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Two new species of the *Rhyacophila nigrocephala* species group from China (Insecta, Trichoptera, Rhyacophilidae)

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Abstract. Two new species of the *Rhyacophila nigrocephala* species group, *R. voluta* sp. nov. and *R. linguiformis* sp. nov., are described, diagnosed and illustrated. *Rhyacophila voluta* sp. nov. is similar to *R. pentagona* Malicky & Sun, 2002 in male genitalia, but can be diagnosed by the inferior appendages of the same length as the complex of preanal appendages and dorsal lobe of segment IX, fused base of the basal segments of inferior appendages, and slightly incised distal margin of apical segment of inferior appendage. *Rhyacophila linguiformis* sp. nov. is similar to *R. rima* Sun & Yang, 1995 and *R. esorima* Mey, 1996 in male genitalia, but can be diagnosed by the progressively narrowed complex of preanal appendages and the dorsal lobe of segment X, the short anal sclerites, and the small gap between the upper and lower lobes of apical segment of inferior appendages. An updated checklist of 23 species recorded from China is presented.

Key words. Caddisfly, taxonomy, species group, subgroup.

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Introduction

The *Rhyacophila nigrocephala* diagnostic species group was established by Ross (1956) to contain 14 species known at that time. Schmid (1970) placed it in his *Rhyacophila divaricata* Branch, and increased the number of species in the group to 32, with one subspecies (*R. putata temba* Schmid, 1970 from Manipur, India). Afterwards, several authors reported 29 species from China (Sun & Yang 1995, 1999; Malicky 1995; Malicky & Sun 2002), Vietnam (Oláh 1987; Mey 1996; Armitage & Arefina-Armitage 2003), Nepal (Kiss 2011), Thailand (Malicky 1991; Malicky & Chantaramongkol 1993; Malicky *et al.* 2004), Japan (Kobayashi 1987) and Korea (Botosaneanu 1970; Kobayashi 1989). Furthermore, additional distribution data have been appended to some species (Armitage *et al.* 2005; Chuluunbat & Morse 2007; Hsu & Chen 2003; Ito 1999; Ivanov 2011; Kiss 2013; Malicky 2007, 2012, 2014; Mey 2005; Morse 2016; Nozaki & Nakamura 2007; Nuntakwang *et al.* 2007; Ohkawa & Hattori 2007; Potikha 2005; Satake & Kuranishi 2007; Wityi *et al.* 2015; Yang *et al.* 2005).

Currently, 61 species/subspecies are placed into the *R. nigrocephala* species group, 53 species/subspecies from the Oriental Biogeographic Region, 7 from the Palearctic Biogeographic Region, and 3 occur in

both the Oriental and Palearctic Biogeographic Region. In addition, 9 species belong to *R. manuleata* sub-group, 52 species/subspecies fall into the *R. nigrocephala* sub-group.

Of 23 Chinese species of the *Rhyacophila nigrocephala* species group (Table 1), 19 are from Oriental China, 1 from Palearctic China and 4 occur in both Oriental and Palearctic China. Furthermore, 5 species belong to the *R. manuleata* sub-group and 18 belong to the *R. nigrocephala* sub-group.

The purpose of this article is to describe two new species, *Rhyacophila linguiformis* sp. nov. and *R. voluta* sp. nov., both from Guangdong, Oriental China. As a result, the total number of species of the *R. nigrocephala* species group now known from China is 25, and the total number of species/subspecies in the species group is 63.

Material and methods

The specimens examined were collected using pan traps with 15-w ultraviolet light tubes set near streams. Rhyacophilid adults were then sorted and stored in 100% alcohol.

The genitalia preparation procedure follows that used by Xu *et al.* (2014). The structures of the male genitalia were traced in pencil using a drawing tube on a Nikon Eclipse 80i microscope. Original pencil drawings were inked digitally with Photoshop® CS4 version to produce illustrations. Each male abdomen was transferred to a microvial with 80% ethanol and stored together with the remainder of the specimen in a larger jar.

Terminology for male genitalia follows that of Schmid (1970). Type specimens have been deposited in the Insect Collection, Nanjing Agricultural University, Nanjing, Jiangsu Province, PR China.

Abbreviations

aed.	=	aedeagus
ab.	=	apical band
aia.	=	apical segment of inferior appendages
as.	=	anal sclerites
bia.	=	basal segment of inferior appendages
com.	=	complex of the preanal appendages and the apicodorsal lobe of segment IX
end.	=	endotheca
IX	=	segment IX
par.	=	parameres
pht.	=	phallosome
sag.	=	sagittal appendage
tb.	=	tergal band

Institutional acronyms:

NJAU = Nanjing Agricultural University, Nanjing, China

Table 1. Species of the *Rhyacophila nigrocephala* species-group recorded from China.

Sub-groups and species	Distribution
<i>R. manuleata</i> sub-group	
<i>altoincisiva</i> Hwang, 1957	China (Fujian)
<i>manuleata</i> Martynov, 1934	China (Taiwan), Japan, Korea, Oussouri, USSR (Far East)
<i>melli</i> Ulmer, 1926	China (Guangdong)
<i>shikotsuensis</i> Iwata, 1927	China (Taiwan), Japan, Russia
<i>linguiformis</i> sp. nov.	China (Guangdong)
<i>rima</i> Sun & Yang, 1995	China (Jiangxi)
<i>R. nigrocephala</i> sub-group	
<i>formosana</i> Ulmer, 1927	China (Taiwan)
<i>kimminsi</i> Ross, 1956	China (Taiwan)
<i>lata</i> Martynov, 1918	China (Heilongjiang), Mongolia, Oussouri, Russia (southern Far East, Siberia)
<i>nigrocephala</i> Iwata, 1927	China (Taiwan), Japan
<i>tecta</i> Morton, 1900	Bhutan, China (Taiwan), India (Khasi Hills, Kameng), Myanmar
<i>amblyodonta</i> Sun & Yang, 1999	China (Sichuan, Yunnan)
<i>anakdjeram</i> Malicky, 1995	China (Sichuan)
<i>anaksungai</i> Malicky, 1995	China (Sichuan)
<i>celata</i> Sun & Yang, 1999	China (Guizhou)
<i>cuneata</i> Sun & Yang, 1999	China (Zhejiang)
<i>euryphylla</i> Sun & Yang, 1999	China (Sichuan)
<i>exilis</i> Sun & Yang, 1999	China (Sichuan, Yunnan)
<i>forcipata</i> Malicky & Sun, 2002	China (Shaanxi)
<i>hadestril</i> Malicky & Sun, 2002	China (Zhejiang)
<i>hamosa</i> Sun, 1995	China (Zhejiang)
<i>pentagona</i> Malicky & Sun, 2002	China (Yunnan)
<i>unisegmentalis</i> Malicky & Sun, 2002	China (Shaanxi)
<i>vascula</i> Malicky & Sun, 2002	China (Shaanxi)
<i>voluta</i> sp. nov.	China (Guangdong)

Results

Family Rhyacophilidae Stephens, 1836

Genus *Rhyacophila* Pictet, 1834

Rhyacophila nigrocephala species group

Diagnosis (modified from Schmid 1970)

The species group can be diagnosed by the combination of following characters. In the male, segment IX is usually long, with the apicodorsal lobe fused with the preanal appendages into a complex, covering the other portion of the male genitalia. The anal sclerites are fused, with the apex slightly incised mesally and curved upwards, its root is large and curved upwards. The tergal band is slender, flattened dorsoventrally, with the apex sagittal, and has been termed as the sagittal appendage by Ross (1956).

The apical band is with two lateral arms articulating, with anal sclerites above and with the tergal band beneath. The phallic apparatus is elongate and cylindrical; the aedeagus with the apex is thin; the parameres, if present, are slender. Schmid (1970) recognized two sub-groups, the *R. manuleata* sub-group and the *R. nigrocephala* sub-group.

Rhyacophila manuleata sub-group

Diagnosis

Rhyacophila manuleata sub-group is characterized by (1) each apical segment of the inferior appendages deeply incised, (2) phallic apparatus simple, (3) the parameres present, (4) the base of the basal segment of inferior appendages not fused mesally.

Rhyacophila linguiformis sp. nov.

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Fig. 1

Diagnosis

This new species is similar to *R. rima* Sun & Yang, 1995 from Jiangxi, China and *R. esorima* Mey, 1996 from Vietnam in the male genitalia, all of them belong to the *R. manuleata* sub-group, but the new species differs in: (1) the complex of preanal appendages and the dorsal lobe of segment X in dorsal view is progressively narrowed from the base to the apex, but in *R. rima* the complex is somewhat spindle-shaped, and in *R. esorima* the complex with two parallel lateral margins, which become narrow near the apex; (2) the anal sclerites in lateral view are shorter than the complex, with the apex moderately concave in dorsal view, but in *R. rima* it extends beyond the apex of the complex, with a deep incision mesally in dorsal view, and in *R. esorima* it extends to the complex, with the apex slightly incised mesally; (3) the gap between the upper and the lower lobes of each inferior appendage is smaller than the width of the lower lobe, but in both *R. rima* and in *R. esorima* the gap at least equals the width of each lower lobe.

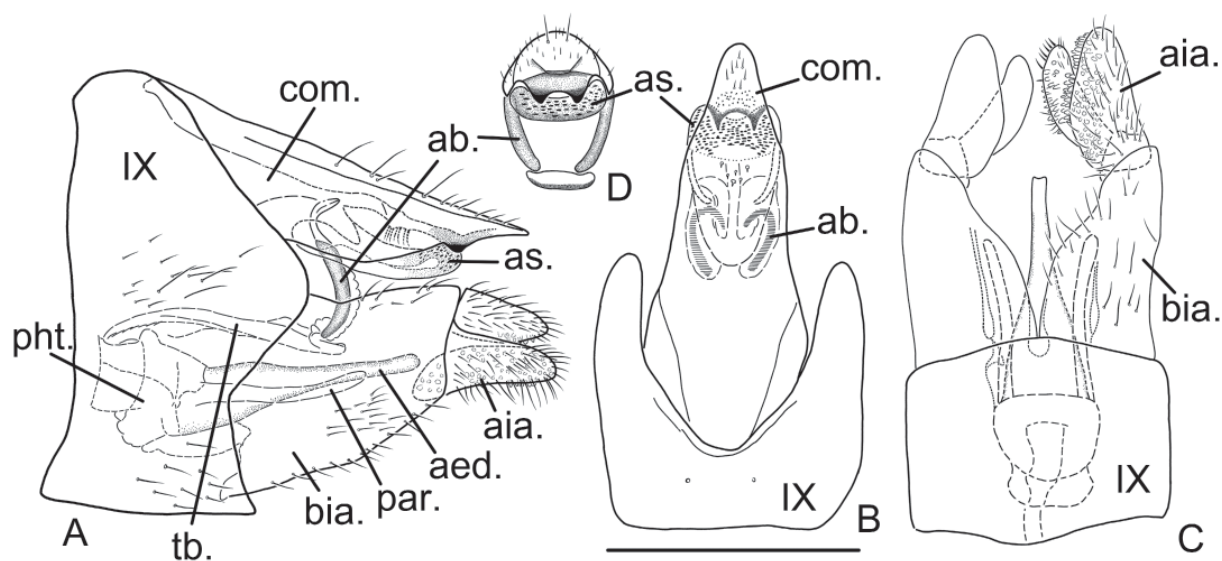


Fig. 1. *Rhyacophila linguiformis* sp. nov., male genitalia. **A.** Lateral view. **B.** Dorsal view. **C.** Ventral view. **D.** Complex of preanal appendages and apicodorsal lobe of segment IX, caudal view. Scale bar: 0.5 mm.

Etymology

The species epithet comes from the Latin word “*linguiformis*”, meaning “tongue-shaped”, in reference to the tongue-shaped complex of the preanal appendages and the apicodorsal lobe of segment IX.

Type material

Holotype

CHINA: ♂, in alcohol, collected in Guangdong Province, Xinyi County, town of Dacheng, Dawuling Nature Reserve, stream inside entrance of Reserve, 111.19° E, 22.27° N, 1021 m, 26 May 2004, Xin Zhou and Sanbao Tang leg. (NJAU).

Description

Male

BODY. Length of each forewing: 1.0 mm (n = 1). Body (in alcohol) dark brown. Head dark brown; eyes black; antennae dark brown, palpi brown. Thorax dark brown dorsally, brown laterally and ventrally; legs brown; wings brown. Abdomen dark brown dorsally and brown ventrally.

MALE GENITALIA (Fig. 1A–D). Segment IX (IX) in lateral view with each anterior margin straight, each posterior margin sinuate, dorsal margins short and ventral margins long (Fig. 1A); in dorsal view anterior margin straight, and posterior margin with deep U-shaped incision (Fig. 1B). Preanal appendages and apicodorsal lobe of segment IX fused tightly into complex (com.), in lateral view complex somewhat trapezoidal with upper margin 3 times as long as the lower margin (Fig. 1A), and in dorsal view somewhat tongue-shaped, tapering from base to apex (Fig. 1B). Anal sclerites (as., Fig. 1A) in lateral view bar-shaped, about ½ times as long as upper margin of complex. Apical band (ab.) in lateral view slender, slightly curved posteriad (Fig. 1A). Tergal band (tb.) membranous, in lateral view elongate. Phallosome (pht.) irregular in lateral view, somewhat rectangular in ventral view; aedeagus (aed.) with a large base, then progressively narrowed to rounded apex; paired parameres (par.) slender and shorter than aedeagus. Basal segments of inferior appendages (bia.) setose sparsely, each is subrectangular in lateral view and triangular in ventral view; apical segments (aia.) setose densely, each divided into 2 lobes, each upper lobe slightly shorter than lower one.

Female

Unknown.

Distribution

China (Guangdong).

Rhyacophila nigrocephala sub-group

Diagnosis

The *Rhyacophila nigrocephala* sub-group can be diagnosed by the combinations of following characters: (1) none of the apical segments of the inferior appendages is incised; (2) parameres absent; (3) basal segments of inferior appendages fused basomesally.

Rhyacophila voluta sp. nov.

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Fig. 2

Diagnosis

The new species belongs to the *R. nigrocephala* sub-group, and is similar to *R. pentagona* Malicky & Sun, 2002 from Yunnan, China, in the male genitalia, but differs in: (1) the inferior appendages of about the same length as the complex of the preanal appendages and the apicodorsal lobe of segment IX (obviously shorter than the complex in *R. pentagona*); (2) the basal segments of the inferior appendages in lateral view are somewhat rectangular and in ventral view with their bases fused (pentagonal in *R. pentagona*, and their bases not fused obviously); (3) the apical segments of the inferior appendages with each distal margin slightly concave (straight in *R. pentagona*).

Etymology

The species epithet comes from the Latin word “*volutus*”, meaning “having been curled”, in reference to the subapical margin of the complex of the preanal appendages and the apicodorsal lobe of segment X extending upward into a curled lamella.

Type material

Holotype

CHINA: ♂, in alcohol, collected in Guangdong Province, Ruyuan County, Nanling National Nature Preserve, Lao-peng Keng at cascading tributary, Route X327, marker 22.5 km, 113.01° E, 24.93° N, 1110 m, 18–19 May 2004, John C. Morse, Xiaoli Tong and Xin Zhou leg. (NJAU).

Paratypes

CHINA: 4 ♂♂, in alcohol, collected at the same locality along with the holotype, except marker 17.45 km, 113.03° E, 24.91° N, 935 m, 21–22 May 2004, John C. Morse and Changhai Sun (NJAU).

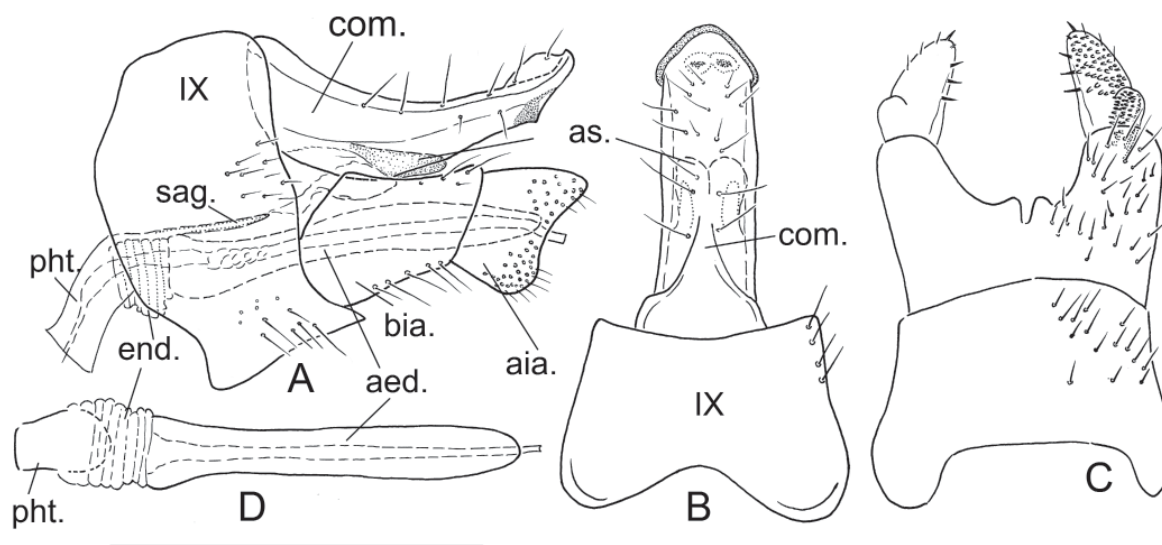


Fig. 2. *Rhyacophila voluta* sp. nov., male genitalia. **A.** Lateral view. **B.** Dorsal view. **C.** Segment IX and inferior appendages, ventral view. **D.** Phallic apparatus, ventral view. Scale bar: 0.5 mm.

Description

Male

BODY. Length 5.0 mm ($n = 3$), length of each forewing 6.0–7.0 mm ($n = 5$). Body (in alcohol) brown. Head dark brown; antennae brown; palpi light brown, eyes black. Thorax brown dorsally, yellow laterally and ventrally; wings dark brown; legs with coxae, trochanters and femora yellow, remainder parts dark brown, spurs dark brown. Abdomen dark brown dorsally and yellowish brown ventrally.

MALE GENITALIA (Fig. 2A–C). Segment IX (IX) in lateral view with middle portion of each anterior margin (about half the height of segment IX) straight and slightly projecting anteriad, each posterior margin almost straight, with posteroventral angle slightly projecting posteriad, dorsal and ventral margins straight; in dorsal view, anterior margin incised in V-shaped, posterior margin slightly concave; in ventral view anterior margin with broad shallow incision and posterior margin convex slightly. Apicodorsal lobe of segment IX and preanal appendages fused into complex (com.), in lateral view it curved downward at middle, with broad base and thin apex, subapex with dorsal margin extended upward to form lamella; in dorsal view complex with the two lateral margins parallel to each other, and apex triangular, the lamella curled. Anal sclerites (as.) large, with base fused into complex of apicodorsal lobe and preanal appendages, in lateral view somewhat triangular, in dorsal view its apex incised. Apical band (ab.) membranous. Sagittal appendage (sag.) in lateral view style-like. Basal segment of each inferior appendage (bia.) in lateral view somewhat rectangular, base slightly broader than apex in lateral view, in ventral view bases fused mesally; apical segment of each inferior appendage (aia.) in lateral view trapezoidal, with distal margin shallowly concave, in ventral view somewhat triangular. Phallic apparatus simple: phallosome (pht.) tubular in lateral view and trapezoidal in ventral view, endothea (end.) membranous, aedeagus (aed.) tubular, with apex narrowed suddenly.

Female

Unknown.

Distribution

China (Guangdong).

Discussion

The *R. nigrocephala* species group has the highest diversity of species within the genus *Rhyacophila*, with 63 members up to date. All species are exclusively distributed in both the Eastern Palearctic and Oriental biogeographic regions.

Twenty-five species of *R. nigrocephala* species group (including the 2 new species described in this paper) are recorded from China (Table 1), which is about 40% of the world fauna of the group. Among them, 18 species are endemic to China, distributed in the provinces of Guangdong (3 spp.), Fujian (1 sp.), Jiangxi (1 sp.), Guizhou (1 sp.), Shaanxi (3 spp.), Sichuan (3 spp.), Yunnan (1 sp.), both Sichuan and Yunnan (2 spp.), Taiwan (2 spp.), and Zhejiang (3 spp.); *R. lata* Martynov, 1918 is the only Palearctic species, distributed in Heilongjiang, China, Mongolia and Russia; *R. manuleata* Martynov, 1934, *R. nigrocephala* Iwata, 1927 and *R. shikotsuensis* Iwata, 1927 are widespread in Palearctic Japan, Korea and even Russia to Oriental Taiwan, but are not recognized from mainland China, this situation may be due to poor sampling efforts in mainland China. In recent papers, *R. nigrocephala* was recorded from the Liao River basin in the northeast of China (Zhao *et al.* 2015), and *R. manuleata* was reported from Mt. Dabie, Hubei Province (Qiu & Yan 2016). So far, *R. tecta* Morton, 1900 is recognized from the Oriental Region, being widely distributed in Bhutan, China (Taiwan), India (Khasi Hills, Kameng) and Myanmar. In summary, the distribution of members of the *R. nigrocephala* species group is confined to

the Eastern Palearctic and Oriental biogeographic regions, but more samples are bound to reveal a more extended distribution of each species within the group.

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