



NEW SPECIES AND RECORDS OF *NEOPERLA* (PLECOPTERA: PERLIDAE) FROM INDIA

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ABSTRACT

Records and descriptions are provided for nine formally recognized species of *Neoperla* collected in India. *Neoperla agumbe* sp. n. from Karnataka State, *N. emarginata* sp. n. from Madhya Pradesh State and *N. orissa* sp. n. from Orissa State are described as new, and new records of several Indian states are given for *N. asperipenis* Zwick, *N. biseriata* Zwick & Anbalagan, *N. hamata* Jewett, *N. nitida* Kimmins, *N. ochracea* Zwick and *N. schlitz* Stark & Sivec. Four additional species represented by females with eggs are described under informal designations, and the putative female and egg are described for *N. schlitz*.

Keywords: Plecoptera, Stonefly, *Neoperla*, India, new species, new records

INTRODUCTION

Our knowledge of the diversity and distribution of Indian *Neoperla* has accumulated slowly since Needham's (1909) and Klapálek's (1909) nearly simultaneous publication of the species name *N. indica*. Zwick & Sivec (1980) addressed this situation which was resolved in favor of the priority of Needham's description, unfortunately the type material is missing and the identity of this species remains in doubt. Banks (1920) and Navás (1930) each added a species (*N. basalis* Banks, 1920; *N. tristis* Navás, 1930) but both are now considered synonyms of *Chinoperla nigriceps* (Banks, 1914) (Zwick & Sivec 1980; Zwick 1981). Banks (1939) added *N. moesta* Banks, 1939 and Zwick (1981)

designated a lectotype and gave a detailed redescription of the male of this species and also provided redescriptions for Kimmins (1950) species, *N. nitida* Kimmins, 1950 and *N. venosa* Kimmins, 1950. Kimmins (1950) also reported an Indian record for *N. quadrata* Wu & Claassen, 1934, however this record has not been confirmed and is considered questionable as suggested by Murányi et al. (2015). Several additional species records published by Jewett (1975) and Harper (1977) for *N. moesta* and *N. nitida* are misidentified according to Zwick (1981), however the record of *N. hamata* Jewett, 1975 is considered valid. Consequently, the current list of Indian *Neoperla* includes 16 species previously documented by Jewett (1975), Zwick &

Sivec (1980), Zwick (1981), Zwick et al. (2007) and Stark & Sivec (2008a). These species and their known distributions by Indian state are listed in Table 1.

The current study is based primarily on specimens collected in the Agumbe Ghats of Karnataka State and from the Jaintia Hills of Meghalaya State by G. Svenson and colleagues of the Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah (BYUC). Holotypes

are deposited in the United States National Museum of Natural History, Washington, D.C. (USNM) through the courtesy of the Monte L. Bean Life Science Museum. A few additional specimens from the United States National Museum collection are included in the study. This material includes three species described as new to science and new records for six previously recognized species. These species and records, included in Table 1, increase the known Indian *Neoperla* to 19 species.

Table 1. Annotated checklist of 19 *Neoperla* species currently recognized from India (provisional species, all from Karnataka, not included).

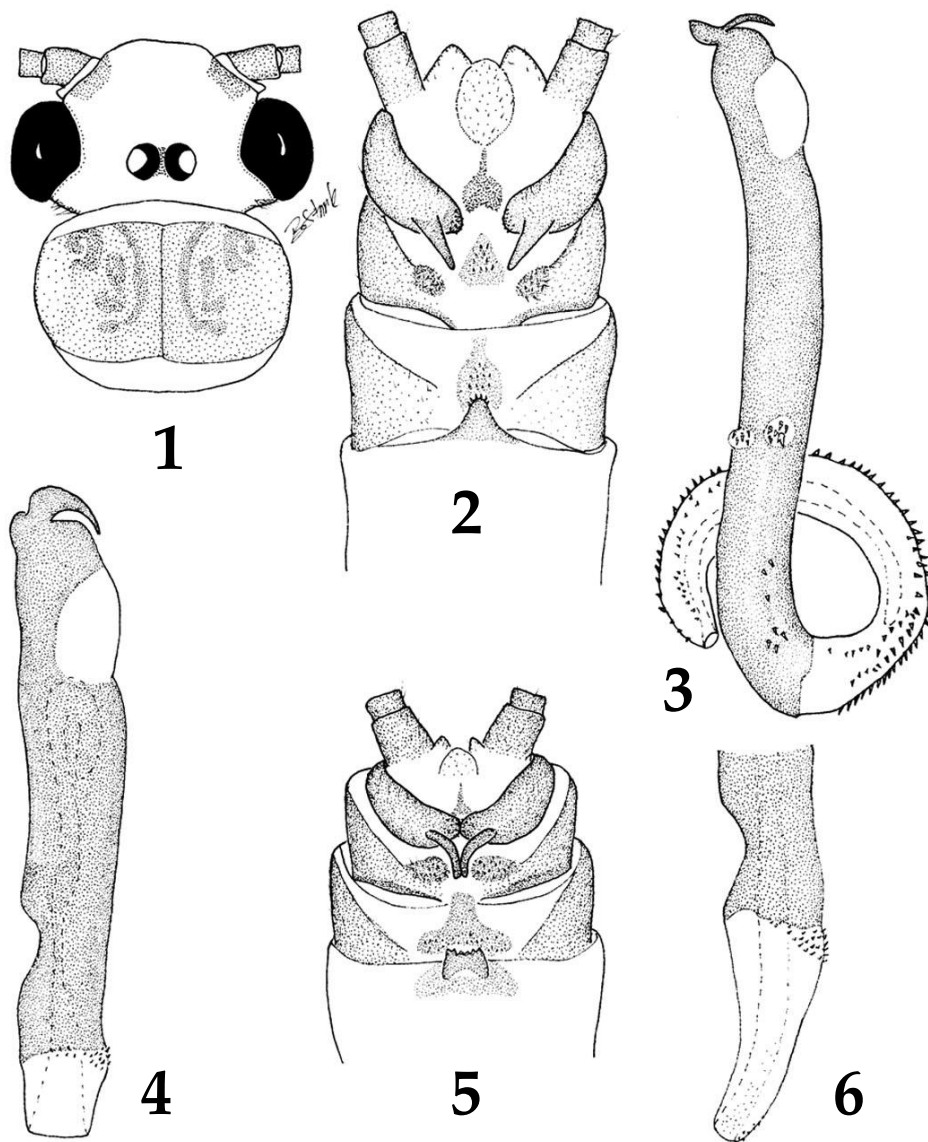
Species	Authors	Known Distribution by State
<i>agumbe</i>	sp. n.	Karnataka
<i>asperipenis</i>	Zwick, 1980	Assam, Kerala, Meghalaya, Orissa
<i>biseriata</i>	Zwick & Anbalagan, in Zwick et al., 2007	Karnataka, Tamil Nadu
<i>emarginata</i>	sp. n.	Madhya Pradesh
<i>indica</i>	Needham, 1909 (Zwick & Sivec, 1980)	Unknown
<i>hamata</i>	Jewett, 1975	Assam, Meghalaya
<i>katmanduana</i>	Harper, 1977 (Zwick & Sivec, 1980)	Assam, Meghalaya, West Bengal
<i>lushana</i>	Wu, 1935 (<i>sensu</i> Zwick & Sivec, 1980)	West Bengal
<i>moesta</i>	Banks, 1939 (Zwick, 1981)	Karnataka, Kerala, Tamil Nadu
<i>montivaga</i>	Zwick, 1977 (Zwick & Sivec, 1980)	West Bengal
<i>nitida</i>	Kimmins, 1950 (Zwick, 1981)	Karnataka, Kerala, Tamil Nadu
<i>obscura</i>	Zwick, 1981	Kerala, Tamil Nadu
<i>ochracea</i>	Zwick, 1981	Karnataka, Kerala, Tamil Nadu
<i>orissa</i>	sp. n.	Orissa
<i>perspicillata</i>	Zwick, 1980 in Zwick & Sivec, 1980	West Bengal
<i>schlitz</i>	Stark & Sivec, 2008	Karnataka, Kerala
<i>schmidiana</i>	Zwick, 1981	Kerala
<i>tortipenis</i>	Zwick, 1980 in Zwick & Sivec, 1980	Uttaranchal
<i>venosa</i>	Kimmins, 1950 (Zwick, 1981)	Tamil Nadu

MATERIALS AND METHODS

Genitalic structures of male specimens were prepared using the cold maceration technique of Zwick (1983) and females were prepared by boiling the terminal abdominal segments in 10% KOH. Eggs removed prior to boiling were examined with SEM, and these were prepared for study using the techniques of Stark & Green (2011).

Most BYU specimens were originally collected in 95% ethanol and kept under cryogenic

conditions. A small sample of specimens which had not been placed under -80°C were initially sent for identification; these were maintained and stored in 80% ethanol. When this sample was found to contain undescribed species, additional specimens from samples kept under cryogenic conditions were sent. These were sorted and examined in 95% alcohol and post-dissection genitalic specimens were associated with the bodies of the respective specimens and returned to



Figs. 1-6. *Neoperla* male structures. 1-3. *N. agumbe*. 1. Head and pronotum. 2. Male terminalia, dorsal. 3. Aedeagus, lateral. 4-6. *N. emarginata*. 4. Aedeagus, lateral. 5. Male terminalia. 6. Aedeagal tube apex with sac partially everted.

95% ethanol, except for those specimens designated as holotypes, which were placed in vials of 80% ethanol.

RESULTS AND DISCUSSION

Neoperla agumbe sp. n.
(Figs. 1-3)

Material examined. Holotype ♂, INDIA: Karnataka, Agumbe Ghats, 13° 29.386'N, 75°

04.537'E, 9 October 2004, G. Svenson, light trap (USNM).

Adult habitus. General color yellow-brown. Head mostly yellow but with small brown spot between ocelli; lappets and antennae pale brown. Pronotal pattern obscured by specimen condition, but disc yellow-brown with slightly darker rugosities (Fig. 1). Femora pale yellow brown, tibiae similar, but with a small, dark proximal area. Wings pale amber, veins brown except pale C, Sc and apical 2/3 of R vein.

Male. Forewing length 7.5 mm. Hemitergal processes of tergum 10 wide basally and relatively short (Fig. 2). Process of tergum 7 triangular in outline, but with rounded apex bearing 3-4 large, spine-like sensilla basiconica. Tergum 8 with a low mound-like mesal sclerite bearing a cluster of ca. 14 small sensilla basiconica; membranous areas adjacent to mesal sclerite with a few scattered sensilla basiconica. Tergum 9 bearing a median and two small adjacent sublateral sensilla basiconica patches set on small sclerites. Aedeagal tube sclerotized and armed with three small patches of spines on each side (Fig. 3); dorsomedian patches consist of angled rows of ca. 3 spines, lateromedian patches, located ventrad to dorsomedian patches, consist of a single larger forked spine and several small spines, and lateroapical patches include ca. 7, somewhat scattered spines (Fig. 3). Aedeagal sac membranous, not fully everted in Fig. 3, but similar to tube in length and armed along dorsolateral surface for most of length with ca. 6 rows of spines; number of rows reduced distally and a ventral row of smaller spines begins near midlength (near apex of partially everted sac in Fig. 3).

Female. Unknown.

Larva. Unknown.

Etymology. The species name, based on the type locality in the Agumbe Ghats, is used as a noun in apposition.

Diagnosis. The new species is a member of the *N. clymene* group. The aedeagus of this species is similar to that of *N. monacha* Stark & Sivec, 2008b in having multiple small patches of spines near midlength of the tube. However, the placement and number of spines varies between the species [compare Fig. 14 in Stark & Sivec (2008b) with Fig.

3], and the sac armature, adult habitus, hemitergal processes and detail of tergum 9 are also quite different. The head and pronotum of *N. monacha* is mostly dark brown, the hemitergal processes are slender and much longer than in the new species, and tergum 9 lacks sensilla basiconica patches [see Figs. 12-14 in Stark & Sivec (2008b)]. The aedeagal sac armature of *N. agumbe* is reminiscent of that of *N. triangulata* Kawai, 1975 from Sri Lanka, but that species has a pair of small spiny membranous bulbs located near the tube apex (Zwick 1980).

Neoperla asperipenis Zwick

Neoperla asperipenis Zwick in Zwick & Sivec, 1980:126. Holotype ♂ (Naturhistorisches Museum Basel), Garo Hills, Darugiri, Meghalaya, India

Material examined. INDIA: Assam, Gawahati Forest Area, 26° 05.153'N, 91° 46.435'E, 24 October 2004, G. Svenson, 1♂ (BYUC). Orissa, Jeypore, 1775' [ft. asl], September 1958, P.S. Nathan, 1♂ (USNM).

Comments. Zwick (in Zwick & Sivec 1980) described this species from Meghalaya State and Assam in northern India, and later (Zwick 1981) reported the species from a single male collected in Kerala State in southern India. The two male specimens examined in this study were collected in Orissa State, central India and in Assam.

Neoperla biseriata Zwick & Anbalagan

Neoperla biseriata Zwick & Anbalagan in Zwick et al., 2007:142. Holotype ♂ (Zoological Survey of India, Calcutta), Ayyan Odai stream, Karandmalai, Dindigul District, Tamil Nadu, India

Material examined. INDIA: Karnataka, Agumbe Ghats, 13° 29.386'N, 75° 04.537'E, 9 October 2004, G. Svenson, light trap, 14♂ (BYUC). Same location, 11 October 2004, canopy light trap, G. Svenson, 1♂ (BYUC). Jog Falls, 14° 16.480'N, 74° 44.436'E, 6 October 2004, Miller, Svenson, Cameron, 1♂ (BYUC).

Comments. Zwick et al. (2007) recently described this species based on adult, egg and larval

specimens collected in Tamil Nadu State, India. These are the first records from Karnataka State.

Neoperla emarginata sp. n.
(Figs. 4-6)

Material examined. Holotype ♂, **INDIA: Madhya Pradesh**, Jabalpur, 1600' [ft. asl], September 1957, P.S. Nathan, (USNM). Paratype, 1♂ (USNM). Same collection data as holotype.

Adult habitus. General color yellow brown with limited darker markings. Pattern obscure due to specimen condition.

Male. Forewing length 11.5 mm. Hemitergal processes of tergum 10 slender and curved gently laterad (Fig. 4); tergum 8 bearing a mushroom-shaped median sclerite armed with sensilla basiconica; anterior margin of tergum 8 thick and upturned under median process of tergum 7. Outline of tergum 7 process quadrangular in dorsal aspect; posterior margin bearing 6-8 thick spines. Tergum 9 bearing a pair of low mounds covered with sensilla basiconica; mounds located slightly laterad of hemitergal processes. Aedeagal tube sclerotized along ventral and dorsal margins, and slightly less so laterally; dorsal margin of tube bearing a concave subapical emargination (Fig. 5). Aedeagal sac membranous, about as long as tube and rather sparsely armed with small triangular spines; small basal cluster of spines located ventrally just beyond tube apex is bordered by a short, bare distal section, followed by sparse groupings of small to minute spines over much of the inverted sac (Fig. 6).

Female. Unknown.

Egg. Unknown.

Larva. Unknown.

Etymology. The species name is based on the subapical emargination of the aedeagal tube.

Diagnosis. This species appears to be a member of the *N. clymene* group. It is distinguished from other members of the group by the unusual, almost quadrangular process on tergum 7, the poorly armed aedeagal sac and the distinctive subapical dorsal emargination on the aedeagal tube. The species does not appear closely related to others known from the Indian subcontinent.

Neoperla hamata Jewett

Neoperla hamata Jewett 1975:131. Holotype ♂ (California Academy of Sciences), Kaziranga, Kohara, Assam, India

Neoperla hamata: Uchida & Yamasaki, 1989:142. Redescription

Neoperla hamata: Stark & Sivec, 2008b:29. Egg and female description

Material examined. **INDIA: Meghalaya**, Jaintia Hills, Narpuh R.F., Umpyrsung, off R. Lubha, Sonapor Town, 25° 07.064'N, 92° 21.634'E, 19 October 2004, G. Svenson, Canopy light trap, 3♂ (BYUC).

Comments. This wide-ranging species is reported at sites from India to Vietnam and Malaysia (Jewett 1975; Stark & Sivec 2008b; Uchida & Yamasaki 1989). Males are distinctive by virtue of a highly modified process on tergum 7. In addition, males of the species are unusual in having the hemitergal processes curved upward into a hook-shaped structure, and the aedeagal sac is covered laterally by thin, dark, appressed, setal-like spines, which is also an oddity.

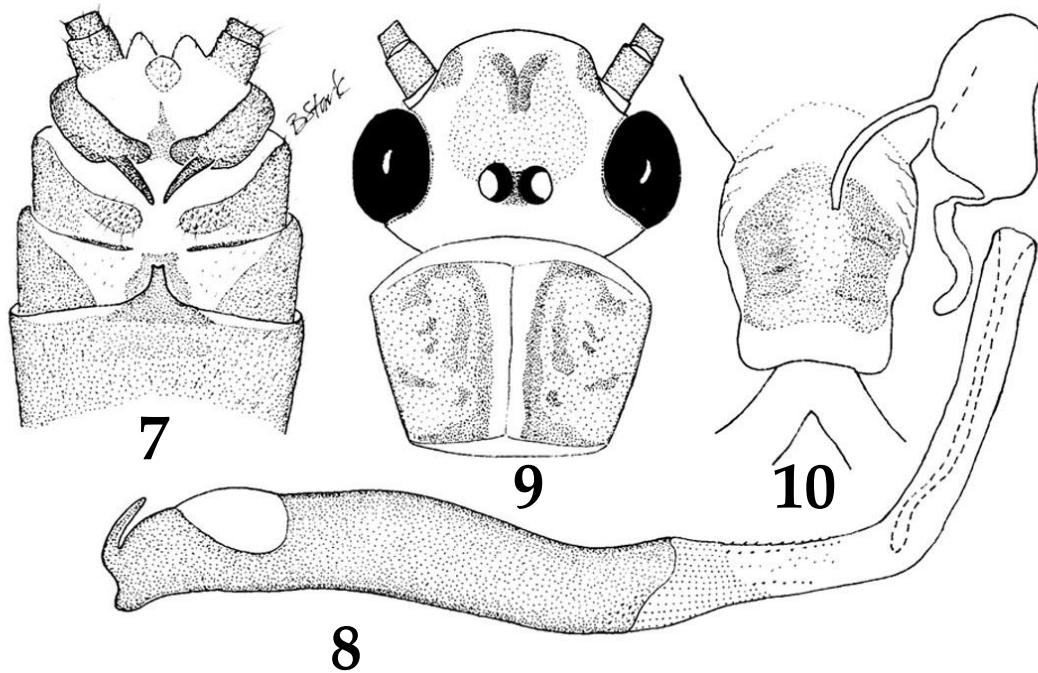
Neoperla nitida Kimmins

Neoperla nitida Kimmins 1950:184. Holotype ♂ (British Museum of Natural History), Narakaidu, Tinnevelly District, [Tamil Nadu] India

Neoperla nitida: Zwick, 1981:118. Redescription

Material examined. **INDIA: Kerala**, Thiruvananthapuram, Pon Mudi, 23 May 2003, Mercury vapor lamp, 5♀ (BYUC). **Tamil Nadu**, Cinchona, Anamalai Hills, 3500' [ft. asl], April 1957, P.S. Nathan, 3♂ (USNM). Same location, May 1957, P.S. Nathan, 2♂ (USNM). Same location, April 1959, P.S. Nathan, 1♂ (USNM).

Comments. Zwick (1981) redescribed this species from type material and from additional specimens collected in Tamil Nadu State. His egg figures, based on light microscopy, show an oval egg with no collar, but with closely packed, narrow striae. Although the external male genitalic structures are quite distinct, the egg and aedeagus of this species appear almost identical to those of *N. schlitzi* Stark



Figs. 7-10. *Neoperla* adult structures. 7-8. *N. orissa*. 7. Male terminalia, dorsal. 8. Aedeagus, lateral. 9-10. *N. schlitz*. 9. Head and pronotum. 10. Vagina and receptacle.

& Sivec (2008a) as discussed below under the account of that species. Female specimens from Kerala, listed above, have eggs that appear indistinguishable from those attributed to *N. schlitz*, but lack the distinctive head pattern found in males and females identified as *N. schlitz*.

Neoperla ochracea Zwick

Neoperla ochracea Zwick 1981:121. Holotype ♂ (California Academy of Sciences), Chinchona, Anamalai Hills, Tamil Nadu, India

Material examined. INDIA: Karnataka, Agumbe Ghats, 13° 29.386'N, 75° 04.537'E, 9 October 2004, G. Svenson, light trap, 16♂, 8♀ (BYUC). Same location, 10 May 2004, G. Svenson, 1♂ (BYUC). Jog Falls, canopy sample 2, west on road, 14° 16.503'N, 74° 44.5221'E, 7 October 2004, G. Svenson, 3♂

(BYUC). **Tamil Nadu,** Chinchona, Anamalai Hills, 3500' [ft. asl], April 1957, P.S. Nathan, 3♂ (USNM).

Comments. Males, females and eggs of this species were described by Zwick (1981) from approximately 120 specimens collected in Kerala and Tamil Nadu states, South India. In his description, Zwick (1981) notes the variable adult color pattern which is also evident in our samples. The most heavily pigmented individuals we observed had a small dark spot extending forward from between the ocelli and terminating in an acute line. These specimens also have a small dark spot near each tentorial callus, dark lappets and a prominent, median bell or triangular spot on the anterior frons, but other specimens have almost no dark head pigment. The specimens listed above include three topotype males and the first records from Karnataka State. In addition to the specimens listed above, two males in the USNM collection,

from Orissa State, Jeypore, 1775', collected in September 1958 by P. Susai Nathan, are similar in aedeagal shape and general features, but appear slightly different in having an area near the tube apex covered with small spicules rather than the patch of larger spines found on other specimens. The aedeagal sac armature for these specimens also shows some variation from typical *N. biseriata* and *N. ochracea*. These specimens may represent an additional species in this complex but are not treated as such until additional data are available for the group.

Neoperla orissa sp. n.
(Figs. 7-8)

Material examined. Holotype ♂, **INDIA: Orissa**, Jeypore, 1775' [ft. asl], September 1958, P.S. Nathan, (USNM). Paratypes, 2♂ (USNM). Same collection data as holotype.

Adult habitus. General color yellow brown with limited darker markings. Most pigment pattern obscure due to specimen condition, but a dark spot occurs between ocelli and pale amber wings have slightly darker veins.

Male. Forewing length 8 mm. Hemitergal processes of tergum 10 slender and curved slightly laterad (Fig. 7); tergum 9 with low, midlateral mounds sparsely covered with sensilla basiconica and a few long setae, median patch of sensilla basiconica absent; tergum 8 bearing a low median mound with a few sensilla basiconica, mostly hidden by process on tergum 7; tergum 7 with a slender, median projection which appears truncate in dorsal aspect but with small notch in apical aspect. Aedeagal tube sclerotized, slightly sinuate with apex curved ventrad; dorsoapical margin of tube bearing a patch of minute denticles (Fig. 8); aedeagal sac slightly longer than tube and armed with minute spines in basal fourth, no obvious spines occur on the more distal region of the sac; spines arranged in multiple close-set rows which extend a short distance from tube apex; longest rows occur along dorsal and ventral sac margins (Fig. 8).

Female. Unknown.

Egg. Unknown.

Larva. Unknown.

Etymology. The species name, based on the Indian state in which the specimens were collected, is used as a noun in apposition.

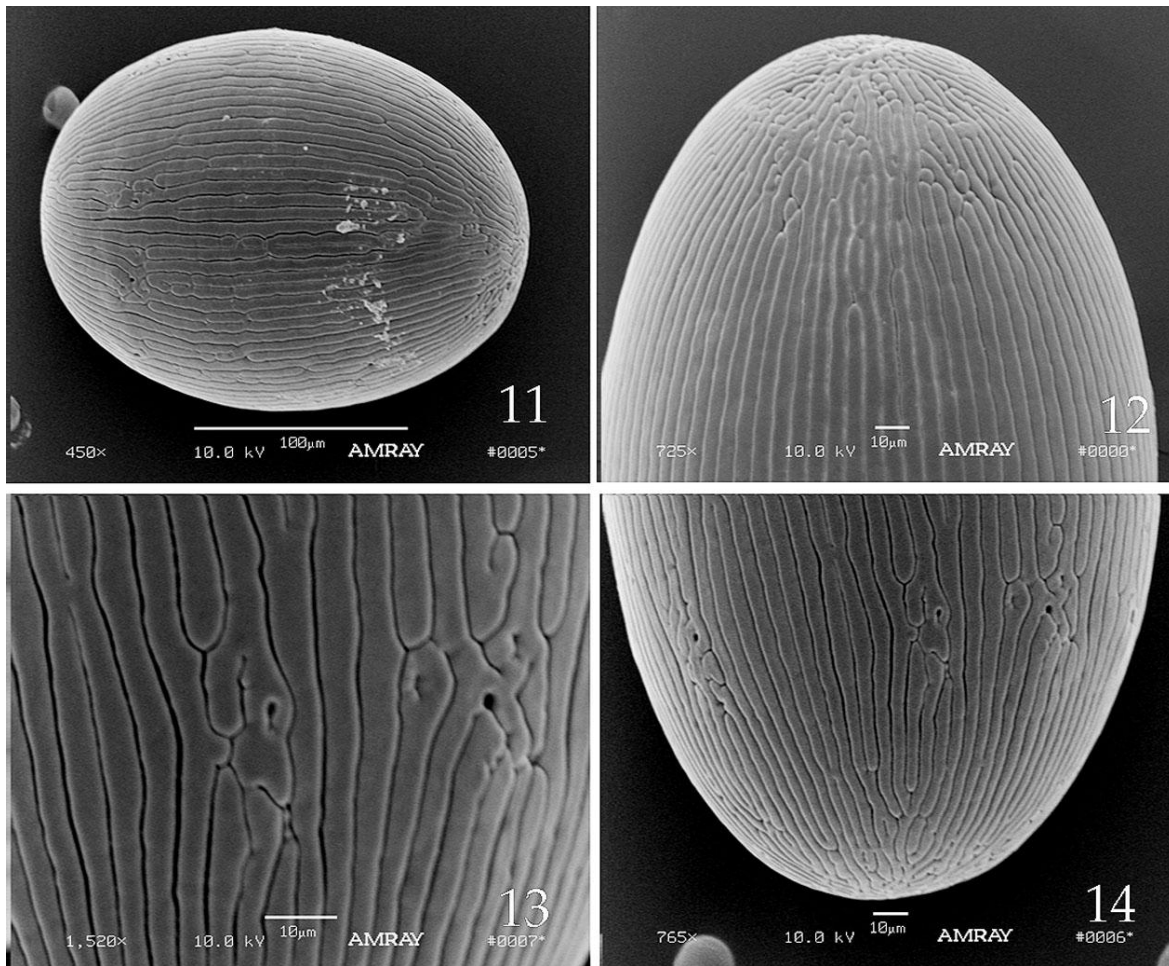
Diagnosis. This species is a member of the *N. clymene* species group and is generally similar in male genital features to *N. ochracea* but the aedeagal tube of that species bears a much more prominent dorsoapical patch of spines and the aedeagal sac is also more prominently armed than the new species. In addition, the process of tergum 7 is more slender in the new species.

Neoperla schlitzi Stark & Sivec
(Figs. 9-14)

Neoperla schlitzi Stark & Sivec 2008a:5. Holotype ♂ (Zoological Museum Amsterdam), Chambrá Peak area, Calicut District, Kerala, India

Material examined. **INDIA: Karnataka**, Agumbe Ghats, 13° 29.386'N, 75° 04.537'E, 9 October 2004, G. Svenson, light trap, 7♂, 3♀ (BYUC). Same site but 10 October 2004, canopy light trap, G. Svenson, 1♂ (BYUC). Same site but 11 October 2004, canopy light trap, G. Svenson, 1♂ (BYUC).

Comments. This species was previously known from the holotype male collected in Kerala, an Indian state adjacent to Karnataka. Because no female specimens were available for the previous study, and the head and pronotal pigment patterns were obscured in the holotype, we are adding these details below based on the current sample. The species is assigned to the *N. montivaga* species group of Zwick (1983, 1986); as Stark & Sivec (2008a) noted, the aedeagus of *N. schlitzi* is quite similar to that of *N. nitida* (Zwick 1981), however males of the two species are readily distinguished based on the 7th tergal processes (compare Fig. 12 in Stark & Sivec, 2008a with Fig. 3a in Zwick 1981). Remarkably, the eggs of these species may also be virtually identical unless the description of one or the other is based on an incorrect association. In the limited material available to us all the males with *N. schlitzi* type terminalia displayed the unusual V-shaped brown area on the anteromedian frons (Fig. 9) and this was also present in females we identified as *N. schlitzi*. A few females without this



Figs. 11-14. *Neoperla schlitzi* eggs. 11. Entire egg, lateral. 12. Collar end. 13. Micropyle and chorionic detail. 14. Lid and micropylar zone.

marking, but with identical eggs present in the samples, were identified by us as *N. nitida* and are listed with that species above.

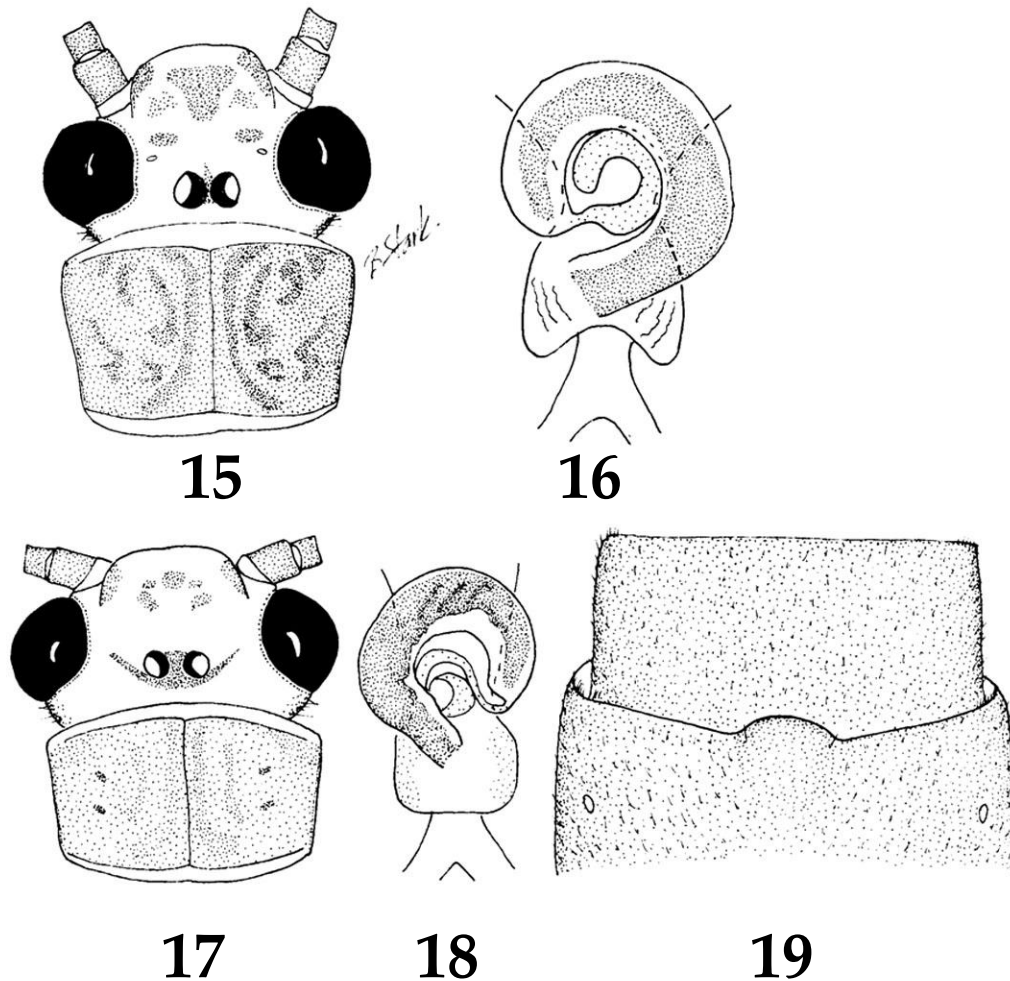
Adult habitus. General color pale yellow-brown. Head with a small dark spot between ocelli, a small V-shaped area on the anteromedian frons, lappets and antennal bases brown (Fig. 9). Pronotum with a pale median band, but most of disc pale brown with darker rugosities. Wings pale amber, veins darker except pale C vein. Male with hair brushes on abdominal sterna 3-5 and more weakly on sternum 6.

Male. Described by Stark & Sivec (2008a).

Putative female. Forewing length 12-12.5 mm.

Posterior margin of sternum 8 unmodified, or at most, slightly produced at midlength. Vagina a membranous bag with numerous concentric wrinkles on ventrolateral and anteroventral surfaces; dorsal surface consists of a dark sclerite. Receptacle membranous and lacking internal scales, sausage-shaped, attached to vagina by a slender stalk (Fig. 10).

Putative egg. Outline oval without collar; length ca. 271 μm , equatorial width ca. 192 μm (Fig. 11). Striae very slender, ca. 6-7 μm , closely packed and extending almost pole to pole (Figs. 11-14). Lid reduced and sulci not visible in SEM preparations. Follicle cell impressions absent. Micropyles



Figs. 15-19. *Neoperla* adult structures. 15-16. *Neoperla* sp. Id-A. 15. Head and pronotum. 16. Vagina and receptacle. 17-19. *Neoperla* sp. Id-B. 17. Head and pronotum. 18. Vagina and receptacle. 19. Subgenital plate.

subequatorial in position, orifices simple, but longer than wide (Figs. 13-14).

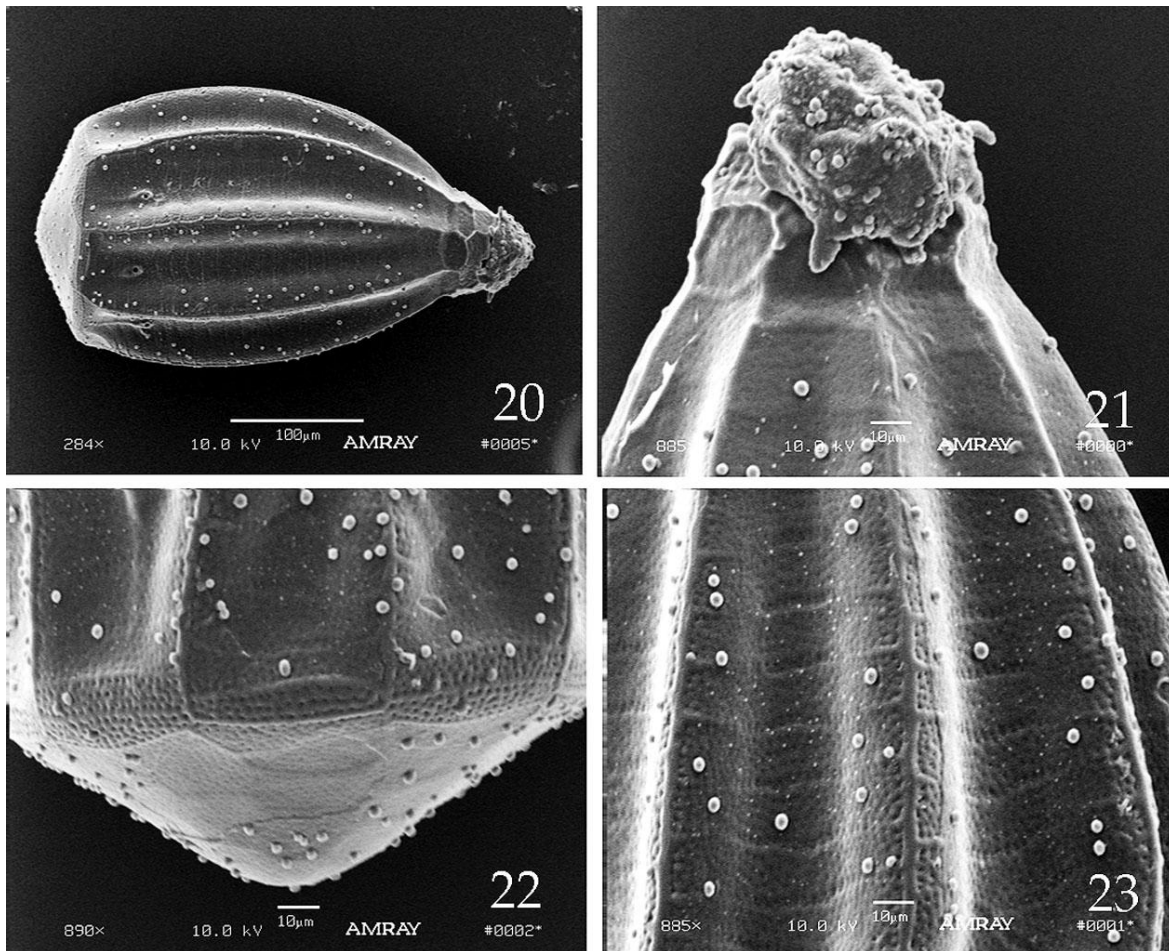
Larva. Unknown.

Neoperla sp. Id-A
(Figs. 15-16, 20-23)

Material examined. INDIA: Karnataka, Agumbe Ghats, 13° 29.452'N, 75° 04.221'E, 7 October 2004, G. Svenson, 1♀ (BYUC). Same site, 9 October 2004, Svenson, Cameron, Miller, 1♀ (BYUC). Same site, 9

October 2004, G. Svenson, 3♀ (BYUC).

Adult habitus. General color yellow brown with darker markings on head and pronotum. Head with a small dark spot between ocelli, attenuated on anterior margin forming a sharp point. A pair of small, dark, oval spots occur anterolateral of ocelli and a larger median dark spot occurs on the frontoclypeus. Lappets dark brown, antennal bases pale brown (Fig. 15). Wing membrane transparent, veins pale brown except C and Sc pale. Legs missing, cerci and antennae broken.



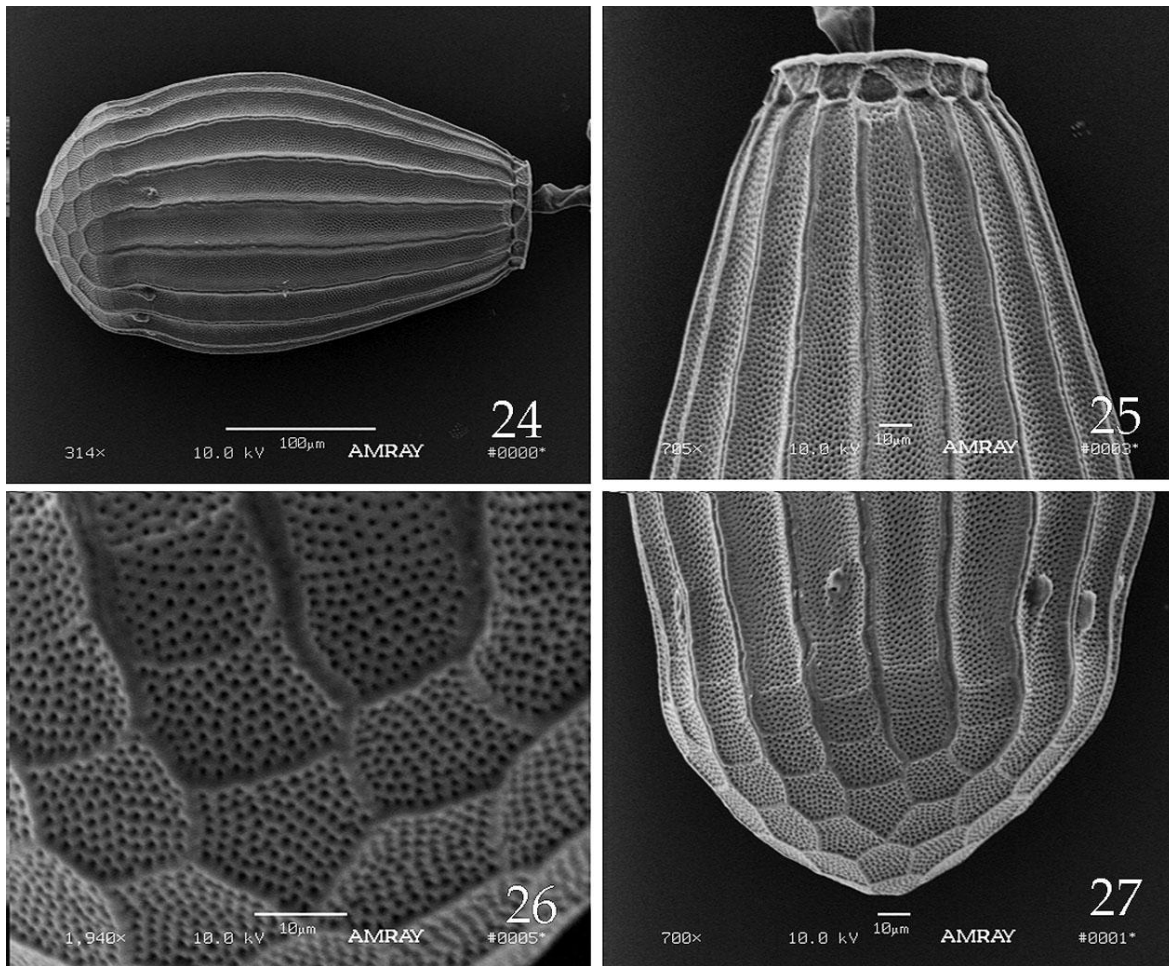
Figs. 20-23. *Neoperla* sp. Id-A eggs. 20. Entire egg, lateral. 21. Collar end with anchor. 22. Lid and eclosion line. 23. Median field.

Male. Unknown.

Female. Forewing length 10.5 mm. Subgenital plate undeveloped. Vagina membranous, without apparent internal structures; lateral margins constricted near mid-length (Fig. 16). Receptacular duct coiled into an almost complete O-shaped ring; duct contains brown scales in an almost complete internal coating, but with slightly more unscaled area near apex. Seminal receptacle membranous, sausage shaped and coiled into space within coils of duct.

Egg. Outline flask-shaped with narrow collar and expanded lid (Figs. 20-21). Length ca. 333-346 μm , equatorial width ca. 212 μm . Collar short, height ca. 38 μm , slightly offset from egg body at base and

tapered from basal width of ca. 79 μm ; sides of collar with lateral ornamentation consisting of about 6 hexagonal units. Anchor a globular mass covered sparsely with globular bodies and with a few marginal projections (Fig. 21). Body of egg with ca. 5 striae in lateral profile separated by wide, finely punctate sulci; striae bearing a narrow, smooth, thread-like longitudinal line along ridge (Fig. 23). Micropyles set on low mounds in sulci near eclosion line; eclosion line rather densely punctate, width ca. 15 μm . Lid outline somewhat triangular in lateral aspect (Fig. 22), surface with faint follicle cell impressions and very fine punctations.



Figs. 24-27. *Neoperla* sp. Id-B eggs. 24. Entire egg, lateral. 25. Collar end. 26. Lid, chorionic detail. 27. Lid and micropylar zone.

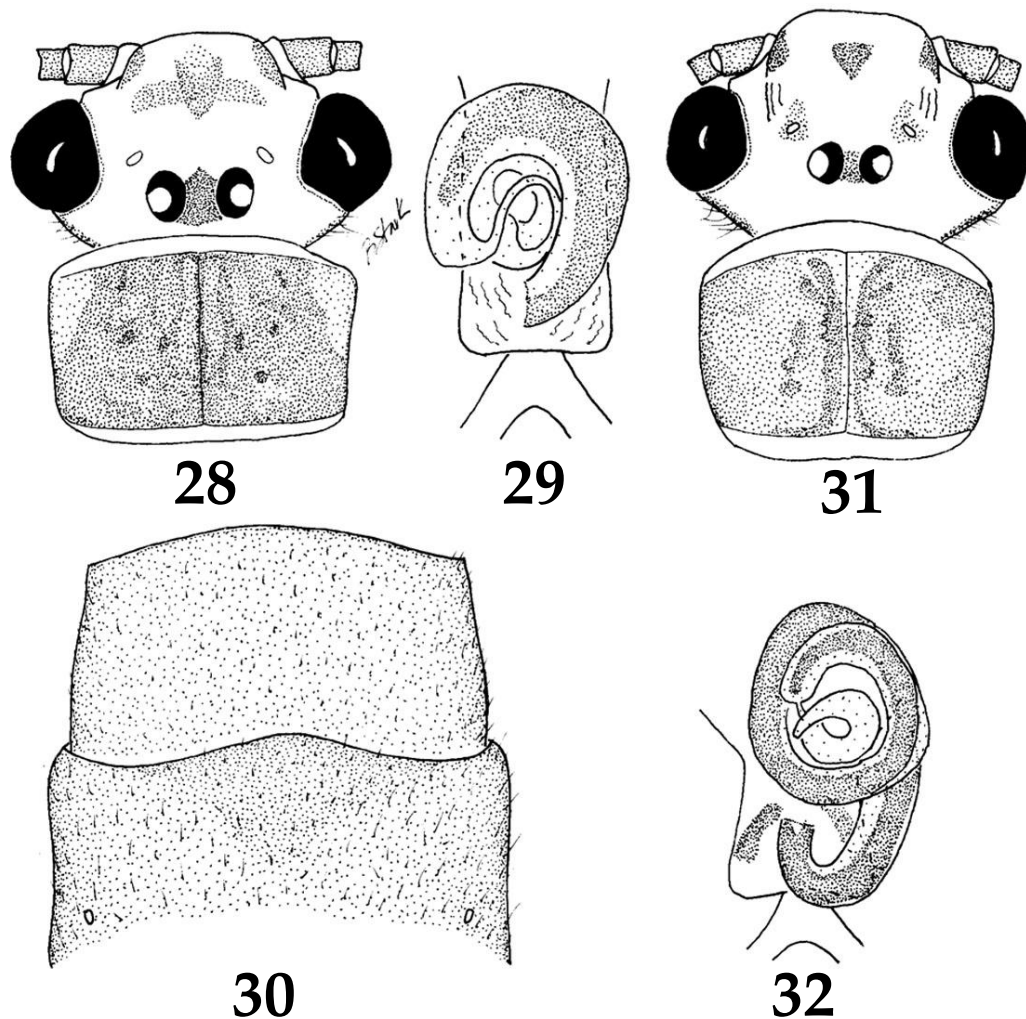
Larva. Unknown.

Comments. Zwick (1981) described the egg for four of the eight species known at that time from South India. The egg of this species does not appear to match any of those, but is similar in general shape to that of *Neoperla* sp. B in Stark (1983) from Thailand. The surface detail, however, is quite distinctive for this species, consequently, these females may represent one of the Indian species known only from the male stage, or they may represent an undescribed species.

Neoperla sp. Id-B
(Figs. 17-19, 24-27)

Material examined. INDIA: Karnataka, Jog Falls, 5 km E town, 16° 13.692'N, 74° 53.542'E, 7 October 2004, Svenson, Cameron, Miller, 1♀ (BYUC).

Adult habitus. General color yellow-brown with slightly darker markings. Head yellow with dark spot over ocelli extending laterally along ecdysial suture as a thin dusky line; three obscure, pale brown spots occur on the frontoclypeus, and the lappets are pale brown (17). Antennal bases are pale brown and the flagellum slightly darker brown. Pronotal sutures brown, disc pale brown with slightly darker rugosities. Wing membrane transparent, veins brown except pale costa and subcosta. Femora pale, tibiae pale brown except



Figs. 28-32. *Neoperla* adult structures. 28-30. *Neoperla* sp. Id-C. 28. Head and pronotum. 29. Vagina and receptacle. 30. Subgenital plate. 31-32. *Neoperla* sp. Id-D. 31. Head and pronotum. 32. Vagina and receptacle.

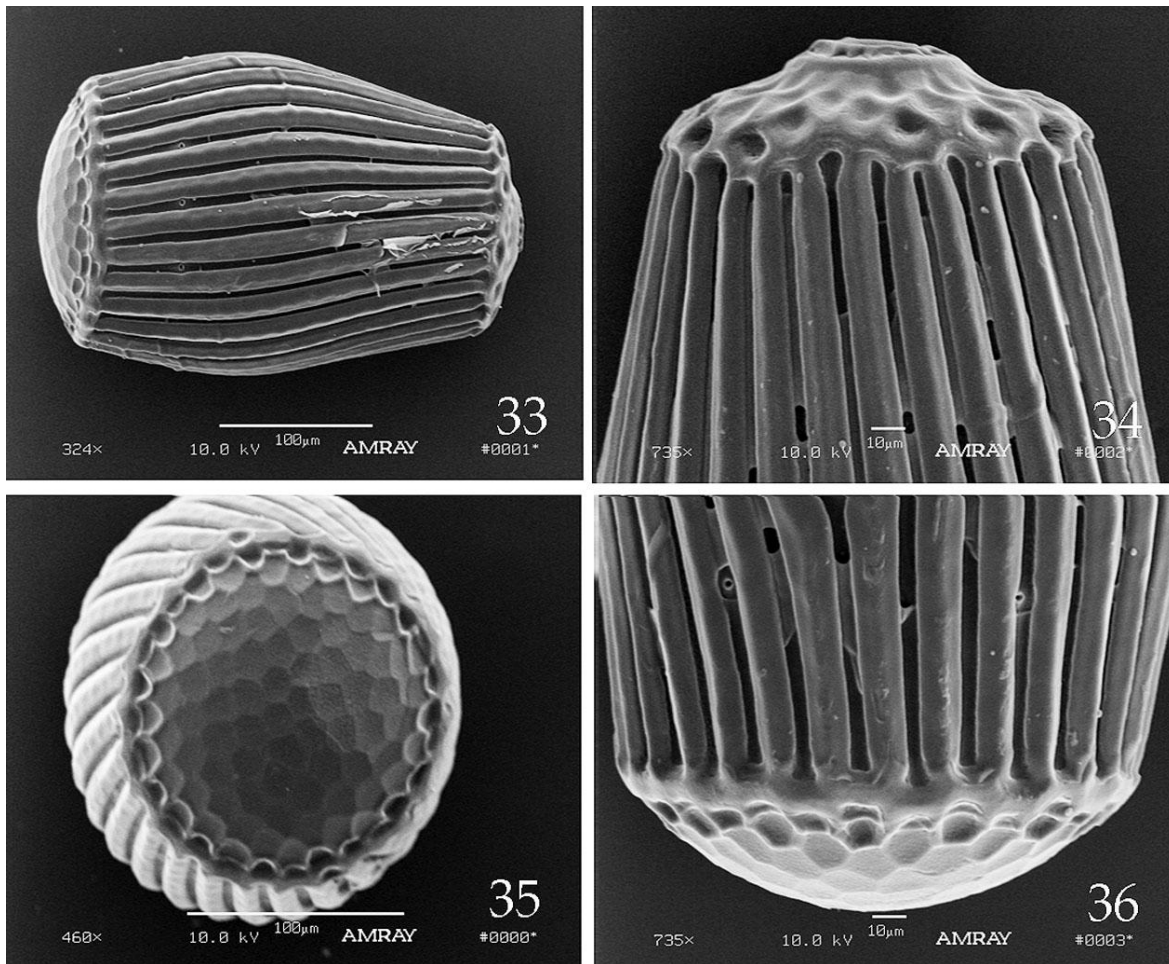
slightly darker at knee.

Male. Unknown.

Female. Forewing length ca. 10.5 mm. Subgenital plate (Fig. 19) slightly produced as a small rounded tab-like, almost bare structure scarcely projecting beyond posterior margin of sternum 8. Vagina (Fig. 18) membranous and constricted near midlength; receptacular duct C-shaped and lined almost full length with brown scales. Several short lines of darker scale clusters occur near midlength of duct;

inner margin of scaled area irregular (Fig. 18). Seminal receptacle membranous and attached to duct by a slender stalk; receptacle tightly coiled within inner margins of C-shaped receptacular duct.

Egg. Outline barrel-shaped with moderately wide collar and small lid (Figs. 24-25). Length ca. 327 μm , equatorial width ca. 187 μm . Collar short, ca. 12 μm high and ca. 63 μm wide; rim narrow, slightly flanged with relatively smooth margin,



Figs. 33-36. *Neoperla* sp. Id-C eggs. 33. Entire egg, lateral. 34. Collar end. 35. Lid, apical aspect. 36. Lid and eclosion line.

sides of collar surrounded by a single irregular row of 3-5 sided cells (Fig. 25). Anchor a globular mass set on a moderately long pedicel; anchor surface bears scattered globular bodies. Body of egg with ca. 9 narrow, impunctate striae which separate wide, densely punctate sulci; sulci width ca. 25 µm, and bearing ca. 9-12 punctations on each row which transects the sulcus (Fig. 25). Micropyles set on low mound-like sperm guides in subequatorial position at a point near the lid which corresponds to a slight constriction in egg diameter (Figs. 24, 27). Lid bears conspicuous, densely punctate follicle cell impressions over the entire surface (Fig.

26); eclosion line absent.

Larva. Unknown.

Comments. The egg of this species is not one of those described by Zwick (1981), and therefore this specimen might represent one of the south Indian species for which no female has been discovered, or the female of an undescribed species. The wide, densely punctate sulci are similar to those of *Neoperla ochracea*, although in that species the chorionic punctations are not as prominent, the follicle cell impressions on the lid are scarcely discernable and the collar of the egg is longer and narrower.

Neoperla sp. Id-C
(Figs. 28-30, 33-36)

Material examined. INDIA: Karnataka, Agumbe Ghats, 13° 29.386'N, 75° 04.537'E, 9 October 2004, G. Svenson, light trap, 1♀ (BYUC). Jog Falls, canopy sample #2, 14° 16.503'N, 74° 44.5221'E, 7 October 2004, G. Svenson, 1♀ (BYUC).

Adult habitus. General color pale yellow-brown, patterned with darker brown. Ocellar area with a small dark spot between ocelli and extending forward as a small projection; frontoclypeal region with an obscure, bird-shaped dusky area; lappets dusky, basal two antennal segments brown, flagellum black (Fig. 28). Wing membrane transparent, veins brown except for pale white or whitish brown C and Sc. Hind femora pale in basal 2/3, becoming slightly darker in distal third; tibiae brown but darker on outer margin at knee.

Male. Unknown.

Female. Forewing length 12 mm. Subgenital plate scarcely developed (Fig. 30), but mesal margin protruding slightly and almost hairless. Vagina membranous, elongate, narrow and with subparallel lateral margins; seminal receptacle duct coiled dorsally above vagina, forming an almost complete ring around membranous, coiled receptacle; receptacle duct densely lined with brown scales for most of duct length (Fig. 29).

Egg. Barrel-shaped with broad lid and small collar base with narrow orifice (Fig. 33). Length ca. 317 µm, greatest subequatorial width ca. 145 µm. Collar scarcely stalked, basal collar width ca. 122 µm, orifice width ca. 32 µm; rim narrow, smooth and unflanged; base with ca. 3-4 irregular rows of large depressions on sides of collar (Fig. 34). Striae broad, smooth, with a slight sinistral curve and separated by narrow sulci; width of striae ca. 15-17 µm. Lid separated from egg body by smooth eclosion line; lid short in lateral aspect (Fig. 36), apical diameter ca. 145 µm (Fig. 35); follicle cell impressions distinct on lid adjacent to eclosion line, but obscure nearer apex; floors of follicle cell impressions without distinct punctations (although their presence is not ruled out due to membrane on lid). Micropyles with simple orifices and without sperm guides; openings set in sulci on equatorial

side of eclosion line (Fig. 36).

Larva. Unknown.

Comments. The egg of this species is another of those apparently not included in the sample available to Zwick (1981). It is generally similar to the egg of *N. nebulosa* Stark & Sivec, 2008b, a Vietnamese species, but the striae are relatively straight in that species and the collar of *N. nebulosa* differs from the egg of this species. Among species known from South India, the egg collar is similar to that of *N. obscura*, but in that species the striae are narrow, sulci are wide and densely punctate, the lid is distinctly narrowed apically and bears conspicuous follicle cell impressions (Zwick 1981).

Neoperla sp. Id-D
(Figs. 31-32, 37-42)

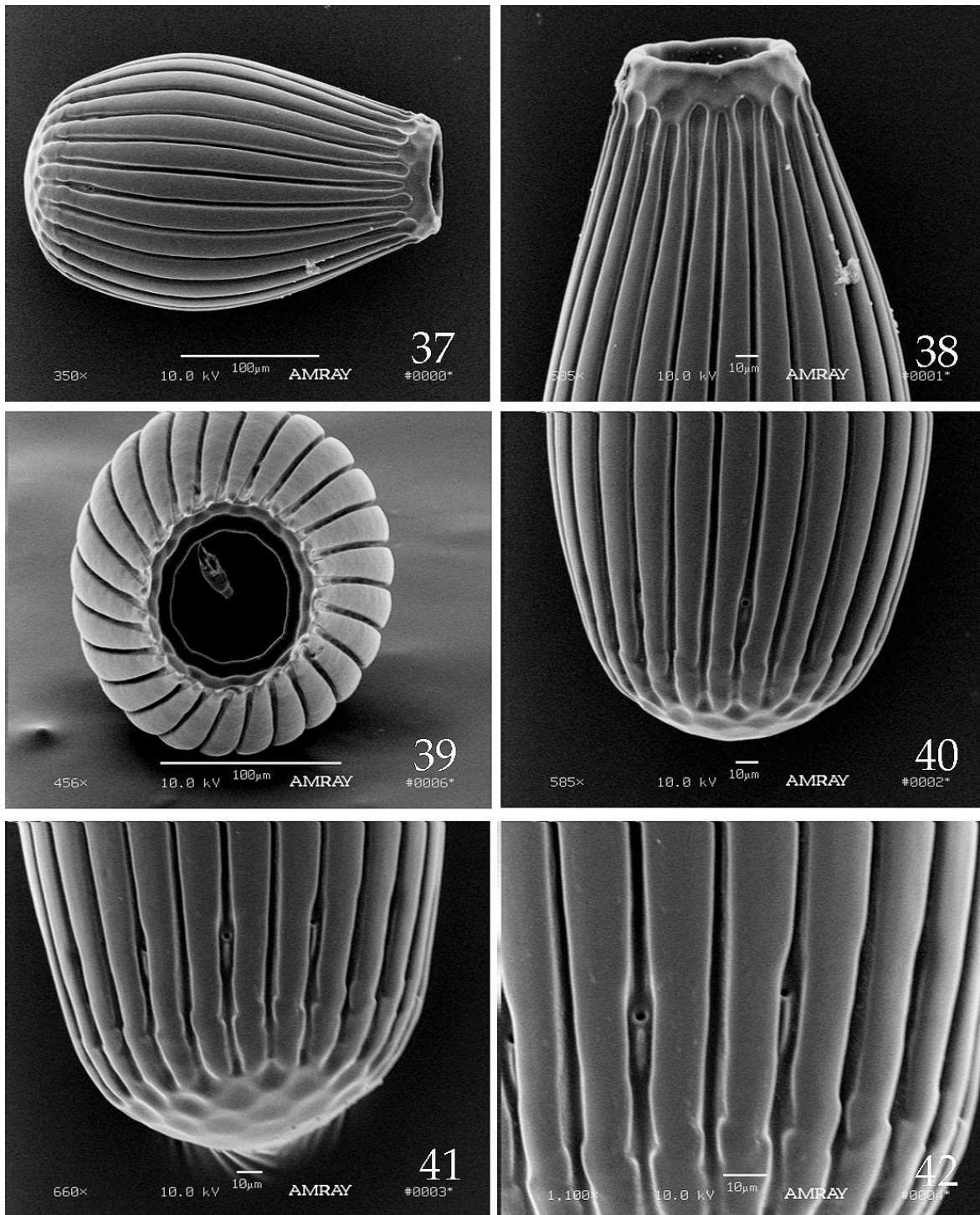
Material examined. INDIA: Karnataka, Agumbe Ghats, 13° 29.386'N, 75° 04.537'E, 9 October 2004, G. Svenson, 1♀ (BYUC).

Adult habitus. General color yellow-brown. Head yellow-brown with dark spot connecting ocelli and an obscure dusky brown area over tentorial calluses (Fig. 31); anteromedian area of frons and lappets darker brown; antennal bases pale brown. Pronotum pale brown with darker rugosities. Legs pale, slightly darker on upper tibiae. Wings transparent, veins pale brown except C and Sc pale.

Male. Unknown.

Female. Forewing length 11.5 mm. Subgenital plate undeveloped. Vagina membranous, but with a pair of thick parenthesis-shaped areas surrounding base of seminal receptacle duct (Fig. 32). Receptacular duct long and coiled twice around dorsal vaginal surface and base of membranous, sausage-shaped, coiled seminal receptacle. Receptacular duct lined full length with brown scales but in apical third scales restricted to median section of tube, not reaching lateral margins; in basal half, scales occur along outer margin, not extending to inner margin.

Egg. Outline jar-shaped with broad, short lid and narrow, sessile collar (Fig. 37). Length ca. 298 µm, equatorial width ca. 188 µm. Collar defined by a smooth ring ca. 18 µm wide; collar diameter ca. 69-77 µm (Figs. 38-39). Egg surface consists of ca. 25,



Figs. 37-42. *Neoperla* sp. Id-D eggs. 37. Entire egg, lateral. 38. Collar end. 39. Lid and micropylar zone. 40. Collar, apical aspect. 41. Micropylar zone. 42. Micropylar detail.

gently sinuate, smooth, wide striae; striae width near equatorial zone, ca. 15-16 μm ; sulci very narrow. Lid short and bearing obscure follicle cell impressions with smooth, apparently impunctate floors (Fig. 40). Ecdysis line absent; micropyles located subequatorially near lid but slightly beyond a zone with irregularly notched striae (Fig. 40); micropylar orifices slanted and set on elongate ridges (Figs. 41-42).

Larva. Unknown.

Comments. The egg of this species is similar to, and perhaps indistinguishable from that of *N. biseriata*, and the specimen was collected with a series of males determined as that species (see above). Because the receptacular duct of this female appears longer than in *N. biseriata* (Zwick et al. 2007), we are treating it as a possible separate species.

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