rectangula*-like populations need to be revised worldwide, as this is one of the most complex taxa in the Aloninae (Van Damme and Dumont, 2008b; Van Damme *et al*., 2010).

Coronatella sp. (Fig. 7A and 7B). This is an undescribed species, but we only had a single specimen, insufficient for adequate description. The Laotian specimen is identical to *Coronatella* sp. in Sinev and Kotov (2012).

Euryalona Sars, 1901

Euryalona orientalis (Daday, 1898) (Figs. 7C-G and 8). It is a very characteristic circumtropical genus and species, which needs to be revised worldwide. *Euryalona orientalis* is common in the SE Asian countries (Rajapaksa and Fernando, 1987b; Korovchinsky, 2013a). The morphology of *E. orientalis* is now discussed by Van Damme and Maiphae (2013), who suggest that it likely is a species complex.

Karualona Dumont & Silva-Briano, 2000

Karualona cf. *iberica* (Alonso & Pretus, 1989). Apparently, some populations of *Karualona* resemble *K. iberica*, which was originally described from Spain (Alonso and Pretus, 1989) and then also recorded in SE Asia (Maiphae *et al*., 2005, 2008; Van Damme *et al.,* 2013). It could be either a species widely distributed in the tropics-subtropics of Asia, or just confused with *K.* cf. *karua* (see below) (Van Damme *et al.,* 2013),

Karualona cf. *karua* (King, 1853) (Figs. 7H-L, 9 and 10). *Karualona karua* is a very common tropical-subtropical species originally described from Australia (King, 1853), but it probably consists of a series of cryptic species; Van Damme *et al*. (2013) illustrated different morphotypes in South Thailand. We also found at least two morphotypes, which could be different species. The two morphotypes differ in: i) shape and distance of the teeth on the postero-ventral valve margin [thin and spacely located (Fig. 9F) *vs* thick and closely located (Fig. 10C)]; ii) shape of the distal margin of the postabdomen

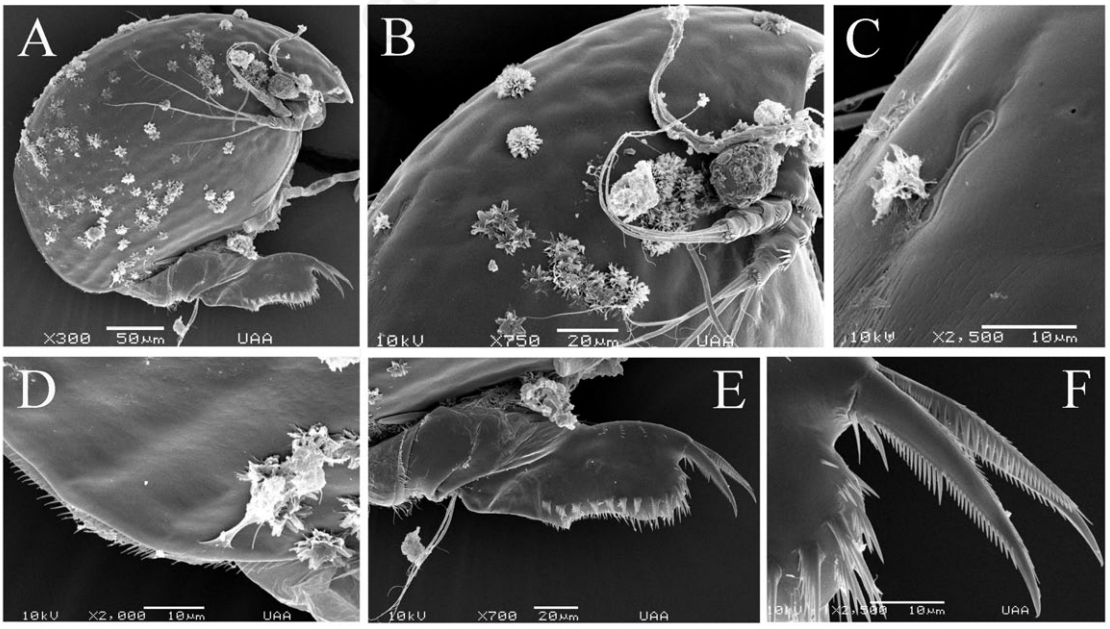

Fig. 6. Scanning electron microscopy of *Anthalona harti*, parthenogenetic female from VP3.1 - Ban Phang Hang fish pond, Vientiane province, Laos. A) General view; B) head; C) head pores; D) postero-ventral valve portion; E,F) postabdomen.

[convex (Fig. 9G) *vs* almost straight (Fig. 10E)]; iii) length of denticles on the branches of antenna II [short (Fig. 9B) *vs* long (Fig. 10D)]. These observations confirm the suggestion by Van Damme *et al.* (2013) that the *karua*-group in SE Asia needs to be revised.

Karualona cf. *kwangsiensis* Jiang, 1963. Few populations from Laos belong to *K. kwangsiensis,* described from China (Jiang, 1963) and then found in India (Venkataraman, 1999). This is a taxon recognisable by the denticles on the postero-ventral portion of the valve, which are projected downwards instead of being directed posterior, as opposed to the typical *K. karua*. It could be a separate taxon or a morphotype of *K. karua*, and needs to be revised (Van Damme *et al*., 2013). In any case, it is

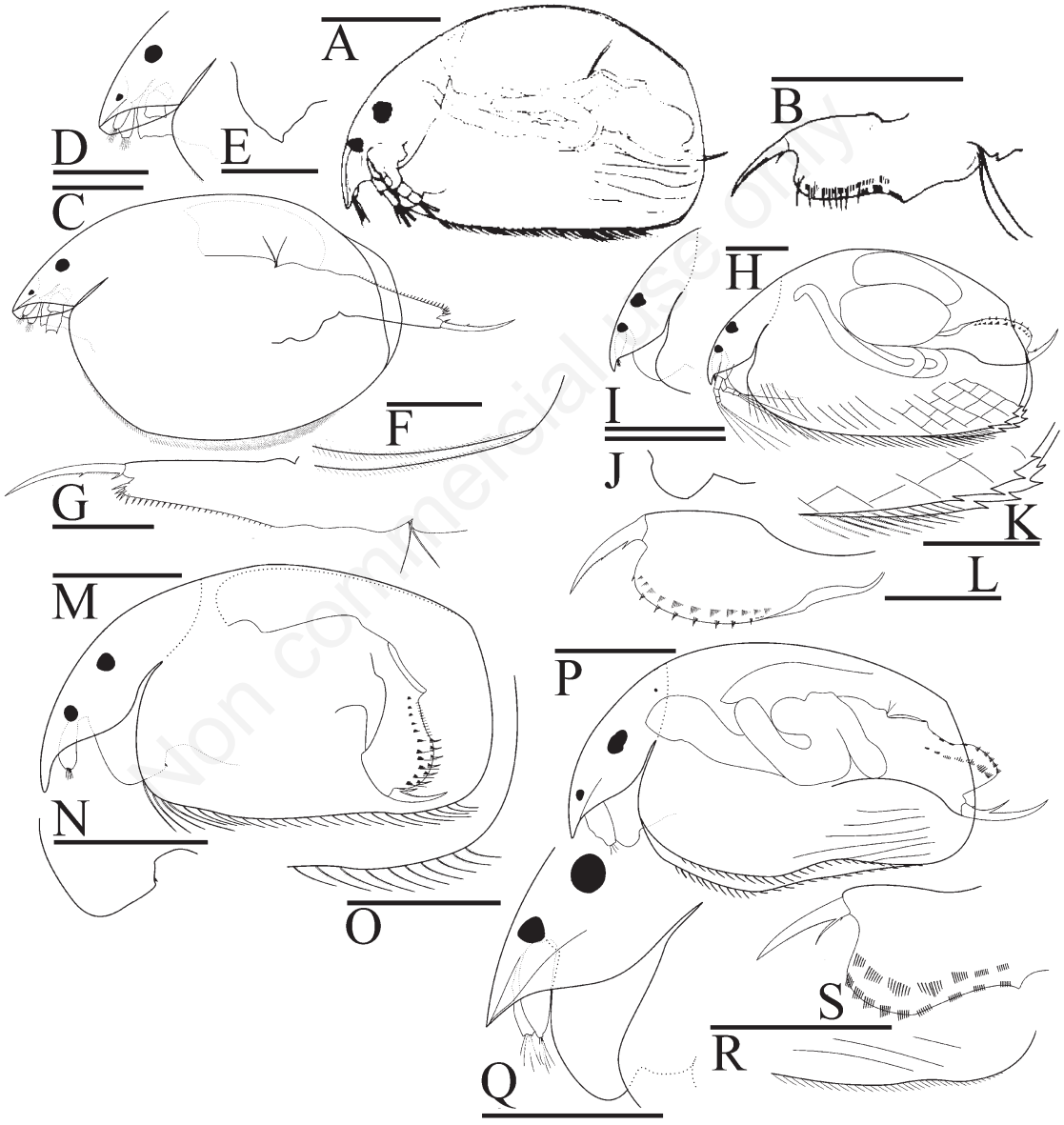

Fig. 7. Aloninae from Vientiane province, Laos. A,B) *Coronatella* sp. from Ban Hui Sawn rice field, general view, head and postabdomen; C-G) *Euryalona orientalis* from Nong Thongpane, adult in general view, its head, labrum, postero-ventral portion of valves and postabdomen; H-L) *Karualona* cf. *karua* from Nam Cheng (Napho village), adult in general view, its head, labral keel, postero-ventral portion of valve and postabdomen; M-O) *Matralona freyi* from Nam Ngum dam 1, adult in general view, labral keel and postero-ventral portion of valve; P-S) *Nicsmirnovius eximius* from Nam Ngum1 (Donekeud), adult in general view, its head, postero-ventral portion of valve and postabdomen. Scale bars: 0.1 mm.

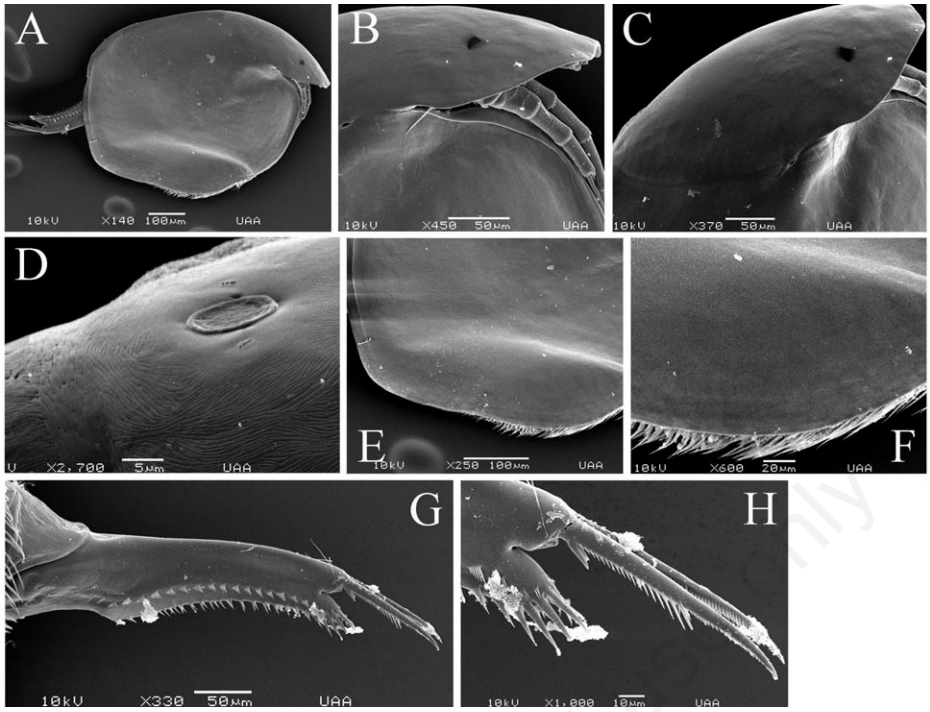

Fig. 8. Scanning electron microscopy of *Euryalona orientalis*, parthenogenetic female from LV11 - Hui Sawn swamp 2, Vientiane municipality, Laos. A) General view; B,C) head; D) head pores; E) postero-ventral valve portion; F) antero-ventral valve portion; G,H) postabdomen.

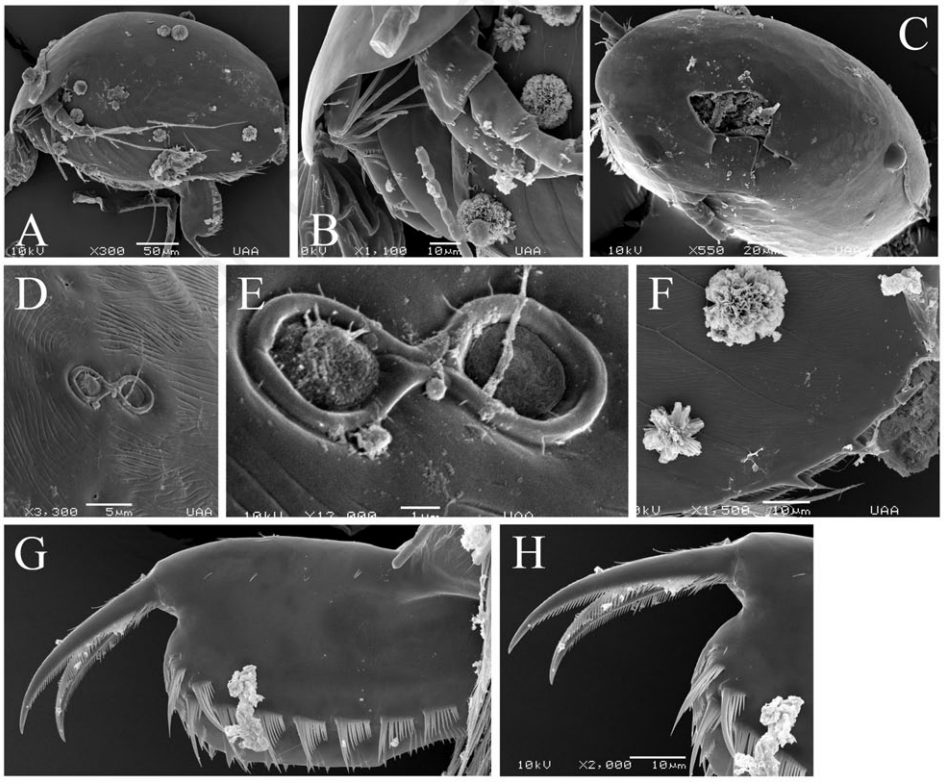

Fig. 9. Scanning electron microscopy of *Karualona* cf. *karua*, morphotype 1, parthenogenetic female from LV03 - Nong Suem lotus pond, Vientiane municipality, Laos. A) General view; B) head; C) dorsal view; D,E) head pores; F) postero-ventral valve portion; G,H) postabdomen.

clear that the taxonomy of SE Asian *Karualona* is more complex (Van Damme *et al.*, 2013).

Karualona sp. nov. This animal is described by Van Damme *et al.* (2013) and recorded by Sinev and Korovchinsky (2013a, 2013b) in this volume, a new species for the region.

Kurzia Dybowski & Grochowski, 1894

Kurzia brevilabris Rajapaksa & Fernando, 1986. Common species in SE Asia (Rajapaksa and Fernando, 1986) and its presence in Laos was expected.

Kurzia longirostris (Daday, 1898) is an even wider distributed tropicopolitan species of the Old World (Rajapaksa and Fernando, 1986) and the New World (Elías-Gutiérrez *et al*., 2006, 2008b). In East Asia, it occurs as far north as South Korea (Kotov *et al.,* 2012). *Kurzia longirostris* is recorded for all SE Asian countries (Korovchinsky, 2013a), and up to now there are no indications of the existence of a cryptic species complex (in the Old World).

Leberis Smirnov, 1989

Leberis diaphanus (King, 1853) (Fig. 11). The species was described from Australia as *Alona* by King (1853) and then transferred to the genus *Leberis* (Sinev *et al*., 2005). Males in SE Asia were described by Sinev and Sanoamuang (2011). It is very common in the tropics-subtropics of the Old World. The taxon could be regarded as tropicopolitan, reaching Korea in the north of its distribution (Yoon, 2010).

Leberis sp. Besides the more common *L. diaphanus*, we found specimens that cannot be attributed to the latter, but seem closer to the Neotropical *L. davidi* or a yet undescribed species. We prefer to keep this record here as *L.* sp., because there are also still unrevised *Leberis* species in the region that can be valid. For example, Daday (1898) described a *Leberis* from Sri Lanka (as *Alonella punctata*) which has never been formally re-evaluated. In any case, it seems to us that there is more than one *Leberis* species in the region.

Leydigia Kurz, 1875

Leydigia ciliata Gauthier, 1939. Described from Africa (Gauthier, 1939) and then found to be tropicopolitan (Smirnov, 1971; Kotov *et al*., 2003, 2012; Kotov, 2009). Sinev and Sanoamuang (2011) found some differences between the males from SE Asia and those from Africa, which could suggest a specific status of the Oriental populations (species or subspecies). Analysis of the descriptions and re-examination of the available material have not confirmed the occurrence of any other species of *Leydigia* in SE Asia. Therefore, *L. ciliata* seems to be the only *Leydigia* known so far from the region.

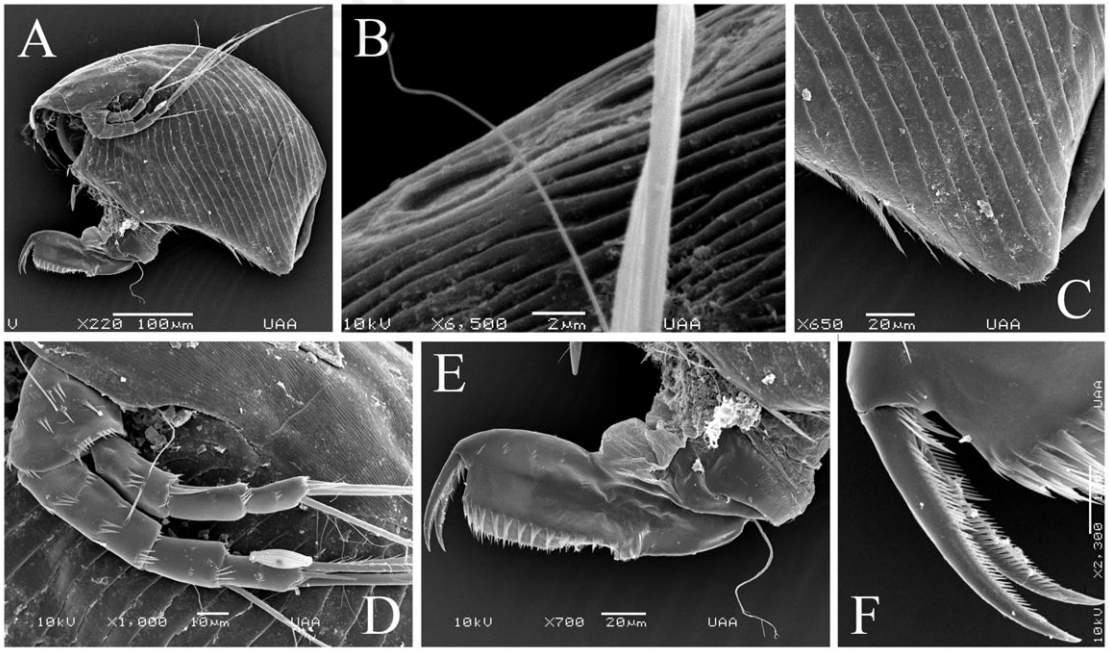

Fig. 10. Scanning electron microscopy of *Karualona* cf. *karua*, morphotype 2, parthenogenetic female from VM1.1 - Ban Phang Hang, Vientiane municipality, Laos. A) General view; B) head pores; C) postero-ventral valve portion; D) antenna II; E,F) postabdomen and postabdominal claws.

Leydigiopsis Sars, 1901

Leydigiopsis sp. This is apparently a new taxon, rare yet occuring in different countries of the Oriental region (Sanoamuang, 1998; Maiphae *et al.,* 2005; Tanaka and Ohtaka, 2010; Van Damme *et al*., 2013). The species is described by Van Damme and Sinev (2013).

Matralona Van Damme & Dumont, 2009

Matralona freyi Idris & Fernando, 1981 (Fig. 7M-O). This taxon was originally described as *Alona* from West Malaysia (Idris and Fernando, 1981; Idris, 1983) and then suggested as belonging to *Matralona* by Van Damme and Dumont (2009), to which it was subsequently translocated (Sinev and Kotov, 2012). To date this species was known from Malaysia only (Sinev and Kotov, 2012), our finding is the first record outside of Malaysia. The species seems to be very rare and endemic to SE Asia.

Nicsmirnovius Chiambeng & Dumont, 1999

Nicsmirnovius eximius (Kiser, 1948) (Figs. 7P-S and 12A-E). Described from the Pearl river in SE China (Kiser, 1948) as *Alona* and then translocated to the genus *Nicsmirnovius* (Van Damme *et al.*, 2003). There is a single species in the Oriental zone, *N. eximius,* which occurs in different SE Asian (Idris, 1983; Kotov and Sanoamuang, 2004a; Tanaka and Ohtaka, 2010; Van Damme *et al.,* 2013; Korovchinsky, 2013a) and South Asian countries (Chatterjee *et al*., 2013), but being a rheophilic species it is not very common in littoral sam-

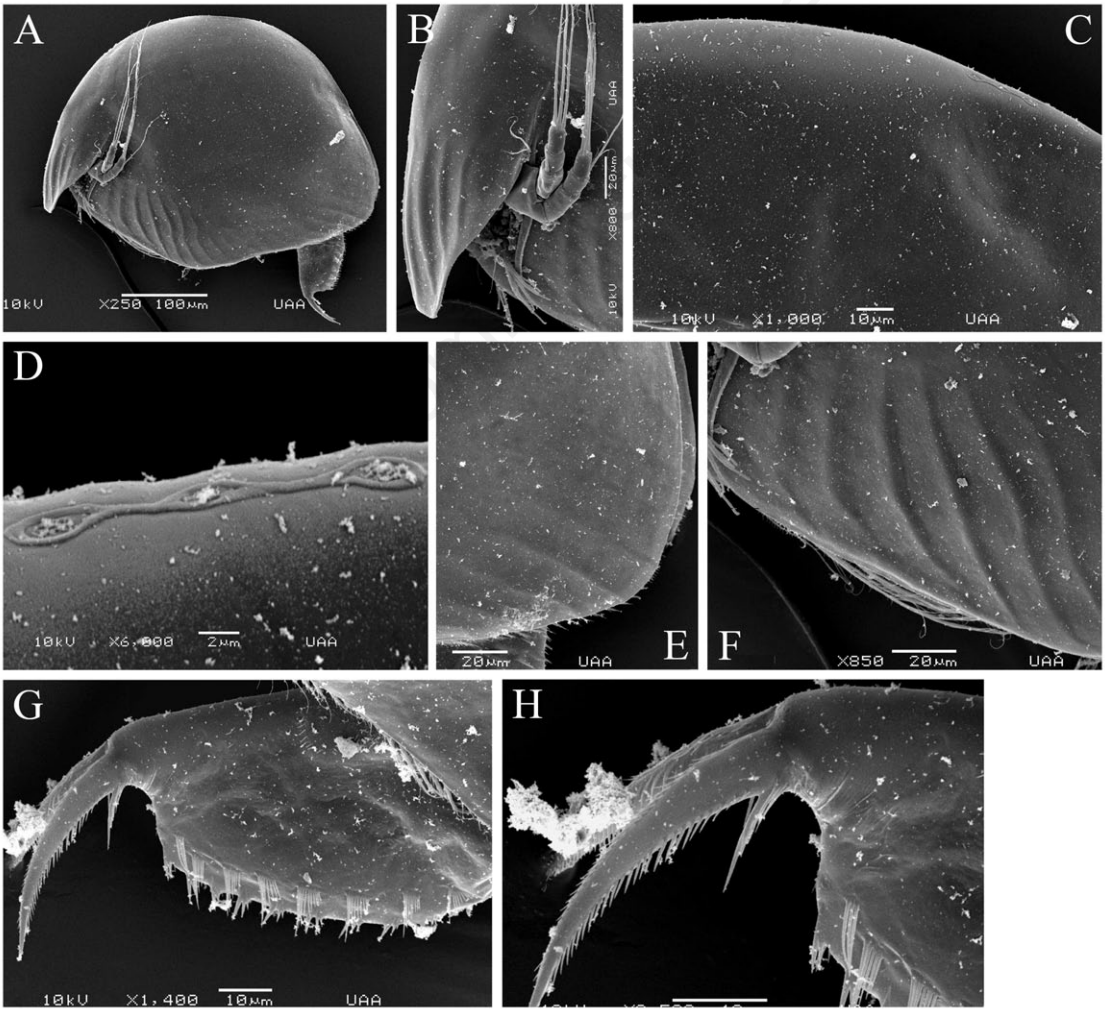

Fig. 11. Scanning electron microscopy of *Leberis diaphanus*, parthenogenetic female from VM1.1. - Ban Phang Hang, Vientiane municipality, Laos. A) General view; B) head, lateral view; C) dorsum, region of head pores; D) head pores; E) postero-ventral valve portion; F) antero-ventral valve portion; G,H) postabdomen and postabdominal claws.

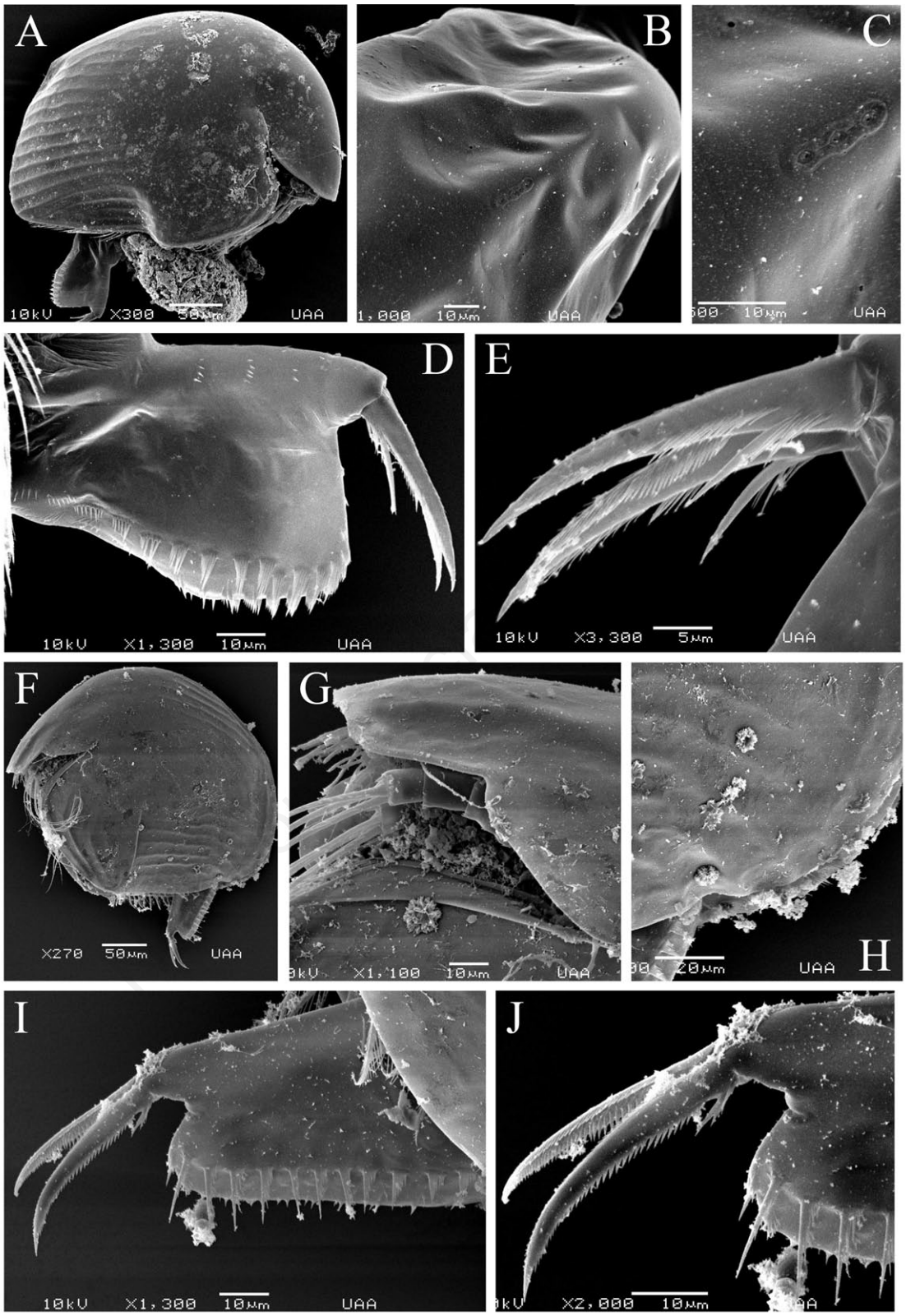

Fig. 12. Scanning electron microscopy of Aloninae from Vientiane municipality, Laos. A-E) *Nicsmirnovius eximius*, parthenogenetic female from LV08 - Ban Nonsa-art rice field: A) General view; B,C) head pores, dorsal view; D,E) postabdomen; F-J) *Notoalona globulosa*, parthenogenetic female from LV11 - Hui Sawn swamp 2: F) general view; G) head, lateral view; H) postero-ventral valve portion; I-J) postabdomen.

ples (Van Damme *et al*., 2003), as such habitats are rarely sampled.

Notoalona Rajapaksa & Fernando, 1987

Notoalona globulosa globulosa (Daday, 1898) (Fig. 12F-J). Described from Sri Lanka (Daday, 1898) as *Alona*, then moved to *Indialona* by Smirnov (1971) and later to *Notoalona* (Rajapaksa and Fernando, 1987c). The latter authors concluded that *N. globulosa* occurs also in the tropical part of the New World, and subsequently similar populations were also found in Southern Mexico (Elías-Gutiérrrez *et al*., 2006, 2008). In the Old World, records refer to *N. globulosa, N.* cf. *freyi* and one new species (Van Damme *et al.,* 2013), yet we found only *N. globulosa*.

Oxyurella Dybowski & Grochowski, 1894

Oxyurella singalensis (Daday, 1898). Originally described from Sri Lanka (Daday, 1898) and later recorded from tropical countries in the Old World (Smirnov, 1971). It is an easily recognisable species with relatively wide distribution. Males have been described by Sinev and Sanoamuang (2011) from Thailand.

Subfamily Chydorinae Dybowski & Grochowski, 1894 emend. *Frey 1967*

Alonella Sars, 1862

Alonella cf. *excisa* (Fischer, 1854) (Figs. 13 and 14). Described from European Russia (Fischer, 1854) and now regarded as a widely distributed species (Smirnov, 1971),

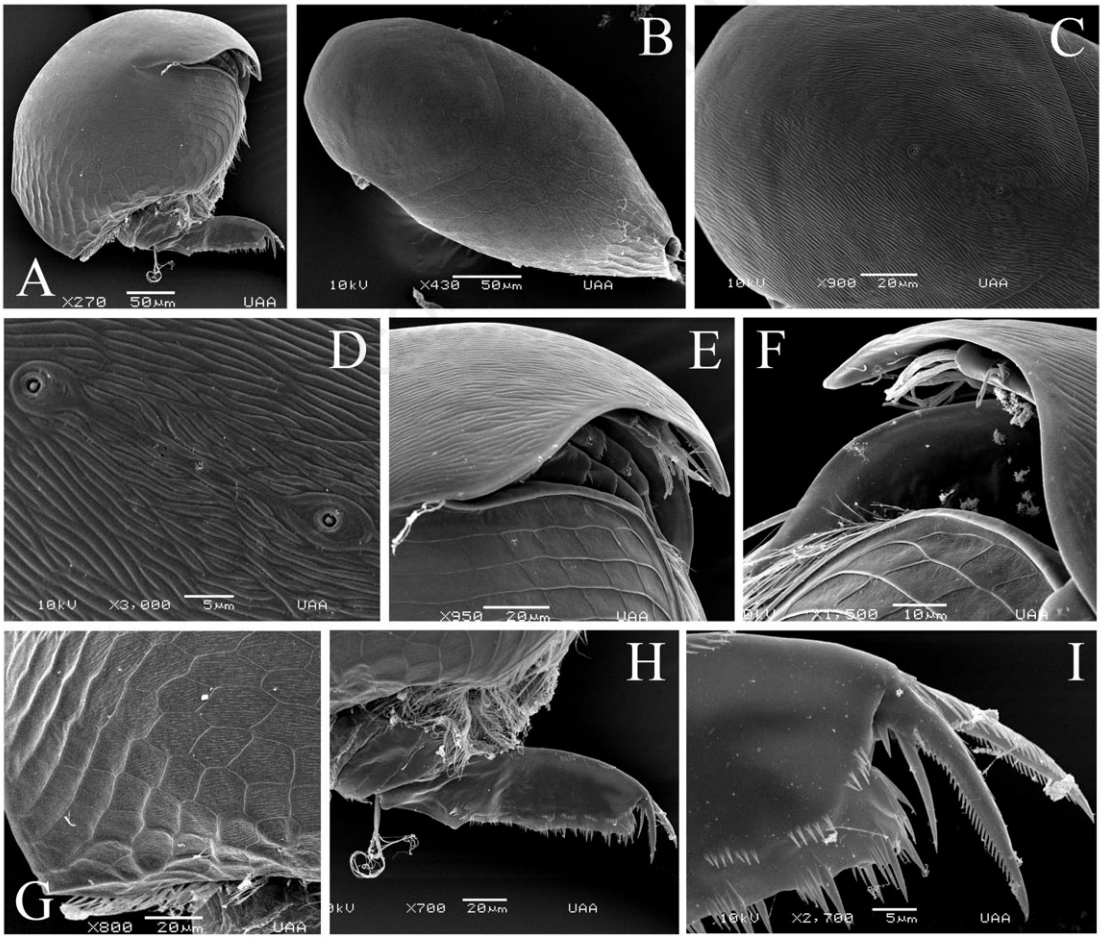

Fig. 13. Scanning electron microscopy of *Alonella* cf. *excisa*, morphotype 1, parthenogenetic female from VP3.1 - Ban Sansa-art fish pond, Vientiane municipality, Laos. A) General view; B) dorsal view; C,D) head pores; E,F) head, lateral view; G) postero-ventral valve portion; H,I) postabdomen and postabdominal claws.

most likely species complex (Smirnov, 1996). Again, the Laotian populations form two morphotypes that differ in: i) expression of the small-sized striation between the reticulation meshes [strong (Fig. 13C, 13D, and 13G) *vs* weak (Fig. 14D, 14F-G)]; ii) length of rostrum [short (Fig. 13E and 13F) *vs* long (Fig. 14B)]; iii) shape of the distal portion of the postabdomen [dorso-distal angle projected (Fig. 13H and 13I) *vs* not projected at all (Fig. 14H and 14I)]; iv) relative size of the basal spine on the postabdominal claw [longer than half of the claw length (Fig. 13I) *vs* shorter (Fig. 14I)]. This could indicate the presence of two different species even in SE Asia.

Chydorus Leach, 1816

Chydorus cf. *eurynotus* Sars, 1901 (Fig. 15A-D). Described from Brazil (Sars, 1901), and widely distributed in the Neotropics, but found worldwide in tropical and subtropical regions (Smirnov, 1996). In comparison to the Neotropical populations, the SE Asian forms are still poorly understood and need a revision. The male morphology is discussed and some drawings of the Brazilian type material of true *C. eurynotus* are provided by Van Damme and Dumont (2010).

Chydorus obscurirostris tasekberae Frey, 1987 (Fig. 16G and 16H). A honeycombed *Chydorus*, described from Malaysia (Frey, 1987) (the other subspecies – *C. o. obscurirostris* Frey, 1987 – is from Australia) and mentioned as subspecies or as *C. obscurirostris* (Maiphae *et al.*, 2008) in the region. Other honeycombed species are also present in SE Asia and might be expected in Laos (*e.g. C. opacus* Frey, 1987).

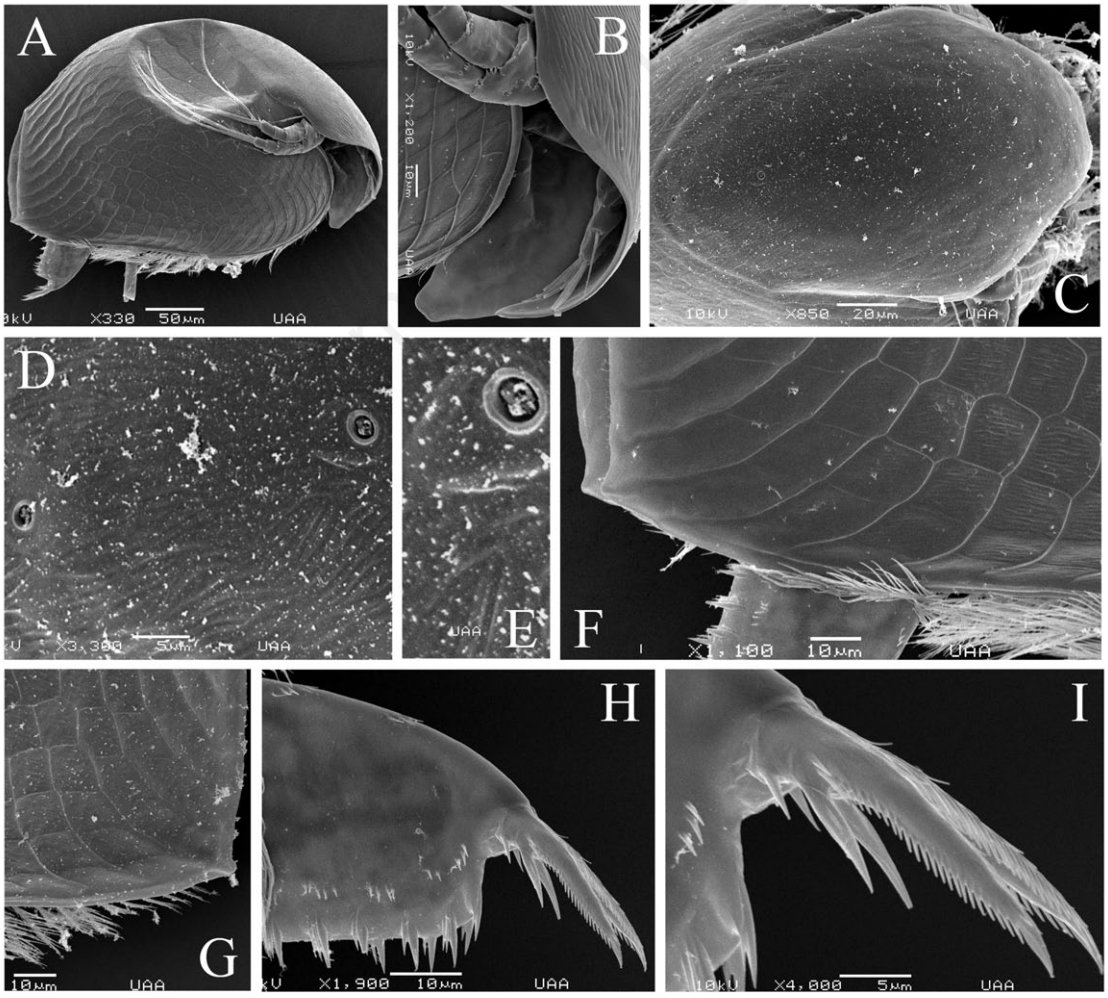

Fig. 14. Scanning electron microscopy of *Alonella* cf. *excisa*, morphotype 2, parthenogenetic female from VP1.1 - Ban Phang Hang fish pond, Vientiane municipality, Laos. A) General view; B) head; C) dorsal view; D,E) head pores; F,G) postero-ventral valve portion; H,I) postabdomen.

Chydorus parvus Daday, 1898. Described from Sri Lanka by Daday (1898) and easily recognisable by the projection(s) inside the frontal valve margin. It is common in SE Asia and the Laotian records of this species are confirmed here, but other tropical populations outside the Oriental region should be revised.

Chydorus cf. *pubescens* Sars, 1901 (Fig. 17). Similarly to *C. eurynotus*, *C. pubescens* is a species described from Brazil (Sars, 1901), with wide distribution in the tropics (Smirnov, 1996), which needs to be revised. This species is very easily recognisable by its *hairy* carapace. There are numerous records from SE Asia (Idris and Fernando, 1981; Korovchinsky, 2013a; Maiphae *et al*., 2008), but those might eventually refer to a sibling species.

Chydorus reticulatus Daday, 1898 (Fig. 16A-F). Oriental species described from Sri Lanka (Daday, 1898). It was expected to occur in Laos as well, as it is known from the neighbouring countries and common in SE Asia (*e.g.* Sanoamuang, 1998; Smirnov, 1996).

Chydorus ventricosus Daday, 1898 (Fig. 15E and 15F). Very common, large Oriental species that is expected throughout the region. Records from the rest of the tropics should be revised, as this is likely a group of species.

Dadaya Sars, 1901

Dadaya macrops (Daday, 1898) (Fig. 18). Described from Sri Lanka (Daday, 1898) as *Alona*, then placed in the genus *Dadaya* (Sars, 1901). It is regarded as circumtropical (Smirnov, 1971, 1996; Rajapaksa and Fernando, 1982).

Disparalona Fryer, 1968

Disparalona hamata (Birge, 1879) (Fig. 19). It was described from North America (Birge, 1879), but *D. hamata* is common in East Asia, from the tropics to Korean peninsula and the Amur basin (Kotov *et al.,* 2011, 2012) and present even in Europe (Hudeč, 2010). Sinev and Sanoamuang (2011) found that males of the Thai populations differ from the North America ones, which may indicate that the Thai form belongs to a separate species.

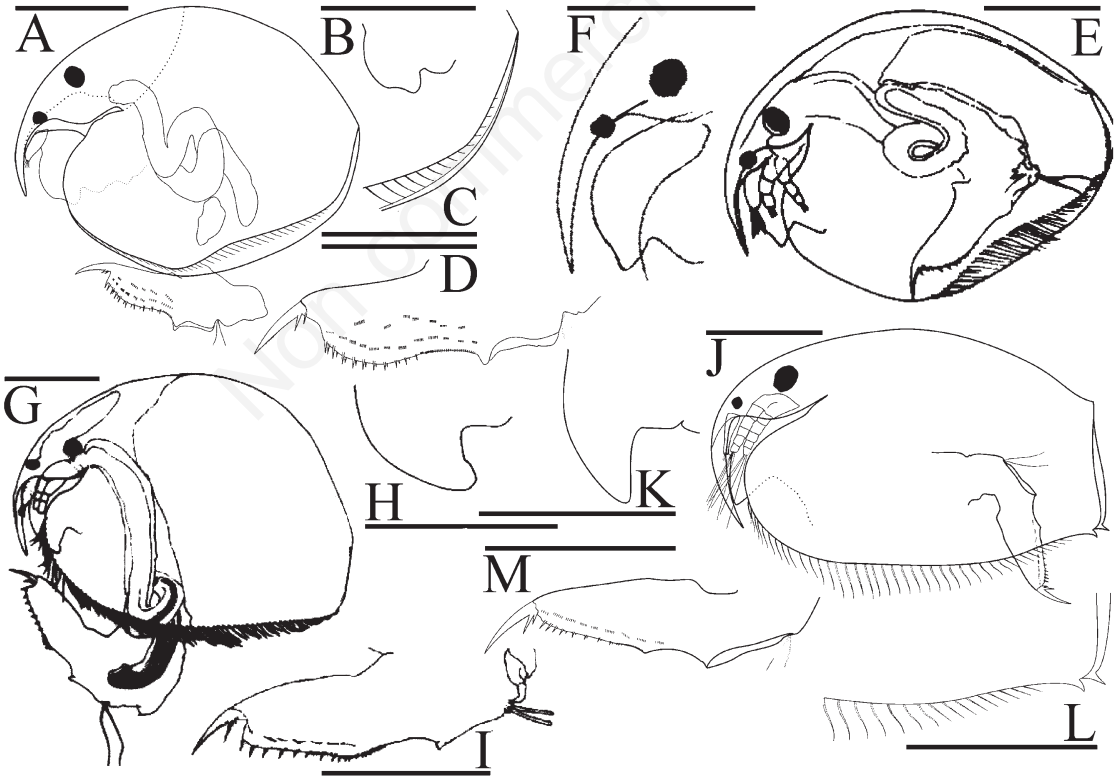

Fig. 15. Chydorinae from Vientiane province, Laos. A-D) *Chydorus eurynotus* from Nam Ngum dam, adult in general view, labral keel, postero-ventral portion of valve and postabdomen; E,F) *Chydorus ventricosus* from Nong Suem swamp 2, lateral view and head; G-I) *Picripleuroxus* cf. *laevis* from from Phonexay bridge (Roadside channel), adult in lateral view, labral keel, postero-ventral valve portion and postabdomen; J-M) *Picripleuroxus* cf. *denticulatus* from Ban Sansa-art fish pond, lateral view, labral keel and postabdomen. Scale bars: 0.1 mm.

Dunhevedia King, 1853

Dunhevedia crassa King, 1853. Described from Australia (King, 1853) and regarded as a cosmopolitan taxon (Smirnov, 1996). It needs to be revised worldwide.

Dunhevedia serrata Daday, 1898. Described from Sri Lanka (Daday, 1898) and distributed in the tropics of the Old World (Rajapaksa and Fernando, 1987d; Smirnov, 1996).

Ephemeroporus Frey, 1982

Ephemeroporus cf. *barroisi* (Richard, 1894) (Fig. 20). Described from Syria (Richard, 1894) as *Pleuroxus*, then moved to a special genus *Ephemeroporus* (Frey, 1982b) and found to be tropicopolitan (Smirnov, 1996; Kotov *et al.,* 2011, 2012). It is widely distributed in other SE Asian countries (Maiphae *et al.,* 2005, 2008; Tanaka and Ohtaka, 2010; Korovchinsky, 2013a). Maiphae *et al.* (2005, 2008) identified three other species of the genus *Ephemeroporus* from Thailand, but all our populations were similar to *Ephemeroporus barroisi.* This species is not described in detail and needs to be revised in the future.

Picripleuroxus Frey, 1993

Picripleuroxus cf. *denticulatus* (Birge, 1879) (Fig. 15G-I). Described from the USA (Birge, 1879) and found to be common in the tropics-subtropics, penetrating Europe (Hudeč and Illyová, 1998) in the west and the Amur basin (Kotov *et al.,* 2011) in East Eurasia. It is relatively common in SE Asian countries (Sinev and Sanoamuang, 2011; Korovchinsky, 2013a). This group definitively needs to be revised worldwide. The Asian populations belong to a separate taxon awaiting a formal description; our record might refer to *P. quasidenticulatus* Smirnov, 1966, having a distinctively short and robust postabdominal claw (Sinev, personal communication), yet this species

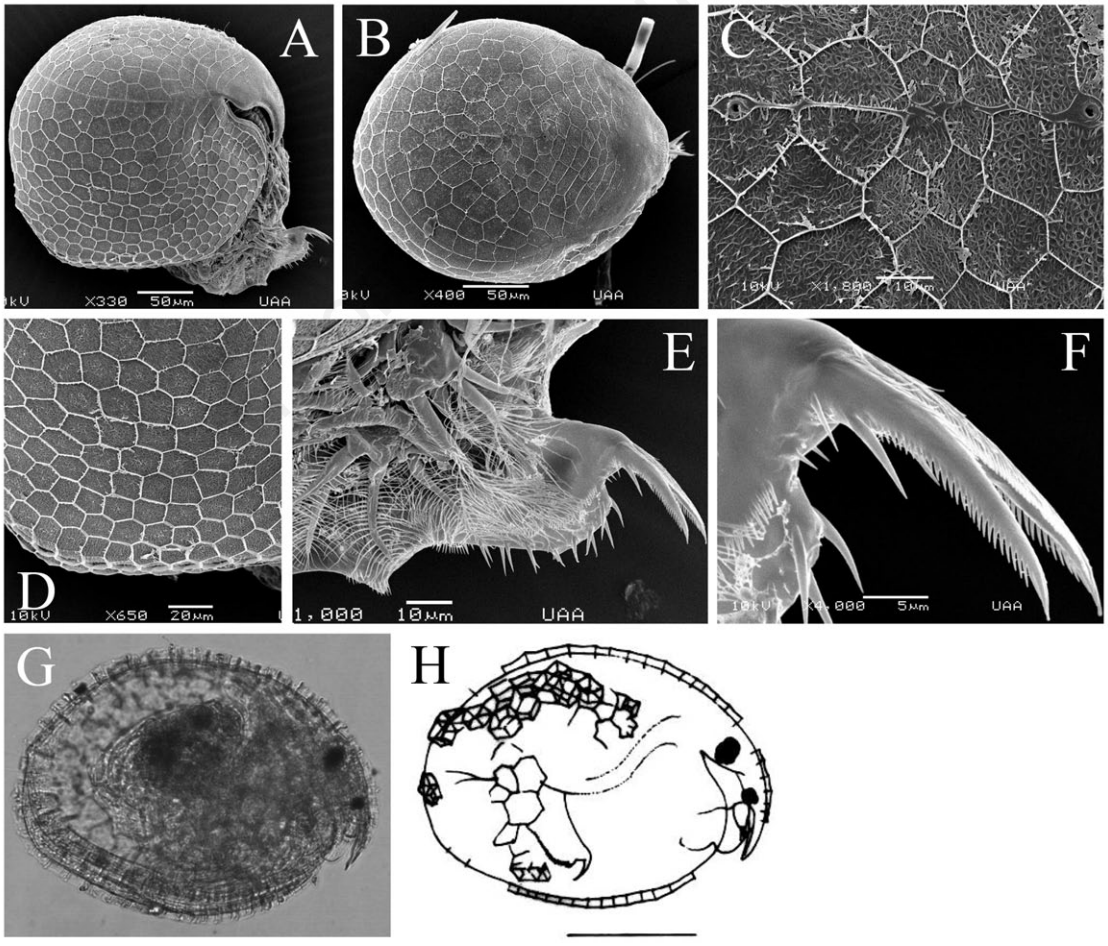

Fig. 16. *Chydorus* from Vientiane municipality, Laos. A-F) Scanning electron microscopy of *C. reticulatus*, parthenogenetilc female from VP1.1 - Ban Phang Hang fish pond: A) general view; B) dorsal view; C) head pores; D) postero-ventral valve portion; E,F) postabdomen. G-H) *C. obscurirostris tasekberae* from LV08 - Ban Nonsa-art rice field, lateral view.

also needs redescription. The latter species has also been found in Vietnam (Sinev and Korovchinsky, 2013).

Picripleuroxus laevis Sars, 1862 (Fig. 15J-L). Described from Northern Europe (Norway) (Sars, 1862). In fact, it is a widely distributed species complex, the revision of which was started by Frey (1988) but never tackled since then. *Picripleuroxus laevis*-like populations have been also found in other SE Asian countries and need to be revised. There are serious objections to the separation of the genus *Picripleuroxus* from *Pleuroxus* Baird, 1843 (Chiambeng and Dumont, 2004; Smirnov *et al.,* 2006), which means that future revisions need to include a larger set of the species.

Species richness during rainy and wet season

Tabs. 1-3 demonstrate the results of our comparison of the dry- and rainy-season fauna of the Cladocera in Vientiane province and municipality. Our sampling represents a realistic biodiversity for the region, as the estimations from the models are only somewhat higher than the empirical numbers (Tab. 2). The number of species during the dry season (both empirical and estimated by models) is only about 20% smaller than the species number during the rainy season. During both rainy and dry seasons a similar set of dominant species occurs (Tab. 3). Almost all species, revealed for this territory, are present during the rainy season; still, both maximum and average number of species per sample is two times higher in the rainy season and relative abundances shift between the seasons.

DISCUSSION

Most publications on tropical cladocerans concern zooplankton only, not the benthic or the littoral species. It means that only a very small portion of the biodiversity is revealed in such papers. The total number of littoral forms is significantly higher than the number of planktonic taxa in SE Asia (Idris, 1983; Tanaka and Ohtaka, 2010) and in fact, everywhere. Our study led to the finding of 70 cladoceran taxa in only a small portion of Laos, previously almost unknown to cladoceran taxonomists. We can conclude that our sampling was relatively full and adequate: our model estimations suggest the presence of about 77 species in this territory. We

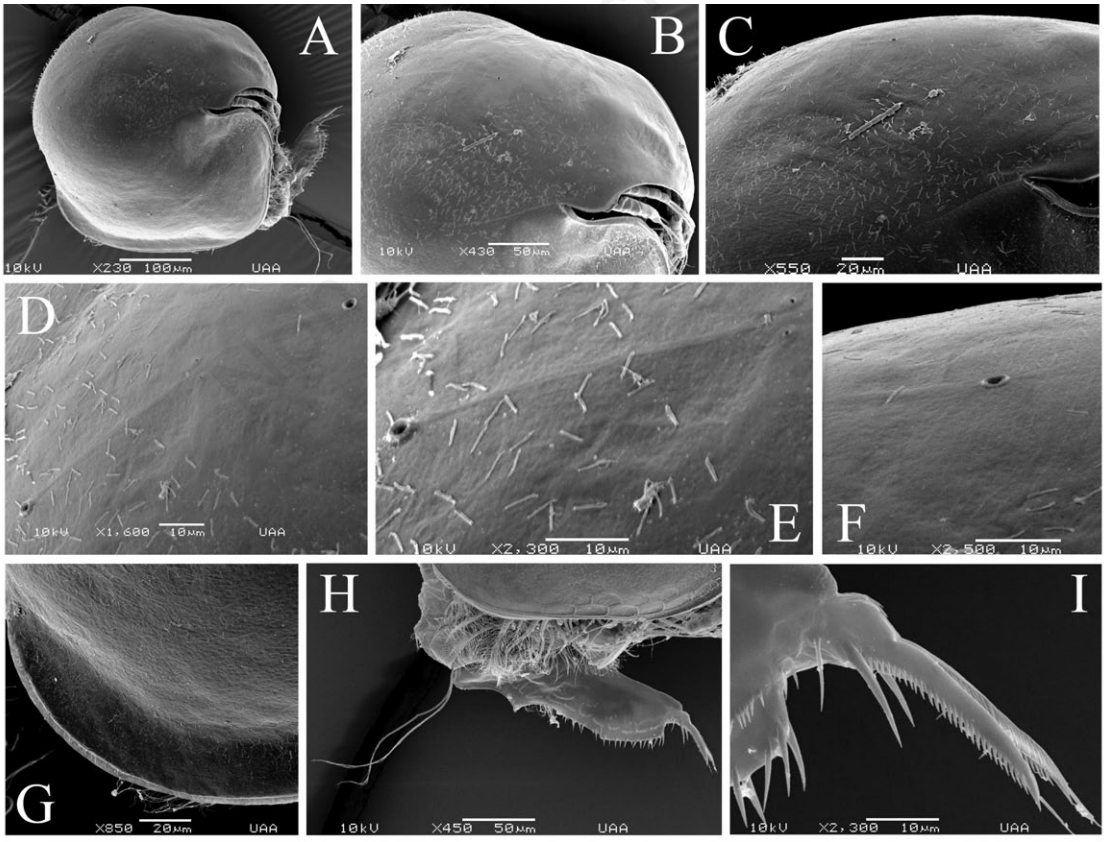

Fig. 17. Scanning electron microscopy of *Chydorus* cf. *pubescens*, parthenogenetic female from VP3.1 - Ban Sansa-art fish pond, Vientiane municipality, Laos. A) General view; B) head; C-D) region of head pores; E,F) head pores; G) postero-ventral valve portion; H,I) postabdomen and postabdominal claws.

found that differences between the rainy and dry seasons in the dominant species complexes are small, but many rare species are absent during the dry season. Therefore, intense collection during different seasons – not just in one season – in the tropics is necessary for an adequate description of the cladoceran faunas.

This is the first detailed faunistic report published on the Laotian Cladocera, so the tally is far from complete. The species number shown here is not representative for the species richness of the country and should not be used as a standard. Several taxa that are present, or even common in the Oriental region, are still lacking. We can suggest a list of species which will be most probably found in Laos in the future, because they occur in other SE Asian countries (Maiphae *et al.,* 2005, 2008; Tanaka and Ohtaka, 2010; Korovchinsky, 2013a, 2013b): *Diaphanosoma volzi* Stingelin, 1905; *D. elongatum* Korovchinsky & Sanoamuang, 2008; *Macrothrix pholpunthini* Kotov, Maiphae & Sanoamuang, 2006; *M. malaysiensis* Idris & Fernando, 1981; *Guernella* cf. *raphaelis* Richard, 1892; *Bosmina* cf. *longirostris* (O. F. Müller, 1785); *B. fatalis* Burckhardt, 1924; *Graptoleberis* cf. *testudinaria* (Fischer, 1848); *Alonella* cf. *nana (*Baird, 1843); *A. clathratula* (Sars, 1896); *Disparalona caudata* Smirnov, 1996; *Chydorus sinensis* Frey, 1987; *C. opacus* Frey, 1987; *Pseudochydorus* cf. *globosus* (Baird, 1843), *etc*. The absence of these taxa does not reflect a natural phenomenon but it is just a simple result from sampling bias.

Ponthalith (2006) reported on 40 cladoceran taxa in Champasak province of Laos, with few taxa different from those of our list. Among ctenopods, he recorded *D. voltzi* Stingelin, 1905, *D. modigliani* Richard, 1894, and *D. sene-*

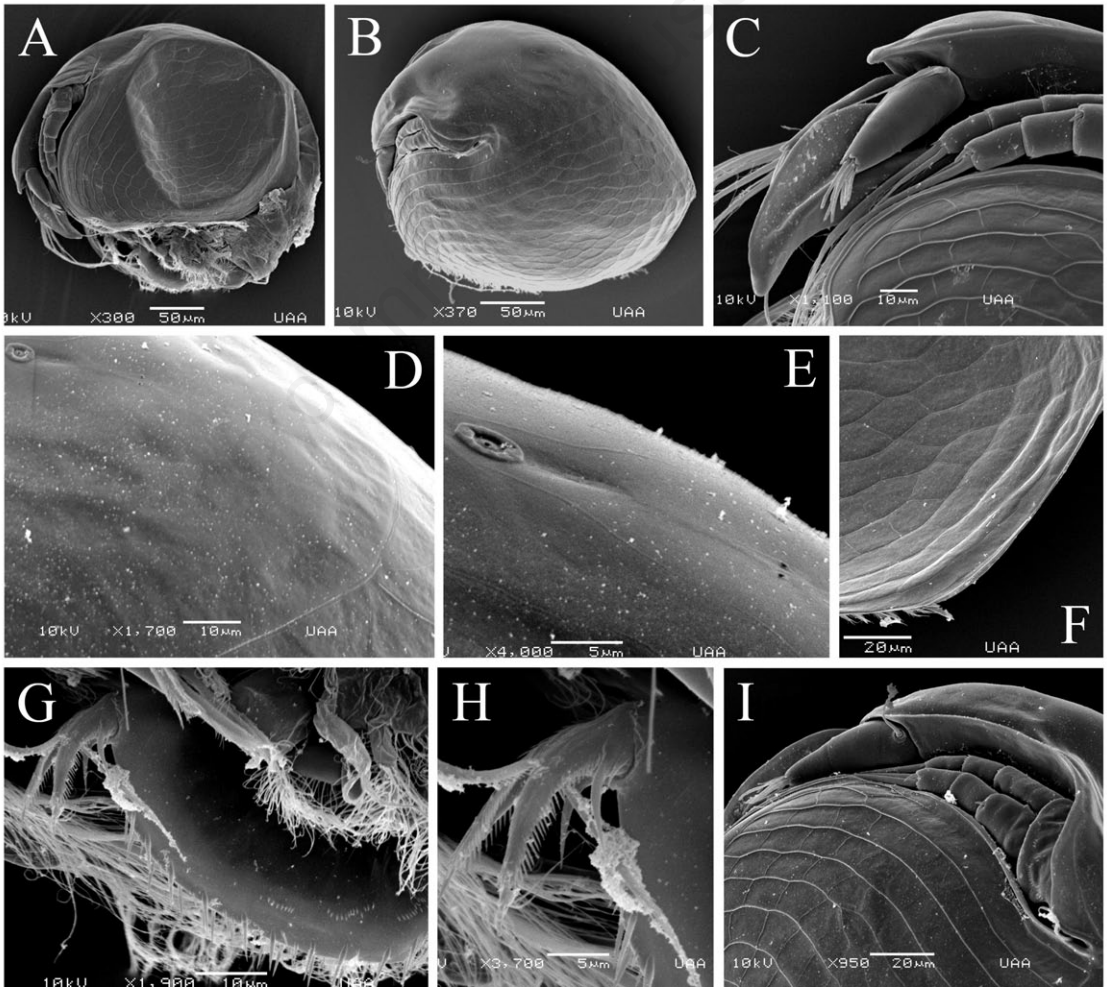

Fig. 18. Scanning electron microscopy of *Dadaya macrops*, parthenogenetic female from LV03 - Nong Suem lotus pond, Vientiane municipality, Laos. A-B) General view; C) labral keel and antenna I; D,E) head pores; F) postero-ventral valve portion; G,H) postabdomen and postabdominal claws; I) antenna I and II.

gal Gauthier, 1951. But Korovchinsky (2013b), re-studying these samples, confirmed only the latter determination (as *D. senegal isanensis* Korovchinsky & Sanoamuang, 2008). While the presence of *D. voltzi* in Laos is possible (it is present in neighboring Thailand), the finding of *D. modigliani* seems to be very dubious (Korovchinsky, 2013b). *Chydorus* cf. *brevilabris* Frey, 1980 in the list of Ponthalith (2006) seems to be a misidentification, but then again *Chydorus* is a very difficult genus for which no good revision exists. *Ephemeroporus* cf. *epiaphantoii* Alonso, 1987 is also recorded from Thailand (Maiphae *et al*., 2008). The genus *Ephemeroporus* contains several species in SE Asia and needs to be revised. Therefore, at least some species absent in our list were previously found in Laos, but these results remain unpublished.

Earlier Tanaka and Ohtaka (2010) found 60 taxa in 21 samples collected in the vicinities of Lake Tonle Sap, while Idris (1983) recorded only 62 species in the whole of Malaysia. In Thailand, Maiphae *et al.* (2005, 2008) reached a *realistic* stable species diversity of around *ca.* 100 species. Even so, new taxa and records are being found (Van Damme *et al.,* 2013) and there is also a lot to be revised among the known species groups with representatives throughout the tropics (Korovchinsky, 2013a). Among these, species that have been described in the Neotropics, Palaearctic or in the Afrotropics and that form widespread species groups, should be evaluated in detail (*e.g. C. pubescens, C. eurynotus, A. affinis, A. costata*, *etc.*) (Korovchinsky, 2013a). The same goes for other countries in the Oriental region where recent taxonomical efforts have been made (Thailand – Maiphae *et al*., 2008; India – Chatterjee *et al*., 2013). Some records of the species described from other continents and from other SE Asian countries, such as *Onchobunops* cf. *tuberculatus* Fryer & Paggi, 1981, *Leydigia australis* Sars, 1885 or *Chydorus dentifer* Daday, 1905 (Tanaka and Ohtaka, 2010), are likely separate species and need to be formally described.

An increase of the country's biodiversity can be expected after accurate revisions of some of the most difficult groups: *Ceriodaphnia*, *Alona* and *Chydorus*. In the former two genera, all populations which are now assigned to taxa described from Europe, probably compose of groups of cryptic species with unknown distribution: tropical, or tropicopolitan, or endemics of SE Asia.

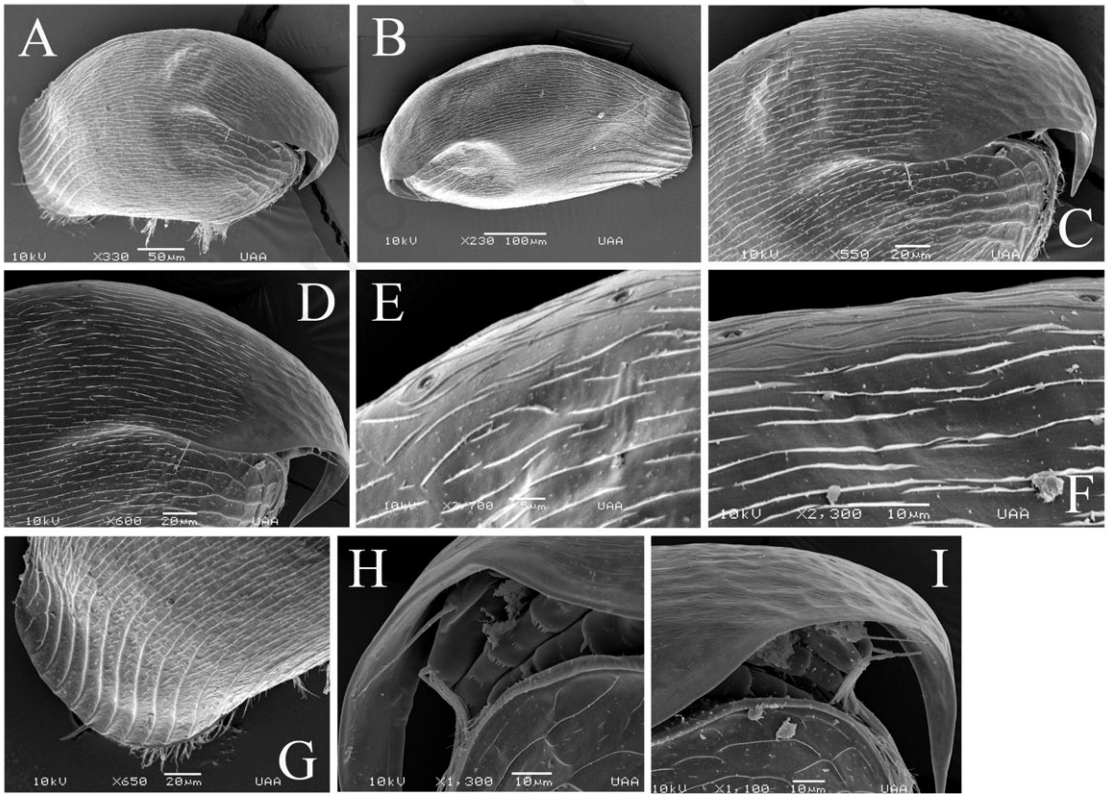

Fig. 19. Scanning electron microscopy of *Disparalona hamata*, parthenogenetic female from LV08 - Ban Nonsa-art rice field, Vientiane municipality, Laos. A,B) General view; C,D) head, region of head pores; E,F) head pores; G) postero-ventral valve portion; H,I) head with antenna I and II.

Hence, it is too early to draw conclusions on the comparative richness of the Laotian Cladocera and it is clear that further surveys will allow more realistic numbers. In any case, with this work, we hope that an important step has been made towards the knowledge of the Laotian cladocerans.

CONCLUSIONS

The study of the cladoceran fauna of Laos is now in its initial phase. In the Results section, we used the expression *needs to be revised* too often. This comes as a result of the recent state of the cladoceran taxonomy in SE Asia and in fact, in the tropics worldwide. Recent morphological studies using new standards and techniques can significantly increase the biodiversity estimates and the number of cladoceran endemics in different regions (and can be tested by molecular methods). We believe that Laos in particular and SE Asia in general will not be an exception to this rule. Now that the taxonomical foundations have been built, the future step is to increase sampling efforts in Laos in terms of areas and types of habitats

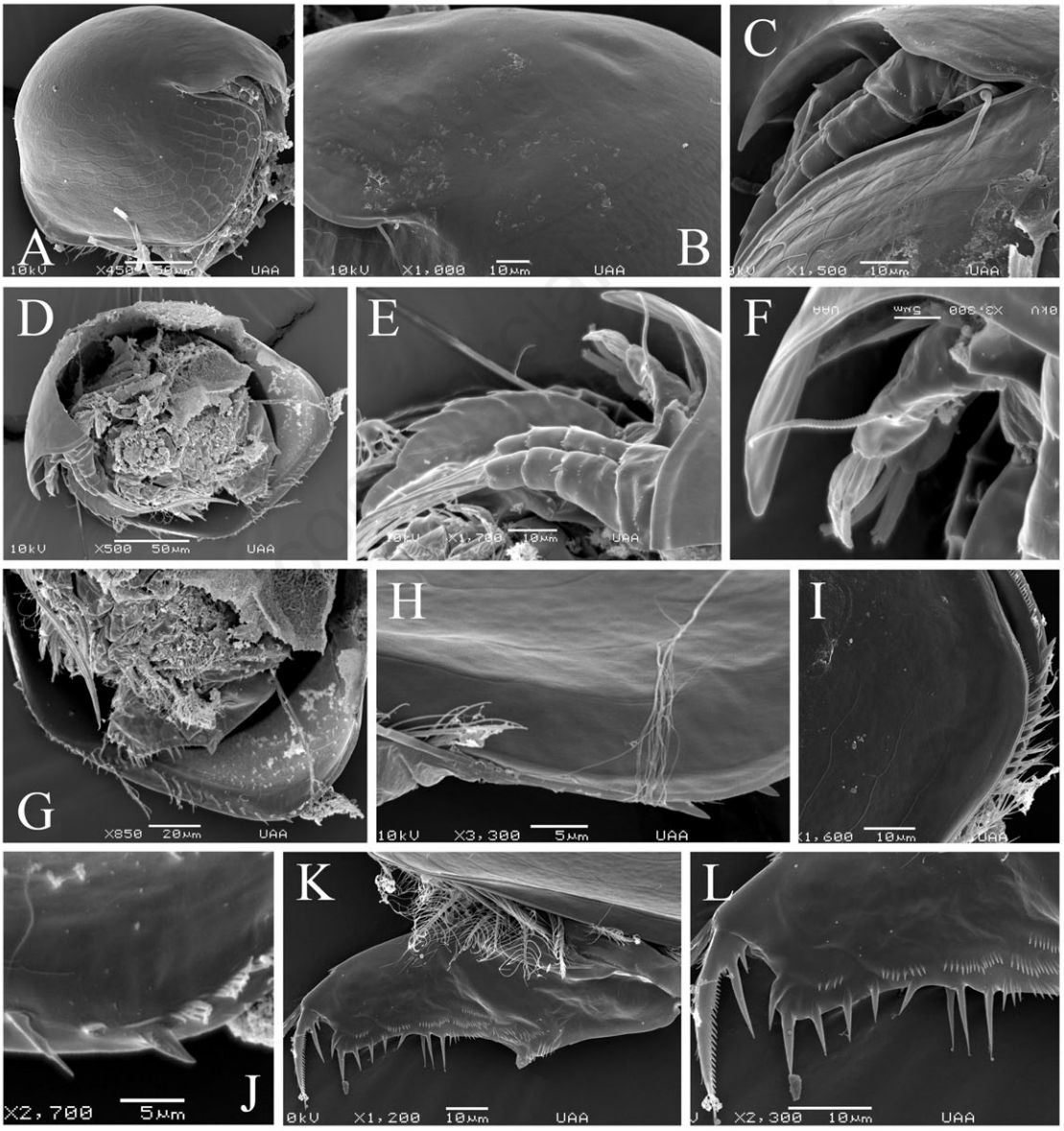

Fig. 20. Scanning electron microscopy of *Ephemeroporus* cf. *barroisi*, parthenogenetic female from VP3.1 - Ban Sansa-art fish pond, Vientiane municipality, Laos. A) General view; B) region of head pores; C) head, lateral view; D) general view, valve removed; E) labral keel, antenna I and antenna II; F) antenna I; G-J) postero-ventral valve portion; K,L) postabdomen.

Tab. 1. Number of localities where the species were found at dry and rainy seasons.

N.	Family	Taxon	Records in all 97 samples (n)	Records in 39 samples from dry season 2010 (n)	Records in 36 samples from rainy season 2011 (n)
1	Chydoridae	*Acroperus harpae* (Baird, 1834)*	1	0	1
2	Chydoridae	*Alona* cf. *affinis* Leydig, 1860	14	5	9
3	Chydoridae	*Alona cambouei* Guerne & Richard, 1893	12	3	9
4	Chydoridae	*Alona* cf. *costata* Sars, 1862	13	3	10
5	Chydoridae	*Alona* cf. *guttata* Sars, 1862	3	1	2
6	Chydoridae	*Alona kotovi* Sinev, 2012*	1	0	1
7	Chydoridae	*Alona sarasinorum* Stingelin, 1900	6	1	5
8	Chydoridae	*Alona siamensis* Sinev & Sanoamuang, 2007*	1	0	1
9	Chydoridae	*Alonella* cf. *excisa* (Fischer, 1854)	27	8	13
10	Chydoridae	*Anthalona harti* Van Damme, Sinev & Dumont, 2011	52	14	29
11	Chydoridae	*Anthalona sanoamuangae* Sinev & Kotov, 2012*	2	0	2
12	Bosminidae	*Bosmina meridionalis* Sars, 1904	11	4	3
13	Bosminidae	*Bosminopsis deitersi* Richard, 1895	42	19	18
14	Chydoridae	*Camptocercus vietnamensis* Thang, 1980	5	2	3
15	Chydoridae	*Celsinotum macronyx* (Daday, 1898)*	3	0	3
16	Daphniidae	*Ceriodaphnia cornuta* Sars, 1888	43	17	19
17	Daphniidae	*Ceriodaphnia* cf. *laticaudata* P.E. Müller, 1867	1	1	0
18	Daphniidae	*Ceriodaphnia reticulata* (Jurine, 1820)*	2	0	2
19	Chydoridae	*Chydorus eurynotus* Sars, 1901	47	10	25
20	Chydoridae	*Chydorus obscurirostris tasekberae* Frey, 1987*	2	0	2
21	Chydoridae	*Chydorus parvus* Daday, 1898	11	3	8
22	Chydoridae	*Chydorus* cf. *pubescens* Sars, 1901	3	2	0
23	Chydoridae	*Chydorus reticulatus* Daday, 1898	17	5	12
24	Chydoridae	*Chydorus ventricosus* Daday, 1898	15	3	10
25	Chydoridae	*Coronatella* cf. *monacantha* (Sars, 1901)	2	1	1
26	Chydoridae	*Coronatella* cf. *rectangula* Sars, 1862	20	4	13
27	Chydoridae	*Coronatella* sp.*	1	0	0
28	Chydoridae	*Dadaya macrops* (Daday, 1898)*	7	0	4
29	Sididae	*Diaphanosoma dubium* Manuilova, 1946	8	4	4
30	Sididae	*Diaphanosoma excisum* Sars, 1885	72	32	31
31	Sididae	*Diaphanosoma sarsi* Richard, 1895	19	6	13
32	Sididae	*Diaphanosoma* sp.	4	2	2
33	Daphniidae	*Daphnia lumholzi* Sars, 1885	2	0	0
34	Chydoridae	*Disparalona hamata* (Birge, 1879)	5	3	0
35	Chydoridae	*Dunhevedia crassa* King, 1853*	2	0	1
36	Chydoridae	*Dunhevedia serrata* Daday, 1898*	4	0	4
37	Chydoridae	*Ephemeroporus* cf. *barroisi* (Richard, 1894)	56	15	32
38	Chydoridae	*Euryalona orientalis* (Daday, 1898)	6	1	4
39	Macrothricidae	*Grimaldina brazzai* Richard, 1892	4	2	2
40	Ilyocryptidae	*Ilyocryptus spinifer* Herrick, 1882	39	12	23
41	Ilyocryptidae	*Ilyocryptus thailandensis* Kotov & Sanoamuang, 2004*	2	0	2
42	Chydoridae	*Karualona* cf. *iberica* (Alonso & Pretus, 1989)*	1	0	1
43	Chydoridae	*Karualona* cf. *karua* (King, 1853)	23	5	15
44	Chydoridae	*Karualona* cf. *kwangsiensis* Jiang, 1963	2	1	1
45	Chydoridae	*Karualona* sp. 2 (sp. nov.)*	1	0	1
46	Chydoridae	*Kurzia brevilabris* Rajapaksa & Fernando, 1986	11	5	6
47	Chydoridae	*Kurzia longirostris* (Daday, 1898)	10	3	7
48	Sididae	*Latonopsis australis* Sars, 1888	8	1	6
49	Chydoridae	*Leberis diaphanus* (King, 1853)*	8	0	4
50	Chydoridae	*Leberis* sp.	12	1	11
51	Chydoridae	*Leydigia ciliata* Gauthier, 1939	4	1	3
52	Chydoridae	*Leydigiopsis* sp.	3	1	2
53	Macrothricidae	*Macrothrix odiosa* Gurney, 1916*	5	0	4
54	Macrothricidae	*Macrothrix vietnamensis* Silva-Briano, Dieu & Dumont, 1999	4	2	2
55	Macrothricidae	*Macrothrix spinosa* King, 1852	50	16	24
56	Macrothricidae	*Macrothrix triserialis* Brady, 1886	43	13	25
57	Chydoridae	*Matralona freyi* Idris & Fernando, 1980*	1	0	1
58	Moinidae	*Moina micrura* Kurz, 1874	34	15	15
59	Moinidae	*Moina brachiata* (Jurine, 1820)*	1	0	1
60	Moinidae	*Moinodaphnia maclaeyi* (King, 1853)	22	3	16
61	Chydoridae	*Nicsmirnovius eximius* (Kiser, 1948)	11	3	7

To be continued on next page.

Tab. 1. Continued from previous page.

N.	Family	Taxon	Records in all 97 samples (n)	Records in 39 samples from dry season 2010 (n)	Records in 36 samples from rainy season 2011 (n)
62	Chydoridae	*Notoalona globulosa globulosa* (Daday, 1898)	11	4	6
63	Chydoridae	*Oxyurella singalensis* (Daday, 1898)	8	3	5
64	Chydoridae	*Picripleuroxus* cf. *denticulatus* (Birge, 1879)*	1	0	0
65	Chydoridae	*Picripleuroxus laevis* Sars, 1862	6	3	3
66	Sididae	*Pseudosida szalayi* (Daday, 1898)	11	1	9
67	Daphniidae	*Scapholeberis kingi* Sars, 1903	15	3	11
68	Daphniidae	*Simocephalus congener* (Koch, 1841)	1	1	0
69	Daphniidae	*Simocephalus heilonjangensis* Shi & Shi, 1994	3	2	0
70	Daphniidae	*Simocephalus serrulatus* (Koch, 1841)	20	8	12

**Species absent during dry season. Notice that species are rare during rainy season.*

Tab. 2. Empiric and estimated number of species in Vientiane province, Laos using EstimateS.

Variant	Empiric number of species	Estimated number of species	Best model	Maximum number of species in a sample	Average number per sample
All data	70	77	Chao2	30	9.5
All data of 2010-2011	67	77	Chao2	30	10.5
Only rainy season of 2011	62	72	Jacknife1	30	14.1
Only dry season of 2010	50	59	Chao2	15	7.1

Tab. 3. Top ten most common species during all seasons, dry season and rainy season.

All seasons		Dry season		Rainy season	
Taxon	Samples where taxon was found (%)	Taxon	Samples where taxon was found (%)	Taxon	Samples where taxon was found (%)
Diaphanosoma excisum	74	*Diaphanosoma excisum*	82	*Ephemeroporus* cf. *barroisi*	89
Ephemeroporus cf. *barroisi*	58	*Bosminopsis deitersi*	49	*Diaphanosoma excisum*	86
Anthalona harti	54	*Ceriodaphnia cornuta*	44	*Anthalona harti*	81
Macrothrix spinosa	52	*Macrothrix spinosa*	41	*Chydorus eurynotus*	69
Chydorus eurynotus	48	*Ephemeroporus* cf. *barroisi*	38	*Macrothrix triserialis*	69
Macrothrix triserialis	44	*Moina micrura*	38	*Macrothrix spinosa*	67
Ceriodaphnia cornuta	44	*Anthalona harti*	36	*Ilyocryptus spinifer*	64
Bosminopsis deitersi	43	*Macrothrix triserialis*	33	*Ceriodaphnia cornuta*	53
Ilyocryptus spinifer	40	*Ilyocryptus spinifer*	31	*Bosminopsis deitersi*	50
Moina micrura	35	*Chydorus eurynotus*	26	*Moinodaphnia maclaeyi*	86

and to continue systematic efforts in order to assess the country's cladoceran biodiversity.

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