

Heptageniidae of Taiwan (Ephemeroptera)

臺灣的扁蜉科(蜉蝣目)

S. C. Kang C. T. Yang

康世昌

楊仲圖

JOURNAL OF TAIWAN MUSEUM 47(1): 5-36 JUNE 1994

臺灣省立博物館半年刊 第四十七卷第一期 5~36

中華民國八十三年

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Shih-Chang Kang & Chung-Tu Yang*

Accepted November 25, 1993

摘要

康世昌·楊仲圖 臺灣的扁蜉科(蜉蝣目) 臺灣省立博物館半年刊 47(1): 5–36

本文描述分布於臺灣的扁蜉科，共計5屬11種，分別為：*Epeorus erratus* Braasch, *Rhithrogena parva* (Ulmer), *R. ampla* n.sp., *Electrogena fracta* n.sp., *Afronurus hyalinus* (Ulmer), n. comb., *A. floreus* n.sp., *A. chipenensis* n.sp., *A. nanhuensis* n.sp., *Nixe (Nixe) littoralis* n.sp., *N. (N.) mitificus* n.sp.及*N. (N.) obscurus* n.sp.。種類的判別均根據稚蟲特徵。其中9種的卵經用掃描式電子顯微鏡觀察與描述。文中附屬及種的檢索表。

關鍵詞：扁蜉科，*Epeorus*, *Rhithrogena*, *Electrogena*, *Nixe*, *Afronurus*, 稚蟲，卵，臺灣。

Abstract

Five genera and eleven species of Heptageniidae from Taiwan were described in this present work, i.e. *Epeorus erratus* Braasch, *Rhithrogena parva* (Ulmer), *R. ampla* n.sp., *Electrogena fracta* n.sp., *Afronurus hyalinus* (Ulmer), n. comb., *A. floreus* n.sp., *A. chipenensis* n.sp., *A. nanhuensis* n.sp., *Nixe (Nixe) littoralis* n.sp., *N. (N.) mitificus* n.sp. and *N. (N.) obscurus* n.sp. All of the species were described on basis of the nymphal stage. The eggs of nine species were observed via a scanning electron microscope. Key to the genera and species was offered.

Key words: Heptageniidae, *Epeorus*, *Rhithrogena*, *Electrogena*, *Nixe*, *Afronurus*, nymph, egg, Taiwan.

Introduction

Information regarding the widespread family Heptageniidae in Taiwan is insufficient. The pioneer is Ulmer (1912), whom obtained some imaginal specimens of mayflies from Sauter's collection and reported nine species including three species of Heptageniidae. Uéno (1928) reported four unnamed species of Heptageniidae from Taiwan on the basis of the on nymph, in 1931, having provided a simple

list for Taiwanese mayflies. Fifty years have passed since 1931 without any report mentioning Taiwanese mayflies except for a short check list of Uéno (1969). Braasch (1981) modified the misidentification of *Epeorus psi* Eaton by Ulmer in 1912, having described it as a new species, *E. erratus*. Some ecologists investigated Taiwanese stream having reported a few unnamed or incorrect names of Heptageniidae (Her & Hsu, 1988; Yang *et al.* 1980).

This family was previously reviewed by

*Department of Entomology, National Chung Hsing University, Taichung 402, Taiwan, Republic of China.

Jensen (1972) and Kluge (1988). Kluge concluded that thirteen close general, i.e. *Thalerosphyrus* Eaton, 1981; *Afronurus* Lestage, 1924; *Cinygmina* Kimmins, 1937; *Paracinygmula* Bajkova, 1975; *Componeuriella* Ulmer, 1939; *Notonurus* Crass, 1947; *Afghanurus* Demoulin, 1964; *Ecdyonuroides* Thanh, 1975; *Notacanthurus* Tshernova, 1974; *Leucrocuta* Flowers, 1980; *Nixe* Flower, 1980; *Electrogena* Zurwerra et Tomka, 1985 and *Asionurus* Brassch et Soldan, 1986 are synonymous of *Ecdyonurus* Eaton, 1868. The basic reason is that all of above genera were established on the basis of imaginary characters. The most popular species of those genera differed no less strongly than in any other known species included under *Ecdyonurus*. Genera *Afronurus*, *Electrogena* and *Nixe* of those thirteen genera also found in Taiwan. A carefully comparing them with nymphal and egg stages revealed that they distinctly differed in nymphal and egg stages. We found they differ in nymphal and egg stages distinctly. The conclusion would be that *Afronurus*, *Electrogena* and *Nixe* are not synonymous with *Ecdyonurus*.

The chorionic structure of several species of Heptageniidae was previously observed by European investigators (Gaino et al, 1987; Gaino & Mazzini, 1988; Koss, 1968; Sartori, 1992; Sartori & Oswald, 1988; Sartori & Sowa, 1992; Zurwerra & Tomka, 1985). All of the egg materials used in this study were obtained from mature female nymphs (with black wing pads). Nine species were observed here via a scanning electron microscope (SEM), with a comparison being made between them and their European species.

In the following description, term 'mde' is the most short distance between eyes; 'MDE' is the distance between outer margins of eyes. 'KCT' is chorionic structure, knob-terminated coiled threads.

All of the holotypes of the following named species are deposited at the Entomology Department of Chung Hsing University, Taichung, Taiwan (NCHU). A partial of the paratypes is deposited at the National Museum of Natural Science, Taichung, Taiwan (NMNS) and in the Zoological Museum Lausanne,

Switzerland (ZML).

Key to the genera and species of Heptageniidae of Taiwan
(for nymph only)

1. Caudal filaments with only 2 cerci (*Epeorus*) *Epeorus erratus* Braasch
- Caudal filaments with 2 cerci and 1 terminal filament 2
2. Gills overlapped to form ventral disc. (*Rhithrogena*) 3
- Gills not as above 4
3. Number of filaments of fibrilliform portion of gill VII over 20; length of head 2/3 of width; ridgy groove of molar short, less than 1/2 width of molar (Fig. 2-C)
. *Rhithrogena parva* (Ulmer)
- Number of filaments of fibrilliform portion of gill VII less than 10; length of head less than 2/3 of width; ridgy groove of molar long, over than 2/3 width of molar (Fig. 3-C) *Rhithrogena ampla* n.sp.
4. Gill I lanceolated, apex acute (Figs. 5-G; 6-G; 7-G; 8-G); labrum strong expanded laterally, somewhat produced posteriorly (Figs. 5-D; 6-D; 7-D; 8-D); (*Afronurus*) 5
- Gill I oblique oval, apex blunt or round (Figs. 4-G; 9-K; 11-K; 12-K); labrum expanded moderate (Figs. 4-D; 10-A) 8
5. Caudal filaments pale on basal segments, dark from basal 1/6 to median part distinctly; posterior and lateral margins of sternum IX with dark band (Fig. 5-E)
. *Afronurus hyalinus* n.comb.
- Caudal filaments uniform pale or slight brown; posterior and lateral margins of sternum IX without dark band (Figs. 6-E; 7-E; 8-E) 6
6. Apex of gill VII round (Fig. 7-M); median area of fore femur without long oblong setae (Fig. 7-Nb)
. *Afronurus chipenensis* n.sp.
- Apex of gill VII acute (Figs. 6-M; 8-M); median area of fore femur with long oblong setae (Figs. 6-Nb; 8-Nb) 7

7. Lamellae of each gill with arborescent dark trachea distinctly (Figs. 6-G-M)
 *Afronurus floreus* n.sp.
- Lamellae of each gill with no visible arborescent trachea (Figs. 7-G-M)
 *Afronurus nanhuensis* n.sp.
8. Caudal filaments 2/3 as long as body, both sides fringe with long fine setae (Fig. 10-I) (*Nixe*) 9
- Caudal filaments 2 times as long as body, without fringed long fine setae (*Electrogena*) *Electrogena fracta* n.sp.
9. Markings of head (Fig. 12-A) and legs (Fig. 12-F) faint, unclear; gill I slender, 1/3 as wide as long (Fig. 12-K); claws without distinct denticle (Fig. 12-G)
 *Nixe (Nixe) obscurus* n.sp.
- Markings of head (Figs. 9-A; 11-A) and legs (Figs. 9-F; 11-F) distinct; gill I 1/2 as wide as long (Figs. 9-K; 11-K); claws with denticles clearly (Figs. 9-G; 11-G) . . . 10
10. Sternum IX with 3 dark markings on anterior margin (Fig. 9-I); posterior margin of abdominal tergite X with triangular, acute denticles (Fig. 9-J); the 1st pectinate spine of maxilla eight-forked (Fig. 17, E) *Nixe (N.) littorsus* n.sp.
- Sternum IX with 4 dark dots on each corner (Fig. 11-I); posterior margin of abdominal tergite X with irregular, loose denticles, most denticles with sharp cleft at apex (Fig. 11-J); the 1st pectinate spine of maxilla five-forked (Fig. 11, E)
 *Nixe (N.) mitificus* n.sp.

Epeorus erratus Braasch

Fig. 1, 13

Epeorus psi Eaton, 1885: Ulmer, 1912, Entomol. Mitt. Zool. Stinst. Zool. Mus. Hamburg 1: 369–375; Uéno, 1931b. Trans. Nat. Hist. Soc. Formosa, 21: 213–215. (misidentification).

Epeorus erratus Braasch, 1981, Dutsch. Entomol. Z. 28(1): 113–115.

Mature nymphs:

Body length, female 13.5–19.92 mm,

male 13.16–14.72 mm; general coloration brown to dark brown.

Head: brown, dark medially, pale in front of median ocellus and with an oblong pale marking anteromedially; vertex with fine setae; anterior margin fringes with fine setae; mde of female and male 0.26–0.31 × and 0.18–0.20 × width of head. **Labrum:** suboblong, middle line ridgy; anterior margin with a U-shaped emargination; venter with numerous long acute setae laterally. **Hypopharynx:** apex of lingua with 3 lobes, superlinguae suboblong, apex oblique. **Mandibles:** margins of outer and inner incisors crenate; ventral margins of incisors fringe with long fine setae. **Maxillae:** anterolateral corner with 3 large, blunt canine teeth; mesal surface with 3 ridges, each ridge fringes with long fine setae; maxillary palpus 2-segmented, segment II brown. **Labium:** 0.66–0.73 × width of head; glossa triangular, dorsum with a row of closely set fine setae medially and long fine setae on mesal margin, venter with acute setae on posterolateral area; paraglossa oval, dorsum with closely set fine setae on mesal half, scatter triangularly.

Thorax: mesonotum with a acute spine posteromedially. **Legs:** femora pale with brown markings as Fig. 1-G, in the middle with a purple marking, posterior margin fringes with long pinnate setae; dorsum of femora scatter with cordate setae; lateral margins of tibiae fringe with closely set long fine setae; fore tibia slightly longer than fore femur, middle tibia and femur subequal in length, hind tibia slightly shorter than hind femur; each claw with 3 denticles near the middle.

Abdomen: abdominal tergites II–IX each with a large, acute spine posteromedially and dentate at posterior margin; with posterolateral projections on abdominal segments I–VIII, of which on segments I and VIII small and blunt, on segments II–VII large and acute; middle line of abdominal tergites with a row of fine setae; dorsum of each tergites scatter with long oval setae, apex of those setae emarginate; posterior margin of sternum IX of female with a emargination and basal 1/4 with fine setae, male with a U-shaped emargination

and a pair of 2-segmented processes posterolaterally. Gills: gill I subtriangular, with a sclerotic band on lateral 1/3; gills II–VII with sclerotic on anterior and mesal margins, brown on upper 2/3; tracheae of each gill unclear. Caudal filaments: dark brown, cerci 1.25 x length of body, with a row of dorsal long fine setae from basal to middle segments.

Eggs: (Fig. 13)

Same as for known European species *E. zaitzevi* Tshernova, 1981 (egg chorionic structure described by Sartori 1992), the exochorionic of *E. erratus* very smooth without any peculiar structures or polar cap. 2–3 micropyles visible in the equatorial area.

Mature nymphal specimens examined:

1♀, Liukuei, Kaohsiung Hsien, Taiwan, 07-I-1989, S. C. Kang; 5♀♀, Maolin, Kaohsiung Hsien, Taiwan, 27-I-1990, S. C. Kang; 2♀♀, Pahsienshan, Hopping, Taichung Hsien, Taiwan, 31-III-1990, S. C. Kang; 5♂♂, Lona, Hsini, Nantou Hsien, Taiwan, 19-VI-1990, S. C. Kang & H. C. Chang; 1♂, 4♀♀, Yangmingshan, Taipei, 16-VII-1990, W. B. Yeh; 3♀♀, Taipingshan, Nanao, Ilan Hsien, Taiwan, 11-VIII-1990, S. C. Kang & H. C. Chang; 1♂, 5♀♀, Liukuei, Kaohsiung Hsien, Taiwan, 13-X-1990, W. B. Yeh; 2♂♂, 4♀♀, Pihuchiao, Pinglin, Taipei Hsien, Taiwan, 17-XI-1990, S. C. Kang & H. C. Chang; 8♀♀, Tatung (Chilan-Minchih), Ilan Hsien, Taiwan, (1,000 m), 18-XI-1990, S. C. Kang & H. C. Chang; 2♀♀, Taoyuan, Kaohsiung Hsien, Taiwan, (570 m), 13-XII-1990, S. C. Kang; 3♀♀, Saoleinchi, Taoyuan, Kaohsiung Hsien, Taiwan, 14-XII-1990, S. C. Kang; 1♂, 1♀, Chihpen, Peinan, Taitung Hsien, Taiwan, (180 m), 15-XII-1990, S. C. Kang; 3♂♂, 2♀♀, Fuli, Hualien Hsien, Taiwan, (370 m), 16-XII-1990, S. C. Kang; 1♂, Tungho, Taitung Hsien, Taiwan, (70 m), 16-XII-1990, S. C. Kang; 5♂♂, 3♀♀, Chinfeng, Taitung Hsien, Taiwan, (105 m), 17-XII-1990, S. C. Kang; 1♂, 5♀♀, Shityu, Pintung Hsien, Taiwan, (380 m), 17-XII-1990, S. C. Kang; 2♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (280 m), 02-I-1991, S. C. Kang; 2♂♂, 4♀♀, Lalashan, Fuhsing, Taoyuan Hsien, Taiwan, 05-I-1991, J. T. Yang; 2♂♂, 3♀♀, Paolai,

Taoyuan, Kaohsiung Hsien, Taiwan, (430 m), 02-IV-1991, S. C. Kang; 10♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (225 m), 03-IV-1991, S. C. Kang; 1♀, Chenwuchiao, Hopping, Taichung Hsien, Taiwan, (1,525 m), 04-IV-1991, S. C. Kang; 5♀♀, Lenchih, Tatung, Ilan Hsien, Taiwan, (90 m), 30-V-1991, S. C. Kang & H. C. Chang; 6♂♂, 10♀♀, Chiayang, Hopping, Taichung Hsien, Taiwan, (1,500 m), 11-VI-1991, H. C. Chang; 1♂, 6♀♀, Hwesunlinchun, Lenai, Nantou Hsien, Taiwan, (750 m), 20-VIII-1991, H. C. Chang; 5♂♂, 12♀♀, Luku-Hsitou, Luku, Nantou Hsien, Taiwan, (1,040 m), 30-VIII-1991, S. C. Kang & H. C. Chang; 7♀♀, Tapa, Wufeng, Hsinchu Hsien, Taiwan, (1,775 m), 23-X-1991, S. C. Kang & H. C. Chang; 2♀♀, Tapachienshen, Wufeng, Hsinchu Hsien, Taiwan, (1,835 m), 24-X-1991, S. C. Kang & H. C. Chang; 1♂, 2♀♀, Chingchuan, Wufeng, Hsinchu Hsien, Taiwan, (570 m), 24-X-1991, S. C. Kang & H. C. Chang.

Distribution:

Taiwan.

Note:

Ulmer (1912) identified this species from Taiwan as *Epeorus psi* Eaton based on imaginal specimens, and deposited them in Deutsch. Entomol. Museum, Berlin. Braasch (1981) checked them and found they were not *E. psi*, then he described and identified it as a new species, *E. erratus*. Only one species of *Epeorus* was identified in our study as being distributed throughout Taiwan. They live in a very rapid current of stream.

Rhithrogena parva (Ulmer)

Figs. 2, 15

Ecdyurus parvus Ulmer, 1912. Entomol. Mitt. Zool. Stinst. Zool. Mus. Hamburg 1: 369–375.

Rhithrogena formosicola Matsumura, 1931, Ins. Jap. Empire, pp. 1466–1480. (Syn. nov.)

Rhithrogena vitre Walker var. *parva* Ulmer, 1920, Stettin. Entomol. Z., 81: 97–144; Uéno, 1931b, Trans. Nat. Hist. Soc. Formosa,

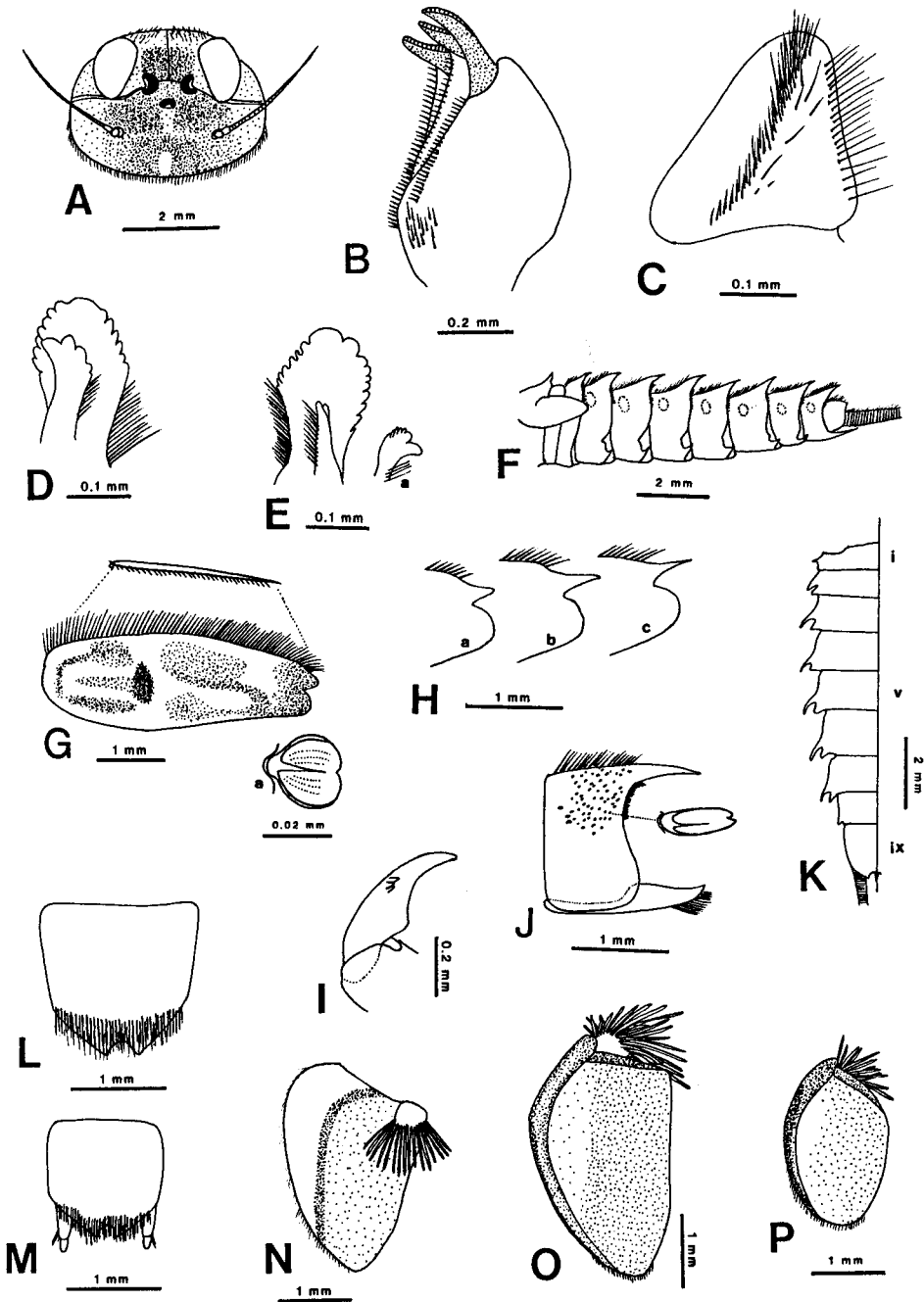


Fig. 1. Nymph of *Epeorus erratus* Braasch. A. head, female; B. galea-lacinia of maxilla, ventral; C. glossa, dorsal; D. incisors of left mandible, mesal; E. a. incisors of right mandible, mesal, b. inner incisor, ventral; F. abdomen, lateral; G. left femur, dorsal, a. setae; H. distal area of femora, a. fore, b. middle, c. hind; I. fore claw; J. abdominal segment IX (remove segment X), lateral; K. abdomen, ventral; L. sternum IX, female; M. sternum IX, male; N. gill I; O. gill IV; P. gill VII.

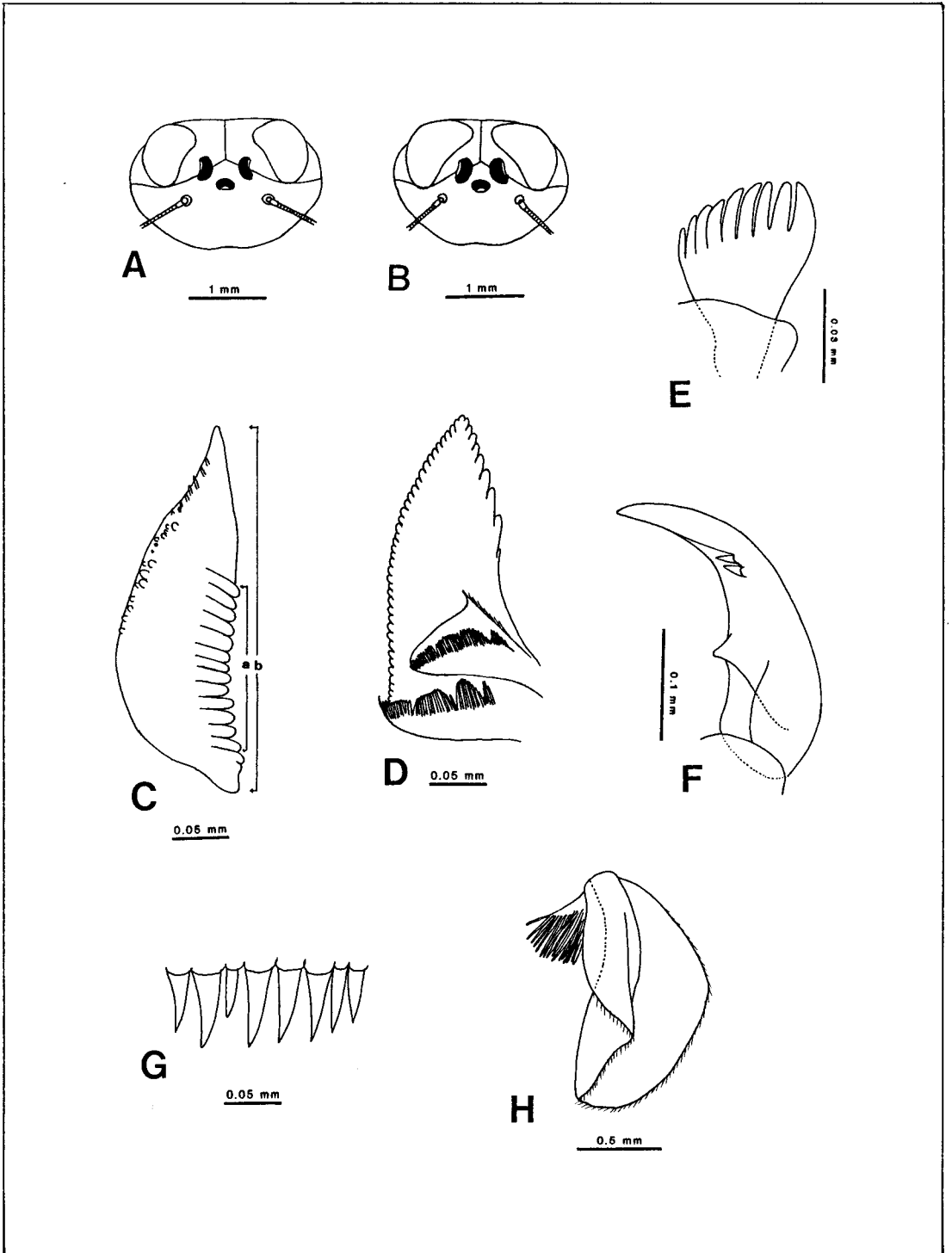


Fig. 2. Nymph of *Rhithrogena parva* (Ulmer). A. head, female; B. head, male; C. molar of right mandible, anterior view; D. incisors of right mandible, mesal; E. the 2nd pectinate spines of maxilla; F. fore claw; G. posterior margin of abdominal tergite VI; H. gill VII.

21: 210–216.

Rhithrogena parva Ulmer, 1940. Arch. Hydrobiol. (Suppl.) 16: 443–692; Uéno, 1969, Oriental Insects, 3(3): 221–238.

Mature nymphs:

Body length, female 9.10–10.35 mm, male 8.40–9.68 mm; general color bright brown.

Head: dorsum of head capsule uniform brown, about 2/3 as long as wide; anterior margin with a shallow emargination; lateral margins curve smoothly. **Labrum:** narrow triangular, anterior margin with 4–5 pairs of small blunt tubercles. **Right mandible:** margins of outer incisor crenate; molar with 13–14 ridges, width of ridges narrow, about 1/3 as wide as molar. **Maxillae:** galea-lacinia with 10–11 palm-shaped pectinate spines on crown, each pectinate spines with 8–10 subequal long processes. **Labium:** glossa oval, with a ventral acute setae near apex; paraglossa subquadrate; venter with acute setae on anteromedian area, the setae biforked and both forks pinnate on same face.

Thorax: anterior and posterior margins of pronotum concave; mesonotum convex on anterior margin and with 2 small posterior processes between fore wing pads. **Legs:** femora brown, with a pale oblong marking and a dark round marking medially. Posterior margin of femora fringe with long blunt setae, apices of the setae somewhat plated or linguulate; dorsum of femora with oblong setae near anterior margin and with long oval setae medially; apical 1/3 of fore claw with 2 of 3 denticles.

Abdomen: tergites bright brown, slight brown or pale on posteromedian area; each posterior margin of tergites I–X dentate; posterior margin of sternum IX of female with a shallow emargination medially, male with a median retuse lobe and a pair of 2-segmented processes. **Gills:** margins of each gill fringe with fine setae; fibrilliform portion of gill VII with over 20 filaments. **Caudal filaments:** uniform light brown, middle segments with whorl of blunt triangular spines and arrowy setae, the arrowy setae filamented and with triangular apex.

Eggs: (Fig. 15)

General shape ovoid. One of the poles with large KCTs densely, the whole chorion covered with small granules uniform and scatter with small KCTs loosely, a large micropyle on subequatorial area.

Mature nymphal specimens examined:

1♂, Chian, Hualien Hsien, Taiwan, 01-IV-1990, S. C. Kang; 5♂♂, 10♀♀, Sinwuchaio, Hsituan, Taitung Hsien, Taiwan, (500 m), 15-XII-1990, S. C. Kang; 5♂♂, 7♀♀, Chihpen, Peinan, Taitung Hsien, Taiwan, (180 m), 15-XII-1990, S. C. Kang; 6♂♂, 4♀♀, Danan, Peinan, Taitung Hsien, Taiwan, (165 m), 16-XII-1990, S. C. Kang; 5♂♂, 1♀, Luyehchichiao, Yenping, Taitung Hsien, Taiwan, (155 m), 16-XII-1990, S. C. Kang; 3♀♀, Luyeh, Yenping, Taitung Hsien, Taiwan, (260 m), 16-XII-1990, S. C. Kang; 1♂, 1♀, Chinfeng, Taitung Hsien, Taiwan, (105 m), 17-XII-1990, S. C. Kang; 11♂♂, 9♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (280 m), 02-I-1991, S. C. Kang; 5♂♂, 8♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (225 m), 03-IV-1991, S. C. Kang; 5♂♂, 4♀♀, Sanchan, Hsincheng, Hualien Hsien, Taiwan, (65 m), 03-IV-1991, S. C. Kang; 4♂♂, 7♀♀, Techu Talenchao, Hoping, Taichung Hsien, Taiwan, (1,020 m), 28-V-1991, S. C. Kang & H. C. Chang; 3♂♂, 4♀♀, Tuling, Tatung, Ilan Hsien, Taiwan, (1,440 m), 29-V-1991, S. C. Kang & H. C. Chang; 4♀♀, Sunchitsun, Tatung, Ilan Hsien, Taiwan, (750 m), 30-V-1991, S. C. Kang & H. C. Chang; 2♀♀, Sinchungheng, Hsini, Nantou Hsien, Taiwan, (620 m), 18-XI-1991, S. C. Kang; 2♂♂, 3♀♀, Weichuan, Liukuei, Kaohsiung Hsien, Taiwan, (235 m), 20-XII-1991, S. C. Kang.

Distribution:

Siberia (Kamchatka), Taiwan.

Note:

The chorionic surface of this species resembles those of European species *Rhithrogena grischuna* Sartori & Oswald 1988 and *R. hercynia* Landa, 1969. However, the granules of surface are larger and the terminal knob of KCT

is cup-like, not round-shaped.

Rhithrogena ampla Kang & Yang n.sp.

Figs. 3, 16

Mature nymphs:

Body length, female 9.25–12.68 mm, male 8.36–11.89 mm; general color yellowish brown.

Head: dorsum of head capsule uniform yellowish brown, with a pair of small pale spots between eyes but sometime unclear; head capsule $3/5$ as long as wide; anterior margin with a shallow emargination; lateral margins roundly curved. **Labrum:** narrow triangular, anterior margin with 3–4 pairs of small blunt tubercles. **Right mandible:** margins of outer incisor crenate: molar with 17–19 ridges, width of ridges wide, $2/3$ as wide as molar. **Maxillae:** galea-lacinia with 10–11 palm-shaped pectinated spines on crown, each pectinate spines with 9–11 gradually smaller processes. **Labium:** glossa reniform, apex somewhat acute, with 1 or 2 ventral acute setae near apex; paraglossa oblong; venter with acute setae on anteromedian area, the setae biforked and both forks pinnate on the same face.

Thorax: anterior and posterior margins of pronotum concave; mesonotum convex on anterior margin and with 2 small posterior processes between fore wing pads. **Legs:** femora yellowish brown, with a pale oblong marking and a dark round marking medially. Posterior margin of femora fringe with long blunt setae; dorsum of femora with oblong or oval setae; apical $1/4$ of fore claw with 2 denticles.

Abdomen: tergites yellowish brown, somewhat slight on median area of each tergite, middle line somewhat blackish; posterior margins of tergites I–X dentate; posterior margin of ternum IX with a shallow emargination medially. **Gills:** margins of each gill fringe with fine setae; fibrilliform portion of gill VII with less than 10 fine filaments. **Caudal filaments:** uniform light brown, median segments with whorl of blunt triangular spines and arrow-shaped setae, the arrow-shaped

setae filamented and with a triangular apex.

Eggs: (Fig. 16)

General shape long ovoid. Both poles with large KCTs densely, the whole chorion scatter with small KCTs loosely and irregularly, those small KCTs surrounded by several granules; a large micropyle on equatorial area.

Holotype:

Mature female nymph, Tzuenchiao, Hsiulin, Hualin Hsien, Taiwan, (2,010 m), 04-IV-1991, S. C. Kang, in collection NCHU.

Paratypes (mature nymph):

6♂♂, 6♀♀ same data as for holotype; 7♂♂, 8♀♀, Nanhutashan, Tatung, Ilan Hsien, Taiwan, (2,450 m), 06-VII-1991, H. C. Chang. 7♂♂, 7♀♀, in collection NCHU; 3♂♂, 4♀♀, in collection ZML; 3♂♂, 3♀♀, in collection NMNS.

Other mature nymphal specimens examined:

3♂♂, 5♀♀, Chungyangchienshan, Hoping, Taichung Hsien, Taiwan, 12-V-1990, W. B. Yeh; 3♂♂, 4♀♀, Hsini, Nantou Hsien, Taiwan, 21-VI-1990, S. C. Kang; 2♂♂, 4♀♀, Hohuanchi, Lenai, Nantou Hsien, Taiwan, (2,900 m), 03-XII-1990, W. B. Yeh; 4♂♂, 6♀♀, Tienchih, Taoyuan, Kaohsiung Hsien, Taiwan, (2,445 m), 14-XII-1990, S. C. Kang; 13♂♂, 20♀♀, Tienchih, Taoyuan, Kaohsiung Hsien, Taiwan, (2,310 m), 02-IV-1991, S. C. Kang; 3♂♂, 4♀♀, Chiayang, Hoping, Taichung Hsien, Taiwan, (1,500 m), 11-VI-1991, H. C. Chang; 7♂♂, 7♀♀, Nanhutashan, Tatung, Ilan Hsien, Taiwan, (2,285 m), 07-VII-1991, H. C. Chang; 3♂♂, 6♀♀, Wufeng, Hsinchu Hsien, Taiwan, (1,955 m), 24-X-1991, S. C. Kang & H. C. Chang; 7♂♂, 8♀♀, Wufeng, Hsinchu Hsien, Taiwan, (1,970 m), 24-X-1991, S. C. Kang & H. C. Chang.

Distribution:

Taiwan.

Note:

This new species resembles *Rhithrogena parva* (Ulmer). Distinguishing them from nymphal characteristics is rather difficult. Drawing a clear line between their nymph is

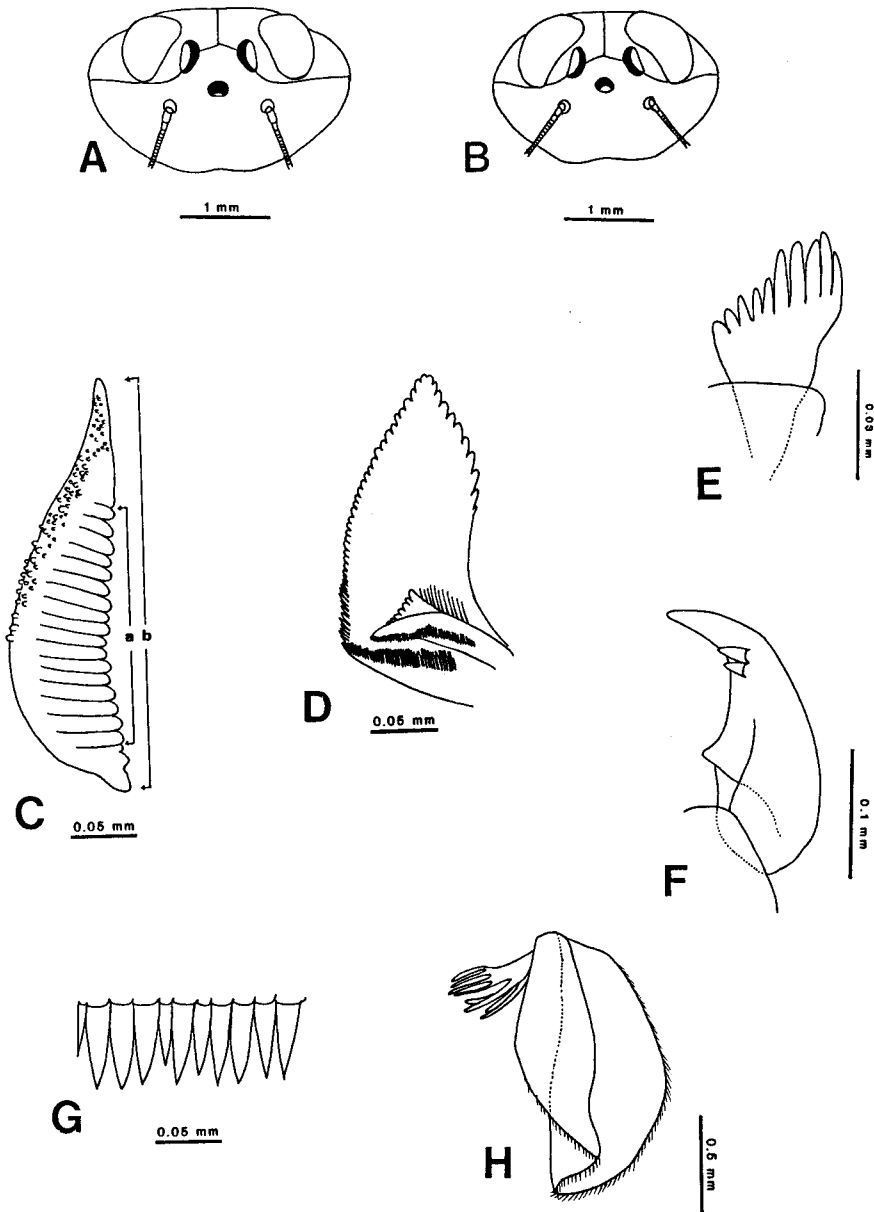


Fig. 3. Nymph of *Rhithrogena ampla* n.sp. A. head, female; B. head, male; C. molar of right mandible, anterior view; D. incisors of right mandible, mesal; E. the 2nd pectinate spines of maxilla; F. fore claw; G. posterior margin of abdominal tergite VI; H. gill VII.

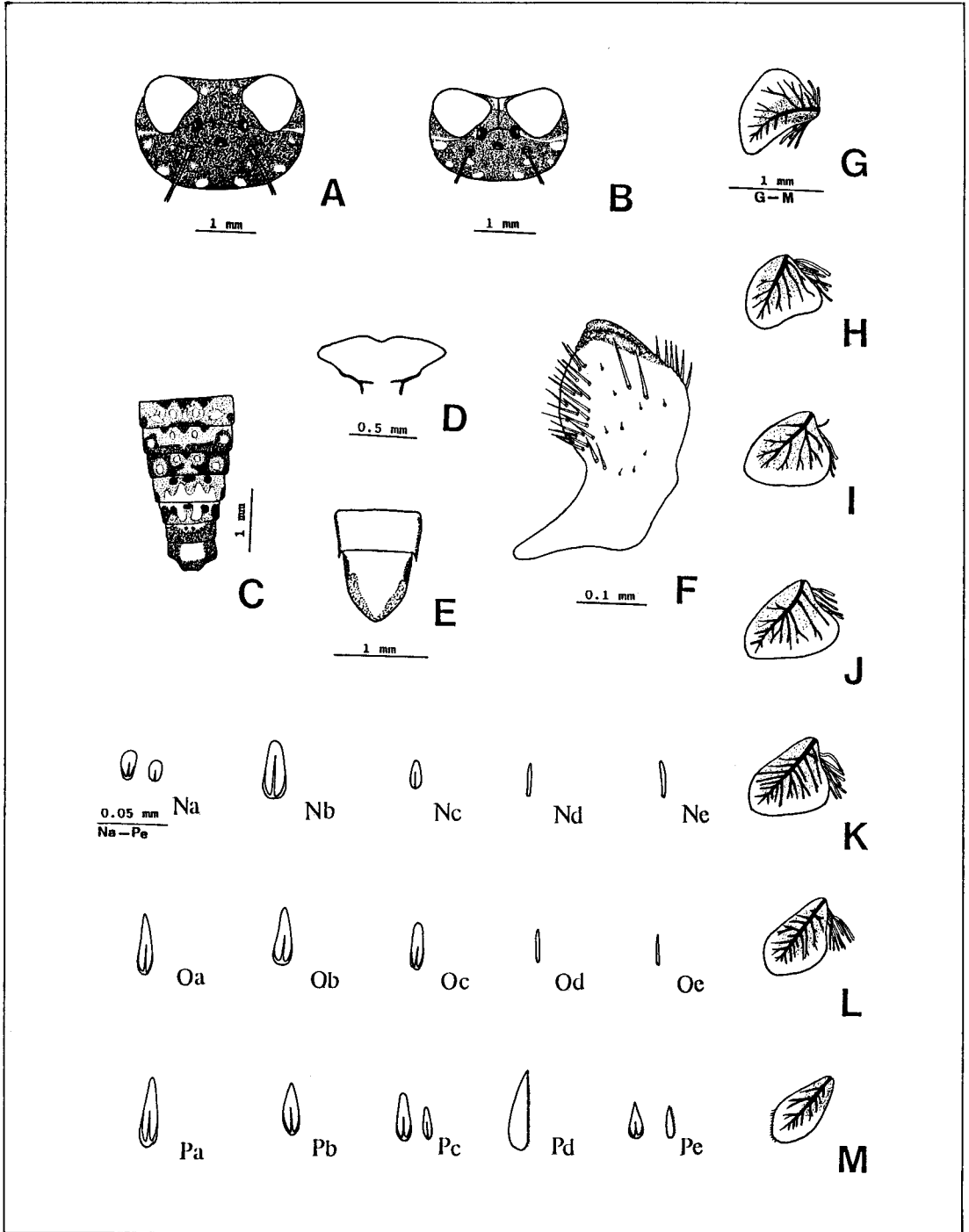


Fig. 4. Nymph of *Electrogena fracta* n.sp. A. head, female; B. head, male; C. abdomen, female, dorsal; D. labrum, dorsal; E. abdominal sternite VIII and IX; F. glossa, ventral; G-M. gills, (G, I; H, II; I, III; J, IV; K, V; L, VI; M, VII); Na-Pe. setae of legs, Na-Ne. fore leg; Oa-Oe. middle leg; Pa-Pe. hind leg; a. basal area of femur; b. median area of femur; c. distal area of femur; d. lateral margin of tibia; e. lateral margin of tarsus.

actually impossible but can be clearly differentiated in the surface ultrastructure of eggs. Localities of those two species are different in Taiwan, *parva* lives in about below 1,500 m of altitude; *ampla* lives in high mountain, above 1,500 m. The following minor characteristics to be considered in distinguishing between their nymphs are: (1) head capsule of *ampla* is wider than in *parva*; (2) number of filaments of fibrilliform portion of gills of *ampla* are less than in *parva*; (3) ridgy area of right mandible of *ampla* is well developed than in *parva*; (4) the shape of pectinate spines of maxillae is different; (5) apex of claws of *parva* is acuter and longer than in *ampla*.

Electrogena fracta Kang & Yang n.sp.

Figs. 4, 14

Mature nymphs:

Body length, female 8.56–10.05 mm, male 5.88–7.38 mm; cerci length: female 14.45–15.83 mm, male 12.30–12.83 mm. General coloration dark brown with pale markings.

Head: dark brown to black with 6 pale dots along subanterior margins; a row of 4 pale dots in front of antennae bases; a pair of pale speckings between eyes. Capsule of female and male 1.40–1.54 × and 1.50–1.70 × as wide as long; anterior and lateral margins slightly convex, posterior margin concave. mde of female and male 0.25–0.26 × and 0.11–0.12 × width of capsule. **Labrum:** with shallow anterior emargination, 0.34–0.39 × width of head. **Maxillae:** galea-lacinia 1.44–1.78 × as long as wide, with 19–23 pectinate spines on crown, ventral setae scattered subtriangularly; apical segment of palpus 1.54–1.60 × length of basal segment. **Labium:** 0.77–0.81 × width of thead, with U-shaped separation between glossae; apex of glossae subulate; paraglossae elongated laterally, 0.79–0.85 × width of labium; palpus with 2-segmented, subequal in length.

Thorax: dark brown with pale markings. Pronotum as wide as head. **Legs:** femora pale with dark brown markings, distal areas of fore

femora with small turbinate setae; middle and hind tibiae, tarsi with lanceolate setae; hind tibiae and tarsi with some semipinnte setae. Fore femur of female 0.92–1.01 × length of fore tibia, 3.01–3.68 × length of fore tarsus; fore femur of male 2.83–2.97 × length of tarsus; middle femur 1.04–1.12 × length of middle tibia, 4.22–4.89 × length of middle tarsus; hind femur 1.18–1.35 × length of hind tibia, 4.75–5.61 × length of hind tarsus. Fore tarsus 1.21–1.32 × length of middle tarsus.

Abdomen: abdominal segments II–VIII with posterolateral projections; tergites with complex paired marking as Fig. 4-C. Tergites X with pale subsquare marking medially; posterior margins of each tergites with various size denticles. Posterior margin of sternum IX of female convex, of male with 2 posterior processes, with dark pigment along lateral and posterior margins. **Gills:** with lamellae broader on gills II–VI, narrower on gills I and VII; fibrilliform portion of gills I–V well developed, reduced on gill VI and absent on gill VII; lamellae of gills with distinct black arborescent tracheae. **Caudal filaments:** brown, basal half with dark area on every other articulations; on distal half with pale annulus in each segment medially.

Eggs: (Fig. 14)

Chorionic surface characterized by a granular ground matrix, round-shaped tubercles, KCTs and small pores, each tubercles with small granules and look roughly; 5–6 micropyles visible surround the subequatorial area; KCTs increase the size and number toward one pole of chorionic, the other pole with small KCTs loosely; the knob terminal of large KCTs cup-like.

Hqolotype:

Mature female nymph, Shanlinhsi, Luku, Nantou Hsien, Taiwan, (1,010 m), 30-VIII-1991, S. C. Kang & H. C. Chang, in collection NCHU.

Paratypes (mature nymph):

4♂♂, 4♀♀, same data as for holotype; 2♂♂,

3♀♀, Pinglin, Taipei Hsien, Taiwan, (340 m), 07-XI-1990, S. C. Kang & H. C. Chang; 8♀♀, Shityu, Pintung Hsien, Taiwan, (380 m), 17-XII-1990, S. C. Kang; 5♀♀, Hsitou, Chushan, Nantou Hsien, Taiwan, (760 m), 22-VIII-1991, S. C. Kang & H. C. Chang. 2♂♂, 12♀♀, in collection NCHU; 2♂♂, 4♀♀, in collection ZML; 2♂♂, 4♀♀, in collection NMNS.

Distribution:

Taiwan.

Note:

This new species is different from other known species of genus *Electrogena* by color pattern; however, the chorionic surface resembles known species especial European species *Electrogena grandiae* (Belfiore, 1981) (egg described by Gaino et al. 1987). It can be differentiated from the others in the following egg characteristics: (1) the shape of knob terminal of KCTs differs from in *E. grandiae* but resembles West Asian species, *E. galileae* (Demoulin, 1973) (egg described by Sartori 1992); (2) the number of micropyles of this new species is more than in *E. grandiae*.

Afronurus hyalinus (Ulmer) n.comb.

Figs. 5, 17

Ecdyurus hyalinus Ulmer, 1912. Entomol. Mitt. Zool. Stinst Zool. Mus. Hamburg, 1: 369–375.

Ecdyurus sp. No. 2 Uéno, 1928. Mem. Coll. Sci. Kyoto Univ., B. 4(1): 19–63.

Ecdyonurus hyalinus Uéno, 1931b. Trans. Nat. Hist. Soc. Formosa, 21: 210–216.

Ecdyonurus yoshidae Takahashi, 1924: Her and Hsu, 1977, Ann. Mus. Nat. Hist. Soc. Formosa, 20: 1–49. (misidentification)

Mature nymphs:

Body length, female 8.88–13.11 mm, male 6.77–8.28 mm. General coloration brown with pale markings.

Head: yellow to brown with 4 pale dots near anterior margin, a row of 4 pale dots in front of antennae bases, 3 pairs of pale

markings between eyes. Capsule of female and male 1.40–1.61 x and 1.37–1.48 x as wide as long; anterior and lateral margins slightly convex, posterior margin slightly concave. mde of female and male 0.28–0.32 x and 0.12–0.17 x width of capsule. **Labrum:** subtriangular, 0.42–0.49 x width of head, densely setaceous dorsally, a row of stout subapical setae ventrally. **Mandibles:** mesal surface of outer incisors serrate; a tuft of 4–6 long pinnate setae near the inner incisor base. **Maxillae:** galea-lacinia 1.38–1.58 x as long as wide, 14–21 pectinate spines on crown, ventral setae scattered subtriangularly; apical palpus 1.45–1.67 x length of subapical palpus. **Labium:** 0.75–0.84 x width of head, with U-shaped separation between glossae; paraglossae expanded laterally, 0.69–0.78 x width of labium; palpus with 2-segmented, subequal in length.

Thorax: brown with pale markings. Pronotum as wide as head, posterior margin with a shallow emargination medially. **Legs:** femora pale with brown markings, posterior margin fringe with long setae densely; anterior margin, dorsum of femora, tibiae, and tarsi with numerous acute setae; median areas of fore femora, lateral margins of fore and middle tibiae with some blunt setae; lateral margin of hind tibia with a few long blunt setae; lateral margins of each tarsus with small oval setae. Fore femur 2.40–2.57 x as long as wide, subequal in length of fore tibia, femur of female and male 3.49–3.92 x and 3.12–3.21 x length of fore tarsus; middle femur 2.66–2.83 x as long as wide, 1.12–1.22 x length of middle tibia, 4.76–5.26 x length of middle tarsus; hind femur 2.70–3.41 x as long as wide, 1.23–1.33 x length of hind tibia, 5.26–5.88 x length of hind tarsus. Fore tarsus 1.12–1.26 x length of middle tarsus. Claw bowed-shaped with 3–5 subapical denticles.

Abdomen: segments II–VIII each with posterolateral projections; tergites II–VII with paired pale markings at submedian and posterolateral areas, submedian marking of tergite V fused, large; tergites VIII–IX each with submedian pale marking; tergites X with anterior pale area; posterior margins of each tergites

with various size denticles; posterior margin of sternum IX of female smoothly convex, with a brown band along lateral to posterior margins, of male with 2 posterior processes.

Gills: with lamellae broader on gills II–VI, narrower on gill I–VII; fibrilliform portion of gills I–V well developed, reduced on gill VI and absent on gill VII; lamellae of gills V and VI with an apical process. **Caudal filaments:** basal segments pale, segments X to XX brown, distal half brown, then gradually paling to apex; every segments with whorl of spines at articulations.

Eggs: (Fig. 17)

The chorionic surface of the egg has a unique arrangement of a large and small KCTs, both of poles with small KCTs densely; equatorial and subequatorial areas with 3–4 large KCTs; a large micropyle beside one of large KCTs closely; on the equatorial and subequatorial areas are filled with blunt tubercles.

Mature nymphal specimens examined:

3♂♂, 2♀♀, Peinan, Taitung Hsien, Taiwan, 01-IV-1991, H. C. Chang; 5♀♀, Lenchih, Taitung, Ilan Hsien, Taiwan, (90 m), 30-V-1991, S. C. Kang & H. C. Chang; 7♂♂, 11♀♀, Kanchiao, Shuangchi, Taipei Hsien, Taiwan, 30-V-1991, S. C. Kang & H. C. Chang; 6♂♂, 8♀♀, Pingsin, Shuangchi, Taipei Hsien, Taiwan, 31-V-1991, S. C. Kang & H. C. Chang; 1♂, 4♀♀, Luku-Hsitou, Luku, Nantou Hsien, Taiwan, (1,040 m), 30-VIII-1991, S. C. Kang & H. C. Chang; 2♂♂, 2♀♀, Wufeng, Hsinchu Hsien, Taiwan, (304 m), 24-X-1991, S. C. Kang & H. C. Chang; 3♂♂, 3♀♀, Sinchungheng, Hsini, Nantou Hsien, Taiwan, (620 m), 18-XI-1991, S. C. Kang; 3♂♂, 5♀♀, Meishan, Chia Hsien, Taiwan, (815 m), 19-XI-1991, S. C. Kang; 1♂, 7♀♀, Kuohsiung, Nantou Hsien, Taiwan, (285 m), 22-XI-1991, S. C. Kang; 3♀♀, Peikang, Kuohsiung, Nantou Hsien, Taiwan, (310 m), 22-XI-1991, S. C. Kang; 5♀♀, Shanping, Maolin, Kaohsiung Hsien, Taiwan, 11-XII-1991, J. T. Yang; 4♂♂, 2♀♀, Tona, Maolin, Kaohsiung Hsien, Taiwan, (335 m), 20-XII-1991, S. C. Kang; 3♂♂, 3♀♀, Kanchiao, Shuangchi, Taipei

Hsien, Taiwan, (140 m), 28-III-1992, S. C. Kang.

Distribution:

Taiwan.

Note:

Ulmer (1912) established this species on the basis of imaginary characteristics, drawing a genitalia figure but too simple, in fact, the pennis lobes of this species with complex structure, not only like 'dish'. Kluge (1988) considered that *Afronurus* was synonymous of *Ecdyonurus* based on imaginary characteristics. We, however, don't agree this aspect. The chorionic structure of this genus of Taiwan and Philippine species *A. philippinensis* Flower & Pescardor, all of them with large KCTs in equatorial and subequatorial areas but the chorionic structure of *Ecdyonurus* similar as *Rhithrogena*, without large KCTs in equatorial areas. For this reason, *Afronurus* is considered as being a natural group and differs from *Ecdyonurus* clearly.

Afronurus floreus Kang & Yang n.sp.

Fig. 6

Ecdyurus sp. No. 1 Uéno, 1928. Mem. Coll. Sci. Kyoto Univ., B. 4(1): 19–63.

Mature nymphs:

Body length, female 10.32–13.90 mm, male 8.27–10.16 mm. General coloration brown with pale markings.

Head: light brown to brown with 2 pale markings on anterior area, dark between eyes, several dark patches on median area. Capsule of female and male 1.34–1.58 × and 1.38–1.46 × as wide as long; anterior and lateral margins convex, posterior margin straight. Eyes of female 0.45–0.48 × length and 0.25–0.30 × width of head. mde of female and male 0.26–0.31 × and 0.11–0.13 × width of head; MDE of female 0.78–0.88 × width of head. **Labrum:** 0.41–0.46 × width of head. **Maxillae:** galealacinia 1.28–1.44 × as long as wide, with 20–27 pectinate spines on crown. **Labium:** 0.67–

0.84 × width of head; glossae oval; paraglossae 0.73–0.86 × width of labium.

Thorax: brown with pale markings. Pronotum as wide as head. **Legs:** femora pale with brown markings, posterior margin fringe with long fine setae densely; anterior margin, dorsum of femora, tibiae, and tarsi with numerous setae; basal areas of femora, median and posterior area of femora with blunt setae; distal area of fore femora with small oblong setae; median area of fore and middle femora with several long oblong setae; tibiae and tarsi with oblong setae; hind tibia with several long acute setae; fore femur 0.94–1.16 × length of fore tibiae, fore femur of female and male 3.24–3.99 × and 1.32–1.40 × length of fore tarsus; middle femora 1.06–1.13 × length of middle tibiae, 4.36–4.72 × length of middle tarsi; hind femora 1.18–1.22 × length of hind tibiae, 4.90–5.37 × length of hind tarsi.

Abdomen: tergite I pale with faint brown pigments; tergites II–IV each with paired pale markings on posterior area, markings of tergites V fused submedially; markings on posterior area of tergites VIII, IX fused like twin peak; tergites VI, VII and X each with paired pale markings submedially and small oblong pale marking medially. Posterior margins of each tergites with various size denticles; posterior margin of sternum IX of female convex, of male with 2 posterior processes. Each sternum with pair faint subtriangular pigments near lateral margins. **Gills:** with lamellae broader on abdominal gills II–VI, narrower on gills I and VII; lamellae of each gill dark submedially and with arborescent dark tracheae distinctly.

Holotype:

Mature female nymph, Chingchuan, Wufeng, Hsinchu Hsien, Taiwan, (570 m), 30-V-1991, S. C. Kang & H. C. Chang, in collection NCHU.

Paratypes (mature nymph):

2♂♂, 7♀♀, same data as for holotype; 3♂♂, 5♀♀, Hsitou, Chushan, Nantou Hsien, Taiwan, (760 m), 22-VIII-1991, S. C. Kang & H. C. Chang; 4♂♂, 4♀♀, Tona, Maolin, Kaohsiung

Hsien, Taiwan, (335 m), 20-XII-1991, S. C. Kang. 5♂♂, 9♀♀, in collection NCHU; 2♂♂, 4♀♀, in collection ZML; 2♂♂, 4♀♀, in collection NMNS.

Other mature nymphal specimens examined:

3♂♂, 4♀♀, Liukuei, Kaohsiung Hsien, Taiwan, 07-I-1989, S. C. Kang; 4♂♂, 2♀♀, Maolin, Kaohsiung Hsien, Taiwan, 27-I-1990, S. C. Kang; 6♂♂, 5♀♀, Hanchanchiao, Hsinchuang, Hualien Hsien, Taiwan, 01-IV-1990, S. C. Kang; 12♂♂, 10♀♀, Lona, Hsini, Nantou Hsien, Taiwan, 19-VI-1990, S. C. Kang & H. C. Chang; 7♂♂, 13♀♀, in the middle way between Taian and Wenchuan, Taian, Miaoli Hsien, Taiwan, 31-X-1990, S. C. Kang; 5♂♂, 8♀♀, Fushan, Yuanshan, Ilan Hsien, Taiwan, (480 m), 18-XI-1990, S. C. Kang & H. C. Chang; 3♂♂, 8♀♀, Chilun-Minchih, Tatung, Ilan Hsien, Taiwan, (1,000 m), 18-XI-1990, S. C. Kang & H. C. Chang; 1♂♂, 3♀♀, Hengshan, Hsinchu Hsien, Taiwan, (220 m), 19-XI-1990, S. C. Kang; 6♂♂, 11♀♀, Taoyuan, Kaohsiung Hsien, Taiwan, (570 m), 13-XII-1990, S. C. Kang; 3♂♂, 9♀♀, Shityu, Pintung Hsien, Taiwan, (380 m), 17-XII-1990, S. C. Kang; 2♂♂, 3♀♀, Lalashan, Fuhsing, Taoyuan Hsien, Taiwan, 05-I-1991, J. T. Yang; 3♂♂, 7♀♀, Techu, Hoping, Taichung Hsien, Taiwan, (1,400 m), 17-III-1991, H. C. Chang; 4♂♂, 9♀♀, Chinho, Taoyuan, Kaohsiung Hsien, Taiwan, (635 m), 02-IV-1991, S. C. Kang; 7♂♂, 12♀♀, Tulingchao, Tatung, Ilan Hsien, Taiwan, (1,520 m), 29-V-1991, S. C. Kang & H. C. Chang; 11♂♂, 19♀♀, Sunchit-Tatung, Tatung, Ilan Hsien, Taiwan, (720 m), 30-V-1991, S. C. Kang & H. C. Chang; 2♂♂, 5♀♀, Hwesunlinchun, Lenai, Nantou Hsien, Taiwan, (750 m), 19-VIII-1991, H. C. Chang; 5♂♂, 13♀♀, Weichuan, Liukuei, Kaohsiung Hsien, Taiwan, (235 m), 20-XII-1991, S. C. Kang.

Distribution:

Taiwan, Japan.

Note:

The nymphs of this species resemble west Asian species *Afromurus kugleri* (Demoulin) but their eggs differ on chorionic surface structures.

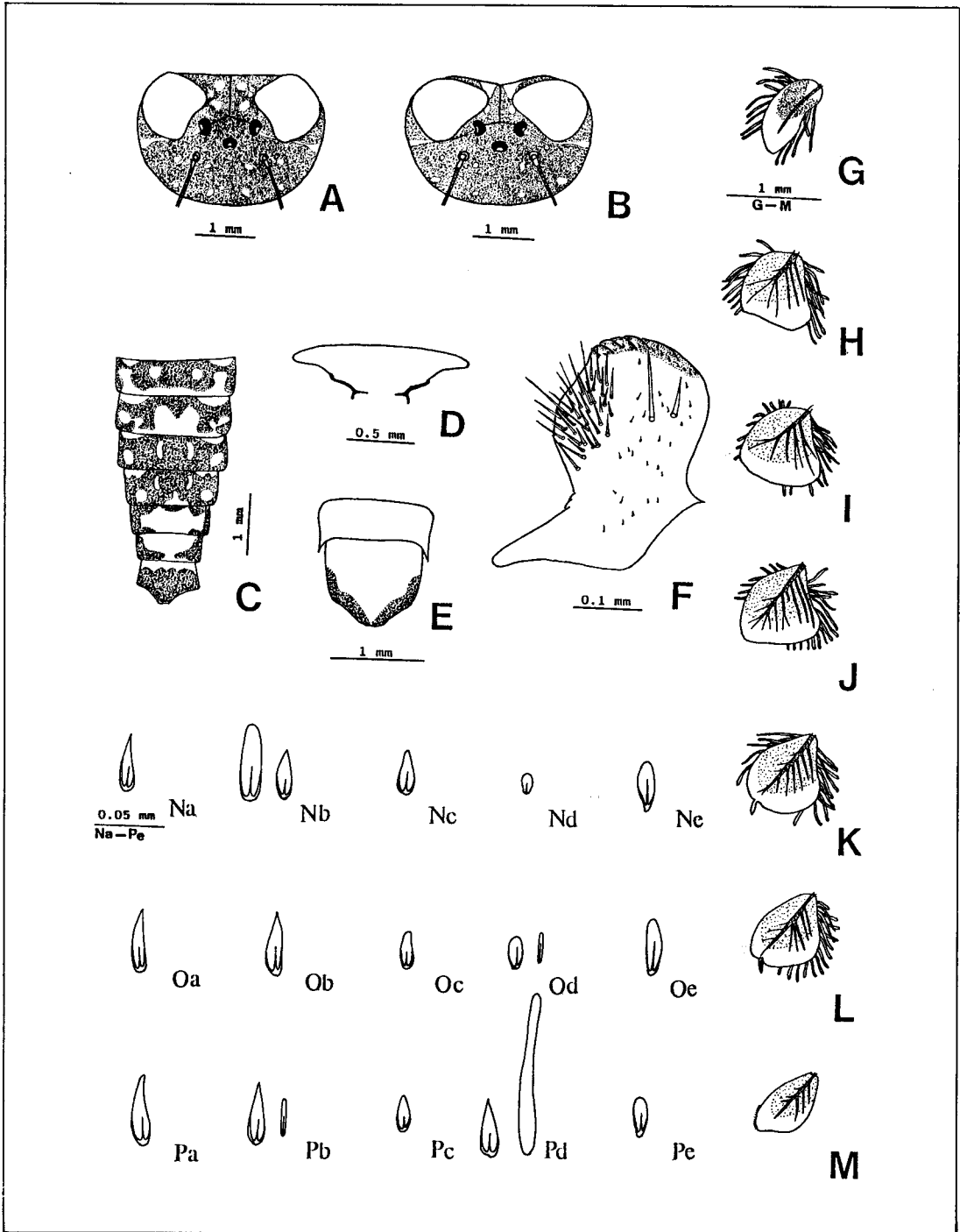


Fig. 5. Nymph of *Afronurus hyalinus* (Ulmer) n.comb. A. head, female; B. head, male; C. abdomen, female, dorsal; D. labrum dorsal; E. abdominal sterna VIII and IX; F. glossa, ventral; G-M. gills, (G, I; H, II; I, III; J, IV; K, V; L, VI; M, VII); Na-Pe. setae of legs; Na-Ne. fore leg; Oa-Oe. middle leg; Pa-Pe. hind leg; a. basal area of femur; b. median area of femur; c. distal area of femur; d. lateral margin of tibia; e. lateral margin of tarsus.

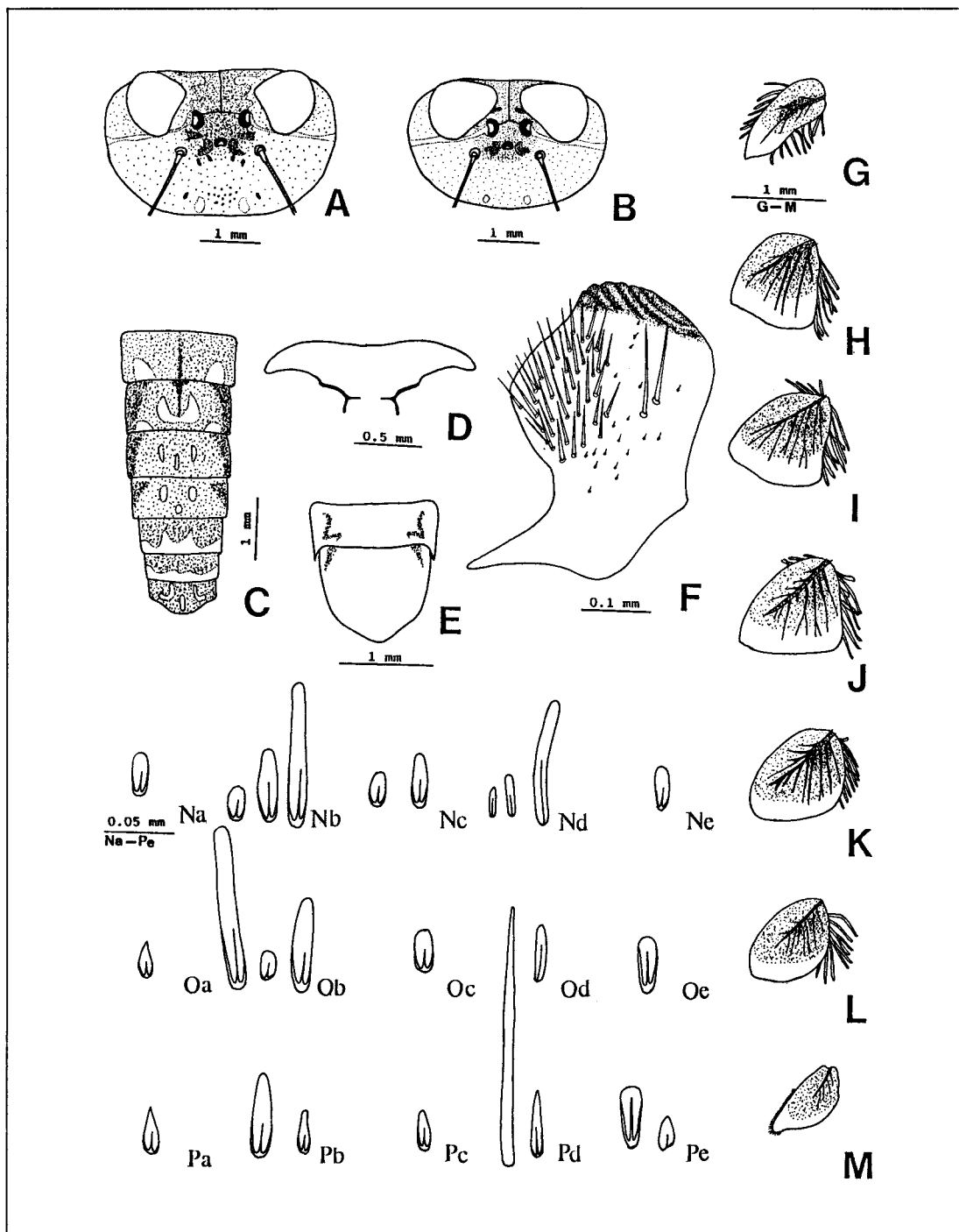


Fig. 6. Nymph of *Afronurus floreus* n.sp. A. head, female; B. head, male; C. abdomen, female, dorsal; D. labrum, dorsal; E. abdominal sterna VIII and IX; F. glossa, ventral; G–M. gills, (G, I; H, II; I, III; J, IV; K, V; L, VI; M, VII); Na–Pe. setae of legs; Na–Ne. fore leg; Oa–Oe. middle leg; Pa–Pe. hind leg; a. basal area of femur; b. median area of femur; c. distal area of femur; d. lateral margin of tibia; e. lateral margin of tarsus.

Chorionic structures of this species resembles in *A. hyalinus* (Ulmer) but equatorial and sub-equatorial area smooth, not granular-like.

Afronurus chihpenensis Kang & Yang n.sp.

Figs. 7, 18

Mature nymphs:

Body length of female and male 10.21–12.90 mm and 9.14–10.54 mm. General coloration brown with pale markings.

Head: brown with a pair of faint pale spots in front of antennae bases and a few dark specks on anterior area; between antennae and eyes with dark markings. Capsule of female and male 1.36–1.42 × and 1.29–1.35 × as wide as long; anterior and lateral margins convex, posterior margin straight. Eyes of female 0.44–0.48 × length and 0.28–0.30 × width of head; mde of female and male 0.24–0.28 × and 0.11–0.16 × width of head. **Labrum:** 0.39–0.43 × width of head. **Maxillae:** galea-lacinia 1.18–1.42 × as long as wide, with 21–24 pectinate spines on crown, ventral setae scattered subtriangularly. **Labium:** 0.79–0.88 × width of head; glossae oval; paraglossae 0.71–0.77 × width of labium.

Thorax: brown with pale markings. Pronotum as wide as head. **Legs:** femora pale with brown markings, posterior margin fringe with long fine setae; anterior margin, dorsum of femora, tibiae, and tarsi with numerous setae; dorsum of fore femora with pyriform and turbinate setae; lateral margins of fore tibiae with small lanceolate and small blunt setae; lateral margins of tarsi with oval setae; distal area of middle and hind femora and lateral surface of hind tibiae with acute setae; basal area of each femur with blunt setae. Fore femur subequal or less than length of fore tibia, female and male 3.23–3.50 × and 2.78–2.98 × length of fore tarsus; middle femur 1.03–1.10 × length of middle tibia, 4.09–4.69 × length of middle tarsus; hind femur 1.10–1.18 × length of hind tibia, 4.48–5.41 × length of hind tarsus. Claw with 2–3 subapical denticles.

Abdomen: tergite I pale with faint brown

pigment; tergites II–X each with paired pale markings on submedian and posterior areas, submedian markings of tergites V and IX fused; tergites V–VIII with small oblong, pale marking medially. Posterior margins of each tergite with serrated denticles. Posterior margin of sternum IX of female smoothly convex, dark on lateral margins, of male with 2 posterior processes. **Gills:** with broader lamellae on gills II–VI, narrower on gill I, gill VII oval; lamellae of each gills with arborescent dark tracheae distinctly; lamellae of gills V and VI both with an apical process. **Caudal filaments:** pale, with long acute setae in each articulation; on distal part, each segment with subanterior bold band.

Eggs: (Fig. 18)

The chorionic surface of egg with large and small KCTs. Both poles covered with small KCTs densely. Equatorial and subequatorial areas with 3–5 large KCTs and 1–2 large micropyle beside large KCTs closely; the remainder smooth, without any tubercle or other structure.

Holotype:

Mature female nymph, Chihpen, Peinan, Taitung Hsien, Taiwan, 15-XII-1990, S. C. Kang, (180 m), in collection NCHU.

Paratypes (mature nymph):

10♂♂, 12♀♀ same data as for holotype; 5♂♂, Chinfeng, Taitung Hsien, Taiwan, (105 m), 17-XII-1990, S. C. Kang. 8♂♂, 5♀♀, in collection NCHU; 4♂♂, 3♀♀, in collection ZML; 4♂♂, 3♀♀, in collection NMNS.

Distribution:

Taiwan.

Note:

This new species resembles *Afronurus floreus* n.sp. but can be distinguished by the following characteristics: (1) dorsum area of fore femur with pyriform and turbinate setae; (2) each femur without long oblong setae (3) tibiae and tarsi with oval setae and without long acute setae; (4) the shape of lamella of

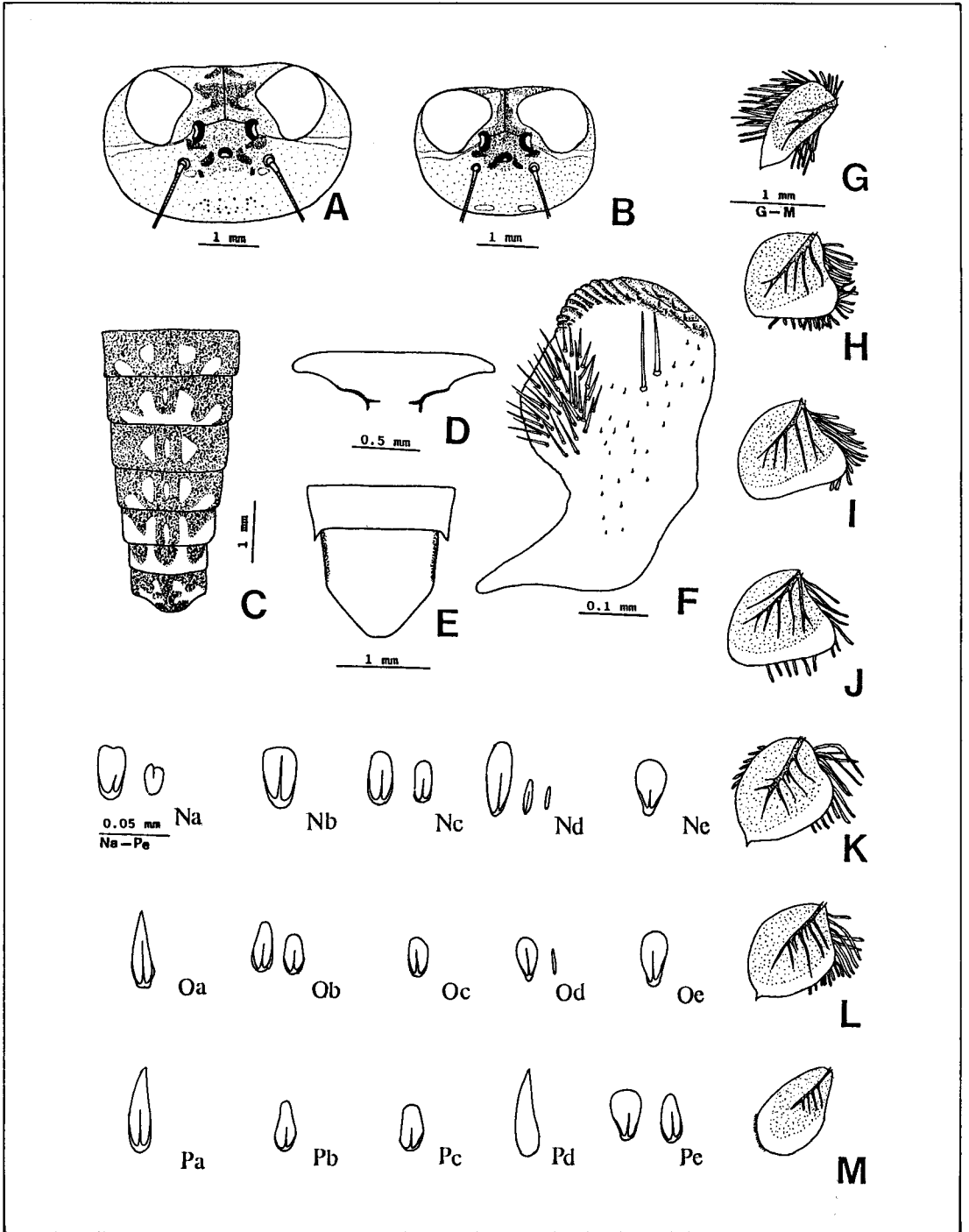


Fig. 7. Nymph of *Afronurus chipenensis* n.sp. A. head, female; B. head, male; C. abdomen, female, dorsal; D. labrum, dorsal; E. abdominal sterna VIII and IX; F. glossa, ventral; G-M. gills, (G, I; H, II; I, III; J, IV; K, V; L, VI; M, VII); Na-Pe. setae of legs; Na-Ne. fore leg; Oa-Oe. middle leg; Pa-Pe. hind leg; a. basal area of femur; b. median area of femur; c. distal area of femur; d. lateral margin of tibia; e. lateral margin of tarsus.

gill VII oval, distal margin round. This new species only distributes itself on the eastern part of Taiwan. The KCTs of eggs of this species with two different size, on equatorial and subequatorial areas with large KCTs which have same form as in *A. hyalinus* n.sp. but the surface of equatorial and subequatorial area very smooth.

Afronurus nanhuensis Kang & Yang n.sp.

Fig. 8

Mature nymphs:

Body length, female 9.63–11.29 mm, male 9.09–9.63 mm; general coloration brown with faint pale markings.

Head: brown, dark submedially. Capsule of female and male 1.47–1.57 × and 1.45–1.48 × as wide as long; posterior margin straight or slightly emarginate. Eyes of female 0.40–0.41 × length and 0.21–0.25 × width of head. mde of female and male 0.27–0.28 × and 0.10–0.15 × width of head; MDE of female 0.70–0.77 × width of head. **Labrum:** subtriangular, 0.41–0.44 × width of head. **Maxillae:** galea-lacinia 1.35–1.47 × as long as wide, with 24–28 pectinate spines on crown. **Labium:** 0.76–0.84 × width of head; glossae oval; paraglossae 0.72–0.77 × width of labium.

Thorax: brown with faint pale markings. **Legs:** femora brown with faint pale markings; dorsum of femora, tibiae, and tarsi with numerous setae; basal areas of fore femur and fore tarsus with oblong, apical blunt setae; median areas of fore and middle femur with short and long oblong setae; hind femur without long oblong setae; basal area of hind femur with acute setae; distal area of each femur with blunt setae; hind tibia with acute and long acute setae. Fore femur 0.95–0.96 × length of fore tibia; fore femur of female and male 3.07–3.18 × and 2.64–2.88 × length of fore tarsus; middle femur 1.01–1.06 × length of middle tibia, 3.94–4.36 × length of middle tarsus; hind femur 1.11–1.15 × length of hind tibia, 4.45–4.57 × length of hind tarsus. claw with 2 subapical denticles.

Abdomen: tergites V–VIII each with paired faint pale markings; markings on tergites VIII, IX fused posteromedially, like twin peak; each tergite dark medially; posterior margins of each tergite with various size denticles, in which mixed a few forked denticles. Posterior margin of sternum IX convex; each sternum with paired lunate pigments on lateral area. **Gills:** with lamellae broader on gill II–VI, narrower on gills I and VII, dark submedially, no visible arborescent tracheae.

Holotype:

Mature female nymph, Nanhutashan, Ta-tung, Ilan Hsien, Taiwan, 08-V-1990, W. B. Yeh, (2,300 m), in collection NCHU.

Paratypes (mature nymph):

6♂♂, 2♀♀, same data as for holotype; 1♂, 2♀♀, Hoping, Taichung Hsien, Taiwan, (2,890 m), 12-V-1990, W. B. Yeh. 1♂, 4♀♀, in collection NCHU; 1♂, 2♀♀, in collection ZML; 1♂, 2♀♀, in collection NMNS.

Distribution:

Taiwan.

Note:

The nymph of this new species resembles *Afronurus floreus* n.sp. but can be distinguished by the following characteristics: (1) body surface with faint markings; (2) gills no visible arborescent tracheae. They were found on a high mountain and in cold, small streams with a moderate current, at an elevation of 2,300–3,500 m.

Nixe (Nixe) littorosus Kang & Yang n.sp.

Figs. 9, 10, 19, 20

Mature nymphs:

Body length, female 6.05–7.30 mm, male 5.16–6.50 mm. General coloration light yellow.

Head: capsule light yellow, with 8 pairs of pale dots, 2 between yeas, 6 in front of ocelli, 2 on lateral areas, 4 near anterior margin and 2 close to anterior margin medially.

Hypopharynx: lingua conical at apex with shallow V-shaped median emargination. **Mandibles:** inner incisor of left mandible with acute spine in basal half of lateral margin and apex trifurked, processes subequal in level. **Maxillae:** galea-lacinia with pectinate spine on crown, first spine eight-furked; segment I of palpus with acute setae on posterior margin and long fine setae on anterior margin; segment II light brown.

Thorax: nota light yellow with markings.

Legs: femur with 2 light brown markings, distal a Y-shaped, basal 1 pale on the middle; dorsum of femur with oval or long oval setae, posterior margin fringes with long acute setae; claw acute at apex, apical 1/3 with 2–5 denticles.

Abdomen: abdominal segments III–VIII each with posterolateral projections; tergite I pale, with 2 light brown markings medially; tergites II–VII with 7 markings, 2 on lateral areas, 2 on median and 3 on posterior margin; tergite VIII without posteromedian marking; tergite IX pale, dark on lateral areas and with 4 light brown markings on anterior margin; tergite X with a twin peaked marking on anterior margin; abdominal sterna II–VII brown, pale on lateral areas, with 4 pale dots medially; sternum IX pale, dark on lateral areas, with a triangular marking on anterior margin medially and 2 brown dots near anterior margin, of male with 2 processes; posterior margin of tergite X with irregular, triangular, acute denticles. **Gills:** lamella of gill I reniform, 1/2 as wide as long, gills II–VI subtriangular, gill VII oval, widest medially. **Caudal filaments:** light brown, basal segments pale; surface of each segment covered with semicircular scales; basal segments with whorl of short acute setae distally; median segments with curved, long setae distally and both side fringe with long fine setae.

Eggs: (Figs. 19, 20)

Chorionic surface with mesh-like reticular ridge; every "mesh" with a small KCT, KCT increases its size toward one pole of chorion; the ridge smooth, humped on connection; only a visible small micropyle on equatorial

area.

Holotype:

Mature female nymph, Sinchungheng, Hsini, Nantou Hsien, Taiwan, (620 m), 18-XI-1991, S. C. Kang, in collection NCHU.

Paratypes:

4♂♂, 5♀♀, same data as for holotype; 5♂♂, 8♀♀, Chinho, Taoyuan, Kaohsiung Hsien, Taiwan, (540 m), 14-XII-1990, S. C. Kang; 11♂♂, 4♀♀, Taimali, Taitung Hsien, Taiwan, (50 m), 17-XII-1990, S. C. Kang. 10♂♂, 7♀♀, in collection NCHU; 3♂♂, 3♀♀, in collection ZML; 3♂♂, 3♀♀, in collection NMNS.

Other mature nymphal specimens examined:

1♂, 1♀, Maolin, Kaohsiung Hsien, Taiwan, 27-I-1990, S. C. Kang; 4♂♂, 4♀♀, Sanmin, Kaohsiung Hsien, Taiwan, 12-X-1990, W. B. Yeh; 3♂♂, Taian-Wenchuan, Taian, Miaoli Hsien, Taiwan, 31-X-1990, S. C. Kang; 2♂♂, 1♀, Sinwuchaio, Haituan, Taitung Hsien, Taiwan, (500 m), 15-XII-1990, S. C. Kang; 2♂♂, 3♀♀, Danan, Peinan, Taitung Hsien, Taiwan, (165 m), 16-XII-1990, S. C. Kang; 8♂♂, 12♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (280 m), 02-I-1991, S. C. Kang; 3♂♂, 6♀♀, Paolai, Taoyuan, Kaohsiung Hsien, Taiwan, (430 m), 02-IV-1991, S. C. Kang; 3♀♀, Fuyuan, Juisui, Hualien Hsien, Taiwan, (225 m), 03-IV-1991, S. C. Kang; 1♂, Sanchan, Hsincheng, Hualien Hsien, Taiwan, (65 m), 03-IV-1991, S. C. Kang; 1♀, Chilan, Tatung, Ilan Hsien, Taiwan, (200 m), 30-V-1991, S. C. Kang & H. C. Chang; 1♀, Pingsin, Shuangchi, Taipei Hsien, Taiwan, 31-V-1991, S. C. Kang & H. C. Chang; 1♂, 3♀♀, Shenmuh, Hsini, Nantou Hsien, Taiwan, (990 m), 18-XI-1991, S. C. Kang; 3♂♂, 4♀♀, Shaping, Liukuei, Kaohsiung Hsien, Taiwan, (635 m), 19-XII-1991, S. C. Kang; 5♂♂, 4♀♀, Kuolai-Kanchiao, Pinglin, Taipei Hsien, Taiwan, (365 m), 30-III-1992, S. C. Kang.

Distribution:

Taiwan.

Note:

Genus *Nixe* and two subgenera, *Akkarion*

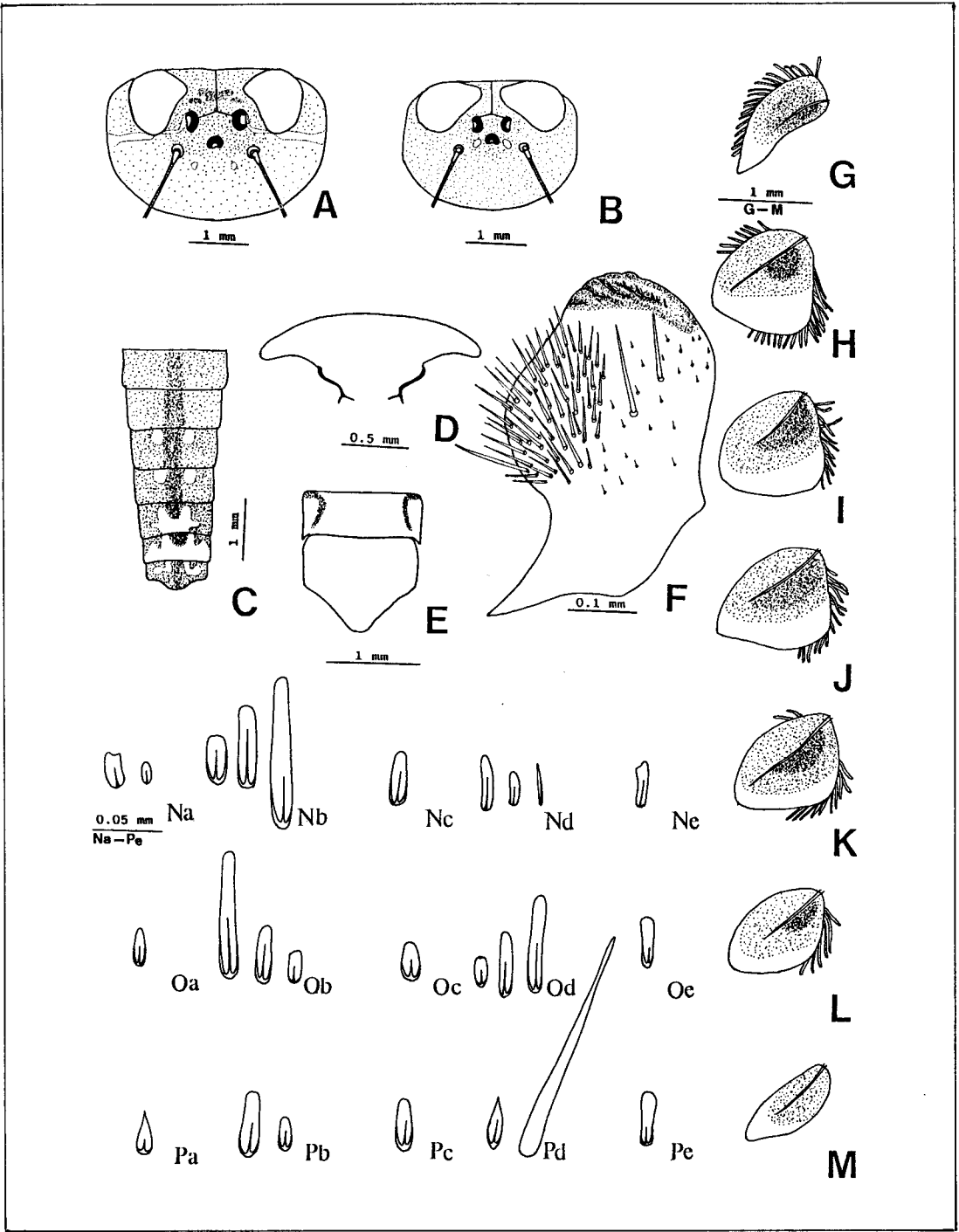


Fig. 8. Nymph of *Afronurus nanhuensis* n.sp. A. head, female; B. head, male; C. abdomen, female, dorsal; D. labrum, dorsal; E. abdominal sterna VIII and IX; F. glossa, ventral; G–M. gills, (G, I; H, II; I, III; J, IV; K, V; L, VI; M, VII); Na–Pe. setae of legs; Na–Ne. fore leg; Oa–Oe. middle leg; Pa–Pe. hind leg, a. basal area of femur; b. median area of femur; c. distal area of femur; d. lateral margin of tibia; e. lateral margin of tarsus.

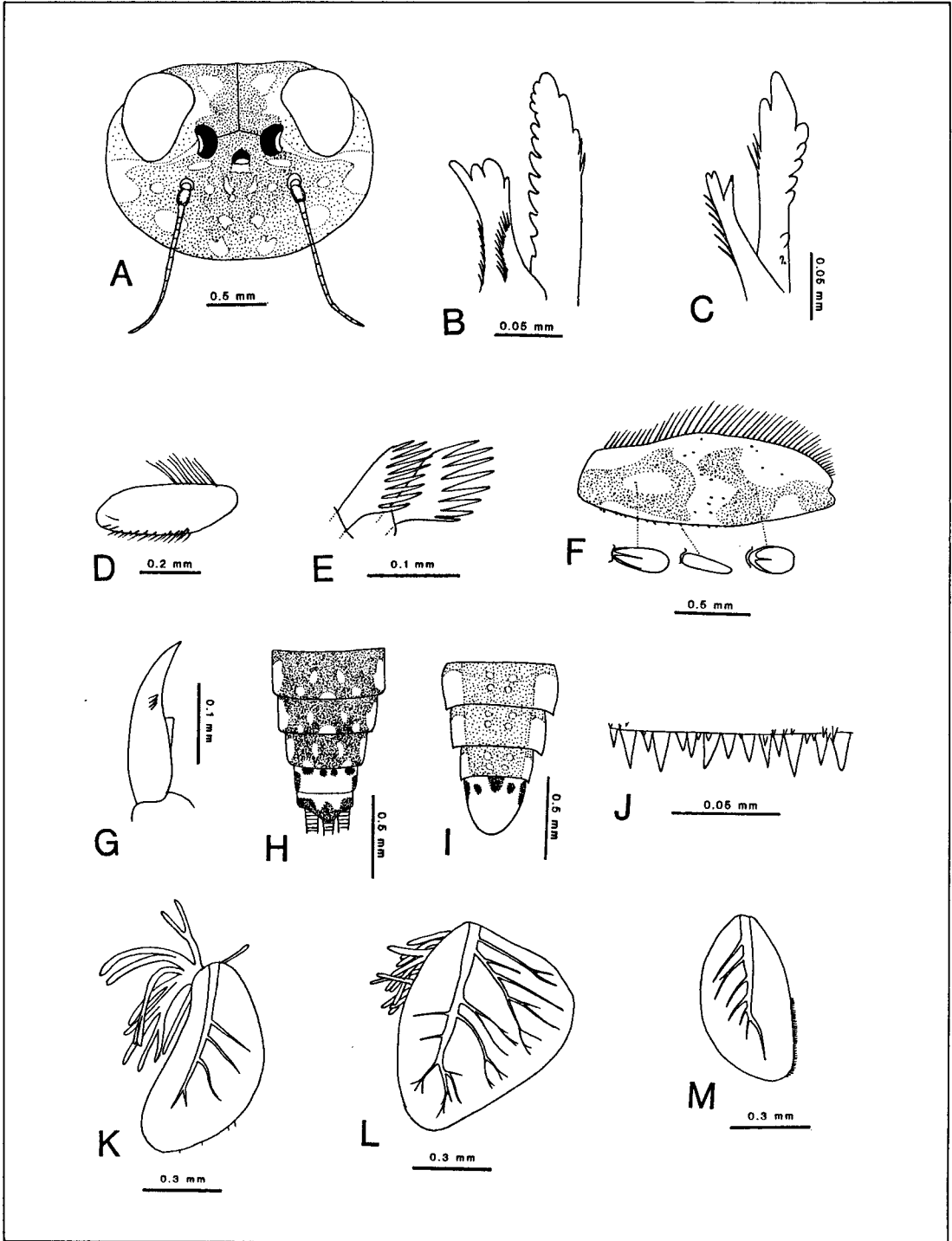


Fig. 9. Nymph of *Nixe (Nixe) littoralis* n.sp. A. head, female; B. incisors of left mandible, mesal; C. incisors of right mandible, mesal; D. maxillary palp, segment I; E. maxillary pectinate spine, the 2nd and 3rd; F. left fore femora, dorsal; G. fore claw; H. abdominal tergites VI-X, female; I. abdominal sternites VI-IX, female; J. posteromedian margin of abdominal tergite X; K. gill I; L. gill IV; M. gill VII.

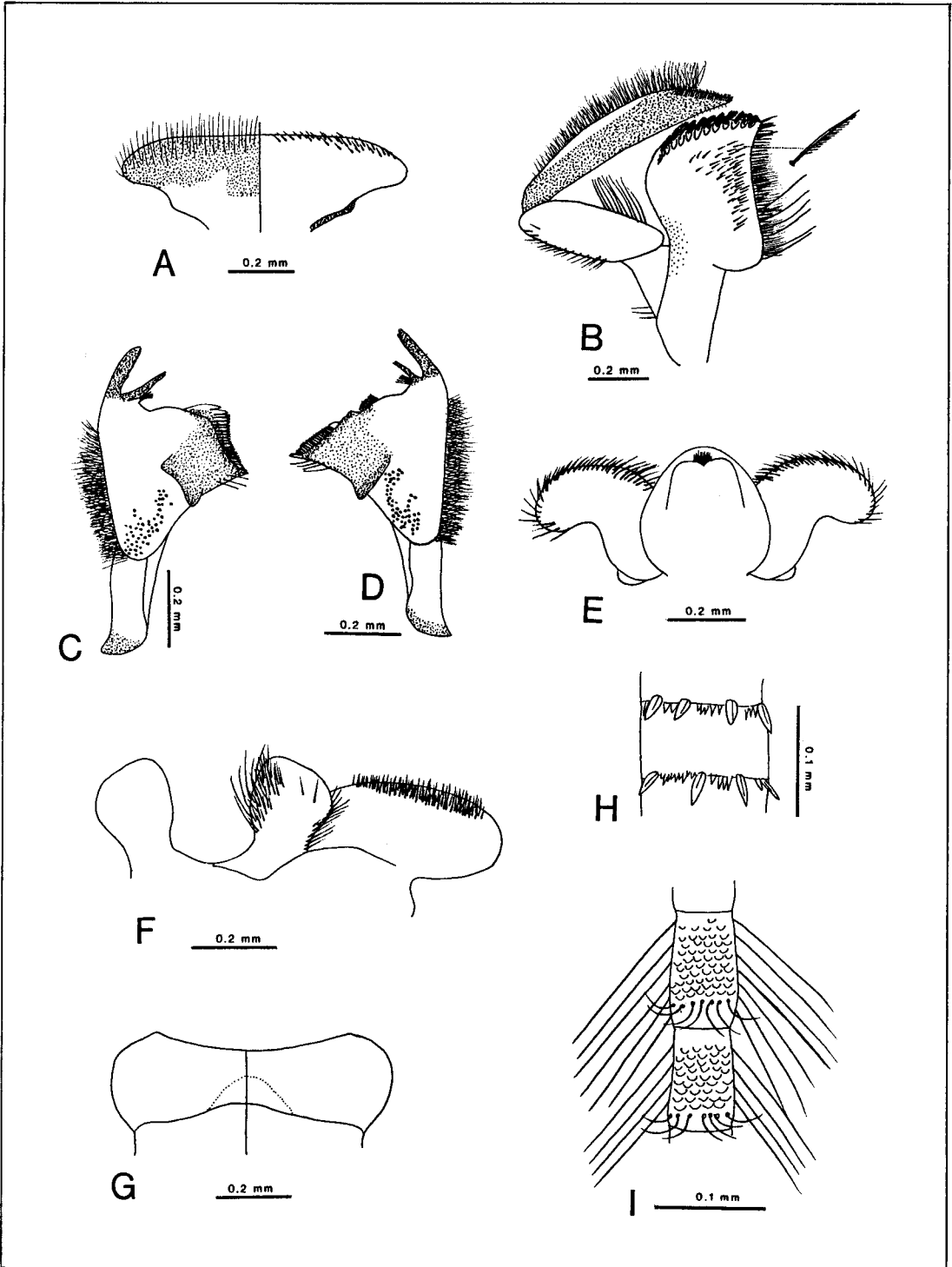


Fig. 10. Nymph of *Nixe (Nixe) littoralis* n.sp. A. labrum, a. dorsal, b. ventral; B. right maxillae, ventral; C. left mandible, dorsal; D. right mandible, dorsal; E. hypopharynx, ventral; F. labium, ventral; G. pronotum, dorsal; H. basal segments of caudal filament; I. middle segments of caudal filament.

and *Nixe* were erected by Flower (1980) to receive species which transferred from genera *Heptagenia* and *Ecdyonurus*. All of the species are found in North America; only one species, *N. subspinosa* found from Korea (Braasch and Soldán, 1988). This and following two new species from Taiwan are the second time found in East Asia. As in known subgenus *Nixe*, chorionic surface shows the same reticulated pattern. The chorionic structure of this subgenus of Taiwan and the other known species with mesh-like reticular ridges. For this reason, they are considered here as being a nature group and clearly differ from *Ecdyonurus*.

Nixe (Nixe) mitificus Kang & Yang n. sp.

Figs. 11, 21, 22

Mature nymphs:

Body length, female 5.90–7.06 mm, male 5.10–6.35 mm. General coloration light brown with pale markings.

Head: capsule light brown, with a pale subtriangular marking, with a pair markings between eyes, with 11 pale markings on anterior half, 7 submedial, 4 near anterior margin; posterior margin straight. **Hypopharynx:** lingua conical at apex with broad, shallow, emargination medially. **Mandibles:** inner incisor of left mandible with acute spines in basal half of lateral margins; apex of left inner incisor triforked, a lateral process higher than median and another lateral processes. **Maxillae:** galealacinia with pectinate spines on crown, the first spine five-forked; segment I of palpus dark on distal 1/3, venter with pores, anterior and posterior margins with long fine setae loosely; basal 1/2 of segment II dark.

Thorax: nota light brown with markings. **Legs:** dorsum of femur pale, basal area dark, with 3 brown markings submedially and scatter with oval setae; posterior margin of femur fringes with long acute setae; claw distinctly curved at apex, apical 1/3 with 3 or 4 denticles.

Abdomen: abdominal segment II–VIII each with postero-lateral projections; tergite I pale, with 2 light brown markings medially;

tergites II–VII brown, each with 7 pale markings, 2 on lateral, 2 medial, oval, 1 postero-medial, small, triangular, and 2 on posterior margin, subquadrate; the 3 posterior markings sometimes connected with each other; tergite IX pale, with 2 oblique stripes medially; sterna VI and VII dark and with 2 pale markings medially; sternum XIII of female pale, with 3 markings, 1 medial, 2 lateral, marking of male like sternum VII; sternum IX pale, with 4 brown dots, 2 on anterolateral corner, 2 on posterolateral corner; posterior margin of tergite X with irregular, loose denticles, most denticle sharply cleft at apex. **Gills:** lamella of gill I oblique oval, width slightly larger than 1/2 of length, gills II–VI subquadrate, gill VII long oval, widest at distal 1/3. **Caudal filaments:** cerci 0.59–0.63 × length of body, slightly darker and larger than terminal filament, basal segments pale; caudal filaments with semicircular scales on each segment; basal segment of each filament with whorl of short acute setae distally; median segments with whorl of curved, long setae distally and both side fringe with long fine setae.

Eggs: (Figs. 21, 22)

Chorionic surface with mesh-like reticular ridges; every "mesh" with a large KCT, all KCTs subequal in size; the ridge undulate, hunch-like; a visible small micropyle on equatorial area.

Holotype:

Mature female nymph, Kanchiao, Shuangchi, Taipei Hsien, Taiwan, (140 m), 28-III-1992, S. C. Kang, in collection NCHU.

Paratypes:

16♂♂, 12♀♀, same data as for holotype. 8♂♂, 6♀♀, in collection NCHU; 3♂♂, 3♀♀, in collection ZML; 3♂♂, 3♀♀, in collection NMNS.

Other mature nymphal specimens examined:

5♂♂, Pihuchiao, Pinglin, Taipei Hsien, Taiwan, 17-XI-1990, S. C. Kang & H. C. Chang; 1♂, 1♀, Hontung, Juifang, Taipei Hsien, Taiwan, (120 m), 29-III-1992, S. C. Kang; 2♂♂, 4♀♀,

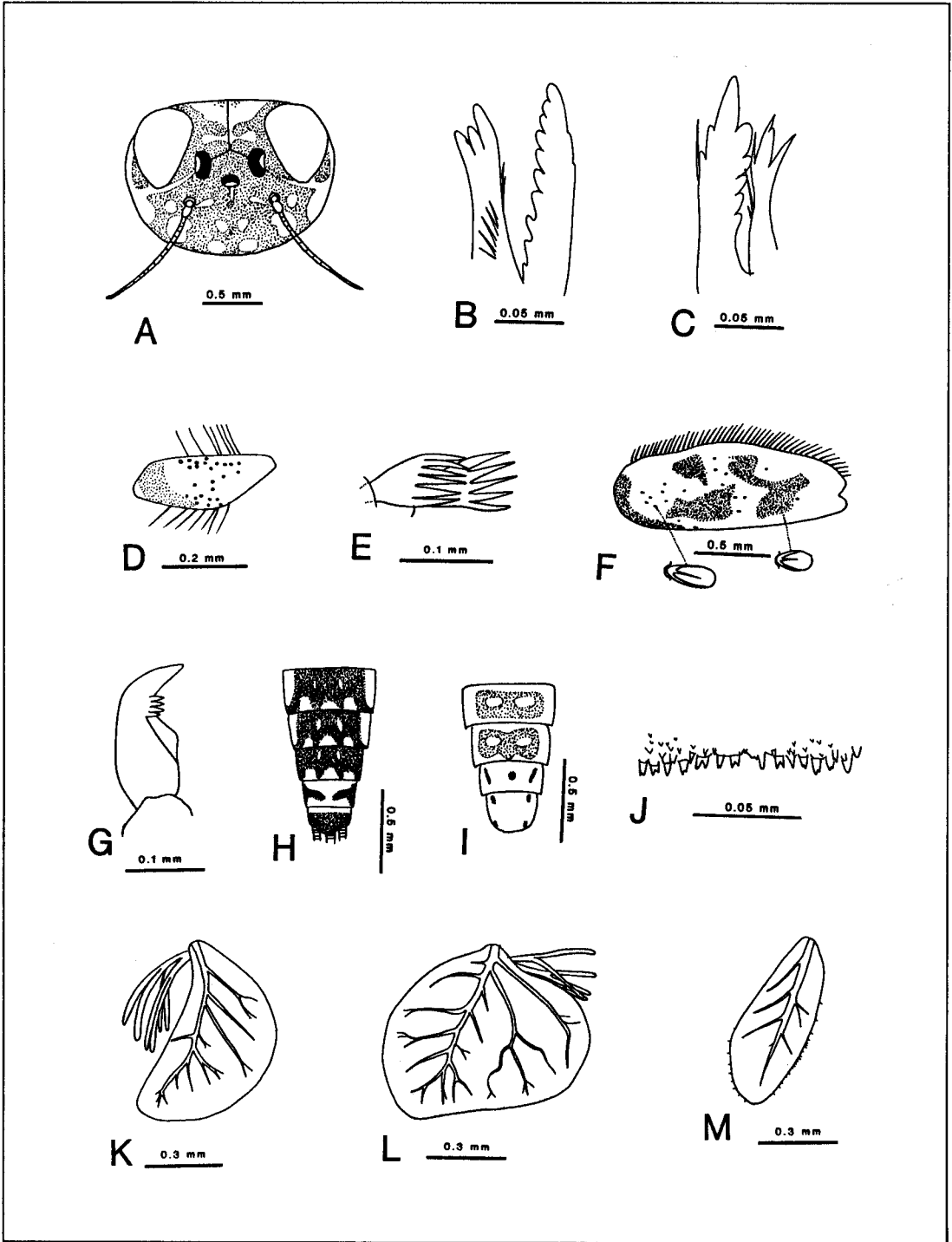


Fig. 11. Nymph of *Nixe (Nixe) mitificus* n.sp. A. head, female; B. incisors of left mandible, mesal; C. incisors of right mandible, mesal; D. maxillary palpus, segment I; E. maxillary pectinate spine, the 2nd and 3rd; F. left fore femora, dorsal; G. fore claw; H. abdominal tergites VI-X, female; I. abdominal sterna VI-IX, female; J. posteromedian margin of abdominal tergite X; K. gill I; L. gill IV; M. gill VII.

Kuolai, Pinglin, Taipei Hsien, Taiwan, (315 m), 30-III-1992, S. C. Kang.

Distribution:

Taiwan.

Note:

This new species resembles *Nixe (Nixe) littorosus* n.sp. but can be differentiated in the nymphs by the following characters: (1) marking pattern on head is not the same as in *N.(N.) littorosus*, especial on front; (2) apical processes of inner incisor of left mandible are unequal in level; (3) ventroapical 1/3 of segment II of maxillary palpus is dark and scatters with pores; (4) the first maxillary pectinate spine five-forked; (5) femur with 3 markings; (6) markings on abdominal tergites IX and X and sterna VIII and IX very different from *N. (N.) littorosus*; (7) posterior margin of abdominal tergite X has irregular, loose denticles, most denticles sharply cleft at apex. The egg can be differentiated by undulate ridge and KCTs which are larger than in *N. (N.) littorosus*.

Nixe (Nixe) obscurus Kang & Yang n.sp.

Figs. 12, 23, 24

Mature nymphs:

Body length, female 6.38–7.75 mm, male 5.26–6.88 mm. General coloration brown, with vague markings.

Head: capsule uniform brown or light brown on posterior half, with 4 vague markings on anterior area. **Hypopharynx:** lingua conical at apex, with shallow V-shaped median emargination. **Mandibles:** inner incisor of left mandible with long fine spines in basal half and apex triforked, median process smaller and lower than on lateral. **Maxillae:** galealacinia with pectinate spines on crown, the first spine five-forked, lateral margins convex; segment I of palpus with acute setae on posterior margin, anterior margin without or only with a long setae; segment II brown.

Thorax: nota brown, with vague markings; pronotum narrower than head, lateral margins

of nota convergent posteriorly. **Legs:** femur with 3 light brown, vague markings, 1 on distal area, 2 on basal area; dorsum of femur with long oblong setae; posterior margin fringes with long acute setae; fore claw with a median process on mesal margin, blunt at apex; middle and hind claw each with a distinct process on middle of mesal margin and some small acute denticles medially.

Abdomen: abdominal segments II–VIII each with posterolateral projection; tergite I pale, tergites II–VIII brown, with 5 pale markings, 2 on lateral areas, large, 2 submedian and 1 on posteromedian margin, vague, or invisible; tergite IX with a marking on posteromedian margin; tergite X brown, with 2 vague markings on anterior margin; abdominal sterna VI–IX dark on sublateral area, light on median; sterna VI and VII with 2 oblique, dark stripes medially; sterna VIII and IX with 3 dark dots near anterior margin; posterior margin of tergite X with nearly regular, triangular, acute denticles. **Gills:** lamella of gill I reniform, 1/3 as wide as long, gills II–VI subtriangular, gill VII oval, widest at distal 1/3. **Caudal filaments:** light brown; terminal filament wider than or equal to cerci; surface of each segment covered with long rhombic scales; each segment of basal part with whorl of long acute setae distally; median segments with whorl of curved, fine setae, long fine setae and long acute setae distally; both side of median segments fringe with long fine setae.

Eggs: (Figs. 23, 24)

Chorionic surface with mesh-like reticular ridges; every "mesh" with a KCT, KCTs increase their size toward one pole of chorionic; the ridge smooth, sharp; a visible small micropyle on equatorial area.

Holotype:

Mature female nymph, Wufeng, Hsinchu Hsien, Taiwan, (1,970 m), 24-X-1991, S. C. Kagn & H. C. Chang, in collection NCHU.

Paratypes:

2♂♂, 1♀, same data as for holotype. 1♂,

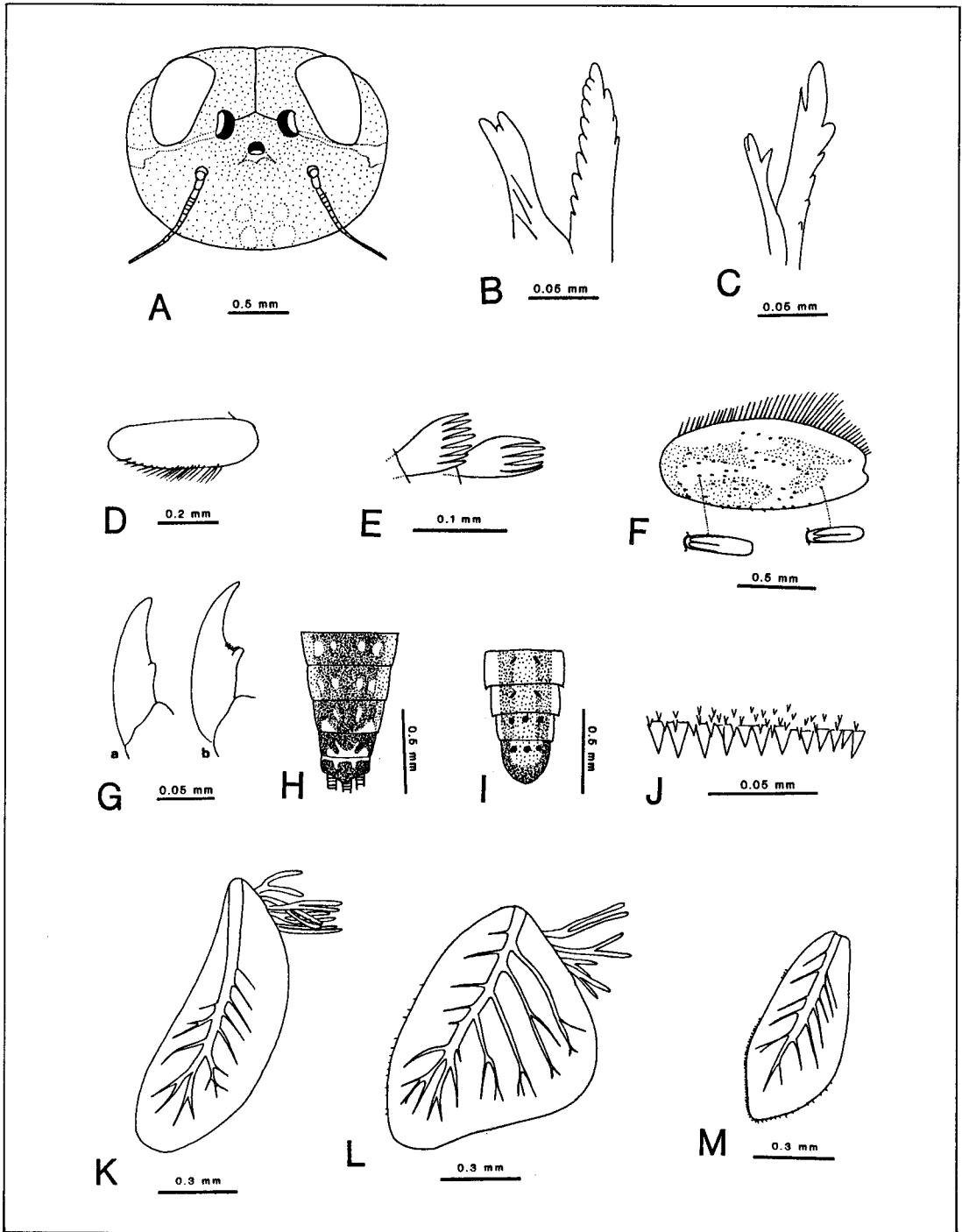
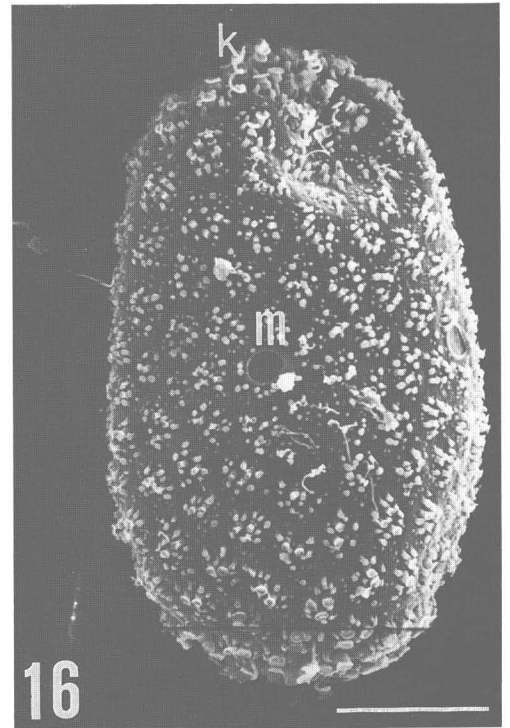
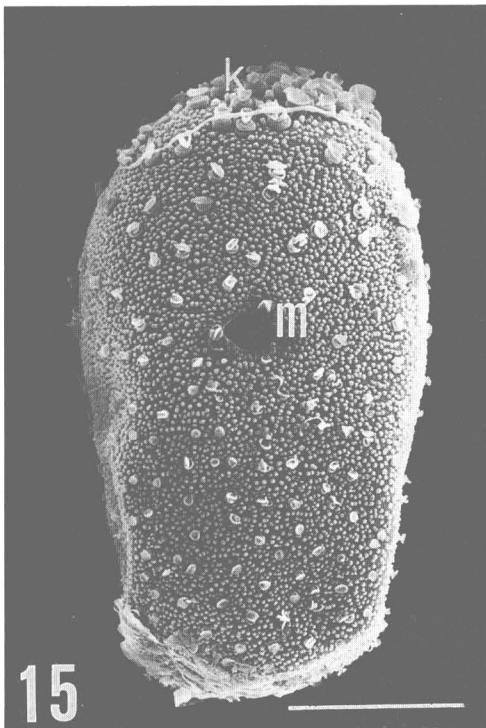
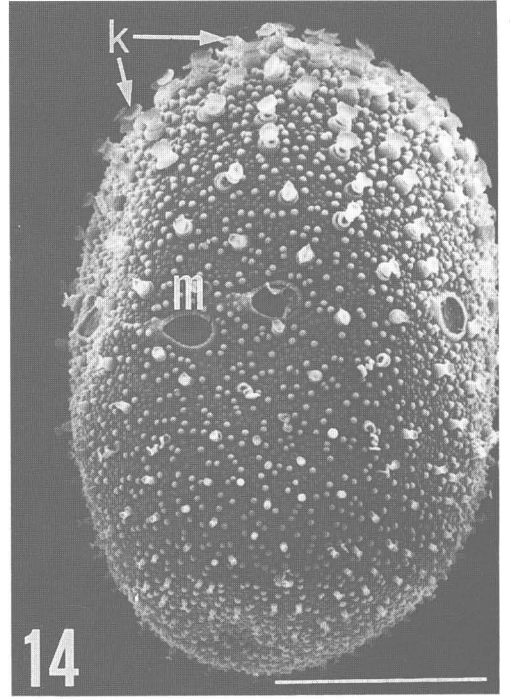
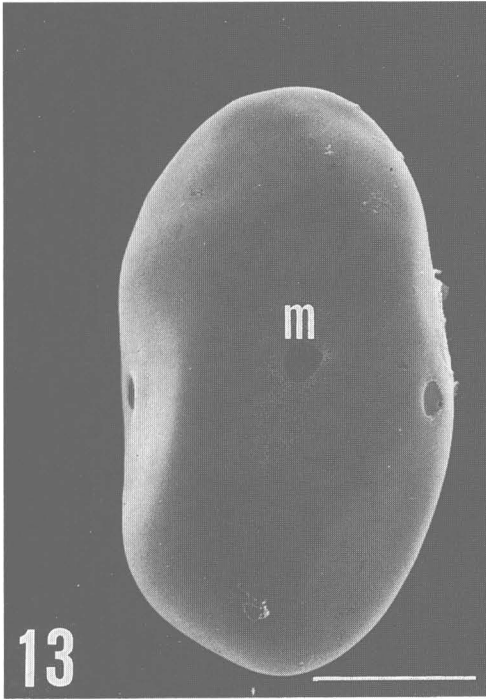
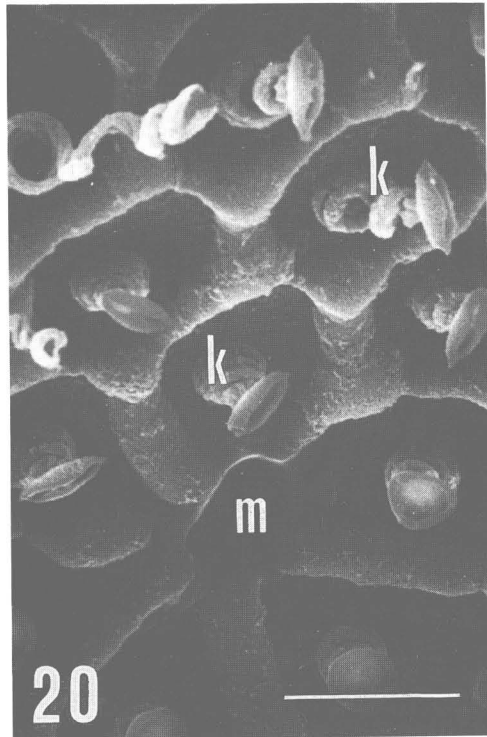
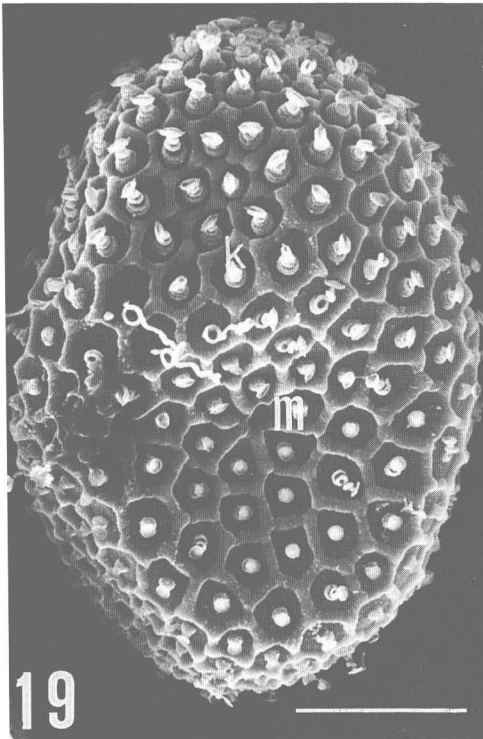
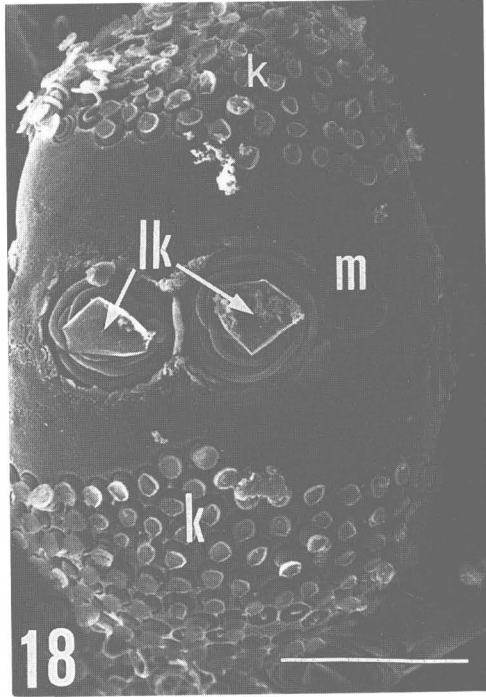
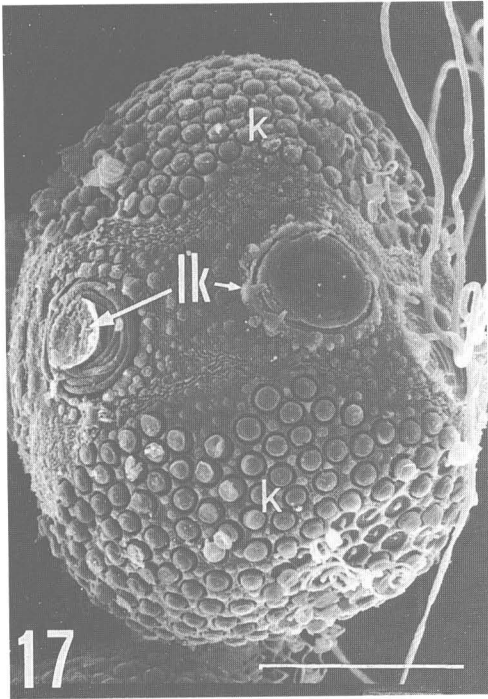


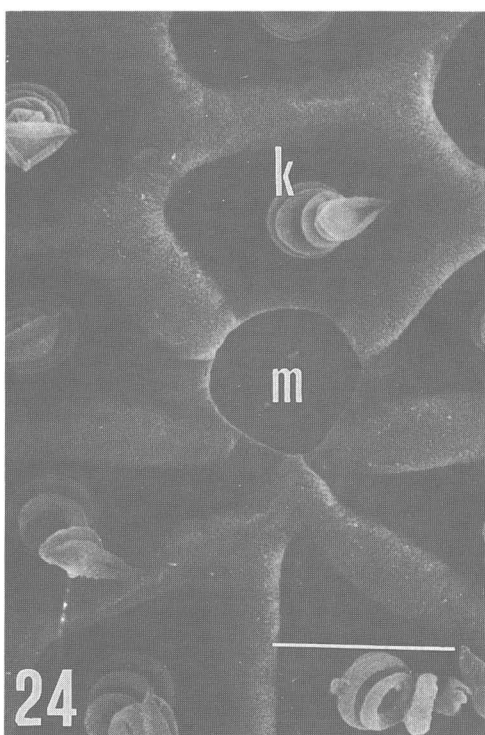
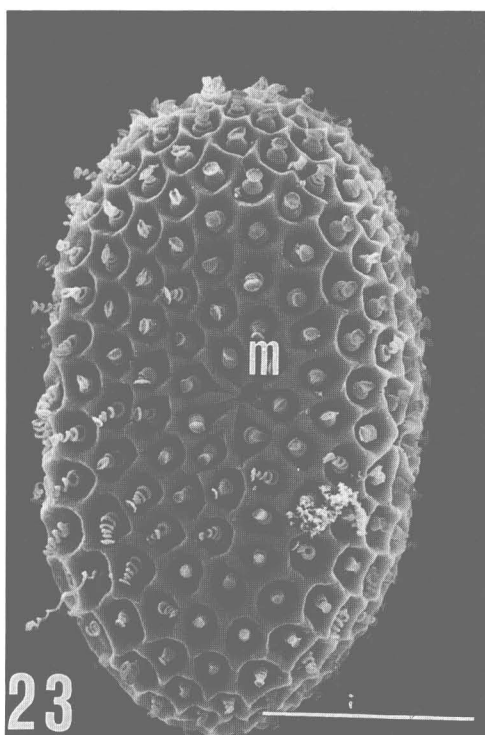
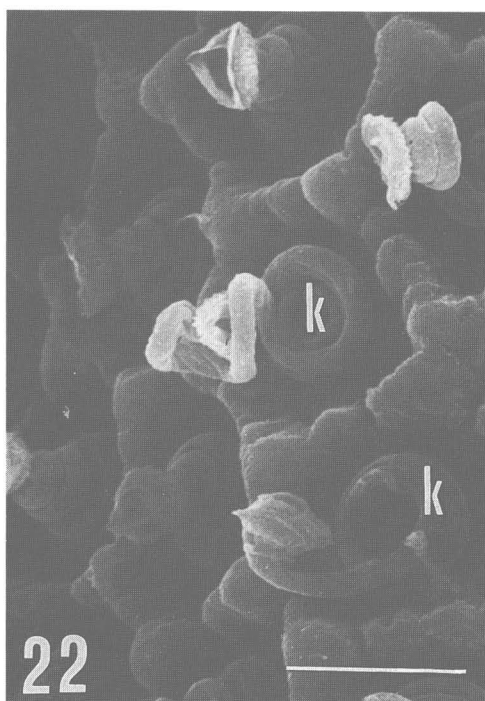
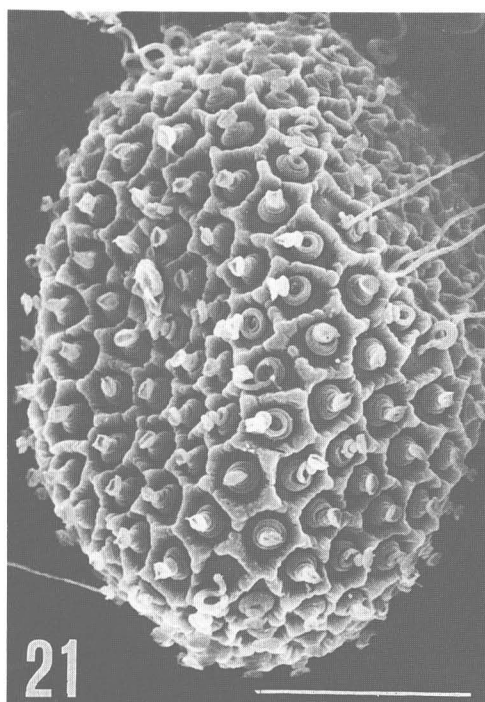
Fig. 12. Nymph of *Nixe* (*Nixe*) *obscurus* n. sp. A. head, female; B. incisors of left mandible, mesal; C. incisors of right mandible, mesal; D. maxillary palpus, segment I; E. maxillary pectinate spine, the 2nd and 3rd; F. left fore femora, dorsal; G. claws (a. fore leg; b. hind leg); H. abdominal tergites VI-X, female; I. abdominal sterna VI-IX, female; J. posteromedian margin of abdominal tergite X; K. gill I; L. gill IV; M. gill VII.



Figs. 13 – 16. Eggs. 13. *Epeorus erratus* Brasch; 14. *Electrogena fracta* n.sp.; 15. *Rhithrogena parva* (Ulmer); 16. *Rhithrogena ampla* n.sp. (m: micropyle; k: KCT, knob-terminated coiled thread) [scale = 50 μm].



Figs. 17 – 20. Eggs. 17. *Afronurus hyalinus* (Ulmer) n.comb.; 18. *Afronurus chipenensis* n.sp.; 19–20. *Nixe* (*N.*) *littoralis* n.sp.; 19. general view; 20. detail. (m: micropyle; k: KCT, knob-terminated coiled thread; lk: large KCT) [scale: 17–19 = 50 μ m; 20 = 10 μ m].



Figs. 21–24. Eggs. 21–22. *Nixe (N.) mitificus* n. sp., 21. general view; 22. detail; 23–24. *N. (N.) obscurus* n. sp.; 23. general view; 24. detail. (m: micropyle; k: KCT, knob-terminated coiled thread) [scales: 21, 23 = 50 μm ; 22, 24 = 10 μm].

3♀♀, Tapachienshen, Wufeng, Hsinchu Hsien, Taiwan, (1,835 m), 24-X-1991, S. C. Kang & H. C. Chang. 1♂, 2♀♀, in collection NCHU; 1♂, 1♀, in collection ZML; 1♂, 1♀, in collection NMNS.

Distribution:

Taiwan.

Note:

This new species resembles *Nixe (N.) littorosus* n.sp. However, it can be differentiated in the nymphs by the following characteristics: (1) head capsule is uniform brown or bright on anterior half, has 4 vague marking on anterior area; (2) apical processes of inner incisor of left mandible are unequal in level, median one is lower and smaller than on lateral; (3) the first maxillary pectinate spine five-forked; (4) markings of abdominal tergite IX and sternum VIII are very different from in *N. (N.) littorosus* and (6) gill I selenders, is 1/3 as wide as long. The ridges of chorionic surface are smoother and sharper than in *N. (N.) littorosus*.

Acknowledgements

This research was financially supported by National Science Council (NSC), project number is NSC81-0409-B-005. The authors would also like to thank Mr. Hsien-Cheng Chang and Mr. Win-Bin Yeh for their contributions to the collection.

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