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The nymph, habitat, and status of *Eatonigenia* in China (Ephemeroptera: Ephemeridae)

JUN-ZHI SUN, JUAN-YAN LUO & CHANG-FA ZHOU
The Key Laboratory of Jiangsu Biodiversity and Biotechnology, College of Life Sciences, Nanjing Normal University, Nanjing 210046, China. E-mail: zhouchangfa@njnu.edu.cn

Abstract

The nymphs of a new species of *Eatonigenia* have more modified labrum and smaller foreclaws than congeners, and the males have a more reddish-brown colored body, cerci, genitalia and more sclerotized projections of gonopores. These characters indicate a new species which is named *E. zhangi* **sp. nov.** The nymphs live in fine sandy/muddy substrates of large rivers.

Key words: *Eatonigenia*, new species, China, ecology, habitat

Introduction

The genus *Eatonigenia* (Ephemeroptera: Ephemeridae) was established by Ulmer (1939) and revised and re-defined by McCafferty (1973). By then, the genus included four species: *E. chaperi* (Navás, 1935), the type-species, known based on nymphs and imago; *E. seca* McCafferty, 1973, imago only, from Thailand; *E. indica* (Chopra, 1924), female adult from India; and *E. trirama* McCafferty, 1973, nymph, also from India (McCafferty, 1973,1991). In addition, two poorly described species were transferred into the genus by McCafferty (1991) and accepted by Kluge (2004): *Heterogenesia chinei* Dang, 1967, a species described based on nymphs from Vitenam; and *Hexagenia philippina* Navás, 1933, described based on female imago from Philippines. These species, however, were not included in the World checklist of burrowing mayflies from Hwang *et al.* (2008). Pending further study, we recognize the present placement of these species in *Eatonigenia*.

Zhang (1988) reported *Eatonigenia* for the first time from China, based on the imaginal specimens attributed to *E. chaperi* from Hainan Island. Unfortunately, nymphs were not collected and no other information is available. In order to expand our knowledge of *Eatonigenia* among the list of Chinese species, we revisited the same locality collected by Dr. Zhang in 1986, in 2014 and 2015. Fortunately, one male subimago and 16 nymphs were found. Based on these and the specimens studied by Zhang (1988), the Chinese representative of *Eatonigenia* is recognized as a new species. The nymphal and additional imaginal characters are described herein.

Eatonigenia zhangi sp. nov.

Eatonigenia chaperi Zhang, 1988: 68 (male, female, subimago) (*nec. Hexagenia chaperi* Navás, 1935: 99, misidentification); Zhang *et al.*, 1995: 74; She *et al.*, 1995: 80; You and Gui, 1995: 91.

Diagnosis. The new species can be distinguished from the other species of the genus based on the following characteristics: in males, larger and more colorful body, slightly projected apex of penis and three tips of gonopores; in nymphs, larger and paler body, smaller fore-claw and asymmetrical labrum.

Nymph (in alcohol, not mature, Figs. 1, 3A): Body length 20.0 mm, cerci 4.0–6.0 mm, terminal filament 3.0 mm. Body ivory pale, with golden setae on most parts of body.

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FIGURE 1. Nymphal habitus of *Eatonigenia zhangi* sp. nov. (digital photo)

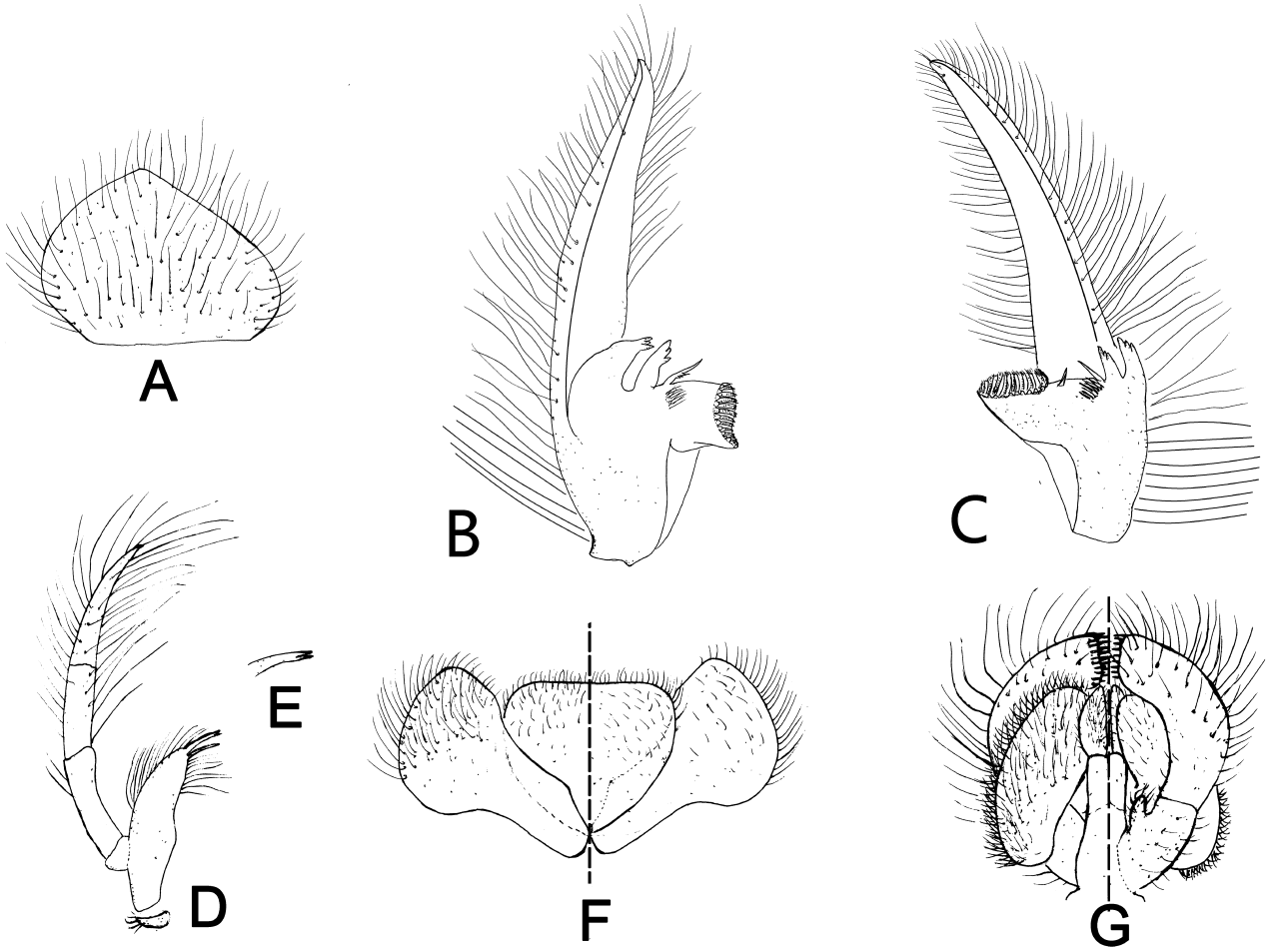

FIGURE 2. Mouthparts of *E. zhangi* **sp. nov.** nymph: A. Labrum; B. Left mandible (ventral view); C. Right mandible (ventral view); D. Maxilla; E. Apex of upper denticle on maxillary galia-lacinia; F. Hypopharynx (dorsal view on left; ventral view on right); G. Labium (dorsal view on left; ventral view on right)

Head (Figs. 1, 3A, 5A): Length of frontal processes slightly shorter than width, its anterior margin smoothly convex and narrower than posterior margin; all free margins with dense golden setae; base of antenna projected forwards with relatively long setae on supra-antennal surface; scape of antenna slightly longer than pedicel, the latter with setae on basal half; flagella with sparse setae; length of antenna subequal to head width; compound eyes dark, surrounded with a row of setae; upper half of ocelli pale, lower half dark; area between 3 ocelli slightly pigmented grey; vertex pale (Fig. 5A).

Mouthparts: Labrum generally heart-shaped, asymmetrical; free margins and dorsal surface with long anteriorly directed setae (Figs. 2A, 5F), ventral surface with short mesally directed setae but no long setae (Fig. 5G). Mandibles asymmetrical, tusk of left mandible shorter than right in dorsal view; triangular mandibular tusks densely setaceous dorsally and laterally with setae progressively shorter toward apex; outer incisor of left mandible much stronger than inner incisor; apex of both incisors of left mandible divided into 3 denticles; prostheca of left mandible modified into a thick spine, with 2 denticles near apex and a small setal tuft next to prostheca (Fig. 2B); outer incisor of right mandible slightly stronger than inner incisor, apex of both incisors divided into 3 denticles; prostheca represented as 2 spines, one near inner incisor, other close to mola, an additional small setal tuft between them (Fig. 2C). Maxillae slender, outer margin with relatively long hair distally, inner margin with long spines and hair, apex of galea-lacinia extended to form 2 large spines (canine and dentiseta) (Fig. 2D), apex of distal spine (canine) bifurcate (Fig. 2E); maxillary palp 3-segmented although segmentation between second and third segment indistinct; basal and second segment subequal in length, apical segment slightly longer; basal segment with only 2 long setae on outer margin near apex but other segments with long setae over entire surface, those on inner margin longer; cardo with small spine-like setae (Figs.2D, 5H). Hypopharynx with lingua slightly emarginated to straight on free margin; surface of lingua and superlinguae with setae, setae more abundant on dorsoapical surface and free

margin (Fig. 2F). Labium with dense setae on paraglossae forming brush-like setal tuft; labial palp 2-segmented, apical segment ca. 2× length of basal segment, basal segment with a thumb-like protuberance, apical segment with fan of long setae and dense spines on surface near apex (Fig. 2G).

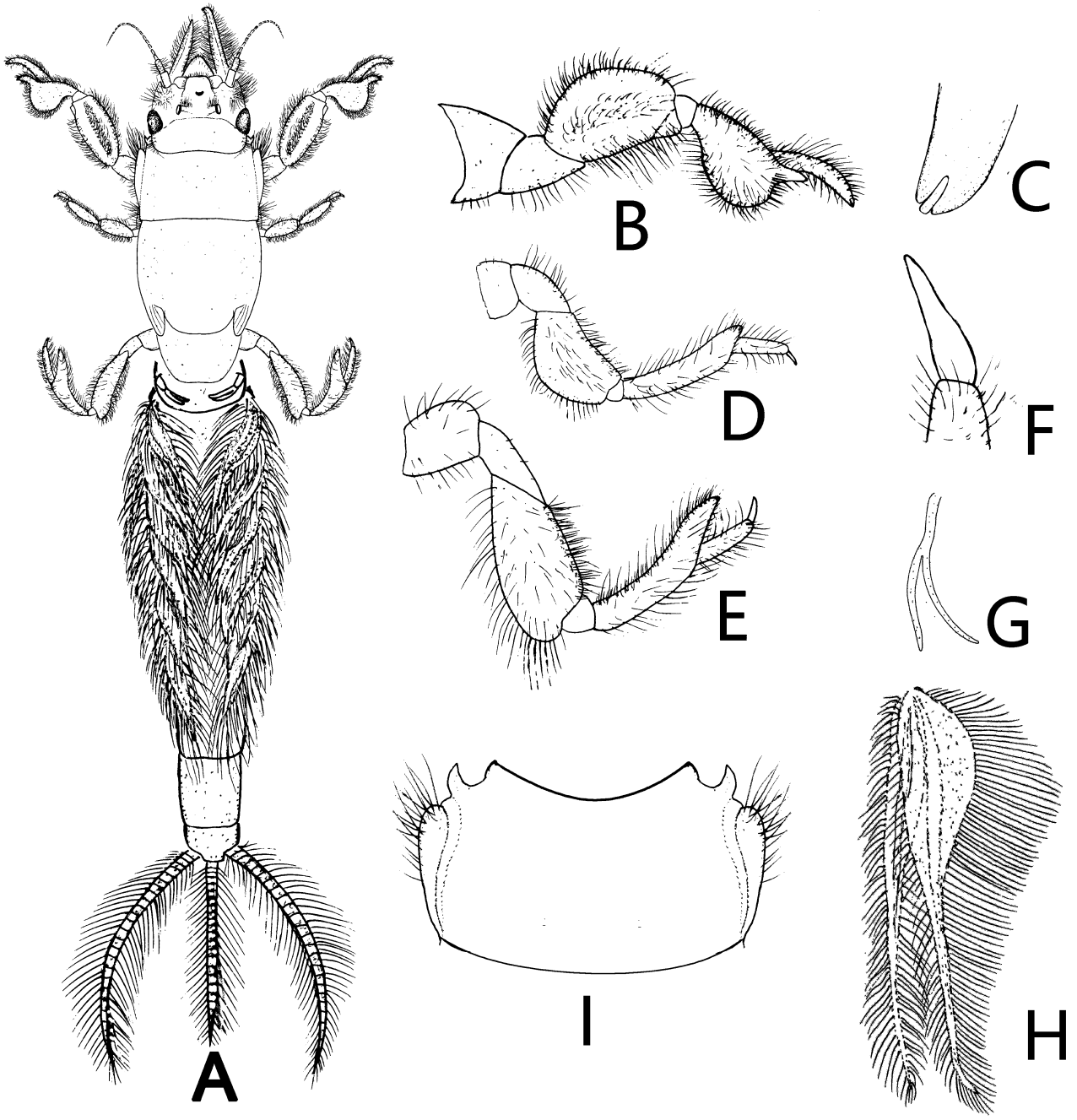

FIGURE 3. Nymphal structures of *E. zhangi* **sp. nov.**: A. Nymphal habitus in dorsal view; B. Foreleg; C. Foreclaw; D. Midleg; E. Hindleg; F. Hindclaw; G. Gill 1; H. Gill 5; I. Pronotum (dorsal view)

Thorax: totally pale to pale grey; pronotum slightly produced laterally, forming a lobe-like structure on anterolateral corners with additional hooked projection and cluster of golden setae, lateral margins with golden setae (Figs. 3A, 3I, 5A). Length ratio of femur, tibia and tarsus of foreleg 7: 5: 3.6, ratio of midleg 2: 2: 1, hindleg 9.2: 8: 3, midleg shorter than other legs; ventral margin of coxa and trochanter of foreleg with setae, those on trochanter longer and more abundant; forefemur rounded, dorsal surface with 3 longitudinal rows of setae (one median row and rows near margins); foretibia greatly expanded with curved, pointed apex and long setae on margins, sparse and short setae on surfaces (Figs. 3B, 5C); foretarsus with setae on dorsal surface, apex with cleft,

vestigial claw recessed in cleft (Figs. 3C, 5B); femur and tibia of midleg expanded slightly, tarsi without apical cleft but with slender claw, setal pattern similar to that of foreleg (Figs. 3D, 5D); all segments of hindleg longer than midleg, coxa with setae on margins and surface, trochanter with very sparse short setae, other segments with longer, and denser setae (Figs. 3E, 5E); apex of tibia expanded to form large curved projection, its length subequal to tarsus; claw similar to that of midleg but slightly longer and stronger (Fig. 3F).

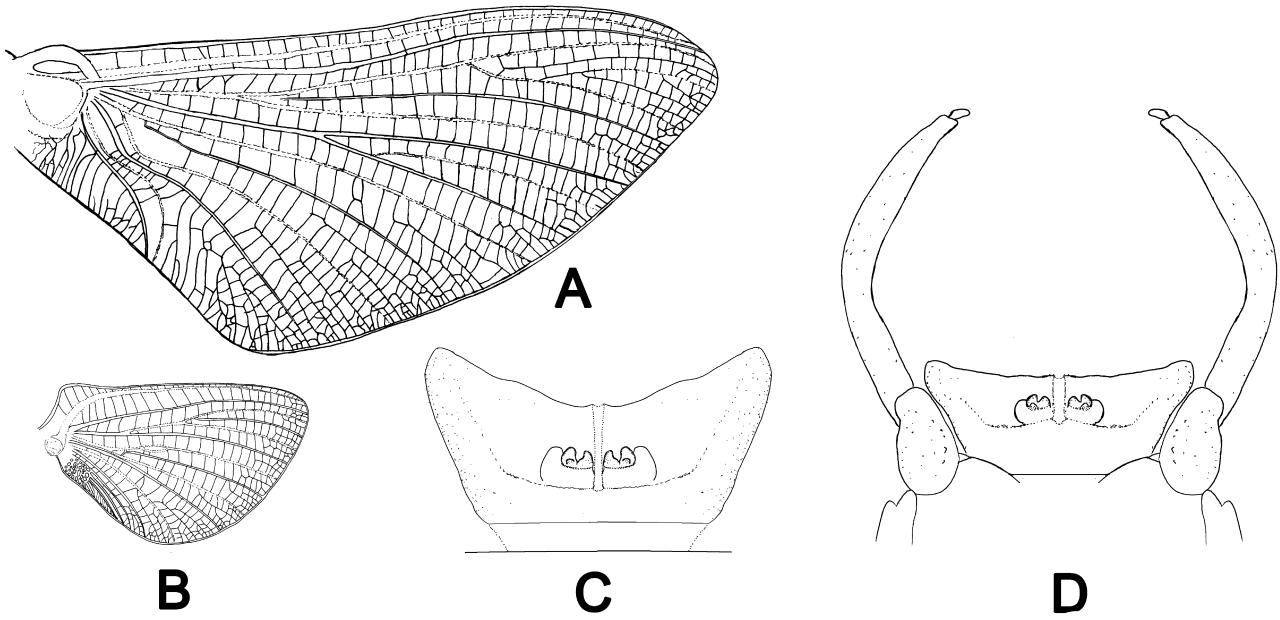

FIGURE 4. Imaginal structures of *E. zhangi* **sp. nov.**: A. Forewing; B. Hindwing; C. Penes; D. Genitalia.

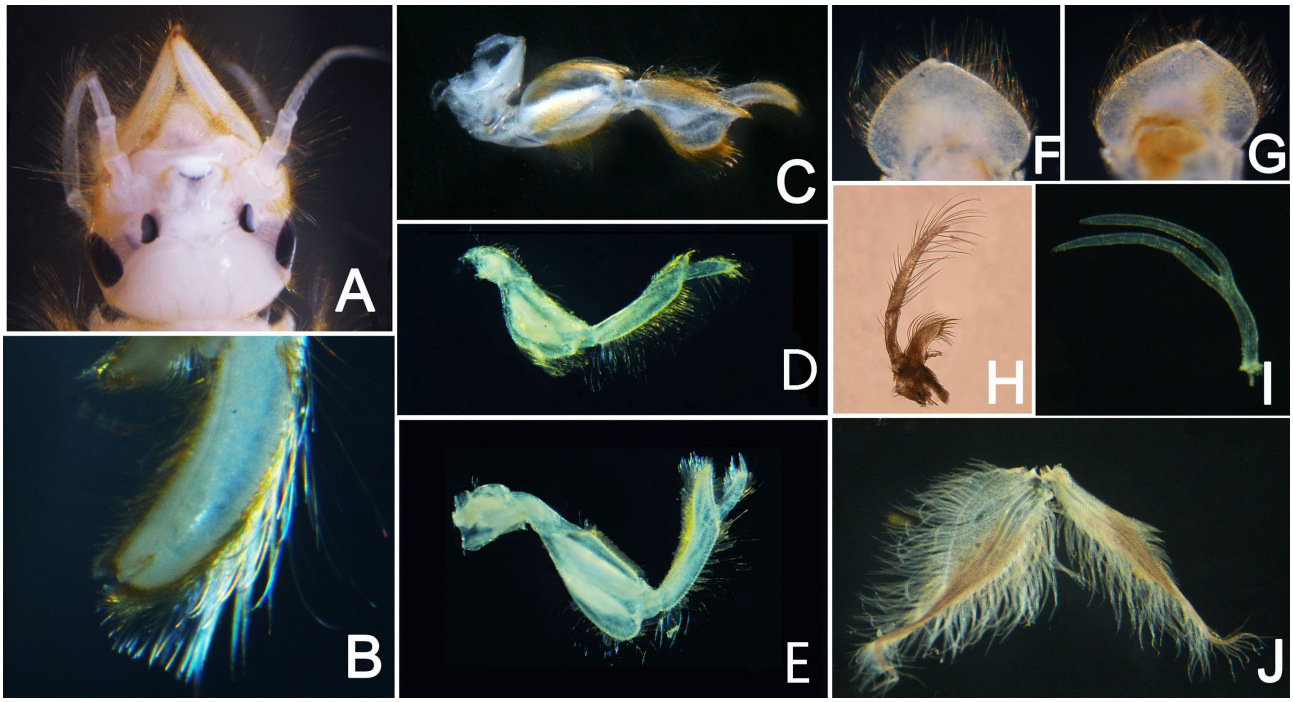

FIGURE 5. Nymphal structures of *E. zhangi* **sp. nov.** (digital photos): A. Head of nymph; B. Foreclaw; C. Foreleg; D. Midleg; E. Hindleg; F. Labrum (dorsal); G. Labrum (ventral); H. Maxilla; I. Gill 1; J. Gill 3

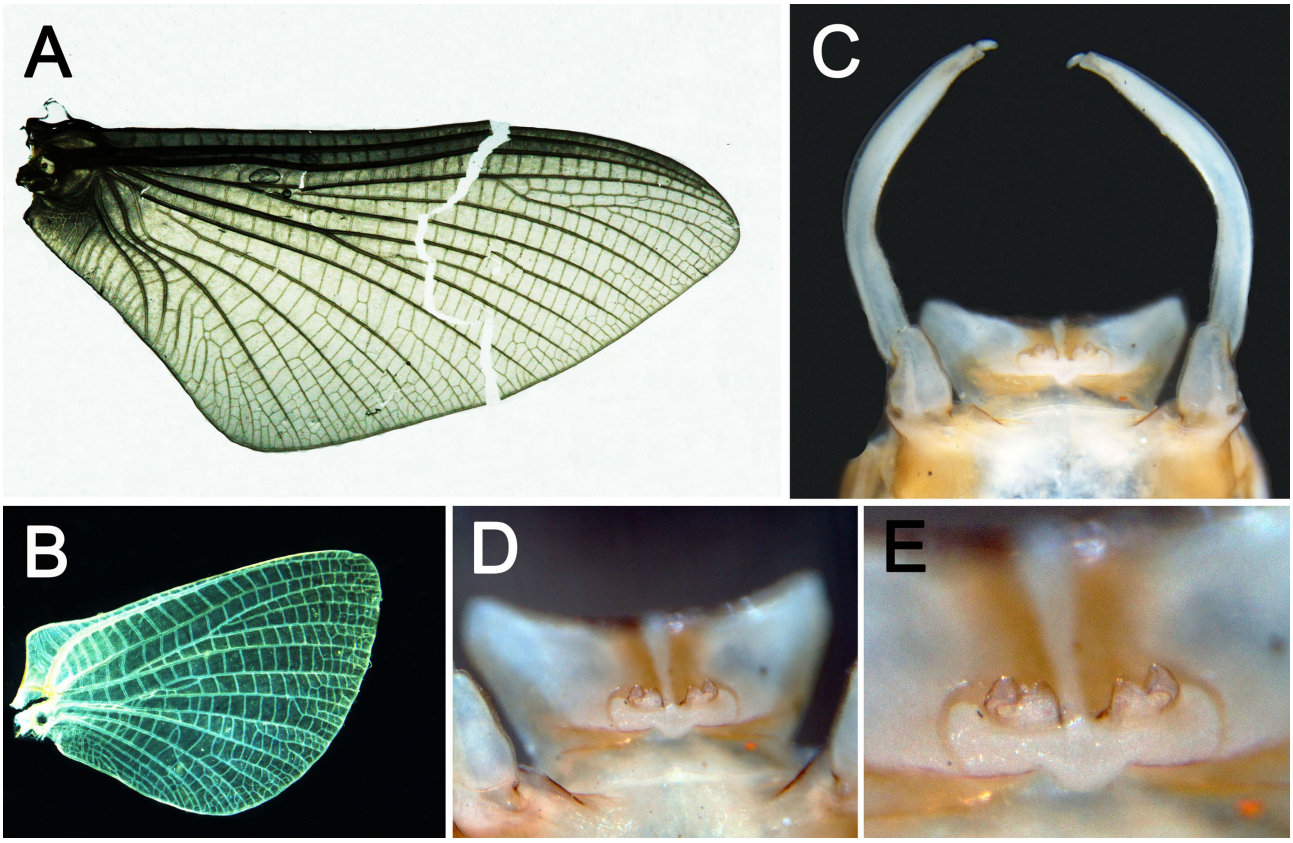

FIGURE 6. Imaginal structures of *E. zhangi* **sp. nov.** (digital photos): A. Forewing; B. Hindwing; C. Genitalia; D. Penes; E. Sclerotized projections of gonopores

Abdomen: ivory or pale, with golden hair on lateral margins of terga; gills I forked deeply to one third distance from base (Figs. 3G, 5I); gills II–VII similar in shape, each of them divided into two lamellae, dorsal lamella broader at base and ventral lamella slender and tapered (Figs. 3H, 5J); each lamella of gills further divided into large number of fringed filaments; main trachea of gills II–VII clear to pigmented grey to brown; gills VII smaller than anterior pairs; margins of 3 caudal filaments with dense setae, terminal filament shorter than cerci.

Male imago (in alcohol, additional characters to those provided by Zhang 1988): Body length 20.0–23.0 mm; forewings 14.0–15.0 mm (Figs. 4A, 6A), hindwings 6.0–7.0 mm (Figs. 4B, 6B); body general yellowish brown.

Genitalia (Figs. 4D, 6C): basal segment of forceps broader than distal segments, chestnut pigmented; second segment about 6× length of basal segment, curved with basal one-third light purplish red; apical segment very small, length slightly longer than broad. Apical two-thirds of fused penes slightly sclerotized and reddish brown. except for pale median groove; posterolateral corners of penes expanded apically forming trapezoidal shape (Figs. 4C, 6D); basal third of penes membranous; sclerotized projections of gonopores with 3 tips, ventral tip slightly smaller than two dorsal tips (Figs. 4C, 4D, 6E).

Eggs (Figs. 8A, 8B, dissected from female body): Length 0.2 mm, width 0.1 mm; oval, chorionic surface without distinct structure, surface made up of many polygons; small micropyle with long sperm guide visible on equatorial area.

Material examined and collecting information. Holotype: ♂, Wan-quan River, near Jia-ji Bridge, Qonghai County, Hainan Province, China, leg. Shu-Sheng SHE and Jun ZHANG, 23-V-1986; Paratypes: 3♂♂, 5♀♀, same as the holotype. Others: 10♀♀ subimagos, 22-V-1986; 10♀♀, 13-V-1986, other information same as types; 1 male subimago, 13-VII-2014, about 2 km downstream Jia-ji Bridge, 13-VII-2014, Jian-Hua DAI, Dan ZHOU and Jun-Zhi SUN; 16 larvae, Qionghai, Wan-quan River (110.465784°E, 19.226526°N), 4 km upstream of Jia-ji Bridge, 6-I-2015, Leg. Chang-Fa ZHOU, Jun-Zhi SUN and Yi-Ke HAN. All specimens are deposited in the Institute of Genetic Resources, College of Life Sciences, Nanjing Normal University, P. R. China.

The nymphs described here were collected from fine silt and sand substrates of Wan-quan River, Hainan Island, southern China. The river is wide, averaging at least 80 m in width, and more than 300 m at some sections

visited (Fig. 7). It has deep water current in all seasons. Other mayflies collected at the same habitat and time include *Ephemera* and *Caenis*. This is consistent with the information provided by McCafferty (1973, 1979).

FIGURE 7. Collecting site and habitat of *E. zhangi* **sp. nov.**

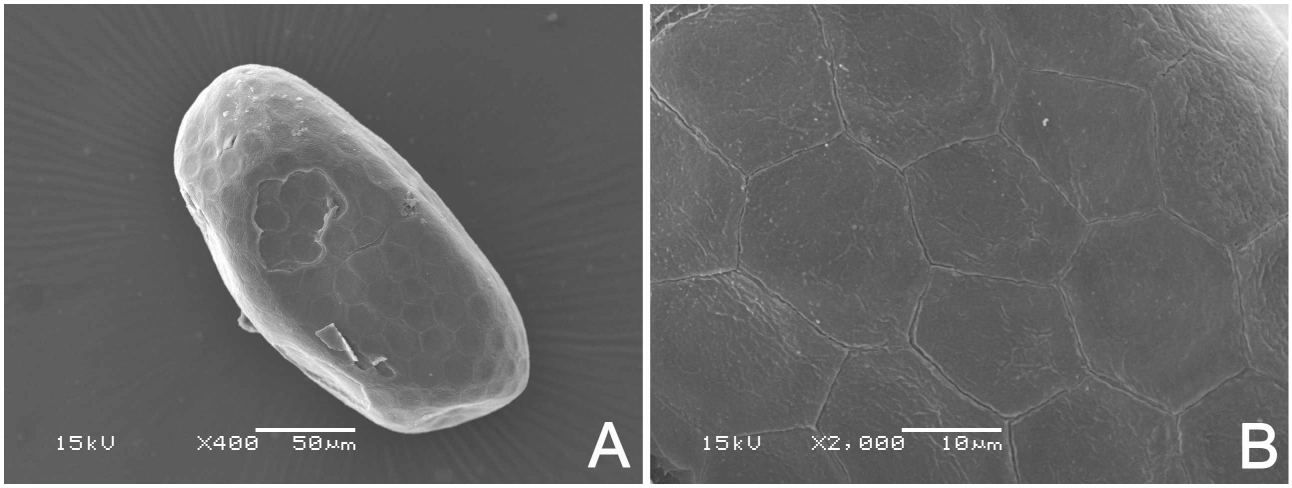

FIGURE 8. Egg of *E. zhangi* **sp. nov.** (SEM photo): A. shape and micropyle; B. Partial enlarged detail.

Discussion

Based on description and drawings of McCafferty (1973), the male of *Eatonigenia zhangi* **sp. nov.** is similar to *E. chaperi* in the shape of the penes (posterolateral corners of penes slightly projected, so posterior margin is shallowly concave instead of straight as in *E. seca*) and abdominal color pattern (a pair of pale oblique stripes on each tergum and sternum). However, *E. zhangi* **sp. nov.** can be differentiated from *E. chaperi* by the following characters: 1) generally, the body of *E. zhangi* **sp. nov.** is pigmented with pale chestnut to chestnut color but the body of the *E. chaperi* male is light pale to pale chestnut; 2) in fresh material, segment I and the basal part of segment II of forceps of *E. zhangi* **sp. nov.** are washed with reddish to reddish brown pigmentation; this character is not found in *E. chaperi*; 3) the forewings of *E. chaperi* have a cinnamon brown color but the wings of *E. zhangi* **sp. nov.** are totally clear and transparent; 4) the small sclerotized projections of the gonopores of *E. zhangi* **sp. nov.** have three tips while that of *E. chaperi* have only two of a different shape. Zhang (1988) pointed out the projections of *E. zhangi* **sp. nov.** were located more basally than those of *E. chaperi*, but this might have resulted from different angles of observation or illustration errors.

Compared to known nymphs of *E. chaperi* and *E. trirama*, *E. zhangi* **sp. nov.** resembles *E. trirama* because of the similar claw on foreleg (smaller than that of *E. chaperi*) and frontal process (larger than *E. chaperi*). However, the nymphs of *E. trirama* are smaller and darker than *E. chaperi*. Based on adult descriptions, *E. indica* and *E. seca* are also smaller. The nymph of *E. zhangi* **sp. nov.**, even not yet fully mature, is bigger than the nymph of *E. trirama*. Additionally, the nymph of the new species is paler and the labrum is asymetrical.

The details of mandibles, gills, projections on nymphal pronotum, setal pattern on legs, shape of mid- and hindclaws, projections of gonopores on penes of *E. zhangi* **sp. nov.** are for the first time described for the genus. The exact differences between known species need more associated species, examinations on types or specimens and review on the genus.

Finally, given its large size, we recognize that *E. zhangi* **sp. nov.** may be a synonym of *E. chinei* which is presently known only from a poorly illustrated nymph (Dang 1967). Given our current knowledge concerning *E. chinei*, the only clearly distinguishable character is the symmetrical labrum of this species. At present, however, it seems preferable to describe *E. zhangi* as a new species with detailed descriptions and illustrations of important characters in order to expand our limited knowledge of the genus.

McCafferty (1973, 1979, 2004) grouped six extant genera (*Ephemera* Linnaeus, 1758, *Afromera* Demoulin, 1955, *Hexagenia* Walsh, 1863, *Litobrancha* McCafferty, 1971, *Eatonigenia* Ulmer, 1939 and *Eatonica* Navás, 1913) into the family Ephemeridae. Kluge (2004) added the genus *Sinephemera*. Three genera (*Sinephemera*, *Ephemera* and *Eatonigenia*) are distributed in China. According to our observations on Chinese Ephemeridae, *Sinephemera* nymphs usually occupy the headwaters and creeks, while *Ephemera* inhabits streams to rivers, and *Eatonigenia* lives in large rivers. In North America and Africa, similar ecological types are represented by other genera of the family Ephemeridae.-

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