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GUIDE TO THE AQUATIC HETEROPTERA OF SINGAPORE AND PENINSULAR MALAYSIA: VII. FAMILY HELOTREPHIDAE

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ABSTRACT. **–** This is the seventh part of a series of guides to the aquatic Heteroptera of Singapore and Peninsular Malaysia. Eleven species belonging to seven genera and two subfamilies of Helotrephidae are known from the peninsula. Keys are provided for the identification of genera and species known from Singapore, Peninsular Malaysia, and southern Thailand; illustrations for key characters are included. Distributional and ecological data are summarised.

KEY WORDS. **–** Water bugs, Helotrephidae, Southeast Asia, key to genera, key to species.

INTRODUCTION

The hemispherical backswimmers, family Helotrephidae, are small, typically semiglobular or rarely round and flattened Nepomorpha and sister group of the Pleidae (Chen et al., 2005), which were treated in a previous guide by Nieser (2004). Helotrephidae are distributed in the tropics and subtropics of the world, but they are absent from the Australian and Pacific faunal regions. Their most peculiar morphological character is the so-called cephalonotum, a unique fusion of head and pronotum, often with a weak W-shaped impression remaining on its dorsal surface (Figs. 1–11). There is a gradual reduction of antennal segments from 2 to 0 and tarsal segments (tarsal formula = number of tarsomeres on fore, middle, and hind leg) from 3–3–3 to 1–1–2. Most Helotrephidae (except *Fischerotrephes*) have an enlarged mesoscutellum. The fore wings are always elytraceous. Flightless, hindwing-brachypterous morphs are common and in many species predominating, in some species even the only form known. Sterna of thoracic segments (pro-, meso- and metasternum) and anterior abdominal sternites possess ventromedian laminate keels (carinae), which are low or strongly reduced in benthic genera; they are important structures for genus and species identification (Figs. 20–23). The most reliable species-diagnostic characters are the variously modified genitalia of males (aedeagus and parameres; Figs. 26–28, 30–32, 35–37, 39–41, 48–59, 64–76) and the last externally visible sternum of females (sternum 7 = "subgenital plate"; Figs. 25, 29, 33, 44–47, 60–63). The genitalia of males are strongly asymmetrical, the genital capsule is rotated counter clockwise, so that the right paramere is situated dorsally. Asymmetry, in various degrees, is also observed in the terminalia of females of several taxa. Additional useful characters for identification are body size, colour pattern, microstructures (puncturation, micropuncturation, reticulation) of the dorsum, and, in Helotrephini, the shapes of the genal and pronotal plates (Figs. 42, 43) located ventrolaterally on the cephalonotum. During the last 25 years, substantial progress was achieved in the taxonomy and systematics of Helotrephidae, especially in Southeast Asia, including descriptions of numerous species, several genera, and even the discovery of two new subfamilies, Trephotomasinae and Fischerotrephinae (Papáček et al., 1988; Zettel, 1994). In a more recent survey of the Helotrephidae of the world, Papáček & Zettel (2005) listed 171 species, of which 137 are Oriental in a broad sense, including Wallacea. Another 13 species (all from the Oriental region) were described since then. In Malesia, the eastern distribution border is at Weber's Line. Highest species diversity is found in southern India, on the Southeast Asian mainland ("Indochina"), on Borneo, on Sulawesi, and in the Philippine Archipelago. Only 11 species are presently

known from West Malaysia, one species from Singapore, and five from southern Thailand (Sites & Polhemus, 2002; Zettel, 2005). It seems possible that four further species of Helotrephini, which are known from southern Thailand, may occur in Malaysia too. Therefore, they are included in this study.

Compared with taxonomy and distribution of the species, little is known about the biology of the hemispherical backswimmers. Like most Nepomorpha, they are predacious fluid-suckers on small invertebrates and live in various kinds of freshwater habitats. Habitat notes have been provided for a considerable number of species in a rather anecdotal way. Helotrephidae are subaquatic with most species in the marginal areas of running waters where flow is minimised, but also in lentic waters such as ponds, lakes, pools, lithotelms, or even small artificial water bodies (e.g., ceramic bowls); a few genera, i.e., *Fischerotrephes*, *Platytrephes*, and *Distotrephes* are known as the benthos of clean streams (see, e.g., Miyamoto, 1952; Papáček et al., 1988; Zettel, 1994, 1997a, 1999). *Mixotrephes* (*Thermotrephes*) *thermophilus* (Papáček & Kovac, 2001b) lives in tiny lithotelms, on the surfaces of wet rocks at waterfalls (exposed to intensive sunlight), and also below hot springs in pools with water temperature up to 43.5°C (Papáček & Kovac, 2001b: as *Limnotrephes thermophilus*). Of those species which occur on the Malay Peninsula, the biology of *Idiotrephes asiaticus* has been studied intensively in the laboratory (Papáček, 1993: as *I. chinai*). Locomotion is by creeping on the ground on steep river banks and rock sides or on living and dead plants, and by swimming either venter up, as in notonectids, or venter down. Flight activity has not been observed, but must be expected for species living in astatic waters. In most species, oxygen supply is from the air at the water surface into a ventral and subelytral storage ("physical gill"), but some benthic species probably exclusively take oxygen via a plastron ("incompressible gas gill") directly from the water without replenishing.

We follow the systematics by Papáček et al. (1988), Polhemus (1990), and Mahner (1993). As pointed out by Zettel (1997b) and Chen et al. (2005) the position of the Limnotrephini as a tribe of the Helotrephinae (Polhemus, 1990) is questionable; they may belong to the Idiocorinae. However, a complete phylogeny is still under discussion. For that reason we treat Limnotrephini and Helotrephini separately in this guide. We include also information on Trephotomasinae, because *Platytrephes* which is known from both Indochina and Borneo is expected also to occur in the Malay Peninsula.

Check-list of the Helotrephidae of Singapore, Peninsular Malaysia, and Thailand south of the Isthmus of Kra, with records of species distributions

Subfamily Fischerotrephinae Zettel, 1994

Fischerotrephes Zettel, 1994

Fischerotrephes jaechi Zettel, 1994: West Malaysia (Perak), Thailand (Songkhla).

[Subfamily Trephotomasinae Papáček, Štys & Tonner, 1988]

Not recorded.

Subfamily Helotrephinae – Tribus Limnotrephini

Distotrephes Polhemus, 1990

Distotrephes (s.str.) *zetteli* Papáček & Kovac, 2001b: Malaysia (Selangor), Thailand (Kampaeng Phet).

Idiotrephes Lundblad, 1933

Idiotrephes asiaticus Papáček & Zettel, 2000: Vietnam (Dong Nai, Hanoi), Thailand (Mae Hong Son, Chiang Mai, Phitsanulok, Phetchabun, Khon Kaen, Sakhon Nakhon, Satun), Malaysia (Selangor).

Idiotrephes chinai Lundblad, 1933: Malaysia (Selangor, Perak, Johor, Sarawak), Indonesia (Kalimantan Timur, North Sumatra), Thailand (Phattalung, Songkhla).

Tiphotrephes Esaki & China, 1928

Tiphotrephes indicus (Distant, 1910): India (Maharashtra), Myanmar (Yangon Division), Thailand (Loei, Phetchabun, Sakhon Nakhon, Nakhon Ratchasima, Khon Kaen, Chayaphum, Udon Thani, Bangkok, Surin Ayuttayah, Kalasin, Phitsanulok), Malaysia (Selangor, Perak), Singapore, Indonesia (Borneo: Kalimantan Barat).

Subfamily Helotrephinae –Tribus Helotrephini

Ascetotrephes Polhemus & Polhemus, 2003

Ascetotrephes edmundsorum Polhemus & Polhemus, 2003: West Malaysia (Pahang, Perak, Selangor).

Helotrephes Stål, 1860

Helotrephes affinis Zettel & Polhemus, 1998: Thailand (Songkhla).

Helotrephes australis Zettel & Polhemus, 1998: Thailand (Mae Hong Son, Chiang Mai, Chayaphum, Narathiwat, Trang, Songkhla, Yala, Phattalung, Satun), Laos (Luang Nam Tha), Malaysia (Selangor, Pahang), China (Yunnan).

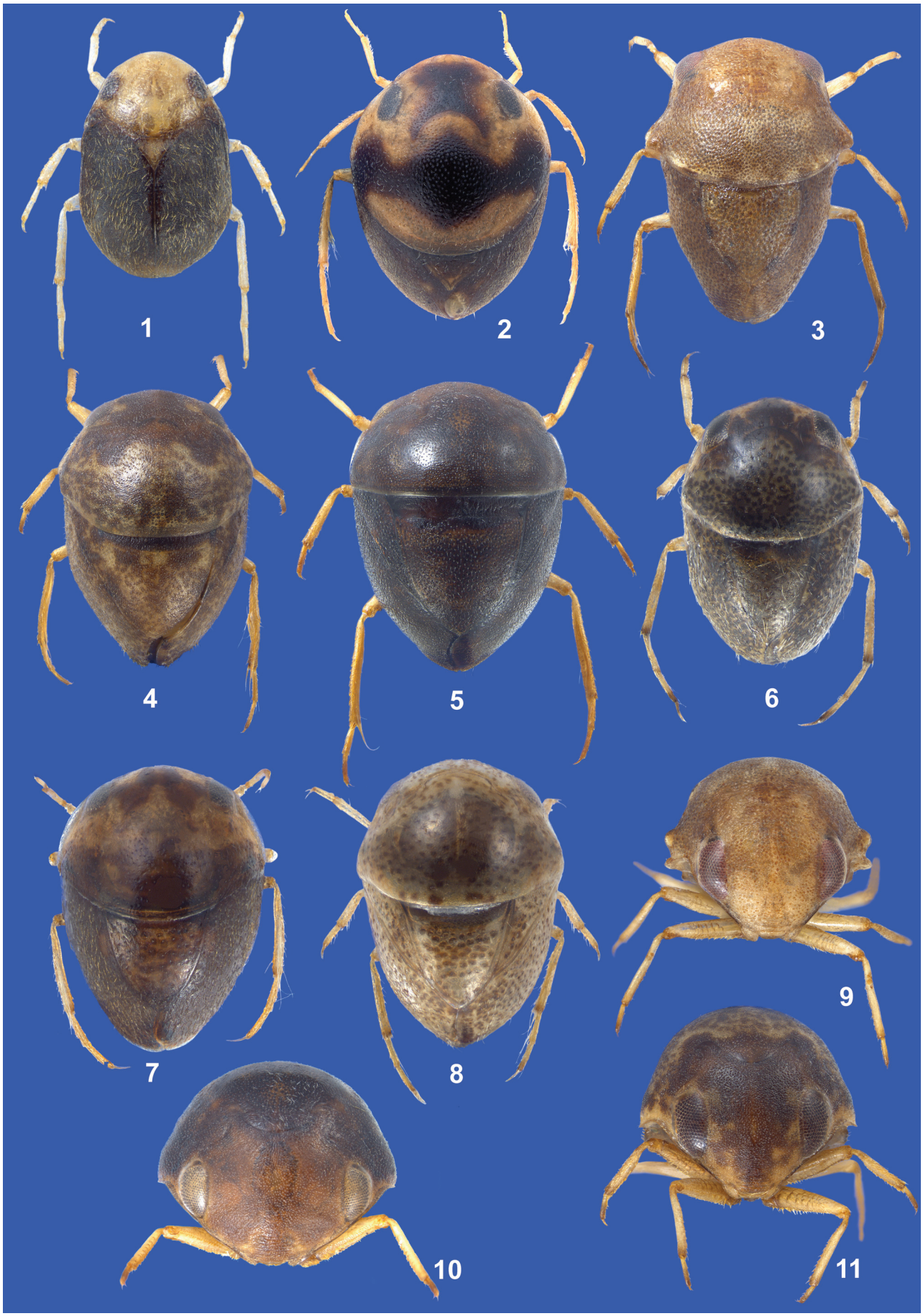
Helotrephes flaviceps Zettel & Polhemus, 1998: Thailand (Mae Hong Son, Yala, Songkhla, Narathivat), West Malaysia (Terrenganu).

Helotrephes rompinensis Kovac & Papáček, 2000: Thailand (Phang Nga), Malaysia (Pahang) (originally described as subspecies of *H. flaviceps* by Kovac & Papáček, 2000, raised to species by Zettel, 2005).

Hydrotrephes China, 1935

Hydrotrephes benomensis Zettel, 2009: Malaysia (Pahang)

Hydrotrephes langkawicus Zettel & Tran, 2009: Malaysia (Kedah).



Figs. 1–11. 1–8, Habitus, dorsal aspect; 9–11, frontal aspect. (1) *Fischerotrephes jaechi*; (2) *Platytrephes sitesi;* (3, 9) *Helotrephes rompinensis*; (4, 11) *Hydrotrephes benomensis*; (5, 10) *Ascetotrephes edmundsorum*; (6) *Idiotrephes chinai*; (7) *Distotrephes zetteli*; (8) *Tiphotrephes indicus*. (© NHMW Hemiptera Image Collection; published with permission). Images not to scale.

Hydrotrephes maculatus Papáček & Kovac, 2001a: Thailand (Narathivat).

Hydrotrephes mixtus Papáček & Kovac, 2001a: Thailand (Narathivat).

Hydrotrephes sitesi Zettel, 2005: Thailand (Suratthani, Songkhla, Kanchanaburi, Phitsanulok).

Notes. – The record of *Hydrotrephes yupae* Zettel, 1998 from southern Thailand (Phattalung) by Sites & Polhemus (2002) was published prior to the description of a similar species, *H. sitesi*. Present records of the two species suggest allopatric distribution. The material from Phattalung could not be studied for verification.

Key to the subfamilies, tribes, and genera
(simplified and modified from Chen et al., 2005)

1 Hemielytron with curved pseudendocorium reaching pseudomembrane (Fig. 12) in all morphs, and with additional claval suture in rare macropterous specimens (clavus similar to other macropterous Helotrephidae). Tarsal formula 2–2–3 (note: first tarsomere very short and difficult to see). Cephalonotum extremely large, much larger than hemielytra in dorsal aspect (Fig. 2). Subfamily Trephotomasinae ..... [*Platytrephes*]

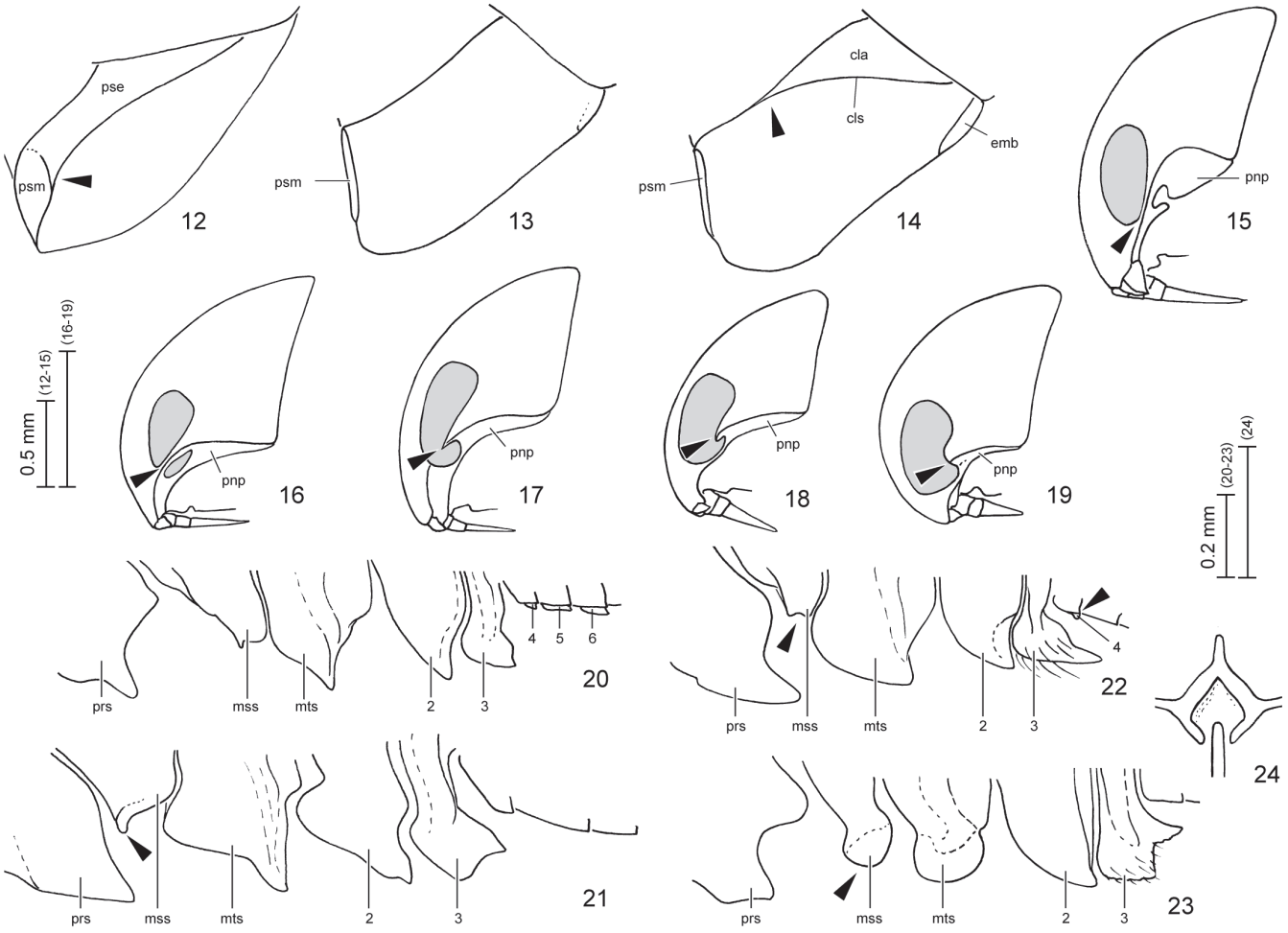
– Hemielytron without pseudendocorium (Fig. 13), but macropterous morph with claval suture not reaching pseudomembrane but ending at lateral margin of mesoscutellum (Fig. 14). Tarsal formula 1–1–2 or 3–3–3. Cephalonotum comparatively small (Figs. 1, 3–8) 2

2 Mesoscutellum small, triangular (Fig. 1). Tarsal formula 3–3–3 (note: first tarsomere very short and difficult to see). Very small species (up to 1.6 mm) with slightly elongate, depressed body (Fig. 1). Subfamily Fischerotrephinae ..... ***Fischerotrephes***

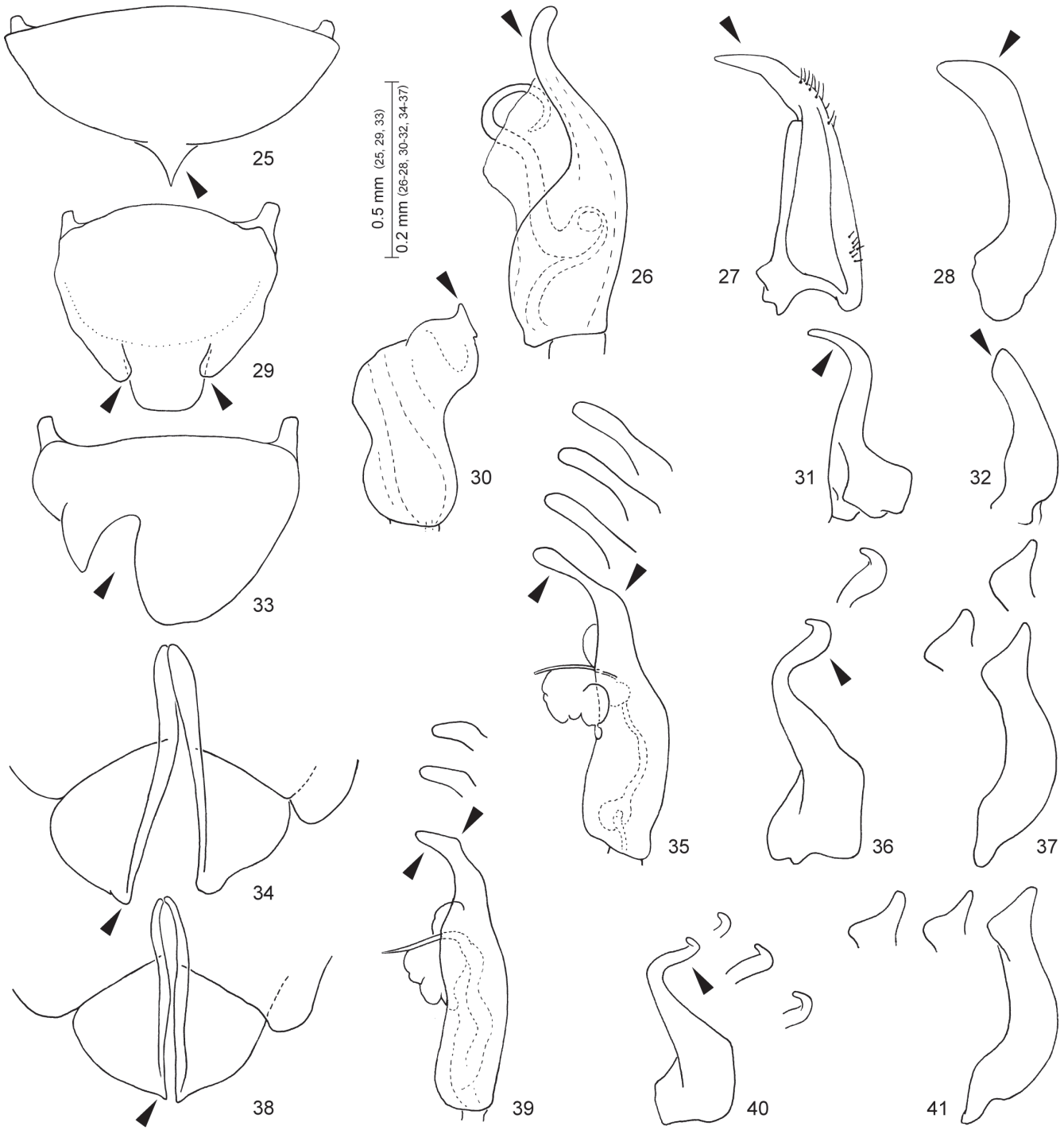
– Mesoscutellum large (Figs. 3–8). Tarsal formula 1–1–2. Body roundish, and usually semi-globular, rarely depressed. Subfamily Helotrephinae 3

3 Eye ovate; lateral margin of cephalonotum continued ventrally of eye (Fig. 15). Relatively large species, body length usually more than 1.9 mm. Cephalonotum often densely or coarsely punctured and dull (Figs. 9–11). Hind margin of subgenital plate of female symmetrical (Figs., 44–45, 60–63) or moderately asymmetrical (Figs. 46, 47). Tribe Helotrephini 4

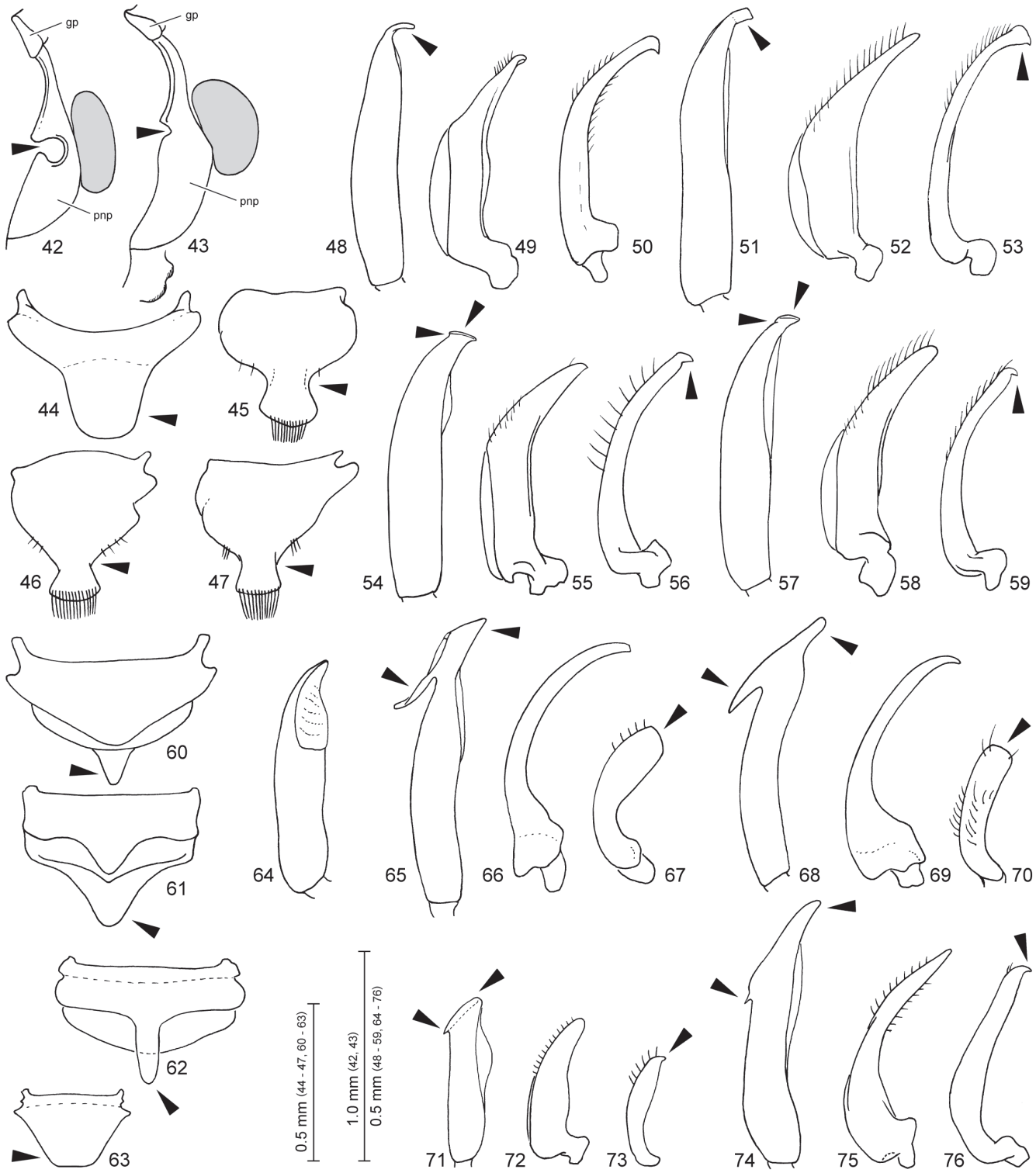
– Eye reniform or divided; postero-lateral margin of cephalonotum either dividing or indenting eye (Figs. 16–19). Small species, body length less than 1.9 mm. Cephalonotum with small, scarce



Figs. 12–24. Key characters of helotrephid genera. 12–14, Hemielytron in situ, dorsolateral aspect; cla = clavus, cls = claval suture, emb = embolium, pse = pseudendocorium, psm = pseudomembrane. (12) *Platytrephes sitesi*, hindwing-brachypterous morph, (13) *Helotrephes australis*, hindwing-brachypterous morph, and (14) *Helotrephes australis*, macropterous morph. 15–19, Cephalonotum (pnp = pronotal plate), lateral aspect, of (15) *Helotrephes australis*, (16) *Distotrephes zetteli*, hindwing-brachypterous morph, (17) *Distotrephes pavelstysi* Zettel, 1999, macropterous morph, (18) *Tiphotrephes indicus*, (19) *Idiotrephes chinai.* 20–23, Ventromedial carinae of thoracic and abdominal sternites, lateral aspect; prs – prosternum, mss – mesosternum, mts – metasternum, 2, 3, 4 etc. abdominal sternites 2, 3, 4 etc. (20) *Helotrephes australis*, (21) *Ascetotrephes edmundsorum*, (22) *Hydrotrephes mixtus*, (23) *Hydrotrephes belomensis*. 24, Metasternal carinae in *Distotrephes zetteli*, ventral aspect. Images not to scale.



Figs. 25–41. Key characters of species of Limnotrephini. Female terminalia in ventral, male genitalia in lateral (left) aspect. (25, 29, 33) Subgenital plate of female, (34, 38) first valvulae of female, (26, 30, 35, 39) aedeagus of male, (27, 31, 36, 40) left paramere of male, (28, 32, 37, 41) right paramere of male. 25–28, *Distotrephes zetteli*, 29–32, *Tiphotrephes indicus*, 33–37, *Idiotrephes chinai*, 38–41, *Idiotrephes asiaticus*. Redrawn from Papáček & Zettel, 2000, 2003 and Papáček & Kovac, 2001b, respectively; some parts slightly modified.



Figs. 40–76. Key characters of species of Helotrephini. (40, 41) Pronotal plate (pnp) and genal plate (gp), ventrolateral aspect, (44–47, 60–63) Subgenital plate of female, ventral aspect, pilosity omitted in Figs. 44, 60–63) male genitalia in lateral (left) aspect: (48, 51, 54, 57, 64, 65, 68, 71, 74) aedeagus of male, (49, 52, 55, 58, 66, 69, 72, 75) left paramere of male, (50, 53, 56, 59, 67, 70, 73, 76) right paramere of male. 42, 44, 48 – 50, *Helotrephes australis*, 45, 51–53, *Helotrephes affinis*, 43, 46, 54–56, *Helotrephes flaviceps*, 47, 57–59, *Helotrephes rompinensis*, 60, 65–67, *Hydrotrephes sitesi*, 61, 68–70, *Hydrotrephes maculatus* (redrawn from Papáček & Kovac, 2001a; slightly modified), 62, 74–76, *Hydrotrephes benomensis*, 63, 71–73, *Hydrotrephes langkawicus*, 64, *Hydrotrephes mixtus.*

punctures and shining (Figs. 6–8). Hind margin of subgenital plate of female symmetrical or asymmetrical (Figs. 25, 29, 33). Tribe Limnotrephini 6

4 Abdominal sternites 4 and 5 (or 4–6) with median carina (Fig. 20) ..... ***Helotrephes***

– Abdominal sternites 5 and 6 without median carina; sternite 4 with or without small tooth (Figs. 21–23) 5

5 Anterior margin of head very broadly rounded in frontal view (Fig. 10). Median carina of mesosternum terminating in sharp apex (Fig. 21) ..... ***Ascetotrephes***

– Anterior margin of head more narrowly rounded in frontal view (Fig. 11). Median carina of mesosternum either low or with laminate distal zone (Figs. 22, 23) ..... ***Hydrotrephes***

6 Metasternal carina in posterior half with two rami forming a diamond-shaped structure (Fig. 24). Eye of brachypterous morph completely divided by lateral margin of cephalonotum (Fig. 16) (with separated part ventrally), eye of rare macropterous morph deeply incised, but narrowly connected at anterior third (Fig. 17). Subgenital plate of female with sharply pointed medial tip (in West Malaysian species; Fig. 25). Aedeagus of male with narrow apex (in West Malaysian species; Fig. 26); left paramere with acuminate apex (Fig. 27); right paramere with rounded, truncate, or acuminate apex (Fig. 28) ..... ***Distotrephes***

– Median metasternal carina simple all over length. Eye never completely divided by lateral margin of cephalonotum, at most with deep indention in posterior half (Figs. 18, 19). Subgenital plate of female and genitalia of male strongly different 7

7 Lateral margin of cephalonotum not extending onto eye surface, only indistinctly indenting eye at posterior margin (Fig. 19). Subgenital plate of female nearly symmetrical, with two narrow incisions laterally of small medial lobe (Fig. 29). Left paramere of male distally with simple bend (Fig. 31) ..... ***Tiphotrephes***

– Lateral margin of cephalonotum clearly extending onto eye surface, deeply indenting eye surface (Fig. 18). Subgenital plate of female strongly asymmetrical, with deep dextrocaudal incision (Fig. 33). Left paramere of very characteristic shape, with apical hook (Figs. 36, 40) ..... ***Idiotrephes***

Subfamily Fischerotrephinae Zettel, 1994

The subfamily contains only one genus distributed from southern India to Borneo, and six described species (Papáček & Zettel, 2005; Chen et al., 2006). In West Malaysia it is represented by a single species, *Fischerotrephes jaechi*, described from Perak and also recorded from Songkhla, southern Thailand (Sites & Polhemus, 2002). Two further species are described from Thailand (Chen et al., 2006). *Fischerotrephes* can easily be recognized by small size, relatively flat body, short cephalonotum, small mesoscutellum (Fig. 1), and tarsal formula 3–3–3. In hindwing-brachypterous specimens, eyes are minute and the antennae are absent – a unique character in adult Insecta. The hemielytron is densely sculptured and matt, with some long, appressed hairs. *Fischerotrephes jaechi* differs from most congeners in coloration (Fig. 1). *Fischerotrephes* species are very rarely collected because they are small and live cryptically on sand or fine gravel bottoms in the middle of clean brooks and streams.

Subfamily Trephotomasinae Papáček, Štys & Tonner, 1988

At present, the subfamily Trephotomasinae is unknown from the study area. It is here included because the genus *Platytrephes* Zettel, 2005 (five described species) is widely distributed from southern China to Borneo (Zettel, 2005), and possibly some species may be found in West Malaysia in the future. Two further monotypic genera are known in the subfamily, but their presence in the study area is unlikely: *Trephotomas compactus* Papáček, Štys & Tonner, 1988 has been recorded from southern China, northern Vietnam, northern and central Thailand; and *Papacekia microphthalma* Zettel, 2005 from Borneo. Trephotomasinae possesses two unique characters, the pseudendocorium (Fig. 12) and the tarsal formula 2–2–3. The genus *Platytrephes* can easily be recognized by its weakly convex and broad habitus (Fig. 2) and wide, flattened medial areas on the metasternum and sternite 2. As far as their habitats are known, Trephotomasinae is benthic on gravelly bottoms of clean streams.

Subfamily Helotrephinae – Tribe Limnotrephini

According to present classification (Papáček & Zettel, 2005), this tribe contains seven genera including four from Southeast Asia and three from the study area. *Distotrephes* and *Tiphotrephes* each are represented by single species on the Malay Peninsula: *Distotrephes zetteli* is known from Central Thailand to West Malaysia (Selangor). *Tiphotrephes indicus* is widely distributed from India to Borneo; it has been collected in Selangor and Perak and it is the only helotrephid so far recorded from Singapore. The distributions of two extremely similar species of *Idiotrephes* overlap in Malaysia (Papáček & Zettel, 2000): the chiefly Southeast Asian *I. asiaticus* and the West Malesian *I. chinai*. They can only be distinguished by discrete differences in the structures of the males' genitalia and the apices of the females' first valvulae (compare Figs. 34–41; main differences marked by arrows).

These three genera differ distinctly in their preferred habitats. *Distotrephes* is benthic and prefers clean streams. *Idiotrephes* is usually found in lithotelms, but also in other small, stagnant water bodies. *Tiphotrephes* can be found in various kinds of stagnant waters and is probably the most euryoecious helotrephid species worldwide.

Mixotrephes thermophilus is so far recorded from northern Myanmar (Sagaing Division, Shan States) and northern Thailand (Chiang Mai, Kampaeng Phet) (Papáček & Kovac, 2001b; Papáček & Zettel, 2006); its tolerance for warm water (Papáček & Kovac, 2001b) suggests that this cryptic species also might occur further south.

Subfamily Helotrephinae – Tribe Helotrephini (sensu Polhemus, 1990)

According to the presently accepted classification (Papáček & Zettel, 2005), the tribe contains seven genera including

three in Southeast Asia and the study area. *Ascetotrephes* contains only eight species in Peninsular Malaysia, Sumatra and Borneo (Zettel, 2004, 2009). Among them, *Ascetotrephes edmundsorum* is the only species known from Peninsular Malaysia. *Helotrephes* and *Hydrotrephes* are very specious. Three species of *Helotrephes* and two species of *Hydrotrephes* have been recorded from West Malaysia, but another four species have been recorded from the better investigated south of Thailand (south of the Isthmus of Kra) and can be expected in Malaysia, too. The discovery of additional undescribed species is likely.

Species of Helotrephini are typically found in bays of streams and rivers, or along banks between tree roots or accumulated plant debris where they live near the water surface, often in large numbers of adults and nymphs.

Key to the species of *Helotrephes*

1 Pronotum at hind margin without tubercles. Pronotal plate near eye with very deep, roundish incision (Fig. 42). Subgenital plate of female with broad medial lobe (Fig. 44). Apex of aedeagus narrow, hook-shaped (Fig. 48). *Helotrephes australis* species group ..... ***Helotrephes australis***

– Pronotum at hind margin with distinct tubercles (Figs. 3, 9). Pronotal plate near eye with small incision (Figs. 43). Subgenital plate of female with narrow medial process (Figs. 45–47). Apex of aedeagus broad, not hook-shaped (Figs. 51, 54, 57). *Helotrephes otoeis* species group 2

2 Cephalonotum yellowish with numerous brown speckles. Medial process of subgenital plate of female large, with weakly narrowed "neck" (Fig. 45). Aedeagus of male with broad apical lamella (Fig. 51). Southern Thailand ..... [*Helotrephes affinis*]

– Cephalonotum almost totally bright yellow. Medial process of subgenital plate of female narrow, with distinct "neck" (Figs. 46, 47). Aedeagus of male with small, completely delimited apical plate (Figs. 54, 57) 3

3 Subgenital plate of female moderately asymmetrical at base (Figs. 46). Aedeagus of male with wide, posteriorly sharply delimited apex (Fig. 54). ..... ***Helotrephes flaviceps***

– Subgenital plate of female strongly asymmetrical at base (Figs. 47). Aedeagus of male with narrow, posteriorly curved apex (Fig. 57) ..... ***Helotrephes rompinensis***

Key to the species of *Hydrotrephes*

1 Metasternal carina long, with straight ventral margin; abdominal sternite 4 with small medial tubercle (Fig. 22). Aedeagus simple (Figs. 64). Southern Thailand. *Hydrotrephes mirus* group .... [*Hydrotrephes mixtus*]

– Metasternal carina short, with convex ventral margin; abdominal sternite 4 without medial tubercle (e.g., Fig. 23). Aedeagus modified, posteriorly or postero-subapically with process or tooth (Figs. 65, 68, 71, 74) 2

2 Subgenital plate of female with triangular apical lamella (Figs. 60, 61). Hind margin of aedeagus with long process (Figs. 65, 68). Right paramere stout, with broad apex (Figs. 67, 70). *Hydrotrephes bouvieri* group 3

– Subgenital plate of female distally either with broad lobe or with long and slender process (Figs. 62, 63). Hind margin of aedeagus with short tooth (Figs. 71, 74). Right paramere slender, with pointed apex (Figs. 73, 76). *Hydrotrephes martini* group 4

3 Subgenital plate of female with small distal lamina (Fig. 60) Aedeagus with triangular apex and curved posterior process (Fig. 65). Southern Thailand ..... [*Hydrotrephes sitesi*]

– Subgenital plate of female with large distal lamina (Fig. 61). Aedeagus with elongate apex and straight posterior process (Fig. 68). Southern Thailand ..... [*Hydrotrephes maculatus*]

4 Body length 1.9–2.2 mm, cephalonotum width 1.3–1.5 mm. Subgenital plate of female distally with broad lobe (Fig. 63). Aedeagus with roundish apex (Fig. 71) .... ***Hydrotrephes langkawicus***

– Body length 2.6–2.8 mm, cephalonotum width 1.8–2.1 mm. Subgenital plate of female distally with long and slender process (Fig. 62). Aedeagus with elongate apex (Fig. 74). ..... ***Hydrotrephes benomensis***

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