A revision of the world species of the genus *Neotelmatoscopopus* Tonnoir (Diptera: Psychodidae)

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Abstract. The moth-fly genus Neotelmatoscopus Tonnoir (Diptera: Psychodidae) has been revised to include 13 species. Three new species are described: N. aurulentus sp.n. from northern Thailand, and N. acutus sp.n. and N. rotundus sp.n. from Sri Lanka. Previously unknown life stages of N. horai Tonnoir and N. inachus Quate are described, and redescriptions of larvae, pupae and adults of N. horai, N. indicus (Feuerborn), N. bifidens Quate and N. inachus are given. Five described species are transferred from Telmatoscopus Eaton to Neotelmatoscopus: N. longiceps (Quate), N. digitoides (Quate), N. sagittalis (Quate), N. parsilobus (Quate) and N. canlaonis (Quate). Keys to instar IV larvae, pupae and adults of all known species of Neotelmatoscopus and a phylogenetic analysis of Neotelmatoscopus are provided.

Introduction

The Psychodidae (moth flies), with nearly 2900 species, are among the most taxonomically diverse families of Diptera. Most existing classifications of Psychodidae recognize six subfamilies: Phlebotominae, Bruchomyiinae, Sycoracinae, Trichomyiinae, Horaiellinae and Psychodinae; however, classification of the family is still strongly contested. Although somewhat unexpected of a weak-flying insect, psychodids have invaded a range of niches from wastewater drains and sewage treatment filters to torrential montane streams. Owing to their frequent abundance in these habitats, moth flies play important roles in nutrient cycling and as a source of nutrients (Duckhouse, 2004). Furthermore, certain psychid species in the subfamily Phlebotominae can be important vectors of human disease.

Psychodid adults are small, densely-haired nematocerous flies, whose flight is short and erratic. Wings of most species are characterized by branched, longitudinal veins; crossveins are almost absent and restricted to the basal half of the wing. Many moth flies in the subfamily Psychodinae hold their wings horizontally over the abdomen when at rest, giving the superficial appearance of small moths; hence, the common name. The behaviour and feeding habits of most Psychodidae remains largely unknown because of a paucity of ecological studies (Lloyd, 1937; Masteller & Wagner, 1984).

Psychodid larvae are extremely diverse in morphology, but all species are eucephalic with ten distinct trunk segments (three thoracic and six abdominal segments, and a complex anal division). In most subfamilies (excluding Sycoracinae and Trichomyiinae), perhaps the most striking larval character state is the subdivision of thoracic and abdominal segments (annulated trunk).

Larval habitat also varies greatly among the Psychodidae. In the subfamilies Phlebotominae, Bruchomyiinae and Trichomyiinae, larvae are fully terrestrial but remain closely associated with moisture. In contrast, larvae of the subfamilies Sycoracinae, Horaiellinae and Psychodinae are usually aquatic, semi-aquatic or marginal in habitat. Furthermore, the latter subfamilies include some genera whose larvae bear unique adaptations (e.g. ventral friction pads) for life in fast-flowing streams.

Pupae of all Psychodidae are (more or less) uniform in shape, making distinctions at the species- or even genus-level difficult (Wagner, 2000). Some groups, however, exhibit sufficient characters for distinguishing species (i.e. rheophilic genera) because they are modified from the typical psychid pupa to a form more like that of the Blephariceridae. The Oriental psychid fauna contains at least one group that ranks among the most highly specialized of these rheophilic flies: Neotelmatoscopus Tonnoir.

Neotelmatoscopus is common in mountain streams, where the immature stages frequent the splash-zones of waterfalls and wetted margins of emergent rocks. Despite its peculiarity and distinctness, Neotelmatoscopus has been the subject of few systematic investigations. In particular, a poor generic diagnosis and a lack of complete descriptions of all...
known species have sparked a debate about the placement of *Neotelmatoscopus* within the Psychodinae. Thus Feuerborn (1932) discussed a possible relationship between the genus *Maruina* Müller, whose larvae possess ventral friction pads, and several superficially similar specimens that he collected from Java. This new Javanese species was placed in the genus *Maruina* based on the larval ventral friction pads. Subsequently, Tonnoir (1933) described *Neotelmatoscopus* as a subgenus of *Telmatoscopus* Eaton that includes rheophilic larvae having six ventral friction pads. A new Indo-Malayan species, *Telmatoscopus* (*Neotelmatoscopus*) *horai* Tonnoir was selected as the type species. In the same paper, Tonnoir suggested a congeneric relationship between *Maruina indica* Feuerborn and *T. (N.) horai*, thus placing *M. indica* in *T. (Neotelmatoscopus)* and dismissing Feuerborn’s suggested relationship between *Maruina* and *T. (Neotelmatoscopus)*. Tonnoir noted also the existence of another species in the same location as *T. (N.) horai*, one that was apparently intermediate in character between *T. (N.) horai* and *T. (N.) indicus*. However, only larval specimens were collected and the species was not described.

Quate (1962) described the Borneo species *T. (N.) inachus* subsequently from several larvae and a single male imago dissected from a pupa. No description was provided of the adult female, and a larva was designated as the holotype. Quate noted that there were no subgeneric characters separating *Neotelmatoscopus* adults from other subgenera of *Telmatoscopus*. After his work with *T. inachus*, Quate (1965) described *T. (N.) bifidens* from Philippine adults collected on rocks in a torrential mountain stream. Larvae and pupae were collected, although attempts at rearing the pupae failed, and these life stages were not associated with adults.

*Neotelmatoscopus* was subsequently raised to genus level by Duckhouse (1966) on the basis of ‘antennal characteristics in the male and the genitalic structure of both sexes’. Duckhouse included *N. horai*, *N. indicus* and *N. inachus* in the new genus, but did not add *N. bifidens* until later (Duckhouse, 1973). Further, he rekindled Feuerborn’s idea that certain larval characters suggest a close association between *Neotelmatoscopus* and *Maruina*. Since Duckhouse (1973), only one species of *Neotelmatoscopus*, *N. ctenophorus* Ilango (1994), has been described. A regional catalogue of Psychodidae (Duckhouse, 1973) describes *Neotelmatoscopus* as restricted to the Oriental region, being recorded only from the Philippines, Indonesia and India. Recent collections have shown *Neotelmatoscopus* to be present also in Thailand, Nepal, Malaysia and Sri Lanka. Thorough descriptions of all life stages have not been completed for any species and no phylogenetic studies on *Neotelmatoscopus* exist. The classification of *Neotelmatoscopus* has been confounded further by the lack of agreement on its tribal placement, as well as the controversy about the relationships and composition of all psychodine tribes. *Neotelmatoscopus* has been placed by various authors in the tribes Paramormiini and Telmatoscopini, although sometimes based on weak or unjustified characters, and often without even a clear delineation of what these tribes represent.

Paramormiini was proposed as a subtribe by Enderlein (1937) and raised to tribe by Jezek (1984) based on an inadequate description of wing venation characters. *Telmatoscopus* s. lat. was included, but *Neotelmatoscopus* was not recognized in this diagnosis. Wagner (1990, 2000) did not recognize the tribe Paramormiini, but used an earlier classification of the tribe Telmatoscopini (sensu Vaillant, 1973, 1990); however, the constituent genera of the Telmatoscopini (sensu Vaillant) are now divided among the Paramormiini, Mormini and Psychodini (sensu Duckhouse, 1987). A general diagnosis of Paramormiine adults based on few characters of the male head, wings and genitalia was provided by Duckhouse (1987), who noted that the wing venation of some *Neotelmatoscopus* species did not fit the diagnosis, yet included the genus in the tribe Paramormiini. This arrangement was followed by Ilango (1994), who provided no character basis. Unfortunately, larval and pupal characters of Paramormiine genera have yet to be discussed.

This paper provides a systematic review of *Neotelmatoscopus*, including a re-description of the genus, descriptions of one new species from northern Thailand and two new species from Sri Lanka, and, where possible, complete descriptions of all life stages (larval instars I–IV, pupae, adult male and female) of all known species. Five Philippine species of the genus *Telmatoscopus* are transferred to *Neotelmatoscopus*. Dichotomous keys to all known life stages of the world species of *Neotelmatoscopus* are provided. A revised diagnosis of Paramormiini is given. Phylogenetic analyses of species within *Neotelmatoscopus* and generic relationships within Paramormiini are discussed.

### Materials and methods

#### Study area

This project focused on specimens collected from Nepal, Sri Lanka and Thailand, the latter providing the bulk of examined material (Fig. 18). The study area in Thailand focused on mountain streams in provinces north and west of approximately 17°N and 102°E, respectively. Many specimens of *Neotelmatoscopus* were collected during general surveys of these streams, as well as from several sites selected for intensive sampling and nearly continuous monitoring with Malaise/emergence traps.

#### Material

This research is based on an examination of all known species of the genus *Neotelmatoscopus*. Most specimens were collected between 1993 and 2004 by Malaise trap, mercury vapour light, black light and benthic sampling. Association of pupae with adults mainly was by rearing pupae individually to emergence (Courtney, 1998). Pupa–adult associations were made using the ontogenetic method (Hogue & Bedoya-Ortiz, 1989), which involved dissection of pharate adults from mature pupae. All other associations remain
somewhat tenuous being based on specimens collected from the same microhabitat (e.g. a particular larva and pupa – seemingly conspecific – may be collected from one rock in a stream, while those of a different species may be collected from a different rock in the same general area).

Additional specimens were borrowed from, or are deposited with, the following (acronyms used throughout the text): ISIC, Iowa State Insect Collection, Iowa State University, Ames, Iowa, United States; UTK, The University of Tennessee, Department of Entomology and Plant Pathology, Knoxville, Tennessee, United States; BMNH, The Natural History Museum, London, United Kingdom; BPBM, Bernice P. Bishop Museum, Honolulu, Hawaii, United States; CMU, Chiang Mai University, Department of Biology, Chiang Mai, Thailand; DATH, National Insect Collection, Department of Agriculture, Bangkok, Thailand; KUEN, Kasetsart University, Department of Entomology, Bangkok, Thailand; QSFG, Queen Sirikit Botanic Garden, Mae Rim, Chiang Mai, Thailand; PZ, the private collection of Dr. P. Zwick, courtesy of Dr. R. Wagner, Schwarzer Stock 9, 36110, Schlitz, Germany; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Specimen preparation

Field-collected and laboratory-reared specimens were fixed in 70 or 95% EtOH. Morphological studies were based on slide-mounted specimens and scanning electron microscopy (SEM). Slides were prepared using cedarwood oil to clear specimens and Canada balsam as a mounting medium. Specimens were observed using an Olympus SZX-12 dissecting microscope (Olympus America Inc., Center Valley, PA) and a Nikon E800 compound microscope (Nikon Instruments Inc., Melville, NY), both fitted with an optical micrometer. Drawings were rendered with the aid of a drawing tube on the Nikon system. Photomicrographs are composites of images captured using a SPOT RT® Color digital camera and Adobe Photoshop® 7.0. Composite images were created using Helicon Focus® 3.10. Material for SEM examination was critical point dried and sputter-coated with gold-palladium. SEM images were captured digitally on a JEOL JSM5800LV microscope.

Terminology

Descriptions of adult morphology follow mainly Merz & Haenni (2000) as well as papers on Psychodidae (Hogue 1973, 1990; Quate & Brown, 2004). Terminology of the male terminalia is that of Sinclair (2000) and Wagner (2000). General female postabdomen terminology follows Kotrba (2000) and Quate & Brown (2004); however, the complex structure and function of the female genitalia in Psychodini- nae remains poorly understood relative to that of other subfamilies (e.g. Phlebotominae). True spermathecae are absent in female Psychodinae, but some authors (Hogue, 1973; Ilango, 1994) have described the genital ducts (i.e. paired, ovoid components of the oviduct) as spermathecae. Furthermore, Hogue (1973) and Quate & Brown (2004) have referred to the components of the oviduct collectively as the ‘spermathecal complex’, although we refrain from using this term because it implies the presence of spermathecae. General larval terminology is that of Courtney et al. (2000); placement of tergal plates was adapted from Vaillant (1963) and Hogue (1973); and shape of the alveolar integument was adapted from Hogue (1973). Pupal terminology follows Hogue (1973), except pupal respiratory horn morphology, which follows the general terminology used by Tonnoir (1933) and Quate (1955).

Hogue (1973) used a larval chaetotaxy system for Maruina based on Feuerborn (1927) and Vaillant (1963), noting that this system is useful only for Maruina, as the chaetotaxy of other psychodid larvae has yet to be homologized. For this reason, a detailed study of the chaetotaxy for Neotelmatoscopus was not attempted in the current study; however, certain terms used for specific setae in Maruina (e.g. mouthpart chaetotaxy) can be transferred to Neotelmatoscopus with confidence that they apply to homologous structures in all psychodids.

Descriptive format

Diagnoses are provided for all species. Complete descriptions of adult male and female, pupa and larval instars I–IV are provided for new species, where specimens are available. Previously unknown life stages for described species are described, and revised descriptions of known life stages for described species are given, where appropriate. When applicable, sample sizes are provided before each description with measurements in millimeters presented as a mean followed by a range in parentheses. Adult head width was measured at the point of greatest width of the eyes. Adult head length was measured from the vertex to the anterior margin of the clypeus. Palpal ratios were computed as proportions, considering the basal palpomere as one. Wing length and width were measured at the points of greatest length and width, respectively. Measurements were not taken for pharate adults. Unless otherwise noted, larval characters refer to instar IV. Larval head capsule width was measured at the point of greatest width. Total length of larvae was measured from the anterior-most point of the head capsule to the posterior most point of the anal division, excluding the respiratory fans. Comparisons of larval size (i.e. in the remarks for various species) are based on the relative total lengths of different Neotelmatoscopus species, with species such as N. bifidens (total length = 3.28 mm) considered large, and species such as N. acutus (total length = 2.15 mm) considered small. Length and width of pupae were measured at the points of greatest length and width, respectively. All known pupae of Neotelmatoscopus species exhibit some degree of dorsoventral compression. A pupa whose width is less than or equal to 2.5 times its height is considered
moderately compressed, while a pupa whose width is greater than 2.5 times its height is considered strongly compressed.

Abbreviations for life stages: L = Larva; P = Pupa; Pex = Pupal exuviae; A = Adult. Abbreviations for label and locality information include the following: E = East; Kh = Kholo (stream); N = North; NP = National Park; NT = Namtok (waterfall); Rd = Road; S = South; trib = tributary of; W = West.

**Phylogenetic analysis**

Phylogenetic relationships were evaluated according to cladistic principles [sensu Hennig (1966), as modified by Wiley (1981), Schuh (2000) and others]. Selection of outgroup taxa was confounded by the inadequately resolved phylogenetic relationships among psychodine genera; however, several outgroups were chosen on the basis of morphological similarity to *Neotelmatoscopus*. Outgroup generic characters were determined by examining specimens, where available, and from the most recent generic re-descriptions (Hogue, 1973 for *Maruina*, Vaillant 1971–1983 and Duckhouse, 1987 for other genera).

Thirty-three characters and 18 taxa were evaluated (Supporting information S1). Of the characters, 24 were adult characters, four pupal characters and five larval characters (Supporting information S2). Unclear, continuous and autapomorphic characters were excluded. Cladistic analyses were performed using PAUP 4.0b10 (Swofford, 2002) and character transformations viewed in MACCLADE 4.05 (Maddison & Maddison, 2002). PAUP analyses consisted of a branch and bound search with all characters weighted equally. Multistate characters were considered as unordered. Bootstrap values were calculated for 500 replicates.

**Tribe Paramormiini Enderlein**

Paramormiini Enderlein, 1937: 96 [as subtribe]
Telmatoscorpini Vaillant, 1971: 37 [in part]

**Diagnosis.** Larva. Typical Psychodine form, head capsule ovoid (or with genae extended to lobes in some *Neotelmatoscopus*). No reduction of abdominal segments, each abdominal segment with a tergal plate on each annulus (except some *Neotelmatoscopus*: abdominal segment I reduced, abdominal segment II–VII with two tergal plates). Trunk with prominent setae or lacking setae, never with accessory setae or cuticular projections. Some species with six circular ventral friction pads (*Neotelmatoscopus*). Anal division of most species about as long as wide, or in some species, elongated, tubular (e.g. *Peripsychoda*).

Pupa. Typical nematoceran form, dorsoventrally compressed in some species of *Neotelmatoscopus*; with few setae or cuticular projections; respiratory horn club-like, not more than four times longer than wide, pores paired, arranged in longitudinal rows on dorsal surface.

Male. Head usually rounded in frontal view; eye bridge contiguous or divided by a width of ≤5 facet diameters; frontal hair patch divided or undivided; antenna with scape one to four times as long as wide, flagellomeres strongly nodiform, terminal three never fused; ascoids paired or numerous on each flagellomere, digitiform or multi-branched, never Y-shaped. Wings ovate or lanceolate, held horizontally over the body, nearly always lacking vestiture (except few species of *Panimerus* Eaton and *Elsahowia* Duckhouse); apex of Sc vein at or beyond base of Rs, or joining with R1 vein (e.g. *Neotelmatoscopus*). Hypopygium with gonocoxites stout, kidney-shaped or narrow, cylindrical; gonocoxal apodemes never forming ball and socket articulation with aedeagal apodeme; gonostyli simple or bifurcate, rami of equal or unequal length; aedeagus nearly always symmetrical (except few species of *Telmatoscopus*), consisting of basiphallus and distiphallus; cercopodia of equal length to or longer than gonopods, straight or curved, with multiple retinacul.

Female. Head and wing similar to male. Terminalia with hypovalvae distinctly bilobed; cerci one to four times as long as basal height, never semi-circular from lateral view, heavily sclerotized (e.g. *Telmatoscopus*) or nearly membranous (e.g. *Neotelmatoscopus*).

**Key to species of Neotelmatoscopus**

**Instar IV larvae**

Larvae of *N. canlaonis, ctenophorus, digitoides, longiceps, parsilobus* and *sagittalis* are unknown.

1. Anal division (Fig. 1) with three or four rigid macrotrichia inserted along lateral margins of dorsal sclerite (Fig. 4A, B) ................................................................. 2
   – Anal division with rigid macrotrichia absent laterally, lateral margins of dorsal sclerite entire (e.g. Fig. 2A, B) ......................................................................................... 3

2. Anal division with three rigid macrotrichia inserted along lateral margins of dorsal sclerite (Fig. 4A), macrotrichia with apices acute; head capsule with dorsal and lateral vestiture of macrotrichia; prothoracic tergal plate with a row of 18 macrotrichia, each with a basal diameter wider than 1/2 the length of the plate ................................................................. *N. bifidens* (Quate)
   – Anal division with four rigid macrotrichia inserted along lateral margins of dorsal sclerite (Fig. 4B), macrotrichia with apices appearing frayed, not acute; head capsule vestiture alveolar with few setae present; prothoracic tergal plate with few setae, each with a basal diameter far less than 1/2 the length of the plate ................................................ *N. inachus* (Quate)
3. Head capsule with genae extended posterolaterally as prominent lobes (Fig. 15C, D); abdominal segment 2 apparently with pro- and mesotergal plates fused (Fig. 2 A, B) ................................................................. 4

– Head capsule round in shape from dorsal view, genae without prominent posterolateral lobes (Figs 1; 15A); abdominal segment 2 clearly with three tergal plates ......................................................... N. aurulentus sp.n.

4. Deep incision behind the posterolateral lobe of gena, lobe directed posteriorly (Fig. 15C); abdominal segments 2–7 apparently with two tergal plates present on each segment ......................................................... 5

– Incision behind the posterolateral lobe of gena shallow, lobe directed laterally, not posteriorly (Fig. 15D); abdominal segment 2 apparently with two tergal plates, segments 3–7 clearly with the tergal plates (Figs 2A; 15F) ......................................................... N. horai (Tonnoir)

5. Anterior buccal setae brush-like (Fig. 2B), directed anteriorly; dorsal alveolar processes with simple, acute apices; body colour tan .......... N. indicus (Feuerborn)

– Anterior buccal setae fan-shaped (Fig. 3A, B), directed anterolaterally; dorsal alveolar processes rounded (Fig. 16A) or with multiple acute apices (Fig. 16C); body colour brown or black dorsally and brown or tan ventrally ................................. 6

6. Dorsal alveolar processes rounded; body colour black dorsally and tan ventrally .......... N. rotundus sp.n.

– Dorsal alveolar processes with multiple acute apices; body colour brown ..................... N. acutus sp.n.

Pupae

Pupae of N. canlaonis, ctenophorus, digitoides, longiceps, parsilobus and sagittalis are unknown.

1. Lateral margin of each trunk segment bearing one to three fan-shaped setae and many elongate spiniform tubercles (Fig. 8B) ............. N. bifidens (Quate)

– Lateral margin of trunk segments entire, without setae or elongate spiniform tubercles ......................................................... 2

2. Dorsum bearing many stout macrotrichia; surface of respiratory horn wrinkled (Fig. 5) .......... N. aurulentus sp.n.

– Dorsum with only minute setae; surface of respiratory horn pitted, ribbed or rasp-like ......................... 3

3. Body moderately compressed dorsoventrally; surface of respiratory horn ribbed, arranged in convergent longitudinal rows .... N. inachus (Quate)

– Body only slightly compressed dorsoventrally; surface of respiratory horn pitted or rasp-like ......................... 4

4. Genital sclerite bearing two pairs of spines; respiratory horn moderately compressed laterally, with surface pitted laterally and ventrally (Fig. 6B) ................................................................. N. indicus (Feuerborn)

– Genital sclerite without spines; respiratory horn club-like, not compressed, with surface pitted or rasp-like ......................................................... 5

5. Respiratory horn with surface comprised of numerous imbricate scales whose borders form distally directed ridges, appearing rasp-like (Fig. 6A) ................................................................. N. horai Tonnoir

– Respiratory horn surface without imbricate scales, pitted, not rasp-like ......................................................... 6

6. Respiratory horn with surface smooth dorsally, pitted laterally and ventrally; paired row of pores as wide as horn (Fig. 7A) ......................... N. acutus sp.n.

– Respiratory horn with surface pitted, pits sparse dorsally; paired row of pores not as wide as horn (Fig. 7B) ......................................................... N. rotundus sp.n.

Adult males

Adult males of N. canlaonis and N. parsilobus are unknown.

1. Gonostyli bifurcate (Figs 10B, 13F) ....................... 2

– Gonostyli simple (Fig. 9D, G) ................................. 9

2. Gonostyli with rami subequal in length (Fig. 10G) ......................................................... 3

– Gonostyli with rami unequal in length (Figs 10B, 11D) ................................................................. 5

3. Retinacula 7–8, with apices bifurcate (Fig. 10G) ................................................................. N. horai Tonnoir

– Retinacula more than eight, with apices simple, appearing frayed ......................................................... 4

4. Retinacula 15; cercopodia with distal halves curved dorsally approximately 90° (Fig. 13B); sclerites of distiphallus appearing fleshy (Fig. 13C) ................................................................. N. longiceps (Quate)

– Retinacula more than 15; cercopodia with distal halves straight (Fig. 13G); sclerites of distiphallus filamentous (Fig. 13F) ......................................................... N. digitoides (Quate)

5. Gonostyli with lateral rami short, stub-like, directed laterally; cercopodia with distal halves curved dorsally approximately 90°; retinacula 4 (Fig. 10B) ......................................................... N. indicus (Feuerborn)

– Gonostyli with lateral rami about 1/2 the length of medial rami, directed apically; cercopodia straight, or with apical 1/3 curved dorsally approximately 45° ......................................................... 6

6. Cercopodia with apical 1/3 curved dorsally approximately 45° (Fig. 48); retinacula 6, with apices simple; sclerites of distiphallus bearing numerous spicules (Fig. 12B) ......................................................... N. bifidens Quate

– Cercopodia straight; retinacula with apices bifurcate; distiphallus without spines ......................................................... 7

7. Retinacula 15; tergite 10 constricted apically, digitiform (Fig. 11F) ......................................................... N. acutus sp.n.

– Retinacula fewer than 15; tergite 10 triangular in shape (Fig. 11K) ......................................................... 8

8. Retinacula 5–6 .................. N. ctenophorus Ilango

– Retinacula 9 ................................. N. rotundus sp.n.

9. Retinacula 18, with apices bifurcate .... N. inachus Quate

– Retinacula fewer than 18, with apices simple .... 10

10. Retinacula 8 .................. N. aurulentus sp.n.

– Retinacula 4 ................................. N. sagittalis (Quate)
Adult females

Adult females of *N. aurulentus, N. digitoides, N. longiceps, N. rotundus* and *N. sagittalis* are unknown.

1. Subgenital plate with posteromedial knob-like process (Fig. 10F) ......................................................... 2
   - Subgenital plate smoothly rounded, or with slight posteromedial bulge, not developed into knob-like process ................................................................. 4
2. Frontal scar patch quadrangular, not divided medially; hypovalvae bi-lobed ................... *N. horai* Tonnoir
   - Frontal scar patch divided medially; hypovalvae bi-lobed or with single lobe .................... 3
3. Frontal scar patch forming pair of quadrangular patches; hypovalvae with single lobe ...... *N. acutus* sp.n.
   - Frontal scar patch forming pair of sub-circular patches; hypovalvae bi-lobed .......... *N. ctenophorus* Ilango
4. Wing lanceolate (Figs 12D, 14I), at least three times longer than wide ....................... 5
   - Wing ovate, no more than 2.5 times longer than wide .................................................. 6
5. Wing about three times longer than wide; frontal scar patch not divided medially; hypovalvae reduced, wider than long (Fig. 12G) ......................... *N. bifidens* Quate
   - Wing about 3.5 times longer than wide; frontal scar patch divided medially (Fig. 14G); hypovalvae about as long as wide, constricted basally (Fig. 14F) ......................... *N. canlaonis* (Quate)
6. Hypovalvae with lobes digitiform, directed laterally (Fig. 14B) ............................. *N. parsilobus* (Quate)
   - Hypovalvae with lobes rounded, directed posterolaterally ............................................. 7
7. Subgenital plate with posteromedial bulge (Fig. 10D) ........................................ *N. indicus* (Feuerborn)
   - Subgenital plate rounded posteromedially, without bulge ........................................... *N. inachus* Quate

*Neotelmatoscopus* Tonnoir 1933


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**Fig. 1.** *Neotelmatoscopus aurulentus* n. sp. Thorax, abdominal segments I, II, VI, VII and anal division of larva, dorsal (left) and ventral (right) view. Scale bar = 0.5 mm. (abbreviations: P = pro-thorax; M = mesothorax; T = metathorax; AD = anal division).

**Fig. 2.** (A) *Neotelmatoscopus horai* Tonnoir; (B) *N. indicus* (Feuerborn). (A) Thorax, abdominal segments I, II, VI, VII and anal division of larva, dorsal (left) and ventral (right) view; (B) thorax, abdominal segments I, II, VI, VII and anal division of larva, dorsal (left) and ventral (right) view. Scale bars = 0.5 mm.
Diagnosis. Larva. Dorsoventrally compressed. Ventral surface of abdominal segments II–VII each with an independent circular friction pad. Pro- and mesothoracic segments reduced, each bearing a single divided tergal plate; abdominal segment I reduced, bearing a single undivided tergal plate. Trunk with 25 annuli; abdominal segment VII with only two annuli. Posterior annulus of segments II–VI constricted posteriorly, creating deep lateral incisions between segments. Pupa. Onisciform (convex dorsally, flat ventrally). Integument more heavily sclerotized dorsally than ventrally; macrotrichia and microtrichia absent from venter. Adult. Eye bridge contiguous with four facet rows. Antenna 16-segmented, flagellomeres with nodes strongly bulbous, internodes (connected basal and apical necks) not longer than preceding node. Ascoids two to five branched, inserted distally on the node of flagellomeres 3–16; flagellomeres gradually decreasing in length and width, terminal three not diminutive. Mouthparts reduced; labellum bulbous, without blunt apical teeth. Wing with Sc vein ending in or approaching R₁. Tarsomere 5 with anteromedial lip extending apically between tarsal claws. Male terminalia with gonocoxites stout, kidney-shaped; aedeagus sheathed, symmetrical with basal sclerite Y-shaped. Female cerci triangular in shape from lateral aspect, slightly longer than tall, their inner (medial) surface with a dense vestiture of setae, setulae and microtrichia.

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Description. Larva. Body typically 2 to 3.5 mm long, dorsoventrally compressed; trunk parallel-sided or tapering in width from anterior to posterior. Integument alveolar; each alveolus with a dark central process varying in shape from flat to conical or spiniform, alveoli more abundant dorsally than ventrally. Pigmentation generally light brown to black. Eucephalic. Head capsule varying in shape; genae often with prominent posterolateral lobes, sometimes rounded posterolaterally. Antennal shaft absent; antenna represented anterolaterally on genae by circular protuberance bearing three stout trichoid sensilla, two elongate microtrichia and several short, cup-shaped sensilla. Mouthparts projecting through a circular anteroventral orifice. Labrum with four longitudinal rows of posterovertrally curved, setiform or brush-like macrotrichia bordered anteriorly by two longitudinal rows of setiform microtrichia that vary in size. Mandible broad basally, constricted medially and expanded apically into several posteriorly directed comb-like teeth. Mandibular comb fan-shaped, obscuring mandibular teeth when mandible is retracted. Prostheca on medial margin of mandible, basad to mandibular comb, comprising tuft of setiform macrotrichia or single feather-like macrotrichium. Maxilla with endites fused; posteromediae lateral (lacinial) region with many transverse rows of comb-shaped setae arranged in a ribbed pattern. Maxillary palpus on small, subcircular prominence with numerous apical setiform and bulbous sensilla, bordered posteriorly by a fringe of microtrichia. Postmentum with two teeth placed anterolaterally and separated by a medial fringe of brush-shaped microtrichia. Trunk divided into 25 annuli as follows: thoracic segments and abdominal segment I each with two annuli, abdominal segments II–VI each with three annuli and segment VII with two annuli. Transverse tergal plates on all trunk segments with general arrangement as follows: posterior annulus of prothorax with mesally divided metatergal plate; anterior annulus of mesothorax with mesally divided mesotergal plate; anterior annulus of metathorax with undivided mesotergal plate, posterior annulus of metathorax with undivided metatergal plate. All tergal plates on abdomen undivided mesally; posterior annulus of abdominal segment I with metatergal plate; anterior, mesal and posterior annuli of abdominal segments II–VI with pro-, meso- and metatergal plates, respectively; anterior annulus of abdominal segment VII with pro- and mesotergal plates, posterior annulus of segment VII with metatergal plate. Protergal plate on abdominal segment II (or segments II–VI, depending on the species) sometimes fused with mesotergal plate giving the appearance of only two tergal plates present on each segment. Thoracic and abdominal segments with series of intersegmental and/or intersegmental platelets arranged in transverse rows between thoracic annuli, between thoracic segments and between abdominal segments; number and size of platelets varying among species. Abdominal segment I with a cluster of three to four dorsolateral platelets placed laterally to the metatergal plate. Abdominal segments II–VII each with series of dorsolateral platelets arranged as follows: a cluster

Fig. 6. (A) Neotelmatoxus horai Ton-noir; (B) N. indicus (Feuerborn). (A) Left half of pupa, dorsal view (left) and enlargement of respiratory horn (right); (B) left half of pupa, dorsal view (left) and enlargement of respiratory horn (right). Scale bars = 1 mm.
placed anterolaterally to lateral margin of mesotergal plate (or the associated position in those species in which the pro- and mesotergal plates are fused), comprised of one ovate platelet surrounded or bordered posteriorly by many relatively smaller platelets; in some species, this cluster is apparently fused into one plate. A second cluster placed in a sulcus lateral to meso and metatergal plates, comprised of four to ten platelets of varying shape, size and arrangement, none distinctly smaller or larger than the others. Sterna of abdominal segments 2–7 each with an independent circular friction pad. Friction pads simple, not hydraulic suckers as in the Blephariceridae; comprised of a central cluster of platelets encircled by a fringe of setiform cuticular projections with apices expanded, brush-like and intertwined creating a seemingly contiguous disc. Amphipneustic. Anterior spiracles dorsolateral on the anterior annulus of the mesothorax; some species with spiracle at apex of protruding stub. Posterior spiracles housed within anal division. Anal papillae with eight digitiform appendages radiating from a central stalk.

Pupa. Body ovoid from dorsal view, onisciform to dorsoventrally compressed. Integument with round tubercles sparse or abundant; tubercles protruding only slightly from surface. Heavily sclerotized dorsally, lightly sclerotized to membranous ventrally. Dorsal surface and lateral margins with numerous macrotrichia and/or microtrichia. Ventral surface without macrotrichia and microtrichia. Dorsolateral surface of tergites with minute to elongate spiniform tubercles. Respiratory horn typical of Psychodinae; erect, projecting posterolaterally; integument varying in structure.

Adult male. Head strongly rounded to slightly ovoid from anterior aspect. Vertex rounded or extending slightly posteriorly. Frontal scar patch quadrangular, constricted medially or divided into two subcircular patches; never extending posteriorly at median. Anterior margin of clypeus hemispherical or bilobed. Eyebridge with four rows of facets, contiguous at median. Palpi typical of Psychodinae; first palpomere never more than 0.5× the length of second palpomere, distal 3 palpomeres subequal or increasing in length; medial surface of palpomeres with numerous erect setiform sensilla directed medially, palpomere 4 with one setiform sensillum apically. Antenna 16-segmented; scape constricted basally, barrel-shaped, 1.5–2× the length of pedicel; pedicel globular; flagellomeres 3–15 nodiform, gradually decreasing in length and width; nodes strongly bulbous, as wide as scape and pedicel; internodes (connected basal and distal necks) subequal in length to preceding node. Flagellomeres 3–16 with 12 or more two to five branched ascods encircling nodes distally. Terminal flagellomere with finger-like preapical process covered in microtrichia. Mouthparts extending slightly beyond palpomere 1; labellose bulbous, bearing numerous setiform macrotrichia of varying length. Body with vestiture typical of Psychodinae; dense patches of spatulate hairs. Wings held horizontally over body in life; varying in shape from ovate to lanceolate; veins R₅ and CuA₁ basally wider and with darker pigmentation than adjacent veins, vein Sc approaching or ending in
Terminalia with tergites IX and X fused, forming a basal wing with identical venation, but often larger than in males. Legs as in male.

Vein R₁. Legs relatively long, slender with femora constricted basally and apically, tibia constricted basally; tibial spurs absent; tarsomere 5 in most species with anteromedial lip extending between tarsal claws, giving the appearance of claws being recessed into tarsomere. Terminalia with the posterior margin of hypandrium (sternite IX) arched, situated visor-like over a gonocoxyte base; epandrium (tergite IX) short, subequal in length to gonocoxytes. Aedeagus symmetrical; basiphallus consisting of a single Y-shaped sclerite that is elongate, extending anteriorly into the abdomen to the level of tergite VI, or short, not extending beyond tergite VIII; distiphallus often reduced, or with sclerites paired, narrow and filamentous or stout, sometimes bearing spicules. Parameres extending posteriorly from gonocoxyte apodeme; fused dorsally and ventrally forming a sheath around aedeagus; sheath varying in length and width. Gonocoxytes stout, kidney-shaped; appearing contourous anteriadorsally by a narrow bridge; vestiture of spatulate hairs dense basally, absent ventrally. Gonocoxites stout, kidney-shaped; appearing contiguous basally and apically, tibia constricted basally; tibial vein R₁; gonostyli bifurcate, rami of equal length; cercopodia variable in shape; typically subequal in length to gonopods; tapered, curved dorsal or constricted apically; with 4–18 retinacula inserted dorsiopically, varying in length among species, with apices generally simple or bifurcate.

Adult female. Head nearly identical to male; antennae with only one or two ascoids inserted distally on the node of flagellomeres 3–16; nodes of flagellomeres 3–16 noticeably narrow compared with scape and pedicel. Legs as in male. Wing with identical venation, but often larger than in males. Terminalia with tergites IX and X fused, forming a basal collar around cerci. Cerci triangular in shape from lateral aspect, slightly longer than tall, not elongate or arched dorsally; with dense vestiture of macrotrichia and microtrichia on medial surface; sparse vestiture of microtrichia on lateral surface. Subgenital plate (hypogynium) often medially convex or protruding posteroventrally to form a knob-like process. Hypovalvae varying in shape, generally bilobed with dense vestiture of microtrichia dorsally and ventrally; 6–10 elongate macrotrichia inserted along posterior margin, directed posteriorly. Oviduct with genital ducts ovoid to sub-circular, often appearing sculptured laterally, usually with an apparent ribbed or reticulated pattern ventrally; longitudinal and lateral struts uniform among species, appearing as simple bands, less than half as wide as genital ducts, arranged longitudinally and transversely (respectively) on each genital duct.

Remarks. Larvae are drastically modified from the typical form of Psychodinae and are easily distinguished by the presence of six ventral friction pads. Pupae are modified to a lesser extent, but can be recognized by a flattened venter. A suite of characters from the head and terminalia will separate adults of both sexes from similar genera (e.g. *Paramormia* and *Telmatoscopus*). All life stages are also remarkable for their association with madicolous and splash-zone habitats around torrential streams, although adults are not restricted to these habitats.

*Neotelmatoscopus horai* (Tonnoir)  
[Figs 2A; 6A; 10(F–J); 15D, F; 16D; 17; 18]

*Telmatoscopus* (*Neotelmatoscopus*) *horai* Tonnoir 1933: 65 [original description].


**Diagnosis.** Larva. Head capsule with genae extended posterolaterally into prominent rounded lobes; genal lobes not directed posteriorly; integument light brown in colour; lateral alveolar processes conical or undeveloped; abdominal segment I with protorgal plate apparently divided and fused to mesotergal plate; dorsal sclerite of anal division with setae absent laterally. Pupa. Moderately dorsoventrally compressed; dorsum with only setulae; respiratory horn with integument appearing rasp-like, comprised of many imbricate sclerites. Male. Frontal scar patch quadrangular, undivided medially; wing strongly ovate, vein Sc ending in vein R₁; gonostyli bifurcate, rami of equal length; cercopodia constricted distally, with 7–8 retinacula having bifurcate apices. Female. Subgenital plate with posteroomedial knob-like process extending ventrally; genital ducts ovoid, with reticulated pattern ventrally, not appearing sculptured laterally.

**Description.** Larva (Figs 2A;15D, F; 16D). Measurements, instar I (N = 3) total length 0.51 mm (0.50–0.52), cranial width (0.10) mm; instar II (N = 1) total length 0.72 mm, cranial width 0.18 mm; instar III (N = 5) total length 1.49 mm (1.35–1.55), cranial width 0.30 mm; instar IV

![Fig. 8. (A, B) Neotelmatoscopus bifidens Quate; (C) *N. inachus* Quate. (A) left half of mesoscutum with respiratory horn, dorsal view; (B) abdominal tergite V, dorsal view; (C) left half of pupa, dorsal view (left) and enlargement of respiratory horn (right). Scale bars = 0.5 mm (A, B) 1 mm (C).](image_url)
Fig. 9. (A–D) *Neotelmatoscopus aurulentus* n. sp.; (E–I) *N. sagittalis* (Quate). (A) Male head, frontal view; (B) wing; (C) tarsomeres IV and V, lateral view; (D) male terminalia, medial (left) and lateral (right) view; (E) wing; (F) male head, frontal view; (G) male terminalia, epandrium removed, dorsal (left), and ventral (right) view; (H) tarsomeres IV and V, dorsal (left) and lateral (right) view; (I) cercopod. Scale bars = 1.0 mm (B, E) 0.3 mm (A, F) 0.1 mm (C, D, G–I).
Fig. 10. (A–E) Neotelmatoscopus indicus (Feuerborn); (F–J) N. horai Tonnoir. (A) Male head, frontal view. (B) Male terminalia, lateral (left) and medial (right) view. (C) Wing; (D) Female terminalia, lateral view; (E) Tarsomeres IV and V, lateral view; (F) Female terminalia, lateral view; (G) Male terminalia, posterolateral view; (H) Male head, frontal view; (I) Tarsomeres IV and V, ventral view; (J) Wing. Scale bars = 1.0 mm (C, J) 0.5 mm (A, H) 0.1 mm (B, D–G, I).
Fig. 11. (A–E) Neotelmatoscopus ctenophorus Ilango; (F–H) N. acutus sp.n.; (I–K) N. rotundus sp.n. (A) Male head, frontal view. (B) Wing; (C) tarsomeres IV and V, ventrolateral view; (D) male terminalia, epandrium removed, dorsal view; (E) cercopod; (F) male terminalia, right gonocoxite removed, dorsal view (left), right cercopod removed, ventral view (right); (G) male head, frontal view; (H) tarsomeres IV and V, lateral view; (I) male head, frontal view; (J) tarsomeres IV and V, lateral view; (K) male terminalia, right gonocoxite removed, dorsal view (left), left cercopod removed, ventral view (right). Scale bars = 1.0 mm (B), 0.3 mm (A, I) 0.2 mm (G), 0.1 mm (C–F, H, J, K).
(N = 15) total length 2.56 mm (1.95–2.85), cranial width 0.46 mm (0.42–0.50). Trunk tapering in width from anterior to posterior. Integument light brown in colour; alveoli more numerous dorsally than ventrally with central processes shaped as follows: multiple or single acute apices dorsomedially, undeveloped dorsolaterally, conical laterally and spiniform ventrolaterally. Head capsule with genae extended posterolaterally into prominent rounded lobes; genal lobes not directed posteriorly. Abdominal segment II with protergal plate apparently divided mesally and fused to mesotergal plate. Abdominal segments II–VII with two rounded lateral lobes. Chaetotaxy: anterior buccal seta brush-like, directed anteriorly; posterior buccal seta fan-shaped, directed posterolaterally; thoracic and abdominal tergal plates with only setiform microtrichia; dorsal sclerite of anal division with a pair of setiform microtrichia and two pair of brush-like microtrichia placed posterodorsally, arranged symmetrically.

Pupa (Fig. 6A). Measurements, (N = 4) length 2.04 mm (1.85–2.31), width 0.93 mm (0.85–1.00). Body ovoid, moderately dorsoventrally compressed. Integument with tubercles appearing as irregular pattern of dots, more numerous dorsally than ventrally, not longer than their basal diameter; shaped as follows: dorsomedial surface with conical or undeveloped processes; dorsolateral surface with mostly conical, minute processes; lateral surface with conical processes; ventral surface with conical, minute processes. Dorsum with setiform microtrichia on mesoscutum and trunk segments, arranged symmetrically in transverse rows. Respiratory horn covered in numerous imbricate scales, appearing rasp-like; paired row of pores restricted to its distal half, inserted dorsomedially, extending to apex.

Adult male (Fig. 10G–J). Measurements, (N = 1) head width 0.37 mm, head length 0.35 mm, wing length 1.71 mm,
Wing width 0.72 mm, palpomere proportion: 1–1.4–1.4–2.4. Head strongly rounded, vertex extending posteriorly the length of one facet diameter. Frontal scar patch quadrangular, contiguous medially. Anterior clypeal margin bilobed. Antennal flagellomeres onion-shaped, with internodes not constricted basally. Flagellomeres 3–13 with 15 ascoids; 14–15 with two ascoids. Wings ovate, vein Sc ending in vein R1. Terminalia: basiphallus with single Y-shaped sclerite, short, not extending anteriorly beyond tergite VIII; distiphallus apparently trimerous; with sclerites narrow, filamentous. Parameral sheath conical, basally wide, extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami only slightly tapered, digitiform, subequal in length with rounded apices. Cercopodia straight, constricted along their apical 1/3; 7–8 retinacula inserted dorsoapically; apices of retinacula bifurcate.

Adult female (Fig. 10F). Measurements, (N = 2) head width 0.35 mm, head length 0.36 mm (0.35–0.37), wing length 2.25 mm (2.24–2.26), wing width 0.85 mm (0.84–0.86), palpomere proportion: 1–1.4–2.4. Head nearly identical to male; nodes of flagellomeres 3–16 noticeably narrow compared with scape and pedicel, each with two ascoids. Wing width identical venation, but often larger than in males.
Fig. 14. (A–D) Neotelmatoscopus parsilobus (Quate); (E) N. inachus Quate; (F–I) N. canlaonis (Quate). (A) Female head, frontal view. (B) Female terminalia, ventral view; (C) Wing; (D) Tarsomeres IV and V, ventrolateral view; (E) Male terminalia, right gonocoxite removed, dorsal view; (F) Female terminalia, ventral view; (G) Female head, frontal view; (H) Tarsomeres IV and V, ventral view; (I) Wing. Scale bars = 1.0 mm (C, I), 0.3 mm (A, G), 0.1 mm (B, D–F, H).
Terminalia: Cerci not elongate, about 1.5 times longer than tall. Subgenital plate with posteromedial knob-like process extending posteroventrally; hypovalvae with lobes nearly contiguous medially. Oviduct with genital ducts ovoid, not sculptured laterally, with a reticulated pattern ventrally.

Type material. Holotype [adult male]: INDIA: Teesta Bridge, 7.ii.1931 (S. L. Hora). Allotype [adult female]: same data as holotype. Paratypes [larva and pupa?]: same data as holotype. Type series possibly deposited at the Indian National Museum.


Fig. 15. Light micrographs of larval and pupal Neotelmatoscopus. (A) Larval habitus of Neotelmatoscopus aurulentus, dorsal view; (B) larval habitus of N. aurulentus, ventral view; (C) larval head capsule of N. acutus, dorsal view; (D) larval head capsule of N. horai, ventral view; (E) larval habitus of N. rotundus, dorsal view; (F) larval habitus of N. horai, dorsal view; (G) pupal habitus of N. aurulentus, dorsal view. Scale bars: 0.25 mm (A, B, E–G); 0.10 mm (C, D).
similar to adults of \( N. \) ctenophorus, \( N. \) acutus and \( N. \) rotundus but can be distinguished by the retinacula numbering 7–8 and the gonostyli having rami of subequal length in the male, lack of sculpture laterally on the oviducts in the female and the posterior extension of the vertex in both sexes.

**Neotelmatoscopus indicus** (Feuerborn)  
[Figs 2B; 6B; 10(A–E); 17; 18]

*Maruina indica* Feuerborn, 1932: 1 [original description].
*Telmatoscopus* (Neotelmatoscopus) *indicus* (Feuerborn): Tonnoir, 1933: 71 [new combination].

**Diagnosis.** Larva. Head capsule with genae extended posterolaterally into prominent rounded lobes; genal lobes directed posteriorly; anterior buccal setae brush-like, directed anteriorly; integument tan in colour; dorsal alveolar processes with single acute apices, lateral alveolar processes conical or spiniform; abdominal segments II–VII with protergal plate fused to mesotergal plate, so that each segment appears to have two plates; dorsal sclerite of anal division with setae absent laterally. Pupa. Moderately dorsoventrally compressed; dorsum with only setulae; respiratory horn with integument appearing pitted laterally and ventrally, without scale pattern; genital sclerite with paired dorsal and paired ventral spines, the former being hook-shaped. Male. Frontal scar patch quadrangular, undivided medially; wing strongly ovate, vein Sc ending in vein R1; gonostyli bifurcate, rami not of equal length, lateral rami short, stub-like; cercopedia curved dorsal approximately 90°, with 4 spatulate retinacula. Female. Subgenital plate with posteromedial bulge, not elongate; hypovalvae nearly contiguous medially; genital ducts ovoid, with a reticulated pattern ventrally, not appearing sculptured laterally.

**Description.** Larva. (Fig. 2B). Measurements, instar II (*) \( N = 3 \) total length 1.4 mm (1.3–1.5), cranial width 0.3 mm; instar III (*) \( N = 9 \) total length 1.95 mm (1.75–2.25), cranial width 0.40 mm (0.39–0.41); instar IV (*) \( N = 20 \) total length 2.64 mm (2.35–2.95), cranial width 0.46 mm (0.44–0.50). Trunk tapering in width from anterior to posterior. Integument tan in colour; alveoli more numerous dorsally than ventrally, with central processes shaped as follows: single acute apices dorsomedially, conical or undeveloped dorsolaterally, conical or spiniform laterally and spiniform ventrolaterally. Head capsule with genae extended posterolaterally into prominent rounded lobes; genal lobes directed posteriorly. Abdominal segments II–VII with pro- and mesotergal plates fused, appearing as two plates per segment. Abdominal segments II–VII each with two rounded lateral lobes. Chaetotaxy: anterior buccal seta brush-like, directed anteriorly; posterior buccal seta fan-shaped, directed posterolaterally; thoracic and abdominal tergal plates bearing only setiform microtrichia; dorsal sclerite of anal division with a pair of brush-like microtrichia.
and two pair of setiform microtrichia placed posterodorsally, arranged symmetrically.

Pupa (Fig. 6B). Measurements, \((N = 1)\) length (1.96) mm, width (0.75) mm. Body ovoid, moderately dorsoventrally compressed. Genital sclerite with paired dorsal and paired ventral spines, the former being hook shaped. Integument with tubercles appearing as pattern of dots, more numerous dorsally than ventrally; shaped as follows: dorsomedial surface with undeveloped processes; dorsolateral surface with undeveloped processes; lateral surface with conical processes; ventral surface with minute, conical processes. Scutum with tubercles arranged in a symmetrical pattern of clusters. Dorsum with setiform microtrichia on mesoscutum and trunk segments, arranged symmetrically in transverse rows. Respiratory horn laterally compressed; lateral and ventral surfaces with numerous pits arranged in a uniform pattern, dorsal surface appearing wrinkled; paired row of pores restricted to its distal half.

Adult male [Fig. 10(A–C), E]. Measurements, \((N = 1)\) head width 0.37 mm, head length 0.39 mm, wing length 1.80 mm, wing width 0.73 mm, palpomere proportion: 1–2.4–2.4–3. Head strongly rounded, vertex extending posteriorly the length of less than one facet diameter. Frontal scar patch quadrangular, contiguous medially. Anterior clypeal margin bilobed. Antennal flagellomeres flask shaped, with internodes somewhat constricted basally. Flagellomeres 3–13 each with 18 ascoids; 14–15 each with five ascoids; 16 with two ascoids. Wings ovate, vein Sc ending in vein R\(_1\). Terminalia: basal sclerite of aedeagus short, not extending anteriorly into abdomen; distal shafts apparently trimerous; shafts narrow, filamentous. Parameral sheath slender, not conical; elongate, extending posteriorly beyond gonocoxites. Gonostyli bifurcate; lateral rami short, stub-like, rounded apically; medial rami digitiform with apices tapered, acute. Cercopodia curved dorsad approximately 90°; 4 retinacula inserted dorsoapically; apices of retinacula spatulate.

Adult female (Fig. 10D). Measurements, \((N = 1)\) head width 0.37 mm, head length 0.39 mm, wing length 2.12 mm, wing width 0.86 mm, palpomere proportion: 1–2.4–3–3.4. Head nearly identical to male; nodes of flagellomeres 3–16 noticeably narrow compared with scape and pedicel, each with two ascoids. Wing with identical venation, but often larger than in males. Terminalia: Cerci not elongate, about 1.3 times longer than tall. Subgenital plate with posteromedial bulge; hypovalvae bilobed. Oviduct with genital ducts ovoid, with a reticulated pattern ventrally, not appearing sculptured laterally.

Type material. Feuerborn provided information about collection sites and distribution (fundplätze), but did not designate a holotype or specify a location where specimens were deposited. Sites included East Java (x.-xi. 1928); Sudsamatra (1.ii.1929 & 5.v.1929); and Teesta Bridge (5.ii.1931); the latter because, at the time, Feuerborn believed Hora’s collection of \(N. horai\) was conspecific with \(N. indicus\) (Tonnoir 1933). We borrowed from the BMNH three slides containing larvae of \(N. indicus\) from East Java, 29.x.1928; however, we could not determine if any of these specimens were among the original series, as the collection dates provided in the description spanned 2 months. For this reason, a lectotype was not designated for this species. Voucher specimens from Thailand are deposited in the USNM.

Fig. 17. Distribution of the species of *Neotelmatoscopus* in the Oriental region.

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Fig. 18. Provinces in Thailand where specimens of *Neotelmatoscopus* were collected (indicated by numbers).
**Remarks.** Known from East Java and Thailand, and likely occurs throughout Malaysia. May be sympatric with *N. horai* and various undescribed species. Instar IV larvae are easily distinguishable from other known larvae of *Neotelmatoscopus* by head capsule shape, presence of two tergal plates on abdominal segments II–VII and tan body colour.

Pupae, while similar to *N. horai*, *N. acutus* and *N. rotundus*, can be recognized by the sculpture of the respiratory horn and the presence of spines on the genital sclerite. Adults of *N. indicus* are unique among known adults of *Neotelmatoscopus*, characterized in the male by curved cercopodia with four retinacula and gonostyli having distinctly shaped rami; as well as in the female by the shape of the subgenital plate.

**Neotelmatoscopus bifidens** (Quate)  
[Fig. 4A; 8(A–B); 12(A–G); 17]

Telmatoscopus (*Neotelmatoscopus*) *bifidens* Quate 1965: 828 [Original Description].
Neotelmatoscopus bifidens (Quate), Duckhouse, 1973: 232 [Oriental catalog].

Diagnosis. Larva. Head capsule triangular in shape from dorsal aspect, with vestiture of macrotrichia dorsally and laterally; integument dark in colour; lateral alveolar processes undeveloped or elongate, spiniform; abdominal segment I with protergal plate not reduced; dorsal sclerite of anal division with stout spiniform macrotrichia inserted laterally. Pupa. Lateral margin bearing numerous brush-like macrotrichia and elongate spiniform tubercles; respiratory horn integument with ribbed pattern of gill-like tufts. Male. Frontal scar patch quadrangular, constricted medially; wing lanceolate, vein Sc approaching but not ending in vein R1; sclerites of distiphallus paired, bearing spicules; gonostyli bifurcate, rami not of equal length; lateral rami 2× the length of medial rami; distal 1/3 of cercopodia curved dorsad approximately 45°, with six retinacula. Female. Subgenital plate postomerodially entire, only slightly convex; genital ducts ovoid, with a reticulated pattern ventrally, not appearing sculptured laterally; hypovalvae constricted basally, reduced in length.

Description. Larva (Fig. 4A). Measurements, instar IV (N = 3) total length (3.28) mm (2.9–3.75), cranial width (0.45) mm. Trunk tapering slightly in width from anterior to posterior. Integument dark in colour; alveoli abundant dorsally with processes shaped as follows: undeveloped dorsomedially, conical or undeveloped dorsolaterally, conical or elongate spiniform laterally and spiniform ventrolaterally. Head capsule (excluding cervix) triangular in shape. Abdominal segments II–VII each with protergal plate separate from mesotergal plate. Abdominal segments II–VII trapezoidal in shape, with a single, entire lateral lobe. Chaetotaxy: head capsule with dorsal and lateral vestiture of setiform macrotrichia; anterior buccal seta brush-like, directed anteriorly; posterior buccal seta fan-shaped, directed posterolaterally; thoracic and abdominal tergal plates with numerous stout spiniform macrotrichia and setiform microtrichia; dorsal sclerite of siphonial segment with two pair of stout, spiniform macrotrichia inserted dorsally, and three pair inserted laterally, arranged symmetrically.

Pupa (Fig. 8A, B). Integument with tubercles appearing as pattern of dots, sparse dorsally, abundant dorsolaterally, absent ventrally; shaped as follows: dorsomedial surface with undeveloped or no processes; dorsolateral surface with undeveloped processes; lateral margin with elongate spiniform processes; ventral surface with minute spiniform processes. Lateral margins of each trunk segment with three brush-like macrotrichia. Dorsum with brush-like macrotrichia present anteriorly. Respiratory horn integument with numerous gill-like tufts arranged in a scale pattern; paired row of pores extending from base to apex.

Adult male [Fig. 12(A–D), F]. Measurements, (N = 7) head width 0.42 mm, head length 0.39 mm, wing length 2.26 mm, wing width 0.77 mm, palpmere proportion: 1–1.4–1.4–1.4. Head appearing broader than long, vertex extending posteriorly the length of three facet diameters. Frontal scar patch quadrangular, constricted mediadlly. Anterior clypeal margin bilobed. Antennal flagellomeres with internodes about as long as their preceding nodes. Flagellomeres 3–13 each with 10–12 ascoids; 14–15 each with four ascoids; 16 with two ascoids. Wings lanceolate, vein Sc approaching, but not ending in vein R1. Terminalia: basiphallus with sclerite elongate basally, extending anteriorly into abdomen to the level of tergite VI; distiphallus with sclerites paired, bearing numerous spicules; Parameral sheath conical, elongate, extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami not of equal length; lateral rami 2× the length of medial rami; distal 1/3 of cercopodia curved dorsad approximately 45°, with six retinacula inserted dorsoapically; apices of retinacula appearing frayed.

Adult female (Fig. 12E, G). Measurements, (N = 5) head width 0.40 mm (0.39–0.43), head length 0.39 mm (0.39–0.41), wing length 2.5 mm (2.28–2.75), wing width 0.84 mm (0.76–0.90), palpmere proportion: 1–1.4–1.4–1.4. Head nearly identical to male; nodes of flagellomeres 3–16 noticeably narrow compared with scape and pedicel, each with two ascoids; some specimens with frontal scar patch nearly divided medially. Wing with identical venation, but often larger than in males. Terminalia: Cerci not elongate. Subgenital plate ventromedially entire, only slightly convex; hypovalvae reduced in length, laterally constricted basally, with digitiform lobes distally. Oviduct with genital ducts ovoid, with a reticulated pattern ventrally, not appearing sculptured laterally.


Remarks. Known only from the type locality. Larvae are distinguished by their large size and the presence of many stout macrotrichia on the tergal plates. Pupae are known only from a partial exuviae, but available characters for the respiratory horn and integument are sufficient to separate it from other species of Neotelmatoscopus. Adult males are unique for having spicules on the aedeagus, while females may only be distinguishable by the size and shape of the wing. A larva similar to that of N. bifidens, but apparently of another species, was collected from the same location as N. bifidens. Only one specimen (mounted on a slide with N. bifidens larva) is available, and is in poor condition; however, it is likely that this unknown larva belongs to either N. parsilobus or N. longiceps, as these species occur in the same location as N. bifidens.
Neotelmatoscopus aurulentus Curler and Courtney, sp.n. [Figs 1; 5; 9(A–D); 15(A, B, G); 16(E, G); 17; 18]

Diagnosis. Larva. Head capsule round in shape from dorsal aspect; integument black in colour; lateral alveolar processes undeveloped or conical; abdominal segment I with protorotal plate not reduced; tergal plates with only setiform microtrichia. Pupa. Dorsum bearing numerous stout, setiform macrotrichia; respiratory horn integument appearing wrinkled. Male. Frontal scar patch divided into two subcircular patches; wing ovate, vein Sc ending in vein R1; gonostyli simple; distal 2/3 of cercopodia curved dorsad approximately 45°; with eight retinacula. Female. Unknown.

Description. Larva (Figs 1; 15A, B, 16E, G). Measurements, instar II (N = 7) total length 1.75 mm (1.65–1.85); cranial width 0.26 mm (0.25–0.30); instar III (N = 12) total length 2.54 mm (2.0–2.85); cranial width 0.40 mm (0.38–0.40); instar IV (N = 15) total length 3.04 mm (2.55–3.55); cranial width 0.45 mm (0.42–0.50). Trunk tapering slightly in width from anterior to posterior. Integument black in colour; alveoli abundant with central processes shaped as follows: conical dorsomedially, conical or undeveloped dorsolaterally, conical or undeveloped laterally and conical ventrolaterally. Head capsule round in shape from a dorsal aspect. Abdominal segment II with protorotal plate separate from mesotergal plate, undivided. Abdominal segments II–VII hexagonal in shape from a dorsal aspect, with a single, entire lateral lobe. Chaetotaxy: head capsule segments II–VII hexagonal in shape from a dorsal aspect, separate from mesotergal plate, undivided. Abdominal segment II with protergal plate not reduced; tergal plates with only setiform microtrichia; anterior buccal setae fan-shaped, directed laterally; posterior buccal setae oriented dorsolaterally; thoracic and abdominal tergal plates with setiform microtrichia; dorsal sclerite of siphonal segment with two pair of thoracic and abdominal tergal plates with setiform microtrichia. Pupae (Figs 5; 15G). Measurements, (N = 2) length (1.8) mm, width (0.9) mm. Body ovoid, strongly dorsoventrally compressed. Integument with tubercles sparse dorsally, restricted to anterior and posterior borders of trunk segments, more numerous laterally and ventrolaterally; shaped as follows: dorsal surface with multi-toothed or minute spiniform processes; lateral surface with minute spiniform processes; ventrolateral surface with minute spiniform processes. Dorsum with numerous elongate setiform macrotrichia; mesoscutum and tergites of trunk with four pairs and two single macrotrichia arranged symmetrically in a transverse row. Respiratory horn integument appearing wrinkled; paired row of pores inserted dorsomedially in a lightly pigmented longitudinal sclerite, restricted to the distal half.

Adult male [Fig. 9(A–D)]. Measurements, (N = 1) head width 0.43 mm, head length 0.37 mm, wing length 1.90 mm, wing width 0.84 mm, palpomere proportion: 1–2.3–2.5–3.5. Head appearing broader than long, vertex extending poste-riory the length of two facet diameters. Frontal scar patch divided into two subcircular patches. Anterior clypeal margin rounded. Antennal flagellomeres flask shaped, with internodes slightly constricted basally. Flagellomeres 3–13 with 10 ascoids; 14–15 with six ascoids; 16 with four ascoids. Wings ovate, vein Sc ending in vein R1. Terminalia: basiphallus with sclerite not elongate, extending anteriorly into abdomen to the level of tergite VIII; distiphallus apparently trimerous, sclerites filamentous; parameral sheath conical, elongate, extending posteriorly beyond gonoxocites. Gonostyli simple; rami sharply tapered, of subequal length to gonoxocites. Cercopodia with bases bulbous, distal 2/3 curved dorsad approximately 45°; with eight retinacula inserted dorsoungulpically; apices of retinacula appearing frayed.

Type material. Holotype [adult male]: THAILAND: Chiang Mai Province, Doi Inthanon NP, Nam Mae Klang near Ban Mae Sob, 18°31’N 98°36’E, 11.iv.2000 (G.W. Courtney)(USNM). Specimen dissected, mounted on micro slide. Paratypes [larvae]: same data as holotype; 1 instar II, 1 instar III, 13 instar IV (13 slides). Paratypes deposited at ISIC, CMU, QSBG, and USNM.


Etymology. From the Latin aurulentus meaning ornamented with gold, in reference to the tergal plates of only abdominal segment V appearing golden in many larval specimens of this species.

Remarks. Collected in northern Thailand from various locations in Doi Inthanon National Park. Larvae are distinguished by their large size, dark colour and rounded head capsule. Pupae are unique for having numerous setiform macrotrichia on the dorsum. Adult males are separated by the shape of the gonostyli and frontal scar patch. An adult female bearing some similarities to the male was collected several miles upstream from the type location. While it is possible that this is the female of N. aurulentus, an association was not made owing to a lack of more convincing evidence.

Neotelmatoscopus acutus Curler and Courtney, sp.n. [Figs 3A; 7A; 11(F–H); 15C; 16C; 17]

Diagnosis. Larva. Head capsule with genae extended posteroventrally into prominent rounded lobes; genal lobes directed posteriorly; anterior buccal setae fan-shaped,
directed anterolaterally; integument dark brown in colour; dorsal alveolar processes with two or three acute apices, lateral alveolar processes conical; abdominal segments II–VII with protergal plate fused to mesotergal plate so that each segment appears to have two plates. Pupa. Slightly dorsoventrally compressed; dorsum with only setiform microtrichia; respiratory horn slightly laterally compressed with integument appearing pitted laterally and ventrally, paired row of pores as wide as horn, extending along its distal half. Male. Frontal scar patch divided into two subcircular patches; gonostyli bifurcate, rami of unequal length; cercopodia straight, with 15 retinacula. Female. Subgenital plate with posteromedial knob-like process.

Description. Larva (Figs 3A; 15C). Measurements, instar IV ($N = 5$) total length 2.15 mm (1.87–2.27), cranial width 0.37 mm (0.34–0.39). Trunk stout, tapering slightly in width from anterior to posterior. Integument dark brown in colour; alveolar processes more numerous dorsally than ventrally, shaped as follows: each process with two or three acute apices dorsomedially, conical or undeveloped dorso-laterally, conical or undeveloped laterally and conical ventrolaterally. Head capsule with genae extended posterolaterally into prominent rounded lobes; genal lobes directed posteriorly. Abdominal segments II–VII with pro- and mesotergal plates fused, so that each segment appears to have two plates. Chaetotaxy: head capsule with few setiform microtrichia; anterior buccal seta fan-shaped, directed anterolaterally; posterior buccal seta fan-shaped, directed postero-laterally; thoracic and abdominal tergal plates with several setiform microtrichia; dorsal sclerite of siphonal segment with two pair of brush-like microtrichia and one pair of setiform microtrichia inserted posterodorsally, arranged symmetrically.

Pupa (Fig. 7A). Measurements, ($N = 1$) length 1.48 mm, width 0.73 mm. Body ovoid, strongly dorsoventrally compressed. Integument with tubercles sparse dorsally, arranged in a pattern of dots, shaped as follows: dorsal surface with minute spiniform or undeveloped processes; lateral surface with minute spiniform processes; ventrolateral surface with minute spiniform processes. Dorsum with setiform microtrichia on mesoscutum and trunk segments arranged symmetrically in transverse rows. Respiratory horn integument appearing smooth dorsally, pitted laterally and ventrally; paired row of pores as wide as horn, restricted to the apical half.

Adult male [Fig. 11(F–H)]. Head appearing round, vertex extending only slightly posteriorly less than the length of one facet diameter. Frontal scar patch divided into two subcircular patches. Antenna with internodes shorter than their preceding nodes. Terminalia: Parameral sheath conical, elongate, extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami of unequal length, the medial twice the length of the lateral. Cercopodia straight, constricted along their distal 1/4, with 15 retinacula inserted dorsoapically; apices of retinacula bifurcate.

Adult female. Terminalia: Subgenital plate with posteromedial knob-like process; hypovalvae bilobed.

Type material. Holotype [male imago dissected from pupa]: SRI LANKA: Kandy District, Creek near km post 5, Laxapana Rd, =06°50’N 80°32’E, 18.vii.1993 (Courtney and Mallampalli) (USNM). Specimen dissected, mounted on micro slide. Paratypes: same data as holotype [1 male P (slide); 1 female imago Pex (slide); 5 instar IV L (5 slides)]. Paratypes deposited at ISIC and USNM.

Other material examined. SRI LANKA: Badulla District, Bambarakanda creek below falls, 06°46’N 80°50’E, 20.vii.1993 [L] (Courtney and Mallampalli). Specimens deposited at USNM and ISIC.

Etymology. From the Latin acutus meaning ‘spiky’, referring to the shape of the dorsal alveolar processes on the larva.

Remarks. Collected from two locations in Sri Lanka. Larvae are distinguished by their small size, brown colour, head capsule shape and dorsal alveolar processes. Pupae have a unique respiratory horn, and lack spines on the terminal abdominal segment. Adult males are separated by the shape of the gonostyli, frontal scar patch and number of retinacula. The female of this species is known only from one relatively immature specimen, thus, few distinguishing characters are available.

Neotelmatoscopus rotundus Curler and Courtney, sp.n. [Figs 3B; 7B; 11(I–K); 15E; 16A, B, H; 17]

Diagnosis. Larva. Head capsule with genae extended postero laterally into prominent rounded lobes; genal lobes directed posteriorly; anterior buccal setae fan shaped, directed anterolaterally; integument black dorsally, tan ventrally; dorsal alveolar processes rounded, lateral alveolar processes spiniform; abdominal segments II–VII with protergal plate fused to mesotergal plate so that each segment appears to have two plates appearing as two plates. Pupa. Slightly dorsoventrally compressed; dorsum with only setiform microtrichia; respiratory horn with integument appearing pitted laterally and ventrally, paired row of pits not as wide as horn, extending along its distal half. Male. Frontal scar patch divided into two subcircular patches; gonostyli bifurcate, rami of unequal length; cercopodia straight, with nine retinacula. Female. Unknown.

Description. Larva (Figs 3B; 15E; 16A, B, H). Measurements, instar IV ($N = 5$) total length 1.98 mm (1.95–2.03), cranial width 0.38 mm (0.36–0.39); instar III ($N = 1$) total length 1.36 mm, cranial width 0.27. Trunk stout, tapering slightly in width from anterior to posterior. Integument black dorsally, tan ventrally; alveolar processes more numerous dorsally than ventrally, shaped as follows: round dorso medially, spiniform dorsolaterally, spiniform laterally and
conical ventrolaterally. Head capsule with genae extended postero laterally into prominent rounded lobes; genal lobes directed posteriorly. Abdominal segments II–VII with pro-and mesonotal plates fused, giving the appearance of two plates per segment; tergal plates bearing transverse rows of round tubercles. Chaetotaxy: head capsule with few setiform microtrichia; anterior buccal seta fan-shaped, directed anterolaterally; posterior buccal seta fan-shaped, directed postero laterally; thoracic and abdominal tergal plates with several setiform microtrichia; dorsal sclerite of siphonal segment with two pair of brush-like microtrichia and one pair of setiform microtrichia inserted postero dorsally, arranged symmetrically.

Pupa (Fig. 7B). Measurements, \((N = 1)\) length 1.37 mm, width 0.73 mm. Body ovoid, strongly dorsoventrally compressed. Integument with tubercles sparse dorsally, shaped as follows: dorsal surface with rounded processes; lateral surface with minute spiniform processes; ventral surface with minute spiniform processes. Dorsum with setiform microtrichia on mesoscutum and trunk segments arranged symmetrically in transverse rows. Respiratory horn integument appearing pitted, pits sparse dorsally; paired row of pores not as wide as horn, restricted to its distal half.

Adult male [Fig. 11(I–K)]. Head appearing round, vertex not extending posteriorly. Frontal scar patch divided into two subcircular patches. Terminalia: Parameral sheath conical, elongate, extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami of unequal length, the medial twice the length of the lateral. Cercopodia straight, constricted along their distal 1/4, with nine retinaculal inserted dorsoapically; apices of retinacula bifurcate.

Adult female. Unknown.

**Type material.** Holotype [male imago dissected from pupa]: SRI LANKA: Badulla District, Creek near km post 4/9, Rd A-16, 20.vii.1993 (Courtney and Mallampalli) (USNM). Specimen dissected on micro slide. Paratypes: same data as holotype [one male P (slide); eight instar IV L (eight slides); 1 instar III L (slide)]. Paratypes deposited at ISIC and USNM.

**Other material examined.** SRI LANKA: Kandy District, Creek near km post five, Laxapana Rd, \(\approx 06^\circ 50'\text{N}\ 80^\circ 32'\text{E}, \) 18.vii.1993 [L] (Courtney and Mallampalli); Hapugastenna Estate Crossing, \(\approx 07^\circ 05'\text{N}\ 80^\circ 33'\text{E}, \) 18.vii.1993 [L] (Courtney and Mallampalli). Specimens deposited at USNM and ISIC.

**Etymology.** From the Latin *rotundus* meaning ‘rounded’, referring to the shape of the dorsal alveolar processes on the larva.

**Remarks.** Collected from three locations in Sri Lanka. Larvae are distinguished by their small size, body pigmentation, head capsule shape, dorsal alveolar processes and tubercles present on the tergal plates. Pupae have a unique respiratory horn, and lack spines on the terminal abdominal segment. Adult males are separated by the shape of the gonostyli, frontal scar patch and number of retinacula.

**Neotelmatoscopus inachus** (Quate) (Figs 4B; 8C; 14E; 17)

**Telmatoscopus (Neotelmatoscopus) inachus** Quate 1962: 25 [original description].


**Diagnosis.** Larva. Head capsule triangular in shape from dorsal aspect, with setae absent dorsally and laterally; integument light in colour; lateral alveolar processes elongate, spiniform; abdominal segment I with proteral plate not divided or fused to mesonotal plate. Anterior cluster of dorsolateral platelets fused; dorsal sclerite of anal division with stout spiniform macrotrichia laterally; posterior annuli of abdominal segments II–VII subrotund in shape. Pupa. Strongly dorsoventrally compressed; dorsum with only setiform microtrichia; respiratory horn with integument appearing ribs, without scale pattern. Male. Frontal scar patch quadrangular, constricted medially; wing strongly ovate; gonostyli not bifurcate; cercopodia straight, with 18 retinacula. Female. Subgenital plate postero medially convex, not elongate; hypovalvae bilobed, not contiguous medially.

**Description.** Larva (Fig. 4B). Measurements, instar III \((N = 1)\) total length 1.35 mm, cranial width 0.25 mm; instar IV \((N = 18)\) total length 2.06 mm (1.55–2.45), cranial width 0.35 mm (0.35–0.37). Trunk ovoid, not taping from anterior to posterior. Integument light in colour; alveoli abundant dorsally with central processes shaped as follows: conical dorsomedially, conical or undeveloped dorsolaterally, elongate spiniform or undeveloped laterally and spiniform ventrally. Head capsule (excluding cervix) triangular in shape, genal lobes rounded. Abdominal segments II–VII each clearly with three tergal plates. Abdominal segments II–VII with posterior annuli subrectangular in shape. Anterior cluster of dorsolateral platelets fused, appearing as one plate. Chaetotaxy: anterior buccal seta brush-like, directed laterally; posterior buccal seta fan-shaped, directed postero laterally; thoracic and abdominal tergal plates with several five or six-branched setiform microtrichia and simple setiform microtrichia; dorsal sclerite of anal division with two pairs of setiform microtrichia placed posterodorsally and four pairs of stout spiniform macrotrichia inserted laterally, arranged symmetrically.

Pupa (Fig. 8C). Measurements, \((N = 2)\) length (1.73) mm (1.70–1.75), width (0.98) mm (0.95–1.00). Body ovoid, strongly dorsoventrally compressed. Integument with tubercles appearing as pattern of dots, sparse dorsally, dense only along segmental borders; nearly absent ventrally;
shaped as follows: dorsomedial surface with undeveloped or no processes; dorsolateral surface with undeveloped processes; lateral surface with conical processes; ventral surface with minute spiniform processes. Tubercles arranged in a symmetrical pattern of clusters anteradorsally. Dorsum with only setiform microtrichia present. Respiratory horn appearing swollen basally; integument with numerous ribs arranged in convergent rows; row of pores paired, inserted dorsomedially, extending from base to apex.

Adult male. See Ilango 1994. [Fig. 11(A–E)]; Frontal scar patch quadrangular, narrowly divided medially. Antennal flagellomeres flask-shaped. Wings ovate. Terminalia: Gonostyli not bifurcate, with medial lobe distally. Cercopodia apparently straight; 18 retinacula inserted dorsosapically; apices of retinacula forked.

Adult female. Terminalia: Cerci not elongate. Subgenital plate smoothly rounded posteromedially; hypovalvae bilobed, separate medially.

**Type material.** Holotype [Larva]: NORTH BORNEO [MALAYSIA, SABAH]: Paring Hot Springs, 13 km N of Ranau, 10.x.1958 (MALAYSIA, SABAH); 8.9 x; 13 km N of Ranau, 10.x.1958 (L.W. Quate) (BPBM).

**Remarks.** Known only from northern Borneo. Larvae are very distinct and easily separated from other Neotelmatoscopus by their ovoid body shape. Pupae are similar in body shape and appearance to *N. horai*, but can be separated by the apices of retinacula forked.

**Description.** Larva, Pupa. Unknown.

**Neotelmatoscopus ctenophorus** Ilango [Figs 11(A–E); 17]

**Diagnosis.** Male. Frontal scar patch quadrangular; wing with posterior margin strongly convex, vein Sc ending in vein R1; gonostyli bifurcate, rami of subequal length; distal 1/2 of cercopodia curved dorsad approximately 90°, with 16 retinacula.

**Description.** Adult male. See Ilango 1994. [Fig. 11(A–E)]; Frontal scar patch quadrangular, narrowly divided medially. Palpal proportions: 1:1.6:1.8:2.5. Antennal flagellomeres flask shaped, distal necks basally wide. Wings ovate, vein Sc ending in vein R1. Terminalia: Parameral sheath wide basally, trapezoidal in shape from dorsal aspect. Gonostyli bifurcate, rami of unequal length. Cercopodia straight, constricted distally; five to six retinacula inserted dorsoapically, apices of retinacula forked.

**Neotelmatoscopus longiceps** (Quate) [Figs 13(A–E); 17]

**Telmatoscopus longiceps** Quate 1965: 832 [Original Description].

**Diagnosis.** Male. Frontal scar patch quadrangular; wing with posterior margin strongly convex, vein Sc ending in vein R1; gonostyli bifurcate, rami of subequal length; distal 1/2 of cercopodia curved dorsad approximately 90°, with 16 retinacula.

**Description.** Adult male. Measurements, (N = 1) head width 0.45 mm, head length 0.52 mm, wing length 2.87 mm, wing width 1.37 mm, palpomere proportions: 1:1.8:1.6:1.7. Head appearing longer than broad, vertex extending posteriorly the length of three facet diameters. Frontal scar patch quadrangular. Anterior clypeal margin bilobed. Antennal flagellomeres nodiform, ascods three to five branched. Wings ovate, with posterior margin strongly convex, vein Sc ending in vein R1. Terminalia: basiphallus with sclerite elongate basally, extending anteriorly into abdomen to the level of tergite VI; distiphallus with paired sclerites, appearing fleshy, without spines; parameral sheath short, not extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami of equal length; distal 1/2 of cercopodia curved dorsad approximately 90°, with 15 retinacula inserted dorsoapically; apices of retinacula appearing frayed.

**Type material.** Holotype [adult male]: PHILIPPINES: Mindanao, Bukidnon, Mt. Katanglad, 1480 m, 27–31.xi.1959 (L.W. Quate) (BPBM).

**Remarks.** Known only from the type series collected in southern India. Larvae and pupae of this species were not collected. Adults are similar in body shape and appearance to *N. horai*, *N. acutus* and *N. rotundus* but can be separated by the number of retinacula in the male and shape and appearance of the genital ducts in the female.
presence of fleshy distal appendages on the aedeagus. As mentioned above, an unknown larva collected with *N. bifidens* may belong to this species.

**Neotelmatoscopus digitoides** (Quate)  
[Figs 13(F–K); 17]

**Telmatoscopus digitoides** Quate 1965: 832 [Original Description].

**Diagnosis.** Male. Frontal scar patch quadrangular, not constricted medially; wing ovate, vein Sc ending in vein R1, medial fork with vein M2 incomplete at base; gonostyli bifurcate; rami of equal length; distiphallus with paired sclerites filamentous.

**Description.** Adult male [Fig. 13(F–K)]. Measurements, \((N = 1)\) head width 0.36 mm, head length 0.39 mm, wing length 1.75 mm, wing width 0.80 mm, palpomere proportion: 1–2.5–2.3–3.5. Head appearing slightly longer than broad, vertex extending posteriorly the length of two facet diameters. Frontal scar patch quadrangular, not constricted medially. Anterior clypeal margin bilobed. Antennal flagellomeres with internodes subequal in length to their preceding nodes. Wings ovate, with anterior and posterior margins equally convex, vein Sc ending in vein R1, medial fork with vein M2 incomplete at base. Terminalia: basiphallus with sclerite slightly elongate basally, extending anteriorly into abdomen to the level of tergite VII; distiphallus with paired sclerites appearing filamentous, without spines; parameral sheath short, not extending posteriorly beyond gonocoxites. Gonostyli bifurcate; rami of equal length; distal 2/3 of cercopodia curved dorsad approximately 45°, with many retinacula inserted dorsoapically; apices of retinacula appearing frayed.

**Type material.** Holotype [adult male]: PHILIPPINES: Mindanao, Agusan, 10 km SE of San Francisco, 17.x.1959 (L.W. Quate) (BPBM).

**Remarks.** Known only from the type locality. This species is known only from one adult male specimen. It is distinguished by characters of the genitalia, including bifurcate gonostyli and the unique aedeagus with a seemingly contiguous basiphallus and distiphallus. Although somewhat similar to *N. aurulentus*, the present species differs in the shape of the male head and frontal scar patch, as well as the genitalia.

**Neotelmatoscopus canlaonis** (Quate)  
[Figs 14(F–I); 17]

**Telmatoscopus canlaonis** Quate 1965: 830 [Original Description].

**Diagnosis.** Female. Frontal scar patch narrowly divided medially; wing lanceolate, vein Sc approaching but not ending in vein R1; hypovalvae constricted basally, bilobed.

**Description.** Adult female [Fig. 14(F–I)]. Measurements, \((N = 1)\) head width 0.35 mm, head length 0.22 mm, wing length 1.82 mm, wing width 0.51 mm, palpomere proportion: 1–1.2–1.8–2.4. Head appearing broader than long, vertex extending posteriorly the length of two facet diameters. Frontal scar patch narrowly divided medially. Anterior clypeal margin bilobed. Wings lanceolate, vein Sc approaching, but not ending in vein R1; hypovalvae constricted basally, bilobed; cerci not longer than their combined basal widths; Oviduct with genital ducts ovoid, with a reticulated pattern ventrally, not appearing sculptured laterally.
**Type material.** Holotype [adult female]: PHILIPPINES: Negros Or., Mt. Canlaon, 915m, 20–25.xii.1959 (L.W. Quate) (BPBM).

**Remarks.** Known only from the type locality. This species is known only from one adult female specimen. Although very similar to *N. bifidens*, it is distinguished by characters of the genitalia, mainly the shape of the subgenital plate.

*Neotelmatoscopus parsilobus* (Quate)  
[Figs 14(A–D); 17]

**Description.** Adult female [Fig. 14(A–D)]. Measurements, \(N = 1\) head width 0.37 mm, head length 0.39 mm, wing length 2.24 mm, wing width 1.00 mm, palpomere proportion: 1–1.75–2.13–2.75. Head appearing round, vertex extending posteriorly the length of two facet diameters. Head and pronotum extending beyond tarsal claw for more than half its length – present, extending beyond tarsal claw for less than half its length – present, extending beyond tarsal claw for more than half its length – present, extending beyond tarsal claw for less than half its length – present, extending beyond tarsal claw for less than half its length – present, extending beyond tarsal claw for less than half its length – present.

**Type material.** Holotype [adult female]: PHILIPPINES: Mindanao, Bukidnon, Mt. Katanglad, 1480 m. 27.x.1959 (L.W. Quate) (BPBM).

**Remarks.** Known only from the type locality. This species is known only from one adult female specimen. The wing venation is very similar to *N. digitoides*; however, until additional specimens are collected, a positive association cannot be made.

**Phylogenetic analysis**

**Results.** Parsimony analysis of 33 characters resulted in 92 trees of length 74 steps. A strict consensus of these trees (Fig. 19) had a Consistency Index (CI) of 0.649, a Retention Index (RI) of 0.750, and a Rescaled Consistency Index (RC) of 0.486. Bootstrap values strongly supported few nodes of the consensus tree.

**Discussion.** The present analysis was conducted to determine the phylogenetic relationship of *Neotelmatoscopus* to other Paramormiine genera, test for monophyly of *Neotelmatoscopus* and evaluate phylogenetic relationships of species within *Neotelmatoscopus*. The Paramormiine genera *Telmatoscopus*, *Peripsychoda* and *Paramormia* were chosen as outgroups for this analysis based on their morphological similarity to *Neotelmatoscopus*. *Maruina* and *Setomima* were included to clarify whether there is a relationship between *Maruina* and *Neotelmatoscopus*. While *Telmatoscopus* and *Peripsychoda* appear to be distantly related to *Neotelmatoscopus*, several characters suggest *Paramormia* as its sister group. These include characters 13 (contiguous eye bridge), 19 (presence of a parameral sheath) and 22 (presence of an anterior gonocoxal bridge). In contrast, there is significant support for a close relationship between *Maruina* and *Setomima*, but no evidence suggesting their relationship with any Paramormiine genus.

The monophyly of *Neotelmatoscopus* is supported by several compelling synapomorphies: (i) larvae with six ventral friction pads, (ii) larvae with abdominal segments I and VII reduced, (iii) pupae dorsoventrally compressed, (iv) adult eye bridge contiguous with four facet rows, (v) adults with dorsomedial lip present on tarsomere V, (vi) male hypopygium with parameres fused into an aedeagal sheath, (vii) female terminalia with hypovalvae reduced in length.

Deciphering relationships within *Neotelmatoscopus* has been hampered by a lack of specimens of all life stages of all species. Larvae, pupae and adult males and females are known for only five of the 13 described species. Of these five species, two are known only from relatively immature imagoes and few instar IV larvae. Furthermore, the eight remaining species include six species known from adults alone, and in many cases, only a single male or female. Despite the lack of information on certain life stages, two species groups (i) *horai* group [*horai* + *ctenophorus* + *acutus* + *rotundus*] and (ii) *bifidens* group [*bifidens* + *canlaonis*] were resolved in the current analysis. This phylogenetic hypothesis is based largely on features of the adult terminalia and, to a lesser extent, on larval characters. A transformation series involving the adult tarsomere V (character 30, dorsoapical lip on tarsomere V absent – present, extending beyond tarsal claw for less than half its length – present, extending beyond tarsal claw for more than half its length) is one of the most compelling characters. Support for monophyly of the *horai* group is currently provided by only character 26 (apices of retinaculae bifurcate), whereas many characters support the *bifidens* group: 10 (shape of head broader than long), 12 (frontal scar patch undivided), 27 (wing lanceolate) and 28 (wing vein Sc ending free). Other characters support monophyly of the Sri Lankan species *acutus* + *rotundus*: 1 (larval head capsule with genae widened, lateral lobes directed posteriorly) and 12 (frontal scar patch distinctly divided). *Neotelmatoscopus digitoides* and *N. longiceps* both exhibit plesiomorphic character states in the male genitalia. It is unclear whether these species are closely related and, until their immature stages are known, it is impossible to determine their affinities to other species of *Neotelmatoscopus*.

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General discussion

The objective of this investigation was to establish a baseline classification of a genus that includes many more species than the five known previously. Unlike the immature stages of most Psychodidae, larvae and pupae of *Neotelmatoscopus* can provide reliable characters for species identification. A suite of characters including shape of the alveolar processes, head capsule and tergal plates will separate instar IV larvae, while pupae are distinguished by sculpture of the respiratory horn and shape of the dorsal tubercles. Further detailed (i.e. SEM) studies of larval and pupal morphology should elucidate additional characters of taxonomic importance.

Adults of *Neotelmatoscopus* are readily distinguishable at the species level. Males are separated by a combination of genitalic characters (e.g. shape of distiphallus, gonostyli and cercopodia); wing venation (e.g. placement of Sc vein) and cranial features (e.g. length vs. width, and shape of the frontal scar patch), while females are identified by the shape of several external genitalic characters (e.g. subgenital plate and cerci) and few internal characters (e.g. shape of the genital ducts). Despite the fact that many descriptions of psychodid species are based solely on the adult female, few studies have included a detailed examination of the female terminalia, especially the internal structure.

Unplaced specimens

Although several new species have been added to *Neotelmatoscopus*, many larval and adult female specimens of presumably distinct species remain undescribed. Collections from numerous locations in Thailand and Sri Lanka (Supporting information, S3) have shown that a different species occurs in almost every location; however, because of a lack of specimens for more than one life stage, it is difficult to distinguish these specimens from those of described species. Also, phenology and unpredictable weather often confound research on groups like *Neotelmatoscopus*. Larvae are present often in high numbers, but pupae and adults may only be found at one time of the year.

Supporting Information

Additional Supporting Information may be found in the online version of this article from Wiley InterScience under DOI reference: doi: 10.1111/j.1365-3113.2008.00439.x

**Figure S1** Matrix of characters and states used in cladistic analysis of *Neotelmatoscopus*.

**Figure S2** Characters and states used in cladistic analysis of *Neotelmatoscopus*.

**Figure S3** Additional specimen data.

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