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NEW STONEFLIES (PLECOPTERA) FROM ASIA

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ABSTRACT

Kamimuria zwicki sp. n. and *Neoperla peterzwicki* sp. n. are described from specimens collected in South Korea and East Kalimantan, Indonesia respectively, *Agnetina zwicki* sp. n. from Sichuan, China, *Neoperla schlitz* sp. n. from Kerala State, India, and *Haploperla zwicki* sp. n. and *Isoperla peterzwicki* sp. n. are described from Thai specimens. Each species is compared with related congeners and a provisional key for males of the *Neoperla borneensis* species subgroup is provided.

Keywords: Plecoptera, *Kamimuria, Neoperla, Agnetina, Haploperla, Isoperla,* new species, Asia

INTRODUCTION

During the course of our work with various Asian stonefly families and genera four new species of perlids and a single new chloroperlid and a new isoperlid have surfaced which do not fit within the context of other recent or on-going studies with either a regional or a systematic organizing principle (e.g. Sivec et al. 2005; Stark & Sivec 2007, 2008). Because we do not anticipate additional related material, we take this opportunity to bring these species of *Haploperla, Isoperla, Agnetina, Kamimuria* and *Neoperla* to the attention of the scientific community in order to promote awareness of these uncommon insects. The specimens of *Haploperla* and *Isoperla* are particularly noteworthy as the first records of their respective families from the Southeast Asian peninsula. The site where these specimens were collected is in Doi Inthanon National Park where the highest mountains in Thailand are located.

Specimens are deposited in the following museums or private collections as indicated in the text: Slovenian Museum of Natural History, Ljubljana (PMSL), Stark Collection, Clinton, Mississippi (BPS); Illinois Natural History Survey, Urbana (INHS); Museum Zoologicum Bogoriense, Indonesian Institute of Sciences, Bogor (MZB); Royal Ontario Museum, Toronto (ROM), and Zoological Museum, Amsterdam (ZMA). We thank H. Malicky, Lunz, Professor Dr. P. Chantaramongkol and her students of the Chiang Mai University team, E. DeWalt of the Illinois Natural History Survey and B. Hubley of the Royal Ontario Museum for their loan or gift of material. This research was partially funded by National Science Foundation (Biotic Surveys and Inventories) Grant DEB-0103144, awarded to G. Courtney, Iowa State University. We also thank the National Research Council of Thailand (NRCT) and Royal Forestry Department (RFD) for permission to conduct research and use facilities in the national parks of Thailand.

RESULTS AND DISCUSSION

Kamimuria zwicki sp. n.

(Figs. 1-4)

Material examined. Holotype ♂ and 3 ♂ paratypes

from South Korea, Jirisan, Mamyang-gun, Songjeon-li, Mansu-sa, 400 m, 27 June-27 July 2004, Tripotin Rec (Holotype, 1 paratype, INHS; 2 paratypes, BPS).

Adult habitus. General color yellow brown. Head pale with darker U-shaped marking connecting ocelli; posterolateral margins of head, narrow line behind ocelli and lappets dusky (Fig. 1). Antennae pale brown, palpi pale. Pronotum brown with slightly darker areas scattered on disc. Wing membrane yellowish, veins pale brown. Femora and tibiae pale brown but tibiae slightly darker at knee; basal tarsal segments brown, apical segment pale except for tip of segment. Cerci pale.

Male. Forewing length 20-22 mm. Abdominal terga 8-9 with median patches of sensilla basiconica larger on 9. Projecting portion of hemiterga about twice as long as basal width; posteromesal margins of hemiterga with linear patch of sensilla basiconica (Fig. 2). Hair brushes on abdominal sterna 5-7. Aedeagal apex bearing a prominent, ventral pair of large pincer shaped sclerites and two short median rows of 2-4 small tooth-like spines; proximal end of spine rows usually with a few minute spinules centered between spines (Figs. 3-4). Median section of aedeagal tube armed with large patch of minute spinules; patch encircles ventrolateral area but is interrupted dorsally by a median longitudinal bare area.

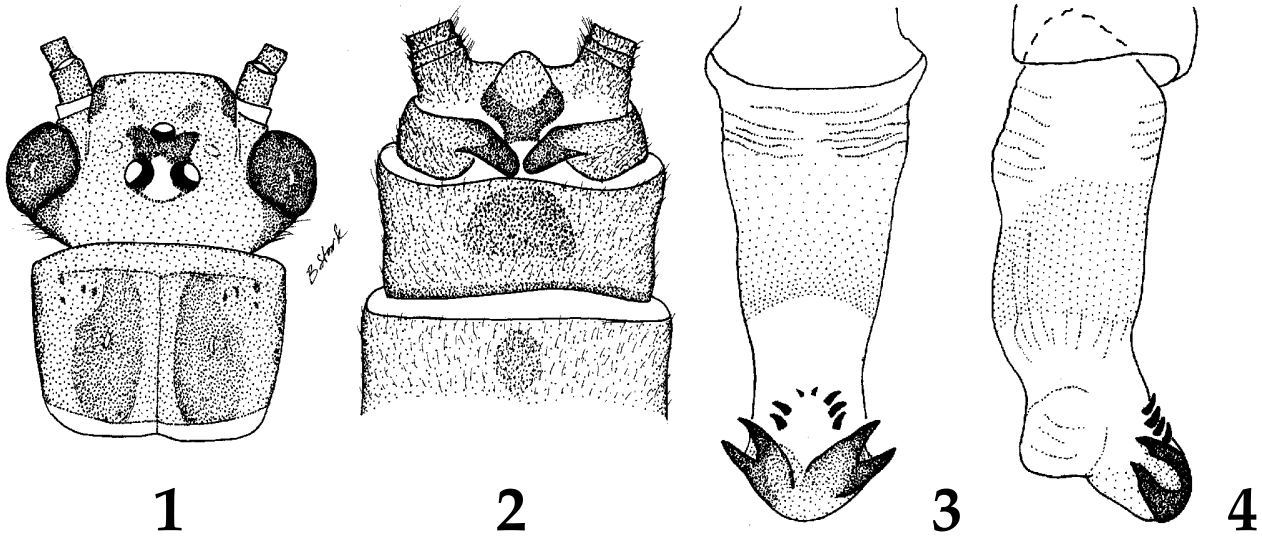
Female. Unknown.

Larva. Unknown.

Etymology. The patronym honors our friend and colleague, Professor Dr. Peter Zwick, in recognition of his early studies of the Korean stonefly fauna (Zwick 1973a, 1973b), and in recognition of his systematic resurrection of genus *Kamimuria* (Zwick 1977)

Diagnosis and Discussion. *Kamimuria zwicki* is related to *K. lyubaretzi* Teslenko and *K. sparsula* Du, two recently described species in which the apex of the aedeagus bears prominent sclerites (Teslenko 2006; Du et al. 2001). The former species from the Russian Far East bears a single pair of long slender spines and several (ca. 7) smaller spines arranged in a proximal circumlinear row near the bases of the large spines. The latter species from Tianmu Mountain, Zhejiang Province, China bears a pair of enlarged spines on both the dorsal and ventral margins near the aedeagal apex.

Kamimuria males from Thailand and Vietnam (Sivec & Stark unpublished), Japan (Uchida & Isobe 1991; Sivec et al. 1988), Bhutan (Zwick 1977) and other areas where there is sufficient documentation, are known to have simple aedeagal armature usually consisting of patches of small spines. The discovery of species with complex armature from East Asia is an interesting development.



Figs. 1-4. *Kamimuria zwicki*. 1. Head and pronotum, 2. Male abdominal terga 8-10, 3. Aedeagus, ventral, 4. Aedeagus lateral.

***Neoperla peterzwicki* sp. n.**
(Figs. 5-11)

Material examined. Holotype ♂ and 1 pinned ♀ paratype from Indonesia, East Kalimantan, Long Tua, Bahan River, 3° 10′ N, 115° 47′ E, 440 m, 5-9 April 1994, IIS 940526, B. Hubley, D.C. Darling (MZB). Paratypes: Indonesia: East Kalimantan, Balungan, Kayan Mentarang Nature Reserve, Lalut Birai Research Station, 115° 48′ E, 02° 51′ N, 355 m, 20 February-4 March 1993, IIS 930000, D.C. Darling, 1 ♂ pinned (ROM).

Adult habitus. General color pale brown. Head pale brown but with obscure darker spot between ocelli; lappets and triangular area forward of M-line brown; dusky area and small pale spot define obscure M-line (Fig. 5). Basal two antennal segments pale brown, flagellum dark brown; basal palpal segments pale, apical segments brown. Pronotum brown with slightly darker rugosities. Wing membrane pale amber, veins brown. Femora pale brown, darker on dorsum and at narrow knee band; tibiae and tarsi dark brown.

Male. Forewing length 13 mm. Process of tergum 7 wide and notched; apex lined with a few large sensilla basiconica. Median sclerite of tergum 8 slightly raised, weakly sclerotized and bearing a pair of sensilla basiconica patches. Median field of tergum 9 bearing a boomerang shaped mound, slightly sclerotized at each end, and bearing a few sensilla basiconica. Hemitergal tips turned abruptly inwards, posterolateral margins bearing dense row of short stout bristles and a lateral notch; finger lobes slender, relatively long, directed strongly mesad and curved slightly (Fig. 6). Aedeagal tube poorly sclerotized, plump and sparsely armed with small scale-like spines below and forward of bulb and in a narrow mid-dorsal band; apex of tube armed with a pair of dorsolateral spiny lobes. Everted aedeagal sac with large basoventral spiny lobe, large cushion-like basodorsal spiny lobe and a pair of small lateral spiny lobes at midlength; apex of sac bearing a subapical ring of large spines and, near bases of lateral lobes on dorsal margin, a pair of small patches of ca. 5-6 large spines; much of sac surface covered with fine spinules grading into small spines (Figs. 7-8).

Female. Forewing length 17 mm. Subgenital plate scarcely produced, posterior margin of sternum 8 almost straight but with two widely separated small projecting points on either side of a slightly scalloped area (Fig. 9). Vagina approximately circular with tiers of internal wrinkles; most of vaginal area with brown lining; spermatheca J-shaped without apical hook (Fig. 10).

Egg. Outline oval, collar short but distinctly stalked; rim of collar flanged and emarginate (Fig. 11). Chorion finely punctate throughout; equatorial region with obscure follicle cell impressions enclosing punctations.

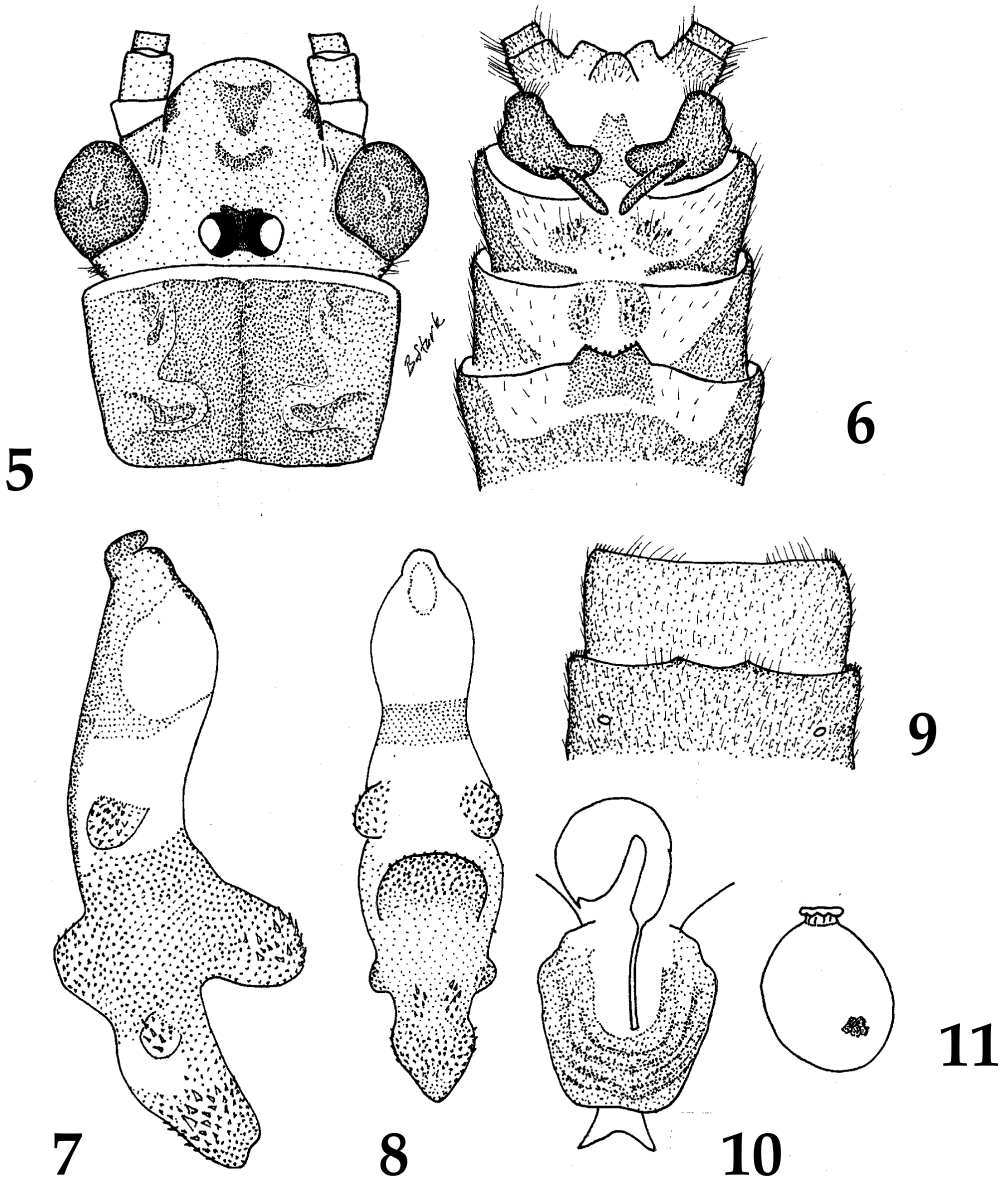
Larva. Unknown.

Etymology. The patronym honors our friend and colleague Professor Dr. Peter Zwick in recognition of his major contributions to the systematics of *Neoperla* (e.g. Zwick 1980, 1981, 1983, 1988) and in the study of Bornean stoneflies (Zwick 1986).

Diagnosis and Discussion. *Neoperla peterzwicki* is a member of the "*Borneensis* Subgroup" of the *Montivaga* Group of *Neoperla.* As defined by Zwick (1986), males of the subgroup have a notched or bifurcate process of tergum 7 and the hemiterga have relatively wide bases. The subgroup is presently known only from Borneo and includes seven species or subspecies recognized and described by Zwick (1986). Externally the new species is quite similar to *N. harina* Navas, *N. furcifera* Klapálek, *N. bilobata* Zwick and *N. furcata* Zwick and less similar to other members of the complex. The aedeagal lobing and armature are suggestive of *N. bilobata* and *N. harina*; from the latter, the new species differs in having a much more prominent dorsobasal spiny cushion and in having small spines scattered over most of the sac surface; from the former species it differs in having a larger ventrobasal spiny lobe and in having the largest spines in the apical region arranged in a circumlinear subapical patch rather than along the dorsal margin in a more linear arrangement. The following key is offered for males of the subgroup.

Provisional Key for Males of the *Borneensis* Subgroup of *Neoperla*

1 Notch on process of tergum 7 wider than projecting lobes ……...…… 2
1′ Notch on process of tergum 7 narrow, bases of projecting lobes touch on inner margins (Fig. 6) …….. 3
2 Posterolateral bases of hemiterga slightly widened, hemitergal finger lobes straight; everted



Figs. 5-11. *Neoperla peterzwicki.* 5. Head and pronotum, 6. Male abdominal terga 7-9, 7. Aedeagus lateral, 8. Aedeagus dorsal, 9. Female abdominal sterna 8-9, 10. Vagina, 11. Egg.

aedeagal sac bearing a small ventrobasal conical process armed with small spines, and area between apical spine patch and dorsobasal lobes armed only with minute spinule ..…….. *borneensis*

2′ Posterolateral bases of hemiterga very wide, hemitergal finger lobes curved slightly outward; everted aedeagal sac without ventrobasal conical process ..…… *naviculata* (2 subspecies)

3 Everted aedeagal sac tubular, without spiny lobes ……..…. *furcifera*

3′ Everted aedeagal sac with one or more spiny lobes …….. 4

4 Largest spiny lobes of aedeagal sac project laterally ……...…… *furcata*

4′ Largest spiny lobes of aedeagal sac project ventrally or dorsally ……... 5

5 Ventrobasal sac lobe conical, narrower in lateral aspect than dorsobasal spiny cushion; apical sac lobe bearing a patch of enlarged spines along mid dorsolateral margin ..... *bilobata*

5′ Ventrobasal sac lobe broadly rounded, larger than dorsobasal spiny cusion in lateral aspect; apical sac lobe without patch of enlarged spines along mid dorsolateral margin 6

6 Everted sac surface without minute spinules scattered over surface; dorsobasal spiny cushion scarcely projecting in lateral aspect ..... *harina*

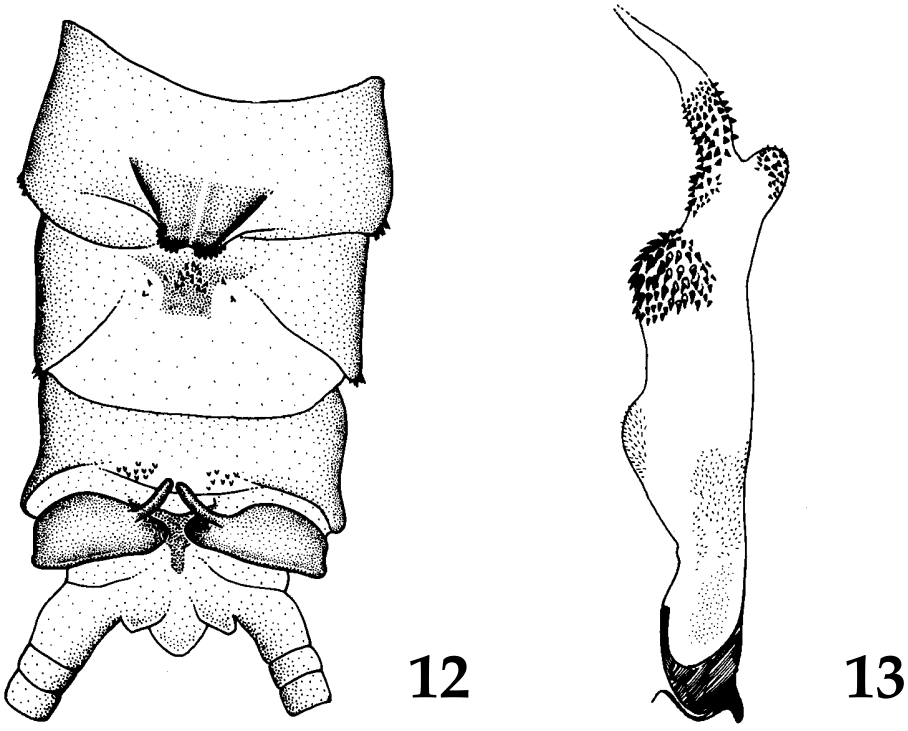
6′ Everted sac surface covered with minute spines; dorsobasal spiny cushion prominent (Fig. 8) ..... *peterzwicki*

***Neoperla schlitz* sp. n.**
(Figs. 12-13)

Material examined. Holotype ♂ from India, Kerala State, Calicut District, Chambra Peak Area, 3500 ft., May 1970, T.R. Susai Nathan (ZMA).

Adult habitus. General color pale yellow without distinctive pigment pattern.

Male. Macropterous, forewing length 11 mm. Process on tergum 7 narrowed from base to a broad, slightly emarginate apex; apicolateral margins of process heavily armed with enlarged, sensilla basiconica (Fig.12). Mesal field of tergum 8 bears a small flat sclerite, truncate on posterior margin, and armed with a patch of sensilla basiconica. Tergum 9 with a pair of small sensilla patches near posterior margin. Hemitergal finger lobes slender, relatively short and convergent to tips. Aedeagal tube mostly membranous but bearing a ventral patch of small spinules and a larger dorsolateral patch of small spinules (Fig. 13); everted sac bears a ventral patch of large, triangular spines, a dorsal patch of smaller spines set on a short, rounded lobe, and a subapical patch of variably sized spines which encircle the cylindrical apical lobe; apex of cylindrical lobe bare.

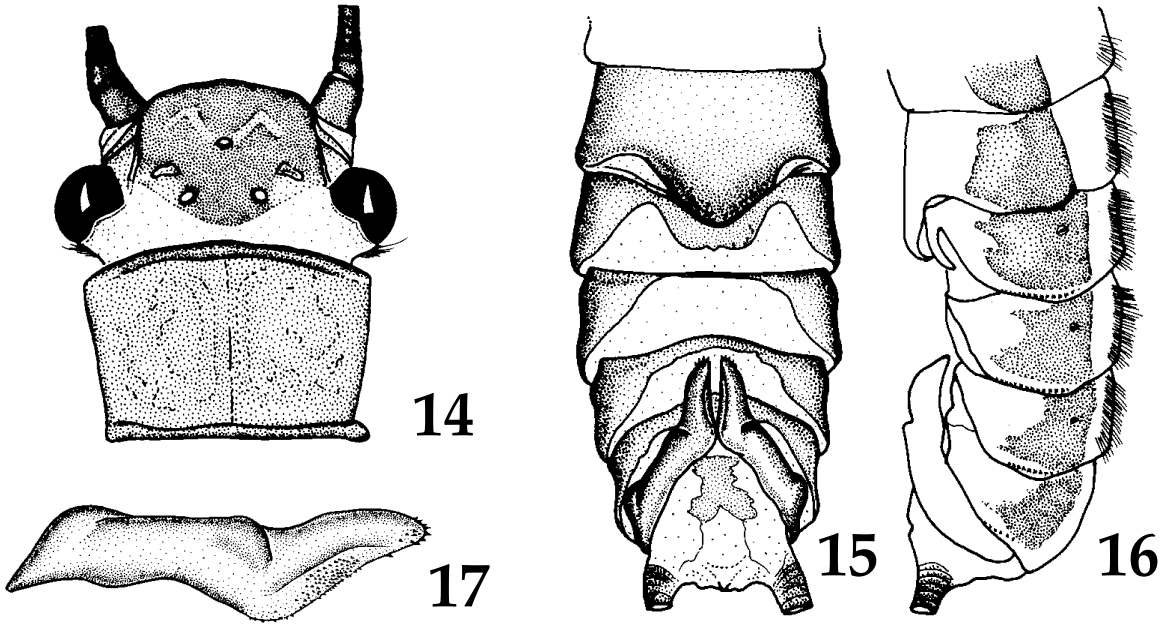


Figs. 12-13. *Neoperla schlitz.* 12. Male abdominal terga 7-9, 13. Male aedeagus, lateral aspect.

Female. Unknown.
Larva. Unknown.
Etymology. The species name, used as a noun in apposition, honors the Limnologische Fluss-Station des Max-Planck-Instituts für Limnologie, formerly located in Schlitz, Germany.
Diagnosis and Discussion. Zwick (1981) recognized seven *Neoperla* species from South India and five of these were reported from Kerala District. None of these species have the 7th tergal process similar to *N. schlitz*, but the aedeagus of *N. nitida* Kimmins is similar in lobing pattern and general armature although they differ in details (Zwick 1981).

Agnetina zwicki sp. n.
(Figs. 14-17)

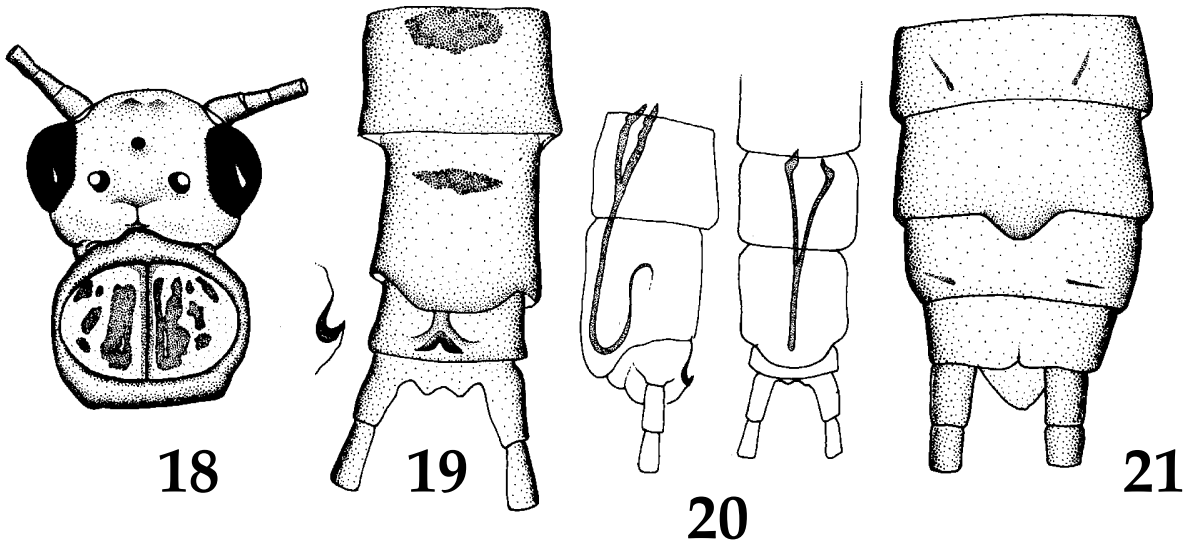
Material examined. Holotype ♂ from China, Sichuan, Emei Shan, 3077 m, 8 August 2007, M. Hrovat (PMSL).
Adult habitus. General color dark brown. Head dark over most of frons; M-line and occiput pale (Fig. 14). Pronotum brown with indistinct rugosities. Femora and tarsi dark brown, tibiae paler except on proximal and distal ends. Cerci pale basally, darker distally. Wings uniformly brown. Abdomen pale except laterally along dark brown pleura.
Male. Macropterous, forewing length 17 mm. Tergum 5 lobe rounded and extending over base of tergum 6 (Fig. 15); mesal field of tergum 6 forming a sclerite that extends almost to posterior margin of tergum. Terga 7-8 sclerotized laterally and along base but with large membranous, mesal field. Hemiterga relatively short, reaching at least to mid-point of tergum 8; apices curved inward in dorsal aspect and bearing a prominent dorsolateral hump opposite "heel" (Figs. 15, 17); lateral aspect of hemiterga with prominent notch forward of hump (Fig.16).
Female. Unknown.
Larva. Unknown.
Etymology. The patronym honors our friend and colleague, Professor Dr. Peter Zwick, in recognition of his important work on this genus (Zwick 1984).
Diagnosis and Discussion. *Agnetina* has been the subject of recent systematic studies in China (Du & Chou 1998; Sivec & Zhiltzova 1997) and the Eastern Palearctic (Sivec et al. 2005), and new Asian species have also been proposed by Cao & Bae (2006) and Stark & Sivec (1991). This new species is distinct from others by virtue of the rounded lobe on tergum 5 and the short hemiterga with a strong basal hump. *Agnetina cadaverosa* (McLachlan) also has short hemiterga but these lack the basal hump and the process on tergum 5 is notched in that species.



Figs. 14-17. *Agnetina zwicki*. 14. Head and pronotum, 15. Male abdominal terga 5-10, 16. Male abdominal segments 5-10, lateral aspect, 17. Left hemitergum, dorsal aspect.

***Haploperla zwicki* sp. n.**
(Figs. 18-21)

Material examined. Holotype ♂ and paratype ♀ from Thailand, Doi Inthanon National Park, 2100 m, 6 April 1993, I. Sivec, B. Horvat (PMSL).
Adult habitus. General color pale yellow in life with obscure brown pattern on head, pronotum (Fig. 18) and abdominal terga. Wings and legs pale.
Male. Forewing length 5.5 mm. Abdominal tergum 9 produced over base of tergum 10. Epiproct a small, acute, triangular tab (Figs. 19-20). Aedeagus armed with a pair of slender rods, expanded apically and fused basally.
Female. Forewing length 6.5 mm. Subgenital plate a small, broadly rounded to triangular, median projection on abdominal sternum 8 (Fig. 21).
Larva. Unknown.
Etymology. The patronym honors our friend and colleague, Professor Dr. Peter Zwick, in recognition of his important synonymy of *Hastaperla* with *Haploperla* (Zwick 1977).
Diagnosis and Discussion. This species is generally similar to *H. longicauda* Zwick (1977), known from Bhutan, but the epiproct of that species is more rounded, the aedeagal sclerites are not expanded apically, and the female subgenital plate is broader. The aedeagal rods of this species appear to be fused basally which is a feature not reported in other chloroperlid groups (Surdick 1985; Zwick 1967).



Figs. 18-21. *Haploperla zwicki*. 18. Head and pronotum, 19. Male abdominal terga 8-10 with lateral aspect of epiproct inset, 20. Male aedeagal rods, lateral and ventral aspect, 21. Female abdominal sterna 7-10.

***Isoperla peterzwicki* sp. n.**
(Figs. 22-28)

Material examined. Holotype ♂ and paratype ♀ from Thailand, Doi Inthanon National Park, Bang Khun Klang, 1200 m, 26 January 1990, P. Chantaramongkol, H. Malicky (PMSL).
Adult habitus. General color brown patterned with pale. Head with a dark brown transverse, arcuate band crossing posterior ocelli, and a wide longitudinal band extending from pale M-line through ocellar triangle (Fig. 22); an additional area of brown pigment extends forward of M-line to near anterior margin of head. Pronotum with mesal and lateral pale bands; disc pale brown with scattered islands of darker pigment. Palpi, antennae, distal part of femur and proximal part of tibiae dark brown.
Male. Forewing length 12 mm. Abdominal terga unmodified; paraprocts weakly sclerotized, slightly curved inward and dorsad, and more or less triangular in outline (Fig. 23). Abdominal sternum 8

bears a wide, slightly projecting, hairy vesicle (Fig. 25). Aedeagal apex membranous, armed with a series of partially sclerotized irregular crenulations along dorsal margin (Fig. 24).

Female. Forewing length 13 mm. Subgenital plate poorly developed; posterior margin of sternum 8 only slightly produced in middle third (Fig. 25).

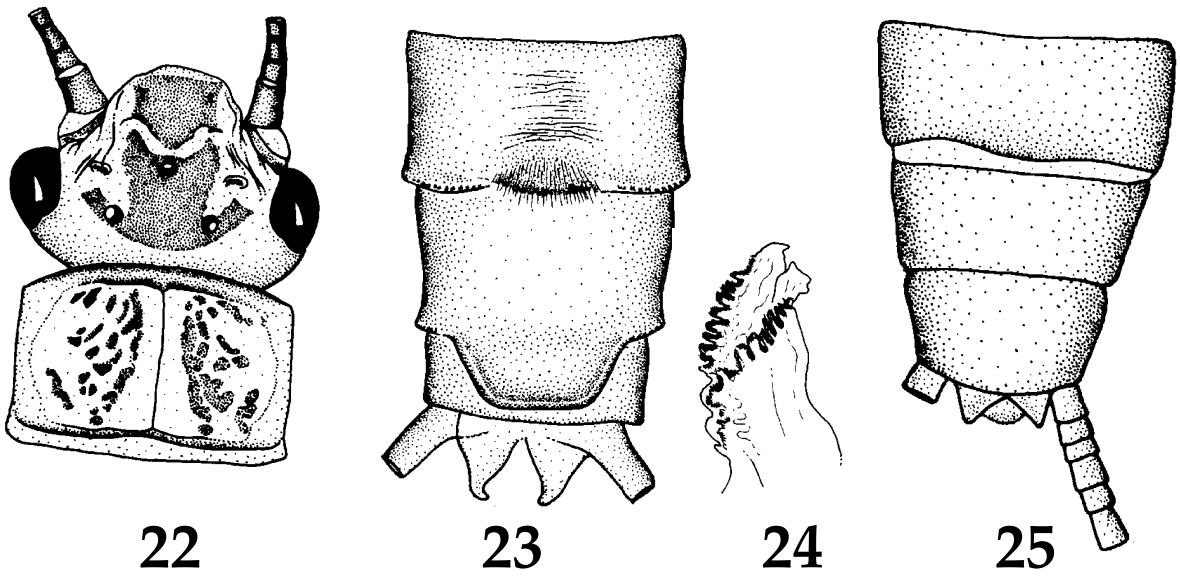
Egg. Oddly shaped with basic cylindrical form impressed by concave depressions on sides and ends giving a child's toy drum appearance (Fig. 26). Anchor pancake-shaped (Fig. 27). Chorion impunctate but covered throughout with follicle cell impressions (Figs. 27-28). Micropyles minute (Fig. 28).

Etymology. The patronym honors Professor Dr. Peter Zwick, in recognition of his recent work with Asian species of genus *Isoperla* (Zwick & Surenkhorloo 2005).

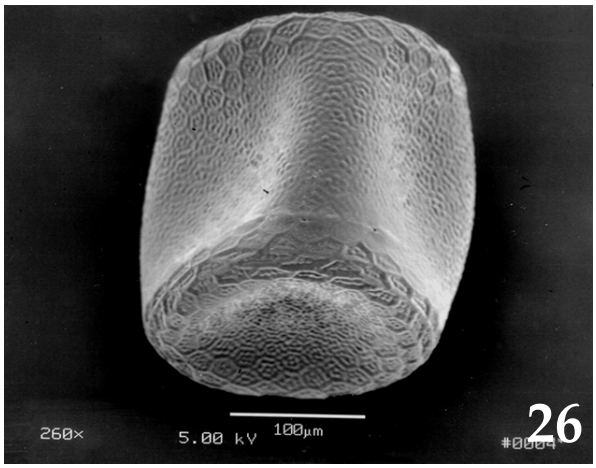
Diagnosis and Discussion. Not much is known of previously described *Isoperla* from the Oriental region, but Wu (1938) includes illustrations for a few species in his monograph of Chinese stoneflies. Unfortunately, the types for all these species are apparently destroyed, but none of the Wu figures show the combination of subgenital plate shape and male vesicle shape of this species, and no *Isoperla* species from Asia with eggs of this type are presently known.

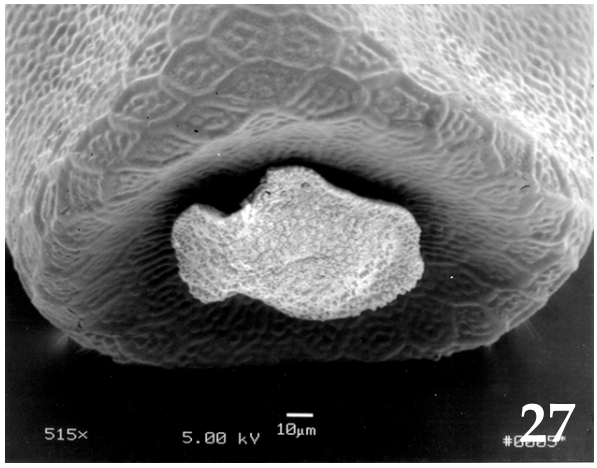
ACKNOWLEDGMENTS

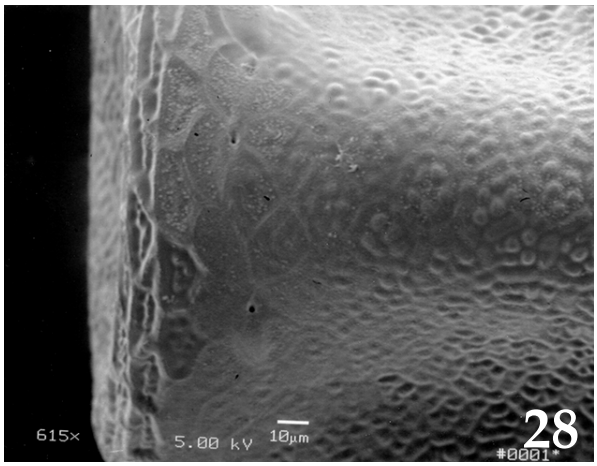
We take the unusual step of proposing multiple patronyms honoring one person in a single paper in order to recognize the extraordinary influence and leadership of one person, Professor Dr. Peter Zwick and his home institution throughout his distinguished career, the famous Limnologische Fluss-Station des Max-Planck-Instituts für Limnologie in Schlitz, Germany. In a very real sense, the institution in Schlitz, under the direction of Professor J. Illies until his death, and subsequently directed by Professor Zwick, served as "Stonefly Central" for many Plecopterologists and other freshwater biologists prior to its closing last year, and Professor Zwick continues to inspire us with his work ethic and with the superior quality and breadth of his research interests.



Figs. 22-25. *Isoperla peterzwicki*. 22. Head and pronotum, 23. Male abdominal sterna 8-10, 24. Male aedeagus, lateral aspect, 25. Female abdominal sterna 8-10.







Figs. 26–28 *Isoperla peterzwicki* egg. 26. Entire egg, lateral aspect from micropylar end, 27. Collar end with anchor, 28. Chorionic detail with micropyles.

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