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# *Paralona sirindhornae* sp. nov. and *Karualona cambodiaensis* sp. nov., Two New Species of Cladocera (Crustacea: Cladocera: Chydoridae) from Southeast Asia

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**ABSTRACT.–** Two new cladocera species of the family Chydoridae (Crustacea: Cladocera) are described from Southeast Asia. Populations of *Paralona sirindhornae* sp. nov. were found in Thailand and Cambodia, while *Karualona cambodiaensis* sp. nov. was detected in Cambodia only. *Paralona sirindhornae* sp. nov. differs from the only other species of the genus *Paralona* Šramek-Hušek, Strašcraba et Brtek, 1962, namely, Holarctic *P. pigra* (Sars, 1862), in its smaller size, different position of the head pores, and the morphology of thoracic limbs III–V. Our data suggest that the populations of *Paralona* from South America and Africa also belong to independent species rather than *P. pigra*. *Karualona cambodiaensis* sp. nov. differs from other species of the genus in the unique morphology of the posteroventral angle of the valves, as well as in the body shape and morphology of the antenna. The morphology and taxonomic position of two new species are discussed. Both new species appear to be extremely rare in Southeast Asia, and their discovery is a result of recent intensive sampling efforts.

**KEYWORDS: biodiversity, Lake Bueng Khong Long, Cambodia, rare species, taxonomy, Thailand**

## INTRODUCTION

Recent studies of Southeast Asian Cladocera (Subphylum Crustacea: Class Branchiopoda) revealed a high local diversity of the families Macrothricidae Norman & Brady, 1867, Ilyocryptidae Smirnov, 1992, and Chydoridae Dybowsky & Grochowsky, 1894 in the region. Taxonomic status of local populations of presumably cosmopolitan or pantropical taxa was clarified, and a number of rare local endemics was revealed (Kotov and Sanoamuang, 2004; Kotov et al., 2005a, b; Sinev and Kotov, 2012; Van Damme and Sinev, 2013; Van Damme et al., 2013; Sinev, 2014; Sinev and Yusoff, 2016; Tiang-nga et al., 2016, 2021; Neretina and Kotov, 2017; Sinev and Semenyuk, 2023; Sinev et al., 2023, 2024, and others). However, the taxonomic status of several species remains unclear, as the local populations were previously identified as belonging to the taxa initially described from other regions, particularly Europe. One such taxon, *Paralona* cf. *pigra* (Sars, 1862), was recently reported based on a single specimen from Vietnam by Gusakov et al. (2025).

The genus *Paralona* Šramek-Hušek, Strašcraba & Brtek, 1962, is superficially similar to *Chydorus* Leach, 1816, in external appearance but differs in several important aspects. In *Paralona*, the posterior group of ventral setae of valves is located at the valve margin, like in *Pleuroxus* Baird, 1843, and *Alonella* Sars, 1862, not at the inner side of valves at a significant distance from the ventral margin, like in *Chydorus*. The head shield of *Paralona* has unique traits for the subfamily Chydoridae; the anterior margin of the valve bears a large triangular inner flange, which is not present (or minimal) in *Chydorus*. The antenna of *Paralona* has only two apical setae on the exopodite instead of three setae as in most Chydoridae. The independent generic status of *Paralona* was not accepted by most authors in the late 20th century (Negrea, 1983; Alonso, 1996; Flössner, 2000; and others), but it was supported by Smirnov (1996), Hudec (2010), and Korovchinsky et al. (2021).

The genus *Paralona* is presumed to be monotypic; its type species is *Paralona pigra* (Sars, 1862), which was originally described from Songsvann Lake in Oslo, Norway, as *Chydorus piger*. This species is distributed mainly in North Eurasia and North America (Dumont and Smirnov, 1996). The morphology of European populations of *P. pigra* was studied by Lilljeborg (1901), Alonso (1996), and Hudec (2010). It was also reported from Zambia (Dumont and Smirnov, 1996), Venezuela, Bolivia, and Ecuador (Dumont and Smirnov, 1996; Hudec, 1998; López et al., 2018); remains of *Paralona* were reported from bottom sediments from a lake in Honduras (Wojewódka et al., 2020). Note that *Paralona pigra* is a rather distinctive species, but it was never reported from India (Michael and Sharma, 1988; Chatterjee et al., 2013) or China (Chiang and Du, 1979; Ji et al., 2015).

Some distinguished taxa of Chydoridae frequently still avoid taxonomic revisions. Two distinctive species of *Rhynchotalona* Norman, 1903, from North America were treated as European *R. falcata* (Sars, 1862) during the 20th century (Sinev and Kotov 2012). All species of *Chydorus* with honeycombed valves were treated as a single species before the revision of Frey (1987). The genera *Pseudochydorus* Fryer, 1968, and *Monospilus*

Sars, 1862, were presumed to be monotypic and cosmopolitan (Smirnov, 1971, 1996). Recent revisions revealed that populations of *Pseudochydorus* in East Asia (Sinev et al., 2016) and Mexico (Sinev and Silva-Briano, 2021) belong to independent species. The same situation was observed in populations of *Monospilus* from East Asia (Kotov and Sinev, 2011) and South America (Sousa et al., 2017). The only attempt at a worldwide revision of *Paralona* cf. *pigra* (Dumont and Smirnov, 1996) revealed morphological differences between populations from different continents, suggesting they could belong to independent species.

A significant proportion of newly identified local endemics in Southeast Asia belong to the tropical genera of small-sized *Aloninae, Karualona* Dumont & Silva-Briano, 2000, and *Anthalona* Van Damme, Sinev & Dumont, 2011. Two species of these genera (*Karualona fatimae* Sinev & Semanyuk, 2023, and *Anthalona harti harti* Van Damme, Sinev & Dumont, 2011) are very common in Southeast Asia, being among the most common and abundant chydorids in the region (Sinev and Kotov, 2012; Sinev and Semanyuk, 2023), while all others (four species of *Anthalona* and three species of *Karualona*) are rather rare, known from few localities each, and never abundant (Van Damme et al., 2011, 2013; Kotov and Sinev, 2011; Tiang-nga et al., 2020, 2021; Sinev et al., 2024). The diversity of these two genera in SE Asia remains inadequately recognized. According to Sinev and Semenyuk (2023), specimens of *Karualona* sp. 2 reported from Laos by Kotov et al. (2013) belong to a separate, yet undescribed species. It differs from most species of the genus in a specific linear sculpture of valves. Sinev and Yusoff (2015) reported an undescribed species of *Anthalona* from Malaysian Borneo. The aim of the present paper is to describe two hitherto undescribed species of the genera *Paralona* and *Karualona*, found in Thailand and Cambodia.

## MATERIALS AND METHODS

Animals were selected from the samples collected during different sampling companies under an Olympus SZ-51 binocular stereoscopic microscope and studied under Olympus CX-41 and CX-51 optical microscopes. Dissections were conducted by electrolytically sharpened tungsten needles. For taking photographs, a LOMO BLM-L optical microscope with an MC-12C digital camera was used. Specimens were photographed with a gradual shift of focus in a glycerol-ethanol mixture drop. The resulting series were merged in Helicon Focus Pro 6.0.8 software, then processed in Adobe Photoshop CC software. Measurements were determined using an eyepiece micrometer; all drawings were made using a camera lucida. A standard system was used for the numeration of setae on thoracic limbs as initially proposed by Kotov (2000) for Aloninae and subsequently applied for Chydorinae (Smirnov et al., 2006).

**The illustrations and text contain various abbreviations.**– I–V = thoracic limbs I–V; as = accessory seta of limb I; e1–e3 = endites 1–3 of limb I; ep = epipodite; ex = exopodite; gfp = gnathobase filter plates of limbs II–V; IDL = inner distal lobe of limb I; IP = interpore distance (distance between anterior and posterior major head pores); ODL = outer distal lobe of limb I; pep = pre-epipodite; PP = postpore distance (distance between posterior head pore and posterior corner of headshield); s = sensillum.

## RESULTS

### Taxonomy

**Class Branchiopoda Latreille, 1817**
**Order Anomopoda Sars, 1865**
**Family Chydoridae Dybowski and Grochowski, 1894 emend. Frey, 1967**
**Subfamily Chydorinae Dybowski and Grochowski, 1894 emend. Frey, 1967**

**Genus *Paralona* Šramek-Hušek, Straškraba et Brtek, 1962**

***Paralona sirindhornae* sp. nov.**
http://zoobank.org/urn:lsid:zoobank.org/66EC1950-6AB6-4816-99F8-704867FCA034
(Figs 1A, 2, 3)

Gusakov et al., 2025: 429–230, fig. 6 (*pigra*).

**Etymology.**– The species is named in honor of Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand, acknowledging her enduring commitment to the study of biodiversity and ecosystem sustainability in Thailand, as well as to commemorate her 70th birthday in 2025. The Plant Genetic Conservation Project, initiated by her, was designed to conserve resources for researchers to investigate the biodiversity and utilization of plants, animals, and microorganisms. This project also aims to cultivate professionals proficient in leveraging these resources for agricultural progress and the advantage of local farmers.

**Type locality.**– Lake Bueng Khong Long, Bueng Khong Long District, Bueng Kan Province, northeast Thailand, geographic coordinates: 19°1′0″ N, 104°5′0″ E.


**FIGURE 1. A,** *Paralona sirindhornae* sp. nov. from Lake Bueng Khong Long, Bueng Khong Long District, Bueng Kan Province, Thailand (type locality), adult parthenogenetic female. **B,** *Karualona cambodiaensis* sp. nov. from a canal at Ropeakpen, Baray district, Kampong Thom Province, Cambodia (type locality), adult parthenogenetic female.

**Material examined.**– Holotype: Parthenogenetic female from the type locality, coll. A.Y. Sinev, 23 August 2024, deposited at the Zoological Museum of M.V. Lomonosov Moscow State University, ML-280. Paratypes: four parthenogenetic females, the same collection data as for the holotype, deposited at the Zoological Museum of M.V. Lomonosov Moscow State University, ML-281; one parthenogenetic female from a swamp at Prei Robos, Kampong Svay District, Kampong Thom Province, Cambodia, geographic coordinates: 12º47′ 36″N, 104º49′29″E, coll. W. Mahasap, 14 June 2007, deposited at the Zoological Museum of M.V. Lomonosov Moscow State University, ML-281.

**Other material examined.**– Four parthenogenetic females from the type locality and a single parthenogenetic female from Cambodia were dissected for the analysis of appendages.

**Description.**– Parthenogenetic female. Body weakly compressed laterally, rounded in lateral view in adults (Figs 1A, 2B–C), oval in juveniles (Fig. 2A), height/length ratio about 0.9, maximum height at body middle portion. Valves and head shield oblique or covered by a tuberculated sculpture. Anterior corner of valve broadly rounded, with a large triangular submarginal flange, characteristic of the genus *Paralona*, on inner side, apex of flange truncated. Ventral margin of valve (Fig. 2C) with about 70 setae; 10 anterior setae very thin, located on inner side of valve close to margin, followed by about 30 very short setae located marginally. Posterior group consists of about 30 long setae, longer than those in anterior group, armed with long setulae (Fig. 2D), located on inner side of valve closely to its ventral margin; maximum length of setae in the middle of each group. One or two denticles of variable shape located closely to last setulated seta (Fig. 2F).

*Head* with a short rostrum, protruding downward and posteriorly (Fig. 2C). Length of rostrum about 1.5–2 times as long as length of antennule. Ocellus 1.5 times smaller than eye. Head shield large (Fig. 2H), rostrum short, triangular, separated from rest of head shield by clear incursions (Fig. 2I), margin between rostrum and mandibular articulation convex. Posterior portion two times longer than anterior portion, oval, with maximum width at middle of posterior portion; its posteriormost portion broadly rounded (Fig. 1H). Two major head pores, PP = 1.2–1.5 IP. Lateral head pores minute, located asymmetrically, close to midline of head shield, a little closer to anterior major head pore (Fig. 2J–K).

*Labrum* with an elongated labral keel (Fig. 2L–M) having a narrow, elongated apex. The keel about 2.5 times as long as width. Anterior margin of labral keel almost straight in two upper thirds, lower portion of keel triangular, not forming an elongated, spine-like apex, characteristic of *Paralona pigra* s. str.

*Postabdomen* (Fig. 2N–P) short, of a characteristic shape, wide in preanal portion, strongly narrowing in anal portion; in its postanal portion margins almost parallel. It is about 1.5 times as long as height at preanal angle. Ventral margin straight. Basis of claws bordered from distal margin by a clear incision. Distal margin straight, distal angle broadly rounded, protruding before base of claws. Dorsal margin straight in postanal portion and strongly concave in anal one. Distal part of postabdomen 1.4–1.5 times longer than preanal portion; postanal and anal portion of similar

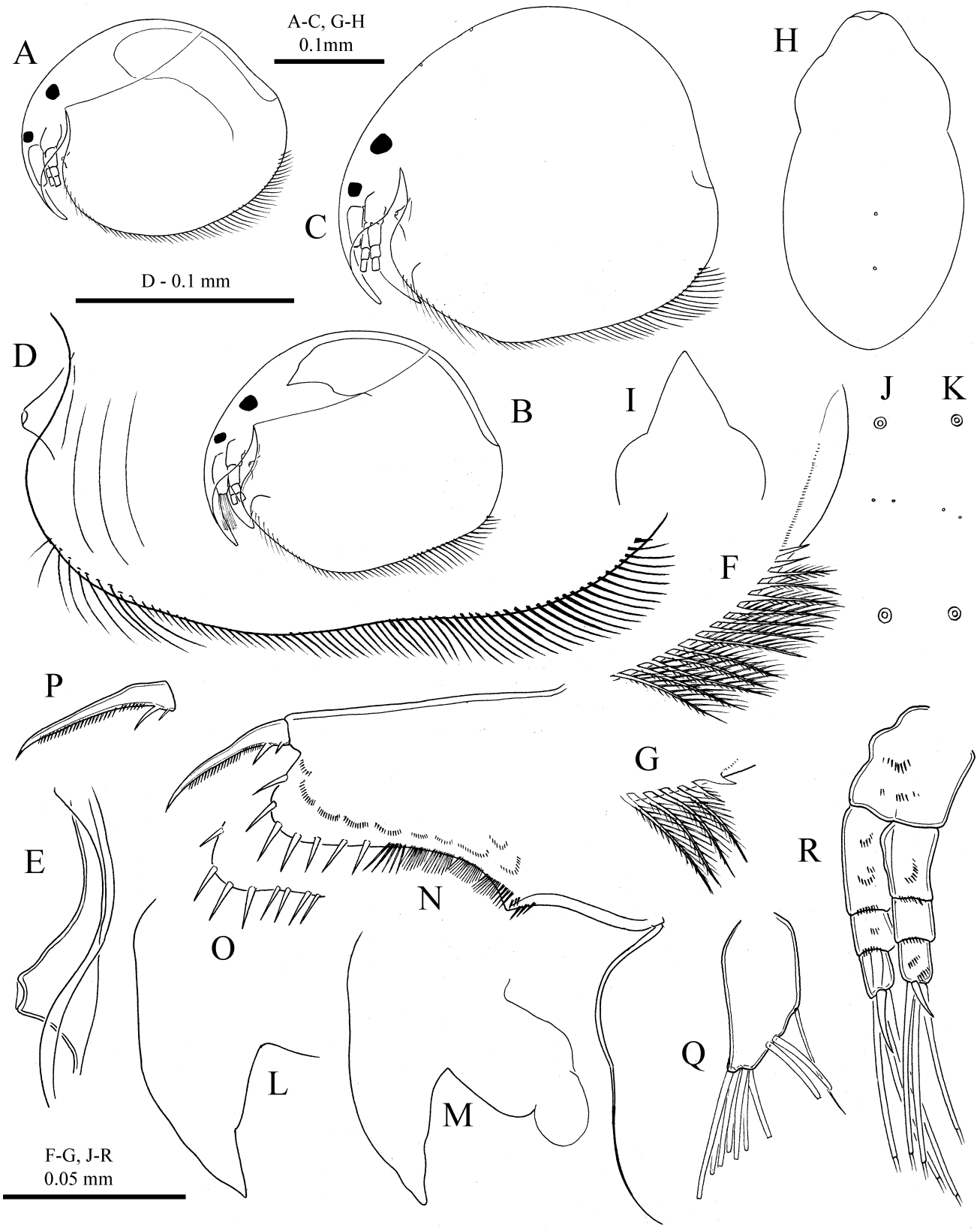


**FIGURE 2.** *Paralona sirindhornae* sp. nov. from Lake Bueng Khong Long, Bueng Khong Long District, Bueng Kan Province, Thailand (type locality). **A**, juvenile female. **B–R**, adult parthenogenetic female. **B–C**, lateral view. **D**, ventral margin of valves (from flattened valve). **E**, anterior flange of valve. **F–G**, postero-ventral angle of valves. **H**, head shield (not flattened). **I**, anterior portion of flattened head shield. **J–K**, head pores, anterior pore up. **L–M**, labrum. **N**, postabdomen. **O**, marginal denticles on opposite side of same postabdomen. **P**, postabdominal claw. **Q**, antennule. **R**, antenna.

length. Preanal angle well-expressed, triangular, prominent; postanal angle not defined. Preanal margin weakly sigmoid. Postanal margin with 7–9 narrow, sharp denticles, length of longest denticles 1.5–2 times greater than width of base of postabdominal claw. Anal margin with 5–6 clusters of long setulae. A row of 9–10 broad lateral groups of very short setulae along dorsal margin of postabdomen.

*Postabdominal claw* (Fig. 2P) slender, of a characteristic shape, with a broad basal third and narrow, almost straight distal portion, 1.2–1.3 times longer than preanal portion of postabdomen, with distinctive pecten of setulae on dorsal margin. Basal portion of pecten consists of 7–10 short setulae, distal portion of about 20 longer setulae. Two basal spines; distal spine 0.2 times as long as length of claw, proximal spine two times shorter.

*Antennule* (Fig. 2Q) of moderate size, with a broad basal half, narrowing distally in distal half, length about 2.5 times as long as width. Antennular seta thin, about 2/3 length of antennule body, implanted at middle of antennule. Two lateral aestetascs with length about half-length of antennule, arising in middle between antennal seta and end of antennule, seven terminal aesthetascs of different lengths, the longest one almost as long as antennule itself.

*Antenna* relatively short (Fig. 2R). Antennal formula: setae 0-0-3/0-1-2; spines 0-0-1/0-0-1. Coxa with two coxal setae, basipodite narrow. Branches relatively short; basal segment of each branch two times longer and thicker than two others. Seta of middle segment of endopodite of similar size with apical setae. Apical segment of each branch with two apical and a single subapical seta of similar size. Spine on basal segment of exopodite very thin, setae-like, frequently unseen under optic microscope. Apical spines longer than respective apical segments.

Thoracic limbs: five pairs.

*Limb I* of moderate size (Fig. 3A–C). Epipodite oval, without a projection. ODL (Fig. 3B) with two setae, seta 2 very short. Accessory seta short. IDL (Fig. 3B) with three setae, setae 2–3 of similar length, slightly shorter than ODL seta 1, seta 1 two times shorter than setae 2–3, and thicker, no setulae on setae 2–3 visible even in high-magnification immersion optics. Endite 3 with four setae, inner seta (1) shorter than each among outer setae (a–c). Endite 2 with inner seta (2) unilaterally armed with spinules and three outer setae (d–f); seta f long, almost as long as limb itself, seta f about 2/3 lengths of seta e. Endite 1 with a well-developed inner seta (3), three 2-segmented setae of similar size (g–i), setulated in distal part, and a flat geniculated seta (j). Anterior face of limb with seven rows of setulae, setulae in distal group thicker and longer than in basal groups. Two ejector hooks, one larger than another. Maxilla process not separated from main body of limb, its seta almost as long as setae of endite 3.

*Limb II* (Fig. 3D–E). Exopodite of an irregular shape, with a single seta two times longer than exopodite. Eight scraping spines armed with fine denticles, scrapers 1–5 long, decreasing in length basally, scrapers 6–8 of similar length, 1.5 times shorter than scraper 5. Slender elongated sensillum between bases of scrapers 3 and 4. Distal armature of gnathobase with four elements, clustered together. Filter plate II with eight setae.

*Limb III* (Fig. 3F–I). Epipodite oval, without a projection. Exopodite (Fig. 3F) subrectangular, with three lateral (1–3) and four terminal (4–7) setae. Seta 4 being longest; seta 6 slightly shorter than seta 4, length of setae 5 and 7 about 2/3 and 4/5 length of seta 4, respectively; lateral setae of similar length, about 2/5 length of seta 4. Setae 1–5 plumose; seta 5 with densely setulated distal portion, seta 6 with row of long setulae at middle, seta 7 with short setulae in distal portion. Distal endite (Fig 3G–H) with three setae, setae 1–2 long, armed with spinules, seta 3 short, naked. Basal endite (Fig. 3G) with 6 plumose setae (a–f) of similar length. Four pointed inner setae (4–7) of similar size (Fig. 3I); a small bottle-shaped sensillum near base of seta 4. Distal armature of gnathobase with three elements: large elongated sensillum, strongly geniculated seta, and two short spines. Filter plate III with eight setae.

*Limb IV* (Fig. 3J–L). Pre-epipodite setulated; epipodite oval, with a projection 1.5 times longer than epipodite. Exopodite (Fig. 3J) rounded, with seven setae; setae 1–2 being longest, setae 3–4 slightly shorter, setae 5 and 7 length about half-length of seta 2, seta 6 longer than setae 5 and 7. Setae 1–5 flat, plumose, seta 6 with unilaterally setulated basal part and short setulae in distal portion, seta 7 with short setulae in distal part. Inner portion of limb IV (Fig. 3K) with four setae, seta 1 scraping, thin, flaming-torch setae (2–4) well-developed, of similar size, each armed with 11–15 long setulae. Small sensillum located near base of seta 2. Four inner setae (a–d) of similar length (Fig. 3L). Gnathobase with a single two–segmented setae, a small hillock distally, and two sensillae. Filter plate IV with six setae.

*Limb V* (Fig. 3M). Pre-epipodite setulated; epipodite oval, with two processes protruding at different sides of exopodite, one as long as epipodite, another two times longer. Exopodite ovoid, with four setae, length of setae evenly decreasing basally, seta 4 about 2/3 length of seta 1. Setae 1–3 plumose, seta 4 bilaterally armed with thick setulae in distal portion. Two small hillocks with thick setulae located on basal side of

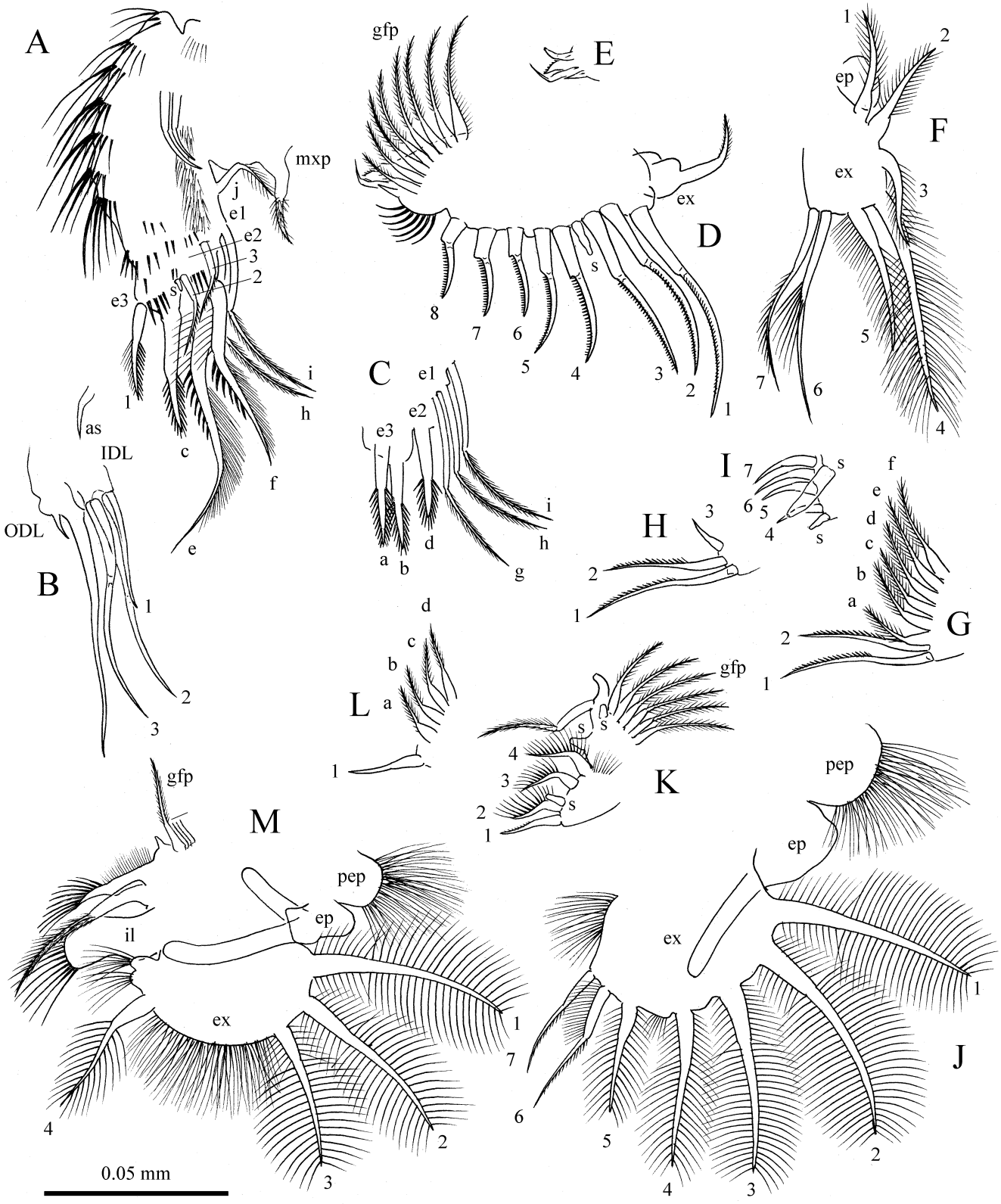


**FIGURE 3.** *Paralona sirindhornae* sp. nov. from Lake Bueng Khong Long, Bueng Khong Long District, Bueng Kan Province, Thailand (type locality), thoracic limbs of parthenogenetic female. **A**, limb I from inner side, setae a, b, d not shown. **B**, IDL and ODL of limb I. **C**, endites of limb I from outer side. **D**, limb II. **E**, gnathobase of limb II. **F**, exopodite of limb III. **G**, distal and basal endites of limb III (seta 3 of distal endite not shown). **H,** distal endite of limb III. **I,** inner setae of limb III. **J**, exopodite of limb IV. **K**, inner portion of limb IV. **L**, inner setae of limb IV. **M**, limb V.

**TABLE 1.** Morphological comparison between *Paralona sirindhornae* sp. nov. and *Paralona pigra* (Sars, 1962) from the type locality.

| Character | *Paralona sirindhornae* sp. nov. | *Paralona pigra* s. str. |
|---|---|---|
| Body length | up to 0.38 mm | up to 0.49 mm |
| Head pore position | pp less than 1.5 ip | pp about 2 ip |
| Exopodite III | seta 5 long, about 2/3 length of seta 3 | seta 5 short, about 1/2 length of seta 3 |
| Epipodite IV | with process much longer than epipodite body | with process much shorter than epipodite body |
| Epipodite V | with two processes much longer than epipodite body | with single process much shorter than epipodite body |

exopodite near seta 4. Inner lobe long, narrow, with inner margin armed with long and thick setulae. At inner face, two setae, first one two times shorter than other one, shorter setae in distal portion armed unilaterally with thick long setulae. Filter plate with four setae.

Ephippial female and male unknown.

**Size.**– In juvenile females, length 0.23–0.25 mm, height 0.20 mm, in adult females, length 0.27–0.38 mm, height 0.22–0.32 mm.

**Differential diagnosis**.– *Paralona sirndhornae* sp. nov. differs from a single taxon regarded as valid within the genus, *Paralona pigra,* in smaller size, different IP/PP ratio, different proportions of the setae on exopodite III, and different morphology of epipodites IV–V. Differences between the species are summarized in Table 1.

**Distribution.**– Northeast Thailand, Cambodia, and South Vietnam.

**Studies of comparative material**

***Paralona pigra* (Sars, 1862)**
(Fig. 4)

Sars, 1862a: 163–164 (*Chydorus piger*); Lilleborg, 1901: 541–542, pl. 77: fig. 26–29, pl. 78: fig. 1–9 (*Chydorus piger*); Smirnov, 1971: 294–295, Рис. 317–319 (*Chydorus piger*); Smirnov, 1996: 149–150, fig. 554–593; Alonso, 1996: 298–302, fig. 134 (*Chydorus piger*); Dumont, Smirnov, 1996: 32–34, fig. 1–35; Flössner, 2000: 245–248, pl. 92 (*Chydorus piger*); Hudec, 2010: 384–385, fig. 94; Korovchinsky et al., 2021: 429, fig. 113, 10–18.

**Type locality.**– Lake Songsvann, Oslo, Norway.

**Material examined.**– 7 parthenogenetic females from type locality, collected on 16 September 2008, by J.-P. Nielssen.

Our specimens from the type locality fully correspond morphologically to those earlier descriptions of Alonso (1996), Dumont and Smirnov (1996), Flössner (2000), and Hudec (2010). They are rather similar to those of previous species in outer morphology (Fig. 4A) but have a greater size (up to 0.46 in studied material); according to literature data, the maximum size of the European females of *P. pigra* is 0.49 mm (Korovchinsky et al., 2021). The shape of the head shield is similar to that in the previous species, but the head pores are located farther from the posterior margin of the head shield, with PP about 2 IP. The morphology of the antennule, antenna, and thoracic limbs is similar to that in previous species, with several exceptions: the IDL setae of limb I appear thicker (Fig. 4G), while exopodite III (Fig. 4H) has a shorter seta 5, which is about half the length of seta 3, and limbs IV–V have exopodites with short single processes (Fig. 4I–J).

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

**Genus *Karualona* Dumont and Silva-Briano, 2000**

***Karualona cambodiaensis* sp. nov.**
http://zoobank.org/urn:lsid:zoobank.org/2F244B86-058B-4984-BF3E-1DEA3E353400
(Figs 1B, 5)

**Etymology.**– The specific epithet is derived from "Cambodia", reflecting the name of the country where the type locality is located. The name is an adjective in the nominative singular, feminine gender.

**Type Locality.**– A canal at Ropeakpen, Baray district, Kampong Thom Province, Cambodia, geographic coordinates: 12°20'44" N 105°6'01" E.

**Material examined.**– Holotype: parthenogenetic female from the type locality, coll. W. Mahasap, 25 October 2007, deposited at Zoological Museum of M.V. Lomonosov Moscow State University, ML-282. Paratypes: two parthenogenetic females from the type locality, deposited at Zoological Museum of M.V. Lomonosov Moscow State University, ML-283.

**Other material examined** (specimens dissected for analysis of appendages, not deposited).– two parthenogenetic females from type locality; one parthenogenetic female from canal at Poserey, Kampong

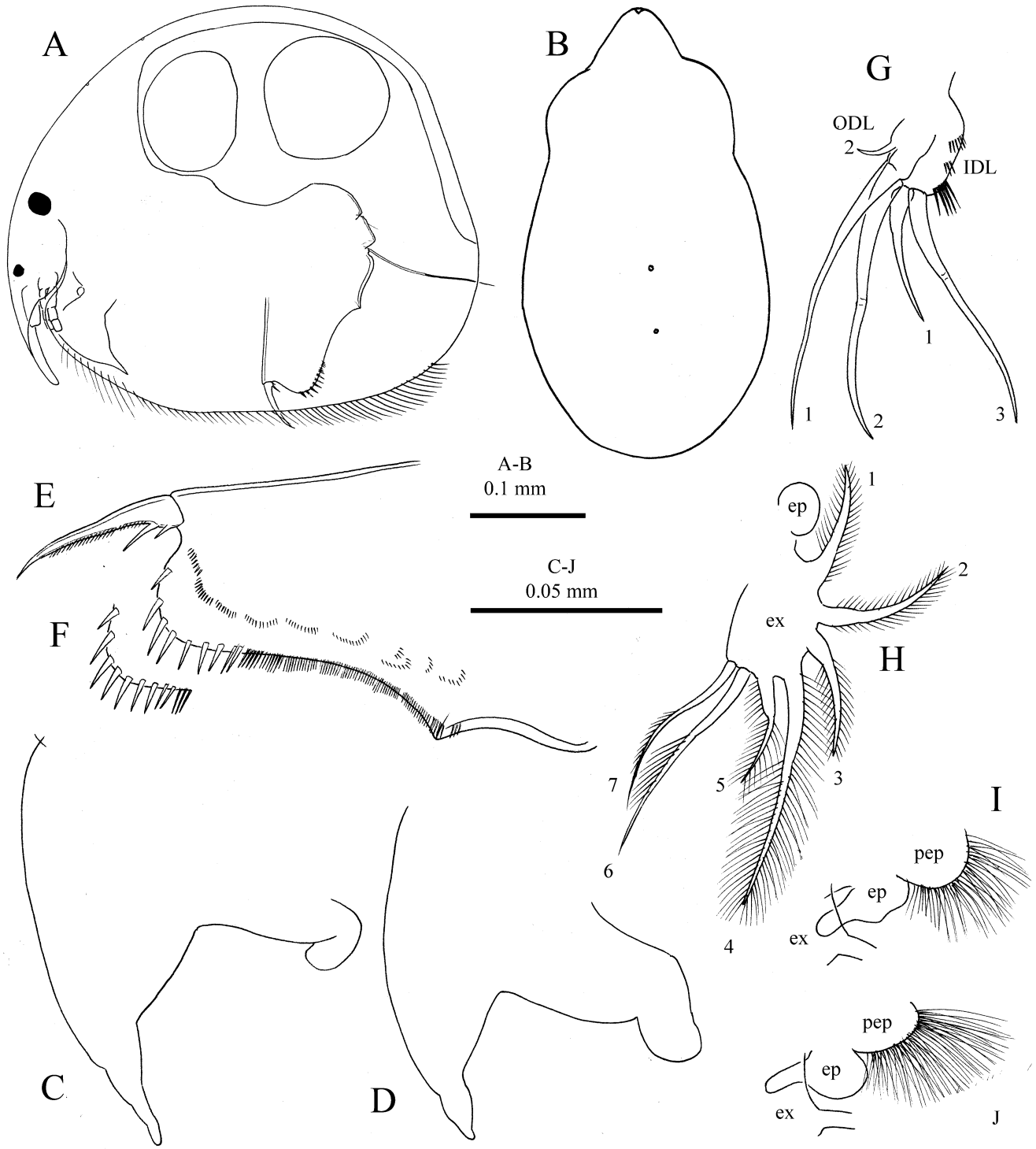


**FIGURE 4.** *Paralona pigra* (Sars, 1862) from Songsvann Lake, Oslo, Norway (type locality), adult parthenogenetic female. **A**, lateral view. **B**, head shield (not flattened). I, anterior portion of flattened head shield. **C–D**, labrum. **E**, postabdomen. **F**, marginal denticles on opposite side of same postabdomen. **G**, IDL and ODL of limb I. **H**, exopodite of limb III. **I,** epipodite of limb IV. **J**, epipodite of limb V.

Kdey, Chi Kraeng district, Kampong Thom Province, 13º06'50"N, 104º21'09"E, 26 October 2007; and one parthenogenetic female from swamp at Mechbar, Choy Sdao, Thma Koul district Battambang Province, Cambodia, 13º20'59" N, 103º02'47" E, coll. W. Mahasap, 28 October 2007.

**Description.**– Parthenogenetic female. Body oval (Figs 1B, 5A–B) in lateral view, moderately compressed laterally, moderately high, height-length ratio in adults about 0.6, maximum height at middle of body. Dorsal margin convex, posterodorsal and posteroventral angles broadly rounded. Posterior margin

convex, slightly undulated in anterior portion, ventral margin almost straight, anteroventral angle rounded. Ventral margin (Fig. 5C) with 40–50 setae, eight anterior setae long, next 15 setae very short, posterior 20 setae thick, located closely to each other, of moderate length. Posteroventral angle (Fig. 5D–E) with 15–25 denticles, forming 4–5 groups, size of denticle in each group increases posteriorly, all denticles with setula at the apex. A row of about 80 setulae on inner side of carapace along posterior margin, lower part of row consists of alternating longer and shorter setulae, upper part of about 30 very short setulae. Valves covered by a well-developed sculpture as about 12 longitudinal lines in posterior half and about 8 vertical lines in anteroventral quarter, anteroventral portion of valves frequently tuberculated.

*Head* relatively small, triangle-round in lateral view, rostrum short, pointing downward. Eye larger than ocellus. Distance from tip of rostrum to ocellus 1.5 times greater than that between ocellus and eye.

*Head shield* with a maximum width behind mandibular articulation, oblique or tuberculated in posterior portion. Rostrum short, broadly rounded. Two major head pores (Fig. 5F) with a broad connection between them, lateral head pores located at about 1.5 IP distance from midline, at midpoint between major head pores.

*Thorax* two times longer than abdomen. Dorsal surface of abdominal segments not saddle-shaped. Abdominal projections absent.

*Postabdomen* (Fig. 5H–I) short, of moderate width, with almost parallel margins in postanal portion and broadly rounded dorsal distal angle. Maximum height at middle of postanal portion. Length about 2.2–2.4 height. Ventral margin weakly convex. Basis of claws bordered from distal margin by a clear incision. Distal margin convex. Dorsal margin with distal part about 1.5 times longer than preanal one; postanal portion slightly longer than anal portion. Preanal angle well defined, postanal angle not defined. Preanal margin sigmoid.

Postabdomen with 7–8 short marginal denticles followed by 2–3 clusters of setulae; 2–3 distal denticles single, other with 1–2 smaller spines near base. Length of longest denticles equal to width of postabdominal claw base. About 10 lateral groups of setulae; in 6–7 postanal groups, in each group a distalmost setula long and thick, its length 1.5 times exceeding width of basal claw base. Number of setules in each group increases from 6–7 in distalmost groups 8–12 in anal ones. Post-abdominal claw (Fig. H–I) weakly curved, of moderate length, as long as preanal portion of postabdomen. Basal spine short, its length slightly less than width of claw base. Basal pecten of setulae well-developed, with setulae of about 2/3 length of basal spine.

*Antennule* (Fig. 5J) of moderate size, with four clusters of short setulae on inner face. Length/width ratio about 2.5. Antennular sensory seta slender, two times shorter than antennule, arising at about 2/3 distance from base. Nine terminal aesthetascs, longest slightly shorter than antennule, others of about 2/3 length of antennule.

*Antenna* short (Fig. 5K). Antennal formula, setae 0–0–3/0–1–3, spines 1–0–1/0–0–1. Basipodite robust, branches short and stout, of similar length. Basal segments of both branches 1.5 times longer than middle + apical segments. We had found no seta on basal segment of endopodite. Seta arising from middle segment of endopodite slightly longer than exopodite. Apical segment of endopodite with setae of similar thickness. Spine on basal segment of exopodite about 2/3 length of middle segment. Spine from apical segments shorter than respective apical segments.

Thoracic limbs: five pairs. Morphology of thoracic limbs typical for the genus. We were unable to fully study limbs due to limited number of specimens.

*Limb I* of moderate size. Epipodite oval, without a process. Accessory seta long, about 1/2 length of ODL seta (Fig. 5L). IDL with 3 setae, seta 3 as long as ODL seta, seta 2 slightly shorter than seta 3, both armed with numerous thin setulae, evenly decreasing in size posteriorly; seta 1 thin, 3 times shorter than seta 2. Morphology of endites typical of the genus. Six-seven rows of thin long setules on ventral face of limb. Two ejector hooks, first one much larger than other.

*Limb II* (Fig. 5M–N). Exopodite elongated, of irregular shape with short distal process. Eight scraping spines armed with thin setules, decreasing in length basally. Distal armature of gnathobase with 4 elements. Filter plate with 7 setae, two distalmost setae much shorter than others.

*Limb III*. Epipodite without a process. Exopodite (Fig. 5O) with length slightly greater than width, slightly narrowing to base, with 6 setae. Seta 3 being longest, seta 4 and 5 about half length of seta 3, setae 1 and 6 of about 1/4 length of seta 3, seta 2 short. Setae 1–3 plumose, seta 4 in basal portion unilaterally armed with long setules, in distal portion plumose, seta 5 bilaterally armed with thick long setules in distal portion, seta 6 naked. Inner portion of limb of typical for the genus morphology.

*Limb IV*. Preepipodite setulated; epipodite oval, with a process as long as epipodite. Exopodite (Fig. 5P) rounded, with 6 setae. Seta 3 being longest, setae 1–2 slightly shorter than seta 3, setae 4 and 5 shorter than setae 1–2, seta 6 extremely short. Setae 1–3 flattened, plumose, seta 4 with wide base armed with

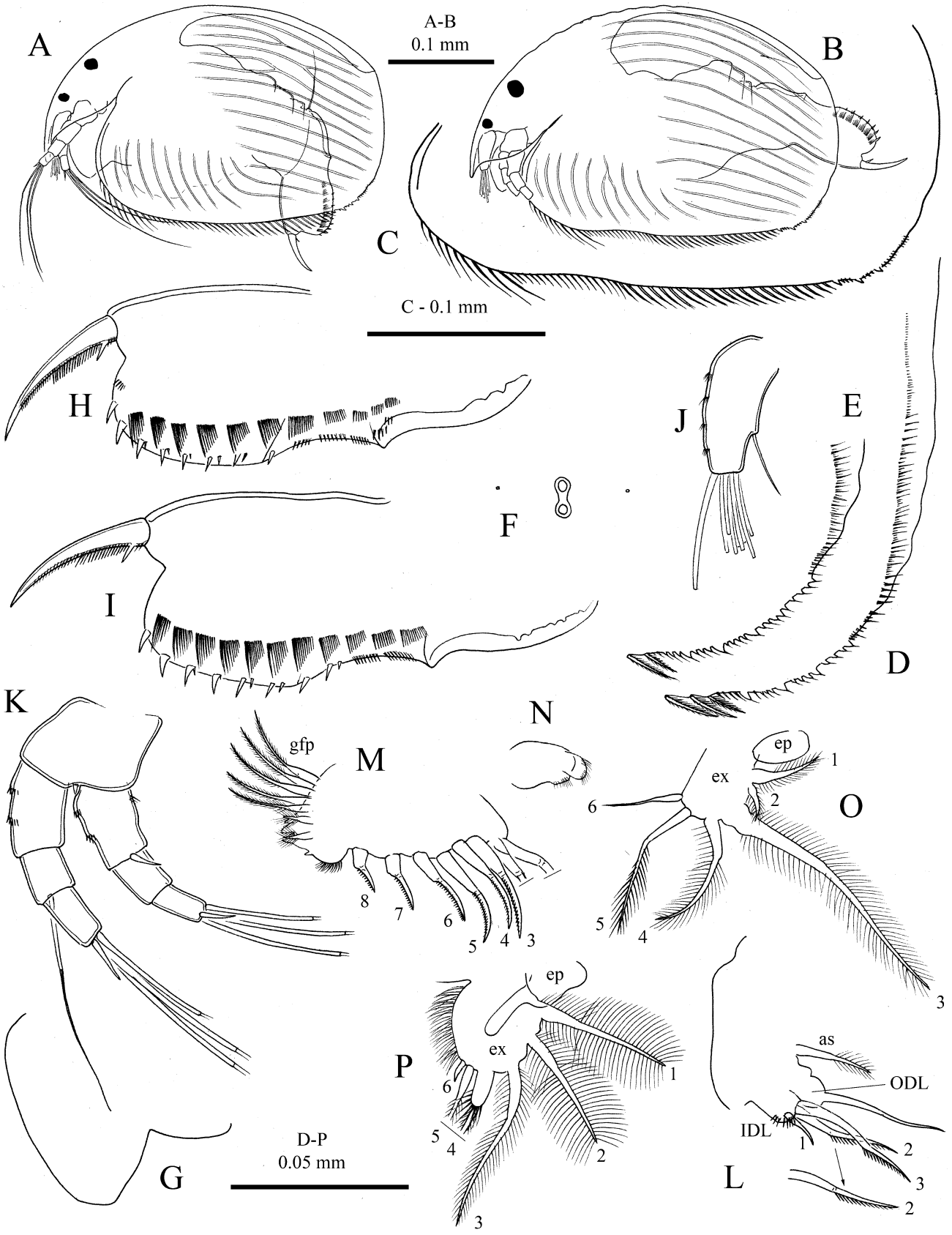


**FIGURE 5.** *Karualona cambodiaensis* sp. nov. from canal at Ropeakpen, Baray district, Kampong Thom Province, Cambodia (type locality), adult parthenogenetic female. **A–B**, lateral view. **C**, ventral margin of valves. **D–E**, postero-ventral angle of valves. **F**, head pores. **G**, labrum. **H–I**, postabdomen. **J**, antennule. **K**, antenna. **L**, IDL and ODL of limb I. **M**, limb II. **N**, exopodite of limb II. **O**, exopodite of limb III. **P**, exopodite of limb IV.

long setulae and narrow setulated posterior portion, seta 5 with short setulae in distal part, seta 6 naked. Inner lobe of typical for the genus morphology, with only 3 marginal setae and sensillum.

*Limb V* of typical for the genus morphology, epipodite oval, with process as long as epipodite.

Ephippial female and male unknown.

**Size.**– In studied adult females, length 0.33–0.36 mm, height 0.21–0.22 mm.

**Differential diagnosis.**– *Karualona cambodiaensis* sp. nov. differs from all other species of the genus (see Dumont and Brancelj, 1994; Alonso and Pretus, 1989; Dumont and Silva-Briano, 2000; Sinev and Holwedell, 2005; Van Damme et al., 2013; Tiang-Nga et al., 2021; Sinev and Semenyuk, 2023) in the unique armament of the posteroventral angle of valves, with 15–25 closely spaced denticles of variable size. Most other species of the genus either have 2–5 large denticles at significant distances from each other (*K. karua* King, 1853); *K. fatimae* Sinev & Semenyuk, 2023; *K. iberica* (Alonso & Pretus, 1989); *K. muelleri* (Richard, 1897); *K. penuelasi* Dumont & Silva-Briano, 2000; *K. socotrana* Dumont & Silva-Briano, 2000; *K. kwangsiensis* (Chiang, 1963); and *K. arcana* Tiang-nga, Sinev & Sanoamuang, 2021) or lack any denticles (*Karualona alsafadii* (Dumont & Brancelj, 1994)). A somewhat similar armature of the posteroventral angle could be found in *K. serrulata* Van Damme, Maiphae & Sa-Adrit, 2013, but in this species denticles are uniform and spaced in groups divided by broad gaps. *Karualona cambodiaensis* sp. nov. also differs from most species of the genus in having an oval, not ovoid, body and valve sculpture as longitudinal lines instead of polygons, and in having apical setae of the antenna exopodite being of similar thickness (in most species one of these setae is much thicker and longer than others); these features are shared only by *K. arcana. Karualona arcana* differs from *K. cambodiaensis* sp. nov. in the shape of the postabdomen, in the absence of setulae on the anterior margin of the labrum, and in the absence of IDL seta 1.

**Distribution.**– *Karualona cambodiaensis* sp. nov. has so far been recorded in Kampong Thom and Battambang Provinces, Cambodia. We expect the species to have a wider area of distribution in Southeast Asia.

## DISCUSSION

*Paralona sirindhornae* sp. nov. differs from *P. pigra* in several independent morphological characters, as well as in body size. The ecological differences between species are also obvious; Eurasian *P. pigra* is distributed in cold to temperate zones; it was reported mostly from oligo-mesotrophic lake littoral and ponds. The northernmost records are found in the Lena River delta (Chertoprud and Novichkova, 2021) and North Kamchatka (Dadykin et al., 2025). Paleolimnological studies revealed it to be one of the few postglacial pioneer taxa in Scandinavian lakes (Duigan and Birks, 2000). The species is extremely rare in Southern Europe (Alonso, 1996; Margaritora, 1985; Negrea, 1983); in Central Asia, it is recorded only in North Kazakhstan. It was never recorded in North Africa, South Korea (Garibian et al., 2020), India (Michael and Sharma, 1988; Chatterjee et al., 2013), and China (Chiang and Du, 1983; Ji et al., 2015).

*Paralona sirindhornae* sp. nov. is a tropical species adapted to warm conditions. Tropical Cladocera species frequently have a smaller size than their Boreal congeners. For example, two recently described tropical species of *Pseudochydorus* have a maximum length of about 0.5 mm, while it is 0.8 mm in Holarctic *Pseudochydorus globosus* (Sinev et al., 2016; Sinev and Silva Briano, 2021).

The study of Dumont and Smirnov (1996) revealed significant differences between Boreal populations of *Paralona pigra* and those from Africa and South America. But they did not describe the latter as separate taxa. These authors did not analyze the morphology of thoracic limbs, the position of head pores, and the size range of studied populations, which prove to be essential in our study. Our data strongly suggests that use of modern morphological analysis will confirm the independent status of other tropical populations of *Paralona*. North American populations of *Paralona* are morphologically (Dumont and Smirnov, 1996) and ecologically (Chengalath, 1982) similar to Eurasian ones but can belong to a separate species as well.

Distribution of *Paralona* is unusual for Cladocera, but it is not unique. Similar distributions are present in the genera *Streblocerus* Sars, 1862, and *Acantholeberis* Lilljeborg, 1853, and in honeycombed species of the genus *Chydorus*. *Acantholeberis curvirostris* (O.F. Muller, 1776) and *Streblocerus serrulatus* Fisher, 1849 are distributed in the cold-temperate area of the Northern Hemisphere (Korovchinsky et al., 2021). Both genera are absent in the arid belt of the Eastern Hemisphere and in Central America. *Streblocerus* includes four tropical taxa: Neotropical *S. pigmaeus* Sars, 1901, and Venezuelan *S. superserricaudatus* Smirnov, Alvarez & Castillo, 1995; West African *S. inexpectatus* Dumont, 1981; and Indo-Malaysian *S. spinulatus* Smirnov, 1992 (Smirnov, 1992; Smirnov et al., 1995). Populations of *Streblocerus* similar to *S.*

*serrulatus* were recently found in northeast Thailand (Tiang-Nga et al., 2020). *Acantholeberis* is so far recorded only in the Neotropics. *A. smirnovi* Paggi and Herrera-Martinez, 2020, is distributed in Colombia and Venezuela, and *A. accolismaris* Sousa, Elmoor-Loureiro & Álvarez-Silva, 2022, is in Southern Brazil (Paggi and Herrera-Martinez, 2020; Sousa et al., 2022). Honeycombed species of the genus *Chydorus* are distributed primarily in the tropics and absent in dry subtropical regions. However, there are two such species in the Nearctic region (see Frey, 1987; Smirnov, 1996), and one more species was recently revealed in Northeast Russia (Sinev et al., 2023).

Sousa et al. (2022) suggested that South American and Holarctic populations of *Acantholeberis* were differentiated at Mesozoic time, and, in our opinion, this is true for all the genera mentioned above. Such distribution can be explained by the extinction of these groups in present-day subtropical regions during the Oligocene aridization.

*Karualona cambodiaensis* sp. nov. and another Southeast Asian endemic, *K. arcana* (see Tiang-nga et al., 2021), differ from the majority of the genus in having an outer morphology of generalized *Alona*-like Aloninae. They have an oval body with maximum height at the middle, a linear sculpture of valves, and apical setae of antennae of uniform thickness. In contrast, typical *Karualona* species (see Alonso and Pretus, 1989; Dumont and Silva-Briano, 2000; Sinev and Holwedell, 2005; Van Damme et al., 2013; Sinev and Semenyuk, 2023) have an ovoid body with maximum height before the midline, polygonal sculpture of valves, and differentiated apical setae of antennae, with one of the endopodite setae being much longer and thicker than the others. *Karualona arcana* also has a postabdomen shape unusual for *Karualona*, more similar to that of *Anthalona*, and lacks IDL seta 1, which is present in all other species of the genus. However, both these species have morphology of head pores characteristic of the genus, posteroventral angle of valves with denticles, armament of postabdomen, and morphology of thoracic limbs, including especially characteristic morphology of limb IV, with very small exopodite seta 6 and only two flaming-torch setae of the inner portion. The attribution of *K. arcana* to *Karualona* was questionable, but the discovery of *K. cambodiaensis* sp. nov. is filling the gap between *K. arcana* and other species of the genus.

Both these species are basal for the genus *Karualona*. Recent data shows that such species tend to be local endemics, which are rare as compared to crown-group species present in the same area. Within *Karualona*, we observe the common pattern of distribution of large genera of Aloninae, with morphologically advanced crown-groups of a genus that are either worldwide or pantropical in distribution, while other species and clades are confined to limited areas and usually rare in comparison with species of the core group. Species of earlier derived clades uniformly have the latter pattern of distribution. Such a situation is observed in genera *Anthalona* Van Damme, Sinev & Dumont, 2011 (Tiang-nga et al., 2016); *Camptocercus* (Sinev, 2018); *Coronatella* Dybowski & Grochowski, 1894 (Sinev, 2020); *Flavalona* Sinev & Dumont, 2016 (Sinev and Dumont, 2016); *Leydigia* Kurz, 1875 (Kotov, 2009); and *Ovalona* Van Damme & Dumont, 2008 (Sinev, 2015), which may suggest common evolutionary patterns for these groups.

Currently, the Indo-Malaysian region has the highest diversity of *Karualona*, five species of the genus (*K. fatimae*, *K. kwangsiensis*, *K. serullata*, *K. arcana*, and *K. cambodiaensis* sp. nov.), and at least one undescribed taxon is still present there. In contrast, only a single taxon of the genus is known from South America (*K. muelleri*), two taxa are known from Central America (*K. muelleri* and *K. penuelasei),* and two are reported from Africa (*K. karua* and *K. iberica*). Two more species of the genus are local endemics of Socotra Island (*K. sokotrana*) and underground waters of the Arabian Peninsula (*K. alsafadii*). Such disproportion is probably a result of intensive studies in Southeast Asia. Rare local species, especially small-sized ones like *Anthalona*, *Paralona*, or *Karualona*, are unlikely to be found during one-season sampling trips and can be revealed only by regular all-year sampling efforts. The presence of more abundant and habitually similar congeners requires thoughtful sample processing and study of each specimen—in our case, specimens of *Paralona sirindhornae* sp. nov. at small magnification during sample sorting can be confused with abundant *Chydorus* spp. present in the same samples, and *Karualona cambodiaensis* sp. nov. with habitually similar *Coronatella rectangula* (Sars, 1862) and *Coronatella acuticostata* (Sars, 1903). However, the presence of two species with basal positions for the genus *Karualona* suggests that the Indo-Malaysian region can be a diversity hotspot for the genus.

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