



## ***Aposthonia* Krauss, 1911 (Embioptera: Oligotomidae) from Thailand, with description of a new species**

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### **Abstract**

Three embiid species of the genus *Aposthonia* Krauss (Oligotomidae) are recognized from Thailand (*Aposthonia borneensis*, *A. ceylonica*, *A. problita* **sp. n.**) and the new species is described. The distribution of the three species in Thailand is shown and keys to the males of 25 species of this genus and to females found in Thailand are provided.

**Key words:** *Aposthonia*, Embioptera, Oligotomidae, Thailand

### **Introduction**

The Embioptera (web-spinners) is a small insect order in terms of the number of described species and genera, with approximately 2,000 species estimated to exist in the world (Ross 2000a). Most embiid species are small to medium sized, narrow-bodied insects and are easily recognized by the large, bulbous basal tarsomere on each fore-leg. They live in silk-lined galleries; the silk is produced by glands and spun when the silk is ejected through hollow hair-like structures on the ventral surface of the basal tarsal segment. Web-spinners feed entirely on vegetable matter such as outer bark, dead leaves and lichens. In general, the distribution of web-spinners is restricted to the tropics and subtropics (Ross 1970, 2000a, 2007), but some representatives are occasionally also found in the warm temperate zones, probably as a result of recent artificial (anthropogenic) introduction through commerce.

The genus *Aposthonia* was established by Krauss (1911) and later synonymized with *Oligotoma* Westwood, 1837 by Davis (1940). Ross (1951) treated *Aposthonia* as a subgenus of *Oligotoma*, but later revised it as a genus in its own right (Ross 1963). Szumik (1996) suggested that *Aposthonia* might be paraphyletic because some characters of *Aposthonia* seem closer to *Oligotoma*; for instance, the anterior medial branch (MA) in the wings is itself unbranched. They also share the shape of the left paraproct (LPPT), but this character is actually missing in some *Aposthonia*. According to Ross (2007), *Aposthonia* differs from *Oligotoma* by the absence of mesal lobing of the left cercus-basipodite (LCB) and the simplicity of the left paraproct process. Currently 24 species are recorded in this genus, but there are estimated to be at least a hundred species worldwide, suggesting that many specimens are likely to undescribed and unclassified (Ross 2007). Further study on embiopteran systematics such as cladistic study (Szumik 1996, 2004, 2008) and evolutionary biology, including behavior, ecology, distribution, diversity and roles in Thai ecosystems will add greatly to our understanding of the taxa.

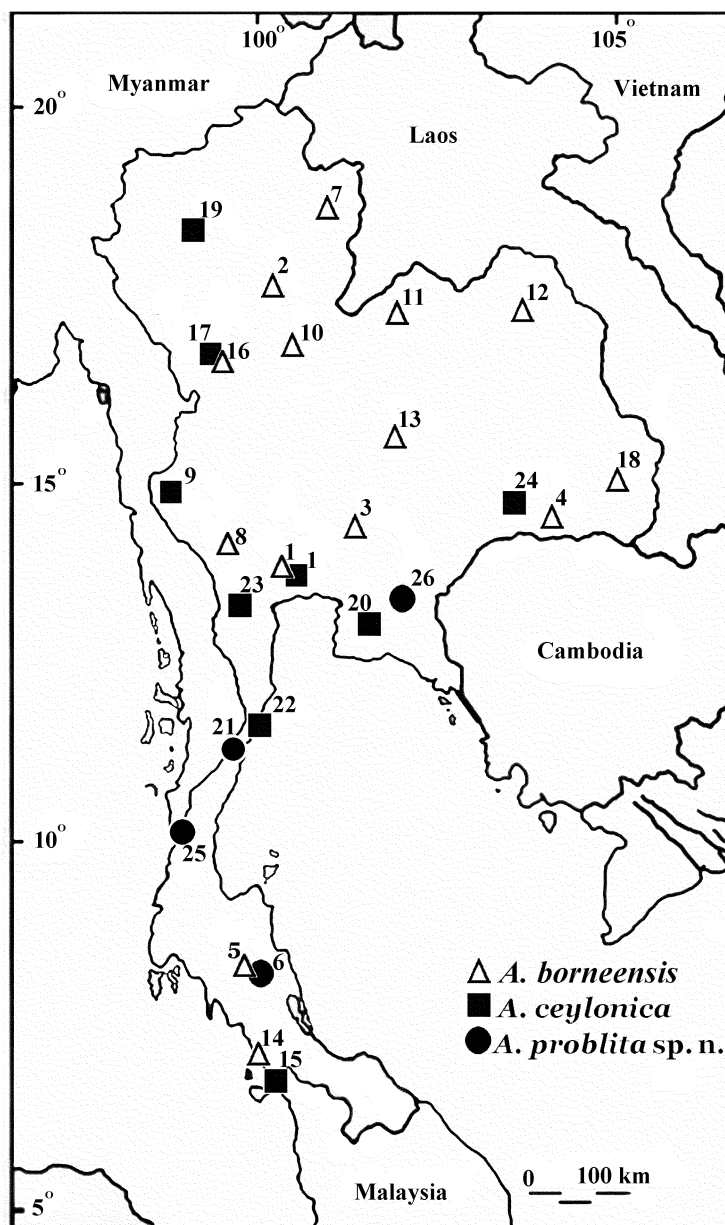
In our survey, three species, *Aposthonia borneensis* (Hagen), *A. ceylonica* (Enderlein) and *A. problita* **sp. n.**, were found in Thailand. The first two species were reported from Thailand previously (Ross 1943, 2000b). The illustrated description of *A. problita* **sp. n.** and additional details of female *A. borneensis* and *A. ceylonica* are presented. A key to the 25 known species of the genus *Aposthonia* and a key to females found from Thailand are provided. Finally, the distribution of the three known species in Thailand is provided.

## Material and methods

Specimens of webspinners were collected from the bark of trees in both forests and human habitat areas in 26 sites (Fig. 1) among 21 provinces in Thailand. Adult insects were directly preserved in 70% ethyl alcohol and deposited in the collection of the Chulalongkorn University Museum of Natural History (CUMNH), Bangkok, Thailand. Nymphal stages were collected live and reared to adulthood in the laboratory, using the bark of trees, lichen and mosses, obtained from the collection locality, as food and shelter. Identification and measurements were made with a handheld digital microscope (AM-413T-FVW Dino-Lite Pro White) and the DinoCapture Program for measurement. The male head and genitalia were illustrated with the aid of a stereomicroscope with a drawing tube attachment. The terminology and symbols used here are those employed by Ross (1940, 2000a, 2007). All collection data are summarized in Table 1.

**TABLE 1.** Collection locality data for Thai Embioptera discussed in this paper. All specimens were collected by P. Poolprasert.

| Site number | PROVINCE, district               | Collection data   |
|-------------|----------------------------------|---|
| 1           | BANGKOK, Pathumwan               | Lumpini Park, 13°45.575'N 100°32.304'E, 7 m, 05.III.2008            |
| 2           | UTTARADIT, Phichai               | Orchard, 17°17.085'N 100°01.209'E, 63 m, 06.II.2010                 |
| 3           | NAKHON NAYOK, Muang              | Plantation, 14°12.109'N 101°12.480'E, 189 m, 09.X.2007              |
| 4           | SISAKET, Uthumphon Phisai        | Botanic garden, 15°06.083'N 104°07.643'E, 143 m, 20.IX.2009         |
| 5           | NAKHON SI THAMMARAT, Thung Song  | Rubber plantation, 08°10.340'N 99°44.505'E, 103 m, 06.II.2010       |
| 6           | NAKHON SI THAMMARAT, Thung Song  | Tropical rain forest, 08°10.340'N 99°44.505'E, 103 m, 26.VII.2008   |
| 7           | NAN, Tha Wang Pha                | Plantation, 19°10.953'N 100°54.934'E, 271 m, 23.XII.2009            |
| 8           | KANCHANABURI, Muang              | Orchard, 14°02.278'N 99°31.770'E, 36 m, 22.VIII.2009                |
| 9           | KANCHANABURI, Sangkhla Buri      | Rubber plantation, 15°18.267'N 99°23.656'E, 297 m, 21.VII.2008      |
| 10          | PHITSANULOK, Muang               | Orchard, 16°49.290'N 100°15.345'E, 123 m, 21.XI.2008                |
| 11          | LOEI, Phu Kradueng               | Orchard, 16°53.315'N 101°53.140'E, 227 m, 03.III.2007               |
| 12          | SAKON NAKHON, Phu Phan           | Plantation, 17°14.010'N 103°58.105'E, 254 m, 02.VIII.2007           |
| 13          | CHAIYAPHUM, Muang                | Plantation, 15°58.916'N 102°02.248'E, 217 m, 09.IX.2007             |
| 14          | SATUN, Muang                     | Beach forest, 06°32.145'N 100°04.001'E, 6 m, 19.X.2008              |
| 15          | SATUN, Muang                     | Beach forest, 06°33.181'N 99°16.513'E, 9 m, 19.X.2008               |
| 16          | TAK, Muang                       | Orchard, 16°46.545'N 99°00.456'E, 123 m, 30.VII.2009                |
| 17          | TAK, Muang                       | Mixed deciduous forest, 16°46.661'N 99°00.245'E, 306 m, 04.III.2009 |
| 18          | UBON RATCHATHANI, Muang          | Public park, 15°13.443'N 104°51.151'E, 123 m, 03.III.2007           |
| 19          | CHIANG MAI, Muang                | Huay Kaeo Arboretum, 18°48.348'N 99°57.585'E, 336 m, 01.II.2008     |
| 20          | CHONBURI, Sri Racha              | Public park, 18°48.348'N 99°57.585'E, 18 m, 20.IV.2008              |
| 21          | PRACHUAP KHIRI KHAN, Bang Saphan | Rubber plantation, 11°19.124'N 99°24.422'E, 63 m, 03.VIII.2009      |
| 22          | PRACHUAP KHIRI KHAN, Muang       | Botanic garden, 11°48.613'N 99°47.329'E, 7 m, 19.X.2008             |
| 23          | RATCHABURI, Saun Phung           | Botanic garden, 13°32.805'N 99°20.126'E, 137 m, 22.VIII.2009        |
| 24          | SURIN, Samrong Thap              | Dry evergreen forest, 15°03.533'N 103°56.566'E, 139 m, 09.V.2008    |
| 25          | RANONG, Muang                    | Tropical rain forest, 09°58.200'N 99°38.250'E, 63 m, 22.II.2009     |
| 26          | SA KAE0, Muang                   | Tropical rain forest, 13°59.633'N 102°12.395'E, 157 m, 03.VII.2010  |



**FIGURE 1.** Distribution of the three *Aposthonia* species found in Thailand. For each species the number shown is the site number and corresponds to that given in the text and table.

## Results

### Family Oligotomidae Enderlein, 1909

#### Genus *Aposthonia* Krauss, 1911

*Aposthonia* Krauss, 1911: 48; Enderlein, 1912: 100 (as syn. of *Oligotoma* Westwood); Davis, 1936: 233; Davis, 1940: 363 (as syn. of *Oligotoma*); Ross, 1956: 316 (as valid genus); Ross, 1963: 135; Ross, 2007: 592.

***Aposthonia borneensis* (Hagen, 1885)**

(Figs. 2A–C, 3A)

*Oligotoma borneensis* Hagen, 1885: 146 (as “*O. saundersii* Westwood”); Krauss, 1911: 39 (= “*O. saundersii* Westwood”); Davis, 1940: 371, figs. 23–27; Ross, 1943: 102, figs. 6–8; Davis, 1948: 100, fig. 1

*Aposthonia vosseleri* Krauss, 1911: 48, pl. II, fig. 14; Friederichs, 1934: 409, 410 (v. *vosseleri*), 427 (female); Davis, 1948: 373 (= *borneensis* Hagen)

*Oligotoma vosseleri* (Krauss). Enderlein, 1912: 101, fig. 65; Silvestri, 1912: 334, fig. 6

*Aposthonia vosseleri intermedia* Friederichs, 1934: 410 (as a form); Davis, 1940: 374 (= *borneensis* Hagen)

*Aposthonia vosseleri obscura* Friederichs, 1934: 412; Davis, 1940: 375 (= *borneensis* Hagen)

*Oligotoma jacobsoni* Silvestri, 1912: 334; Davis, 1940: 373 (= *borneensis* Hagen)

*Aposthonia vosseleri jacobsoni* (Silvestri). Friederichs, 1934: 411

*Oligotoma maerens* Roepke, 1919: 5, figs. 1–12; Davis, 1940: 374 (= *borneensis* Hagen)

*Oligotoma nana* Roepke, 1919: 20, figs. 13–15; Davis, 1940: 374 (= *borneensis* Hagen)

*Aposthonia vosseleri nana* (Roepke). Friederichs, 1934: 412.

*Oligotoma masi* Navás, 1923: 39; Navás, 1932: 923; Davis, 1940: 374, fig. 32 (= *borneensis*, Hagen, see reference to *masi* type)

*Aposthonia borneensis* (Hagen). Ross, 1978: 5, fig. 2; Ross, 2000b: 30; Ross, 2007: 592, fig. 14; Yang, 1999: 66, fig. 18-1c

**Diagnosis.** Males of *A. borneensis* can be distinguished from congeners by the basal region of the left cercus being distally expanded and lobed, and by the presence of an outcurved hook on the left cercus-basipodite. The female is chestnut brown with blackish brown cranium, golden prothorax and brown legs except for the pale femoral-tibial joints.

**Lectotype.** Male. Museum of Comparative Zoology (MCZ), U.S.A.

**Type locality.** Malaysia (Borneo).

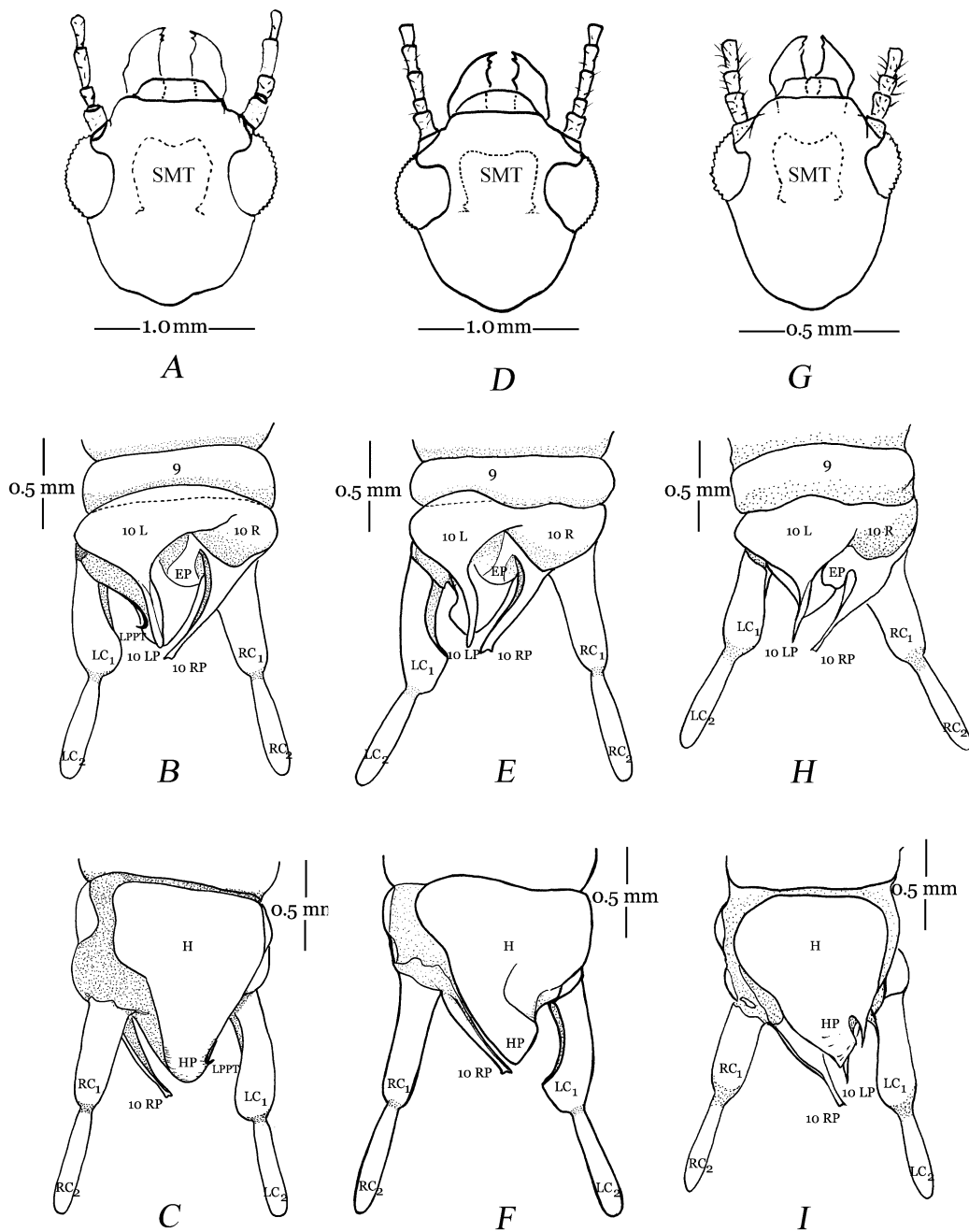
**Material examined.** The studied material consisted of 17 males and 26 females, all collected by P. Poolprasert from the following 14 sites (collection accession numbers in parentheses): Site 1, 1 male and 1 female (CUMZ-EMB-Oli.2010.01-02); Site 2, 1 male and 3 females (CUMZ-EMB-Oli.2010.03-06); Site 3, 1 male, (CUMZ-EMB-Oli.2010.07); Site 4, 2 males and 4 females (CUMZ-EMB-Oli.2010.08-13); Site 5, 2 males and 8 females (CUMZ-EMB-Oli.2010.14-23); Site 7, 1 male and 3 females (CUMZ-EMB-Oli.2010.24-27); Site 8, 2 males and 3 females (CUMZ-EMB-Oli.2010.28-32); Site 10, 1 male and 1 female (CUMZ-EMB-Oli.2010.33-34); Site 11, 1 male (CUMZ-EMB-Oli.2010.35); Site 12, 1 male (CUMZ-EMB-Oli.2010.36); Site 13, 1 male and 2 females (CUMZ-EMB-Oli.2010.37-39); Site 14, 1 male and 1 female (CUMZ-EMB-Oli.2010.40-41); Site 16, 1 male and 3 females (CUMZ-EMB-Oli.2010.42-45); Site 18, 1 male (CUMZ-EMB-Oli.2010.46).

**Distribution.** China (Canton, Hainan), Hong Kong, Indonesia (Java, Sumatra), Laos, Malaysia (Borneo), Papua New Guinea, Vietnam and Thailand.

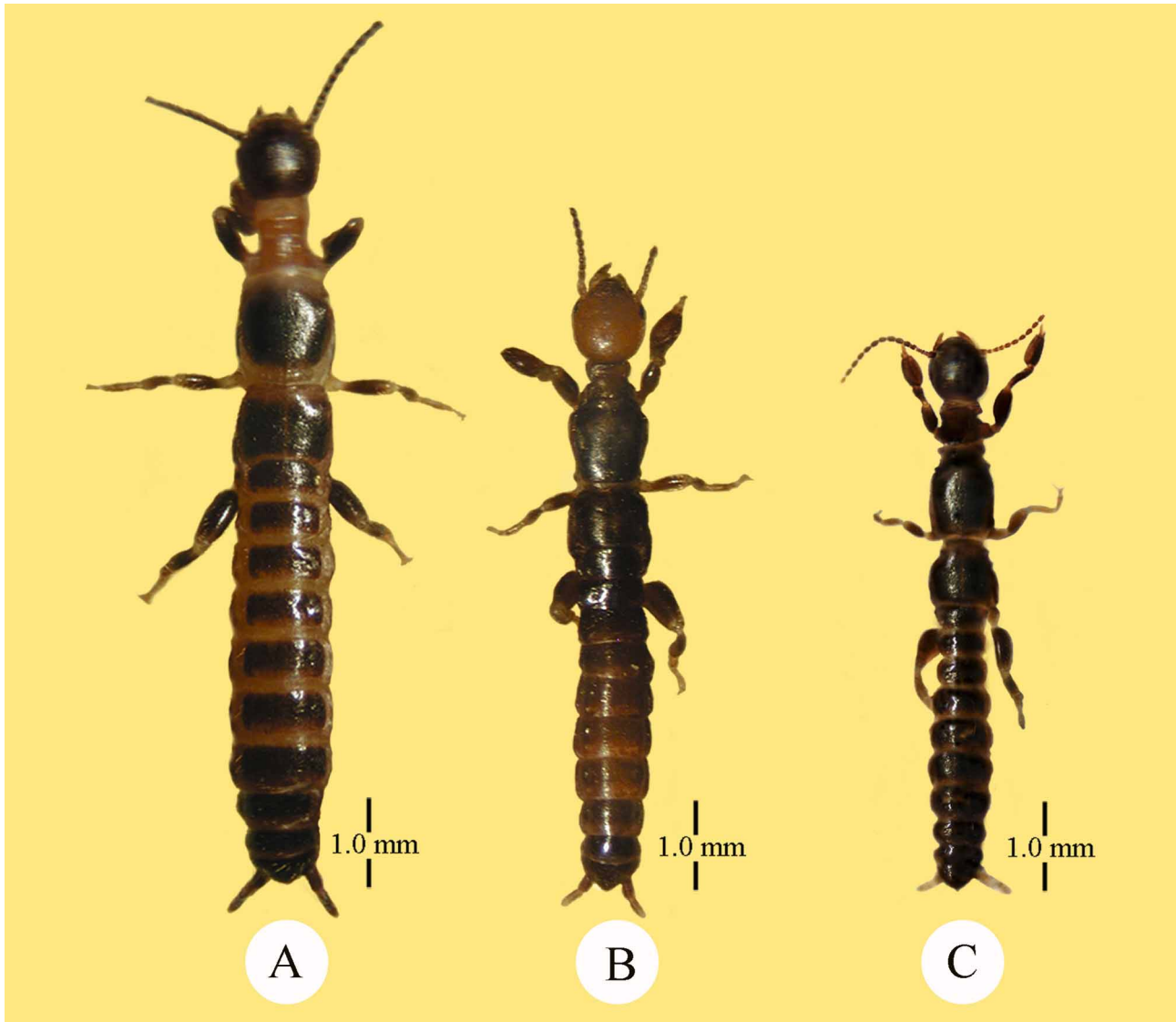
**Description.** Alate male (n = 17, mean (range) ± SD): Head width × length 1.1 (0.9–1.2) ± 0.11 × 1.5 (1.3–1.6) ± 0.10 mm; body length 8.2 (7.6–8.6) ± 0.23 mm, width 1.5 (1.3–1.6) ± 0.12 mm; forewing 6.5 (5.9–6.8) ± 0.26 mm, hindwing 5.7 (5.3–6.2) ± 0.22 mm. Head capsule brownish, slightly longer than broad with large, prominent, kidney-shaped eyes, sides behind eyes rounded, converging posteriorly. Clypeus pale, labrum pale, with large brown middle spot, maxillary palpi brown, labial palpi similar in color. Submentum trapezoidal with medial concave anterior margin (Outline as fig. 2A), blackish. Mandible dark. Antennae brownish throughout, 19-segmented. Prothorax yellowish, much narrower than head, longer than broad, meso- and metathorax generally dark fuscous, with paler articulations. Wings medium brown throughout; anterior medial vein (MA) not forked. All legs fuscous except the articulations, tarsi of the front legs pale. Hind leg with only one basitarsal papilla. Abdomen grayish brown throughout with terminalia darker. Terminalia with left (10L) and right (10R) hemitergites of segment 10 of equal width. Process of 10 L (10LP) elongate, slender, narrowly rounded distally, process of 10R (10RP) greatly elongated, narrow, membranous inner side, with small outer hook at the apex. Process of H (HP) simple, rounded. Left paraproct (LPPT) narrow, sclerotized, hooked outward and upward terminally and acutely pointed. Left cercus-basipodite (LCB) represented by a blackish plate at base of left cercus. Basal segment of left cercus (LC<sub>1</sub>) dilated distally and lobed without echinulation.

Apterous female (n = 26, mean (range) ± SD): head width × length 1.2 (1.0–1.3) ± 0.09 × 1.8 (1.3–1.9) ± 0.13 mm; body length 9.9 (9.3–10.3) ± 0.29 mm, width 1.5 (1.3–1.6) ± 0.05 mm. Head capsule blackish brown, convex, longer than broad. Eyes dark, smaller and less kidney-shaped than in male. Antennae brown throughout without

white tips, 16-segmented. Prothorax golden, cream-white intersegmental banding anterior and posterior to mesoscutum. All legs brown except for whitish mid and hind coxae and trochanters. Hind leg with only one basitarsal papilla. Abdomen chestnut-brown throughout; tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.



**FIGURE 2.** Important characters of male *Aposthonia borneensis* (A–C), *A. ceylonica* (D–F) and *Aposthonia problita* **sp. n.** (G–I). A, D, G) Head. B, E, H) Dorsal views of terminalia. C, F, I) Ventral views of terminalia. Abbreviations: 10L and 10R = left and right hemitergites of the tenth segment; 10LP and 10RP = left and right tergal processes; EP = epiproct (segment 11); H = hypandrium (sternite 9); HP = hypandrium process; LPPT = left paraproct; LC<sub>1</sub> and LC<sub>2</sub> = first and second segments of the left cercus; RC<sub>1</sub> and RC<sub>2</sub> = first and second segments of the right cercus; SMT = submentum.



**FIGURE 3.** Light micrographs of females. A) *Aposthonia borneensis*. B) *A. ceylonica*. C) *A. problita* sp. n.

**Remarks.** Ross (1943, 1978) provided a thorough description of this species. However, we have added more detail regarding some important morphological characteristics of Thai specimens, including the head, papilla and genitalia of the male. Thai female specimens differ from previously described specimens in color pattern (Fig. 3A). In the current survey the habitat of this species was always on the bark of shade trees and near residential or developed areas, such as orchards, botanic gardens (ornamental plants) and plantations, but never in forest habitats. This species is an anthropogenic “weed” species with a wide distribution in the commercial areas of many localities in southern Asia, Indonesia, Laos and Malaysia, and has previously been recorded from Nan Province in Thailand (Ross 1978). These records suggest that this species is now relatively common and widespread throughout Thailand.

***Aposthonia ceylonica* (Enderlein, 1912)**

(Figs. 2D–F & 3B)

*Oligotoma ceylonica* Enderlein, 1912: 83, fig. 56.

*Oligotoma ceylonica ceylonica* Enderlein. Davis, 1940: 378, figs. 51–56; Kapur & Kripalani, 1957: 126; Bradoo, 1967: 447, figs. 1–11.

*Oligotoma ceylonica* var. *variegata* Mukerji, 1935: 4, fig. 2 a–k; Menon & George, 1936: 91, pl. ii, Figs. 1a–b, 2a–b.

*Aposthonia ceylonica* (Enderlein). Ross, 2000b: 30.

**Diagnosis.** The male of *A. ceylonica* is distinguished from its relatives by the basal segment of the left cercus being less excavate in the basal three quarters and by the absence of an outcurved spine on the left cercus-basipodite. The female is brownish with light brown head, brown prothorax and forelegs, and dark brown middle and hind legs, except that the femoral-tibial joints are pale.

**Holotype.** Male. Stettiner Zoologisches Museum (SZM), Germany.

**Type locality.** Sri Lanka (Ceylon)

**Material examined.** The studied material consisted of 25 males and 26 females, all collected by P. Poolprasert from the following eight sites (collection accession numbers in parentheses): Site 1, 3 males and 1 female (CUMZ-EMB-Oli.2010.94-97); Site 9, 2 males and 1 female (CUMZ-EMB-Oli.2010.52-54); Site 15, 8 males and 7 females (CUMZ-EMB-Oli.2010.55-69); Site 17, 1 male (CUMZ-EMB-Oli.2010.93); Site 19, 4 males (CUMZ-EMB-Oli.2010.47-50); Site 20, 1 male (CUMZ-EMB-Oli.2010.51); Site 22, 1 male and 2 females (CUMZ-EMB-Oli.2010.70-72); Site 23, 2 males and 2 females (CUMZ-EMB-Oli.2010.73-76); Site 24, 3 males and 13 females (CUMZ-EMB-Oli.2010.77-92).

**Distribution.** India, Laos, Madagascar, Malaya, Mauritius, Sri Lanka and Thailand.

**Description.** Alate male ( $n = 25$ , mean (range)  $\pm$  SD): head width  $\times$  length  $1.1 (0.9-1.4) \pm 0.15 \times 1.3 (1.0-1.5) \pm 0.10$  mm; body length  $6.6 (5.7-7.5) \pm 0.51$  mm, width  $1.2 (1.1-1.4) \pm 0.07$  mm, forewing  $5.6 (4.8-6.1) \pm 0.42$  mm, hindwing  $4.5 (3.7-5.4) \pm 0.52$  mm. Head capsule pale brown, longer than broad, sides convergent behind eyes. Eyes dark, moderately large. Labrum light brown, mandibles brownish, slender. Submentum trapezoidal with medial concave anterior margin (Fig. 2D), brownish. Antennae dark chocolate-brown, 17-segmented. Thorax medium brown throughout, pleurites darker. Wings grayish brown, anterior medial vein (MA) not forked. All legs medium brown throughout except for pale joints. Hind leg with only one basitarsal papilla. Abdomen similar in color to thorax. Terminalia with left hemitergite of segment 10 (10L) same width as right hemitergite (10R). Process of 10L (10LP) slender, evenly narrowed to simple round tip, process of 10R (10RP) greatly elongated, membranous inner margin with a hooked apex. Hypandrium (H) produced back anteriorly to an obtuse process (HP), reaching as far as 10LP. Left paraproct (LPPT) weakly developed but distinct. Basal segment of left cercus ( $LC_1$ ) strongly excavate in the basal three-quarters.

Apterous female ( $n = 26$ , mean (range)  $\pm$  SD): head width  $\times$  length  $1.2 (1.0-1.4) \pm 0.13 \times 1.3 (1.2-1.6) \pm 0.10$  mm; body length  $6.7 (5.8-7.5) \pm 0.51$  mm, width  $1.3 (1.2-1.5) \pm 0.09$  mm. Head capsule light brown, weakly convex, longer than broad. Eyes dark, smaller than in male. Antennae 15-segmented with basal 3 segments medium brown, other segments dark brown. Prothorax mostly brown except the anterior becoming light brown. Meso- and metathoracic sclerites dark brown. Forelegs concolorous with pronotum, middle and hind legs entirely dark brown except for pale femoral-tibial joints. Hind leg with only one basitarsal papilla. Abdomen brownish with tergum of segments 3–6 more reddish brown, tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely medium brown.

**Remarks.** Examples of this species have been reported by various authors under the name *Oligotoma ceylonica* (Bradoo 1967; Davis 1940; Enderlein 1912; Kapur & Kripalani 1957; Menon & George 1936; Mukerji 1935). Ross (2000b) transferred this species from *Oligotoma* to *Aposthonia* without description, so we have added to the details of the male characters as well as providing female characters. We found the habitats of *A. ceylonica* to be on the bark of trees in orchards, public parks, plantations, beach forests, dry evergreen forests and mixed deciduous forests in every subregion of Thailand.

### *Aposthonia problita* sp. n.

(Figs. 2G–I, 3C)

**Diagnosis.** The male of *A. problita* is distinguished from congeners by the basal segment of the left cercus being gradually distally expanded but not abruptly lobed, and the absence of an outcurved hook on the left cercus-basipodite. The female body is very dark and shiny except for pale femoral-tibial joints.

**Holotype.** Male. (CUMNH), Thailand, Nakhon Si Thammarat Province, Thung Song District, tropical rain forest,  $08^{\circ}10.340'N$   $99^{\circ}44.505'E$ , 103 m, 26.VII.2008 (Site 6).

**Material examined.** Holotype male, 2 paratype males and 14 paratype females, all collected by P. Poolprasert from the following four sites (collection accession numbers in parentheses): Site 6, holotype male (CUMZ-EMB-

Oli.2010.98), 1 male, 6 females (CUMZ-EMB-Oli.2010.99-105); Site 21, 1 male, 2 females (CUMZ-EMB-Oli.2010.106-108); Site 25, 4 females (CUMZ-EMB-Oli.2010.109-112); Site 26, 2 females (CUMZ-EMB-Oli.2010.113-114).

**Distribution.** This species was collected from four provinces in Thailand: Nakhon Si Thammarat, Ranong, Prachuap Khiri Khan and Sa Kaeo.

**Etymology.** The species is named *Aposthonia problita* (Greek *problita* = jet) referring to the rich, deep black color, particularly in females.

**Description.** Alate male (n = 3, mean (range)): head width × length 0.5 (0.5–0.6) × 0.7 (0.7–0.8) mm; body length 5.2 (5.13–5.33) mm, width 0.5 (0.52–0.55) mm; forewing 4.0 (3.9–4.2) mm, hind wing 3.7 (3.6–3.9) mm. Head capsule blackish, longer than broad, sides caudally convergent. Eyes dark, rather small. Labrum brown. Mandibles brown with apical teeth and inner margins brownish. Submentum trapezoidal with medial concave anterior margin (Fig. 2G), blackish. Antennae with basal 3 segments brownish, remaining segments becoming increasingly lighter brown distally, 16-segmented. Thorax same color as head. All legs blackish throughout except for pale color of joints. Wing light brown with anterior medial vein (MA) not forked. Hind leg with only one basitarsal papilla. Abdomen blackish brown throughout with cerci paler. Terminalia with left hemitergite of segment 10 (10L) broader than right hemitergite (10R). Process of 10L (10LP) slender, narrow, evenly tapered to apex; process of 10R (10RP) greatly elongated, narrow, membranous inner side with small outer hook at tip. Hypandrium (H) broad basally, slightly narrowed caudally, forming a broad process of H (HP) directed gradually toward left cercus and beneath 10LP. Right cercus with two subcylindrical segments (RC<sub>1</sub> and RC<sub>2</sub>). Left cercus with segments (LC<sub>1</sub> and LC<sub>2</sub>) subequal to corresponding segments of right cercus; LC<sub>1</sub> gradually expanded distally but not abruptly lobed.

Apterous female (n = 14, mean (range) ± SD): head width × length 0.6 (0.5–0.6) ± 0.04 × 0.7 (0.6–0.8) ± 0.04 mm, body length 6.1 (5.6–6.6) ± 0.35 mm, width 0.6 (0.5–0.6) ± 0.03 mm. Head capsule dark, convex, longer than broad. Eyes dark, smaller and less reniform than in male. Antennae blackish throughout, 15-segmented. Thorax entirely dark, somewhat shining. All legs concolorous with thorax except for pale femoral-tibial joints. Hind leg with only one basitarsal papilla. Abdomen very glossy, dark. Tenth sternum symmetrically divided longitudinally into two lateral plates. Cerci entirely pale.

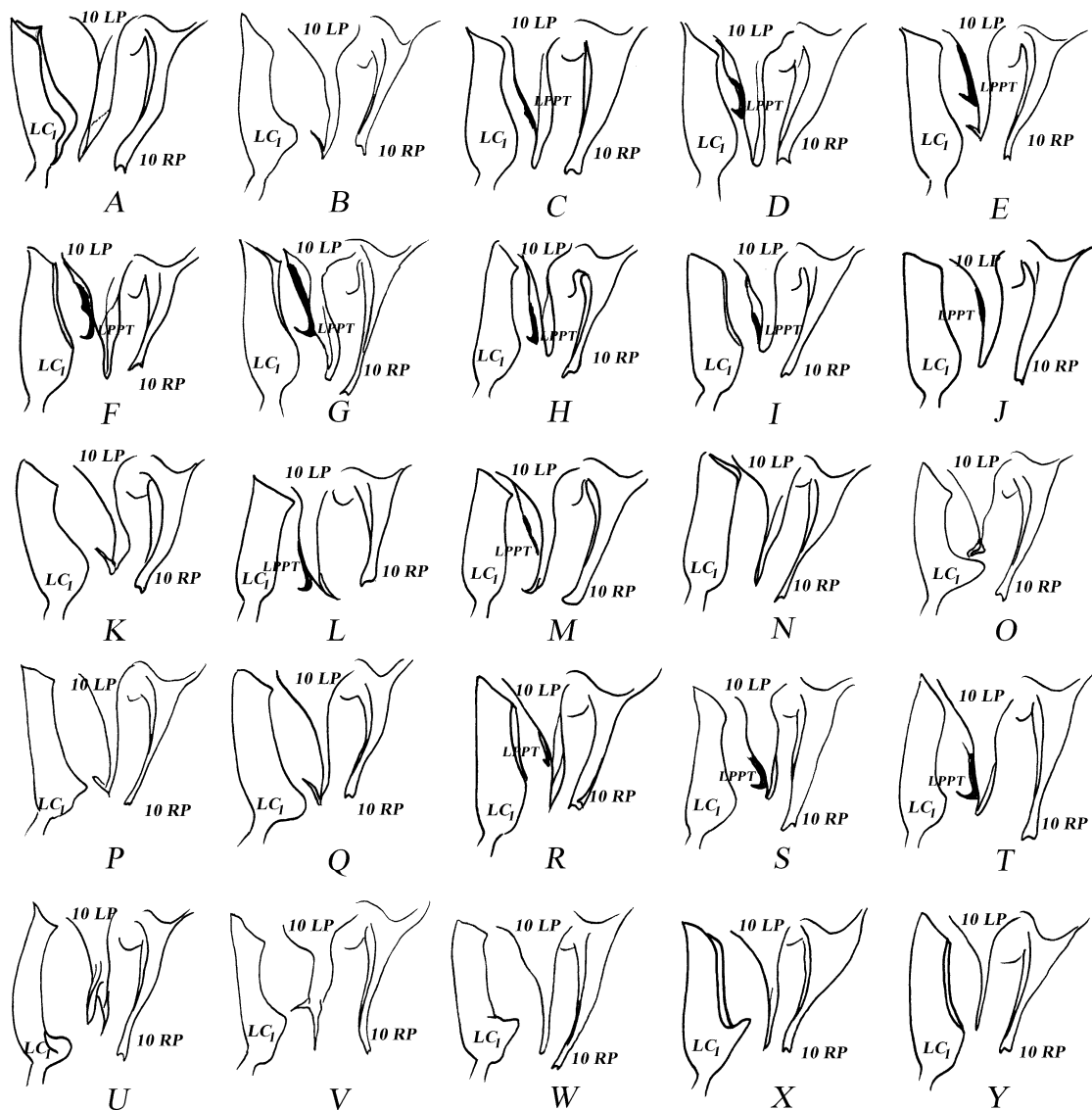
**Remarks.** *Aposthonia problita* sp. n. is the 25th species described in this genus. This species may well be widespread across much of Thailand, as it is commonly found in tropical rain forests and in rubber plantations in southern Thailand (Nakhon Si Thammarat and Ranong Provinces), western Thailand (Prachuap Khiri Khan Province) and eastern Thailand (Sa Kaeo Province).

### Key to adult males of *Aposthonia* Krauss, 1911

1. LC<sub>1</sub> with two inner lobes; 10LP long, truncate, with a longitudinal groove, one side of distally curved to the left; 10RP curved outward slightly terminally, truncate with two terminal teeth. (Fig. 4A) . . . . . *A. minuscula* (Enderlein)
- LC<sub>1</sub> without two inner lobes (Figs. 4B–Y) . . . . . 2
2. LC<sub>1</sub> distally expanded and lobed (Figs. 4B–K) . . . . . 3
- LC<sub>1</sub> not abruptly lobed (Figs. 4L–Y) . . . . . 12
3. LC<sub>1</sub> slender basally, then broadly expanded dorso-mesad as angulate lobe; 10LP long, gradually arced leftward, evenly tapered to apex; 10RP long, apex with outer hook and membranous inner margin (Fig. 4B) . . . . . *A. centralis* (Davis)
- LC<sub>1</sub> slightly incurved basally, then expanded at inner apex as lobe (Figs. 4C–K) . . . . . 4
4. LPPT sclerotized, apex with outer hook (Figs. 4C–H) . . . . . 5
- LPPT without outer hook or without LPPT (Figs. 4I–K) . . . . . 10
5. LPPT with inconspicuous outer hook; 10LP broad, tapered and arcuate caudally; 10 RP long, broad and gradually tapered to apex with outer hook (Fig. 4C) . . . . . *A. davisi* (Ross)
- LPPT with distinct outer hook (Figs. 4D–H) . . . . . 6
6. Eye very large; 10LP slender, broad rounded distally; 10RP somewhat straight, very broad rounded apex with small spine on right side and mostly membranous inner margin (Fig. 4D) . . . . . *A. mandibulata* (Ross)
- Eyes small . . . . . 7
7. 10LP slender, bearing distally small hook directed forwards and downwards; 10RP long, slightly tapered to tip with small outer hook and membranous inner margin (Fig. 4E) . . . . . *A. subclavata* (Davis)
- 10LP without distal small hook (Figs. 4F–H) . . . . . 8
8. 10LP broad, tapered and arcuate caudally; 10RP long, membranous inner margin long with distinct subapical tooth on outer side (Fig. 4F) . . . . . *A. brunnea* (Ross)
- 10LP narrow (Figs. 4G, H) . . . . . 9



9. 10LP slender, narrowly rounded distally; 10RP elongated, narrow, membranous inner margin with small outer hook at apex (Fig. 4G) ..... *A. borneensis* (Hagen)
- 10LP gradually and evenly narrowed and rounded terminally; 10RP somewhat straight, apex with small outer hook and lengthy membranous inner margin (Fig. 4H) ..... *A. maritima* (Ross)
10. 10 LP long, broad, gradually arced leftwards, evenly tapered and rounded terminally; 10RP somewhat straight, rounded apex with outer spine and membranous inner margin (Fig. 4I). ..... *A. aurea* (Ross)
- 10LP narrow (Figs. 4J, K) ..... 11
11. 10LP long, narrow gradually arced leftwards, evenly tapered to apex; 10RP long, lengthy membranous inner margin, apex with two small component teeth (Fig. 4J) ..... *A. albertisi* (Navás)
- 10 LP distinctive, basally rather irregular, distally sharply narrowed and curved downwards and bearing distally acute hook directed upwards; 10RP long, broad, gradually narrowed caudally with small outer hook and mostly membranous inner margin, without LPPT (Fig. 4K) ..... *A. remota* (Davis)
12. LC<sub>1</sub> subcylindrical (Figs. 4L–N) ..... 13
- LC<sub>1</sub> gradually expanded but not lobed (Figs. 4O–Y) ..... 15
13. LPPT sclerotized, apex with outer hook; 10LP long and abruptly tapered caudally; 10RP long, gradually tapered to narrowly rounded apex, subterminally with very small but distinct outer process (Fig. 4L) ..... *A. himalayensis* (Kapur & Kripalanti)
- LPPT without outer hook (Figs. 4M, N) ..... 14
14. 10LP long, curved and slightly tapered leftward, apex with turned up outer hook; 10RP long, broad, rather straight, side caudally convergent to obtuse apex and a small membranous inner margin (Fig. 4M) ..... *A. oculata* (Ross)
- 10LP long, not curved, narrow and evenly tapered to apex; 10RP elongated, narrow, membranous inner side with small outer hook at tip (Fig. 4N) ..... *A. problita* sp. n.
15. 10 LP with terminal hook (Figs. 4O–Q) ..... 16
- 10 LP without terminal hook (Figs. 4R–Y) ..... 18
16. 10 LP broad, apex tapered with anchor-like hook; 10RP slender with hooked apex; LC<sub>1</sub> strongly produced inwards into a transverse lobe reaching almost to the middle line (Fig. 4O) ..... *A. glauerti* (Tillyard)
- 10LP narrow (Figs. 4P, Q) ..... 17
17. LC<sub>1</sub> distally curved inwards to tapered obtuse beak; 10LP slender, curving slightly to the left and bearing distally small hook directed forwards and downwards; 10RP elongated, tapering distally but ending smoothly, and with lengthy membranous inner margin (Fig. 4P) ..... *A. gurneyi* (Froggatt)
- LC<sub>1</sub> with blunt subterminal inward projection, inner margin basal to projection slightly and smoothly concave; 10LP long, slightly tapered leftward, apex with slender acute terminally spine directed forward and to the left; 10RP long, lengthy membranous inner margin, apex with outer hook (Fig. 4Q) ..... *A. spinulosa* (Davis)
18. Under 10 LP, hooked LPPT present (Figs. 4R–T) ..... 19
- Under 10 LP, hooked LPPT absent (Figs. 4U–Y) ..... 21
19. LPPT sclerotized, apex with inconspicuous outer hook, 10LP long, gradually . . . arced leftward, evenly tapered to apex; 10RP elongated, rounded apex with small spine on right side and slightly membranous inner side. (Fig. 4R) . . . *A. hollandia* . . . (Ross)
- LPPT sclerotized, apex with outer hook (Figs. 4S–T) ..... 20
20. LC<sub>1</sub> very broad, slightly expanded at basal third, then apically attenuated and curved caudally; 10LP broad, round distally, apex truncate with a single serration at outer angle; 10RP long, broad and gradually tapered to apex and lengthy membranous inner margin (Fig. 4S) ..... *A. micronesiae* (Ross).
- LC<sub>1</sub> inwardly lobed distally, 10LP broad, tapered and arcuate caudally; 10RP long, lengthy membranous inner margin, apex with small outer hook (Fig. 4T) ..... *A. oceania* (Ross)
21. 10LP with lateral lobe (Figs. 4U–V) ..... 22
- 10LP without lateral lobe (Figs. 4W–Y) ..... 23
22. 10LP forcipate, right-hand lobe heavily sclerotized, curved to the left and acute terminally, left-hand lobe more dorsal in position, flat, less heavily clavate on the concave inner side. 10RP elongated, gradually narrowed caudally with small outer hook; LC<sub>1</sub> terminally incurved to form spatulate process (Fig. 4U) ..... *A. tillyardi* (Davis)
- 10LP terminally tapering to point, slight incurved with subterminal flat, acute projection directed to the left; 10RP slender, terminally tapered to obtuse apex and lengthy membranous inner margin; LC<sub>1</sub> clavate, produced inwards subterminally (Fig. 4V) ..... *A. approximans* (Davis)
23. LC<sub>1</sub> strongly excavated on inner side in basal half (Figs. 4X–Y) ..... 24
- LC<sub>1</sub> not strongly excavated on inner side in basal half; 10LP long, gradually arced leftward, evenly tapered to apex; 10RP long, membranous inner margin long, apex with outer hook (Fig. 4W) ..... *A. japonica* (Okajima)
24. LC<sub>1</sub> produced inwards into strong beak; 10 LP slender, evenly narrowed to simple round tip; 10RP greatly elongated, membranous inner margin with outer hook (Fig. 4X) ..... *A. indica* (Davis)
- LC<sub>1</sub> not produced inward into strong beak; LP slender, evenly narrowed to simple round tip; 10RP greatly elongated, membranous inner margin with hooked apex (Fig. 4Y) ..... *A. ceylonica* (Enderlein)



**FIGURE 4.** Left cercus ( $LC_1$ ) and left and right tergal processes (10 LP and 10 RP) of *Aposthonia* spp. A) *A. minuscula*. B) *A. centralis*. C) *A. davisi*. D) *A. mandibulata*. E) *A. subclavata*. F) *A. brunnea*. G) *A. borneensis*. H) *A. maritima*. I) *A. aurea*. J) *A. albertisi*. K) *A. remota*. L) *A. himalayensis*. M) *A. oculata*. N) *A. problita* **sp. n.** O) *A. glauerti*. P) *A. gurneyi*. Q) *A. spinulosa*. R) *A. hollandia*. S) *A. micronesiae*. T) *A. oecania*. U) *A. tillyardi*. V) *A. approximans*. W) *A. japonica*. X) *A. indica*. Y) *A. ceylonica*. Abbreviations:  $LC_1$  = first segment of the left cercus; 10LP and 10RP = left and right tergal processes; LPPT = left paraproct. Figures are modified from Davis (1936, 1940, 1944), Kapur & Kripalani (1957) and Ross (1948, 1951, 1955).

### Key to females of Thai *Aposthonia*

1. Head light brown. Prothorax brown, meso- and metathorax dark brown. Forelegs concolorous with pronotum, middle and hind legs entirely dark brown. Abdomen brownish with terga of segments 3–6 somewhat reddish brown. Cerci entirely medium brown (Fig. 3B).....*A. ceylonica* (Enderlein)
- Head dark brown or black.....2
2. Head blackish brown. Prothorax light brown orange, cream-white intersegmental banding anterior and posterior to mesoscutum. All legs brown, except middle and hind coxae and trochanters whitish. Abdomen chestnut-brown throughout. Cerci entirely medium brown (Fig. 3A).....*A. borneensis* (Hagen)
- Head dark. Thorax entirely dark. All legs concolorous with thorax. Abdomen very glossy, dark. Cerci pale (Fig. 3C).....*A. problita* **sp. n.**

## Discussion

Three species of embiid in the genus *Aposthonia* Krauss, 1911, *A. borneensis*, *A. ceylonica* and *A. problita* **sp. n.**, were collected in Thailand in this study. Based on results of the present survey, *A. borneensis* and *A. ceylonica* should be considered to occur throughout Thailand. They were distributed in 13 provinces and 21 of 77 Thai provinces surveyed. Ross (2000b) speculated that *A. borneensis* was endemic to continental southeastern Asia or Indonesia, and has naturally migrated or been anthropogenically moved into Thailand. In the same manner, *A. ceylonica* probably was endemic to southern India and Sri Lanka and has since been distributed to Laos, Madagascar, Malaysia, Mauritius and Thailand. Currently, *A. problita* **sp. n.** is known only from Thailand and may be endemic, as it was collected only in tropical rain forests and sometimes in rubber plantations. The genus *Aposthonia* is the largest genus in the order Embioptera, but the taxonomic status of several species is equivocal due to their great similarity to other species of the genus. Thus, many specimens probably need to be reclassified and reconfirmed (Ross 2007) as part of an analysis of embiopteran phylogeny to test the current classification (Szumik *et al.* 2008). The results from this study increase the available information on the zoological distribution of the genus *Aposthonia* within Thailand. It is worthwhile to suggest that a more extensive evaluation of these uncommon and elusive species should be carried out. The study of the biodiversity of Thailand's embiid fauna should be continued and expanded into the other countries of southeast Asia (e.g., Myanmar, Laos and Malaysia) in order to build a better understanding of the biodiversity and biogeography of Embioptera.

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