



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

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ABSTRACT

New records are given for *Neoperla cavaleriei* (Navás), *N. fallax* Klapálek, *N. gordonae* Stark, *N. hamata* Jewett, *N. mnong* Stark, *N. tamdao* Cao & Bae, *N. yentu* Cao & Bae and *N. yao* Stark and 15 new species of *Neoperla* are proposed from Vietnam. New taxa include *N. clara* sp. n., *N. daklak* sp. n., *N. dao* sp. n., *N. erecta* sp. n., *N. hubleyi* sp. n., *N. idella* sp. n., *N. leptacantha* sp. n., *N. monacha* sp. n., *N. multispinosa* sp. n., *N. nebulosa* sp. n., *N. sinuata* sp. n., *N. spinaloba* sp. n., *N. song* sp. n., *N. teresa* sp. n., and *N. zonata* sp. n. Female and/or egg descriptions are also presented for *N. hamata*, *N. mnong*, *N. tamdao* and *N. yao*, and females of two species are described with informal designations. *N. angustilobata* Zwick is placed as a synonym of *N. mnong* Stark. Provisional keys to males and a checklist of Vietnamese *Neoperla* are also presented.

Keywords: *Neoperla*, Plecoptera, Vietnam, New species

INTRODUCTION

Neoperla is perhaps the most speciose stonefly genus in Southeast Asia and, with almost 200 world species, it is also one of the most diverse among Perlidae. Significant progress in documenting this diversity occurred in the 1980's (Zwick 1983, 1986, 1988; Sivec 1981; Sivec & Zwick 1987; Zwick & Sivec 1985; Stark 1983, 1987) but since then the study of Asian *Neoperla* has declined and most recent work is based on descriptions of a few Chinese species (Yang & Yang 1990, 1993a, 1993b, 1995a, 1995b, 1998). Currently 21 *Neoperla* species are known for the combined areas of Vietnam, Laos, Thailand, Cambodia and West Malaysia, whereas Zwick (1986) reported a minimum of 30 species for Borneo alone. The known Vietnamese *Neoperla* include *N. angustilobata* Zwick (herein placed as a synonym of *N. mnong*), *N. cavaleriei* (Navás), *N. coronata* Zwick, *N. hoabinhica* Navás, *N. mnong* Stark, *N. nova* Zwick,

and *N. yao* Stark (Stark 1987; Zwick 1988); three new Vietnamese species, *N. sungi* Cao & Bae, *N. tamdao* Cao & Bae, and *N. yentu* Cao & Bae were recently described by Cao et al. (2007), and three additional species, *N. brachyura*, *N. ramosa*, and *N. vitalisi*, described by Navás from Vietnam, and listed by Illies (1966) as "Unsichere Arten", were unavailable to us.

The present study is based on samples of *Neoperla* collected in Vietnam by personnel of the Royal Ontario Museum, the Zoologisches Museum der Humboldt-Universität and by H. Malicky, Lunz (Austria). Our study of this material indicates a significant number of undescribed *Neoperla* species remain in Vietnam and in describing these new forms we emphasize the need for increased sampling in this region. We recognize 15 previously undescribed *Neoperla* in these samples, seven additional described species, and unassociated females for two species; only four of these were

previously known from Vietnam. The addition of these new species and records brings the known *Neoperla* fauna of Vietnam to 27 named species, if the three uncertain Navás species are excluded (Appendix A). Specimens are deposited in the Royal Ontario Museum, Toronto (ROM), the Slovenian Museum of Natural History, Ljubljana (PMSL), the Institute of Ecology and Biological Resources, Hanoi (IEBR), the Zoologische Museum der Humboldt-Universität, Berlin (ZMB), the United States National Museum of Natural History, Washington (USNM) and the Stark Collection, Clinton (BPS) as indicated in the text. Aedeagi were studied after preparation with the cold maceration technique of Zwick (1983).

RESULTS AND DISCUSSION

THE CLYMENE GROUP

Zwick (1983, 1986) recognized this major subgroup within *Neoperla* to include those species with a rather completely sclerotized aedeagal tube, and an internally spinose seminal receptacle stalk. Our material includes seven members of the *clymene* group.

Neoperla cavalieriei (Navás) (Figs. 88-90)

Ochthopetina cavalieriei Navás, 1922:49. Lectotype ♂ (Muséum National d'Histoire Naturelle) designated by Sivec & Zwick, 1987. Kouy-Tcheou

Material examined. Vietnam: Cao Bang, Ba Be National Park between gates and dorms, 22 May 1995, D. Currie, J. Swann, M. McGuffin, ROM 956119, 2 ♂ (ROM). Same site except near dorm annex, 14-23 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956049, 2 ♂ (ROM, IEBR). Same site except 20 May 1995, D. Currie, J. Whiting, ROM 956106, 2 ♂ (ROM, BPS). Cao Bang, Ba Be, 1 July 1995, C.F. Lee, 11 ♂, 6 ♀ (PMSL). Gia Lai, An Khe District, Tram Lap, Azun River, 3 km NE forestry building, 21 June 1996, D. Currie, J. Swann, ROM 961076, 1 ♂ (ROM).

Remarks. Sivec & Zwick (1987) redescribed this species from the lectotype and indicated an unusually large range including China, Vietnam, Laos, Thailand and Myanmar. The subtle variations

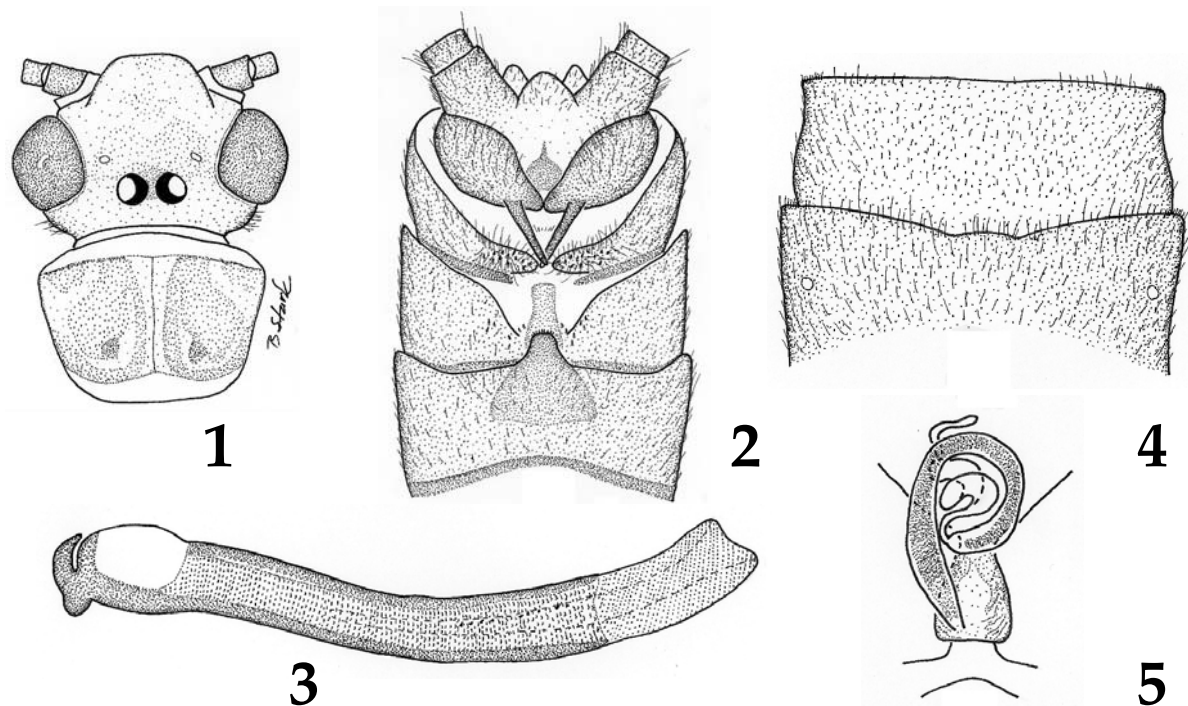
in aedeagal armature they note suggests this is a probable species complex which will require more material from throughout this range in order to gain resolution. Our sample shows little variation in aedeagal armature; the aedeagal tube is slender, sclerotized and bears minute spinules on the apical third. The sac has a prominent dorsobasal spiny cushion, a mid dorsal row of medium size spines and three irregular lateral rows of larger, cultriform spines imbedded proximal to a ventral grouping of fine spinules. Figs. 88-90 show the first SEM images for the egg of this species.

Neoperla clara sp. n. (Figs. 1-5, 91-93)

Material examined. Holotype ♂ and 2 ♀ paratypes from Vietnam, Dac Lac, Yok Don National Park, ca. 2 km SE Ban Don, 12° 53' N, 107° 48' E, 31 May 1997, D.C. Darling, D. Currie, A. Guidotti, ROM 974019 (ROM).

Adult habitus. Biocellate. Head pale with obscure pale brown ocellar spot. Pronotum pale with obscure rugosities; median suture and margins pale brown (Fig. 1). Wing membrane transparent, veins pale amber. Legs pale, tibiae with dark spot at knee.

Male. Forewing length 10 mm. Triangular process of tergum 7 rounded at apex and margined with spines. Median sclerite of tergum 8 a narrow, flattened bar, slightly expanded near anterior margin and without sensilla basiconica. Tergum 9 with lateral sensilla basiconica patches on low humps, median patch absent. Hemitergal processes long, slender and directed inward (Fig. 2). Aedeagal tube well sclerotized on dorsal and ventral margin but membranous laterally; lateral tube membrane covered throughout with small spinules, dorsal tube surface with a mesal patch of small triangular spines near apex, but much of surface bears low, wide spinules which appear as groups of short lines (Fig. 3). Sac about as long as tube and armed rather uniformly over at least basal half with small spines; sac not fully everted, but a group of somewhat larger spines organized as an irregular double row for ca. 7 pairs, and continuing as a single row of progressively smaller spines for ca. 15 additional spines, occurs beyond midlength of sac (Fig. 3).



Figs. 1-5. *Neoperla clara*. 1. Head and pronotum, 2. Male terminalia, 3. Aedeagus, 4. Female terminalia, 5. Vagina and spermatheca.

Putative Female. Forewing length 11.5-12.5 mm. Subgenital plate not produced; posteromesal margin of sternum 8 recessed slightly (Fig. 4). Vagina slender, spermathecal stalk long, coiled and lined for almost entire length with brown spines; spermatheca coiled and bearing a single accessory gland near apex (Fig. 5).

Egg. Length ca. 0.31 mm, width ca. 0.15 mm. Collar not distinctly stalked, but slightly constricted at base; width ca. 0.08 mm at rim (Figs. 91-93). Sides of collar with a single irregular row of poorly formed cells; rim narrow and slightly flanged overlapping cell row. Chorion striate with ca. 14 wide striae and ca. 13 narrow sulci visible in lateral aspect; sulci with three irregular rows of pores near collar and lid. Follicle cell impressions on lid distinct but becoming less so near apex; cells have thick, smooth walls and floors are punctate. Striae join marginal row of FCIs on lid and collar. Micropyles subequatorial in position and with slender, elongate sperm guides set in sulci.

Larva. Unknown.

Etymology. The species name refers to the transparent, or clear, wing membrane.

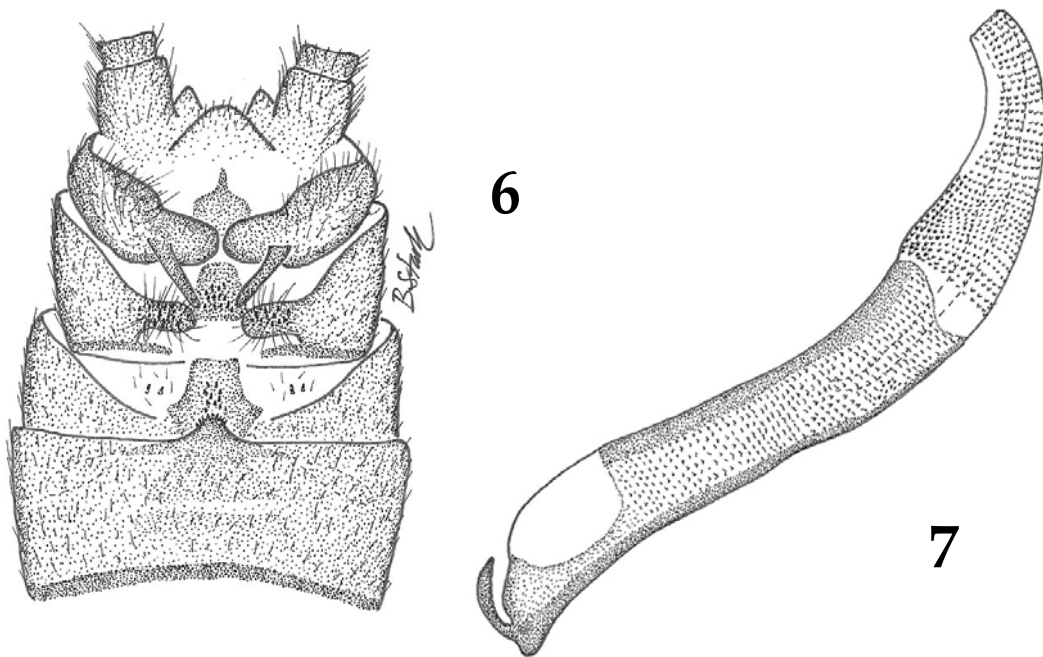
Diagnosis. The aedeagus of this species bears a

general resemblance to that of *N. gordonae* Stark and *N. cavaleriei* but the tube of those species is more fully sclerotized and lacks the extensive lateral spinule patch and dorsoapical spine patch found on the tube of *N. clara*. The species appears to be more closely related to *N. daklak*, a small dark species collected at the same locality. The aedeagal tube of that species is similar but the sac armature has more variably sized spines forming the basolateral patch and this is separated from the tube armature by a narrow bare ring. In addition, the sac of that species lacks the larger spines found beyond midlength, the 9th tergum has a median sensilla patch and the 8th mesal sclerite is larger and more triangular in outline.

***Neoperla daklak* sp. n.**
(Figs. 6-7)

Material examined. Holotype ♂ (pinned) from Vietnam, Dac Lac, Yok Don National Park, ca. 2 km SE Ban Don, 12° 53' N, 107° 48' E, 31 May 1997, D.C. Darling, D. Currie, A. Guidotti, ROM 974019 (ROM).

Adult habitus. Biocellate. Head dark brown. Pronotum dark brown with darker rugosities;



Figs. 6-7. *Neoperla daklak*. 6. Male terminalia, 7. Aedeagus.

median suture and margins black. Wings tinted pale brown, veins darker but costal area pale. Legs brown.

Male. Forewing length 9 mm. Triangular process of tergum 7 broadly rounded and spinulose at apex. Median sclerite of tergum 8 a low triangular mound with sensilla basiconica scattered along its length. Tergum 9 with median and lateral patches of sensilla basiconica set on low humps. Hemitergal processes moderately long and straight (Fig. 6). Aedeagal tube lightly sclerotized and covered over lateral and dorsoapical surfaces with small spinules (Fig. 7). Sac base with a narrow, unarmed ring but otherwise armed with a continuous patch of variably sized spines over at least basal half; no distinctly large spines present near or beyond midlength (Fig. 7).

Female. Unknown.

Larva. Unknown.

Etymology. The species name, used as a noun in apposition, is based on the province where the holotype was collected.

Diagnosis. See above discussion under *N. clara*.

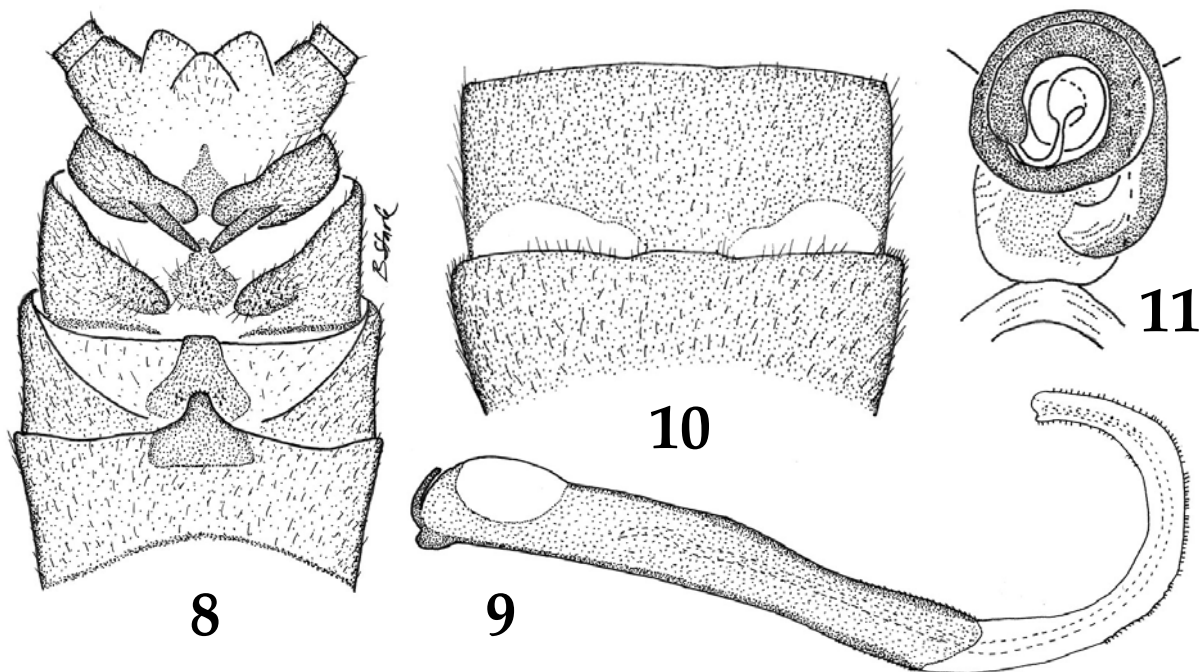
Neoperla gordonae Stark

Neoperla gordonae Stark, 1983:109. Holotype ♂ (National Reference Collection, Thailand). Wannaset Stream, Sahaerate Field Station, Thailand

Material examined. Vietnam: Cao Bang, Ba Be National Park near dorm annex, 14-23 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956049, 1 ♂ (ROM). Dong Nai, Cat Tien National Park, stream near park headquarters, 11° 26' N, 107° 25' E, 23 August 1998, B. Hubley, D. Currie, ROM 982006, 1 ♂ (ROM). Gia Lai, An Khe District, 10 km NW Buoenloy, Cha River, road to Tram Lap, 27 June 1996, D. Currie, ROM 961098, 1 ♂ (ROM). Gia Lai, An Khe District, Dacklest River 5.2 km NE Tram Lap, 14° 24' N, 108° 33' E, 15 June 1996, D. Currie, J. Swann, ROM 961047, 1 ♂ (ROM). Gia Lai, An Khe District, Tram Lap, Azun River, 2 km NE forestry building, 23 June 1996, D. Currie, J. Swann, ROM 961084, 3 ♂ (ROM, IEBR). Same but 17 June 1996, D. Currie, J. Swann, ROM 961056, 2 ♂ (ROM). Gia Lai, Buoenloy, April 1995, A. Gorohov, 2 ♂ (PMSL). Nghe An, ca. 25 km SW Con Cuong, Khe Moi Forestry Camp, tributary Khe Moi River, 18° 56' N, 104° 49' E, 4 June 1995, B. Hubley, J. Swann, ROM 956158, 1 ♂ (ROM). Same except 100 m above Khe Moi Forestry Camp, 5 June 1995, B. Hubley, J. Swann, ROM 956161, 1 ♂ (ROM). Nghe An, Con Cuong, Con River, 2 June 1995, B. Hubley, J. Swann, ROM 956148, 4 ♂ (ROM, IEBR). Nghe An, ca. 25 km SW Con Cuong, Khe Moi Forestry Camp, 18° 56' N, 104° 49' E, 3 June 1995,

ROM 956150, B. Hubley, J. Swann, 1 ♂ (ROM). Tuyen Quang, Pac Ban, Gam River, 21 May 1996, D. Currie, D.C. Darling, J. Swann, ROM 963002, 1 ♂ (ROM). Tuyen Quang, Pac Ban, 25 May 1996, D. Currie, D.C. Darling, J. Swann, ROM 963078, 2 ♂ pinned (ROM). **Remarks.** This species was previously known from Thailand (Stark 1983; Uchida & Yamasaki 1989) and is closely related to *N. leptacantha*, described below. Some variation in distribution of aedeagal sac armature was obvious among these specimens with those from each site generally being fairly consistent. Most of the variation involves relative size and

position of the dorsobasal spine patch. The most common form in these samples has a few fine spicules on the tube apex, a small dorsobasal patch of spinules on the everted sac, and short rows of small, curved hooks on both dorsal and ventral margins; these end well before midlength leaving the apical sac surface unarmed. Other specimens lack the apical tube spicules and have the dorsobasal sac patch more or less expressed and are more similar to the holotype in these respects. This entire complex will need to be analyzed when more female associations and egg studies are available.



Figs. 8-11. *Neoperla leptacantha*. 8. Male terminalia, 9. Aedeagus, 10. Female terminalia, 11. Vagina and spermatheca.

***Neoperla leptacantha* sp. n.**
(Figs. 8-11, 103-105)

Material examined. Holotype ♂, paratype ♀, from Vietnam, Cao Bang, Ba Be National Park, junction Lake Ba Be Road and ethnic village trail, 18 May 1995, D. Currie, J. Swann, ROM 956068 (ROM).

Paratypes: Vietnam: Nghe An, Coa Cuong, Con River, 2 June 1995, B. Hubley, J. Swann, ROM 956148, 3 ♂ (ROM). Tuyen Quang, Pac Ban, 25 May 1996, D. Currie, D.C. Darling, J. Swann, ROM 963078, 1 ♂ pinned (IEBR). Tuyen Quang, Pac Ban, Gam River, 21 May 1996, D. Currie, D.C. Darling, J. Swann, ROM 963002, 1 ♂ (ROM).

Adult habitus. Biocellate. Head yellow brown with small dark ocellar spot. Pronotum pale with indistinct rugosities. Wings pale amber with slightly darker veins; costal area pale. Legs pale but tibiae darker at knee.

Male. Forewing length 9.5-10.5 mm. Tergum 7 process triangular with blunt tip margined by 5-6 spines. Mesal sclerite of tergum 8 a low mound with small sensilla basiconica patch near front of sclerite and sparse, short dark bristle patches anterolateral and posterior to sensilla basiconica patch. Tergum 9 with mesal and lateral sensilla basiconica patches on low mounds. Hemitergal processes short, straight and slanted inward (Fig. 8). Aedeagal tube slender but wider at base, lightly sclerotized, and armed with minute spinules on most of surface (Fig. 9). Aedeagal sac longer than tube and unarmed along ventrobasal margin to near midlength; dorsobasal patch reduced to a few, mostly mesal spinules clearly removed from tube apex; major dorsal sac armature consists of two irregular, crowded rows beginning before ventral armature; largest spines along both margins straight and peg shaped (Fig. 9). No armature occurs on apical third of sac.

Putative Female. Forewing length 11.5 mm. Subgenital plate unproduced, set off from posterior margin of sternum 8 by slight emarginations (Fig. 10). Vagina long and slender with a patch of brown setae lining dorsal wall around base of spermatheca. Spermatheca long, coiled and lined rather completely with brown setae, but lining is incomplete particularly in basal area (Fig. 11).

Egg. Outline oval. Length ca. 0.29 mm, width ca. 0.15 mm. Collar sessile, width ca. 0.065 mm; collar margined by an irregular row of poorly defined cells; rim smooth, narrow and slightly flanged (Figs. 103-105). Chorion striate, striae moderately wide with ca. 14 visible in lateral aspect; sulci about half as wide as striae and densely punctate with ca. 3-4 rows of punctures. Striae slightly notched around micropyles; micropyles set on long, low mounds. Lid small but covered with prominent follicle cell impressions; FCIs densely punctate with ca. 65 or more punctures present in each cell; walls of cells smooth and moderately thick.

Larva. Unknown.

Etymology. The species name refers to the small, slender spines of the aedeagal sac.

Diagnosis. The aedeagus and external male genitalia of this species are similar to those of *N. cavaleriei* and *N. gordonae*. It differs from these and other members of the complex in having the dorsobasal spine patch reduced to a few minute spinules restricted to a sparse, irregular, mesal grouping discreetly removed from the tube apex, and in having the ventral armature absent from the basal third of the sac. In addition, the largest sac armature consists primarily of straight, peg shaped spines mixed with small cultriform shaped spines. The female and egg (if correctly associated) are also of the same general types as found in *N. cavaleriei* and *N. gordonae* but the egg in particular, differs in having relatively prominent FCIs on the lid, and is more similar to the egg of *N. clara*. These species (except *N. clara*) co-occur at the Ba Be National Park sites in Cao Bang province.

Neoperla monacha sp. n.

(Figs. 12-14)

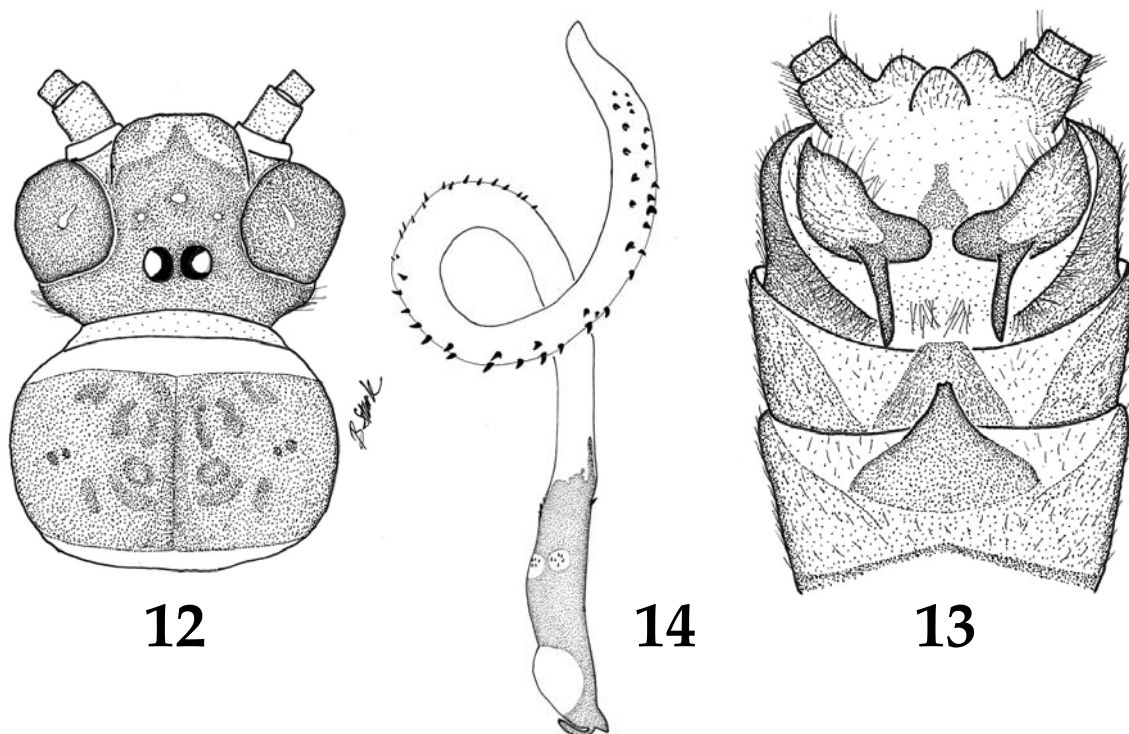
Material examined. Holotype ♂ from Vietnam, Cao Bang, Ba Be National Park near dorm annex, UV light, 17 May 1995, D. Currie, J. Swann, J. Whiting, ROM 956058 (ROM).

Adult habitus. Biocellate. Head dark brown over occiput and most of frons; antennal bases pale. Pronotum brown with darker rugosities (Fig. 12). Wings brown, veins dark brown with basal half of R vein very dark and costal area pale. Legs uniformly dark brown.

Male. Forewing length 10 mm. Tergum 7 process triangular, armed on apex with 2-3 spines. Tergum 8 mesal sclerite a low triangular mound with a few sensilla basiconica. Tergum 9 without sensilla patches. Hemitergal processes straight and relatively long (Fig. 13). Aedeagal tube sclerotized and bearing a small lateral spiny knob in apical third and a pair of low spiny knobs near these on venter; additional spines occur on tube at dorsoapical and ventroapical margins (Fig. 14). Aedeagal sac about 2.5 times as long as tube and sparsely armed along most of sac length with an irregular row of large dorsal spines; short lateral row of additional spines occur at base of sac (Fig. 14).

Female. Unknown.

Larva. Unknown.



Figs. 12-14. *Neoperla monacha*. 12. Head and pronotum, 13. Male terminalia, 14. Aedeagus.

Etymology. The species name refers to the presumed rarity of this species.

Diagnosis. This small, dark brown species has relatively straight, inwardly slanted hemitergal processes, few sensilla basiconica on tergum 8 and none on tergum 9; however a few long setae are present in a mesal patch on tergum 9 between the tips of the hemitergal processes. The aedeagal sac is extraordinarily long, at least 2.5 times as long as the tube and the sac armature consists of an irregular, sparse row of large spines along most of the sac length. The tube bears two pairs of small, ventrolateral spiny knobs beyond midlength. The aedeagus of this species does not appear very similar to any of the known Asian species. The size and color pattern of this species are similar to *N. teresa* and *Neoperla* VN-A (both described below) but *N. monacha* differs from both in having uniformly dark hind femora.

Neoperla sinuata sp. n.
(Figs. 15-18)

Material examined. Holotype ♂ and 1 ♂ paratype

from Vietnam, Dong Nai, Cat Tien National Park, stream crossing road N of park headquarters, 11° 26' N, 107° 25' E, 120 m, UV light, 23 August 1998, B. Hubley, D. Currie, ROM 982006, (ROM). Additional paratype: Vietnam: Dong Nai, Cat Tien National Park, near park headquarters, 11° 25' 22" N, 107° 25' 41" E, 22 August 1998, B. Hubley, D. Currie, ROM 982002, 1 ♂ (IEBR).

Adult habitus. Biocellate. Head pattern mostly pale but with an obscure ocellar spot. Pronotum pale brown with slightly darker rugosities; median suture, anterior and posterior margins dark (Fig. 15). Wing membrane pale amber, veins darker, costal area pale. Femora pale brown, tibiae darker.

Male. Forewing length 7.5-8 mm. Tergum 7 process triangular and armed apically with 3-4 small spines. Mesal sclerite of tergum 8 a low mound with a small patch of sensilla basiconica. Tergum 9 with lateral sensilla basiconica patches set on low mounds and with a small median patch set on a flat sclerite. Hemitergal lobes relatively straight (Fig. 16). Aedeagal tube slender and poorly sclerotized; dorsal margin armed beyond midlength with a few spines and ventral margins with a pair of apical spiny lobes

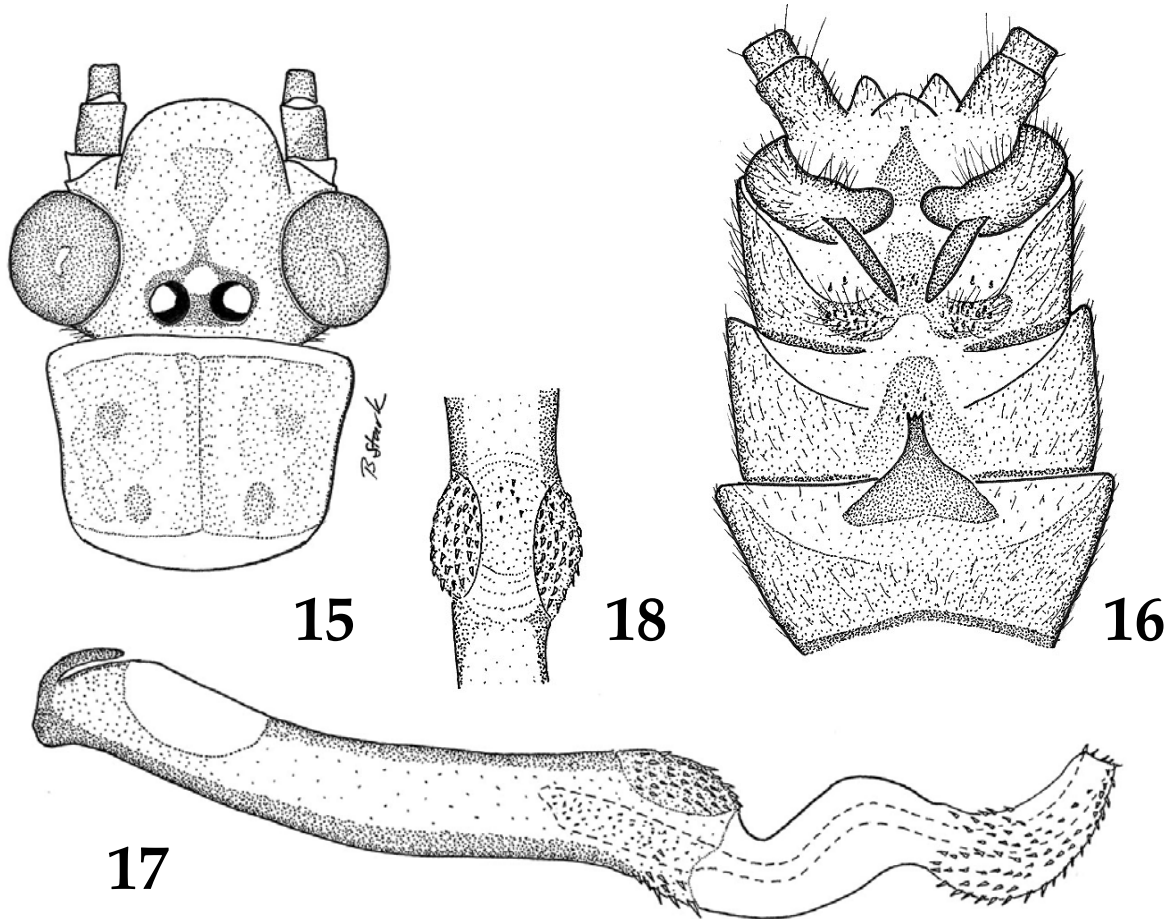
(Figs. 17-18). Aedeagal sac sinuately curved and armed with a spine patch that rings sac near midlength and continues along dorsal margin (Fig. 17).

Female. Unknown.

Larva. Unknown.

Etymology. The species name refers to the sinuate form of the aedeagal sac.

Diagnosis. The aedeagus of *N. sinuata* is generally similar to that of *N. saraburi* Zwick but in that species the ventroapical spiny lobes of the tube are absent (Zwick 1988).



Figs. 15-18. *Neoperla sinuata*. 15. Head and pronotum. 16. Male terminalia. 17. Aedeagus. 18. Aedeagal tube armature, ventral.

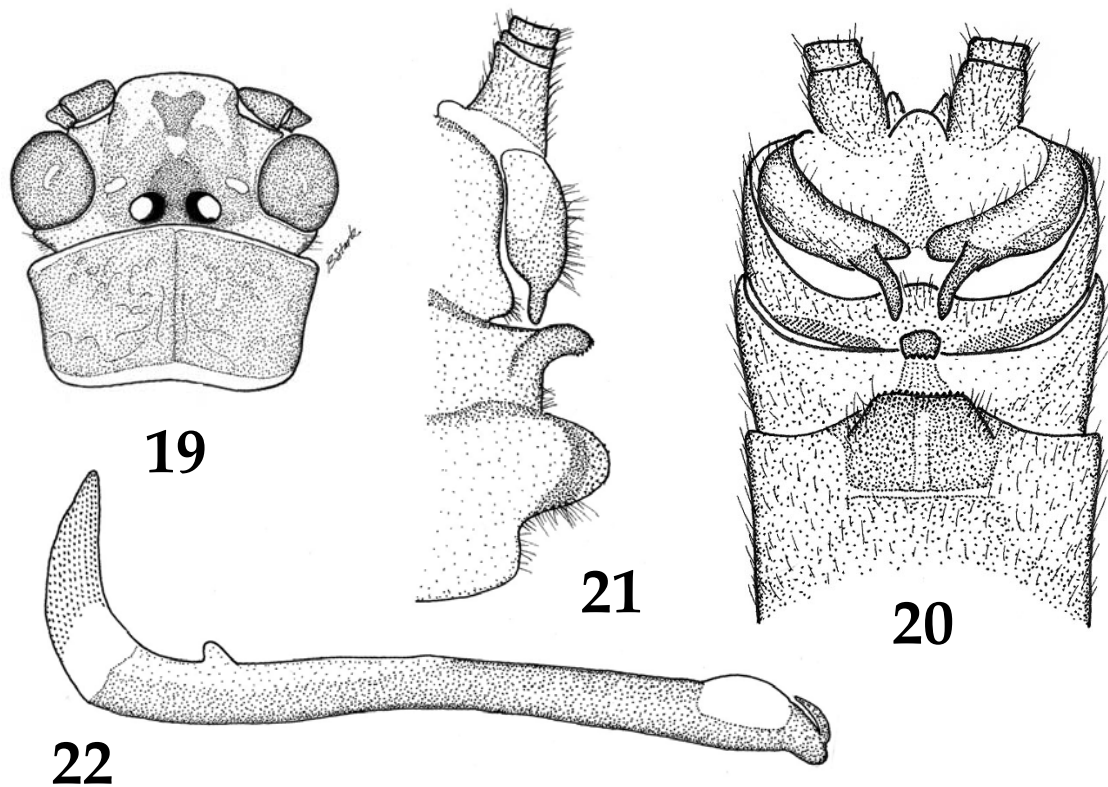
THE MONTIVAGA GROUP

Zwick (1983, 1986) recognized this major subgroup of *Neoperla* as a group of species whose aedeagus has reduced sclerotization, particularly on the ventral surface and a simple, often hook shaped and unlined seminal receptacle. Our material includes records of 16 members of this group.

Neoperla dao sp. n. (Figs. 19-22)

Material examined. Holotype ♂ (pinned) from Vietnam, Vinh Phu, Tam Dao Hill Station, 930 m, UV light, 15 May 1996, B. Hubley, D.C. Darling, M. Hanson, ROM 961032 (ROM). Paratype: Vietnam: Vinh Phu, Tam Dao, 800-900 m, 17-31 May 1995, A. Gorohov, 1 ♂ (PMSL).

Adult habitus. Biocellate. Head mostly dark but M-line, clypeus and tentoria pale. Pronotum brown with darker rugosities (Fig. 19). Wings dark brown, veins darker except pale costal area. Femora pale in basal half and dark brown apically; tibiae dark brown.



Figs. 19-22. *Neoperla dao*. 19. Head and pronotum, 20. Male terminalia, 21. Male terminalia, lateral aspect, 22. Aedeagus.

Male. Forewing length 16 mm. Tergum 7 process a raised plateau armed with scattered sensilla basiconica. Tergum 8 process tongue shaped, erect and curved forward (Fig. 21); anterodorsal margin of process with a small patch of sensilla basiconica. Tergum 9 without sensilla patches. Hemitergal processes short and slender (Fig. 20). Aedeagal tube very slender, relatively straight and heavily sclerotized except for a small subapical nipple shaped lobe (Fig. 22). Aedeagal sac very short, ca. 1/3 tube length; sac without large spines but armed over most of surface with minute spines; base of sac unarmed (Fig. 22).

Female. Unknown.

Larva. Unknown.

Etymology. The species name, used as a noun in apposition, honors the Dao people of Vinh Phu Province.

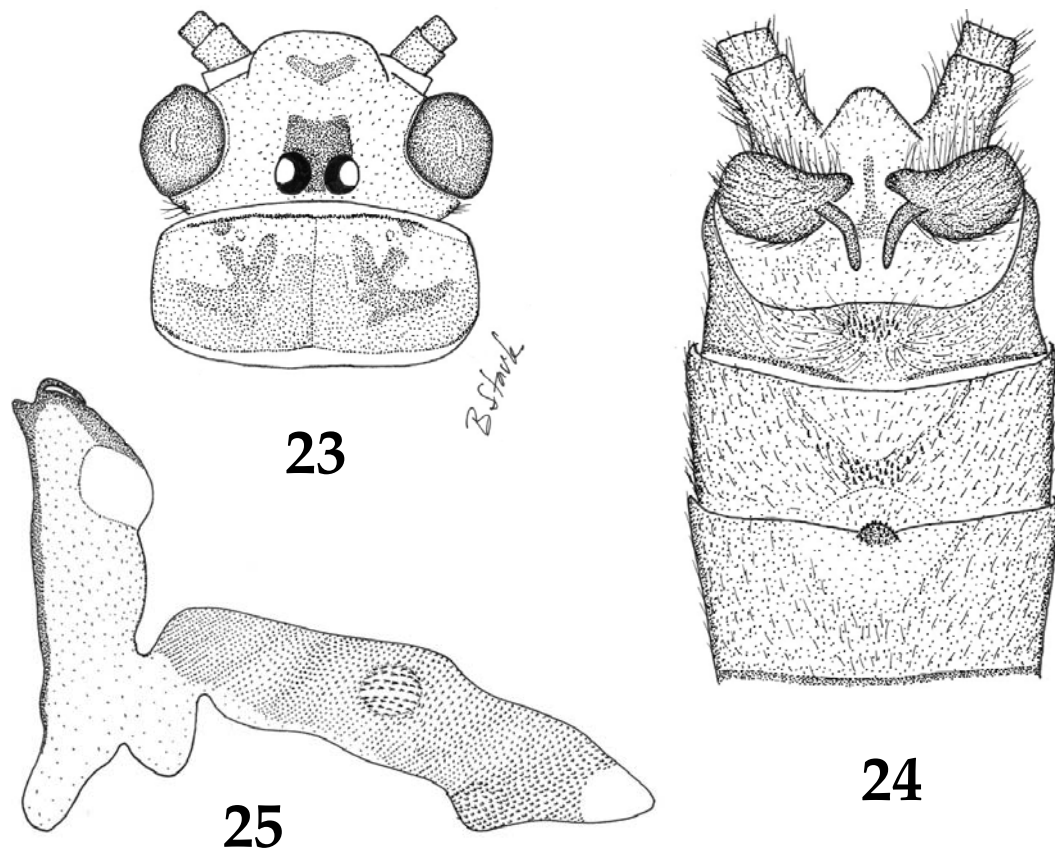
Diagnosis. The aedeagus of this species is generally similar to that of *N. yentu* but that species has a curved aedeagal tube and the ventral process is

bilobed. Yang & Yang (1995a, 1998) described three species which appear to be members of this complex. Two of these, *N. hainanensis* and *N. quingyuanensis*, have bowed aedeagal tubes but the other, *N. longwangshana*, has the tube and ventral lobe more similar to *N. dao*. Unfortunately the aedeagal sac was not shown in an everted position in Yang & Yang (1998), and no material is available for our study, so no detailed comparison can be made for these species.

Neoperla erecta sp. n.
(Figs. 23-25)

Material examined. Holotype ♂ from Vietnam, Lao Cai, Muong Hoa Ho River, 5-12 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956007 (ROM).

Adult habitus. Biocellate. Head pale except for quadrate spot over ocelli and obscure chevron centered on anterior of frons (Fig. 23). Wing membrane, veins and legs pale.



Figs. 23-25. *Neoperla erecta*. 23. Head and pronotum, 24. Male terminalia, 25. Aedeagus.

Male. Forewing length 9.5 mm. Process of tergum 7 small, rounded and margined with spines. Mesal field of tergum 8 bearing a sparse patch of sensilla basiconica; mesal field of tergum 9 bearing long setae and mixed sensilla basiconica (Fig. 24). Hemitergal lobes broad basolaterally and narrow at apex; hemitergal processes long, slender and curved near midlength. Aedeagal tube plump and weakly sclerotized; aedeagal sac longer than tube, erect, strongly directed ventrad, and originating in a preapical position (Fig. 25). Sac armed over most of surface with small triangular spines; spines larger on lateral humps at midlength and in patch near apex.

Female. Unknown.

Larva. Unknown.

Etymology. The species name refers to the upright (but ventrally directed) orientation of the aedeagal sac.

Diagnosis. The aedeagus of *N. erecta* is similar to that of *N. melanocephala* (Navás), a species from Myanmar redescribed by Zwick (1988). That species, however, is very dark and the aedeagal sac is covered rather completely by small spines of uniform size except for slightly larger ones in a partial basal ring. Among known Vietnamese species the aedeagus is generally similar to that of *N. nebulosa* but these species are fundamentally different in the pattern and shape of male tergal lobes in addition to conspicuous differences in aedeagal sac armature.

Neoperla fallax Klapálek

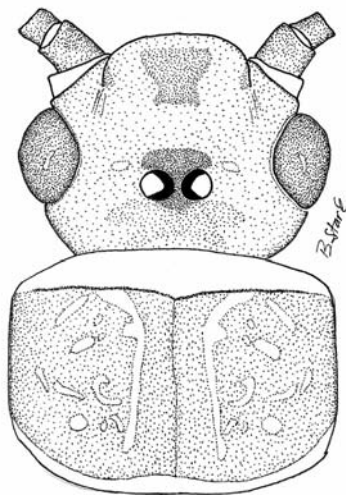
Neoperla fallax Klapálek, 1909:44. Holotype ♀ (National Museum, Prague). Java

Material examined. Vietnam: Gia Lai, An Khe District, Tram Lap, 2 km NW on trail from forestry

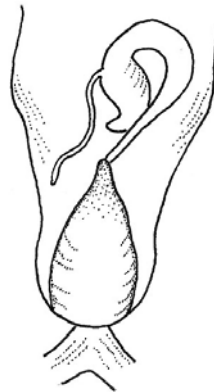
building, 14° 27' N, 108° 33' E, 17 June 1996, D. Currie, J. Swann, ROM 961056, 1 ♂ (ROM).

Remarks. This species was previously reported from Java, Sumatra, Malaysia and Thailand where considerable variation in egg collar morphology was noted (Zwick 1983). This Vietnamese specimen appears to have a more prominent dorsobasal spine

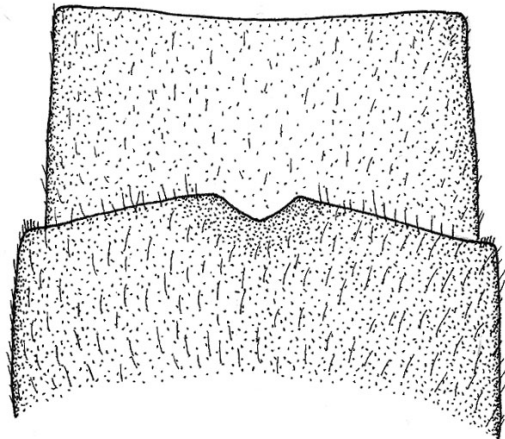
patch on the aedeagal sac, and the subapical spines also appear more prominent than shown for Malaysian specimens (Zwick 1983). In addition the membranous lateral areas of much of the tube are covered with fine spinules in this specimen but these are not mentioned by Zwick (1983).



26



27



28

Figs. 26-28. *Neoperla hamata*. 26. Head and pronotum, 27. Vagina and spermatheca, 28. Female terminalia.

***Neoperla hamata* Jewett**
(Figs. 26-28, 94-96)

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

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

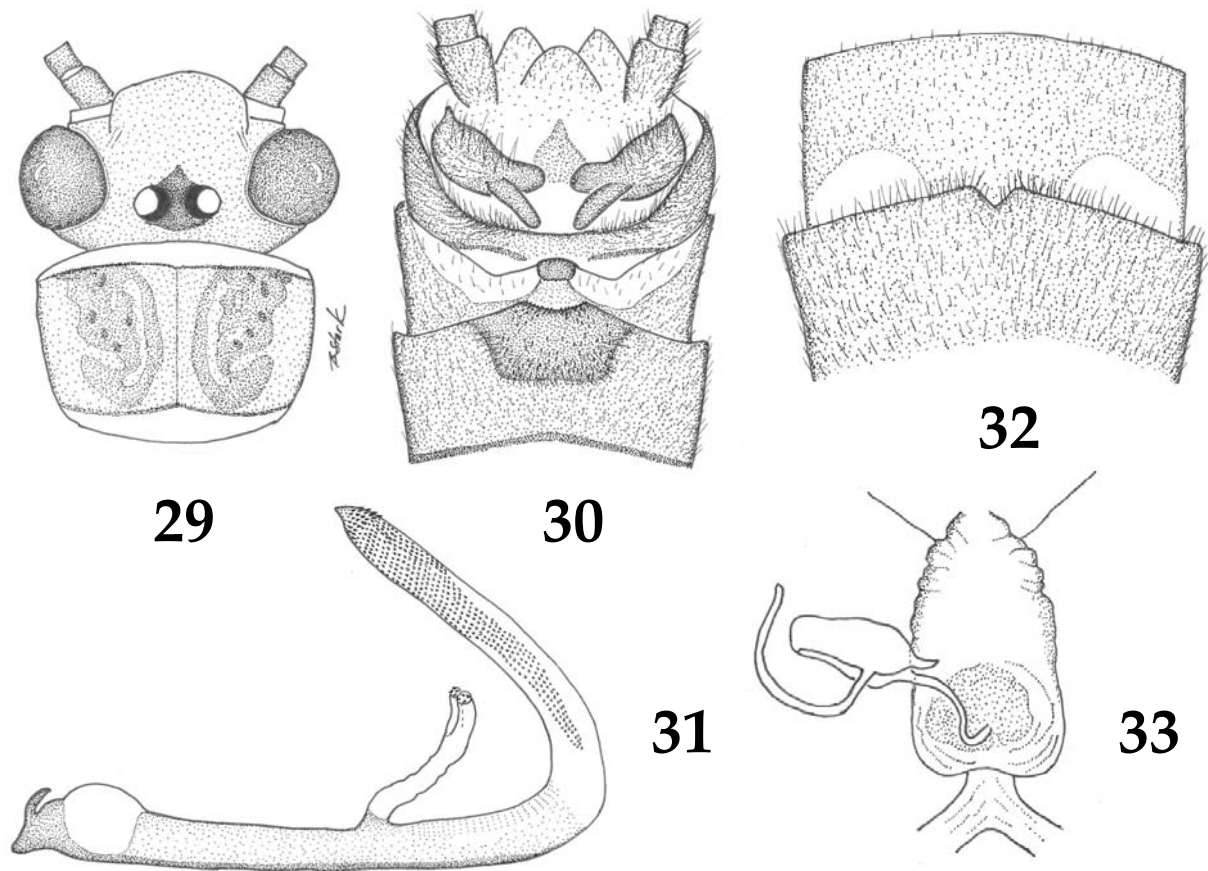
Material examined. Vietnam: Nghe An, W of Con Cuong, Khe Moi Forestry Camp, Khe Moi River, 18° 56' N, 104° 99' E, 23-24 October 1994, D. Currie, ROM 946110, 1 ♀ (ROM). Tuyen Quang, 6 km NE Pac Ban, UV light, 31 May 1996, D. Currie, D. Darling, J. Swann, ROM 963095, 1 ♀ pinned (ROM).

Remarks. In their study of the type material of this species, Uchida & Yamasaki (1989) indicate the female had been incorrectly associated, thus the true female of *N. hamata* has remained unknown. We offer the following description of female and egg for this

species based on our associations from Thai material. Fig. 26. shows details of the head and pronotal color pattern.

Female. Forewing length 16 mm. Subgenital plate slightly produced, relatively wide and with a wide, shallow notch; central region of sternum 8 almost hairless (Fig. 28). Vagina long and slender with upturned apex (Fig. 27). Spermathecal stalk slender; spermatheca slender, short, curled and broadly hooked apically; a single accessory gland occurs near the spermathecal apex.

Egg. Pear shaped. Length ca. 0.31 mm, width ca. 0.22 mm. Collar sessile, ca. 0.08 mm wide at rim; rim not flanged; sides of collar with two irregular rows of cells; lower row of cells punctate; irregular low ridges extend from cell meshwork onto egg body (Figs. 94-96). Chorion coarsely punctate throughout; pores surrounded by 4-6 tiny spikes giving edges, particularly of lid, a spiny appearance.



Figs. 29-33. *Neoperla hubleyi*. 29. Head and pronotum, 30. Male terminalia, 31. Aedeagus, 32. Female terminalia, 33. Vagina and spermatheca.

Neoperla hubleyi sp. n.
(Figs. 29-33, 97-99)

Material examined. Holotype ♂ from Vietnam, Cao Bang, Ba Be National Park, near dorm annex, UV light, 17 May 1995, D. Currie, J. Swann, J. Whiting, ROM 956058, (ROM). Paratypes: Vietnam, Cao Bang, Ba Be National Park, between gates and dorm, UV light, 22 May 1995, D. Currie, J. Swann, M. McGuffin, ROM 956119, 1 ♂ (ROM). Vietnam, Nghe An, ca. 25 km SW Con Cuong, Khe Moi Forestry Camp, 18° 45' N, 104° 49' E, 3 June 1995, B. Hubley, J. Swann, ROM 956150, 1 ♂ (ROM). Vietnam, Thua Thien-Hue, Bach Ma National Park near junction Rhododendron and Five Lakes Trails, 16° 11' N, 107° 51' E, 16 June 2000, B. Hubley, D.C. Darling, ROM 2000531, 1 ♂ pinned (IEBR), 1 ♀ (ROM). Vietnam, Vinh Phu, Tam Dao Hill Station, 3-31 May 1996, B. Hubley, D.C. Darling, M. Hanson, ROM 961002, 1 ♂ pinned (ROM). Same site,

11-13 October 1994, D. Currie, UV light, ROM 946002, 1 ♀ (ROM). Vietnam, Vinh Phu, Tam Dao, lower waterfall on stream flowing through town, 11 May 1996, B. Hubley, D.C. Darling, ROM 961030, 1 ♂ pinned (ROM).

Adult habitus. Biocellate. Head with a small dark spot, pointed medially, over ocelli. Pronotum pale brown with obscure, slightly darker rugosities; anterior and posterior margins and median suture dark brown (Fig. 29). Wing membrane pale amber, veins darker. Femora yellow but slightly darker dorsoapically.

Male. Forewing length 10.5-11.5 mm. Tergum 9 process a rounded plateau, concave on posterior margin and sprinkled with small sensilla basiconica over entire process. Process of tergum 8 tongue shaped, erect and armed on anterodorsal margin with small spines. Tergum 9 without sensilla patches (Fig. 30). Hemitergal processes short and slightly

curved. Aedeagal tube long, slender, lightly sclerotized on ventral margin and bearing in apical third a slender, bifurcate lobe; arms of lobe about half as long as stalk and armed on tips with a few (ca. 4-5) small spines; ventral margin of tube distal to lobe covered with rows of fine spicules (Fig. 31). Aedeagal sac about as long as tube and curved strongly ventrad; small area on apex armed with a patch of slightly larger, red-brown erect spines but most of sac covered with small flattened scale-like spines; dorsal margin unarmed for most of sac length but ventral margin armed for at least half the sac length; a basolateral lobe of scale armature extends nearly to base of sac (Fig. 31).

Putative Female. Forewing length 12-13 mm. Subgenital plate slightly produced and notched. Vagina elongate-oval, lined along lateral margins with sparse patches of pale brown spinules, and lined more densely around base of spermathecal stalk (Fig. 32). Spermathecal stalk slender, unlined and supporting a recurved, sausage shaped spermatheca with hooked apex (Fig. 33).

Egg. Barrel shaped. Length ca. 0.33 mm, width ca. 0.18 mm. Collar not distinctly stalked, width ca. 0.1 mm at rim. Rim smooth, primary striae join rim on sides of collar (Figs. 97-99). Primary striae smooth and widely spaced, ca. 10 visible in lateral aspect; a pair of secondary striae present between each pair of primaries; secondary striae thick near middle of egg but strongly tapered and inconspicuous toward each end. Sulci with three rows of punctations. Lid covered with prominent, thick walled, follicle cell impressions; floors of FCIs punctate.

Larva. Unknown.

Etymology. The patronym honors Brad Hubley of the Royal Ontario Museum in recognition of his efforts in collecting this material and in making it available to us for our study.

Diagnosis. This species is a member of the *N. diehli* Sivec species complex and is quite similar to *N. han* Stark, a species described from Hong Kong (Stark 1987) and subsequently reported from Guizhou Province (Yang & Yang 1993b). The two species can be distinguished by comparing details of the aedeagal sac armature. In *N. han*, the entire sac surface is covered with scale-like spines from the tip to near the base, and the largest spines occur basolaterally, whereas in *N. hubleyi* most of the dorsal

sac margin is unarmed and the scale spines are uniform in size throughout most of the patch with only the apical area having larger spines. The female association is based on co-occurrence at two sites (Bach Ma National Park and Tam Dao Hill Station) for a pair of somewhat teneral females with ocellar patches similar to those of male specimens.

***Neoperla idella* sp. n.**

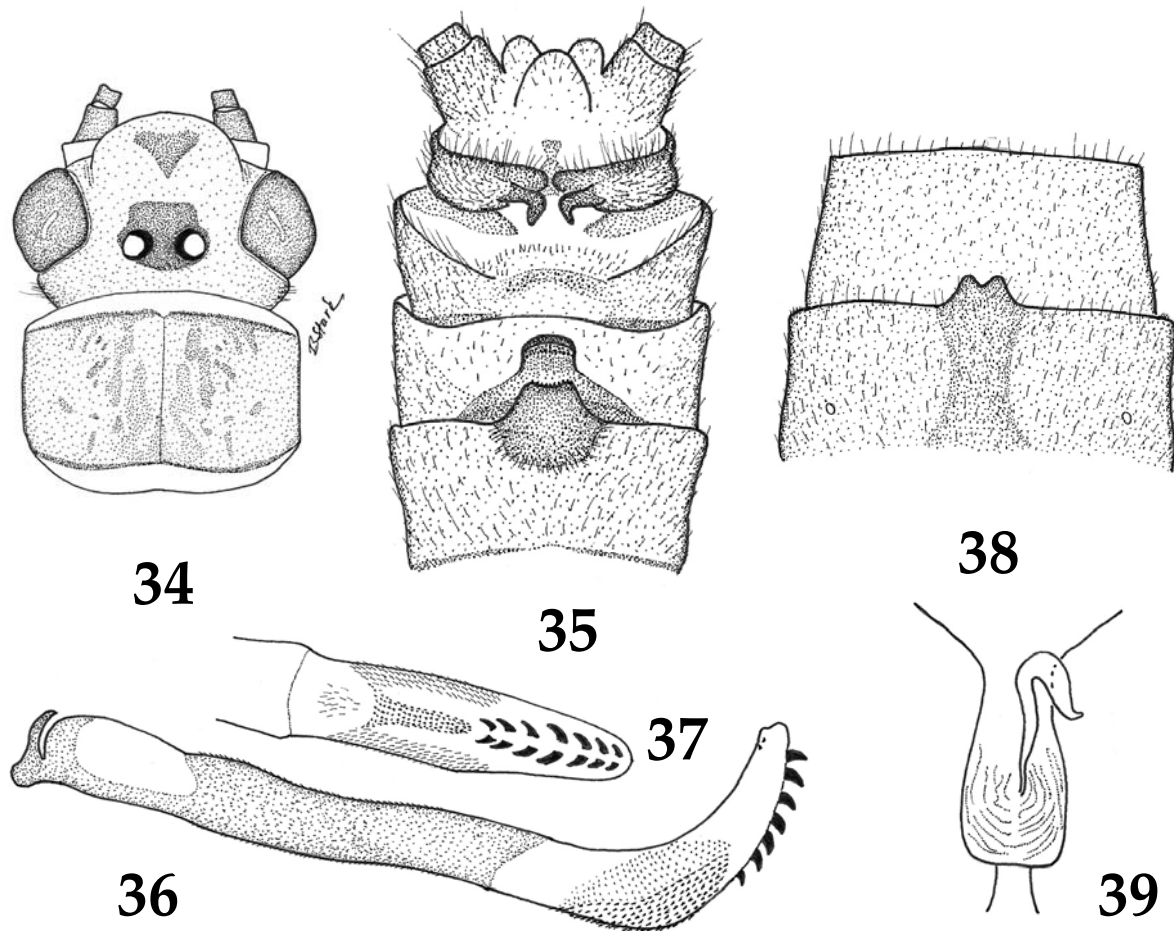
(Figs. 34-39, 100-102)

Material examined. Holotype ♂ and 1 ♂, 1 ♀ paratype from Vietnam, Gia Lai, An Khe District, Tram Lap, Azun River, 2 km NW on trail from forestry building, 14° 27' N, 108° 33' E, 17 June 1996, D. Currie, J. Swann, ROM 961056 (ROM). Additional paratypes: Vietnam, Gia Lai, An Khe District, Tram Lap, Azun River, 2 km NW on trail from forestry building, 14° 27' N, 108° 33' E, 23 June 1996, D. Currie, J. Swann, ROM 961084, 1 ♂ (IEBR). Vietnam, Lao Cai, Muong Hoa, tributary of Ho River, 15 km E Sapa, 926 m, 10 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956033, 1 ♂, 1 ♀ (ROM)

Adult habitus. Biocellate. Head with a dark spot covering ocelli and another near anterior margin of frons. Pronotum pale brown with darker rugosities; anterior and posterior margins and median suture dark brown (Fig. 34). Wing membrane pale amber, veins darker. Femora pale brown, tibiae dark brown at knee and along outer margins.

Male. Forewing length 11.5 mm. Tergum 7 process a rounded plateau, truncate on posterior margin and sprinkled with sensilla basiconica. Process of tergum 8 tongue shaped, erect and armed on anterodorsal margin with small spines. Tergum 9 without sensilla patches (Fig. 35). Hemitergal processes strongly bent and upturned at midlength. Aedeagal tube slender, relatively straight and armed with minute spinules on dorsal and lateral surfaces (Fig. 36). Aedeagal sac about half as long as tube and armed along dorsoapical margin with a double row of 4-7 cultriform spines (Figs. 36-37); most of apical half of sac covered with smaller spines.

Female. Forewing length 13-14 mm. Subgenital plate a short, bilobed, tongue shaped process; notch about as wide as lobes (Fig. 38). Vagina long and slender with small sclerites clustered around spermathecal stalk (Fig. 39). Spermathecal stalk short, spermatheca



Figs. 34-39. *Neoperla idella*. 34. Head and pronotum. 35. Male terminalia. 36. Aedeagus. 37. Aedeagal sac, dorsal. 38. Female terminalia. 39. Vagina and spermatheca.

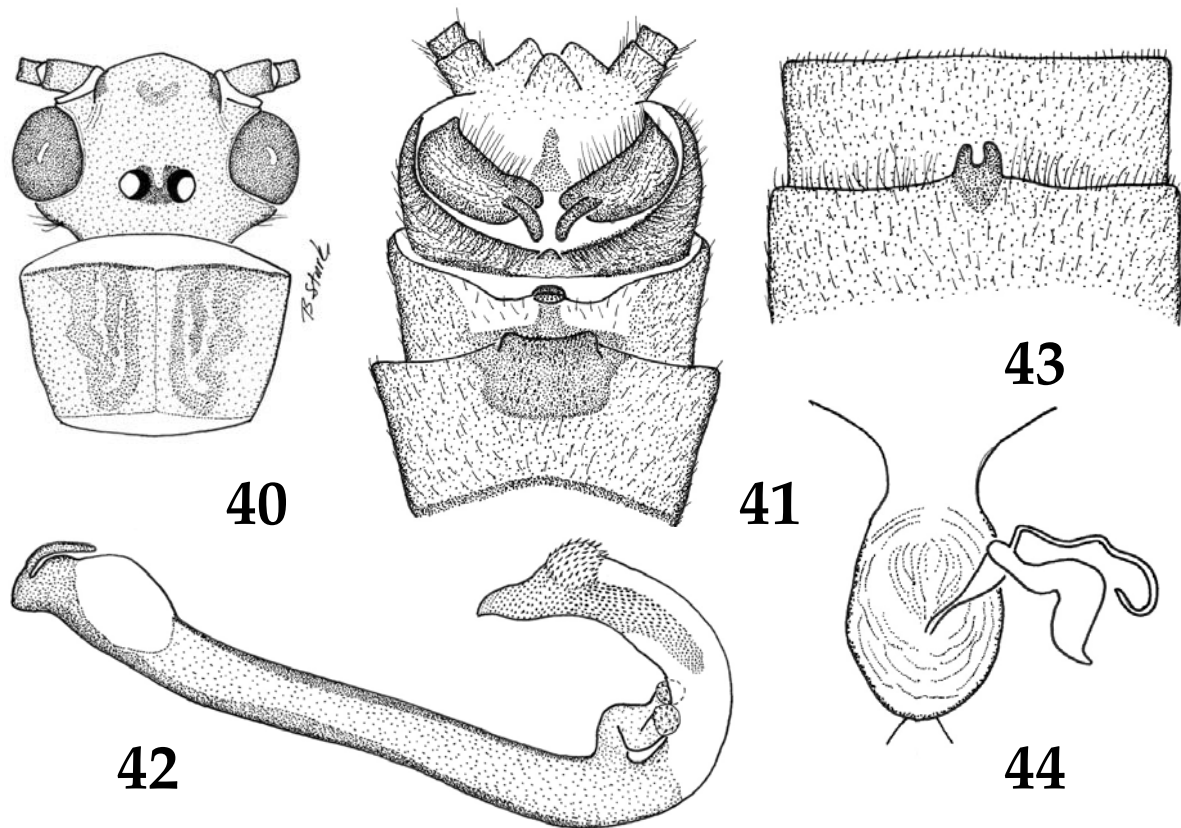
sausage shaped, curved at midlength and hooked at apex; a single accessory gland occurs subapically.

Egg. Barrel shaped. Length ca. 0.35 mm, width ca. 0.21 mm. Collar sessile, width ca. 0.12 mm; collar margined by an irregular row of triangular cells; rim smooth and thin (Figs. 100-102). Chorion striate, striae thin and closely packed with ca. 43 visible in lateral aspect; sulci absent. Primary striae connect to collar cells and to meshwork at margin of lid; each pair of primary striae form a longitudinal unit containing a pair of secondary striae. Lid ringed by an irregular row of deep pits; ca. 11-13 pits visible in lateral aspect; lid covered with obscure follicle cell impressions containing fine punctations; FCIs only evident for marginal rows adjacent to pits. Micropyles subequatorial and without sperm guides.

Larva. Unknown.

Etymology. The species name is from the Greek word *ideo*, meaning “distinctive”, referring to the unusually armed male aedeagal sac.

Diagnosis. The aedeagus of this species is reminiscent of that of *N. laotica* Zwick but in that species the large spines are on the venter of the sac and the tube is less sclerotized (Zwick 1988). In addition the tergal lobes of the two species are quite different with *N. idella* having a plateau type tergum 7 and *N. laotica* having a triangular tergum 7 process. The male paratype from Lao Cai has four pairs of cultriform spines on the aedeagal sac whereas the holotype and male paratypes from Gia Lai have seven pairs of spines.



Figs. 40-44. *Neoperla mnong*. 40. Head and pronotum, 41. Male terminalia, 42. Aedeagus, 43. Female terminalia, 44. Vagina and spermatheca.

***Neoperla mnong* Stark**
(Figs. 40-44, 106)

Javanita costalis Navás, 1932:925. Secondary homonym of *Formosina costalis* Klapálek (Zwick 1988)

Neoperla mnong Stark, 1987:48. Holotype ♂ (California Academy of Sciences). Di Linh, Vietnam

Neoperla angustilobata Zwick, 1988:404. Holotype ♀ (Muséum National d'Histoire Naturelle), New Synonymy

Material examined. Vietnam: Gia Lai, An Khe District, Tram Lap, Azun River, 2 km NW on trail from forestry building, 14° 27' N, 108° 33' E, 17 June 1996, D. Currie, J. Swann, ROM 961056, 4 ♂, 1 ♀ (ROM, BPS). Same site, 23 June 1996, D. Currie, J. Swann, ROM 961084, 1 ♂ (IEBR). Gia Lai, An Khe District, Tram Lap, Azun River, 3 km NE on trail from forestry building, 21 June 1996, D. Currie, J. Swann, ROM 961076, 1 ♂ (ROM). Gia Lai, An Khe

District, Dacklest River, 5.2 km NE Tram Lap on forest road, 14° 24' N, 108° 33' E, 15 June 1996, D. Currie, J. Swann, ROM 961047, 4 ♂ (ROM). Gia Lai, An Khe District, Tram Lap, near pond and coffee plantation, 14 June 1996, UV light, 14° 26' N, 108° 33' E, B. Hubley, D. Currie, J. Swann, ROM 961045, 2 ♂ (ROM). Gia Lai, An Khe District, 6.5 km NE Tram Lap, forest road, 19 June 1996, D. Currie, J. Swann, ROM 961061, 1 ♀ (ROM). Nghe An, ca. 25 km SW Con Cuong, Khe Moi Forestry Camp, tributary Khe Moi River, 4 June 1995, B. Hubley, J. Swann, ROM 956158, 1 ♀ (ROM).

Remarks. This species was first described as *Javanita costalis*, by Navás (1932) from a female specimen and later described as a new species from a male specimen by Stark (1987). Zwick (1988) recognized *J. costalis* as a secondary homonym of *Formosina costalis* Klapálek after both species were transferred to *Neoperla* (Sivec & Zwick 1987), and proposed *N. angustilobata* as a replacement for *N. costalis*, *sensu*

Navás. The conspecificity of *N. mnong* and *N. angustilobata* was suggested when *N. mnong* females were associated in this study.

Adult habitus. Biocellate. Head mostly yellow but small area of brown pigment over ocelli often with distinct anteromesal notch; frons usually marked with an additional dark area near anterior margin (Fig. 40). Pronotum pale brown with slightly darker rugosities. Wings pale, veins amber. Femora and tibiae pale but a little darker at the knee.

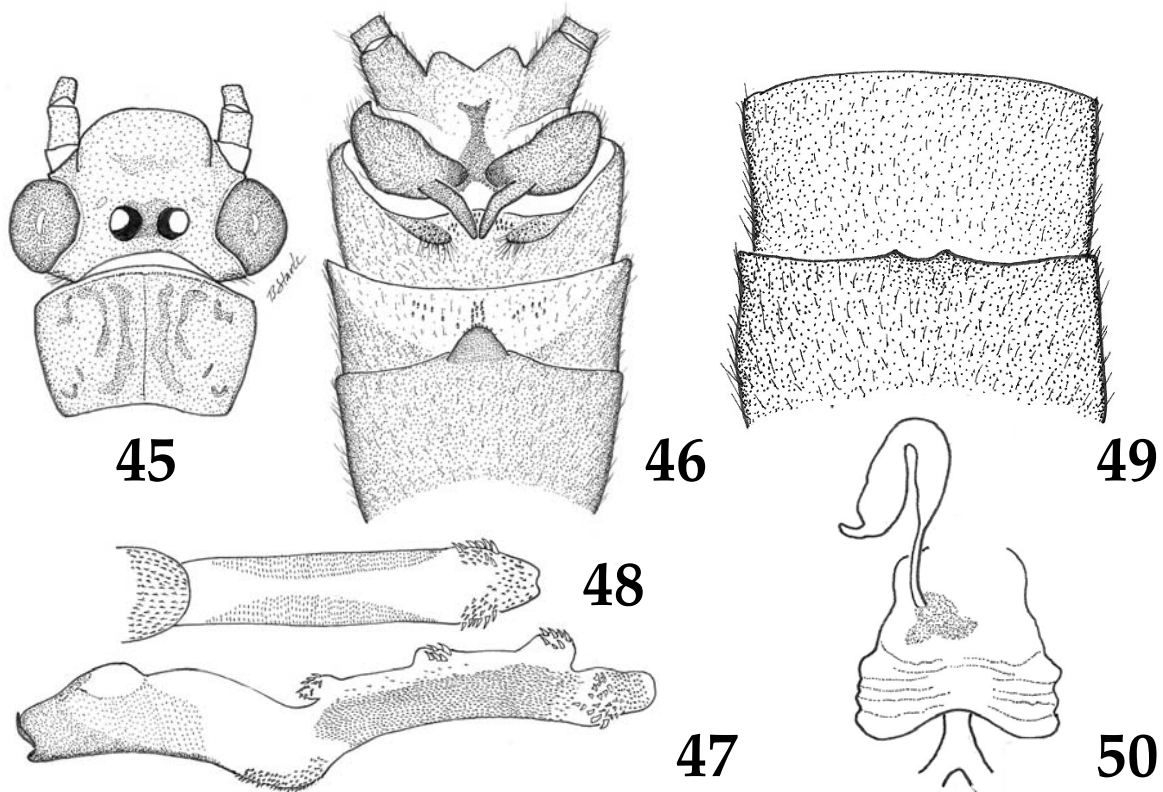
Male. Forewing length 12-13 mm. Described by Stark (1987) but illustrations of the aedeagus and external genitalia are presented in Figs. 41-42 to aid in recognition of this species.

Female. Forewing length 15-16 mm. Subgenital plate produced as a small notched tab; notch U-shaped and about as wide as lateral lobes of plate (Fig. 43). Vagina longer than wide and swollen in posterior half (Fig. 44). Spermathecal stalk short; spermatheca slender, curled, hooked on apex and without internal spinous lining.

Egg. Pear shaped. Length ca. 0.33 mm, width ca. 0.23

mm. Collar wide and not distinctly stalked; sides with vertical ribs extending onto egg body, and with an irregular cell row; rim not flanged (Fig. 106). Chorion appearing relatively smooth but covered throughout with minute, shallow pits.

Diagnosis. This species is a member of a complex which includes *N. diehli* Sivec, a species known from Sumatra (Zwick & Sivec 1985), *N. yao* Stark, a species which also occurs at sites in Gia Lai Province, *N. han* Stark, a species described from Hong Kong (Stark 1987), and *N. hubleyi*, described above from several Vietnamese sites. The aedeagal Y-lobes for *N. diehli*, *N. mnong*, *N. han* and *N. hubleyi* are similar in having short arms supporting spiny apices, but those of *N. han* and *N. hubleyi* have a longer basal stalk, and those of *N. diehli* are more basally located and less spherical than in *N. mnong*. Females of *N. mnong* and *N. yao* have similar, bilobed subgenital plates and color patterns, but differ in egg collar morphology. The eggs of the latter species have stalked collars whereas those of *N. mnong* are unstaked.



Figs. 45-50. *Neoperla multispinosa*. 45. Head and pronotum, 46. Male terminalia, 47. Aedeagus, 48. Aedeagal sac, dorsal, 49. Female terminalia, 50. Vagina and spermatheca.

***Neoperla multispinosa* sp. n.**
(Figs. 45-50)

Material examined. Holotype ♂, 3 ♂ and 1 ♀ paratypes from Vietnam, Vinh Phu, Tam Dao, 800-1100 m, 19 May-13 June 1995, H. Malicky (PMSL).

Adult habitus. Biocellate. Head mostly yellow but interocellar area covered by a small brown spot; basal and second antennal segments pale, flagellum dark brown (Fig. 45). Pronotum brown with indistinct rugosities. Femora pale, tibiae brown, darker brown at knee.

Male. Forewing length 11 mm. Tergum 7 process a small parabolic lobe with spiny margin. Tergum 8 with median and sparse lateral patches of sensilla basiconica. Tergum 9 with small median and larger lateral patches of sensilla basiconica; lateral patches on low humps (Fig. 46). Hemitergal processes moderately long and curved or bent laterad at midlength. Aedeagal tube plump and poorly sclerotized except along dorsum; dorsoapical area

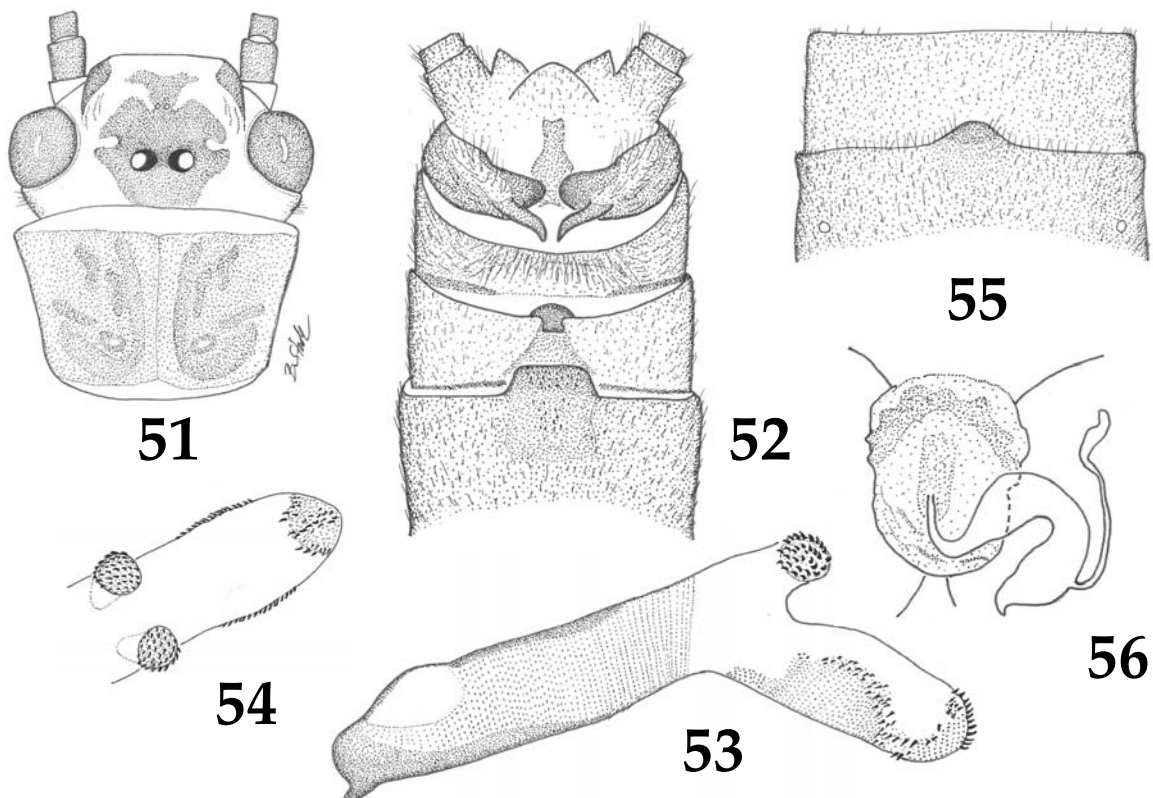
covered by a conspicuous spiny patch (Fig. 47). Aedeagal sac slightly longer than tube, slender but with three pairs of spiny lobes along ventrolateral surface; sac apex with prominent dorsolateral spines and a ring of smaller terminal spines; much of sac covered on dorsolateral surface by smaller spines (Figs. 47-48).

Female. Forewing length 14 mm. Subgenital plate slightly produced as a small emarginate tab (Fig. 49). Spermathecal stalk short and very slender (Fig. 50); spermatheca sausage shaped, strongly bent and apically hooked.

Larva. Unknown.

Etymology. The species name refers to the multiple spiny clusters and lobes of the aedeagal tube and sac.

Diagnosis. Three pairs of small lobes along the ventral sac margin, a large dorsoapical spiny patch on the tube and the broad, irregular ring of apical sac spines distinguishes males of this species from others in the *montivaga* group.



Figs. 51-56. *Neoperla nebulosa*. 51. Head and pronotum, 52. Male terminalia, 53. Aedeagus, 54. Aedeagal sac, dorsal, 55. Female terminalia, 56. Vagina and spermatheca.

***Neoperla nebulosa* sp. n.**
(Figs. 51-56, 109-111)

Material examined. Holotype ♂ and 13 ♂, 7 ♀ paratypes from Vietnam, Lao Cai, Sapa, large waterfall on road from Sapa to Lai Chau, UV light, 8 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956022 (Holotype ROM, paratypes ROM, IEBR, BPS). Additional paratype: Vietnam: Lao Cai, ca. 12 km on road from Sapa to Lai Chau, 30 April-12 May 1999, B. Hubley, ROM 992006, 1 ♀ (pinned, ROM).

Adult habitus. Biocellate. Head with broad dark brown region from occiput to M-line; forward of M-line a brown triangular area occurs (Fig. 51). Pronotum brown with darker rugosities; median suture and anterior and posterior margins dark. Wings membranous and veins brown, costa pale in basal third. Femora pale basally but dark in apical half; tibiae brown.

Male. Forewing length 13-13.5 mm. Tergum 7 process a broadly rounded, elevated plateau. Tergum 8 process tongue shaped, upturned and curved forward. Tergum 9 simple (Fig. 52). Hemitergal processes short and bent laterad at midlength. Aedeagal tube plump and poorly sclerotized except on dorsum; tube armed with minute spines over most of surface (Fig. 53). Aedeagal sac short and trilobed; basoventral portion with a pair of spiny lobes, apical lobe simple but armed on most of surface with spines of various sizes; largest spines clustered near apex and scattered in a lateral patch (Figs. 53-54).

Female. Forewing length 17-18 mm. Subgenital plate a short, rounded tab projecting slightly over sternum 9 (Fig. 55). Vagina longer than wide and lined with golden brown scale setae; folds behind spermathecal stalk darker (Fig. 56). Spermathecal stalk short, spermatheca a U-shaped sausage with apical hook; accessory gland located in apical third.

Egg. Barrel shaped. Length ca. 0.34 mm, width ca. 0.18 mm, collar width ca. 0.09 mm. Collar sessile and surrounded by 2-3 irregular rows of scalloped follicle cell impressions (Figs. 109-111). Striae narrow, wider at midlength, ca. 14 visible in lateral aspect; striae surfaces smooth. Sulci narrower than striae and with three rows of fine punctations visible near poles. Follicle cell impressions on lid with low smooth walls and punctate floors; marginal row with walls more deeply sculpted.

Etymology. The species name refers to the dark appearance of the adults.

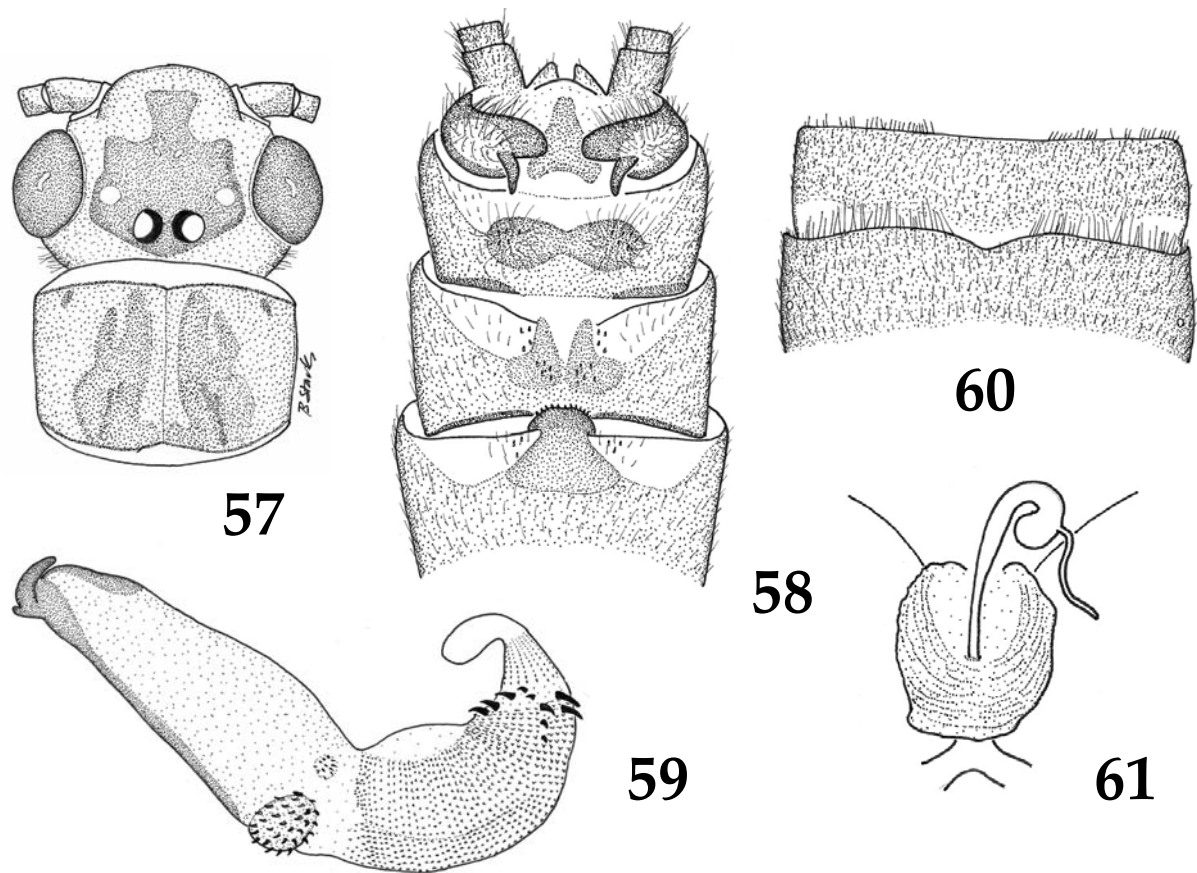
Diagnosis. The aedeagus of this species is similar to that of *N. spinaloba* (described below), *N. signatalis* Banks and *N. quadrata* Wu & Claassen. It differs from the former in having a shorter aedeagal sac positioned at an angle to the tube. The sac of *N. signatalis* is similar in size and shape but the sac armature is relatively more prominent along the ventral margin and reduced along the dorsal margin. In addition, the Taiwanese species is smaller and has a distinctive dark median pronotal band (Sivec & Zwick 1987). The sac of *N. quadrata* is more similar to that of *N. spinaloba* but the tube shares the ventroapical pair of spinulose lobes with all these species.

***Neoperla song* sp. n.**
(Figs. 57-61, 112-114)

Material examined. Holotype ♂ and 1 ♂, 1 ♀ (genitalia damaged) paratypes from Vietnam, Thua Thien-Hue, Bach Ma National Park near junction of Rhododendron and Five Lakes trails, 16° 11' N, 107° 51' E, 1200 m, 16 June 2000, B. Hubley, D.C. Darling, ROM 2000531 (Holotype and ♀ paratype ROM, ♂ paratype IEBR). Additional paratypes: Vietnam: Thua Thien-Hue, Bach Ma National Park, small stream 100 m past Five Lakes Trail, 9 June 2000, B. Hubley, ROM 2000518, 1 ♂, 1 ♀ (pinned, ROM). Thua Thien-Hue, Bach Ma National Park, ca. 13 km on road from park entrance, 15 June 2000, B. Hubley, D.C. Darling, ROM 2000528, 1 ♀ (pinned, ROM).

Adult habitus. Biocellate. Head with large dark area on frons covering ocelli, extending laterally to eye margins, forward to center of frons then abruptly constricted to a short mesal handle (Fig. 57); dark areas interrupted by two pairs of pale spots. Pronotum brown with darker rugosities; median suture, anterior and posterior margins black. Wing membrane amber, veins darker but costal area pale. Femora pale brown, tibiae brown but darker at knee.

Male. Forewing length 11-12 mm. Process of tergum 7 short, wide and broadly rounded on posterior margin. Tergum 8 mesal sclerite not elevated, armed with scattered sensilla basiconica and bearing a V-shaped notch. Tergum 9 with a pair of low mounds sparsely armed with sensilla basiconica; mesal patch absent (Fig. 58). Hemitergal processes short and



Figs. 57-61. *Neoperla song*. 57. Head and pronotum, 58. Male terminalia, 59. Aedeagus, 60. Female terminalia, 61. Vagina and spermatheca.

curved laterad. Aedeagal tube short, plump and poorly sclerotized; dorsoapical tube margin armed with a pair of low spinous lobes and ventroapical margins armed with a smaller pair of spinous lobes (Fig. 59). Aedeagal sac about as long as tube but curved ventrad; sac armed subapically with a linear patch of large cultriform spines; a patch of small spines occurs apically to large spines and sac bears additional patches of small spines along dorsobasal margin and laterally near base and proximal to large spines.

Female. Forewing length 15 mm. Subgenital plate slightly produced but wide, involving more than half the posterior margin of sternum 8 (Fig. 60); margin of plate lined with long setae. Vagina longer than wide and constricted near midlength; anterior chamber somewhat quadrate and lined irregularly with brown scale spines. Spermathecal stalk and spermatheca short, curled at tip and slender (Fig. 61); a single

accessory gland occurs near spermatheca tip.

Egg. Length ca. 0.33 mm, width ca. 0.30 mm. Collar ca. 0.06 mm wide, very short and constricted at base (Figs. 112-114). Chorion without striae or follicle cell impressions, but with minute, shallow pits over entire surface.

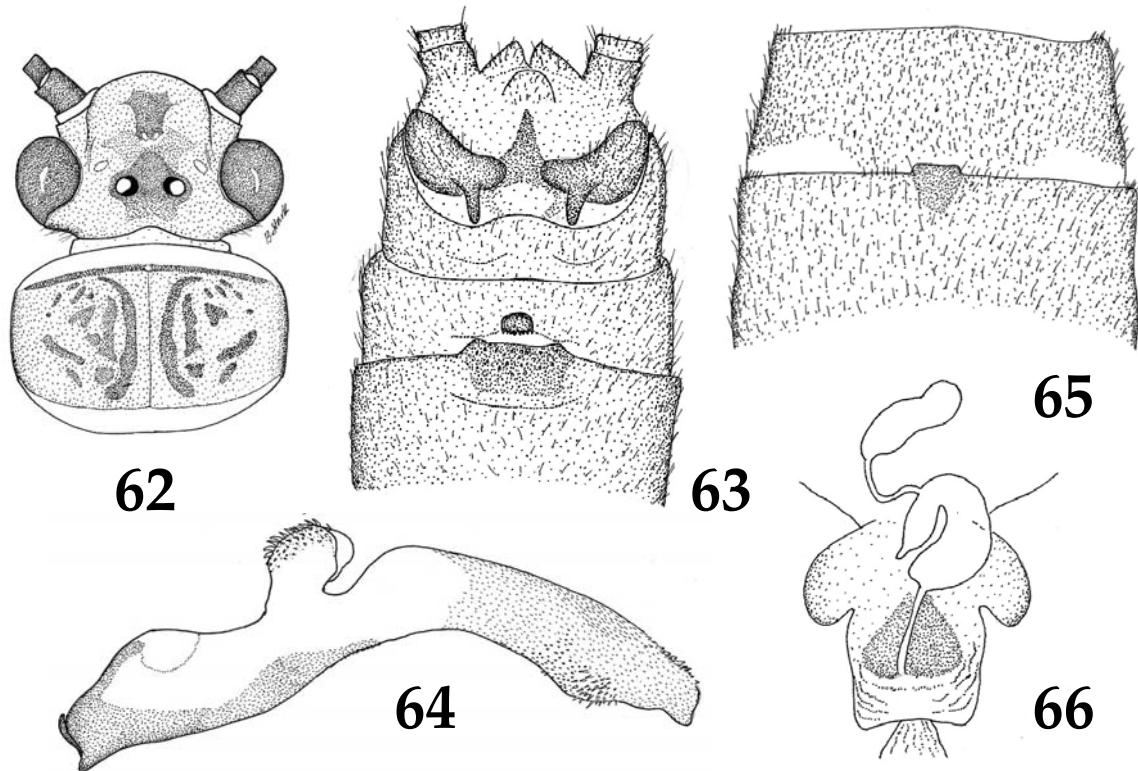
Larva. Unknown.

Etymology. The species name, based on the Vietnamese word for stream or river and used as a noun in apposition, was selected by biology students at Mississippi College in a "name the *Neoperla* contest". The name was suggested by Brandon Webb.

Diagnosis. The aedeagus and external genitalia of this species are somewhat similar to those of *N. tetrapoda* Zwick and other Bornean members of the *N. oculata* Banks complex as defined by Zwick (1986). It differs from these in having a wider and shorter process on tergum 7, a V-shaped notch on the mesal

sclerite of tergum 8, and in lacking the extensive lobing of the aedeagal sac found among species of the *oculata* complex. The egg is similar in shape to

that of *N. boornensis* (Enderlein) however the collar is shorter and wider and the chorionic detail differs (Zwick 1986).



Figs. 62-66. *Neoperla spinaloba*. 62. Head and pronotum, 63. Male terminalia, 64. Aedeagus, 65. Female terminalia, 66. Vagina and spermatheca.

***Neoperla spinaloba* sp. n.**
(Figs. 62-66, 115-117)

Material examined. Holotype ♂ and 8 ♂, 7 ♀ paratypes from Vietnam, Lao Cai, Sapa, large waterfall on road from Sapa to Lai Chau, 8 May 1995, D. Currie, B. Hubley, J. Swann, ROM 956022 (Holotype and 4 ♂, 6 ♀ paratypes ROM; other paratypes IEBR, BPS). Additional paratypes: Vietnam: Sapa, Fan Si Pan Mountain, 1600 m, 22-29 April 1995, L.F. 1 ♂ (ZMB). Lao Cai, 12 km along road from Sapa to Lai Chau, 22° 21' N, 103° 46' E, 29 April-12 May 1999, B. Hubley, ROM 992004, 6 ♂ (pinned, ROM). Same site but 30 April-12 May 1999, B. Hubley, ROM 992006, 5 ♂ (pinned, ROM).

Adult habitus. Biocellate. Head with dark pigment extending from center of occiput, over ocelli and

forward to M-line; anterior to M-line a dark triangular area occurs (Fig. 62). Pronotum brown with darker rugosities.

Male. Forewing length 13-14 mm. Process of tergum 7 a raised plateau with posterior corners slightly projecting. Process of tergum 8 an erect, curved tongue shaped structure. Tergum 9 without sensilla patches (Fig. 63). Hemitergal lobes slender and curved at midlength. Aedeagal tube plump, poorly sclerotized, and bearing a ventroapical pair of prominent spiny lobes (Fig. 64). Aedeagal sac cylindrical and slightly longer than tube; sac armed, except basally, with small spines and two patches of larger spines near apex.

Female. Forewing length 16.5-17.5 mm. Subgenital plate a small truncate tab (Fig. 65). Vagina somewhat T-shaped; triangular shaped sclerite underlies

spermathecal base (Fig. 66). Spermathecal stalk short, slender, spermatheca sausage shaped and curled beyond midlength; accessory gland near tip expanded apically into a large sausage shaped structure.

Egg. Barrel shaped. Length ca. 0.37 mm, width ca. 0.23 mm. Collar sessile with smooth side rim; area surrounding collar with irregular, scale-like impressions attached to rim and to primary striae (Figs. 115-117). Chorion striate with striae closely packed; each pair of primary striae enclose a pair of secondary striae; sulci reduced, visible near lid where a single row of shallow pits occurs in each sulcus. Lid covered with small, shallow pits; follicle cell impressions absent. Micropyles subequatorial, sperm guides absent, but some micropyles associated with irregular, abnormal appearing striae.

Larva. Unknown.

Etymology. The species name refers to the spiny aedeagal lobes.

Diagnosis. This species is very similar in color pattern to *N. nebulosa* and the two species co-occur. The aedeagus is similar to that of *N. quadrata* Wu & Claassen, *N. lushana* Wu (*sensu* Zwick & Sivec 1980), and *N. nebulosa* (described above). The latter species is easily separated on the basis of the short aedeagal sac oriented at an angle from the tube but separation from the other species requires careful examination of aedeagal armature. The aedeagal sac of *N. lushana* has the ventromesal row of spines reduced to a few organized in a short row and these are intersected near the apex by a relatively straight transverse row of similar large spines (Zwick & Sivec 1980). Both *N. spinaloba* and *N. quadrata* have a long linear ventromesal patch of slightly enlarged spines; in the latter species there are no additional enlarged spines on the sac apex or subapex (Stark unpublished) whereas in *N. spinaloba* a prominent subapical ventromesal patch of ca. 20 relatively large spines and a smaller patch of dorsomesal spines occurs.

***Neoperla tamdao* Cao & Bae**
(Figs. 107-108)

Neoperla tamdao Cao & Bae, in Cao et al., 2007. Holotype ♂ (Seoul Women's University Aquatic Insect Collection). Thac Bac, Tam Dao National Park, Vinh Phu Province, Vietnam

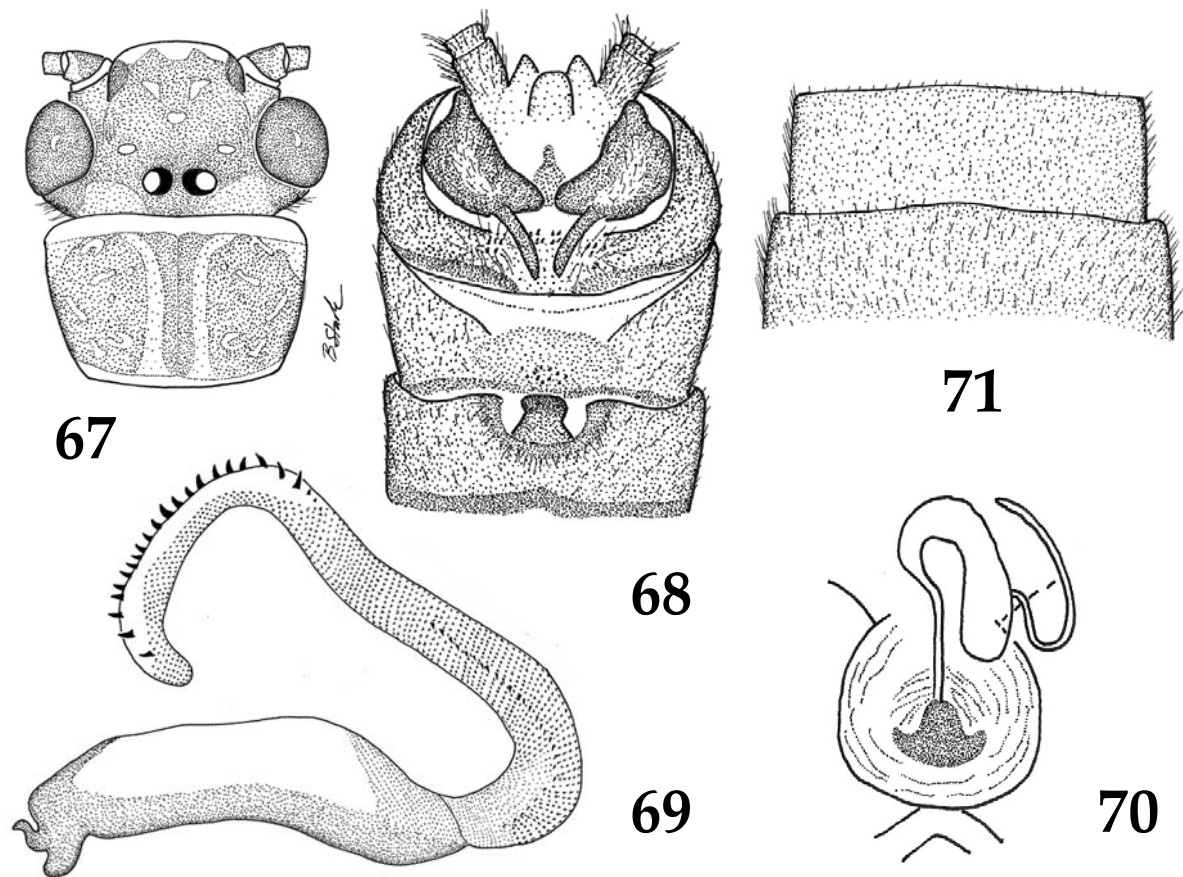
Material examined. Vietnam, Nghe An, ca. 25 km

SW Con Cuong, Khe Moi River Forestry Camp, tributary Khe Moi River, 18° 56' N, 104° 49' E, 308 m, 6 June 1995, B. Hubley, ROM 956172, 2 ♂, 2 ♀ (ROM). Same site, 4 June 1995, B. Hubley, J. Swann, ROM 956158, 11 ♂, 1 ♀ (ROM). Same site, 3 June 1995, B. Hubley, J. Swann, ROM 956150, 6 ♂ (ROM). Same site but 100 m upriver of Forestry Camp, 5 June 1995, B. Hubley, J. Swann, ROM 956161, 4 ♂, 1 ♀ (BPS). Lao Cai, ca. 4 km W Sapa Village, tributary Golden River, 16-23 May 1999, 1200 m, A. Lathrop, ROM 992020, 1 ♂ (ROM). Gia Lai, Buoenloy, April 1995, A. Gorohov, 1 ♂ (PMSL). Gia Lai, An Khe District, Tram Lap, Azun River, 2 km NW on trail from forestry building, 14° 27' N, 108° 33' E, 23 June 1996, D. Currie, J. Swann, ROM 961084, 3 ♂, 2 ♀ (ROM). Same site but 17 June 1996, D. Currie, J. Swann, ROM 961056, 1 ♂, 1 ♀ (IEBR). Gia Lai, An Khe District, NE Tram Lap, 6 m wide tributary Azun River, 20 June 1996, B. Hubley, D. Currie, ROM 961073, 1 ♂ (ROM). Gia Lai, An Khe District, 10 km NW Buoenloy, Cha River, on road to Tram Lap, 27 June 1996, D. Currie, ROM 961098, 1 ♀ (ROM).

Remarks. The process of tergum 7 of this species is somewhat similar to that of *N. furcata* Zwick and related species from Borneo (Zwick 1986), and the aedeagus is also of the general type seen in that species group. *Neoperla tamdao* differs from these in having the tergum 7 process more rounded and less deeply notched, and the aedeagal sac has fewer lobes which are also less spiny. Cao et al. (2007) suggest the egg chorion for this species is smooth but among our specimens the entire chorion is covered with fine punctations and on the lid, punctations are enclosed by obscure follicle cell impressions formed by rows of punctations (Figs. 107-108).

***Neoperla teresa* sp. n.**
(Figs. 67-71, 118-120)

Material examined. Holotype ♂ from Vietnam, Nghe An, ca. 25 km SW of Con Cuong, 100m upriver of Khe Moi River Forestry Camp, 18° 56' N, 104° 49' E, 308 m, 5 June 1995, B. Hubley, J. Swann, ROM 956161 (ROM). Paratypes: Vietnam: Nghe An, ca. 25 km SW Con Cuong, Khe Moi River Forestry Camp, tributary of Khe Moi River, 18° 56' N, 104° 49' E, 308 m, 7 June 1995, J. Swann, ROM 956177, 2 ♀ (ROM). Same site but 4 June 1995, B. Hubley, J. Swann, ROM 956158, 1 ♀ (IEBR).



Figs. 67-71. *Neoperla teresa*. 67. Head and pronotum, 68. Male terminalia, 69. Aedeagus, 70. Vagina and spermatheca, 71. Female terminalia.

Adult habitus. Biocellate. Head mostly brown but with pale areas forming incomplete M-line, covering clypeus and surrounding tentoria near ocelli (Fig. 67). Pronotum brown with paler areas scattered on disc. Wings tinted brown with dark brown veins and pale costal area. Hind femora pale basally, dark brown apically, tibiae dark brown.

Male. Forewing length 8.5 mm. Process of tergum 7 wide, broadly rounded on posterior margin and set forward from tergal margin and margined by a U-shaped pigment bar. Tergum 8 mesal sclerite wide, obscure and bearing a few sensilla. Tergum 9 with a few mesal sensilla basiconica but lateral patches obsolete (Fig. 68). Hemitergal processes slender. Aedeagal tube moderately slender, sclerotized dorsally and bearing a ventrolateral patch of minute spines near apex (Fig. 69). Aedeagal sac slender, longer than tube and armed over much of surface

with fine spines; largest spines grouped along dorsal margin in an irregular double row in the apical third of sac with ca. 20 spines in each row; other moderately large spines form lateral rows extending from near bases to near midlength of sac.

Female. Forewing length 10 mm. Subgenital plate unproduced, posterior margin of sternum 8 straight (Fig. 71). Main body of vagina more or less spherical but with a dark brown triangular sclerite in base of spermathecal stalk (Fig. 70); spermathecal stalk very slender, then expanded into a curved, sausage-like chamber.

Egg. Oval. Length ca. 0.27 mm, width ca. 0.18 mm, collar rim width ca. 0.05 mm. Collar sessile but surrounded by wide, smooth rim (Figs. 118-120). Striae very narrow, ca. 12 primary striae visible in lateral aspect; area between primary striae packed with several irregular rows of anastomosed

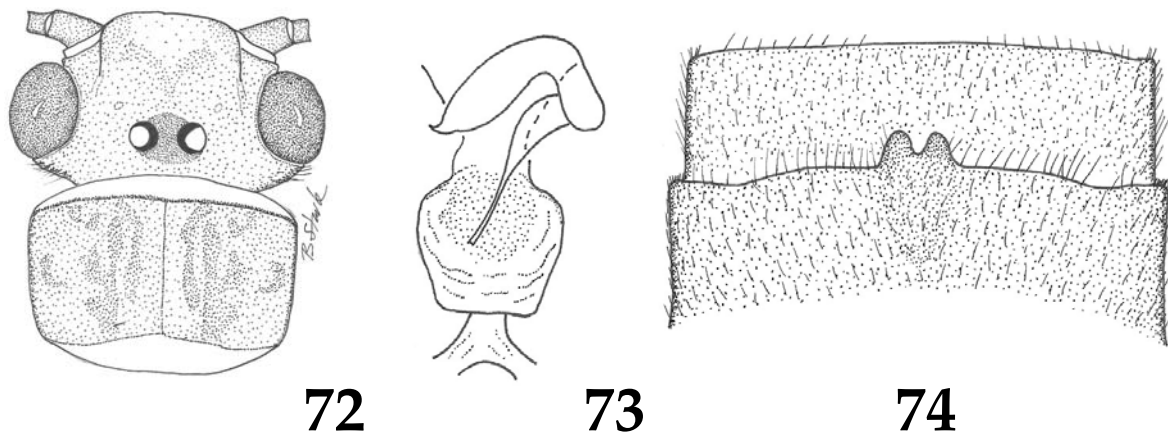
secondary striae; primary striae connect to collar rim and to follicle cell impressions on lid. Sulci narrow with a single row of coarse punctations between any pair of striae. Lid small consisting of two or three rows of follicle cell impressions; FCIs deep, walls smooth, and with floors having ca. 15-22 punctations.

Larva. Unknown.

Etymology. The species name, used as a noun in apposition, honors Teresa Heinz Kerry in recognition of her indomitable spirit, wise “opinions” and her strong support of environmental issues.

Diagnosis. This petite, dark brown species with banded femora is distinct from known congeners by

virtue of the unusually shaped and margined process on male tergum 7. The female subgenital plate is reduced, the spermathecal stalk bears a basal, triangular sclerite, and the egg has a pattern of primary striae enclosing groups of secondary striae each separated by a regular row of coarse punctations. Several females of a similar small brown species were collected together with the type series of *N. teresa* but these females have two dark bands on the hind femora and the spermathecal stalk indicates they belong to a species in the *N. clymene* complex. These females are described below as species VN-A.



Figs. 72-74. *Neoperla yao*. 72. Head and pronotum, 73. Vagina and spermatheca, 74. Female terminalia.

***Neoperla yao* Stark**
(Figs. 72-74, 121-123)

Neoperla yao Stark, 1987:47. Holotype ♂ (B.P. Bishop Museum). 6 km S Dalat, Vietnam

Material examined. Vietnam: Cao Bang, Ba Be National Park, between park gates and pond, UV light, 22 May 1995, D. Currie, J. Swann, M. McGuffin, ROM 956119, 1 ♂ (ROM). Gia Lai, An Khe District, Tram Lap, Azun River, 3 km NE on trail from forestry building, 21 June 1996, D. Currie, J. Swann, ROM 961076, 1 ♂ (ROM). Gia Lai, An Khe District, Tram Lap, near pond and coffee plantation, 14 June 1996, UV light, 14° 26' N, 108° 33' E, B. Hubley, D. Currie, J. Swann, ROM 961045, 1 ♂, 2 ♀ (ROM). Gia Lai, Buoenloy, April 1995, A. Gorohov, 1 ♂ (PMSL).

Remarks. This species was previously known from three males. Two of these are from sites in southern Vietnam and the other in China. These additional males, from the southern region of Vietnam are in close agreement with the description in Stark (1987).

Adult habitus. Biocellate. Head mostly yellow but with a dark spot over ocelli and a second small spot anteromesally on frons; spot over ocelli usually acute on anterior margin (Fig. 72). Pronotum pale brown, disc becoming paler near lateral margins; rugosities obscure. Wing membrane pale, veins pale amber, costal area pale. Femora yellow brown, tibiae slightly darker.

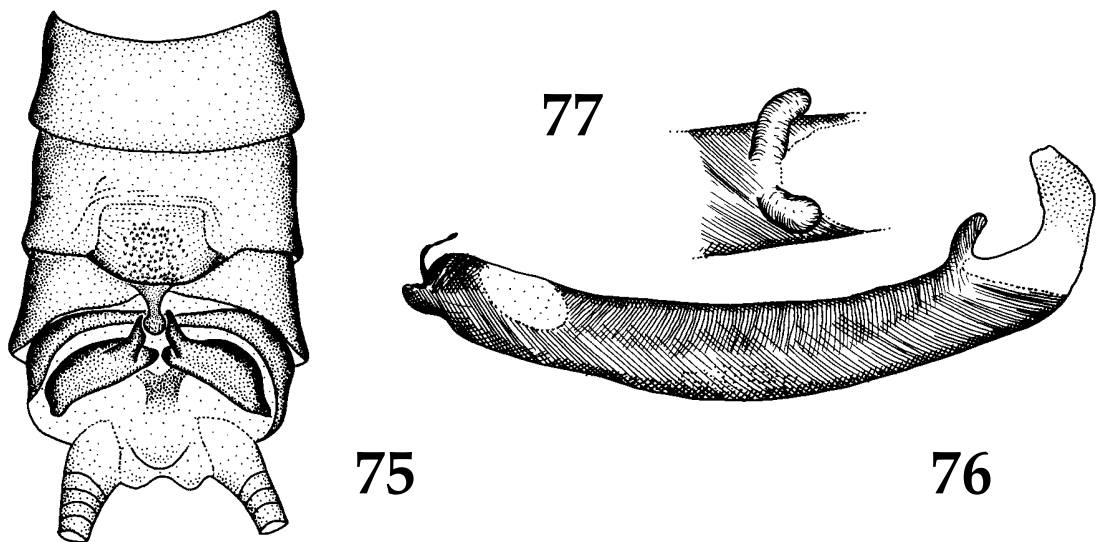
Putative Female. Forewing length 12 mm. Subgenital plate a narrow tab, slightly expanded at apex and broadly U-shaped on posterior margin (Fig. 74). Vagina longer than wide and slightly constricted

near midlength (Fig. 73). Spermathecal stalk short, spermatheca slender, twisted at midlength and slightly hooked at apex.

Egg. Pear shaped. Length ca. 0.31 mm, width ca. 0.23 mm. Collar short with heavy meshwork of irregular shaped and pitted cells on sides; rim slightly flanged,

margin irregularly scalloped; collar ca. 0.08 mm wide (Figs. 121-123). Chorion appearing smooth but with small, shallow pits and obscure FCIs covering surface.

Diagnosis. See above under *N. mnong*.



Figs. 75-77. *Neoperla yentu*. 75. Male terminalia, 76. Aedeagus. 77, Detail of aedeagus lobing.

***Neoperla yentu* Cao & Bae**
(Figs. 75-77)

Neoperla yentu Cao & Bae in Cao et al., 2007. Holotype ♂ (Seoul Women's University Aquatic Insect Collection). Yentu, Quang Ninh, Province, Vietnam

Material examined. Vietnam, Vinh Phu, Tam Dao, 800-1100 m, 19 May-13 June 1995, H. Malicky, 1 ♂, 1 ♀ (PMSL).

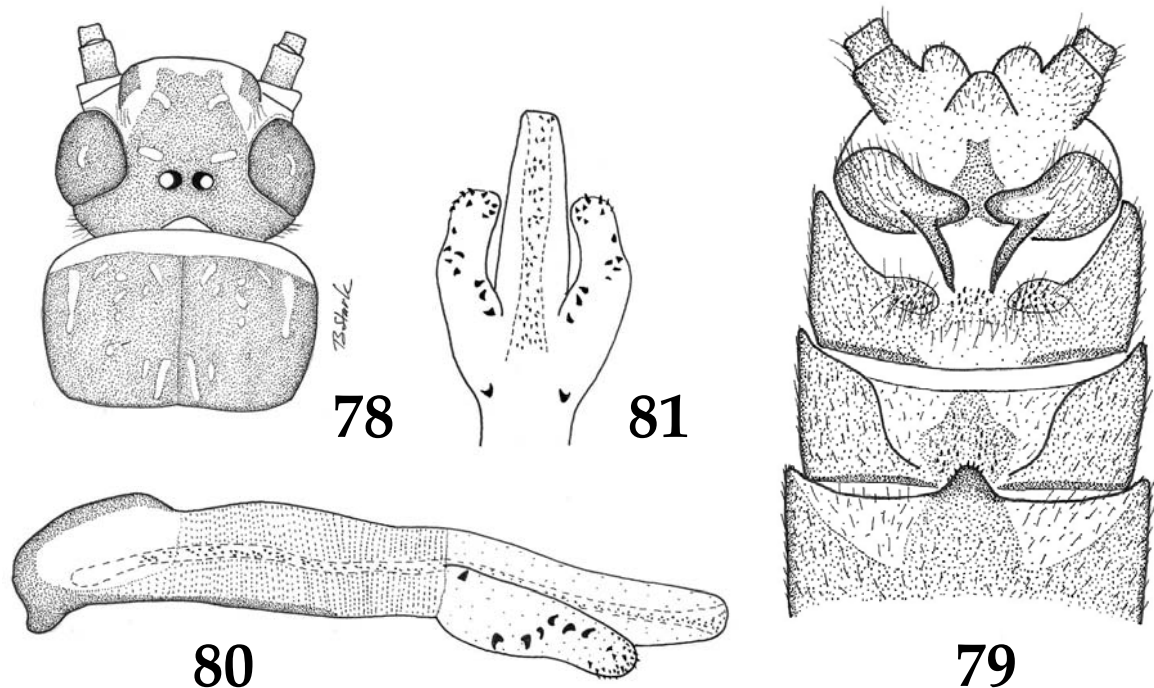
Remarks. The large size and dark habitus of this species will separate it from most *Neoperla*. The aedeagus (Figs. 76-77) and external male genitalia (Fig. 75) are similar to that of *N. ginyuanensis* Yang & Yang but in that species the ventral aedeagal lobe is not shown to be forked at the base (Yang & Yang 1995a). Details of the sac armature are not shown by Yang & Yang (1995a) thus additional comparisons are not possible. Our material is from Tam Dao, the same location where two of the male paratypes were taken (Cao et al. 2007).

***Neoperla zonata* sp. n.**
(Figs. 78-81)

Material examined. Holotype ♂ from Vietnam, Lao Cai, trickle along trail from Sapa to Muong Hoa Ho River, 11 May 1995, D. Currie, J. Swann, ROM 956037 (ROM).

Adult habitus. Biocellate. Head almost entirely dark brown but paired pale spots located over tentoria anterolateral to ocelli and at M-line; clypeus and area adjacent to lappets pale (Fig. 78). Pronotum brown with scattered, indistinct pale spots on disc. Wing membrane amber, veins brown except for costal margin. Hind femora banded with dark basal and apical bands; fore and mid femora and tibiae brown.

Male. Forewing length 10 mm. Process of tergum 7 rounded and spinulose around margin. Mesal sclerite of tergum 8 flat and bearing a few sensilla basiconica. Tergum 9 with sparse lateral sensilla patches on humps and a few scattered in mesal depression (Fig. 79). Hemitergal processes long and slender.



Figs. 78-81. *Neoperla zonata*. 78. Head and pronotum, 79. Male terminalia, 80. Aedeagus, 81. Aedeagal sac, ventral.

Aedeagal tube plump and poorly sclerotized except on dorsum of basal half; apex of tube trilobed; lateral lobes sparsely armed with ca. 6 large spines on sides and with a cluster of smaller spines at tips (Figs. 80-81); mesal lobe unarmed. Aedeagal sac not completely everted but about equal to tube in length and armed sparsely with small spines.

Female. Unknown.

Larva. Unknown.

Etymology. The species name refers to the banding pattern on the hind femora.

Diagnosis. The aedeagus and external genitalia of this species is of the general type seen in *N. taiwanica* Sivec & Zwick but the lateral aedeagal lobes in that species are much smaller than those found in *N. zonata* (Sivec & Zwick 1987).

Unassociated Females

Neoperla Vn-A (Figs. 82-84, 124-126)

Material examined. Vietnam: Nghe An, ca. 25 km SW Con Cuong, Khe Moi River Forestry Camp, tributary of Khe Moi River, 308 m, 6 June 1995, 18° 56' N, 104° 49' E, B. Hubley, ROM 956172, 2 ♀

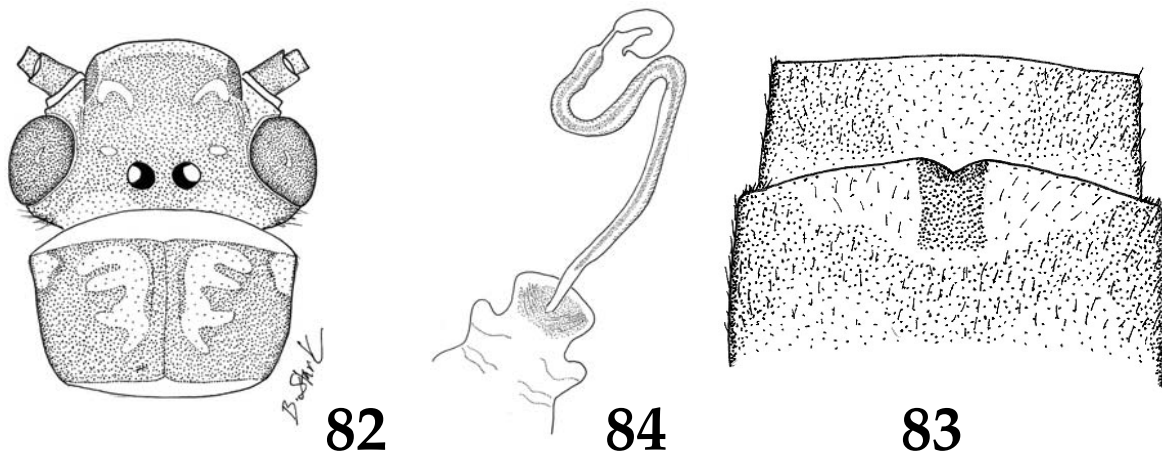
(ROM). Same site but 4 June 1995, B. Hubley, J. Swann, ROM 956158, 3 ♀ (ROM).

Adult habitus. Biocellate. Head mostly dark brown but with obscure pale areas forming incomplete M-line and surrounding tentoria (Fig. 82). Pronotum dark brown. Wings tinted brown with darker veins and pale costal margin. Hind femora with dark brown basal and apical bands and pale mesal band, fore and mid femora dark brown.

Female. Forewing length 10-11 mm. Subgenital plate scarcely produced and mesally emarginate (Fig. 83). Spermathecal stalk very long and slender and lined for most of length with minute spinules (Fig. 84).

Egg. Oval. Length ca. 0.33 mm, width ca. 0.17 mm, collar width ca. 0.09 mm. Collar short and slightly constricted basally with a thin, smooth rim (Figs. 124-126). Striae narrow, ca. 11 primary and 20 secondary striae visible in lateral aspect; primary striae connect to collar rim and to follicle cell impressions on lid; secondary striae occur in pairs between primaries and become less prominent near poles. Sulci narrow with a single row of coarse punctations between any pair of striae. Lid small consisting of two rows of follicle cell impressions; FCIs deep, walls smooth, and with floors having ca. 9 punctations.

Diagnosis. See above for *N. teresa*.



Figs. 82-84. *Neoperla* Vn A. 82. Head and pronotum, 83. Female terminalia, 84. Vagina and spermatheca.

***Neoperla* Vn-B**
(Figs. 85-87, 127-129)

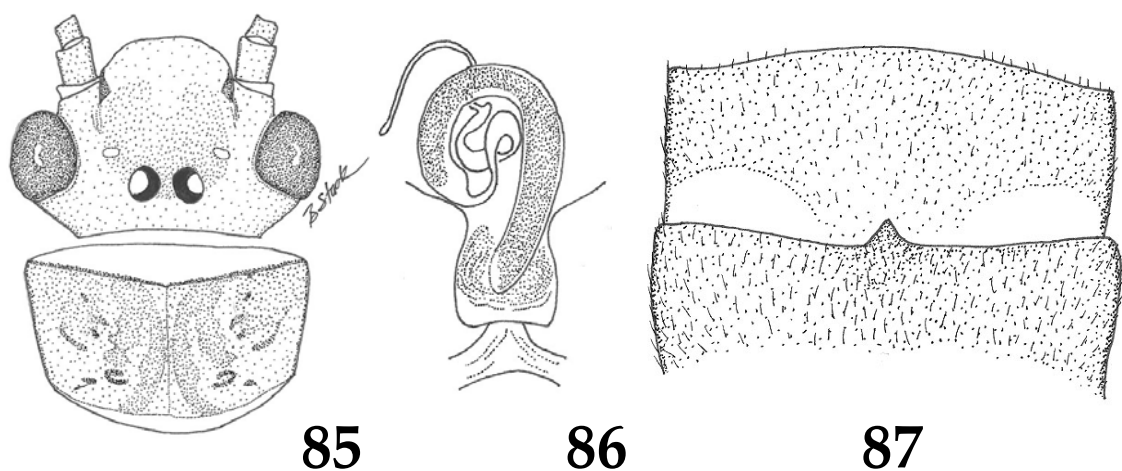
Material examined. Vietnam: Dong Nai, Cat Tien National Park, near park headquarters, 120 m, 22 August 1998, 11° 25' 9" N, 107° 25' 41.5" E, B. Hubley, D. Currie, ROM 982002, 1 ♀ (ROM).

Adult habitus. Biocellate. Head pale with slightly darker area covering central frons from ocelli to near antennal bases (Fig. 85). Pronotum pale brown with darker rugosities. Wing membrane pale veins amber to pale brown. Femora and tibiae pale.

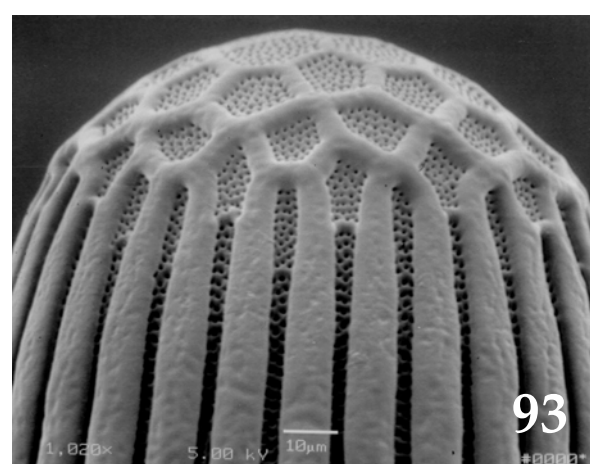
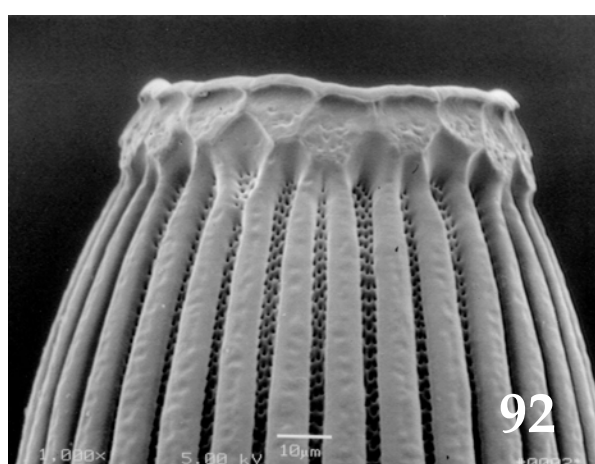
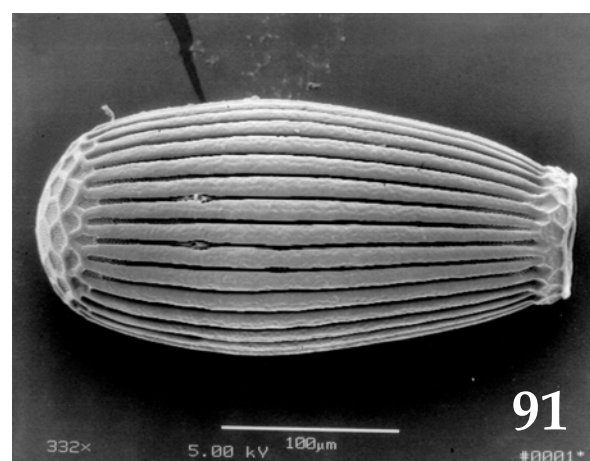
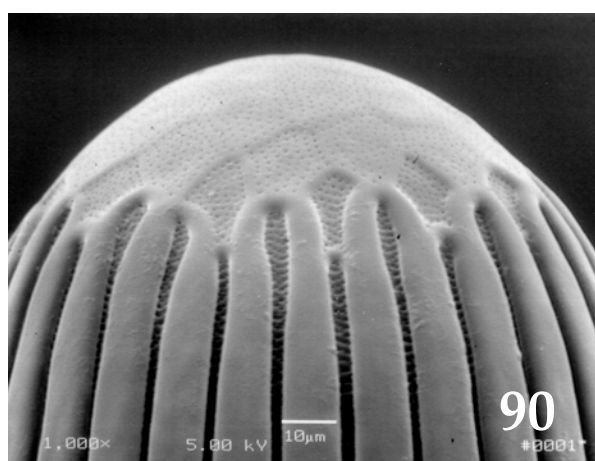
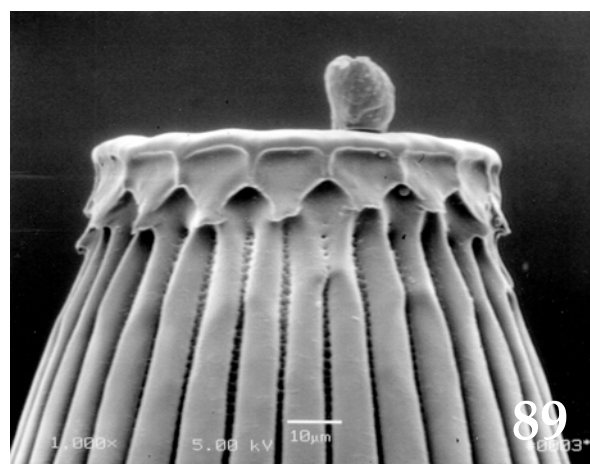
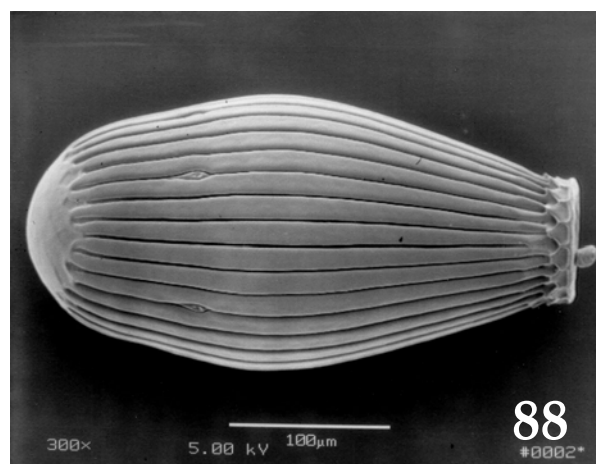
Female. Forewing length 13 mm. Subgenital plate a small triangular tab (Fig. 87). Vagina lined with

golden brown scales forward of spermathecal base (Fig. 86). Spermathecal stalk long, partially coiled and lined rather completely with fine golden brown scales.

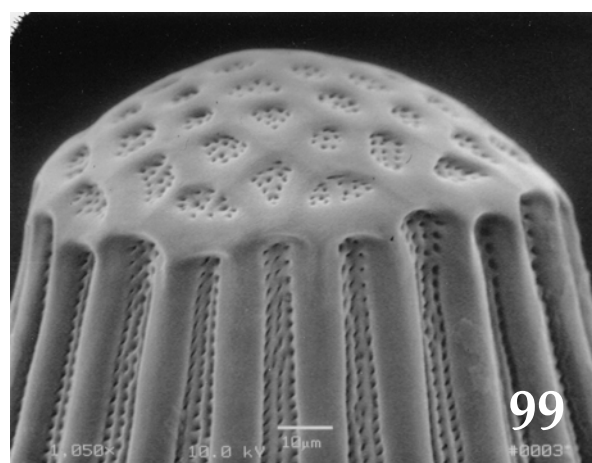
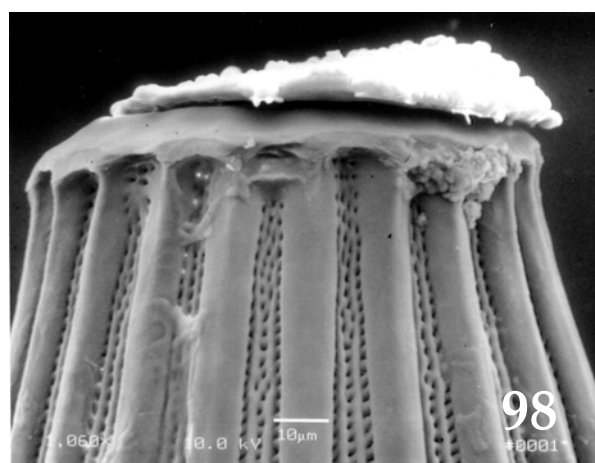
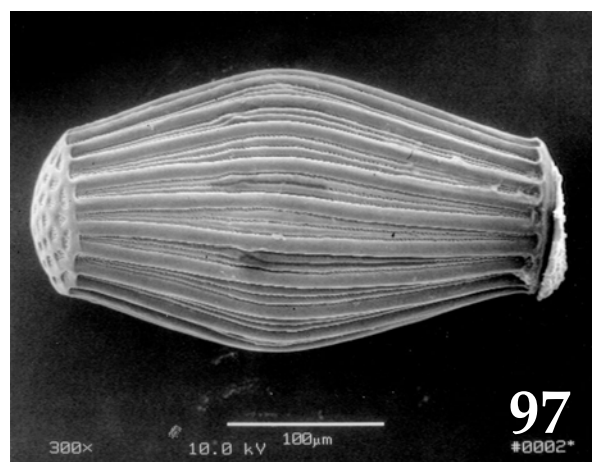
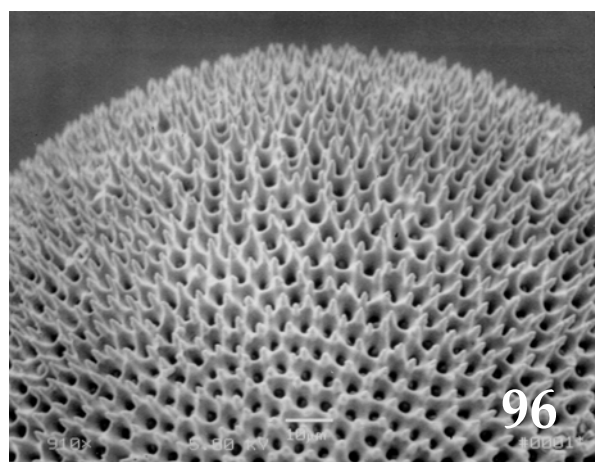
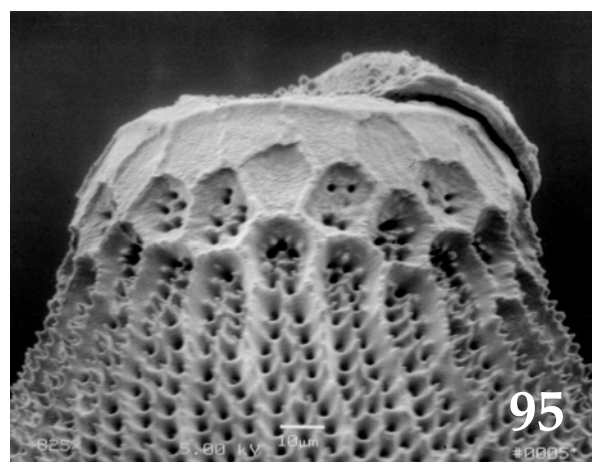
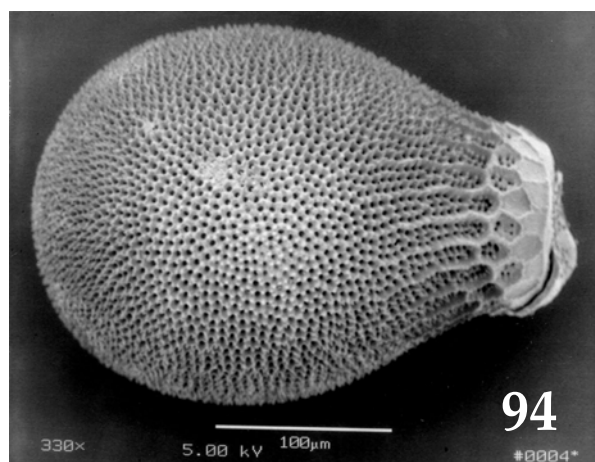
Egg. Barrel shaped. Length ca. 0.33 mm, width ca. 0.17 mm, collar width ca. 0.06-0.07 mm. Collar sessile and surrounded by 1-2 rows of large, irregularly shaped, impunctate cells; rim narrow and smooth; base of collar ringed by a distinct, irregular ridge (Figs. 127-129). Striae wide, ca. 17 visible in lateral aspect; striae separated by narrow punctate sulci. Lid small, covered with fine punctations throughout, follicle cell impressions obscure.



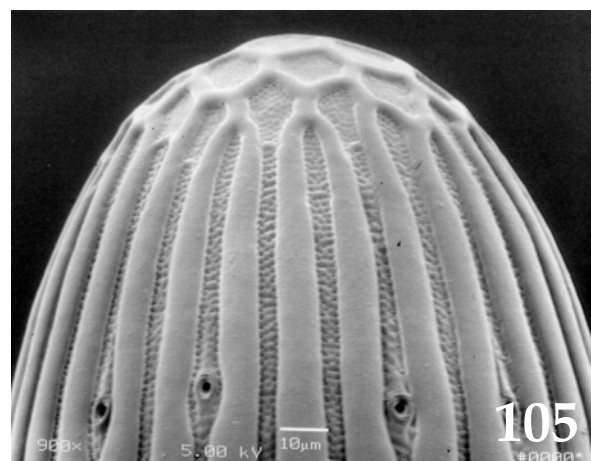
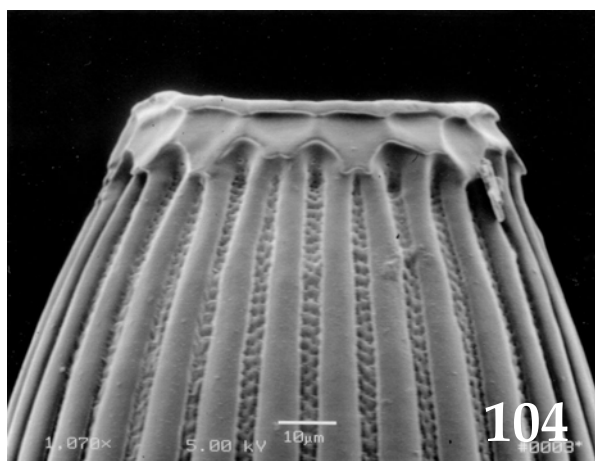
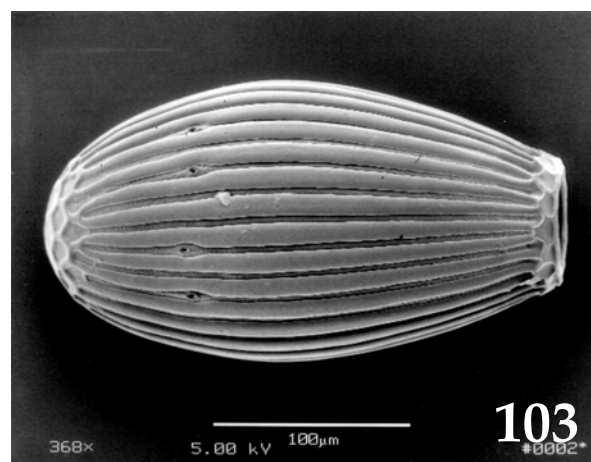
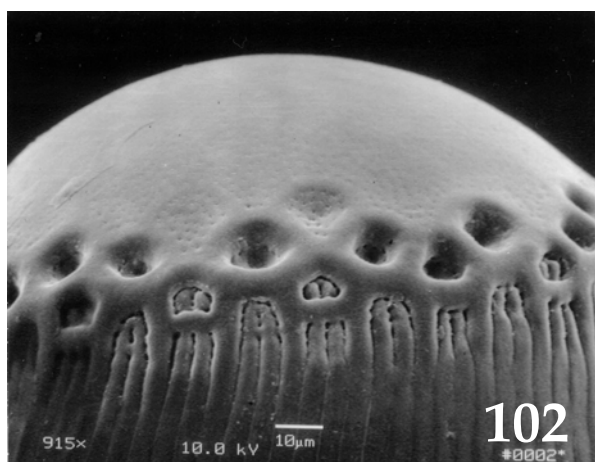
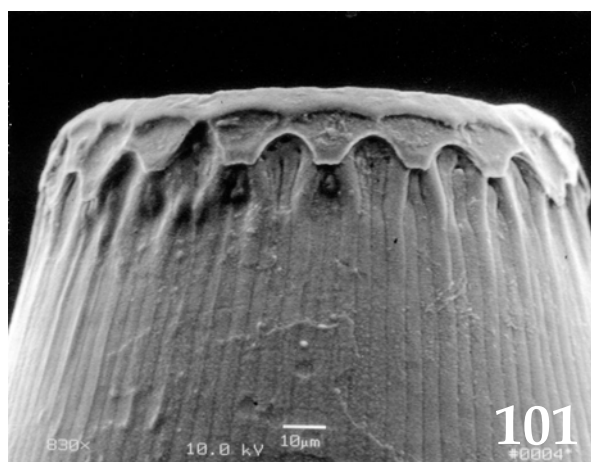
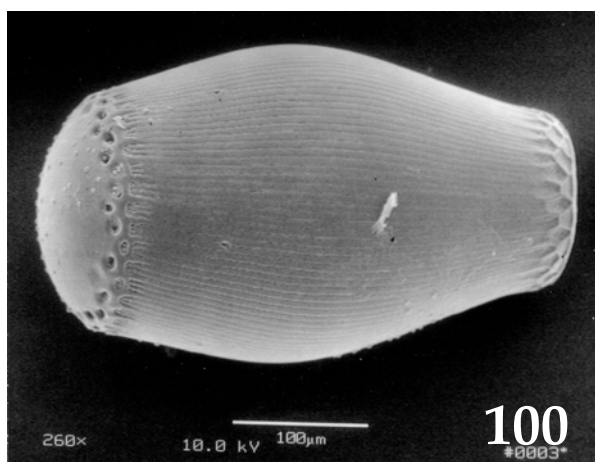
Figs. 85-87. *Neoperla* Vn B. 85. Head and pronotum, 86. Vagina and spermatheca, 87. Female terminalia.



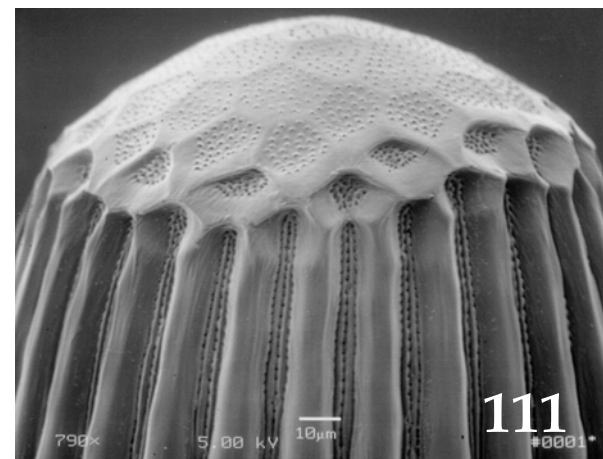
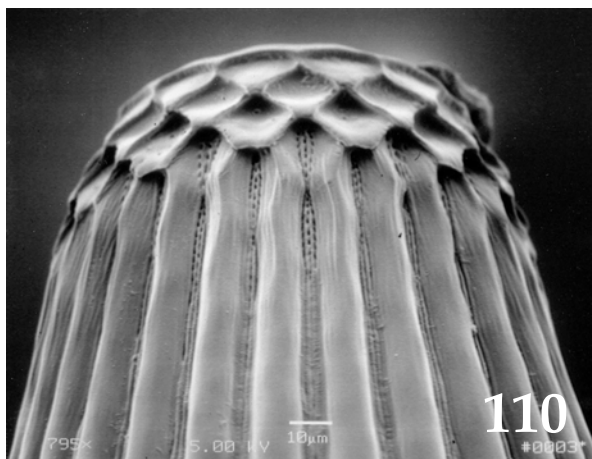
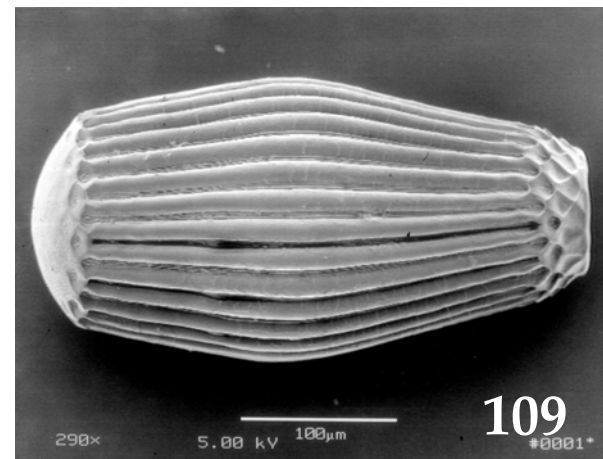
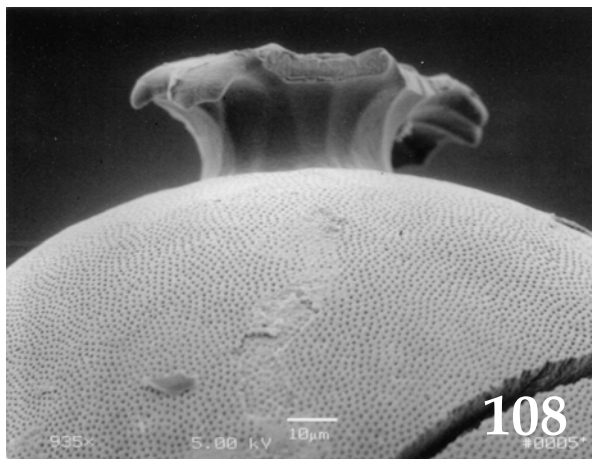
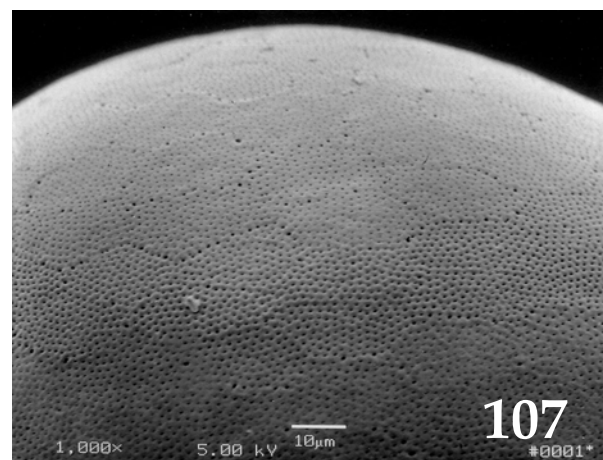
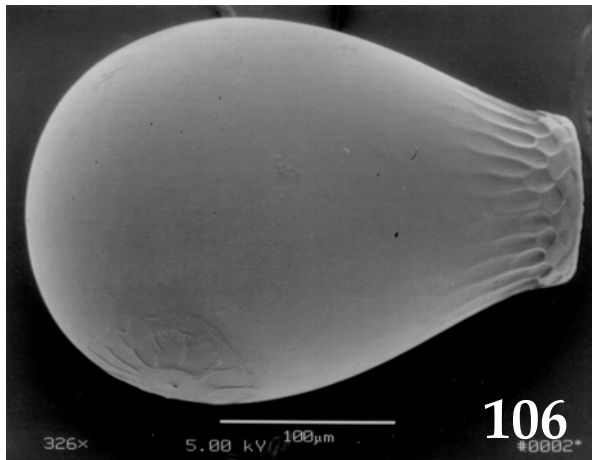
Figs. 88-93. Egg micrographs. 88-90. *N. cavaleriei*. 88. Egg, 89. Collar, 90. Lid. 91-93. *N. clara*. 91. Egg, 92. Collar, 93. Lid.



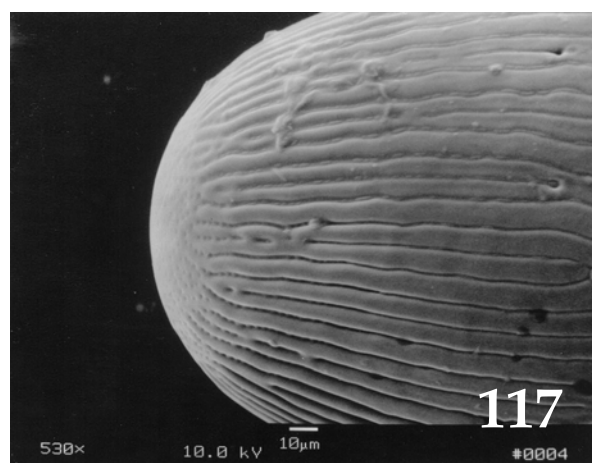
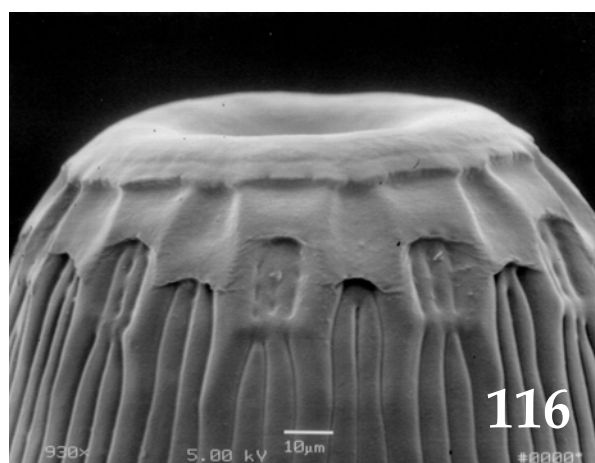
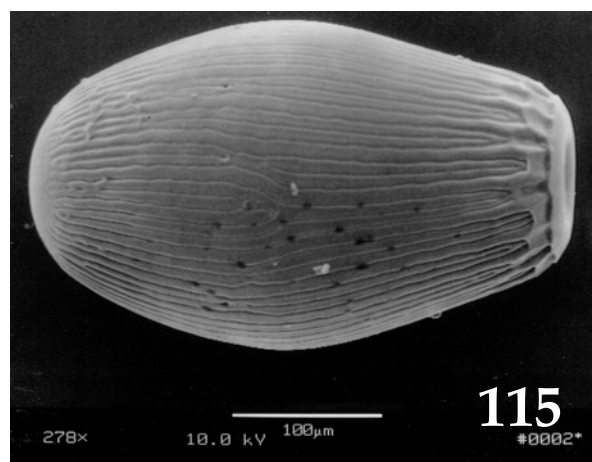
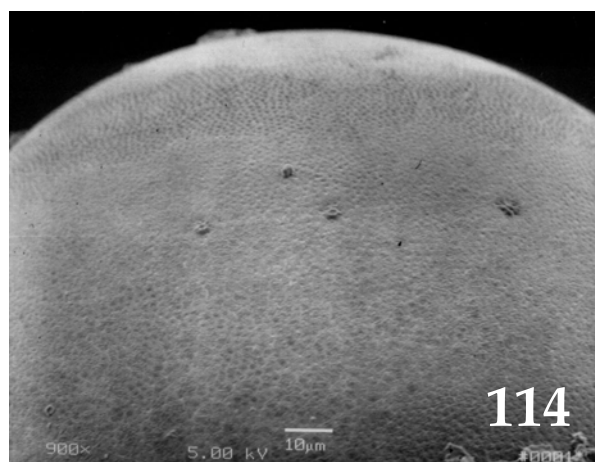
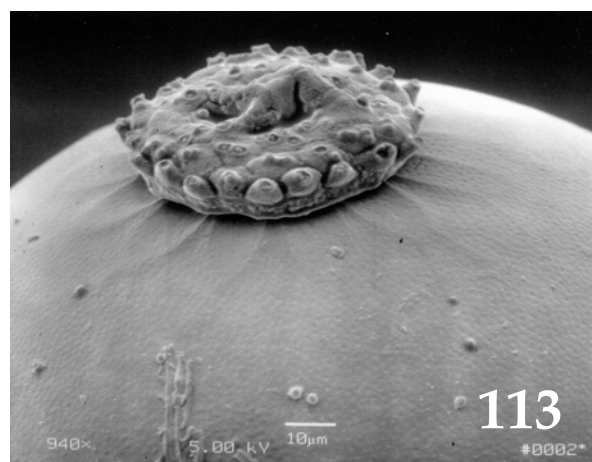
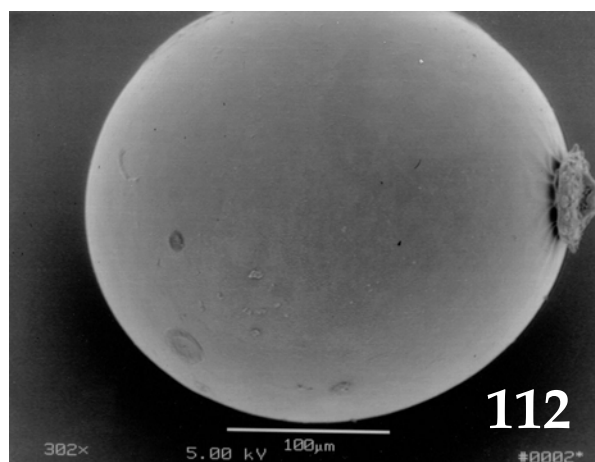
Figs. 94-99. Egg micrographs. 94-96. *N. hamata*. 94. Egg, 95. Collar, 96. Lid. 97-99. *N. hubleyi*. 97. Egg, 98. Collar, 99. Lid.



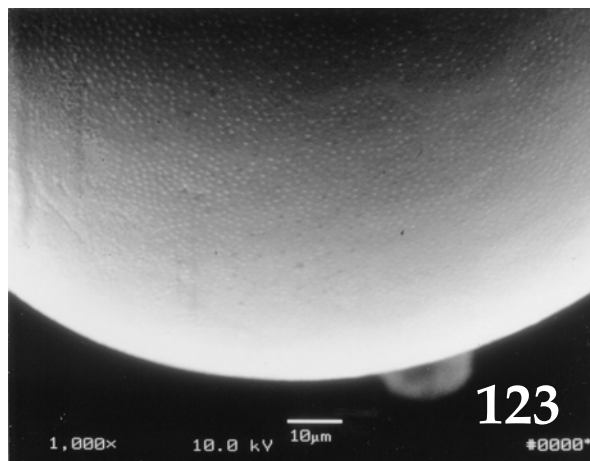
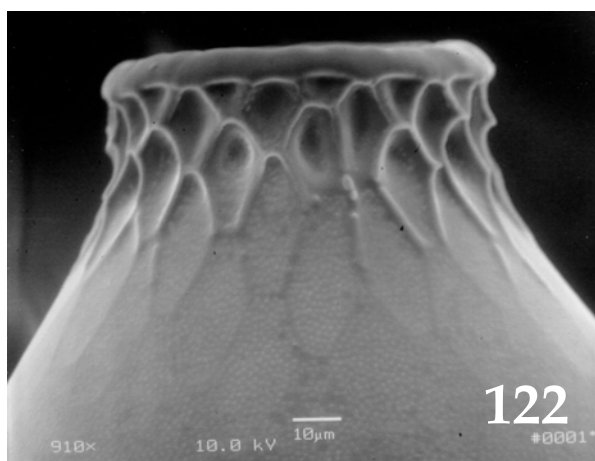
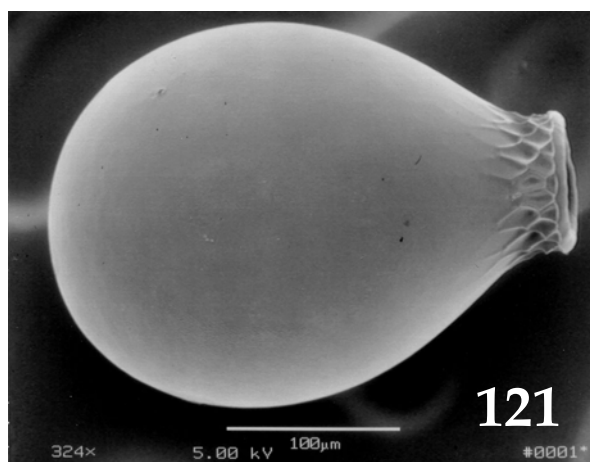
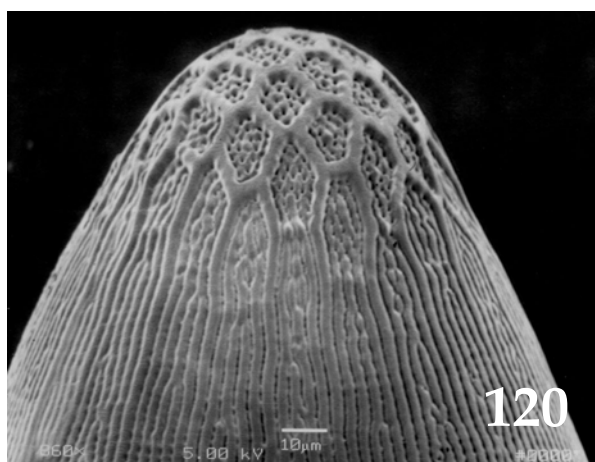
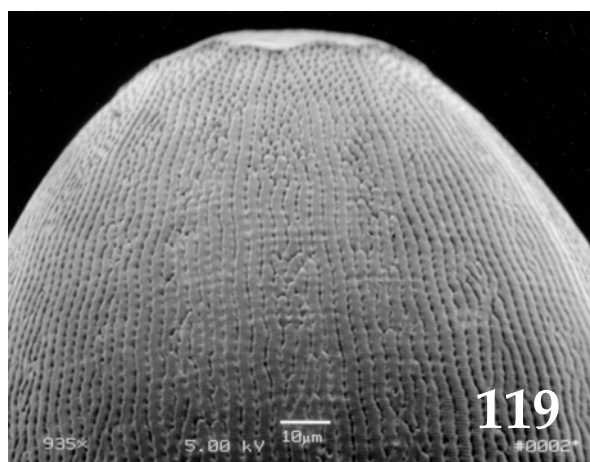
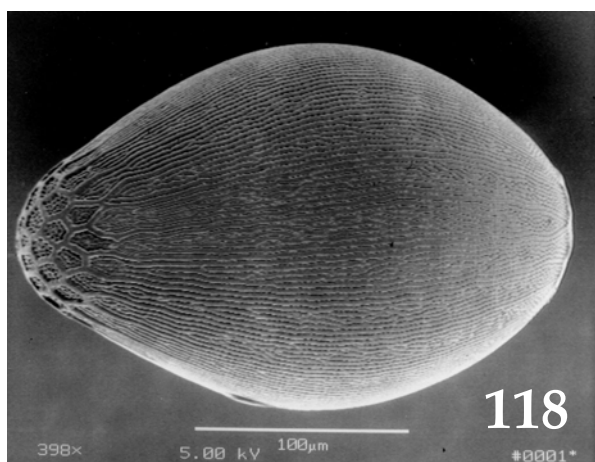
Figs. 100-105. Egg micrographs. 100-102. *N. idella*. 100. Egg, 101. Collar, 102. Lid. 103-105. *N. leptacantha*. 103. Egg, 104. Collar, 105. Lid.



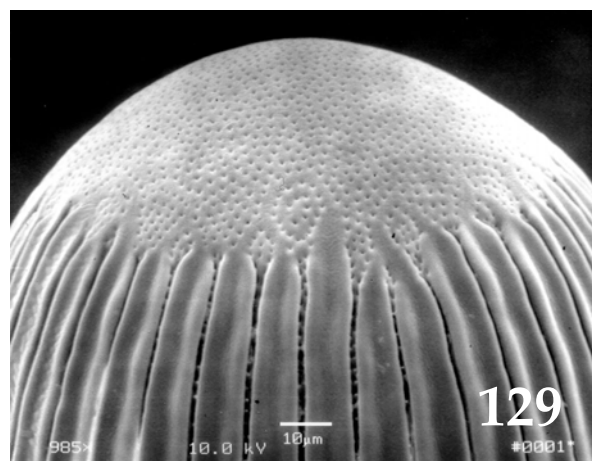
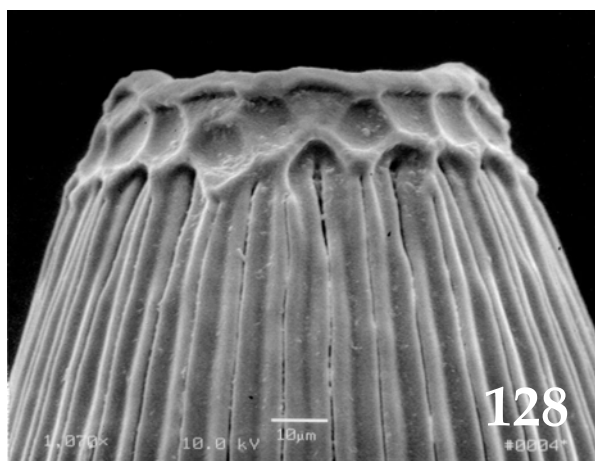
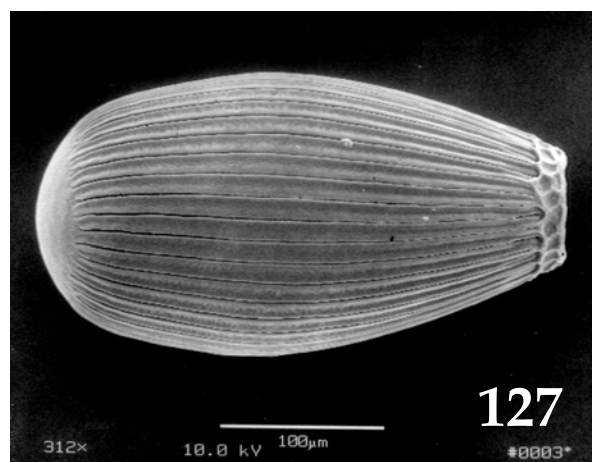
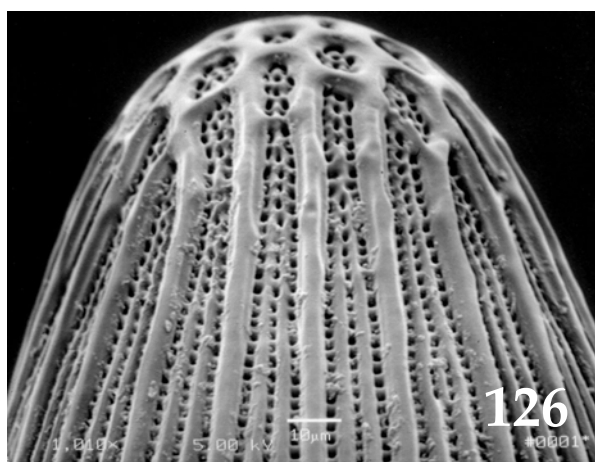
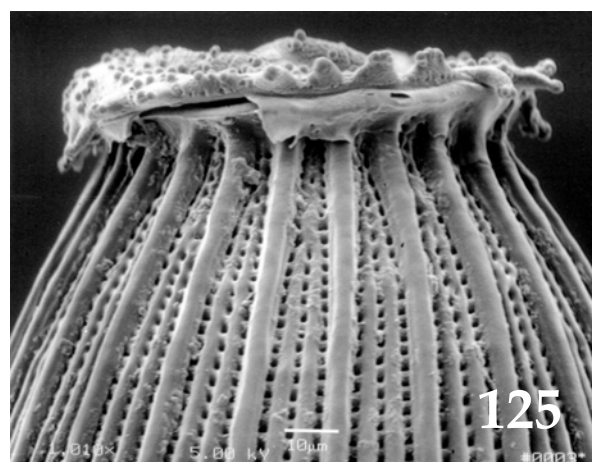
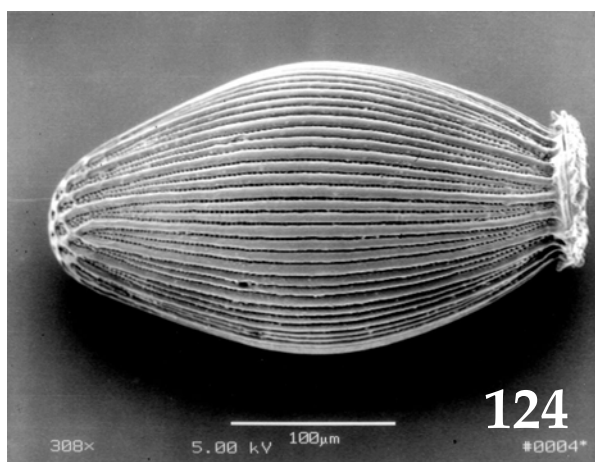
Figs. 106-111. Egg micrographs. 106. *N. mnong*. 106. Egg, 107-108. *N. tamdao*. 107. Egg, 108. Collar. 109-111. *N. nebulosa*. 109. Egg, 110. Collar, 111. Lid.



Figs. 112-117. Egg micrographs. 112-114. *N. song*. 112. Egg, 113. Collar, 114. Lid. 115-117. *N. spinaloba*. 115. Egg, 116. Collar, 117. Lid.



Figs. 118-123. Egg micrographs. 118-120. *N. teresa*. 118. Egg, 119. Collar, 120. Lid. 121-123. *N. yao*. 121. Egg, 122. Collar, 123. Lid.



Figs. 124-129. Egg micrographs. 124-126. *N. Vn-A*. 124. Egg, 125. Collar, 126. Lid. 127-129. *N. Vn-B*. 127. Egg, 128. Collar, 129. Lid.

Diagnosis. This unassociated member of the *clymene* complex is distinctive by virtue of the triangular subgenital plate, and the wide chorionic striae of the egg. The latter feature is reminiscent of *N. coosa* and *N. osage* from the Nearctic region (Stark & Lentz 1988; Smith & Stark 1998). Males of *N. sinuata* and *N. gordonae* were collected with this female but the former species has a distinctive head pattern not shared with this species, and the female of the latter species is known. If this female should at some future time be associated with the male identified as *N. gordonae* from Cat Tien National Park, that would support the argument, presented above, that *N. gordonae* represents a species complex.

IDENTIFICATION KEY FOR *NEOPERLA* FROM VIETNAM

The following provisional key is provided to aid in identification of male *Neoperla* from Vietnam. Identifications obtained with this key should be confirmed by comparisons with figures and descriptions provided elsewhere in this paper or in other sources (Uchida & Yamasaki 1989; Zwick 1983, 1988).

Males

(*N. brachyura*, *N. hoabihnica*, *N. ramosa*, *N. sungi*, *N. vitalisi* not included)

- 1 Tergum 7 bears a broadly truncate, elevated, plateau-like process, tergum 8 bears a slender, erect, curved process (Fig. 30) 2
- 1' Tergum 7 and tergum 8 processes variable, but not as described above 9
- 2 Aedeagal tube bears a projecting, sometimes spiny or forked, slender membranous lobe (Fig. 22) 3
- 2' Aedeagal tube without lobes, or if present, lobes are large and spherical; lobes present or absent on sac (Fig. 53) 7
- 3 Lobe of aedeagal tube a simple, nipple shaped structure (Fig. 22) *dao*
- 3' Lobe of aedeagal tube bifurcate (Fig. 42) 4
- 4 Lobe of aedeagal tube deeply forked 5
- 4' Lobe of aedeagal tube with long Y-stalk and short arms (Fig. 42) 6
- 5 Lobe of aedeagal tube forked to base and without spiny armature; arms of lobe less than three times

- long as wide (Fig. 76) *yentu*
- 5' Lobe of aedeagal tube with a short basal stalk, and armed apically with minute spines; arms of lobe at least five times long as wide *yao*
- 6 Stalk of aedeagal lobe subequal to arms in length; aedeagal sac unarmed on dorsum for most of length proximal to subapical spiny mound (Fig. 42) *mnong*
- 6' Stalk of aedeagal lobe about twice as long as arms; aedeagal sac rather densely and completely armed for all but a short basal section (Fig. 31) *hubleyi*
- 7 Aedeagal sac without spiny lobes but dorsal margin bearing a double row of 4-7 cultriform spines (Figs. 36-37) *idella*
- 7' Aedeagal sac with a pair of spiny lobes (Fig. 53) 8
- 8 Sac angled abruptly dorsad; sac unarmed on ventral margin for most of length distal to lobes (Figs. 53-54) *nebulosa*
- 8' Sac curved gradually dorsad; ventral margin of sac armed for most of length distal to lobes (Fig. 64) *spinaloba*
- 9 Process of tergum 7 broad at tip, often rounded, truncate or notched (Figs. 24, 58) 10
- 9' Process of tergum 7 more or less triangular (Fig. 46) 14
- 10 Everted aedeagal sac extends ventrally at an approximate right angle to tube (Fig. 25) *erecta*
- 10' Everted aedeagal sac curved ventrad but not oriented at a right angle to tube 11
- 11 Aedeagus with one or more spiny lobes (Fig. 59) 12
- 11' Aedeagus without spiny lobes (Fig. 69) 13
- 12 Aedeagal sac with a dorsobasal pair of prominent spiny lobes; sac armed with an irregular, subapical ring of cultriform spines (Fig. 59) *song*
- 12' Aedeagal sac without dorsobasal spiny lobes; sac armed at midlength by a large, ventral lobe and subapically by patches of cultriform spines *tamdao*
- 13 Hemitergal finger lobes curved dorsad near tips; process of tergum 7 truncate; aedeagal sac armature larger on dorsal margin, but not cultriform *hamata*
- 13' Hemitergal finger lobes curved inward; process of tergum 7 rounded (Fig. 68); aedeagal sac armature with a double row of dorsal cultriform spines on

- apical third (Fig. 69) *teresa*
- 14 Aedeagal sac with two or more spiny lobes (Fig. 80) 15
- 14' Aedeagal sac without spiny lobes (Fig. 14) 16
- 15 Aedeagal sac trilobed (Fig. 80) *zonata*
- 15' Aedeagal sac with three ventral lobes arranged linearly (Fig. 47) *multispinosa*
- 16 Aedeagal tube armed with one or more spines in apical half (Fig. 14) 17
- 16' Aedeagal tube armature absent apically or reduced to small spicules (Fig. 3) 19
- 17 Dorsal margin of aedeagal tube armed from near midlength to apical third with a few spines; sac armature extends from near base to apex *nova*
- 17' Dorsal margin of aedeagal tube armed near apex with one or more spines; ventral margin of tube with additional spines (Figs. 17-18); sac armature begins near midlength (Fig. 17) 18
- 18 Aedeagal tube armed at midlength with a pair of small unsclerotized spiny patches; venter with a small patch of about five apical spines; sac armature consists of scattered cultriform spines primarily along dorsal margin (Fig. 14) . *monacha*
- 18' Aedeagal tube without midlength armature; venter with a large apical patch of spines; sac armature covers most of surface at midlength (Fig. 17) *sinuata*
- 19 Base of aedeagal sac with a complete ring of long close-set spines; process of tergum 7 very slender and acute at tip *coronata*
- 19' Base of aedeagal sac without grouping of long spines; process of tergum 7 broadly triangular and rounded or slightly forked at tip (Fig. 2) . 20
- 20 Aedeagal tube somewhat plump and lacking sclerotization except basally and along dorsal margin *fallax*
- 20' Aedeagal tube slender and sclerotized along dorsal and ventral margins (Fig. 3) 21
- 21 Basal patch of small spines of aedeagal sac in contact with tube apex (Fig. 3) 22
- 21' Basal patch of small spines of aedeagal sac clearly separated from tube apex by unarmed membrane (Fig. 7) 23
- 22 Basal patch of small spines on aedeagal sac restricted to dorsolateral surfaces; distal sac armature includes irregular rows of moderately sized spines on dorsal and ventral margins *gordonae*
- 22' Basal patch of small spines completely rings aedeagal sac; distal sac armature not organized into irregular rows of spines (Fig. 3) *clara*
- 23 Base of aedeagal sac bears a dorsal cushion of small spines and longer spines along dorsal margin; ventral sac margin bears a patch of more prominent spines near midlength, apical sac armature reduced on both margins to minute spicules *cavaleriei*
- 23' Base of aedeagal sac without dorsal cushion of spines 24
- 24 Aedeagal sac base completely ringed with small spines but discretely separated from tube apex by narrow band of membrane; margins of sac without larger spines (Fig. 7) *daklak*
- 24' Aedeagal sac unarmed for at least basal 20% of sac length; armature on dorsal margin consists of irregular row of small peg shaped spines; ventral armature begins distally to origin of dorsal armature (Fig. 9) *leptacantha*

APPENDIX A

Checklist of *Neoperla* species reported from Vietnam

The *Clymene* Group

N. cavaleriei (Navás)
N. clara sp. n.
N. coronata Zwick
N. daklak sp. n.
N. gordonae Stark
N. hoabinhica Navás
N. leptacantha sp. n.
N. monacha sp. n.
N. nova Zwick
N. sinuata sp. n.
N. sungi Cao & Bae

The *Montivaga* Group

N. dao sp. n.
N. erecta sp. n.
N. fallax Klapálek
N. hamata Jewett
N. hubleyi sp. n.
N. idella sp. n.
N. mnong Stark
N. multispinosa sp. n.
N. nebulosa sp. n.
N. song sp. n.
N. spinaloba sp. n.

N. tamdao Cao & Bae
N. teresa sp. n.
N. yao Stark
N. yentu Cao & Bae
N. zonata sp. n.

Species of uncertain status

N. brachyura Navás
N. ramosa (Navás)
N. vitalisi Navás

Unassociated females

N. Vn-A
N. Vn-B

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