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Notes on the Helotrephidae (Insecta: Heteroptera) of South India, with description of *Nanotrephes* gen.n. and five new species

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Abstract

The following contributions on the knowledge of South Indian Helotrephidae are presented: *Nanotrephes* gen.n. of the tribus Limnotrephini (subfamily Helotrephinae) is described. It contains five species: *Nanotrephes minutissimus* (ZETTEL, 1997) comb.n. (type species; described as *Limnotrephes minutissimus*), *N. duplicaturus* sp.n., *N. idiomorphus* sp.n., and *N. tuberculatus* sp.n., all from Kerala, and *N. boukali* sp.n. from Karnataka; *Indotrephes latus* sp.n. from Tamil Nadu is described; the last is the first description of a brachypterous morph of the genus *Indotrephes* ZETTEL, 1997. New records are presented for *Indotrephes bufula* ZETTEL, 1997 (from Kerala), and *Fischerotrephes indicus* ZETTEL, 1997 (from Kerala, Karnataka, and Tamil Nadu). The male of *Fischerotrephes indicus* is described for the first time. Keys to the genera of the Helotrephidae from India, Nepal, Bhutan, and Sri Lanka, and to the species of *Nanotrephes* gen.n., are provided.

Key words: Helotrephidae, *Nanotrephes*, *Indotrephes*, *Fischerotrephes*, new genus, new species, description, key to genera, key to species, India.

Zusammenfassung

Die folgenden Beiträge zur Kenntnis südindischer Helotrephidae werden geliefert: *Nanotrephes* gen.n. aus der Tribus Limnotrephini (Unterfamilie Helotrephinae) wird beschrieben. Die Gattung umfaßt fünf Arten: *Nanotrephes minutissimus* (ZETTEL, 1997) comb.n. (Typusart; als *Limnotrephes minutissimus* beschrieben), *N. duplicaturus* sp.n., *N. idiomorphus* sp.n. und *N. tuberculatus* sp.n. aus Kerala sowie *N. boukali* sp.n. aus Karnataka. *Indotrephes latus* sp.n. aus Tamil Nadu wird neu beschrieben; letztere ist die Erstbeschreibung einer brachypteren Morphe der Gattung *Indotrephes* ZETTEL, 1997. Neue Nachweise von *Indotrephes bufula* ZETTEL, 1997 (aus Kerala) und *Fischerotrephes indicus* ZETTEL, 1997 (aus Kerala, Karnataka und Tamil Nadu) werden geliefert. Das Männchen von *Fischerotrephes indicus* wird erstmals beschrieben. Die Arbeit enthält auch Bestimmungsschlüssel für die Helotrephiden-Gattungen in Indien, Nepal, Bhutan und Sri Lanka sowie für die Arten der Gattung *Nanotrephes* gen.n.

Introduction

The three species of Helotrephidae so far described from South India (ZETTEL 1997a, b), are endemic to this region. The same is true for two genera, *Indotrephes* ZETTEL, 1997 and *Nanotrephes* gen.n., and all species here described. Knowledge of Indian helotre-

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phids is very poor, and it is not surprising that an expedition carried out by the excellent field researcher Dr. David Boukal (Ceské Budejovice, Czech Republic) yielded many interesting findings, which are treated in this paper. So far, no species of Helotrephini is known to occur in South India, although - because of larger body size and less hidden way of life - this group is usually more commonly found in the field than Limnotrephini as well as being better represented in collections. All eight species recorded from the southern areas of India are very small, and *Nanotrephes minutissimus* ZETTEL, 1997, is the smallest species of the family. For this reason they are only collected by specialists.

When describing *Limnotrephes minutissimus*, ZETTEL (1997b) noted some aberrant characteristics and placed the species with some reservations in the genus *Limnotrephes* ESAKI & CHINA, 1928. Now fifty-five specimens are available from South India, belonging to five species, which are all closely related and have common characteristics that clearly separate them from *Limnotrephes*. After finishing revisions of the genera *Distotrephes* POLHEMUS, 1990 and *Idiotrephes* LUNDBLAD, 1933 (ZETTEL 1995, 1999, PAPÁČEK & ZETTEL 2000), and after having seen material of all described Oriental species of the tribus Limnotrephini, the authors now have sufficient knowledge of the generically diagnostic characteristics and can recognize *Nanotrephes* gen.n. as a well defined genus.

Material and methods

Specimens were killed and preserved in ethyl-acetate and then dry mounted on card labels. Examination of external structures was carried out by use of a LEICA Wild M10 stereo-microscope (max. 108 x magnification), examination of female and male terminalia by use of a OLYMPUS BX40 microscope (max. 400 x magnification). Drawings were made by using a camera lucida.

Terminology follows MAHNER (1993), PAPÁČEK & al. (1988), and ZETTEL (1997a, b), and it is also partly explained in Figs. 21, 24, and 35. The statement whether specimens are "brachypterous" (= hind-wing-micropterous) or macropterous is made after external examination according to the development of the hemelytron (without or with claval and embolar suture); exact state of the hind wings, i.e. brachy- or micropterous (sensu PAPÁČEK & al. 1989) was not examined.

Material is referred to by the original labels. Each label is marked with ""; the backslash sign \ indicates the break of a line. Red labels bearing the word "Holotypus" or "Paratypus", the name of the species, and the authors' names are attached to all type specimens; these labels are not cited. Material is deposited in the collections listed below.

Acronyms of repositories

NHMW	Naturhistorisches Museum in Wien, Vienna, Austria
SMF	Forschungsinstitut und Museum Senckenberg, Frankfurt am Main, Germany
NCTN	Nico Nieser Collection, Tiel, The Netherlands
UBCB	Working collection of M. Papácek, University of South Bohemia, Ceské Budejovice, Czech Republic
ZSIC	Southern Regional Station, Zoological Survey of India, Chennai, India

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Key to the genera of Helotrephidae known from India, Nepal, Bhutan, and Sri Lanka

1 Tarsal formula 3-3-3 (first segment very short and therefore difficult to see); mesoscutellum small; body strongly depressed; genitalia of male as in Figures 2 - 4; subgenital plate of female narrow triangular, terminating in sharp apex. ..... ***Fischerotrephes***

- Tarsal formula 1-2-2; mesoscutellum large; body less depressed; genitalia of male and subgenital plate of female very different. **2**

2 Posterolateral margin of cephalonotum continued ventrally of eye, not indenting it nor pointing to centre of eye; relatively large species (body length 2.7 mm). ... ***Hydrotrephes***

Note: Here only *H. kirkaldyi* (ESAKI & CHINA, 1928) from Sri Lanka.

- Postero-lateral margin of cephalonotum not continuous ventrally of eye, either indenting it or pointing to centre of eye; relatively small species, body length less than 2.0 mm. **3**

3 Cephalonotum with elevations, coarsely punctured, matt or weakly shining; subgenital plate of female shield-shaped (Figs. 5, 6); right paramere of male very small, squared. ..... ***Indotrephes***

- Cephalonotum without elevations, finely punctured, smooth and strongly shining; right paramere of male elongate. **4**

4 Lateral margin of cephalonotum not extending onto eye surface, hardly indenting eye at posterior margin; left paramere of male distally with distinct bend; subgenital plate of female with two narrow incisions laterally of small middle lobe; macropterous as well as brachypterous morphs highly domed. ..... ***Tiphotrephes***

Note: Here only *T. indicus* (DISTANT, 1910), a widely distributed species; in the studied area with only one old record from Bombay.

- Lateral margin of cephalonotum strongly indenting eye at posterior margin; left paramere of male distally without strong bend; subgenital plate of female without, with one or two incisions; macropterous morph weakly, brachypterous often distinctly depressed. **5**

5 Hemelytron between punctures smooth and shining, with numerous small black dots; aedeagus of male with sharp tip-shaped apex; subgenital plate of female (sub-)symmetrical, without incision or break on right side. ..... ***Limnotrephes***

Note: Here *L. campbelli* ESAKI & CHINA, 1928, *L. kumaonis* POLHEMUS, 1990 and some closely related forms, all from Central and North India, Nepal, and Bhutan.

- Hemelytron between punctures with dense microsculpture, matt, uniformly dark; aedeagus distally blunt (Figs. 7, 13, 16); subgenital plate of female asymmetrical, with incision, break, or impression (Figs. 19 - 25); South India. ..... ***Nanotrephes*** **gen.n.**

Fischerotrephes ZETTEL, 1994

Fischerotrephes ZETTEL, 1994: 1069 ff.

Fischerotrephes is the single genus of the subfamily Fischerotrephinae ZETTEL, 1994. Presently four species are described: two from Borneo (ZETTEL 1994, 1997c), one from West Malaysia (ZETTEL 1994), and one from South India (ZETTEL 1997a).

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Fischerotrephes indicus ZETTEL, 1997 (Figs. 1 - 4)

Fischerotrephes indicus ZETTEL, 1997a: 85 f.

Additional material examined (all brachypterous): 1 ♂, 3 ♀♀ "INDIA: Kerala, 8.1.1999\ 10km WSW Munnar\ Kallar Valley, 1100 - 1200m\ 10°03'N 76°59'E\ leg. D. Boukal (52)" (NHMW, UBCB); 1 ♂, 2 ♀♀ "INDIA: Karnataka Coorg\ Kakkabe env., 23.12.1998\ 12°15'N 75°35'E, 900 - 1200m\ leg. D. Boukal (18)" (NHMW); 8 ♂♂, 1 ♀ "INDIA: Tamil Nadu, 14.1.1999\ Palni Hills, 10°12'N 77°18'E\ 20 km W Kodaikanal, 2000m\ Kilavarai - Vandaravu rd.\ leg. D. Boukal (64)" (NHMW, UBCB, NCTN, SMF, ZSIC).

Notes: This species was described from a single brachypterous female from the Kallar Valley, Cardamom Hills, Kerala. Additional material now available allows the first description of the male. This material also shows that size and colouration of this species is somewhat variable: Light coloured specimens can have a yellow to yellowish brown mesoscutellum and also a very narrow yellowish brown area along interhemelytral suture. The body length of brachypterous females is varying between 1.40 and 1.60 mm.

Brachypterous male: Body length 1.45 - 1.50 mm; maximum body width (behind middle of length) 0.92 - 1.06 mm; width of cephalonotum 0.86 - 0.99 mm; colouration and other main characteristics similar as in female (see ZETTEL 1997a, and notes above).

Subgenital plate (abdominal sternum 8) asymmetrical, with asymmetrical medial incision of its anterior margin (Fig. 1); aedeagus relatively robust, distinctly longer than both parameres, only little sclerotized, with simple round apex (Fig. 2); left paramere longer than the right one, only slightly curved, with shallow emargination on the posteromesal area, and with robust rounded apex (Fig. 3); right paramere basally wide, subapically narrowed, its apex clumsy, with anteriorly directed tip (Fig. 4).

Comparative notes: The male of *F. indicus* differs distinctly from males of all other known species of the genus by the robust apex of the right paramere (Fig. 4) as well as by the relatively wide apical part of left paramere (Fig. 3).

Habitats: Streams as well as beginnings of artificial channels; sites with slow to moderate flow, bed with stones overgrown with moss, gravel, and vegetation packs; diverted from pebbles; (900 -) 1000 - 2000 m a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala, Karnataka, Tamil Nadu.

Indotrephes ZETTEL, 1997

Indotrephes ZETTEL, 1997a: 86 ff.

Indotrephes is endemic to South India. Its phylogenetic position between the Idiocorinae and the tribus Limnotrephini of the Helotrephinae has been discussed by ZETTEL (1997a). One species has been described so far; a second species is added in this paper.

Indotrephes bufula ZETTEL, 1997 (Fig. 5)

Indotrephes bufula ZETTEL, 1997a: 88 ff.

Additional material examined (all macropterous): 3 ♂♂, 8 ♀♀ "INDIA: Kerala, 5.1.1999\ 10km WSW Munnar, 1000m\ Kallar Valley, 10°03'N 76°58'E\ leg. D. Boukal (45)" (NHMW, UBCB); 2 ♂♂, 1 ♀ "INDIA: Kerala, 6.1.1999\ 10km W Munnar, 1100m\ Peschadu - Mangulam rd.\ 10°04'N 76°58'E\ leg. D. Boukal (48)" (NHMW); 5 ♂♂, 8 ♀♀ "INDIA: Kerala, 7.1.1999\ 10km WSW Munnar\ Kallar Valley, 1100 -

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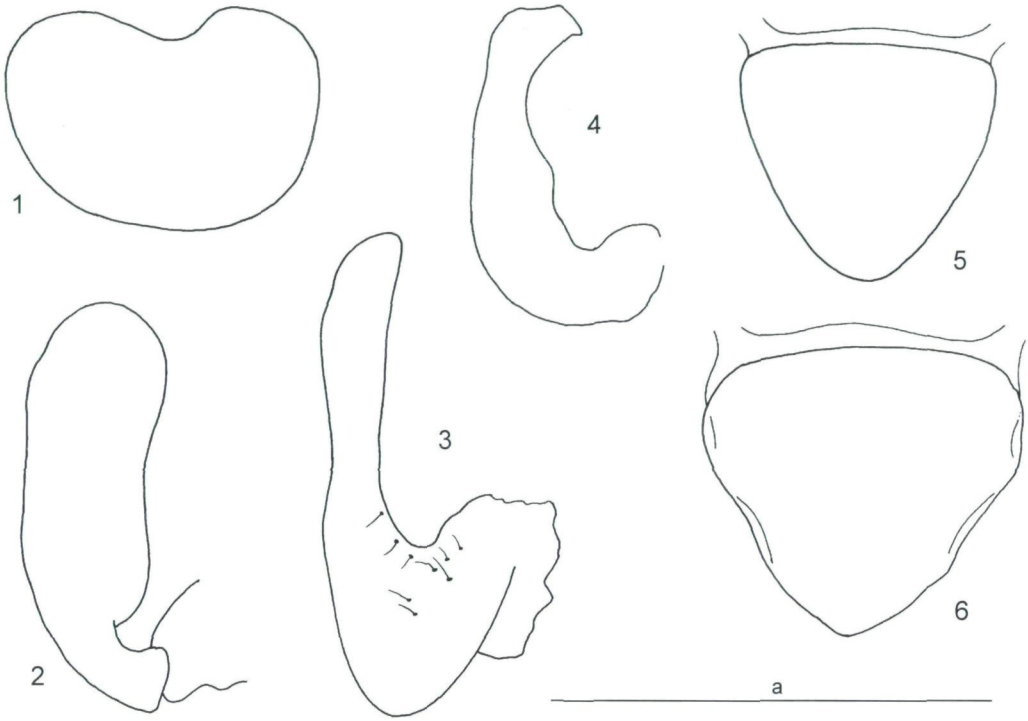

Figs. 1 - 6: (1 - 4) *Fischerotrephes indicus*, male: (1) abdominal sternum 8, (2) aedeagus, (3) left paramere, (4) right paramere; (5) *Indotrephes bufula*, female abdominal sternum 7; (6) *Indotrephes latus* sp.n: female abdominal sternum 7; scale a = 0.25 mm (Figs. 3, 4), = 0.33 mm (Fig. 2), = 0.5 mm (Figs. 5, 6), = 0.7 mm (Fig. 1).

1200m\ 10°03'N 76°58'E\ leg. D. Boukal (49)" (NHMW, UBCB, NCTN, SMF, ZSIC); 1 ♀ "INDIA: Kerala, 7.1.1999\ 10km WSW Munnar\ Kallar Valley, 1100m\ Kallar Valley, 10°03'N 76°59'E\ leg. D. Boukal (51)" (NHMW); 1 ♂ "INDIA: Kerala, 8.1.1999\ 10km WSW Munnar\ Kallar Valley, 1100 - 1200m\ 10°03'N 76°59'E\ leg. D. Boukal (52)" (NHMW).

Notes. This genus and species have been described from six macropterous specimens from the Cardamom Hills. The subgenital plate of the female (abdominal sternum 7) of this species is figured for the first time (Fig. 5); it has an approximately triangular shape with convex lateroposterior margins and a round posteromedial corner.

Habitats: Small to large streams (from 0.5 to 10 metres wide) in degraded primary forests, some of them with inlets, with slow to fast flow; beds with stones of different size, gravel, silt; with leaves and tree roots, and with large stones owergrown with moss; 1000 - 1100 (- 1200) m a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala.

Indotrephes latus sp.n. (Fig. 6)

Holotype (brachypterous female): "INDIA: Tamil Nadu, 12.1.1999\ Palni Hills, 10°16'N 77°33'E\ Perumalmalai, 1500m\ leg. D. Boukal (59)" (NHMW).

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Brachypterous female: body length 1.45 mm; maximum body width (just behind middle of lenght) 0.96 mm; width of cephalonotum 0.90 mm; shape of lateral body outline ovate; dorsal surface weakly shining.

Colour dorsally yellow with numerous small, mostly confluent, blackish spots resulting in brownish appearence; only head with more clear colour pattern, with two anteriorly and posteriorly confluent, black median stripes connected along cephalonotal suture with posterior margin of eyes; ventrally light brown, abdominal sterna and lateral plates dark brown; legs yellow.

Cephalonotum dorsally on head rather finely, on pronotum more coarsely punctate, with maximum width (at hind corners) 1.6 times as long as median length in dorsal view, unevenly sculptured, with transverse elevation between anterior margin of eyes, with shallow grooves behind eyes, and with longitudinal bulges parallel with posterio-lateral margin; anterior part (in front of eyes) strongly deflected, anterior margin parabolic, slightly raised; posterio-lateral margin nearly straight, hardly denticulate, indenting eye in posterior half; eye large, dorsally distinctly raised from surface of head; rostrum rather short, extending to apex of prosternal carina; antenna two-segmented, in shallow groove posterio-medially of eye; mesoscutellum triangular, long, 1.25 times as long as basal width, coarsely punctate; hemelytron without separated clavus and embolium, with hardly denticulate lateral (= costal) margin, with corium not very uneven, with distinct ridges along lateral and posteromedian margins, and with few smaller raised dimples; pseudomembrane of left hemelytron reduced to narrow apical stripe, of right hemelytron lacking; midsternal carinae: prosternal carina rather low, posteriorly rectangular; mesosternal carina abruptly raised; metasternal carina evenly raised; carinae of mesosternum, metasternum, and abdominal sterna 2 - 3 with acute apex; sternum 4 without carina; abdominal sterna with short, semierect pubescence; abdominal sternum 7 broad, triangular with slightly concave section of lateroposterior margins and tip-shaped posteromedial corner (Fig. 6).

Male and macropterous morph unknown.

Comparative notes: Two characteristics easily distinguish *I. latus* sp.n. and *I. bufula*: *Indotrephes latus* sp.n. is distinctly larger than *I. bufula* (body length 1.45 mm vs. 1.15 - 1.25 mm), and the subgenital plate of the female of *I. latus* sp.n. is much broader than that of *I. bufula* (width : length = 1.2 vs. 1.0; comp. Figs. 5 and 6) and has slightly concave lateral margins. These characteristics are not connected with pterygodimorphism in any other genus of Helotrephidae, and there is no reason to believe that it should be so in *Indotrephes*. When small differences in size between the two morphs of helotrephids are known, the macropterous morph always is the larger one. Several other obvious differences (e.g., colour pattern, sculpture of cephalonotum and hemelytra), however, may be connected with the pterygodimorphism of *Indotrephes* and, therefore, must be secured if one of the species becomes known in both morphs.

The two-segmented antenna of the brachypterous morph is an important characteristic for further interpretations of the phylogenetic position of this genus.

Etymology: The specific epithet is derived from the Latin adjective *latus*, meaning "broad".

Habitat: small stream, less than 1 metre wide, partly with bedrocks, partly with stones; with gravel, silt, and some leaf packs; shading variable; moderate flowing; draining cul-

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tivated land, almost unpolluted, not obviously canalised, water partly diverted for irrigation; 1500 m.a.s.l. (D. Boukal, pers. comm.).

Distribution: Tamil Nadu.

Nanotrephes gen.n.

Type species: *Nanotrephes minutissimus* (ZETTEL, 1997), by present designation.

Description: Minute helotrephids, with body length 0.92 - 1.28 mm; body more or less depressed; colour of dorsum brown, of venter light brown to yellowish; cephalonotum with yellow spots or transversal stripe behind cephalonotal suture; dorsal surface of cephalonotum and mesoscutellum smooth, shining and at most with scarce minute pits, of hemelytra (corium) matt or matt with shining small punctures (matt surface caused by secretion, which can be scratched off, below this secretion shining); eye dimorphic, in brachypterous morph very small; eye index in brachypterous morph 4.2 - 5.5, in macropterous morph 2.2 - 3.1; lateral cephalonotal carina extending onto eye surface, but not dividing it; antenna two-segmented in both morphs; mesoscutellum not very large; legs without modifications, tarsal formula 1-2-2; hemelytron of helotrephine type, in macropterous morph with clavus relatively elevated; midsternal carinae (Figs. 26 - 35) simple, sharp, extending onto sternum 4, prosternal carina in most species with posteroapical indetation and with posteroventral portion more or less distinctly produced posteriad, outline of mesosternal carina straight.

Male terminalia: aedeagus simple, peg-shaped, with blunt round apex (Figs. 7 - 10, 13, 16); left paramere longer than right one, curved, with blunt or acuminate tip (Figs. 11, 14, 17); right paramere more or less bar-shaped, straight or slightly curved, with apex rounded (Figs. 12, 15, 18).

Female: abdominal sternum 7 asymmetrical, with subsymmetrical or asymmetrical outline, and with right side impression, break or/and incision (see Figs. 19 - 25).

Comparative notes: Within the Limnotrephini *Nanotrephes* gen.n. differs by the more or less depressed body (except from *Distotrephes*), by relatively uniform yellowish brown to dark brown colour of the dorsum, and by the short aedeagus with blunt round apex. The female abdominal sternum 7 is very similar in *Nanotrephes* gen.n. and *Idiotrephes*, but these genera differ strongly in male genitalia and in the design and colour of the dorsal surface of females as well. See also Discussion.

Etymology: The name *Nanotrephes* is a combination of the Latin noun *nanus*, which means "dwarf" and refers to the extremely small body size of all species, and *trephes*, which is the latinized form of the Greek word "*trephos*" and means "inhabitant", and is traditionally used for generic epithets within the family Helotrephidae. Gender: masculine.

Diversity and distribution: Five species from South India.

Key to the species of *Nanotrephes* gen.n.

1 Prosternal carina with posteroventral corner bearing small indentation, and with posteroventral portion not or at most weakly produced caudad (Figs. 26 - 32). **2**

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- Prosternal carina with posteroventral corner bearing very inconspicuous indentation (Fig. 33, 34) or this indentation completely absent (Fig. 35), and with posteroventral portion strongly produced caudad. **4**

2 Subgenital plate of female with incision on right side of hind margin and with large central tubercle (Fig. 23); prosternal carina as in Fig. 32; male unknown. (Kerala). ..... ***N. tuberculatus* sp.n.**

- Subgenital plate of female without incision and without tubercle, but with shallow impression; prosternal carinae as in Figs. 26 - 31. ..... **3**

3 Body length 0.92 - 1.05 mm; width of cephalonotum 0.64 - 0.70 mm; eye index 2.2 - 2.7; posteroventral corner of prosternal carina not or hardly produced caudad (Figs. 26 - 28); hemelytra with relatively large, more or less shining punctures; macropterous morph relatively domed, on pronotum posterolaterally with distinct elevated areas (humeral tubercles); left paramere of male as in Fig. 11. (Kerala). ..... ***N. minutissimus***

- Body length 1.03 - 1.20 mm (usually 1.10 - 1.20 mm); width of cephalonotum 0.72 - 0.79 mm; eye index 2.7 - 3.1 (usually 3.0 - 3.1); posteroventral corner of prosternal carina more distinctly produced caudad (Figs. 29 - 31); hemelytra with relatively small punctures; macropterous morph relatively flat, on pronotum posterolaterally without elevated areas (humeral tubercles); left paramere of male as in Fig. 14. (Karnataka). ..... ***N. boukali* sp.n.**

4 Prosternal carina with extremely small indentation (Figs. 33, 34); subgenital plate of female with deep incision of right hind margin (Fig. 24); left paramere of male as in Fig. 17. (Kerala). ..... ***N. idiomorphus* sp.n.**

- Prosternal carina without any indentation (Fig. 35); subgenital plate of female with fold (Fig. 25); male unknown. (Kerala). ..... ***N. duplicaturus* sp.n.**

Nanotrephes minutissimus (ZETTEL, 1997) comb.n. (Figs. 7 - 12, 19, 20, 26 - 28)

Limnotrephes minutissimus ZETTEL, 1997b: 683 ff.

Material examined (all macropterous): **holotype** (♂): "S-INDIEN, Kerala\ Cardamom Hills\ 15km SW Munnar\ 76°58'E/10°02'N", "Kallar Valley\ 6.-18.12.1993\ 1000m (7)\ leg. Boukal & Kejval" (NHMW); **paratypes:** 1 ♂, 1 ♀ "S-INDIEN, Kerala\ Cardamom Hills, 300m\ 50km NW Pathanamthitta\ 77°05'E/09°25'N", "Small Stream near\ Pambaiyar River\ 27.-29.12.1993 (12)\ leg. Boukal & Kejval" (NHMW); **additional specimens:** 4 ♂♂, 7 ♀♀ "INDIA: Kerala, 6.1.1999\ 10km W Munnar, 1100m\ Peschadu - Mangulam rd.\ 10°04'N 76°58'E\ leg. D. Boukal (48)" (NHMW, UBCB); 1 ♀ "INDIA: Kerala, 7.1.1999\ 10km WSW Munnar, 1100m\ Kallar Valley, 10°03'N 76°58'E\ leg. D. Boukal (50)" (NHMW); 3 ♀♀ "INDIA: Kerala, 2.1.1999\ 35km NNE Trivandrum, 600m\ Ponmudi, 08°46'N 77°07'E\ leg. D. Boukal (39)" (NHMW); 5 ♂♂, 13 ♀♀ "INDIA: Kerala, 2.1.1999\ 35km NNE Trivandrum, 600m\ Ponmudi, 08°46'N 77°07'E\ leg. D. Boukal (40)" (NHMW, UBCB, NCTN, SMF, ZSIC); 1 ♀ "INDIA: Kerala, 3.1.1999\ 30km NNE Trivandrum, 300m\ Kallar Bridge, 08°45'N 77°05'E\ leg. D. Boukal (42)" (NHMW).

Diagnosis: Macropterous morph: Body length 0.92 - 1.05 mm; width of cephalonotum 0.64 - 0.70 mm; body relatively domed; eyes relatively large; eye index 2.2 - 2.7; pronotum with distinct elevated areas (humeral tubercles); posteroventral portion of prosternal carina not or hardly produced caudad, apically with small indentation (Figs. 26 - 28); hemelytra with relatively large, more or less shining punctures; male: aedeagus short and stout, length/width approximately 2.0 (Figs. 7 - 10); left paramere nearly evenly tapered and curved towards acute apex (Fig. 11); left paramere short, with subparallel sides (Fig. 12); female: sternum 7 with subparallel outline, with right side impression and fine break (Fig. 21 - 22).

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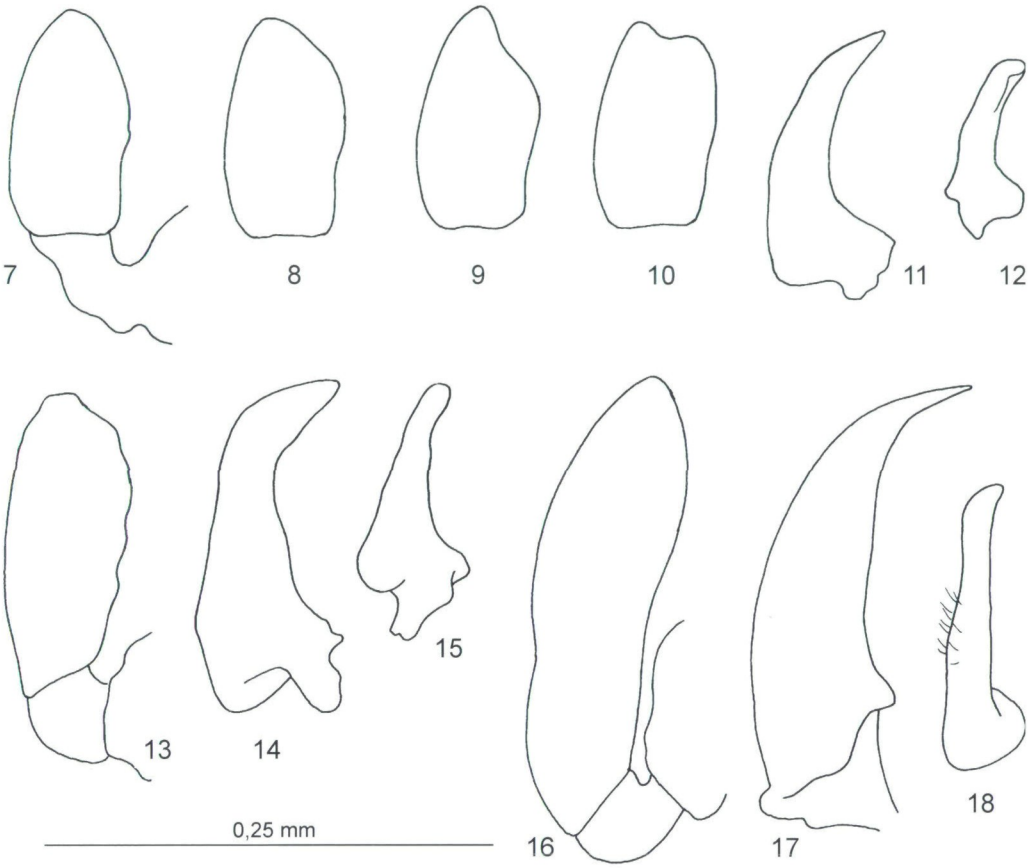

Figs. 7 - 18: (7 - 12) *Nanotrephes minutissimus*: (7) aedeagus with most usual shape of phallosoma, (8 - 10) artificial varibility of phallosoma in dry mounted material, (11) left paramere, (12) right pramere; (13 - 15) *Nanotrephes boukali* sp.n.: (13) aedeagus, (14) left paramere, (15) right paramere; (16 - 18) *Nanotrephes idiomorphus* sp.n.: (16) aedeagus, (17) left paramere, (18) right paramere.

Brachypterous morph: unknown.

Notes: This species has been described from two macropterous males and one macropterous female from the Cardamom Hills. Examination of the additional material and more detailed studies using higher magnification showed that (1) this species is somewhat more variable than exposed in the type specimens described by ZETTEL (1997b), and (2) that the description of the female abdominal sternum 7 is necessary to be corrected: the subgenital plate is asymmetrical with a right side impression (compare Figs. 19, 20 in present paper with description by ZETTEL 1997c: p. 684, Fig. 2). Terminalia of male (Figs. 7 - 12) and female (Figs. 19, 20) are illustrated for comparison and for demonstration of their variability. The aedeagus is apically relatively soft and desclerotized in some specimens; it can have somewhat different artificial shapes in dry mounted material (see Figs. 7 - 10). For distinction of *N. minutissimus* from other species see Key to the species and Comparative notes of *N. boukali* sp.n.

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Habitats: Small to large streams (1 to 10 metres wide); in runs less than 10 to 30 cm deep, with stones, gravel, silt, numerous leaf, vegetation refuse packs; parts almost fully shaded, parts almost unshaded; draining disturbed forest as well as cultivated land; 300 - 1100 m a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala.

Nanotrephes boukali sp.n. (Figs. 13 - 15, 21, 22, 29 - 31)

Holotype (macropterous male): "INDIA: Karnataka, Coorg\ Kakkabe env., 21.12.1998\ 12°15'N 75°35'E, 900 - 1200m\ leg. D. Boukal (12)" (NHMW); **paratypes** (all macropterous): 3 ♂♂, 2 ♀♀, same label data as holotype (NHMW, UBCB); 1 ♂, 2 ♀♀ "INDIA: Karnataka, Coorg\ Kakkabe env., 23.12.1998\ 12°15'N 75°35'E, 900 - 1200m\ leg. D. Boukal (17)" (NHMW); 2 ♂♂ "INDIA: Karnataka, Coorg\ Madikeri env., 20.12.1998\ Abbi Falls Road\ 12°30'N 75°45'E, 900 - 1200m\ leg. D. Boukal (7)" (NHMW).

Description of macropterous morph: Ground colour of dorsal body surface brown to blackish brown; cephalonotum with transverse yellow to yellowish stripe behind well visible cephalonotal suture; venter light brown, legs light brown to yellowish; cephalonotum and mesoscutellum shining; whole surface of hemelytra matt, blackish with very fine granulation (shining punctures very rare) and without any pits or depressions; clavus extremely elevated, claval suture extremely step-shaped; ventral midsternal carinae: prosternal carina with distinct posteroapical incision, with posteroventral portion distinctly produced caudally (but not as strong as in the prosternal carina of *N. idiomorphus* sp.n. and *N. duplicaturus* sp.n.); metasternal part with small posterocaudal projection (Figs. 29 - 31).

Male: body length usually 1.10 - 1.15 mm, but in males from Madikeri 1.03 - 1.05 mm; width of cephalonotum 0.74 - 0.78 mm, but in males from Madikeri 0.72 - 0.73 mm; eye index usually 3.0 - 3.1, but in males from Madikeri 2.7; mesoscutellum width/length 1.33; aedeagus: phallosoma with few small depressions on anterior surface (Fig. 13); left paramere with two posterobasal blunt corners and boomerang-like curved distal part (Fig. 14); right paramere relatively straight, with posterobasal round tubercle and simple round apex (Fig. 15).

Female: body length 1.14 - 1.20 mm; width of cephalonotum 0.77 - 0.79 mm; eye index 3.1; mesoscutellum width/length 1.4; abdominal sternum 7 (Figs. 21, 22) with minute posteromesal tip, with few minute incisions in right posterolateral margin, and with small right side lateromesal impression on the posterolateral area in some specimens.

Brachypterous morph unknown.

Comparative notes: *Nanotrephes boukali* sp.n. is most similar to *N. minutissimus*. Studying the shape of the left paramere, which is apically more acute in *N. boukali* sp.n., is the most certain way to distinguish the two species. The phallosoma of *N. boukali* sp.n. has intermediate proportions (length : width = 2.4 - 2.5), being more elongate than in *N. minutissimus* (length : width = 2.0), but stouter than in *N. idiomorphus* sp.n. (length : width = 3.5 - 3.6). There is only a small overlap of the body lengths of *N. boukali* sp.n. and *N. minutissimus* (only one large specimen of *N. minutissimus* is within the variability of *N. boukali*, only the males from Madikeri are within the variability of *N. minutissimus*), and also the apex of the prosternal carina is diagnostic, with only

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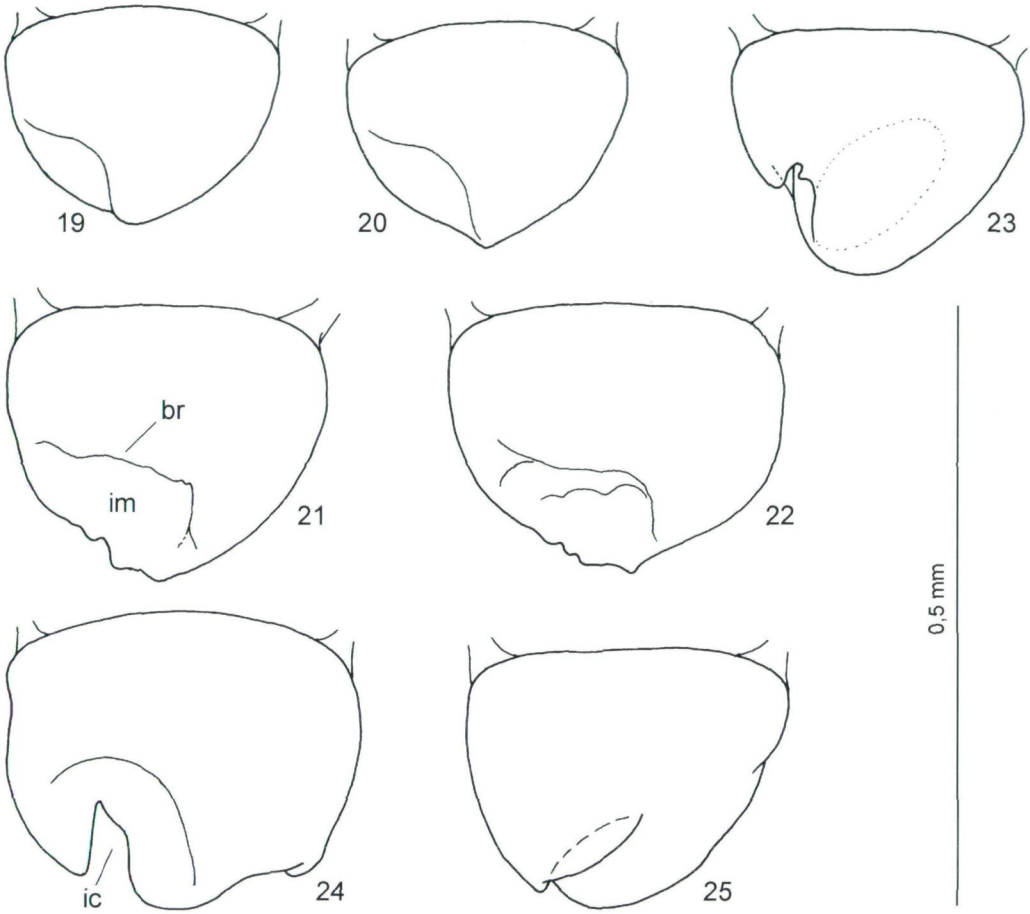

Figs. 19 - 25: Female abdominal sternum 7 of *Nanotrephes* species: (19, 20) *N. minutissimus*, (21, 22) *N. boukali* sp.n., (23) *N. tuberculatus* sp.n., (24) *N. idiomorphus* sp.n., (25) *N. duplicaturus* sp.n.; br - break, ic - incision, im - impression.

little infraspecific variability (Figs. 29 - 31). In *N. minutissimus* the cephalonotum of the macropterous morph bears distinct humeral tubercles close to the hind corner, which are hardly developed in *N. boukali* sp.n. Other characteristics are somewhat variable and difficult to evaluate without direct comparison of both species: e.g., there are differences in size and distribution of punctures of the macropterous morph: the hemelytron of *N. minutissimus* bears larger punctures than that of *N. boukali* sp.n. (with some variability in *N. minutissimus*), and the lateral margin of the pronotum (laterally of the humeral tubercle) bears fine punctures in *N. boukali* sp.n., which are lacking or strongly reduced in *N. minutissimus*. The two males form Madikeri differ in smaller size, larger eyes, and weak incision of the prosternal plate from the males from Kakkabe, but are regarded as conspecific because of identical genitalia structures.

Etymology: This species is named in recognition of the great collecting efforts of Dr. David Boukal (České Budejovice) in South India.

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Habitats: Small to larger streams (0.5 to 5 metres wide) with very shallow water (a few centimetres deep); rocky beds with stones, gravel, silt in pools, gravel or pebbles in small riffles, leaf deposits in some sites; unshaded to rather shaded, some streams slightly polluted; draining cultivated land including rice fields; ca. 900 - 1200 m a.s.l. (D. Boukal, pers. comm.).

Distribution: Karnataka.

Nanotrephes tuberculatus sp.n. (Figs. 23, 32)

Holotype (brachypterous female): "INDIA: Kerala, 30.12.1998\ 30km NNE Trivandrum, 400m\ Kallar Bridge, 08°45'N 77°05'E\ leg. D. Boukal (29)" (NHMW).

Description of brachypterous female: Body length 0.98 mm; width of cephalonotum 0.68 mm; ground colour of dorsal body surface brown; cephalonotum and mesoscutellum yellowish to light brown, head with medial dark stripe in anterior fourth; venter light brown, legs light brown to yellowish; eye index: 5.5; cephalonotum and mesoscutellum shining; whole surface of hemelytra matt, dark brown with very fine granulation and sparse shining punctures; ventral midsternal carinae: prosternal carina with distinct posteroapical incision, with posteroventral portion only weakly produced caudally, with angulation at posterior margin; metasternal part with posteroventral projection, carina of the second abdominal sternum round (Fig. 32); abdominal sternum 7 (Fig. 23) with duplicate incision on the right posterolateral margin; outline of this incision projecting into small protuberance, surface posteromedially with very large tubercle.

Male and macropterous morph unknown.

Comparative notes: *Nanotrephes tuberculatus* sp.n. shares the distinctly indented apex of the prosternal carina with *N. minutissimus* and *N. boukali* sp.n. However, the subgenital plate of the female bears a tubercle and an incision (Fig. 23) and differs clearly from all other species. Males of *N. tuberculatus* sp.n., which are presently unknown, should be possibly recognized by the slightly different posterior margin of the prosternal carina. Other characteristics presently cannot be properly compared, because *N. tuberculatus* sp.n. is known only in the brachypterous morph, but *N. minutissimus* and *N. boukali* sp.n. only in the macropterous morph.

Etymology: Named after the unique characteristic of the tubercle located on the distal centre of the female subgenital plate.

Habitat: Small stream, ca 1.5 metres wide, 10 - 20 cm deep, with current slow to moderate (fast in a few riffles); riffles shallow; bed with stones, gravel, some leaf packs; partly shaded, draining secondary forest and cultivated land, slightly polluted (refuse); 400 m. a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala.

Nanotrephes idiomorphus sp.n. (Figs. 16 - 18, 24, 33, 34)

Holotype (brachypterous male): "INDIA: Kerala, 6.1.1999\ 10km W Munnar, 1100m\ Peschadu - Mangulam rd.\ 10°04'N 76°58'E\ leg. D. Boukal (48)" (NHMW); **paratypes:** 3 ♂♂, 1 ♀ (brachypterous), same label data as holotype (NHMW, UBCB).

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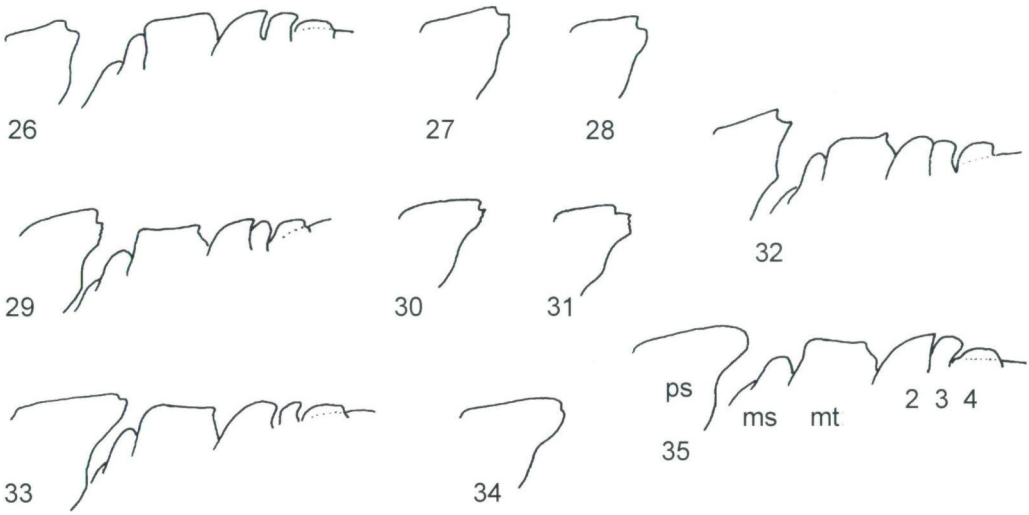

Figs. 26 - 35: Ventral midsternal carina of *Nanotrephes* species (venter turned upward, right view): (26 - 28) *N. minutissimus*: (26) no type from locality no. 48, (27) prosternal carina of no type from loc. no. 40, (28) prosternal carina of paratype male; (29 - 31) *N. boukali* sp. n.; (29) paratype male, (30) prosternal carina of paratype female, (31) prosternal carina of paratype female; (32) *N. tuberculatus*; (33, 34) *N. idiomorphus* sp.n.; (33) holotype female, (34) prosternal carina of paratype male; (35) *N. duplicaturus* sp.n.; ps, ms, mt - pro-, meso-, and metasternal carina; 2, 3, 4 - carinae of abdominal sternum 2, 3, 4, respectively.

Description of brachypterous morph: Body dorsoventrally distinctly depressed, relatively large; ground colouration of dorsal body surface brown to light brown; mesoscutellum and hemelytra somewhat darker than cephalonotum; cephalonotum with transversal yellow stripe along cephalonotal suture, with yellow spot behind eyes; clypeal area light brown to yellowish, cephalonotum and mesoscutellum shining; hemelytra matt, with minute pits; venter and legs yellowish brown; ventral midsternal carinae: posterocaudal portion of prosternal carina long, strongly produced caudad, at corner with minute incision; posterocaudal corner of metasternal carina projecting in small caudally oriented tip; carina of the second abdominal sternum not tip-shaped (Figs 33, 34).

Male: Body length 1.18 - 1.28 mm; width of cephalonotum 0.81 - 0.90 mm; eye index 4.2 - 4.5; mesoscutellum width / length 1.0; aedeagus: phallosoma relatively elongate, with posterobasal depression (Fig. 16); left paramere sickle-shaped, with tip-shaped, acute, anteriorly oriented apex (Fig. 17); right paramere straight, with anteriad curved, slightly rounded apex (Fig. 18).

Female: Body length 1.24 mm; width of cephalonotum 0.86 mm; eye index 5.0; mesoscutellum width / length 1.1; abdominal sternum 7 (Fig. 24) with deeply incised right margin, with shallow impression and break surrounding incision.

Macropterous morph unknown.

Comparative notes: *Nanotrephes idiomorphus* sp.n. is the largest species of the genus. It differs from all other species by the distinctly more elongate aedeagus and the typical

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robust left paramere of the male, and by the abdominal sternum 7 of the female, which bears a very characteristic deep, simple incision.

Etymology: Named after the similarity with *Idiotrephes* in the deeply incised subgenital plate of the female.

Habitat: Large stream, ca. 5 metres wide; material mixed from two sites: (1) steep slope, bedrock; small shore puddles, a few leaves, mud, tiny moss or algal growth on the upper edge of riffles, rather strong current, gravel deposits in slower parts; unshaded (2) slow part, moderate flowing, little gradient; with roots of a shore tree; almost completely shaded; 1100 m a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala.

Nanotrephes duplicaturus sp.n. (Figs. 25, 35)

Holotype (macropterous female): "INDIA: Kerala, 8.1.1999\ 10km WSW Munnar, 1200 m\ Kallar Valley, 10°03'N 76°59'E\ leg. D. Boukal (54)" (NHMW).

Description of macropterous female: Body length 1.20 mm; width of cephalonotum 0.81 mm; ground colour of dorsal body surface very dark brown; head except hind margin yellow; pronotum with transverse, undulate, yellowish stripe behind cephalonotal suture; mesoscutellum with very narrow, indistinct, transverse yellowish stripe; venter light brown; legs yellowish; dorsal surface of cephalonotum and mesoscutellum strongly shining, only with very sparse and very fine punctures; eyes relatively large; eye index 2.3; clavus shining, with large punctures; corium matt, with very fine granulation and sparse shining punctures; ventral midsternal carinae: posterocaudal portion of prosternal carina long, strongly produced caudad, at corner without any incision; (Fig. 35); abdominal sterum 7 with minute right side incision and small right side posteriorly projection, with very prominent duplicature (lobe) overlapping part of posteromesal surface of the sclerite (Fig. 25).

Male and brachypterous morph unknown.

Comparative notes: *Nanotrephes duplicaturus* sp.n. differs distinctly from all other species of *Nanotrephes* by the complete absence of an incision at the posterocaudal corner of prosternal carina (Fig. 35) and by the duplicature on right side of the female abdominal sternum 7 (Fig. 25).

Etymology: Named after the right side duplicature (lobe) of the female abdominal sternum 7.

Habitat: small uphill stream; at site ca. 0.5 metres wide, very shallow, slowly flowing; gravel, stones or leaf packs in runs; rather shaded, draining cardamom plantations; 1200 m a.s.l. (D. Boukal, pers. comm.).

Distribution: Kerala.

Discussion

1. Aedeagus and parameres of male:

Males of most known species of the tribus Limnotrephini have the same ground scheme and similar shape of parameres. Exceptions are only found in the strongly modified left

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Table 1: Comparison of distribution and some generic characteristics in South Asian Limnotrephini.

Characteristic / Genus	***Distotrephes***	***Limnotrephes***	***Tiphotrephes***	***Idiotrephes***	***Nanotrephes***
Distribution	SE Asia, Borneo	India, N Thailand	S - SE Asia, Borneo	SE Asia, Sunda Isl.	South India
Habitus of brachypterous morph "pleid-like", high	no, depressed	no, weakly depressed	yes	yes	no, depressed
Hemelytra "reticulate"	no	yes	yes	yes	no
Dorsally yellow with dark dots	no, mostly dark, with large marks	yes	yes	yes	no, mostly brown
Lateral cephalonotal carina of brachypterous morph incising or dividing eye surface	dividing	incising	no	incising	incising
Propleural plate medially strongly narrowed	no, truncate	yes, acuminate	yes, acuminate	yes, apex rounded	yes, apex rounded
metasternal carina low and posteriorly Y-shaped	yes	no	no	no	no
♂: apex of aedeagus	with long tip	with minute tip	with minute tip	variously modified	blunt, rounded
♀: symmetry of sternum 7	symmetrical, subsymmetrical, or asymmetrical	symmetrical or subsymmetrical	subsymmetrical	right side asymmetry	right side asymmetry
♀: incisions of sternum 7	0	0 or 2 (medial)	2 (medial)	0 - 1 (right side)	0 - 1 (right side)

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paramere in species of *Idiotrephes*, and in the strongly reduced right paramere of *Distotrephes* subgenus *Polhemotrephes*. Therefore, the parameres cannot be used for the generic distinction of most genera. In contrast, individual genera differ distinctly from each other by the distal part (apex) of the aedeagus (Table 1), except *Limnotrephes* and *Tiphotrephes* ESAKI & CHINA, 1928, which both have very similar, short blunt phallosomata with a minute posteroapical tip (see ESAKI & CHINA 1928: figs. 10e, f).

Nanotrephes gen.n. has a simple, blunt, apically rounded aedeagus. Males of other Limnotrephini genera and species have a more or less developed posteroapical part of aedeagus (short to long simple or somewhat arcuate tip, to conspicuous hammer- or axe-like structure respectively). There is an anagenetic trend in the Limnotrephini to extend and develop the posteroapical part of the aedeagus.

2. Abdominal sternum 7 (subgenital plate) of female:

Nanotrephes and *Idiotrephes* species have very similar asymmetrical female abdominal sterna 7 regarding shape and surface structures. Both have right side structures (impression, break and/or incision), which are generically and specifically diagnostic, although in a few species they show some intraspecific variability (see PAPÁČEK & ZETTEL 2000; and the present study). These characteristics distinctly differ females of *Nanotrephes* and *Idiotrephes* from females of other Limnotrephini. It is, however, presently difficult to judge, whether the right side asymmetry and incision is a synamomorphy of *Idiotrephes* and *Nanotrephes* gen.n., or a convergence, which is developed in parallel in both genera in the range of an anagenetic trend to develop a stronger asymmetry of genitalia.

The right side incision and the other associated asymmetrical structures seem to have functional character as an anchoring apparatus in mating. This opinion is derived from the following facts: (1) The right side asymmetry of the subgenital plate corresponds with the position of the male pygophore, which is asymmetrically twisted to the right side, as in other Helotrephidae. (2) The fine parts surrounding the incision of the sclerite are easily broken in some females after copulation (proven by spermatozoids in spermatheca).

3. Differential characteristics of the South Asian genera of Limnotrephini and possible relations of *Nanotrephes* gen.n.:

POLHEMUS (1990: p. 56, table 2) has discussed the differences in the genera of Limnotrephini, but some characteristics he mentions are somewhat doubtful (e.g., the "low" or "high" metasternal carina, the abdominal midsternal carinae extending onto sternum 4 or 5, or the general shape of the propleural plate). Others in fact vary intragenerically (e.g., "symmetry" or asymmetry of the abdominal sternum 7 of the female: see ZETTEL (1999) for *Distotrephes*), and cannot be used for a reliable distinction of the genera, and only with reservation for a phylogenetic analysis.

The single species of *Paralimnotrephes* POISSON, 1951 has been found only in Africa (POISSON 1951) and so far could not be examined by the authors. The monotypic genus *Mixotrephes* PAPÁČEK, ŠTYS & TONNER, 1989 is known from Afghanistan and Iran (PAPÁČEK & al. 1989). The other Limnotrephini genera (i.e., *Distotrephes*, *Idiotrephes*, *Limnotrephes*, *Nanotrephes* gen.n., and *Tiphotrephes*) can be considered South Asian taxa. According to the literature the distribution of *Limnotrephes* is disruptive; however, the unique African species *Limnotrephes stuckenbergi* POISSON, 1960 differs consider-

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ably from the Asian species of the genus (see POISSON 1960: figs. 5, 6, POLHEMUS 1990: pp. 53, 54; and our studies) and should be transferred to a new genus. The position of *Indotrephes* (in the Idiocorinae or Limnotrephini?; see ZETTEL 1997a) is unclear, but this genus seems to be so different, that it is not necessary to include it in the following discussion.

Some characteristics of the South Asian Limnotrephini are compared in Table 1. The low number of characteristics, however, is not yet sufficient for a phylogenetic analysis, which must include all genera of Limnotrephini and Idiocorinae. Nevertheless, the five genera can be arranged into groups by a preliminary division, which are schemata (a - c) open for discussion, still more developed by similarities than by correct judgement of character polarity (phylogenetical relationships) (for character states see Table 1):

(a) Groups formed by (1) general habitus, (2) design and ground colouration of body surface, and (3) lateral cephalonotal carina (supposing that the most plesiomorphic state is "pleid-like").

1. *Tiphotrephes* + *Limnotrephes* + *Idiotrephes* + *Nanotrephes*
    1.1. *Tiphotrephes* + *Limnotrephes* + *Idiotrephes*
    1.2. *Nanotrephes*
2. *Distotrephes*

(b) Groups formed by the shape and structure of the abdominal sternum 7 of the female (supposing that the less derived state is a simple symmetrical sternum without any other surface or marginal structures).

1. *Tiphotrephes* + *Limnotrephes* + *Distotrephes*
    1.1. *Tiphotrephes* + *Limnotrephes*
    1.2. *Distotrephes* (s.str.)
    1.3. *Distotrephes* (*Polhemotrephes*)
2. *Idiotrephes* + *Nanotrephes*

(c) Groups formed by similarities of the aedeagus (supposing that the plesiomorphic state is the aedeagus with short phallosoma, with round distal part, and of a "pleid-like" type; compare ESAKI & CHINA 1928, ZETTEL 1999, PAPÁČEK & ZETTEL 2000, and the present paper).

1. *Nanotrephes*
2. *Limnotrephes* + *Tiphotrephes* + *Distotrephes*
    2.1. *Limnotrephes* + *Tiphotrephes*
    2.2. *Distotrephes*
3. *Idiotrephes*

All of the three above simple combinations share an important characteristic: the group combining *Limnotrephes* + *Tiphotrephes*. The opinion of the close similarity of both genera is also supported by their similar distribution in India and Southeast Asia (see ESAKI & CHINA 1928, and unpublished data).

The genus *Distotrephes* is distinctly defined and separated from other South Asian genera, but its two subgenera are relatively distant from each other.

Nanotrephes gen.n. (distribution: South India) and *Idiotrephes* (distribution: Southeast Asian mainland, Hainan, Sumatra, Borneo) have similar female abdominal sterna 7, but differ distinctly by other characteristics (see Table 1 and the combinations of generic groups, above), and, therefore, *Nanotrephes* gen.n. is a well-defined genus.

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