

***Burmagomphus asahinai* sp. nov., a new species from Cambodia and Thailand, with a description of the male of *B. gratiosus* Chao, 1954**

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Burmagomphus asahinai sp. nov. (holotype ♂: Cambodia, Cardamom Mts., Koh Kong Province, Thma Bang District, 6 km SW of its centre, rapids at the Thma Bang River, 25 August 2011, RMNH) is described from Koh Kong Province of Cambodia and Nakhon Nayok, Chiang Mai and Parhuap Khiri Khan Provinces of Thailand and is compared with its nearest congeners. While the mesepisternum pattern is closest to that of *B. gratiosus* Chao, 1954, the female head sculpture combines structures found separately in *B. gratiosus* and *B. williamsoni* Förster, 1914. A redescription of *B. gratiosus*, including the hitherto unknown male, is provided based on a pair from Guizhou Province, China.

Keywords: dragonfly; Odonata; Anisoptera; Gomphidae, *Burmagomphus asahinai* sp. nov.; *Burmagomphus gratiosus* Chao, 1954; new species; Thailand; Cambodia

Introduction

Burmagomphus Williamson, 1907 is a speciose genus of rather small and slender gomphids ranging widely in East and South East Asia and Sundaland. Until present it included 24 full species and four additional subspecies (Do, 2011; Tsuda, 2000). This does not include the enigmatic *Cyclogomphus? minusculus* Selys, 1878, described from a single female from Tennaserim, Myanmar, and later placed without justification in *Burmagomphus* (Davis & Tobin, 1985; Tsuda, 2000).

Asahina (1986) reported five species of *Burmagomphus* for Thailand (a tally later increased to seven; see Hämäläinen & Pinratana, 1999), but left one of them unnamed, as represented by one partly broken teneral male. Nevertheless, Asahina (1986, figures 12–14) provided drawings of its head and thoracic pattern and the appendages. In April 2010, OK collected in Cambodia four teneral females, in two of which the pattern was developed and nearly the same as that of the above-mentioned male but unlike other known species. These were briefly described (Kosterin,

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2010, pp 65–66 and figure 43, in which the female was erroneously labelled as male) but in the absence of males no new name was proposed. In December 2010 and August 2011, OK revisited the locality, the second time collecting a male of the same species. Meanwhile NM and PD collected the additional specimens in Wang Takhrui, Nakhon Nayok Province of Thailand in June 2011, thus enabling a comprehensive description of the new species.

Material and methods

Specimens of the new species were collected during examination of the Odonata fauna of the respective localities in Nakhon Nayok Province of Thailand and Koh Kong Province of Cambodia and examined in the laboratory using stereomicroscopes. The male from Chiang Dao, Chiang Mai Province of Thailand, was not examined and comparisons are made from the clear drawing in Asahina (1986, figures 12–14) and photographs of the specimen preserved in the National Science Museum, Tokyo (NSMT). Specimens were compared with a male and female of *Burmagomphus gratiosus* Chao, 1954 from Guizhou Province, China.

Illustrations of details of the Cambodian specimens were prepared from serial photographs obtained with a digital Canon PowerShot A640 camera and Zeiss Stemi 2000-C lens at the Institute of Molecular and Cellular Biology of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk. Images; broad focus zones were obtained from serial photos with shifted focus using the software Helicon Focus 5.1 (<http://www.photo-soft.ru/heliconfocus.html>).

Additional information was provided from photographs of living individuals of the new species from Pala-u waterfall, Kaeng Krachan National Park, Prachuap Khiri Khan Province, South-West Thailand taken by PD, Reinthong Ruangrong, Surachai Chanhong and Nathathai Thammasangwan and from the Tatai River, Koh Kong Province, Cambodia, taken by Gee Chartier.

Following Chao (1990), the two longitudinal pale stripes of the mesepisternum are for brevity called the antehumeral stripe (the inferior or more lateral one) and the dorsal stripe (the superior or more dorsal). In many species these stripes are fused into a single stripe, but there are species in which both stripes are complete and run in parallel throughout the mesepisternum length. The small antealear spot present in many species is in fact a remnant of the caudal part of the antehumeral stripe.

Burmagomphus asahinai sp. nov. (Figures 1–6)

Etymology

The species is dedicated to the memory of the late Dr Syoziro Asahina, in recognition of his enormous contribution to our knowledge of Asian Odonata and also the fact that he was the first to make a preliminary description of this species, while leaving it unnamed.

Specimens examined

Holotype ♂ (Figures 1a, 2–3): Cambodia, Cardamom Mts, Koh Kong Province [*Koh Kong khaet*], Thma Bang District [*Thma Bang srok*], 6 km SW of its centre [perhaps *Thma Bang sangkat* but the official name is unclear, Thma Bang village in common practice], rapids at the Thma Bang River, 11°39'40" N, 103°23'46" E, 337 m asl, 25 August 2011, 11:25 am, O. Kosterin leg. Deposited in

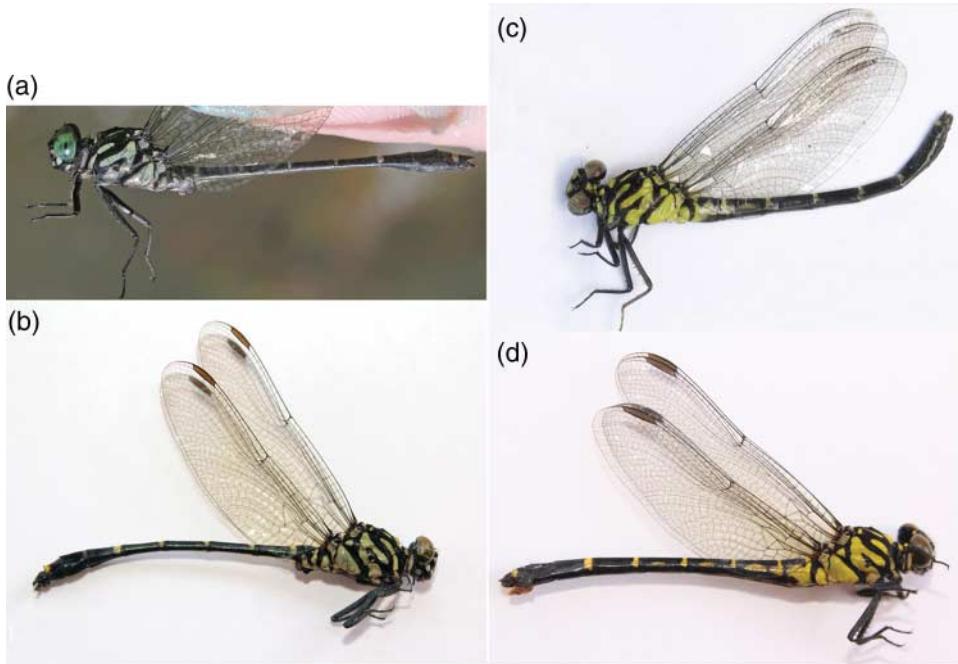


Figure 1. General habitus of *Burmagomphus asahinai* sp. nov. type specimens: (a) holotype, ♂, when captured, Cambodia, Cardamom Mts, Koh Kong Province, Thma Bang District, 6 km SW of its centre, rapids at the Thma Bang River, 25 August 2011, O. Kosterin leg.; (b) a paratype, ♂, Thailand, Wang Takhray, Nakhon Nayok Province, 18 June 2011, N. Makbun leg.; (c) a paratype, ♀, a wide and slow reach of the Thma Bang River, 15 April 2010, O. Kosterin leg.; (d) a paratype, ♀, Thailand, Wang Takhray, Nakhon Nayok Province, 18 June 2011, N. Makbun leg.

NCB Naturalis, Leiden (RMNH). In the holotype the abdomen is detached from the thorax and some wing veins are broken.

Paratypes: teneral ♂, N. Thailand, Chiang Mai Province, Chieng Dao, 5 May 1985, K. Matsuki leg., National Museum of Nature and Science, Tokyo (NSMT, repository number NSMT-I-Od-4001) (Figure 4), see also Asahina (1986, pp. 31–32, figures 12–14).

- 2 ♂♂, Thailand, Wang Takhray, Nakhon Nayok Province, 11 June 2011, P. Dawwrueng et N. Makbun leg., in collections of PD and NM.
- 4 ♂♂ (Figure 5), 1 ♀, Thailand, Wang Takhray, Nakhon Nayok Province, 18 June 2011, N. Makbun leg., in collection of NM.
- 3 teneral ♀♀, a wide and slow reach of the Thma Bang River, 11°39'31" N, 103°24'14" E, 366 m asl [800 m ESE of the locality of the holotype], 15 April 2010, O. Kosterin leg. Two preserved immediately in alcohol (Figure 6b, e–i) and kept at Institute of Cytology & Genetics of Siberian Branch of Russian Academy of Sciences (Novosibirsk). One left to harden for a day and night before death, preserved dry (Figure 6a, c–d), deposited at RMNH.

Diagnosis

The new species may be easily separated from its congeners by the unique pattern of the mesepisternum, with the inferior antehumeral stripe short and widely separated from the short, narrower dorsal stripe; the inferior antehumeral stripe is contiguous with a pale stripe crossing mesinfraepisternum and reaching the mesocoxa. In males the epiproct has long, narrow, divergent lateral arms. Females possesses a unique combination of sculptural characters on the head: a pair of robust

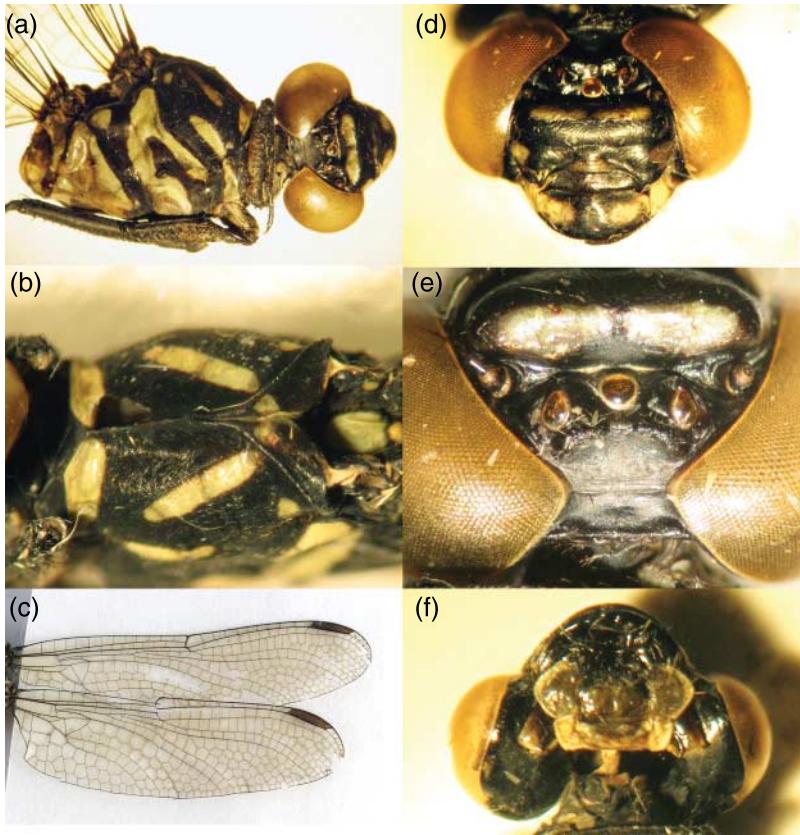


Figure 2. Details of the head and thorax of the holotype of *Burmagomphus asahinai* sp. nov, ♂: (a) head and thorax, right side in lateral view; (b) thorax from oblique dorsal view; (c) right wings; (d) face, frontal view; (e), top of the head, dorsal view; (f) head, ventral view.

spines above the lateral ocelli, a large conical yellow central prominence at the occipital plain and a pair of short black erected protuberances composed of three spines each at the sides of the occipital ridge.

Description of the holotype, male

In general appearance a typical *Burmagomphus*, bicoloured, black with a dull pale greenish yellow pattern, (Figure 1a).

Head. Eyes green while alive (Figure 1a). Face black with pale pattern (Figure 2d, e). Occiput simple, with a raised straight hind margin fringed with hairs and a pair of very slight knobs at its sides, near eyes (Figure 2e). Lateral ocelli on sides of a divided prominence wrapped around central ocellus; in frontal view forming two blunt tubercles behind lateral ocelli with a slight, even incision between them; in dorsal view outlined behind by a distinct concave ridge, its margins ending behind lateral ocelli (Figure 2e). Seam between vertex and frons with a narrow pale streak between antennal bases; antennal segments 1 and 2 black with pale apices (Figure 2e). Frons with a broad pale stripe interrupted at middle. Postclypeus with a central pale patch, with two slight pointed protuberances at its anterior margin, and a pair of roundish spots on either side. Labrum with a pair of large, lateral, oval-shaped pale spots occupying about half of its area (Figure 2d).

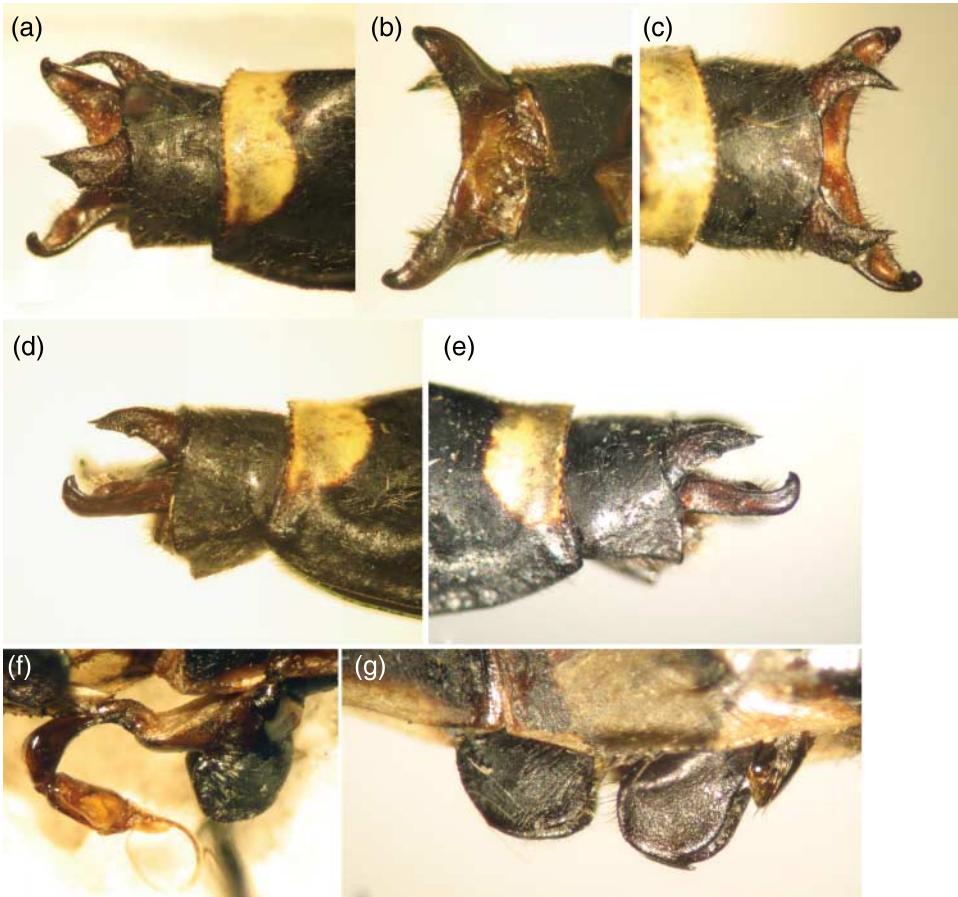


Figure 3. Details of the abdominal structures of the holotype of *Burmagomphus asahinai* sp. nov. ♂: (a) S10 and appendages, oblique dorsal view; (b) the same, ventral view; (c) the same, dorsal view; (d) the same, right lateral view; (e) the same, left lateral view; (f) vesica seminalis with the penile organ extended; (g) accessory genitalia, general lateral view.

Mandible bases entirely pale. Labium unevenly greyish, shortly but gradually darkened at distal margins of palpal lobes and prementum, movable hooks brownish black (Figure 2f).

Thorax. Generally black with a pale pattern (Figures 1a, 2a, b). Prothorax with two pale spots on either side medially, a large upper one and a small one in anterolateral corner, anterior lobe pale; posterior lobe black, hairy.

Synthorax: antealar sinus with twin pale spots against apices of dorsal pale stripes of mesepisternum; triangle inside it pale. Mesepisternum with the following pale pattern: broad stripe, interrupted at middle, along anterior margin; small rounded spot in upper posterior corner near forewing base; two separate, straight, longitudinal stripes: narrower, superior, dorsal stripe and broader, inferior, antehumeral stripe, rounded posteriorly. Antehumeral stripe continued on mesinfraepisternum, there slightly curved and continuing to pale patch on mesocoxa. Mesepimeron and metepisternum pale with black markings; broad black band along anterior margin of mesepimeron fused below to black on metacoxa and to incomplete black band extending upwards along lateral suture between mesepimeron and metepisternum, expanded to form shark-tail shape with lower lobe enclosing spiracle; dorsally a slanting black band from forewing base to middle of metapleural suture, leaving dorsoproximal corner of metepisternum pale. Metepimeron pale with

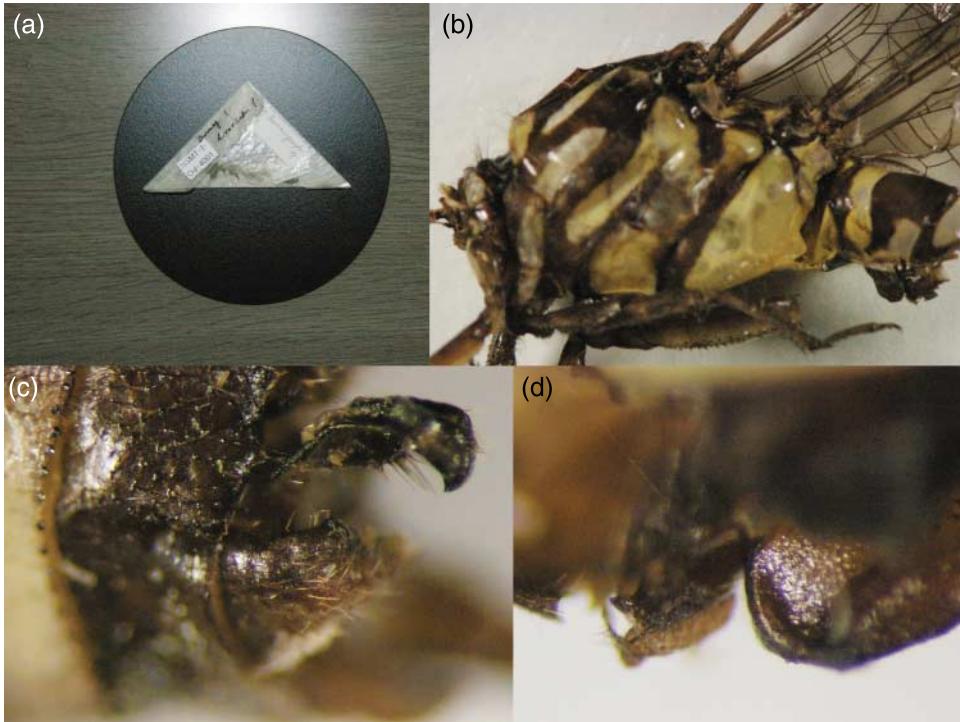


Figure 4. Paratype of *Burmagomphus asahinai* sp. nov, teneral ♂, N. Thailand, Chiang Mai Province, Chieng Dao, 5 May 1985, K. Matsuki leg., preserved in the National Museum of Nature and Science, Tokyo (NSMT, depository number NSMT-I-Od-4001): (a) the envelope and labels; (b) thorax, side view; (c) appendages (deformed), side view; (d) accessory genitalia (deformed) (Photo by T. Kiyoshi).

a black band along metapleural suture. Metinfraepisternum pale (but asymmetrically darkened post mortem). Subalar ridges marked with black lines; subalar and pleural wing processes pale. Poststernum darkened (contrasting with pale metepimera bases), but its caudal plate pale.

Legs black but ventral side of profemur pale; proximal joints of all trochanters pale, coxae with pale stripes on their hind parts.

Wings (Figure 2c) hyaline, very slightly tinted brownish, venation black. Forewings: 12 antenodals above and below Sc; 9 (left wing) and 8 (right wing) postnodals above R_1 , 10 postnodals below R_1 . Hind wing: 8 (left) and 9 (right) antenodals above Sc, 9 (left) and 8 (right) antenodals below Sc; 9 (left) and 8 (right) postnodals above R_1 , 10 below R_1 . Triangles not crossed. Two crossveins between Arc and R_1 – R_4 junction both above and below Rs on forewing, one on hind wing. Anal loop one-celled. Anal triangle 3-celled. Tornus obtuse-angulate; anal margin slightly sinuous; membranula very narrow, grey. Pterostigma brown, with black bordering veins (length-wise ones here swollen), below covering 3.5 (right) and 4.5 (left) cells on forewings and 4 cells on hind wings.

Abdomen. Black with pale marking as follows (Figure 1a): lower part of S1 pale, S2 with two oval pale spots in its lower part, proximal one including auricles; S3–7 with pale semi-rings around anterior margin, that on S7 largest; S9 with large pale spot at distal margin, without anterior point (Figure 3a, c–f). Very fine pale dorsal streak along S3–7 and in proximal half of S8.

Ventral side of S10 deformed in holotype (Figure 3b), epiproct somewhat asymmetrical, left branch 1.12 times longer than right, and skewed. Concavity between its branches very evenly rounded (Figure 3b, c). Branches 1.85 times longer than their width at base in ventral view

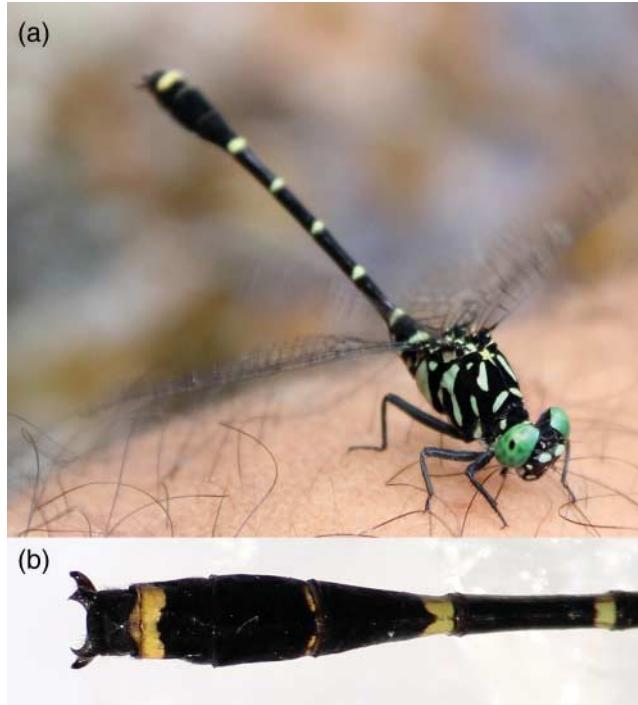


Figure 5. Paratypes of *Burmagomphus asahinai* sp. nov. ♂♂, Thailand, Wang Takhrai, Nakhon Nayok Province, 18 June 2011, N. Makbun leg. (a) a male with the dorsal pale stripe broadened ventrally and the antehumeral stripe narrowed towards the border of the mesinfraepisternum, general view; (b) a male with lateral pale streaks at the S8 proximal margin, the abdomen tip, dorsal view.

(Figure 3b); in lateral view with straight lower margin; upper margin of left branch slightly inflated at base, that of right branch more strongly inflated in basal 2/3; tips hooked to vertical position in lateral view; left branch 1.28 times and right branch 1.10 times longer than cercus (Figure 3d–e). In dorsal view, each cercus with evenly concave inner margin, outer margin made of two straight sections forming blunt angle at about middle, with very small subapical ledge (Figure 3c). In lateral view, cercus with convex upper margin and concave lower margin with a pointed knob just behind middle and narrow apical spine (Figure 3d–e).

Accessory genitalia black (Figure 3g). Anterior hamulus small, pointed, its ventroproximal margin and apex bearing long hairs forming a narrow bunch adpressed to vesica seminalis head and slightly curving around it. Posterior hamulus evenly broad, rounded, its width comprising 0.75 of its length along anterior margin, with apical spine directed forward and down at small angle to hamulus surface; outer surfaces slightly concave because of raised ridges at posterior margin, which bear several hairs of moderate length decreasing in ventral direction, not forming any conspicuous fringe; inner hamule surface set with hairs. Vesica seminalis about same size as posterior hamulus as seen in natural position in side view, but somewhat lower, roundish but 1.5 times longer than high, cleft occupying 0.78 of its length. Penile organ (Figure 3f) of the structure typical for the genus (Do, 2011).

Measurements (mm). Hind wing 22.5, abdomen without appendages 27.2, body (with head and appendages) 40.1.

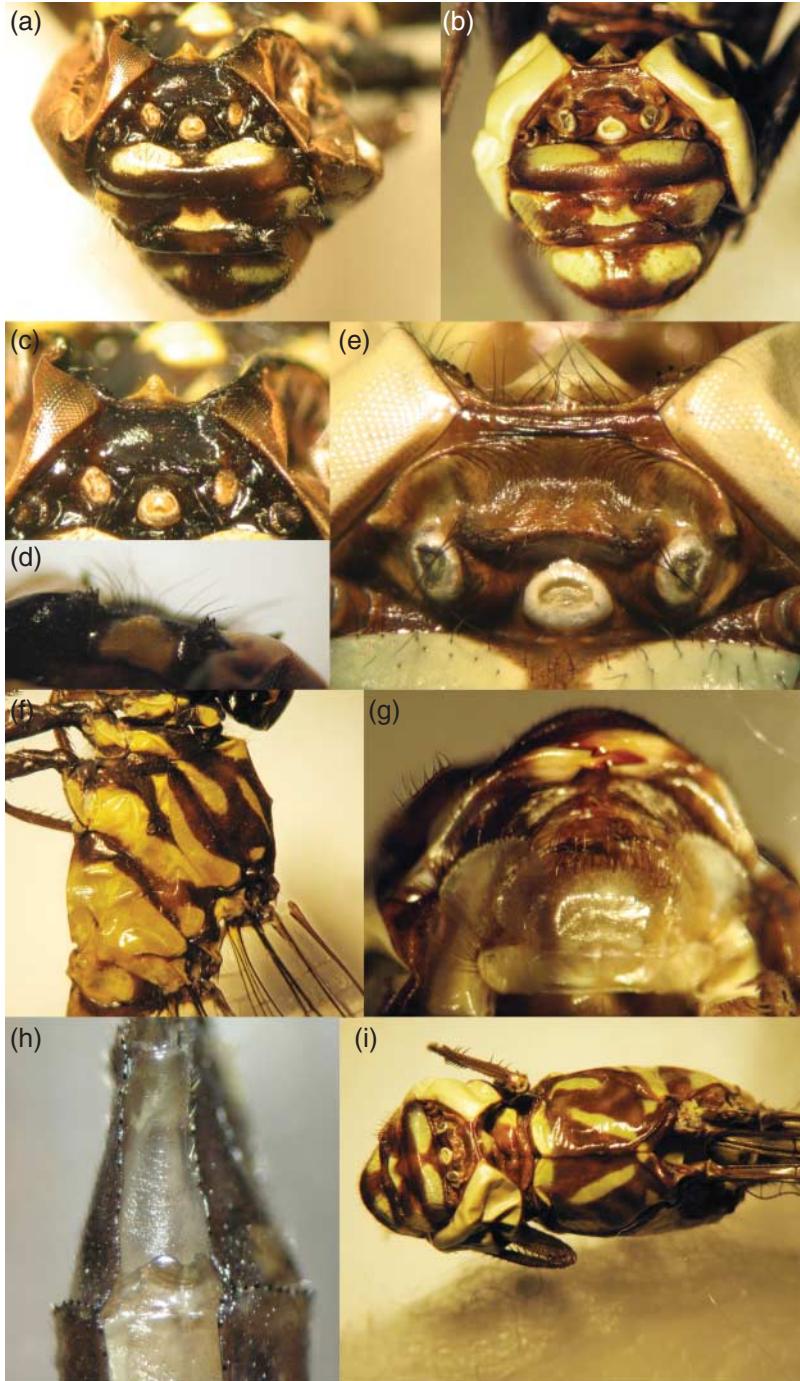


Figure 6. Details of ♀♀ paratypes *Burmagomphus asahinai* sp. nov, a wide and slow reach of the Thma Bang River, 15 April 2010, O. Kosterin leg.: (a, c–d) a paratype collected as terenal, left to harden for day and night and preserved dry, to be deposited at RMNH; (b, e–i) a paratype collected teneral and fixed in alcohol, to be kept at Institute of Cytology & Genetics of Siberian Branch of Russian Academy of Sciences (Novosibirsk); (a) head, dorsofrontal view; (b) head, frontal view; (c, e) top of the head, frontal view; (d) top of the head, oblique dorsocaudal view; (f) thorax, left lateral view; (g) labium; (h) vulvar lamina; (i) head and thorax, dorsal view.

Variation in male paratypes

The paratype males (from Thailand) are somewhat larger than the holotype, the abdomen length varies from 32.3 to 33.3 mm, the hind wing length from 24 to 25 mm.

The male from Chiang Dao has the broad yellow band across the frons not completely interrupted at the middle (Asahina, 1986, figure 12). One of the Thai paratypes has a modified pale pattern on the mesepisternum: the dorsal pale stripe is broadened ventrally while the antehumeral stripe is narrowed towards its short interruption at the border of the inframesepisternum (Figure 5a).

Three of six paratypes from Nakhon Nayok have a pair of additional very narrow lateral pale streaks at proximal margin of S8 (Figure 5b). In two of those paratypes from Nakhon Nayok, the outer margin of tergite 10 is pointed at the middle (Figure 5b), as in *Burmagomphus divaricatus* Lieftinck, 1964, but not so in five of them (one male lacks S9–10 and appendages) and the male from Chiang Dao (as well as in the holotype).

The holotype was collected fully mature and was not deformed while netted, so the slight asymmetry of the epiproct in the holotype seems to be an anomaly. Curiously, the drawing of the Chiang Dao specimen (Asahina, 1986, figure 13) shows a similarly asymmetrical epiproct, but here its right branch is longer. In this specimen, the epiproct branches in lateral view are not longer than the cerci (Asahina, 1986, figures 13–14). The Nakhon Nayok paratypes have the epiproct symmetrical, its branches varying from being not longer to slightly longer than the cerci.

Female

Resembles male (Figure 1c, d), slightly larger, black with pale pattern saturated yellow rather than dull olive green.

Head. Pattern as in male, except occiput, but sculpture more elaborate. Prominence at vertex less developed, forming slightly divided ridge between lateral ocelli; robust straight spine posterolateral to each lateral ocellus, in height nearly equalling ocellus major diameter (Figure 6a–c, e, i). Occipital area bordered anteriorly with raised and very slightly bisinuous black ridge, beside which, just behind inner corners of eyes, is a pair of short black erect protuberances composed of three spines each (Figure 6c–e), better seen in frontal (Figure 6e) or caudal (Figure 6f) view. From occipital area, large yellow triangular central prominence emerges (Figure 6c, e). Labium as in male (Figure 6g).

Thorax. As in male, with somewhat broader pale pattern elements (Figure 6f, i). Poststernum pale. Legs as in male.

Wings hyaline, slight yellow tint present between Cu and A at very bases of both wings. Antenodals: 13–14 above Sc, 11–13 below Sc on forewing, 9–10 above and below Sc on hind wing; postnodals: 9 above R₁, 11–12 below R₁ on forewing, 8 above R₁, 11 below R₁ on hind wing. Two antefurcal crossveins, as in male. Pterostigma light brownish, covering 4.5 cells below in all wings.

Abdomen. Pale pattern (Figure 1c–d) more extensive than in male. S1 mostly pale with broad black distal ring; S2 more pale than black, with broad proximal pale ring fused to very large lateral pale spots; S3–7 with quite broad proximal pale half rings, on S3 broadening distally into pair of oval spots, on S4–5 slightly dilated at their ends at middle of tergite height, on S7 evenly broad; also with elongate lateral pale spots on S3–5; S9 with dorsal pale patch at distal margin, without anterior point; ventral tergite margins outlined with narrowest yellow streaks, no dorsal yellow streaks; cerci black. Vulvar lamina small and very simple (Figure 6i) as is typical for the genus.

Measurements (mm). In the two fully hardened females available, abdomen 30 and 31.5, hind wing 24.3 and 25.

Habitat and behaviour

In Cambodia, *B. asahinai* sp. nov. was found on the medium-sized Thma Bang River flowing through gentle sandstone hills on the southern slope of the Cardamom Mountains, clad throughout with primary lowland tropical forest. The only male, the holotype, was found in late August 2011 perching on the flat surface of a large sandstone boulder in a rapid (a photograph of the site is found in Kosterin, 2011, figure 39). When it was collected, the same boulder was occupied by a male of *B. divaricatus*, and another male of the latter was observed nearby. Four teneral females of *B. asahinai* sp. nov. were found, just c.800 m upstream from the previous locality, in late April 2010, at the very hot end of the dry season. They were disturbed from large sandstone boulders on the bank of a broad and very slow reach of the river (photograph in Kosterin, 2010, figure 26).

Gee Chartier took identifiable photos of a mature male and teneral female of *B. asahinai* sp. nov. on the bank of the Right Tatai River at a broad, slow reach, 11°35'56" N, 103°07'22" E, 59 m asl, that is 35 km SWW from the type locality. The photos were dated 26 March and 2 April 2012, respectively, that is about a month earlier than the emergence observed at the Thma Bang River in 2010.

In Thailand *B. asahinai* sp. nov. occurred on the 10–15 m wide and fast-running Wang Takrai stream with a sandy bottom. The species was observed in both open and partly shaded undisturbed areas of the stream where it perched on tree trunks, sands, stones and plant leaves near the ground. On 18 June 2011, one female was observed to oviposit on an open area of the stream. It laid pale pink eggs on roots near the stream, then flew to perch on leaves of trees. It continued ovipositing and resting on the leaf many times.

Recently PD, together with Reinthong Ruangrong, Surachai Chanhong and Nathathai Thammangwan, found and photographed *B. asahinai* sp. nov. from Pala-u waterfall, Kaeng Krachan National Park, Prachuap Khiri Khan Province, South-West Thailand, on 7 May 2012. The habitat was the same as those of Wang Takrai.

Perhaps breeding in larger rivers, which suffer the most from human activity, is the reason why this seemingly widespread species is so localised in Thailand. The imagines seem to emerge from late March to late April and fly until late August.

Distribution

Northern (Chiang Mai Province), Central (Nakhon Nayok Province) and South-West (Pachuap Khiri Khan) Thailand, SW Cambodia (Koh Kong Province). Apparently a localised but moderately widespread species.

Remarks

B. asahinai sp. nov. is readily recognised by its mesepisternum pattern, with the antehumeral and dorsal stripes short and widely separated, the former continuing to the mesocoxa. The mesepisternum pattern was used by Fraser in his first attempt to subdivide the genus: “The thoracic markings denote the cleavage into two groups, which is further supported by the characters of the genitalia” (Fraser, 1926, p. 408). He isolated the *vermicularis* group as “especially characterised by the fusion of the upper part of the antehumeral thoracic stripe with the lower end of the humeral, so as to form a single vermiform stripe, or one with a bayonet twist at middle” (Fraser, 1926, p. 408) (note the difference in stripe naming, with the meaning of “humeral” not corresponding to present

use), and the *laidlawi* group uniting “all those species in which the antehumeral and humeral stripes are not combined to form an oblique sinuous stripe” (Fraser, 1926, p. 412). In fact, the second group just included the rest of the species: “In the second group, the thoracic markings are by no means so uniform and vary widely in the species; the hamules ... differing more widely than is found to be the case in that [the first] group” (Fraser, 1926, p. 408). Chao (1990) started his key of *Burmagomphus* from the mesepisternum pattern as well. This is a conspicuous character and it would be convenient, based on this pattern as inferred from Needham (1930), Fraser (1926, 1934), Lieftinck (1940, 1964), Chao (1990), Yang and Li (1994) and Do (2011), to subdivide the genus into four phenotypic groups, although not pretending that these are necessarily monophyletic.

Group 1. A single stripe on the mesepimeron, which may or may not have some ledge to make it bayonet-shaped, resulting from fusion of the antehumeral and dorsal stripes: *B. arboreus* Lieftinck, 1940; *B. arthuri* Lieftinck, 1953; *B. divaricatus* Lieftinck, 1964; *B. hasimaricus* Fraser, 1926; *B. insolitus* Asahina, 1986; *B. inscriptus* (Hagen in Selys, 1878) (= *B. jacobsoni* Ris, 1911); *B. insularis* Laidlaw, 1914; *B. johnseni* Lieftinck, 1966; *B. p. pyramidalis* Laidlaw, 1922; *B. plagiatus* Lieftinck, 1964; *B. schneideri* Do, 2011; *B. vermicularis* (Martin, 1904); and *B. williamsoni* Förster, 1914 (= *B. seimundi* Laidlaw, 1931; = *B. siamensis* Fraser, 1926). All these are southern species ranging in India, Ceylon, Sundaland and the Indochinese region, with only two species reaching Southern China: *B. arboreus* (Yunnan) and *B. vermicularis* (Fujian, Taiwan) (Chao, 1990).

Group 2. The antehumeral and dorsal stripes are short and separated. They may approach very close to each other, as in *B. graciosus* Chao, 1954 (Fujian) and *B. pyramidalis sinuatus* Fraser, 1933 (Ceylon; in this taxon, the stripes may be fused as in the nominotypical *B. p. pyramidalis*, see Lieftinck, 1940); or to be widely separated as in *B. laidlawi* Fraser, 1924; *B. cauvericus* Fraser, 1926 (both from the Western Ghats of India); *B. bashanensis* Yang et Li, 1994 (Sichuan); and *B. asahinai* sp. nov. (Thailand and Cambodia).

Group 3. The antehumeral stripe extends throughout the mesepisternum length, while the dorsal stripe is distinctly separated from it: *B. arvalis* (Needham, 1930); *B. collaris* (Needham, 1929) (= *B. campestris* (Needham, 1930)); *B. intinctus* (Needham, 1930); *B. sowerbyi* (Needham, 1930), all from China; and *B. sivalikensis* Laidlaw, 1922 from West Bengal and Uttaranchal in India.

Group 4. Both stripes are long but fuse at their lower ends to form a V-like pattern, the only species *B. v-flavum* Fraser, 1926, known just by two females from North Shan, Burma, and not so confidently placed in *Burmagomphus* (Fraser, 1926, 1934).

B. asahinai sp. nov. belongs to group 2 and shares with *B. graciosus* and *B. pyramidalis sinuatus* rather a narrow dorsal stripe and the antehumeral stripe broad and continuing to the mesocoxa. In *B. bashanensis*, *B. laidlawi* and *B. cauvericus* the situation is the opposite: the dorsal stripe is very broad while the antehumeral stripe is short and narrow, almost vestigial and far from reaching the mesinfraepisternum and mesocoxa (Fraser, 1926; Yang & Li, 1994). From the three last-mentioned species, *B. asahinai* sp. nov. differs substantially also in the hamuli shape. In *B. cauvericus* and *B. laidlawi*, which are close to each other and occur in the same area, the anteroventrally directed spine on the posterior hamulus is very large and there is an additional ventrally directed apical spine caudad of it (Fraser, 1926). In *B. bashanensis*, the posterior hamulus has three additional spines on its posterior margin; besides the epiproct is very different, with short and very thick arms (Yang & Li, 1994). Females are known for *B. cauvericus* and *B. laidlawi*, and it is noteworthy that both have spines above the lateral ocelli, as in *B. asahinai* sp. nov. However, the occiput is “simple, nearly straight” in *B. laidlawi* (Fraser, 1933, p. 222) and “notched in the middle and rounded on either side of the notch” in *B. cauvericus* (Fraser, 1934, p. 223). *B. pyramidalis sinuatus* (= *B. sinatus*) has a variable thoracic pattern so that some individuals formally fell to group 2 as having the antehumeral and dorsal stripes narrowly separated (Lieftinck, 1940). In this species males have hamuli of the same type as *B. asahinai* sp. nov. but a smaller vesica seminalis, while females possess neither the supra-ocellar spines nor occipital prominences (Fraser, 1926, 1934).

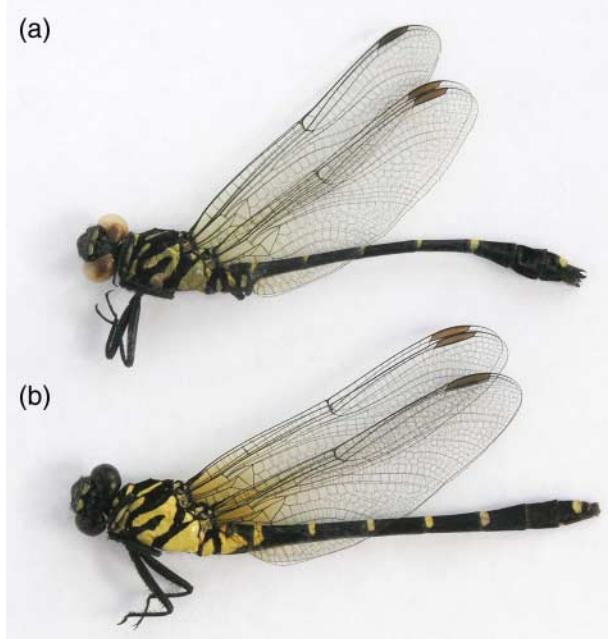


Figure 7. General habitus of *Burmagomphus gratiosus* Chao, 1954, China, Guizhou Province, Libo County, the Zhangjiang River, 10 July 2010, Zhang Haomiao leg.: (a) ♂; (b) ♀.

In the mesepisternum pattern, *B. asahinai* sp. nov. resembles *B. gratiosus* but in the latter the antehumeral and dorsal stripes are set much closer to each other (Figures 7, 8c, 9c–d; Chao, 1990, figure 5; Zhang, 2011, figure 42). In addition, these two species both have a pair of strong spines behind the lateral ocelli in females (Chao, 1954, 1990), shared also by *B. cauvericus* and *B. laidlawi*. *B. asahinai* sp. nov. may be differentiated from *B. gratiosus* by its *c.*12% smaller size, the presence of pale spots on the labrum and postclypeus in both sexes, of antealar spots on the mesepisternum and faint yellow streaks along the dorsal carinae of the abdominal segments in males and lateral pale spots on S3–5 in females, the posterior hamulus broad at base, the vesica seminalis more quadrangular than triangular, much shorter and broader branches of the epiproct and the very different occipital sculpture in females, with a large yellow central prominence and a pair of black tridentate protuberances at the eyes. *B. gratiosus* was described, in Chinese, from a single female from Mt. Baotaishan, Jiangle County, Fujian Province of China (Chao, 1954) with the following diagnosis (as reproduced in English by Zhang, 2011): “1) the labrum entirely black; 2) postclypeus without yellow spots; 3) dorsal stripes disconnected from lower antehumeral stripe; 4) superior spot absent; 5) S8 entirely black; 6) distal S10 with very fine yellow stripes”. Note that the female examined has a pair of tiny antealar dots. The male of *B. gratiosus* has never been described, although its photo was published by H. Zhang (2011, figure 42), so its description is provided below.

At the same time, details of the occipital sculpture in females of *B. asahinai* sp. nov. appear strikingly similar to those of *B. williamsoni* Förster, 1914 (see Lieftinck, 1964, figure 21–23): the large yellow triangular prominence above the occiput is identical; the black tridentate protuberances behind the inner corners of the eyes and the sides of the occipital ridge are similar (the extent of their development was shown to vary in the latter species, see Lieftinck, 1964). These features of the occiput were not recorded in any other *Burmagomphus* species with known females, obviously indicating a close relatedness of *B. asahinai* sp. nov. and *B. williamsoni*, in spite of the different mesepisternal pattern. The studied female of *B. williamsoni* shows a minor difference from

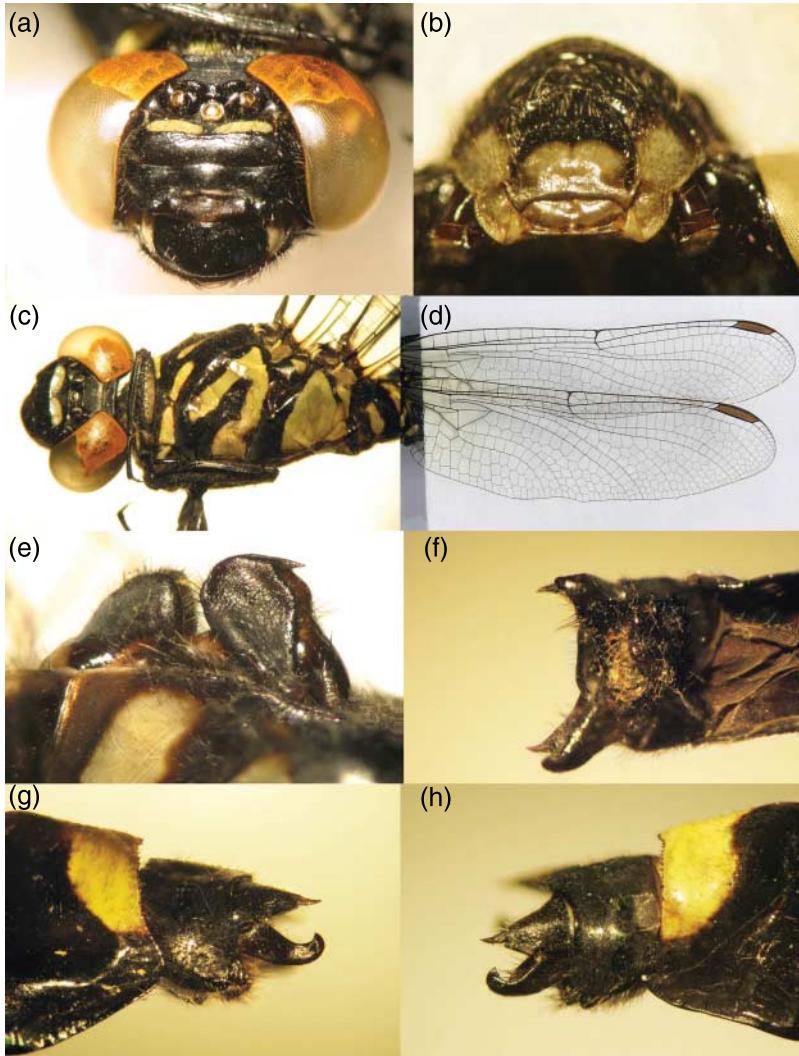


Figure 8. Details of ♂ *Burmagomphus gratiosus* Chao, 1954, China, Guizhou Province, Libo County, the Zhangjiang River, 10 July 2010, Zhang Haomiao; (a) head, frontal view; (b) labium; (c) head and thorax, oblique lateral view; (d) right wings; (e) accessory genitalia, left lateral view; (f) S10 and appendages, ventral view; (g) the same, left lateral view; (h) the same, right dorsolateral view.

B. asahinai sp. nov. in the occipital structure: the anterior margin is not raised and is very straight. On the other hand, females of *B. williamsoni* lack spines behind the lateral ocelli, which are present in *B. laidlawi*, *B. cauvericus* and *B. gratiosus*.

Apart from the distinctly different thoracic pattern in *B. williamsoni*, where the antehumeral and dorsal stripes fuse completely into a single, slightly kinked stripe, *B. williamsoni* exhibits other differences from *B. asahinai* sp. nov. In the male, the prementum has a distinct and broad black outer border; the central pale patch at the postclypeus lower margin is very narrow; the anterior hamulus has a more convex anterior margin but its ventral margin is straight, with the spine directed anteriorly (in *B. asahinai* sp. nov. its anterior margin is straighter while the ventral margin is rounded, the spine being directed anteroventrally), the vesica seminalis is narrower and its posterior margin has a slight prominence at the cleft; the cerci are blunter, with a subapical

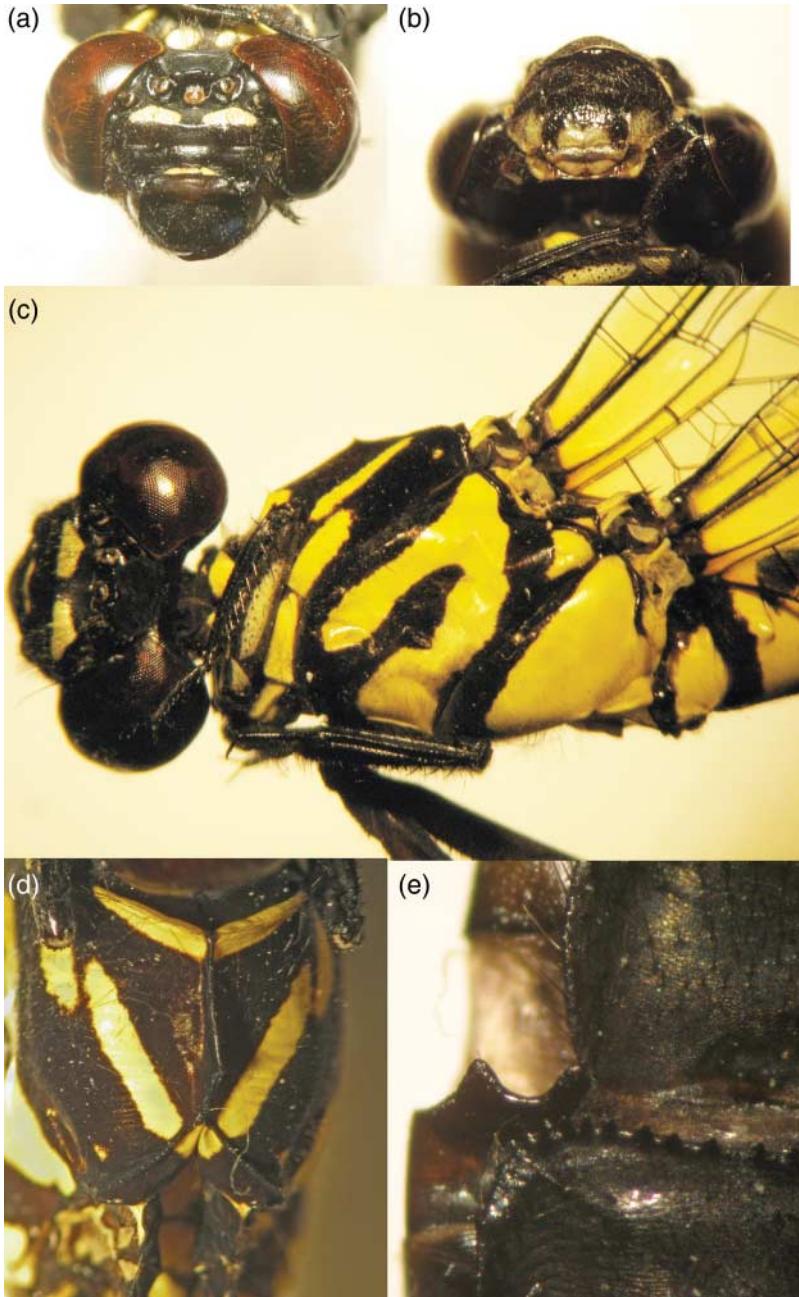


Figure 9. Details of ♀ *Burmagomphus gratiosus* Chao, 1954, China, Guizhou Province, Libo County, Zhangjiang River, 10 July 2010, Zhang Haomiao; (a) head, frontal view; (b) head, ventral view; (c) head and thorax, lateral view; (d) pterothorax fore part, dorsal view; (e) vulvar lamina.

concavity seen from above, the branches of the epiproct are much shorter, never extending beyond the cerci in lateral view. *B. williamsoni* is noticeably larger than *B. asahinai* sp. nov. (abdomen 24.5 mm; hind wing 21 mm in the studied male; 28.5 and 24.4 mm in the studied female).

Thus, in general *B. asahinai* sp. nov. is closest to *B. gratiosus*, from South China, sharing the similar mesepisternal pattern and, in females, robust spines above lateral ocelli; and less close to *B.*

laidlawi and *B. cauvericus* from the Western Ghats of India, also having the spines but with a less similar mesepisternum pattern and quite different hamuli (all these species from group 2). On the other hand, *B. asahinai* sp. nov. shares its elaborate structure of the female occiput, namely a large central yellow prominence and a pair of lateral tridental protuberances, with *B. williamsoni* from the Malay Peninsula, Thailand and Burma (group 1). As it combines together specific structures of the female head found separately in the four last mentioned species, *B. asahinai* sp. nov. may be considered a link between them and hypothesised to inherit the female head structure of their common ancestor.

It is noteworthy that the dorsal spine at S9 in males appeared to be an unreliable specific character in *Burmagomphus*. In *B. asahinai* sp. nov. it was present in two and absent in seven available males. Moreover, among eight males of *B. divaricatus* collected in the same area as the holotype of *B. asahinai* sp. nov. on the same and previous days, one lacked the spine (Kosterin, 2012). This variation within two species decreases the taxonomic relevance of this character in the genus, used by Fraser (1926, p. 410) to additionally characterise his two groups (“it appears to be a group character of *vermiculatus*”) and taken as reliable by Lieftinck (1964).

Redescription of *Burmagomphus gratiosus* Chao, 1954
(Figures 7–9)

Specimens examined

♂, ♀, China, Guizhou Province, Libo County, Zhangjiang River, 10 July 2010, Zhang Haomiao leg.

Diagnosis

Both the inferior antehumeral stripe and dorsal longitudinal stripe on the mesepisternum are short and separated, although their ends closely approach each other, at the same time lateral pale spots on the postclypeus and pale spots on the labrum are lacking. The female has robust spines behind the lateral ocelli but a simple occiput without any specific structure.

Male

Body black with a dull greenish yellow pattern (Figure 7a).

Head. Eyes green when alive (see Zhang, 2011, figure 47). Face (Figure 8a), vertex and occiput black with pale pattern. Occiput simple, with a raised, slightly uneven hind margin fringed with tightly set robust black hairs. Lateral ocelli on sides of a divided prominence wrapped around the central ocellus, set with long hairs, in frontal view forming two rounded humps behind lateral ocelli with a slight, even incision between them; in dorsal view nearly straight but laterally bending to form two short backward directed spurs behind lateral ocelli. Seam between vertex and frons with a pair of narrow streaks between antennal bases; antenna brownish black, with lighter tip. Frons black, with a pair of transversally elongate spots with straight anterior margins and convex posterior margins, rounded at sides. Anteclypeus and postclypeus brownish black, postclypeus with a central pale streak along anterior margin; lateral pale spots absent. Labrum entirely black. Mandible bases entirely pale. Labium pale, with a broad black anterior and lateral border at prementum and broadly black tips of palpi, movable hooks black (Figure 8b).

Thorax. Generally black with pale pattern. Prothorax with two pale spots on either side medially, a large upper one and a small in anterolateral corner, anterior lobe pale; posterior lobe black, hairy.

Synthorax (Figure 8c). Anterior part of antealar sinus almost entirely occupied by twin pale spots set against apices of dorsal pale stripes of mesepisternum; triangle inside sinus pale. Mesepisternum with the following pattern elements: broad stripe, interrupted at middle along anterior margin; two separate straight longitudinal pale stripes: slightly narrower dorsal stripe and slightly broader antehumeral stripe, these two stripes ending at nearly the same level and so not overlapping, gap of black background between them nearly as wide as dorsal stripe; no antealar pale spots. Antehumeral stripe extended onto mesinfraepisternum, interrupted by diffuse and irregular brownish zone below seam between mesepisternum and mesinfraepisternum, there slightly curved and continues without interruption to pale colour on mesocoxa. Mesepimeron and metepisternum mostly pale, with broad black band along mesepimeron anterior margin fused below to black colour on metacoxa and to an incomplete black band going along lateral suture between mesepimeron and metepisternum and moderately inflated to embrace spiracle; there is a slanting black band going from forewing base to middle of metapleural suture, leaving a pale spot in dorsoproximal corner of metepisternum. Metepimeron pale with a black band along metapleural suture to continue to inframetepisternum which is entirely pale except for small brownish black areas in its fore part and dorsolateral corner. Subalar ridges marked with black lines; subalare and pleural wing processes pale. Poststernum dull brownish, as well as metepimera bases; its caudal plate pale.

Legs black but ventral side of profemur and protochanter pale and ventral side of metatrochanter pale; coxae with pale stripes along lateral sides.

Wings (Figure 8d) hyaline, membrane bases slightly yellowish with colour intensity very gradually decreasing to disappear at about triangle tips, venation black. Forewing: antenodals 13 (left) and 14 (right) above Sc, 15 (left) and 13 (right) below Sc; one antenodal below Sc proximal to the 1st primary antenodal, at about 0.6 of distance between wing base and 1st primary antenodal; postnodals 10 (left) and 9 (right) above R₁, 11 (left) and 12 (right) below R₁. Hind wing: antenodals 9 above Sc, 10 (left) and 11 (right) antenodals below Sc; postnodals 9 (left) and 10 (right) above R₁, 12 below R₁. Triangles not crossed. Two crossveins between Arc and R₁–R₄ junction both above and below Rs on forewing, one on hind wing. Anal loop one-celled. Anal triangle 3-celled. Tornus obtuse-angulate but slightly rounded; anal margin straight; membranula brown, hardly noticeable. Pterostigma brown, with black bordering veins (lengthwise ones very slightly swollen), below covering 4 (right) and 4.5 (left) cells on forewings and 3.8 cells on hind wings.

Abdomen (Figure 7a). Black with pale marking as follows: S1 on either side with vertical oval pale spot at hind margin; S2 with pale semi-ring at anterior margin which includes auricles and on either side with oval pale spot in its lower part at about 2/3 of its length; S3–7 with broad pale semi-rings around anterior margin, those on S3–6 with blunt central projections, that on S7 broader and with even margin; S9 with large pale spot at distal margin that is extended centrally into a small cusp; S8 with narrow, short, and very faint streak along proximal part of dorsal carina, no such streaks on other segments.

S10 and anal appendages covered with dense fine pubescence, with longer hairs sprouting from epiproct incision. In lateral view (Figure 8g, h), cerci and epiproct branches extend behind to the same level; cercus lower margin with blunt knob at middle and narrow subapical incision forming a small dent, so apex of cercus appears as robust spine; epiproct branches broad and robustly hooked. In dorsal view, each cercus with evenly concave inner margin, outer margin made of two straight sections forming blunt angle near midlength. In ventral view (Figure 8f), branches of epiproct broad, with convex but slightly S-like curved outer margins and very evenly rounded incision between branches.

Accessory genitalia (Figure 8e) brownish black. Anterior hamulus very narrow and pointed, set with long hairs, close to ligula. Posterior hamulus club-like, narrow at base then inflating and

broadly rounded, with robust apical spine directed forward; outer surfaces concave because of raised ridges at anterior and posterior margin, both bearing numerous but rather small hairs not forming fringes or tufts. Vesica seminalis in lateral view about 1.5 times lower than posterior hamulus, appearing like a skewed and rounded triangle, with anterior margin nearly vertical and posterior one slanting, cleft occupying 0.25 of the latter. Penile organ not dissected because the specimen has been acetoned.

Measurements (mm). Hind wing 27.5, abdomen without appendages 31.2, body (with head and appendages) 45.5.

Female

Resembles male, slightly larger, black with saturated yellow pattern (Figure 7b).

Head (Figure 9a, b). Black but anteclypeus brown at middle, becoming black at sides; pale pattern as in male but without pale streaks along seam between vertex and frons; pale patch at anterior margin of postclypeus broader; very small pale spots present in labrum proximal corners and traces of such spots in postclypeus proximal corners. Prominence of vertex less developed, forming slight ridge between lateral ocelli, becoming lower toward them, with slight central incision in frontal view and arched in dorsal view. Behind each lateral ocellus a robust upright horn-like spine. Occipital plane simple, with slightly convex surface, margined with very low straight ridge. Labium as in male but black colour extended, occupying c.1/3 of length of movable hooks and width of prementum (Figure 9b).

Thorax. Mostly as in male, with somewhat broader pale pattern elements (Figure 9c, d), but mesepisternum pattern somewhat different: antehumeral and dorsal stripes slightly broader, their ends very close to each other leaving very narrow band of black ground colour, and with tiny antealar dot. Poststernum brownish, but its caudal plate pale, as well as lower parts of metinfraepisterna. Legs as in male.

Wings hyaline, with a rather strong amber basal tint extending to enclose triangles and very gradually disappearing, a slight yellow tint follows the costal margin up to about nodus. Antenodals 15 above Sc, 14 below Sc on both forewings, 9 above Sc and 10 (right)–11 (left) below Sc on hind wing; postnodals 11 above R₁, 11 (left)–12 (right) below R₁ on forewing, 10 (right)–12 (left) above R₁, 12 (right)–13 (left) below R₁ on hind wing. Two antefurcal crossveins, as in male. Pterostigma light brownish, covering 3.2–3.7 cells in forewing, 3.2–4.7 cells in hind wing.

Abdomen. Pattern similar to that of male (Figure 7b). S1 black above with broad black ring along proximal margin and narrow one along distal margin; S2 more black than yellow, with a large blunt triangular yellow dorsal spot, extended from proximal margin, with sides embracing vestigial auricles, here fused to very large skewed rectangular yellow lateral spots; S3–7 with quite broad proximal pale half rings, that on S3 pointed at sides and that on S4 pointed at sides and middle, S9 with semicircular dorsal yellow patch at distal margin, which is pointed; S10 with semicircular yellow patch at proximal margin and uneven yellow semi-ring at distal margin, ventral tergite margins outlined with very narrow yellow streaks; cerci black. Vulvar lamina small, with pointed lobes (Figure 9e).

Measurements (mm). Hind wing 31, abdomen 35.4, body 45.6.

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References

- Asahina, S. (1986). A list of the Odonata from Thailand. Part XIII. Gomphidae-1. *Chô Chô*, 9(2), 29–43.
- Chao, H.-F. (1954). [Classification of Chinese Dragonflies from the family Gomphidae (Odonata). Part II.] *Acta Entomologica Sinica*, 4, 23–82 (Chinese, with English summary).
- Chao, H.-F. (1990). *The Gomphid Dragonflies of China (Odonata: Gomphidae)*. Fuzhou: Science and Technology Publishing House (Chinese, with English summary).
- Davis, D.A.L., & Tobin, P. (1985). The Dragonflies of the World, Utrecht, Vol. 2. Anisoptera. *Societas Internationalis Odonatologica Rapid Communications (Supplements)*, 5, X + 151 pp.
- Do, M.C. (2011). *Burmagomphus schneideri* sp. nov., a new dragonfly from the south of Vietnam (Odonata, Gomphidae). *International Journal of Odonatology*, 14, 223–232.
- Fraser, F.C. (1926). Indian dragonflies, part XXIV-2. *Journal of the Bombay Natural History Society*, 31, 408–426.
- Fraser, F.C. (1934). *The Fauna of British India, including Ceylon and Burma. Odonata* (Vol. II). London: Taylor and Francis.
- Hämäläinen, M., & Pinratana, A. (1999). Atlas of the Dragonflies of Thailand. Distribution maps by provinces. Bangkok: Brothers of St. Gabriel in Thailand.
- Kosterin, O.E. (2010). A glance at the Odonata of the Cambodian coastal regions: end of dry season in 2010. *International Dragonfly Fund Report*, 29, 1–75.
- Kosterin, O.E. (2011). Odonata of the Cambodian coastal regions revisited: beginning of dry season in 2010. *International Dragonfly Fund Report*, 40, 1–108.
- Kosterin, O.E. (2012). Odonata of the Cambodian coastal regions in late rainy season 2011. *International Dragonfly Fund Report*, 45, 1–102.
- Lieftinck, M.A. (1940). On some Odonata collected in Ceylon, with descriptions of new species and larvae. *Ceylon Journal of Sciences (B)*, 22, 79–117.
- Lieftinck, M.A. (1964). Some Gomphidae and their larvae, chiefly from the Malay Peninsula (Odonata). *Zoologische Verhandelingen*, 69, 3–38.
- Needham, J.G. (1930). *A Manual of the Dragonflies of China*. Peiping: The Fan Memorial Institute of Biology.
- Tsuda, S. (2000). *A Distributional List of World Odonata*. Osaka: privately published.
- Yang, Z.-D., & Li, S.-S. (1994). A new species of the genus *Burmagomphus* from Western Szechuan (Odonata: Gomphidae). *Acta Entomologica Sinica*, 37, 84–86.
- Zhang, H. (2011). Karst forest Odonata from southern Guizhou, China. *International Dragonfly Fund Report*, 37, 1–35.