RESEARCH ARTICLE



Three species of land leeches from Taiwan, Haemadipsa rjukjuana comb. n., a new record for Haemadipsa picta Moore, and an updated description of Tritetrabdella taiwana (Oka)

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Abstract

Three species of land leeches, including a new combination *Haemadipsa rjukjuana* **comb. n.**, a new record for *Haemadipsa picta* Moore, as well as an updated description for *Tritetrabdella taiwana* (Oka), are reported in this study. Morphological characters and DNA barcode analysis were used to identify these species. In addition, since *H. rjukjuana* had been regarded as a variety of the Japanese land leech *Haemadipsa japonica* for a century, morphological differences between these two species were also compared.

Keywords

Land leech, Haemadipsa rjukjuana, Haemadipsa picta, Tritetrabdella taiwana, Haemadipsa japonica, Taxonomy, Taiwan

Introduction

Land leeches are generally referred to a group of sanguivorous species belonging to different genera that mainly live in the Indo-Pacific. These species are adapted

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to terrestrial life, but are restricted to damp forests with high humidity; hence, the majority of species are distributed in tropical and subtropical areas (Sawyer 1986). Because of their bloodfeeding habit, land leeches have been observed and collected in damp forests during surveys, and many of these species have been described in the last century. According to Sket and Trontelj (2008), there are about 60 described land leech species, of which 50 belong to the Family Haemadipsidae, while the rest are in the Family Xerobdellidae. However, the taxonomy of these bloodfeeding land leeches remained complicated and ambiguous for decades prior to the advent of molecular phylogenetic research at the end of the last century. Sawyer (1986) suggested that the single family Haemadipsidae, which comprises a total of 17 genera divided into the duognathous (two jaws) and trignathous (three jaws) series, should include all the land leech species. However, Moore (1946), Ringuelet (1953, 1972, 1982) and Richardson (1975, 1978) suggested dividing about 30 genera into several families (including Haemadipsidae), to distinguish between bloodfeeding land leeches from the Indo-Pacific, which only have two jaws, and other regions. Ultimately, the controversial higher-level taxonomy of bloodfeeding land leeches was resolved through a series of molecular phylogenetic studies (Trontelj et al. 1999; Borda and Siddall 2004; Kutschera et al. 2007; Borda et al. 2008). Based on these studies, bloodfeeding land leeches are separated into two families, Haemadipsidae and Xerobdellidae, using both morphological characteristics and molecular analysis. However, despite recently published conclusions about the higher taxonomic level of bloodfeeding land leeches, the species-level taxonomy of these groups has been largely ignored. Therefore, a land leech species, such as Haemadipsa zeylanica Whitman, for which many subspecies or varieties have been described, has not been critically investigated.

DNA barcoding is a system of species identification that uses DNA sequences (Hebert et al., 2003). Mitochondrial cytochrome *c* oxidase subunit 1 (COI) sequences have been selected as the DNA barcode for most animal phyla (Hebert et al. 2003). Recently, the need for DNA barcoding in the species identification of leeches has been widely discussed (Bely and Weisblat 2006; Siddall et al. 2007). Bely and Weisblat (2006) found that the laboratory isolates of Helobdella used for developmental biological studies, which had previously been identified as H. triserialis Blanchard and H. robusta Shankland et al., represented five distinct species, including at least two cryptic species. By using the same DNA technique, Siddall and Budinoff (2005) identified the widespread introduction of Helobdella europaea Kutschera into Australia, New Zealand, South Africa, and Hawaii. In Taiwan, Lai et al. (2009) also identified H. europaea through DNA barcoding analysis, as well as two new Helobdella species, H. octatestisaca Lai and Chang and H. melananus Lai and Chang. However, the DNA barcoding of bloodfeeding leeches has only been used to identify different species of commercially available medical leeches, in addition to resolving the taxonomy of these leeches (Trontelj and Utevsky 2005; Siddall et al. 2007), rather than for taxonomic studies of bloodfeeding land leeches.

This study presents the first case where DNA barcoding is applied to assist with new species descriptions for bloodfeeding land leeches. Here, we present a report on two *Haemadipsa* leeches, including a new combination, which was regarded as a variety of *H. japonica* for a century, and a new record of a species in Taiwan. In this study, we compare this new combination against *H. japonica*. In addition, we also include descriptions and molecular analysis of a rarely described haemadipsoid species, *Tritetrab-della taiwana* (Oka).

Methods

Sample collection and preservation

From 2001 to 2009, we collected leeches in the suburban hills and mountains around Taiwan. Collection strategies involved walking along forest trails and streams, as well as searching through damp undergrowth, to attract leeches. We also received leech specimens collected by other field surveyors and friends. Specimens were anesthetized and relaxed in 10% ethanol solution, followed by fixation in 10% formalin solution for 24 h. The specimens were then preserved in 70% ethanol solution for morphological inspection and dissection, or were directly preserved in 75% ethanol solution for DNA extraction and barcoding analyses. All specimens were deposited in the Invertebrate Zoology and Cell Biology Lab, Department of Life Science in National Taiwan University, Taipei, Taiwan.

DNA extraction, PCR, and DNA sequencing

Tissue from the caudal sucker was used to minimize the possibility of contamination from host/prey DNA found in gastric and intestinal regions. The Genomic DNA Mini Kit (Tissue) (IBI Scientific, Iowa, USA) was used for tissue lysis and DNA purification. The extracted DNA was stored at -20 °C.

A 658 bp mitochondrial cytochrome *c* oxidase subunit I (COI) DNA fragment was amplified using the universal primers LCO1490 (5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3') and HCO2198 (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3') (Folmer et al., 1994). PCR amplifications were carried out in a 50 μ l total volume using 1 cycle at 94 °C for 1 min, followed by 6 cycles of denaturation for 30 s at 94 °C, annealing for 30 s at 45 °C, and extension for 50 s at 72 °C, and later by 35 cycles of denaturation for 30 s at 94 °C, annealing for 30 s at 94 °C, and extension for 50 s at 72 °C, and extension for 50 s at 72 °C, with a final extension at 72 °C for 10 min.

The PCR products were checked using 1.0% agarose gel electrophoresis and sequenced in both directions using the same primers as in the PCR. Sequencing was performed with the ABI PRISM BigDye Terminator Cycle Sequencing Ready Reaction Kit, V3.1 (Applied Biosystems, CA, USA). Products were analysed with a ABI 3730 XL DNA Analyzer (Applied Biosystems).

DNA barcoding analyses

COI sequences of haemadipsoid leeches reported by Siddall and Burreson (1998), Borda and Siddall (2004), and Borda et al. (2008) were retrieved from GenBank. Sequences of xerobdellid leeches reported by Borda and Siddall (2004) and Borda et al. (2008) were also retrieved from GenBank and used as outgroups. All sequences used were aligned using the default settings of Clustal X 1.81 (Thompson et al. 1997). A homologous fragment of 604 bp of the COI sequence was used in this study. The sequences obtained were submitted to GenBank (Table 1). Phylogenetic analyses were conducted using MEGA 3.1 (Kumar et al. 2004). Neighbor joining (NJ) analyses were performed using Kimura's two–parameter model (Kimura 1980). A bootstrap analysis with 1,000 pseudo–replicates was conducted to evaluate the robustness of the clades.

Results

Species descriptions

Haemadipsa rjukjuana (Oka, 1910) Lai, Nakano & Chen, 2011, comb. n. http://species-id.net/wiki/Haemadipsa_rjukjuana

Haemadipsa japonica var. rjukjuana Oka, 1910. Annot. Zool. Jap. 7: 165–183
Haemadipsa zeylanica Takahashi, 1934. Rep. Jpn. Sci. Assoc. 10: 744–749
Haemadipsa zeylanica var. Moore, 1938. B. Raffles. Mus. 14: 64–80
Haemadipsa japonica var. rjukjuana Keegan et Toshioka, 1968. Biomed. Rep. 406
Med. Lab. No. 16. United States Army Medical Commend, Japan.
Haemadipsa zeylanica Wu, 1979. Quart. J. Taiwan Mus. 32: 193–207
Haemadipsa japonica Yang, 1996. Fauna Sinica, Annelida: Hirudinea. Science Press, Beijing, China.
Haemadipsa japonica var. ryukyuana Lai et Chen, 2005. Note Newsl. Wildlifers 9: 10–14

Haemadipsa japonica var. ryukyuana Lai et al, 2009. Zootaxa 2068: 27-46

Material examined. L00062 & L00063 collected at 21st Sept. 2003 in the mountain in Yilan County.; L00064 collected at 16th Mar. 2002 in the Fushan Botanical Garden in Yilan County; L00101 collected at 23rd Apr. 2005 in the Fushan Botanical Garden in Yilan County; L00102 collected at 20th Jan. 2002 in the Fushan Botanical Garden in Yilan County; L00103 collected at 21st May 2005 in the Fushan Botanical **Table 1.** Collection localities and GenBank accession numbers of haemadipsoid leeches used in thephylogenetic analyses.

		GenBank	
Taxon	Locality	accession No.	Reference
Ingroup			
Chtonobdella bilineata	Australia	AF003267	Siddall and
			Burreson (1998)
Chtonobdella whitmani	Australia	EU100087	Borda et al. (2008)
Haemadipsa interrupta	Thailand	EU100091	Borda et al. (2008)
Haemadipsa hainana L00153A	Hainan Island, China	HQ322473	This study
Haemadipsa japonica	Japan		Borda and Siddall (2011)
Haemadipsa picta	Borneo	AY425445	Borda and Siddall (2004)
Haemadipsa picta L00151A	Taiwan	HQ322470	This study
Haemadipsa picta L00100A	Taiwan	HQ322471	This study
Haemadipsa picta L00152A	Taiwan	HQ322472	This study
Haemadipsa rjukjuana L00112A	Taiwan	HQ322438	This study
Haemadipsa rjukjuana L00111A	Taiwan	HQ322439	This study
Haemadipsa rjukjuana L00110A	Taiwan	HQ322440	This study
Haemadipsa rjukjuana L00114A	Taiwan	HQ322441	This study
Haemadipsa rjukjuana L00113A	Taiwan	HQ322442	This study
Haemadipsa rjukjuana L00115A	Taiwan	HQ322443	This study
Haemadipsa rjukjuana L00116A	Taiwan	HQ322444	This study
Haemadipsa rjukjuana L00117A	Taiwan	HQ322445	This study
Haemadipsa rjukjuana L00118A	Taiwan	HQ322446	This study
Haemadipsa rjukjuana L00119A	Taiwan	HQ322447	This study
Haemadipsa rjukjuana L00120A	Taiwan	HQ322448	This study
Haemadipsa rjukjuana L00121A	Taiwan	HQ322449	This study
Haemadipsa rjukjuana L00122A	Taiwan	HQ322450	This study
Haemadipsa rjukjuana L00123A	Taiwan	HQ322451	This study
Haemadipsa rjukjuana L00125A	Taiwan	HQ322452	This study
Haemadipsa rjukjuana L00126A	Taiwan	HQ322453	This study
Haemadipsa rjukjuana L00127A	Taiwan	HQ322454	This study
Haemadipsa rjukjuana L00129A	Taiwan	HQ322455	This study
Haemadipsa rjukjuana L00131A	Taiwan	HQ322456	This study
Haemadipsa rjukjuana L00132A	Taiwan	HQ322457	This study
Haemadipsa rjukjuana L00133A	Taiwan	HQ322458	This study
Haemadipsa rjukjuana L00135A	Taiwan	HQ322459	This study
Haemadipsa rjukjuana L00136A	Taiwan	HQ322460	This study
Haemadipsa rjukjuana L00138A	Taiwan	HQ322461	This study
Haemadipsa rjukjuana L00098A	Ryukyu Islands, Japan	HQ322462	This study
Haemadipsa sumatrana	Borneo	AY425446	Borda and Siddall (2004)
Haemadipsa sylvestris	Vietnam	AF003266	Siddall and Burreson (1998)

		GenBank	
Taxon	Locality	accession No.	Reference
Idiobdella seychellensis	Seychelle Islands	EU100094	Borda et al. (2008)
Malagabdella fallax	Madagascar	EU100096	Borda et al. (2008)
Nesophilaemon skottsbergii	Juan Fernandez Islands	EU100098	Borda et al. (2008)
<i>Tritetrabdella taiwana</i> L00141A	Taiwan	HQ322463	This study
Tritetrabdella taiwana L00142A	Taiwan	HQ322464	This study
<i>Tritetrabdella taiwana</i> L00143A	Taiwan	HQ322465	This study
<i>Tritetrabdella taiwana</i> L00144A	Taiwan	HQ322466	This study
<i>Tritetrabdella taiwana</i> L00146A	Taiwan	HQ322467	This study
<i>Tritetrabdella taiwana</i> L00147A	Taiwan	HQ322468	This study
<i>Tritetrabdella taiwana</i> L00150A	Taiwan	HQ322469	This study
Outgroup			
Diestecostoma magna	Mexico	EU100088	Borda et al. (2008)
Diestecostoma mexicana	Mexico	EU100089	Borda et al. (2008)
Diestecostoma trujillensis	Mexico	EU100090	Borda et al. (2008)
Mesobdella gemmata (1)	Chile	AY425454	Borda and Siddall (2004)
Mesobdella gemmata (2)	Chile	EU100097	Borda et al. (2008)
Xerobdella lecomtei	Slovenia	EU100099	Borda et al. (2008)

Garden in Yilan County. L00026 collected at 20th Jan. 2002 in the Fushan Botanical Garden in Yilan County; L00027 collected at 19th Feb. 2002 in the Fushan Botanical Garden in Yilan County; L00098A (two specimens) collected at 16th Mar. 2009 in Mt. Otake, Akuseki-jima, Tokara Islands, Japan (29°27'56"N, 129°35'40"E); L00104 (three specimens) collected at 30th May 2005 in Wufong Town, Hsinchu County; L00105 collected at 16th Mar. 2002 in the Fushan Botanical Garden in Yilan County; L00106 collected at 20th Jan. 2002 in the Fushan Botanical Garden in Yilan County; L00107 collected at 27th Mar. 2004 in Hsoulin Town, Hualien County; and L00108 (two specimens) collected at 4th Aug. 2004 in the mountain in Yilan County.

Diagnosis. This species can be recognized by the reddish, yellowish, or grayish brown dorsum that is blotched with elongated irregular black spots that are more or less connected, and the absence of a distinct median stripe (Fig. 1A). The nearly solid black venter with irregular margins clearly distinguishes this species from other land leech species (Fig. 1B).

External characters. Body length 14–37 mm, maximum body width 2.5–5.3 mm, up to 10.5 mm in specimen filled with blood; anterior sucker diameter 1.2–2.4 mm, posterior sucker diameter 2.6–5.6 mm. Body elongated, slenderly cylindrical, with dorsum moderately depressed from the end of body to the head; venter more or less flat in relaxed specimens. Head of dorsal anterior sucker with usual sub-triangular outline (Fig. 1C), venter of lip with the broad median field marked by narrow, longitudinal ridges and a deep median fissure. Anterior sucker deep, wide, triangularly cupuliform with well-developed lateral buccal lobes and frill. Posterior sucker nearly



Figure 1. *Haemadipsa rjukjuana*. **A** Dorsum. **B** Venter. **C** Dorsal head. **D** Venter of caudal sucker. **E** Reproductive system. atr. Atrium; cod. Common oviduct; eb. Ejaculatory bulb; ep. Epididymis; od. Oviduct; ov. Ovary; te. Testisacs; vad. Vaginal duct; vd. Vas deferens; vs. Vaginal sac. XI and XVI indicate the orders of the ganglia. Each scale indicates 1 mm in the Figure respectively.

circular, slightly longer than wide, diameter equal to or a little larger than maximum body width, with a definite anterior median prominence but no sharply hooked papilla. Auricles large, white or even translucent, trilobate with the middle lobe smallest, and conspicuous by their color in contrast with the body color.

Dorsum strongly tessellated, with three pairs of paramedian, intermediate and supramarginal lines of prominently elevated, translucent-tipped sensillae, and also scattered areas bearing smaller semi-transparent tipped sensillae on annuli in addition to the sensory one. Venter tessellated less and more smooth than dorsum, with white or translucent tipped sensillae in arrangement as those on the dorsum. Dorsum of posterior sucker tessellated, with five or six irregular circles of polygonal areas. Venter of posterior sucker with rays 71 or 72, with strongly flattened ridges terminated in little rounded lobes at the margin, and not penetrated into the relatively large central areolated region (Fig. 1D).

When alive, dorsum reddish, yellowish, or grayish brown, with scattered elongated, more or less connected lateral-posteriorly, irregular black spots. No distinct median stripe on the dorsum, but in some specimens the mid-dorsum less blotched by spots, sometimes similar to an indistinct pale mid-dorsal stripe (Fig. 1A). In lateral body, the region around the sensillae lacking in spots, sometimes similar as a broken pale lateral stripe. Venter uniform, solid black, with highly irregular lateral margins which usually connected with the irregular spots from the lateral body (Fig. 1B). Dorsum of posterior sucker the same but more or less brighter in color than dorsum, with scattered black spots (Fig. 1A). Venter of posterior sucker fawn, sometimes with few scattered dark spots (Fig. 1D).

Eyes five pairs, punctiform, arranged respectively at II (2^{nd} annulus), III (3^{rd} annulus), IV (4^{th} annulus), V (5^{th} annulus) and VI (8^{th} annulus) in parabolic arc (Fig. 1C).

Ninety-seven annuli in total. I, II and III uniannulate, with irregular areas divided and with sensillae in the interocular region. IV uniannulate and the interocular region being divided into irregular areas with sensillae in two transverse rows. V biannulate dorsally ((a1a2)>a3) and uniannulate ventrally, with the a3 as the oral margin of the buccal ring and also the first perfectly definite annulus. VI triannulate with the three annuli approximately equal. VII triannulate with the three annuli of the same length. VIII quadrannulate (a1=a2=b5>b6). IX–XXII midbody somite and quinquannulate, with the five annuli of the same length and a2 projecting above the surface. XXIII quadrannulate (b1=b2=a2>a3). XXIV triannulate (a2>a1=a3). XXV biannulate ((a1a2)=a3), each annulus bearing the first and second auricular lobes at the margins. XXVI uniannulate and bearing the third auricular lobe at the margins. XXVII uniannulate. Anus a small longitudinal slit in XXVII (97th annulus). Gonopores separated by five annuli; male at XI b5/b6 (30th/31st annulus); female at XII b5/b6 (35th/36th annulus); both small transverse slits with pale and projecting margins strictly within furrows.

Internal characters. Jaws three, crescent shaped, moderate size and highly prominent, with 78–80 teeth; one mid-dorsally, the other paired ones ventro-laterally, all in deep buccal chamber beyond the velum. Pharynx in VII–VIII, short, bulbous; with six

muscular ridges of spongy wall in which three continuous with the three jaws and the other three intermediately between the formers and surrounded by numerous unicellular salivary glands. Crop in VIII–XIX; with 12 pairs of caeca in VIII–XIX respectively; first nine pairs simple, unlobed, with the first two pairs small and indistinct; while the last pair of caeca in XIX elongated posteriorly to XXIII and lateral to intestine. Intestine in XIX–XXIII, no caeca, ventral to rectum in XXIII. Rectum short, wide, tapered towards anus.

Ten pairs of testisacs at XIII/XIV–XXII/XXIII. Vas deferens enters epididymis in XII/XIII or XIII. Epididymis in XII/XIII–XVI, in some cases even to XVIII; asymmetrical, one side of which more massive, located between atrium and vaginal sac, and usually covered the ovisacs and oviducts, while the other side extended posteriorly beyond the vaginal sac, elongated, less massive, and with major part covering on or being covered by the vaginal sac. Ejaculatory bulbs moderately large, elongated ellipsoid, lying at a much lower level by the sides of the atrium, connected by slender ejaculatory ducts with a sharp turning backwards into atrium in XI. Atrium large, rounded, conspicuous, rising well dorsad of the level of the nerve cord passing along in the right side. Prostate glands a layer of loosely compact. Ovisacs in XII, large, connected with long and curled common oviduct. Vaginal sac in XIV–XVI, cephalic end sometimes in XIII and the caudal end extended to XVII; elongated egg-shape, bubble-like with thin wall usually, connected with long and thick vaginal stalk extended anteriorly into female gonopore in XII (Fig. 1E).

Distribution. *Haemadipsa rjukjuana* is only recorded in East and South East Asia, including the Indo-Chinese Peninsula, Malay Peninsula, Indonesia, Ryukyu Islands of Japan, and Taiwan. In Taiwan, we recorded this species during recent surveys in the moist forests of low- and middle-elevation mountains in Taipei, Hsinchu, Taichung, Nantou, Pingtung, Yilan, Hualien, and Taitung (Fig. 4).

Habitat. Commonly inhabits the bottom of moist forests. It attaches onto leaf litter, grasses, and low bushes.

Host. Primarily medium- or large-sized mammals, including humans.

Remarks. *Haemadipsa rjukjuana* had previously been recorded with other synonyms, with variable taxonomic status that has rarely been clarified over the last century. Oka (1910) described a new land leech collected from Taiwan, and named it *Haemadipsa japonica* var. *rjukjuana* based on a brief inspection of the external color pattern. After two decades, Takahashi (1934) refered to all the land leeches in Taiwan as *H. zeylanica*, which is a variable land leech species widely distributed in South and South-East Asia. Later, Moore (1938) recorded a land leech specimen from the Malay Peninsula, and illustrated both dorsal and ventral color patterns (Fig. 5, Plate IV in Moore 1938). The scattered spots on the dorsum and the solid black venter with irregular lateral margins indicate that it is very similar to the specimens inspected in this study; thus, it could tentatively be confirmed as *H. rjukjuana*. However, Moore only recognized it as *Haemadipsa zeylanica* var., despite conspicuous differences in external color patterns, and only provided a few external descriptions, instead of a detailed inspection and investigation on its taxonomic status. In addition, Moore (1938) also mentioned that this variety resembled one of the land leeches illustrated, but not described, by Blanchard (1917). Thirty years later, Keegan et al. (1968) described this variety in more detail. They provided the first description of its reproductive system, and compared it against other varieties of H. zeylanica. However, in addition to the external color patterns, they stated that there were no differences in the reproductive system between this variety and the subspecies *H. zeylanica japonica*, i.e., the species H. japonica in our study. At the end of the 1970s, Wu (1979) reviewed the previous studies of the leech fauna in Taiwan, and only referred to the land leech species of Haemadipsa zeylanica in his list. About two decades later, Yang (1996) mentioned that only H. japonica was present in Taiwan, as the other common land leech species in Taiwan, Tritetrabdella taiwana, which had been described as a new combination by Sawyer (1986), had been mistakenly included. Finally, in the first decade of this century, Lai and his colleborators (Lai and Chen 2005; Lai et al. 2009) stated the uncertain taxonomic status of this variety, and suggested the necessity of further studies. By comparing the morphology of *H. japonica* var. rjukjuana specimens against *H. japonica*, we found significant and consistent differences in both external and internal characteristics (Table 2). Therefore, its taxonomic status should be considered as a new species rather than subspecies or variety.

Haemadipsa picta Moore, 1929

http://species-id.net/wiki/Haemadipsa_picta

Haemadipsa picta Moore, 1929. P. Acad. Nat. Sci. Philadelphia 81: 267-295.

Haemadipsa picta Moore, 1935. B. Raffles Mus. 10: 67-78.

Haemadipsa picta Keegan et al, 1968. Biomed. Rep. 406 Med. Lab. No. 16. United States Army Medical Commend, Japan.

Haemadipsa picta Ngamprasertwong et al. 2007. Nat. Hist. J. Chulalongkorn U. 7: 155–159.

Material examined. L00099 collected at 18th Sept. 2005 in Hsoulin Town, Hualien County; L00100A collected at 12th Sept. 2004 in Hualien County; L00151A collected at 15th Oct. 2006 in Hsoulin Town, Hualien County; and L00152A collected at 31st Aug. 2003 in Hualien County.

Diagnosis. This species can be recognized by the longitudinally striped color pattern on the reddish brown dorsum, with a broad, bluish-gray, yellow-greenish, or multicolored median-paramedian field that contains three to five black or dark brown broken stripes inside (Fig. 2A). It has a white or pale yellowish longitudinal marginal stripe with dark-spotted borders, as well as a uniformly yellowish brown venter, which distinguishes this species from other land leech species in Taiwan.

External morphology. Body length 13–33 mm, maximum body width 3.0–5.5 mm, anterior sucker diameter 1.3–2.5 mm, posterior sucker diameter 2.5–3.7 mm. Body elongated, slenderly cylindrical, with dorsum moderately depressed from the

	Species	
Morphological character	Haemadipsa rjukjuana	Haemadipsa japonica
Color pattern, spots and stripes on dorsum	Dorsum reddish, yellowish, or grayish brown, with scattered elongated, more or less connected lateral-posteriorly, irregular black spots, no stripe.	Dorsum red brownish, with a mid-dorsal longitudinal dark stripe and a wide, yellowish mid- dorsal region bordered by two paramedian longitudinal dark stripe, no spot.
Marginal stripe	Sometimes a broken pale stripe formed by a series of pale region around the sensillae.	A continuous, longitudinal pale yellowish stripe.
Color pattern on venter	Uniformly black with highly irregular lateral margins.	Uniformly dark yellowish or red brownish.
Number of transverse rows in interocular region in III	Two	One
Number of rays on venter of posterior sucker	Mostly 71–72	Mostly 74–76
Epididymis morphology and location	Separated, highly asymmetrical. One side more massive, located between atrium and vaginal sac, usually covered the ovisacs and oviducts; while the other side elongated, less massive, usually extended posteriorly beyond the vaginal sac and with major part covering on or being covered by the vaginal sac.	Rarely separated, less asymmetrical. Both of the posterior ends highly massive, folded, curled together or extremely close to each other. The main part located between atrium and vaginal sac.

Table 2. Comparison of diagnostic morphological characters between *Haemadipsa rjukjuana* and *H. japonica*.

end of body to the head; venter more or less flat in relaxed specimens. Head of dorsal anterior sucker with usual sub-triangular outline (Fig. 2B); venter of lip with the broad median field marked by narrow, longitudinal ridges and a deep median fissure. Anterior sucker deep, wide, triangularly cupuliform with well-developed lateral buccal lobes and frill. Posterior sucker nearly circular, slightly longer than wide, diameter equal to or a little larger than maximum body width, with a definite anterior median prominence but no sharply hooked papilla. Auricles large, white, trilobate with the middle lobe smallest, and conspicuous by their color in contrast with the body color.

Dorsum strongly tessellated, with areas bearing semi-transparent tipped sensillae in addition to the sensory annuli of each somite. Venter tessellated less and more smooth than dorsum. Dorsum of posterior sucker tessellated, with five or six irregular circles of polygonal areas. Venter of posterior sucker with rays 67 to 72, mostly 71, which in strongly flattened ridges terminating in little rounded lobes at the margin, and not penetrating into the central areolated region.

When alive, body color of reddish brown, or yellow brown in some specimens. Dorsum with three to five longitudinal, black or dark broken stripes of more or less partially and mutually connecting by dark spots in a broad, bluish gray, yel-



Figure 2. *Haemadipsa picta*. A Dorsum. B Dorsal head. C Reproductive system. atr. Atrium; eb. Ejaculatory bulb; ed. Ejaculatory duct; ep. Epididymis; ov. Ovary; te. Testisacs; vad. Vaginal duct; vd. Vas deferens; vs. Vaginal sac. XI and XV indicate the orders of the ganglia. Each scale indicates 1 mm in the figure respectively.

low-greenish, or multicolored median-paramedian field (Fig. 2A). In lateral body, white, pale yellowish, or dusty yellow-greenish marginal stripes bordered by a series of black spots submarginally and supramarginally, especially in half-posterior body. Venter uniform, yellowish brown or resembling color brighter than that in the dorsum, without any spots or stripes. Dorsum of posterior sucker yellow-greenish or yellowish brown, similar to the venter body. Venter of posterior sucker fawn, brighter than venter body.

Eyes five pairs, punctiform, arranging respectively at II (2^{nd} annulus), III (3^{rd} annulus), IV (4^{th} annulus), V (6^{th} annulus) and VI (9^{th} annulus) in parabolic arc (Fig. 2B).

Ninety seven annuli. I, II and III uniannulate, with irregular areas divided and with sensillae in the interocular region. IV biannulate ((a1a2)>a3) and the interocular region being divided into irregular areas with sensillae in two transverse and sometimes oblique rows. V biannulate dorsally ((a1a2)>a3) and uniannulate ventrally, with the a3 as the oral margin of the buccal ring and also the first perfectly definite annulus. VI triannulate (a2>a1>a3). VII triannulate with the three annuli approximately equal. VIII quadrannulate (a1=a2>b5=b6). IX quinquannulate (a2>b1=b2=b5=b6). X–XXII midbody somite and quinquannulate, with the five annuli of the same length and a2 projecting slightly above the surface. XXIII quadrannulate (a2>a1= b5>b6). XXIV triannulate (b1=b2<a2), with b1 & b2 united at the margins and much reduced ventrally, and a2 bearing the first auricular lobe. XXV and XXVI uniannulate. Anus in the furrow between XXVII (97th annulus) and the posterior sucker. Gonopores separated by five annuli; male at XI b5/b6 (31st/32nd annulus); female at XII b5/b6 (36th/37th annulus); both moderately large transverse slits strictly within furrows.

Internal morphology. Jaws three, crescent-shaped, small and less prominent, with 78–80 teeth; one mid-dorsally, the other paired ones ventro-laterally, all in deep buccal chamber beyond the velum. Pharynx in VII–VIII, short, bulbous; with spongy muscular walls bearing many radiating fibers and surrounded by numerous unicellular salivary glands; extended into crop in IX. Crop in IX–XIX; with 11 pairs of caeca in each somite respectively; first 10 pairs simple and unlobed, while the tenth pair of caeca in XIX elongated posteriorly to XXIII and lateral to intestine. Intestine in XIX–XXIII, no caeca, with sharp sigmoid flexure and ventral to rectum in XXIII. Rectum short, sharply tapered towards anus.

Ten pairs of testisacs at XIII/XIV–XXII/XXIII. Vas deferens enters epididymis in XIII. Epididymis in XII–XIII, massive, convoluted together, totally posterior to the atrium and covered on a small part of the cephalic end of the vaginal sac. Ejaculatory bulbs of moderate size and form, lying at a low level by the sides of the atrium, and connected by slender ejaculatory ducts to atrium in XI. Atrium large, conspicuous, rising well dorsad of the level of the nerve cord passing along in the left side. Prostate glands a layer of highly compact. Ovisacs in XII/XIII, on which with common oviduct long, sigmoid and slender. Vaginal stalk distinctly shorter than vaginal sac, which of an elongated egg-shape with the small apical end directed caudad in XIV–XVI (Fig. 2C).

Distribution. This species is only recorded in South East Asia, including the Indo-Chinese Peninsula and Borneo. In Taiwan, it is a newly recorded species, and was collected in the moist forests of low- and middle-elevation mountains in Yilan, Hualien and Taitung during our recent surveys (Fig. 4).

Habitat. Commonly found on bushes about 1 m above the ground in moist forests. **Host.** Primarily medium- or large-sized mammals, including humans.

Remarks. Unlike many other land leech species which remain on the ground and grass below knee-level, this species usually climbs and waits on bushes and grasses at about 1 m above the ground, and attaches to the hands, arms, shoulders and even neck of passers-by (Keegan et al., 1968). This species has been known to fall onto hikers

from higher bushes or leaves (Chun-Chia Huang, Pers. Comm.). In comparison to other land leech species, the bites of this species are much more painful and difficultto-heal; thus, *H. picta* has been given the common name "stinging land leech" (Moore, 1929). Such painful and difficult-to-heal bites were also confirmed by a friend who collected specimens of *H. picta* for us (Chun-Chia Huang, Pers. Comm.). However, this common name should be shared with another similar species, *H. ornata* Moore, because it also has a similarly painful bite to *H. picta* (Moore, 1929). Nevertheless, this common name is rarely used for *H. picta*, while the name, "tiger leech", has been more commonly used, which refers to the colorful striped pattern (i.e., "picta" in the scientific name).

Tritetrabdella taiwana (Oka, 1910)

http://species-id.net/wiki/Tritetrabdella_taiwana

Haemadipsa japonica var. taiwana Oka, 1910. Annot. Zool. Jap. 7: 165–183 Haemadipsa zeylanica Takahashi, 1934. Rep. Jpn. Sci. Assoc. 10: 744–749

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Tritetrabdella taiwana Lai and Chen, 2005. Note Newsl. Wildlifers 9: 10–14 *Tritetrabdella taiwana* Lai et al., 2009. Zootaxa 2068: 27–46

Material examined. L00084 collected at 9th Jun. 2002 in Wulai Town, Taipei County; L00085 collected at 11th Oct. 2003 in Nantou County; L00086 & L00087 collected at 1st Jun. 2004 in Taipei Zoo, Taipei City; and L00109 collected at 15th Feb. 2007 in Taipei City.

Diagnosis. This species can be recognized by the yellowish dorsum with three dark or black bordered brown stripes, in which the supramarginal pair is simple, and the mid-dorsal one has a few irregular, asymmetrical, elongated circles or loops that extend laterally between two stripes. These circles or loops are either connected the mid-dorsal and the supramarginal stripes, or are disconnected from the stripes to form isolated brown spots with a dark border between the two stripes (Fig. 3A). A mid-body somite with four annuli, rather than the usual five annuli of other land leech species in Taiwan, is also an easily recognized characteristic of this species.

External morphology. Body length 12–25 mm, maximum body width 2–4 mm in relaxed specimens and 4–6 mm in specimens filled with blood; anterior sucker diameter 2.0–2.6 mm, posterior sucker diameter 3.0–4.5 mm. Body elongated, slenderly cylindrical, with dorsum depressed moderately from the end to the head; venter



Figure 3. *Tritetrabdella taiwana*. **A** Dorsum. **B** Dorsal head. **C** Reproductive system. atr. Atrium; eb. Ejaculatory bulb; ep. Epididymis; ov. Ovary; vs. Vaginal sac. XI and XIX indicate the orders of the ganglia. Each scale indicates 1 mm in the Figure respectively.

flat. Clitellum usually conspicuously wider and thicker. Head of dorsal anterior sucker with broadly rounded, less sub-triangular outline (Fig. 3B); venter of lip soft and finely granular, with no permanent furrows anteriorly but a median fissure posteriorly continuing forward the median velar sinus. Anterior sucker deep, wide, triangularly cupuliform with well-developed lateral buccal lobes and frill. On the sides and floor of the buccal chamber are four pairs of folds or lobes reaching to the membranous velum, through the triangular opening of which the three jaws are visible. Posterior sucker large, broadly ovate, slightly longer than wide, diameter larger than maximum body width, with a definite anterior median prominence but no sharply hooked papilla. Auricles obscure, small, white, and trilobate with the middle lobe smallest.



Figure 4. The distribution map of collecting sites for the specimens of the three land leech species collected in recent surveys.

Dorsum strongly tessellated and areolated, with areas bearing semi-transparent tipped and inconspicuous sensillae on each somite. Venter tessellated less, nearly smooth. Dorsum of posterior sucker tessellated, with four or five irregular circles of polygonal areas. Venter of posterior sucker with rays 57 to 61, not extending into the center and leaving a depressed, faintly tessellated circular central area.

Dorsum yellowish, with three broad, dark or black bordered brown stripes, in which the supramarginal pair simple, and the mid-dorsal one with a few irregular, asymmetrical, elongated circles or loops extending laterally between two stripes. Sometimes these circles or loops either connect the mid-dorsal and the supramarginal stripes, or disconnected from stripes and become isolated brown spots with dark border between two stripes. These stripes differ in exact form and position on each individual. In long preserved specimens, however, color of brown stripes has faded, leaving only longitudinal irregular and asymmetrical black borders on the dorsum (Fig. 3A). Venter uniformly yellowish as the dorsum. Dorsum of posterior sucker yellowish; venter of posterior sucker yellowish, or paler than venter body.

Eyes five pairs, punctiform, large and conspicuous (especially the 1st and 2nd pairs), arranging respectively at II (2nd annulus), III (3rd annulus), IV (4th annulus), V (5th annulus) and VI (8th annulus) in parabolic arc (Fig. 3B).

Eighty-two annuli. I uniannulate, with two rows of areola in which the anterior row much smaller and like those of the ventral face of the lip. II and III uniannulate, with the interocular region being divided into two areas in III. IV uniannulate, with the interocular region being divided into four areas. V biannulate dorsally ((a1a2)>a3) with six interocular areas in the first annulus of this somite in dorsum; uniannulate ventrally as the buccal ring. VI triannulate dorsally (a2>a3>a1) and biannulate ventrally ((a1a2)>a3). VII triannulate (a1=a2<a3). VIII quadrannulate (a1=a2>b5=b6). IX–XXII midbody somite and quadrannulate, with the four annuli of the same length. XXIII triannulate (a1=a2>a3), with a1 & a2 partly united ventrally. XXIV triannulate with the three annuli of the same length. XXV biannulate ((a1a2)>a3), with annuli being divided into irregular polygonal areas, and each annulus bearing the first and second auricular lobes at the margins. XXVI uniannulate, being divided into irregular polygonal areas and with the third auricular lobe at the margins. XXVII uniannulate, being divided into irregular polygonal areas. Anus in XXVII (82nd annulus). Clitellum from X b5 (23rd annulus) to XIII a2 (34th annulus). Gonopores separated by three and a half annuli; male at XI b5/b6 (27th/28th annulus); female at XII b5 (31st annulus).

Internal morphology. Jaws three, crescent shaped, small and very prominent, with about 45 teeth of the usual form and no salivary papillae. Pharynx in VII–IX, long and wide with spongy wall. Crop in X–XIX; with 10 pairs of caeca in each segment respectively; first nine pairs simple and unlobed, while the last pair of caeca in XIX elongated posteriorly to XXIV and lateral to intestine. Intestine in XIX–XXIV, without caeca, tapered sharply to rectum in XXIV. Rectum large and wide, tapered towards anus in XXVII.

Ten pairs of testisacs at XIII/XIV–XXII/XXIII. Vas deferens enters epididymis in XV and XVI. Epididymis always posterior beyond the vaginal sac, located variably in

XV–XVII, in some cases from XIII to XIV with a long tail-like caudal part extending from XIV to XXVIII,; moderately to slightly massive, entangled with each other as a whole mass, and with the anterior part of the mass usually covering on or covered by the vaginal sac. Ejaculatory bulbs large, elongated ellipsoid, lying at about the same level lateral-posteriorly or even totally posteriorly to the atrium, and connected by thick and short ejaculatory ducts to atrium in XI. Atrium moderate or small sized, round, rising dorsad of the level of the nerve cord passing along in the right side. Prostate glands of a thick layer covered on the atrium, ejaculatory duct, and anterior part of the ejaculatory bulbs. Ovisacs in XII, with very short oviduct joined into a short, slender, and curled common oviduct. Vaginal sac located variably in XII–XV, elongated ovate, with a very short vaginal stalk extended ventro-anteriorly into female gonopore in XII (Fig. 3C).

Distribution. This species is only recorded in East and South East Asia, including the Indo-Chinese Peninsula, Ryukyu Islands of Japan, and Taiwan. In Taiwan, this species is recorded in the moist forests of low- and middle-elevation mountains around the island. In our recent surveys, it was collected in Taipei, Nantou, Pingtung, Yilan, and Hualien (Fig. 4).

Habitat. Commonly found on the ground in moist forests. It attaches to leaf litter, grasses, and bushes on the ground.

Host. Amphibians and medium- or large-sized mammals. The amphibian is probably the primary host, as this species has been frequently recorded parasitizing frogs and toads in Taiwan, including the common toad *Bufo bankorensis* Barbour, the Taipei green tree frog *Rhacophorus taipeianus* Liang & Wang, the temple tree frog *Chirixalus idiootocus* Kuramato & Wang, Swinhoe's frog *Rana swinhoana* Boulengeer, and the olive frog *Rana adenopleura* Boulengeer.

Remarks. Although Oka (1910) recorded that *T. taiwana* causes a considerable amount of injury by taking blood meals in the nasopharyngeal region of mammals, such as dogs and humans, there is doubt about such parasitic behavior in this species. Oka (1910) mentioned that the leeches of this species enter the nostrils of dogs and men to feed on blood by fastening to the mucous membranes of the nasal passages. However, based on Keegan et al. (1968) and our direct observations of the movement and attaching ability of this species, we argue that the leeches recorded as parasitic in the nasal cavities of mammals may in fact be the nasal leech *Dinobdella ferox* (Blanchard), which is a notorious leech species that specifically parasitizes the nasopharyngeal region of mammal hosts for fast growth before maturation, rather than *T. taiwana*.

In addition, because *T. taiwana* was the only land leech species that has been recorded feeding on frog and toad hosts, sometimes even in groups, it is possible that this species mainly acquires blood from amphibian hosts, whereas mammals covered in body hair are not a primary diet choice. This suggestion may also explain that, while *T. taiwana* is as widely distributed as other land leech species in Taiwan, such as *Haemadipsa rjukjuana*, there are fewer records of *T. taiwana* attacking hikers.



Figure 5. Neighbor joining tree of bloodfeeding land leeches based on COI sequences. Bootstrap values above 50 are shown. Specimens of *H. rjukjuana*, *H. picta* and *T. taiwana* from Taiwan are marked in bold.

DNA barcoding analyses

The neighbor-joining tree of haemadipsoid COI genes has high bootstrap support values for the monophyly of each of *H. rjukjuana*, *H. picta*, *T. taiwana*, and *M. gemmata* (Fig. 5). The barcoding results also strongly support that *H. rjukjuana* is genetically distinct from *H. japonica*, with the occurrence of *H. picta* in Taiwan also being confirmed. In addition, the phylogenetic relationship of *T. taiwana* as a member of the haemadipsoid leech is also revealed. Our analysis shows that, as a trignathous species, *T. taiwana* is phylogenetically more closely related to duognathous land leech species as opposed to other trignathous species (Fig. 5). This result was also found in a recent study (Borda & Siddall, 2011), in which the authors suggested the establishment of a new subfamily, Tritetrabdellinae, for the newly identified trignathous clade of the genus *Tritetrabdella*.

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RESEARCH ARTICLE



A key to species of the genus Gastroserica Brenske of the China (Coleoptera, Scarabaeidae, Sericini), with the description of two new species and two new records for China

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Abstract

Based on a revision of the material housed in Chinese collections and a key to species of *Gastroserica* of China is provided. Two new species are described, habitus photographs, and illustrations of the genitalia are given: *Gastroserica nigrofasciata* **sp. n.** (from China: Guangxi and Guizhou Prov.), *G. yunnanensis* **sp. n.** (from China: Yunnan Prov.). Besides, illustrations of the genitalia of species mentioned in the key are provided. Additional distribution records of the *Gastroserica* species including an updated distribution map are given.

Keywords

Coleoptera, Scarabaeidae, Sericini, Gastroserica, China, new species, key

Introduction

The genus *Gastroserica* was established by Brenske (1897) based on the character of antenna (club with four antennomeres in males, but with three or four in females) and the obsolete anterior angles of pronotum. Currently, the genus is defined by the club with four antennomeres in males, but with three or four in females; mentum oblate; anterior angles of pronotum not produced; pygidium long, apically produced, not completely covered by elytra.

The species of the genus from Asiatic mainland were revised by Ahrens (2000). Since that contribution, eight additional species were described (Ahrens 2002, 2007, Ahrens and Pacholátko 2003). So far, there are 35 species described, all occurring in East and Southeast Asia. From China, so far 20 species are recorded. In this paper, we survey the material hold in Chinese institutional collections. This rich material contained two new taxa that are described herein. In addition to published data, new distribution data including two new species records from China are given, along with an updated distribution map and a key to the species of *Gastroserica* occurring in China.

Material and methods

All descriptions and measurements were made under an Olympus SZ 61 microscope, and all figures were made with a digital camera (Nikon D300S) attached to a stereomicroscope (Zeiss Discovery V12) and Helicon Focus 5.1 software. The distribution map was made with ArcGIS9.2 and Adobe Photoshop CS3. Type specimens and other material are deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZAS), College of Life Sciences, Sun Yat-sen University, Guangzhou, China (LSSYU), National Museum Prague (Natural History), Czech Republic (NMPC), Zoologisches Forschungsmuseum A. Koenig Bonn, Germany (ZFMK).

Taxonomy

Key to the genus Gastroserica of China

Labroclypeus widest at middle, lateral margins more or less distinctly nar-	1
rowed towards base, or subparallel. Pronotum with or without longitudinal	
median impressions	
Labroclypeus widest at base, lateral margins narrowed anteriorly. Pronotum	_
without longitudinal median impression	
Disc of pronotum with shallow longitudinal median impression or addition-	2
ally with a transverse impression behind the middle	
Disc of pronotum without a shallow longitudinal median impression9	_
Disc of pronotum with a transverse impression behind the middle	3

_	Disc of pronotum only with a shallow longitudinal median impression7
4	Eyes strongly protruding, labroclypeus very narrow (ratio maximal width of
	head including eyes/ width of labroclypeus: 1.8–1.9). Pygidium strongly co-
	nical. Pronotum with distinct median transversal impression
	G. impressicollis (Fairmaire, 1891)
_	Eves weakly protruding, labroclypeus relatively wide (ratio maximal width
	of head including eves/ width of labroclypeus: 1.48) Providium moderately
	convex Median transversal impression on proportium weak
5	Dropotum with a distinct longitudinal modian improving on the disc and a
)	ronotum with a distinct longitudinal median impression on the disc and a
	round median impression benind the disc
_	Pronotum with only a longitudinal median impression on the disc
6	Frontoclypeal suture indistinctly impressed. Pronotum with several setae in
	the longitudinal median impression. Aedeagus with a long apophysis on the
	left side of the apical phallobase, and the dorsal lobe of left paramere split from
	basal lobe at base (Fig. 2. J–L) <i>G. kucerai</i> Ahrens & Pacholátko, 2003
-	Frontoclypeal suture distinctly impressed. Pronotum with few setae in the longi-
	tudinal median impression. Aedeagus without a long apophysis on the left side of
	the apical phallobase, and the dorsal lobe of left paramere split from 'basal' lobe
	at middle of paramere's length (Fig. 2 G–I)
7	Punctures on pronotum fine, simple and scarcely scattered; median longitu-
	dinal impression fine and superficial
_	Pronotum strongly and densely punctate, between punctures additionally
	with microscopic fine punctures: median longitudinal impression robust
	<i>G. sulcata</i> Brenske, 1897
8	Both parameters simple, the left one pointed externally (Fig 4 P)
0	<i>G. bicolor</i> Nijima & Kinoshita. 1923
_	Both parameters bifurcate the left one pointed medially (Fig 3 A_{-} C)
	<i>G hargi</i> (Heyden 1887)
0	Appendix of phallobasis short and wide apically lobiform and rounded
)	(Eig 2 L L)
	(11g, 5) = L
-	Aphophysis of phanobasis long and sharply pointed
10	Lateral margins of labroclypeus strongly reflexed
	G. angustula Brenske, 189/
_	Lateral margins of labroclypeus weakly reflexed
11	Disc of pronotum with punctures of equal size bearing minute setae. Apex of
	elytra sclerotized, without a rim of minute microtrichomes. Apical apophysis
	of phallobasis apically without a sharp hook12
-	Disc of pronotum with large punctures bearing each a robust seta and be-
	ing twice as large as smaller ones. Apex of elytra with a membraneous rim
	composed of minute microtrichomes. Apical apophysis of phallobasis apically
	with a sharp hook17
12	Ocular canthus short, ratio length of ocular canthus/ ocular diameter: < 0.33 13
_	Ocular canthus long, ratio length of ocular canthus/ ocular diameter: > 0.4214

13	Apophysis of phallobasis long, exceeding the parameres in length (Fig.3
	M–O) G. fanjingensis Ahrens, 2000
-	Apophysis of phallobasis very short, distinctly shorter than the parametes
	(Fig. 4 D–F) <i>G. nikodymi</i> Ahrens, 2000
14	Metatibia externally along the middle very densely and coarsely punctate.
	Metatasromere 1 slightly shorter than the two following tarsomeres com-
	bined. Colour of pronotum and elytra yellowish brown, sometimes with dark
	spots G. asulcata Ahrens, 2000
_	Metatibia externally along the middle with moderately to feebly punctate.
	Metatasromere 1 distinctly longer than the two following tarsomeres com-
	bined. Colour of pronotum and elytra dark brown
15	Pronotum with two black spots on the disc. Dorsal part of left paramere
	strongly bent (Fig. 4 J–L)
_	Pronotum without spots on the disc. Dorsal part of left paramere slightly
	bent or straight
16	Frontoclypeal suture indistinctly impressed. Phallobase with a wider right
	paramere (Fig. 4 M–O) G. guizhouana Ahrens, 2000
_	Frontoclypeal suture distinctly impressed. Phallobase with a more slender
	right paramere (Fig. 3 P–O) G. shaanxiana Ahrens & Pacholátko, 2003
17	Even intervals of elvtra black, but behind the middle, all the intervals black,
	with two brown spots at the apex of elvtra. Interior apical angle of elvtra with
	a strong seta (Fig. 1 J). Apex of right paramere sharp (Fig. 1 A–C)
	<i>G. vunnanensis</i> sp. p.
_	Only the intervals next to the edge of elytra brown to black, without spots at
	the apex of elvtra. Interior apical angle of elvtra without strong setae. Apex of
	right paramere blunt (Fig. 4 G_I)
18	Left and right parameters fused ventrally (Fig. 2 M_{-})
10	<i>C. marginalis</i> (Brendze 1897)
	Left and right parameters separated 10
10	Derral lobe of left personals strongly surved ventrally. Aper of phillobesis
19	Dorsal lobe of left parameter strongly curved ventrally. Apex of phanobasis
	with a short pointed apophysis at right side (Fig. 1 $D-F$)
	G. nigrofasciata sp. n.
_	Dorsal lobe of left parameter short and straight, strongly curved ventrally.
	Apex of phallobasis without a short apophysis at right side (Fig. 3 D–F)
	G. yingi Ahrens & Pacholátko, 2007

Gastroserica yunnanensis Liu, Ahrens, Bai & Yang sp. n. urn:lsid:zoobank.org:act:7385F187-5998-41D6-98BE-2331467C7D02 http://species-id.net/wiki/Gastroserica_yunnanensis

Type material. Holotype: $1 \circlearrowleft$ "Caiyang River Nature Preserve, Pu'er, Yunnan, 28–29.8.2007, Shi Lei leg." (LSSYU). Paratypes $(1 \circlearrowright +1 \updownarrow)$: $1 \circlearrowright$ "Caiyang River Nature Pre-



Figure 1. A-C Gastroserica yunnanensis sp. n. D-F G. nigrofasciata sp. n. G Habitus, G. yunnanensis sp. n. H Habitus, G. nigrofasciata sp. n. I Interior apical angle of elytra of G. yingi, with strong seta (the longer one). A, D aedeagus, left side lateral view B, E paramere, dorsal view C, F aedeagus, right side lateral view. Scale bar=1mm.

serve, Pu'er, Yunnan, 28–29.8.2007, Shi Lei leg."(LSSYU); 1♀"Caiyang River Nature Preserve, Yunnan, 28–29.8.2007, Li Jiahui leg." (LSSYU).

Description. Length: 6.0–7.0 mm, length of elytra: 4.5–5 mm, width: 3.5–4.0 mm. Body oval, elytra brown, dorsal surface pale yellow to pale brown, densely covered with short, fine, adpressed setae and with moderately dense, long, erect setae interspersed, abdominal sternites dark brown to black. (Fig. 1 G)

Labroclypeus subrectangular and short, widest before apex, lateral margins straight, nearly parallel to each other and weakly convergent toward base, anterior angles broadly rounded, lateral border and ocular canthus produced into a distinct obtuse angle, anterior margin weakly reflexed, straight, surface weakly convex medially and moderately shiny, very coarsely and sparsely punctate, with several long, erect setae; frontoclypeal suture distinctly impressed and moderately curved, smooth area



Figure 2. A-C Gastroserica asulcata Ahrens, 2000 D-F G. hubeiana Ahrens, 2000 G-I G. sichuanana Ahrens, 2000 J-L G. kucerai Ahrens & Pacholátko, 2003 M-O G. marginalis (Brenske, 1897) P-R G. impressicollis (Fairmaire, 1891). A, D, G, J, M, P aedeagus, left side lateral view B, E, H, K, N, Q paramere, dorsal view C, F, I, L, O, R – aedeagus, right side lateral view. Scale bar=1mm.



Figure 3. A-C Gastroserica herzi (Heyden, 1887) D-F G. yingi Ahrens & Pacholátko, 2007 G-I G. sulcata Brenske, 1897 J-L G. haucki Ahrens, 2000 M-O G. fanjingensis Ahrens, 2000 P-R G. shaanxiana Ahrens & Pacholátko, 2003. A, D, G, J, M, P aedeagus, left side lateral view B, E, H, K, N, Q paramere, dorsal view C, F, I, L, O, R aedeagus, right side lateral view. Scale bar=1mm. (P-R from Ahrens and Pacholátko 2003)



Figure 4. A–C Gastroserica angustula Brenske, 1897 D–F G. nikodymi Ahrens, 2000 G–I G. bilyi Ahrens, 2000 J–L G. guangdongensis Ahrens, 2000 M–O G. guizhouana Ahrens, 2000 P G. bicolor Nijima & Kinoshita, 1923. A, D, G, J, M aedeagus, left side lateral view B, E, H, K, N, P paramere, dorsal view C, F, I, L, O aedeagus, right side lateral view. Scale bar=1mm. (A–O from Ahrens 2000, and P from Nomura 1974)

in front of eye slightly wider than long (1.5/1); ocular canthus moderately short and slender, finely and densely punctate. Frons completely black or only the part near the posterior portion brown, other parts of frons black, with coarse, dense punctures, with fine punctures irregularly interspersed, densely erectly setose. Eyes moderately large, ratio of diameter/ interocular width: 0.6. Antenna yellow, club yellow to brown, with ten antennomeres club with four antennomeres equal in length, the length of club a little longer than the remaining antennomeres combined. Mentum strongly elevated and flattened anteriorly.

Pronotum subrectangular, widest at anterior third, lateral margins strongly convergent anteriorly, before posterior angles weakly sinuate, anterior angles not produced and strongly rounded, almost obsolete, posterior angles moderately blunt and moderately produced outward, anterior margin almost straight, with a distinct and fine marginal line, basal margin moderately curved without marginal line, but two weak impressions at a quarter to the lateral margins; surface with moderately dense and fine punctures, with numerous minute setae, which are bent backwards, with a longitudinal, straight, brown line in the middle and two black spots at sides of the disc; anterior and lateral borders setaceous; basal margin of hypomeron strongly produced ventrally, before base distinctly transversely sulcate. Scutellum nearly triangular, apex weakly rounded, with fine and dense punctures, medially smooth and weakly elevated, minute setae present in the punctures.

Elytra oblong, widest at middle, striae distinctly impressed and finely densely punctate, intervals weakly convex, with fine and sparse punctures that are almost concentrated along the striae, minutely setose in the punctures, odd intervals with single coarse punctures bearing each a strong erect seta, near the anterior margin, even intervals black, but behind the middle, all intervals black, with two brown spots at the apex of elytra; epipleural edge moderately strong, ending at the strongly convex external apical angle of elytra, epipleura densely setaceous, apical border chitinous, without short microtrichomes.

Ventral surface dull, with large and dense punctures, with dense, short setae, setae adpressed, metacoxa partly glabrous, laterally with fine adpressed setae, each abdominal sternite with an indistinct transversal row of coarse punctures bearing a short, strong seta between fine and dense punctation, all sternites with fine, short setae. Mesosternum between mesocoxae almost as wide as mesofemur, with numerous strong setae. Ratio of length of metepisternum/ metacoxa: 1/ 1.82. Pygidium long, apically produced and strongly convex, with fine and dense punctures bearing fine setae and a few robust punctures bearing robust setae, without smooth midline.

Legs pale yellow to brown, moderately slender and shiny; femora finely densely punctate and setose, with two longitudinal rows of setae; anterior edge of metafemur acute, lacking an adjacent serrated line, posterior margin weakly convex, with a few fine setae medially, ventrally weakly widened in apical half but not serrate, dorsally serrate, with short setae. Metatibia moderately broad, at middle convexly widened, ratio width/ length: 1/3.4, dorsally sharply carinate, with two groups of spines, the basal group at one third, apical one at two third of metatibia length, basally with a few single spines in punctures; lateral face longitudinally convex, with dense and moderately coarse punctures, some of them longitudinally impressed, ventral edge serrated, medial face not punctate and smooth, apex interiorly near tarsal articulation sharply truncate. Tarsomeres dorsally glabrous and finely punctate, ventrally with sparse, short setae, metatarsomeres dorsally with strong longitudinal impressions, ventrally with a strongly serrated ridge, laterally with a strong longitudinal carina, first metatarsomere as long as the following two tarsomeres combined and twice as long as the upper tibia spur. Protibia short, bidentate, protarsal claws symmetrical.

Aedeagus. Fig. 1 A-C.

Variation. Smooth area in front of eye wider than long (the rate from 1.5/1 to 1.7/1). Ratio of eye diameter / interocular width: (0.60–0.62). There are no brown spots at the end of elytra in some specimens, and after the middle, the odd intervals are still brown. Ratio of length of metepisternum/ metacoxa: (0.43–0.55).

Diagnosis. *Gastroserica yunnanensis* sp. n. is very similar to *G. bilyi* Ahrens, 2000, in shape of male genitalia and habitus. It maybe differentiated from *G. bilyi* by two brown spots at the end of elytra and sharp apex of right paramere.

Derivatio nominis. Named according to its provenience from Yunnan. **Distribution.** Fig. 5.

Gastroserica nigrofasciata Liu, Ahrens, Bai & Yang sp. n. urn:lsid:zoobank.org:act:2957A427-53AC-49A4-87E3-9FF333BF5D03 http://species-id.net/wiki/Gastroserica_nigrofasciata

Type material. Holotype: $1 \Diamond$ "Mt. Tianping Shan, Longsheng, Guangxi, 740 m, 9.6.1963, Wang Shuyong leg." (IZAS). Paratypes $(1 \Diamond + 5 \heartsuit \heartsuit)$: $1 \Diamond$ "Hongmaochong, Longsheng, Guangxi, 900 m, 10.6.1963, Shi Yongshan leg." (ZFMK); $1 \heartsuit$ " Hongmaochong, Longsheng, Guangxi, 900 m, 10.6.1963, Shi Yongshan leg." (ZFMK); $1 \heartsuit$ " Hongmaochong, Longsheng, Guangxi, 900 m, 10.6.1963, Wang Shuyong leg." (IZAS); $1 \heartsuit$ "Mt. Tianping Shan, Longsheng, Guangxi, 740 m, 4.6.1963, Wang Shuyong leg." (IZAS); $1 \heartsuit$ " Neicu River, Longsheng, Guangxi, 840 m, 7.6.1963, Wang Shuyong leg." (IZAS); $1 \heartsuit$ "Mt. Fanjing Shan, Jiangkou, Guizhou, 530 m, 12.7.1988, Wang Shuyong leg." (IZAS).

Description. Length: 5.6–8.0 mm, length of elytra: 4.1–5.1 mm, width: 3.2–4.1 mm. Body oval, elytra and dorsal surface both yellow, densely covered with short, fine adpressed setae and with moderately dense, long, erect setae interspersed (Fig. 1 H).

Labroclypeus subrectangular and short, widest at base, lateral margins straight and moderately divergent from anterior angles to base, anterior angles broadly rounded, lateral border and ocular canthus produced into a distinct obtuse angle, anterior margin weakly reflexed, straight, surface weakly convex medially and moderately shiny, very coarsely and sparsely punctate, with several long, erect setae; frontoclypeal suture distinctly impressed and strongly curved, smooth area in front of eye distinctly wider than long (1.8/1); ocular canthus moderately short and strong, finely and densely punctate. Frons with coarse, dense punctures, with fine punctures irregularly interspersed, densely erectly setose. Eyes moderately large, ratio of diameter/ interocular width: 0.63. Antenna brown, with ten antennomeres, club in male with four antennomeres, first joint of club slight shorter than the others, club slightly longer than the remaining antennomeres combined. Mentum elevated and flated anteriorly.

Pronotum rectangular, widest at half of length, lateral margins strongly convergent anteriorly, before posterior angles weakly sinuate, anterior angles not produced and



Figure 5. The distribution records of *Gastroserica yunnanensis*, *G. nigrofasciata*, *G. bilyi*, *G. haucki*, *G. sichuanana* and *G. fanjingensis* from China.

strongly rounded, almost obsolete, posterior angles moderately blunt and weakly produced outward, anterior margin almost straight, with a distinct and fine marginal line, basal margin moderately curved without marginal line, and two weak impressions at quarter of width to the lateral margins; surface with moderately dense and fine punctures, with numerous minute setae, which are bent backwards and two black spots at the middle, along the middle weakly medially impressed, with a weakly elevated transverse carina behind the middle; anterior and lateral borders setaceous; basal margin of hypomeron strongly produced ventrally, before base distinctly transversely sulcate. Scutellum nearly triangular, apex weakly rounded, with fine and dense punctures, medially smooth, minute setae present in the punctures.

Elytra oblong, widest at middle, striae distinctly impressed and finely densely punctate, intervals weakly convex, with fine and sparse punctures that are almost concentrated along the striae, minutely setose in the punctures, odd intervals with single coarse punctures bearing each a strong erect seta, even intervals brown to black; epipleural edge moderately strong, ending at the strongly convex external apical angle of elytra, epipleura densely setaceous, apical border chitinous, without short microtrichomes.

Ventral surface dull, with large and dense punctures and dense short setae, setae adpressed, metacoxa partly glabrous, laterally with fine adpressed setae, each abdominal sternite with indistinct transversal row of coarse punctures bearing each a short strong seta between fine and dense punctation, all sternites with fine, short setae. Mesosternum between mesocoxae almost as wide as mesofemur, with numerous strong setae. Ratio of length of metepisternum/ metacoxa: 1/ 2.0. Pygidium long, apically produced and strongly convex, with fine and dense punctures bearing fine setae and a few robust punctures bearing each a robust seta, without smooth midline.

Legs pale yellow to yellow brown, moderately slender and shiny, femora finely densely punctate and setose, with two longitudinal rows of setae; anterior edge of metafemur acute, lacking an adjacent serrated line, posterior margin weakly convex, with a few fine setae medially, ventrally weakly widened in apical half but not serrate, dorsally serrate, with short setae. Metatibia moderately broad, at middle convexly widened, ratio width/ length: 1/ 3.2, dorsally sharply carinate, with two groups of spines, the basal group at one third, apical one at two third of metatibial length, basally with a few single spines in punctures; lateral face longitudinally convex, with dense and moderately coarse punctures, some of them longitudinally impressed, ventral edge serrated; medial face not punctate and smooth, apex interiorly near tarsal articulation sharply truncate. Tarsomeres dorsally glabrous and finely punctate, ventrally with sparse, short setae, metatarsomeres dorsally with strong longitudinal impressions, ventrally with a strongly serrated ridge, laterally with a strong longitudinal carina, first metatarsomere as long as the following two tarsomeres combined and twice as long as the upper tibia spur. Protibia short, bidentate, protarsal claws symmetrical.

Aedeagus. Fig.1 D-F.

Variation. Smooth area in front of eye wider than long (the rate from 1.8/1 to 2.0/1). Eyes weakly large, ratio of diameter/ interocular width: (0.60–0.67). Club a little shorter than the remaining antennomeres combined in female. Elytra from yellow to brown, with greenish metallic shine. Three intervals next to the lateral margins of elytra sometimes black. Ratio of length of metepisternum/ metacoxa: (1/ 1.82–2.).

Diagnosis. *Gastroserica nigrofasciata* sp. n. is in habitus very similar to *G. marginalis* (Brenske, 1897). It maybe differentiated from *G. marginalis* by the colour of elytra and dorsal surface, the presence of two long lateral apophyses at the apex of phallobasis, and the shape of parameres.

Derivatio nominis. From the Latin words "*nigro-*" and "*fasciata*" meaning black stripes.

Distribution. Fig.5.

New locality records

Gastroserica bilyi Ahrens, 2000 http://species-id.net/wiki/Gastroserica_bilyi

Gastroserica bilyi Ahrens, 2000: 113.

Material examined. 1∂"Meng'a, Xishuangbanna, Yunnan, 1050 m, 20.5.1958, Pu Fuji leg." (IZAS).

Notes. This is a new record for China, the species was so far known only from Thailand and Laos.

Distribution. Fig.5.

Gastroserica haucki Ahrens, 2000

http://species-id.net/wiki/Gastroserica_haucki

Gastroserica haucki Ahrens, 2000: 110.

Material examined. $2\Im \Im$ "Menghun, Xishuangbanna, Yunnan, 1200–1400 m, 22.5.1958, Zhang Yiran leg."(IZAS); $2\Im \Im$ " Menghun, Xishuangbanna, Yunnan, 1200–1400 m, 22.5.1958, Zhang Yiran leg."(IZAS); $1\Im$ "Menghun, Xishuangbanna, Yunnan, 1200–1400 m, 21.5.1958, Meng Xuwu leg."(IZAS).

Notes. This is a new record for China, the species was so far known only from Thailand and Laos.

Distribution. Fig.5.

Gastroserica herzi (Heyden, 1887)

http://species-id.net/wiki/Gastroserica_herzi

Serica herzi Heyden, 1887: 264. Microserica hertzi: Reitter 1896: 186. Gastroserica herzi: Brenske 1897: 414; Ahrens 2000: 99.

Material examined. China: $3\overline{\partial}\overline{\partial}$ "Huangkeng'aotou, Jianyang, Fujian, 800–950m, 5.5.1960, Pu Fuji leg." (IZAS); $1\overline{\partial}$ "San'gang, Chong'anxingcun, Fujian, 750m, 26.5.1960, Jiang Shengqiao leg." (IZAS); $1\overline{\partial}$, $1\overline{Q}$ "Kuatun, Fukien China, 14.5.1946,

leg. Tschung-Sen/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1∂, 1♀ "Kuatun, Fukien China, 15.5.1946, leg. Tschung-Sen/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 13° "Kuatun, Fukien China, 16.5.1946, leg. Tschung-Sen/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 2 d d "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 8.5.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 19 "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 10.5.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1[♀] "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 12.5.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1⁽⁷⁾ "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 13,51938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1 d "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 25.5.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1^Q "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 26.5.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1 (*Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 1.6.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1♂ "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 8.6.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 1_{c}^{3} , 2♀♀ "Kuatun (2300m) 27,40n. Br. 117,40o.L. J. Klapperich 11.4.1938, (Fukien)/ ex coll. V. Balthasar National Museum Prague, Czech Republic" (NMPC), 233" Mt. Tianmu Shan, Zhejiang, 190m, 12.6.1936, O. Piel leg." (IZAS); 2♂♂"E Mt. Tianmu Shan, Zhejiang, 190m, 12.6.1936, collector unknown." (IZAS); 1⁽²⁾"Lingtian, Lingchuan, Guangxi, 200m, 6.6.1984, Li Yuehua leg." (IZAS); 13" Jinzhong Roud, Jinxiu, Guangxi, 1100m, 10.5.1999, Xiao Hui leg." (IZAS); 1∂"Shiping, Fengdu, Sichuan, 610m, 3.6.1994, Yao Jian leg." (IZAS); 1∂"Cangyuan, Yunnan, 990m, 16.5.1980, Shang Jinwen leg." (IZAS); 1∂"Jianfengling, Hainan, 610m, 21.4.1983, Gu Maobin leg." (IZAS); 1∂"Shiping, Fengdu, Sichuan, 610m, 2.6.1994, Li Wenzhu leg." (IZAS); 1♀"Lingtian, Lingchuan, Guangxi, 200m, 6.6.1984, Wang Jizhen leg." (IZAS); 1^Q"Lingtian, Lingchuan, Guangxi, 200m, 6.6.1984, Luo Guifen? leg." (IZAS); 2♀♀"Mt. Tianmu Shan, Zhejiang, 190m, 12.6.1936, O. Piel leg." (IZAS); 2♀♀"Mt. Leigong Shan, Leishan, Guizhou, 1550m, 30.6.1988, Wang Shuyong leg." (IZAS); 1^Q "Mt. Tianping Shan, Longsheng, Guangxi, 740m, 4.6.1963, Wang Shuyong leg." (IZAS); 1^Q"Neicu Jiang River, Longsheng, Guangxi, 840m, 7.6.1963, Wang Shuyong leg." (IZAS); 1[°]/₊"Mt. Fanjing Shan, Jiangkou, Guizhou, 530m, 12.7.1988, Wang Shuyong leg." (IZAS). S. Korea: 1 ♂ "6.7.2010 Mudeungsan, Gwangju (Südkorea) leg. T. Kölkebeck" (ZFMK), 1 👌 "8.7.2010 Mudeungsan, Gwangju (Südkorea) leg. T. Kölkebeck" (ZFMK), 3 👌 🖒 "27.6.2010 Beomeosa, Busan (Südkorea) leg. T. Kölkebeck" (ZFMK), 2 3 3 "24.6.2010 Gwanggyosan, Suwon (Südkorea) leg. T. Kölkebeck" (ZFMK), 1 🖑 "23.6.2010 Suri-san, Gunpo-si, Geonggi-do (Südkorea) leg. T. Kölkebeck" (ZFMK), 1 ♀ "1.7.2010 Suri-san/ Ansan, Seoul (Südkorea) leg. T. Kölkebeck" (ZFMK), 1 👌 "10.7.2010 Suri-san/ Ansan. Seoul (Südkorea) leg. T. Kölkebeck" (ZFMK).

Distribution. Fig. 7.
Gastroserica sichuana Ahrens, 2000

http://species-id.net/wiki/Gastroserica_sichuana

Gastroserica sichuana Ahrens, 2000: 95.

Material examined. 1∂"Baoguosi, Mt. Emei Shan, Sichuan, 550–750m, 2.5.1957, Wang Zongyuan leg." (IZAS); 1∂"Shiping, Fengdu, Sichuan, 610m, 3.6.1994, Li Wenzhu leg." (IZAS); 2♀♀"Shiping, Fengdu, Sichuan, 610m, 2–3.6.1994, Zhang Youwei leg." (IZAS); 1♀"Nanmuyuan, Changshou, Sichuan, 450m, 9.6.1994, Zhang Youwei leg." (IZAS); 3♀♀"Mt. Emei Shan, Sichuan, 800–1000m, 9–10.5.1957, Wang Zongyuan leg." (IZAS); 1♀"Qiaoting, Wanxian, Sichuan, 1300m, 27.6.1974, Han Yinheng leg." (IZAS). Distribution. Fig.5.

Gastroserica fanjingensis Ahrens, 2000

http://species-id.net/wiki/Gastroserica_fanjingensis

Gastroserica fanjingensis Ahrens, 2000: 104.

Material examined. $2\sqrt[3]{}$ "Huawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Li Wenzhu leg." (IZAS); $1\sqrt[3]{}$ "Huawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Xiao Hui leg." (IZAS); $1\sqrt[3]{}$ "Huawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Yang Xingke leg." (IZAS); $2\sqrt[3]{}$ "Mt. TianpingShan, Longsheng, Guangxi, 740m, 4.6.1963, Wang Chunguang leg." (IZAS); $1\sqrt[3]{}+1\sqrt[9]{}$ "Taiyuan, Pengshui, Sichuan, 800m, 12.7.1989, Yang Longlong leg." (IZAS); $1\sqrt[3]{}+1\sqrt[9]{}$ "Mt. Fanjing Shan, Jiangkou, Guizhou, 530m, 12.7.1988, Wang Shuyong leg." (IZAS); $2\sqrt[9]{}$ "Huawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Xiao Hui leg." (IZAS); $1\sqrt[9]{}$ "Ruawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Xiao Hui leg." (IZAS); $1\sqrt[9]{}$ "Huawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Yang Xingke leg." (IZAS); $1\sqrt[9]{}$ "Ruawangshanzhuang, Jinxiu, Guangxi, 600m, 20.5.1999, Yang Xingke leg." (IZAS): $1\sqrt[9]{}$ "

Distribution. Fig.5.

Gastroserica yingi Ahrens, 2007

http://species-id.net/wiki/Gastroserica_yingi

Gastroserica yingi Ahrens, 2007: 137.

Material examined. 1♂ "Mengzhe, Xishuangbanna, Yunnan, 1200m, 15.6.1958, Wang Shuyong leg." (IZAS); 4♂♂ "Mt. Tianping Shan, Longsheng, Guangxi, 740m, 4–5.6.1963, Wang Shuyong, Shi Yongshan, Wang Chunguang leg." (IZAS); 1♀ "Mengzhe, Xishuangbanna, Yunnan, 1200m, 15.6.1958, Wang Shuyong leg." (IZAS).

Distribution. Fig.6.



Figure 6. The distribution records of *Gastroserica guizhouana*, *G. nikodymi*, *G. bicolor*, *G. angustula*, *G. impressicollis* and *G. yingi* from China.

Gastroserica sulcata Brenske, 1897

http://species-id.net/wiki/Gastroserica_sulcata

Gastroserica sulcata Brenske, 1897: 414.

Material examined. 1∂"Mt. Tianping Shan, Longsheng, Guangxi, 740m, 4.6.1963, Wang Shuyong leg." (IZAS); 1∂"Mt. Tianping Shan, Longsheng, Guangxi, 740m,



Figure 7. The distribution records of Gastroserica guangdongensis, G. kucerai and G. herzi from China.

4.6.1963, Shi Yongshan leg." (IZAS); 1♂"Shanmuhe Tree Farm, Yongshun, Hunan, 600–900m, 8.8.1988, Wang Shuyong leg." (IZAS); 1♂"Mt. Fanjing Shan, Jiangkou, Guizhou, 530m, 12.8.1988, Wang Shuyong leg." (IZAS); 1♂"Mt. Jiulian Shan, Jiangxi, 12.6.1975, Zhang Youwei leg." (IZAS).

Distribution. Fig. 8.

Gastroserica kucerai Ahrens & Pacholátko, 2003

http://species-id.net/wiki/Gastroserica_kucerai

Gastroserica kucerai Ahrens & Pacholátko, 2003: 2.

Material examined. 3 3 3 Tianshidong, Mt. Qingcheng Shan, Sichuan, 1000m, 5.6.1979, Gao Ping leg." (IZAS); 1 Qinghe Tree Farm, Kangxian, Gansu, 1400m, 8.7.1999, Yao Jian leg." (IZAS); 3 2 2 "Shiping, Fengdu, Sichuan, 610m, 3.6.1994, Yang Xingke leg." (IZAS); 2 2 Shiping, Fengdu, Sichuan, 610m, 3.6.1994, Zhang Youwei leg." (IZAS); 1 Congmenhe River, Xingshan, Hubei, 1350m, 14.7.1999, Chen Xiaolin leg." (IZAS).

Distribution. Fig.7.

Gastroserica impressicollis (Fairmaire, 1891)

http://species-id.net/wiki/Gastroserica_impressicollis

Serica impressicollis Fairmaire, 1891: 196. Gastroserica impressicollis: Brenske 1897: 412, 416; Ahrens 2000: 97.

Material examined. 833"Ku-ling, Jiangxi, 7–8.7.1935, O.Piel leg." (IZAS); 233"Mt. Tianmu Shan, Zhejiang, 10–17.7.1935, O.Piel leg." (IZAS); 13"Qingyin'ge, Mt. Emei Shan, Sichuan, 800–1000m, 11.6.1957, Lu Youcai leg." (IZAS); 13"Qiaoting, Wanxian, Sichuan, 1300m, 27.6.1974, Han Yinheng leg." (IZAS); 499" Baiyan, Longsheng, Guangxi, 1150m, 21.6.1963, Shi Yongshan leg." (IZAS).

Distribution. Fig. 6.

Gastroserica hubeiana Ahrens, 2000 http://species-id.net/wiki/Gastroserica_hubeiana

Gastroserica hubeiana Ahrens, 2000: 94.

Material examined. 2♂♂"Longmenhe River, Xingshan, Hubei, 1300m, 10.5.1994, Zhang Youwei leg." (IZAS); 1♂"Xinmaopeng, Mt. Tianmu Shan, Zhejiang, 1300m, 28.6.1957, collector unknown." (IZAS); 1♂"Qingyin'ge, Mt. Emei Shan, Sichuan, 800–1000m, 28.5. 1957, Wang Zongyuan leg." (IZAS).

Distribution. Fig. 8.



Figure 8. The distribution records of *Gastroserica shaanxiana*, *G. marginalis*, *G. asulcata*, *G. hubeiana* and *G. sulcata* from China.

Gastroserica guangdongensis Ahrens, 2000

http://species-id.net/wiki/Gastroserica_guangdongensis

Gastroserica guangdongensis Ahrens, 2000: 90.

Material examined. 2♂♂"Neicu Jiang River, Longsheng, Guangxi, 840m, 6.6.1963, Wang Shuyong leg." (IZAS); 3♂♂"Mt. Tianping Shan, Longsheng, Guangxi, 740m, 4.6.1963, Shi Yongshan leg." (IZAS); 1♂"Tongmu, Mt. Wuyi Shan, Fujian, 610m, 10.6.2001, Ge Siqin leg." (IZAS).

Distribution. Fig. 7.

Gastroserica asulcata Ahrens, 2000

http://species-id.net/wiki/Gastroserica_asulcata

Gastroserica asulcata Ahrens, 2000: 79.

Material examined. 2♂♂♂"Sanmen, Longsheng, Guangxi, 300m, 26.6.1963, Wang Chunguang leg." (IZAS); 1♂"Taojiang River, Leishan, Guizhou, 1000m, 7.7.1988, Huang Fusheng leg." (IZAS); 1♂"Taojiang River, Leishan, Guizhou, 1000m, 5.7.1988, Yang Longlong leg." (IZAS); 1♂"Tianshidong, Mt. Qingcheng Shan, Si-chuan, 1000m, 2.6.1979, Gao Ping leg." (IZAS).

Distribution. Fig. 8.

Gastroserica marginalis (Brenske, 1894)

http://species-id.net/wiki/Gastroserica_marginalis

Serica marginalis Brenske, 1894 : 10.

Gastroserica marginalis var. *puncticollis* Brenske, 1897: 413. Synonymized by Moser 1908: 331.

Gastroserica marginalis: Brenske 1897: 413; Ahrens 2000: 75.

Material examined. 1♂ "Shiping, Fengdu, Sichuan, 610m, 2.6.1994, Zhang Youwei leg." (IZAS); 1♂ "Nanmuyuan, Changshou, Sichuan, 450m, 9.6.1994, Li Wenzhu leg." (IZAS); 1♂ "Mt. Jiulian Shan, Jiangxi, 21.6.1975, Huang Fusheng leg." (IZAS); 1♂ "Mt. Jianfengling, Hainan, 8.4.1983, Gu Maobin leg." (IZAS); 2♂ ♂ "Xinmaopeng, Mt. Tianmu Shan, Zhejiang, 28.6.1957, Gu Maobin leg." (IZAS); 1♂ "Taoyuandong Nature Reserve, Yanling, Hunan, 631m, 5.7.2008, Yang Ganyan leg." (IZAS); 1♂ "Luoxiang, Jinxiu, Guangxi, 450m, 30.6.2000, Li Wenzhu leg." (IZAS); 1♂ "Mt. Tianjing Shan, Ruyuan, Guangdong, 18.6.1974, Chen Guanren leg. En-045835" (LSSYU); 1♂ "Mt. Chebaling Shan, Shixing, Guang-

dong, 1000m, 26.1.1991, Wen Ruizhen leg. En-045872" (LSSYU); $2 \bigcirc \bigcirc$ "Shiping, Fengdu, Sichuan, 610m, 2–3.6.1994, Zhang Youwei leg." (IZAS); $1 \bigcirc$ "Mt. Longxi Shan, Jiangle, Fujian, 26.6.1991, Yang Longlong leg." (IZAS); $1 \bigcirc$ "Wanfeng, Wulong, Hubei, 800m, 7.7.1989, Zhang Xiaochun leg." (IZAS).

Distribution. Fig. 8.

Acknowledgements

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RESEARCH ARTICLE



A review of Biston Leach, 1815 (Lepidoptera, Geometridae, Ennominae) from China, with description of one new species

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Abstract

The genus *Biston* Leach, 1815 is reviewed for China. Seventeen species are recognized, of which *B. mediolata* **sp. n.** is described. *B. pustulata* (Warren, 1896) and *B. panterinaria exanthemata* (Moore, 1888) are newly recorded for China. The following new synonyms are established: *B. suppressaria suppressaria* (Guenée, 1858) (= *B. suppressaria benescripta* (Prout, 1915), **syn. n.** = *B. luculentus* Inoue, 1992 **syn. n.**); *B. falcata* (Warren, 1893) (= *Amphidasis erilda* Oberthür, 1910, **syn. n.** = *Amphidasis clorinda* Oberthür, 1910, **syn. n.** = *B. emarginaria* Leech, 1897, **syn. n.**); *B. panterinaria panterinaria* (Bremer & Grey, 1853) (= *B. panterinaria abraxata* (Leech, 1889), **syn. n.** = *B. panterinaria lienpingensis* (Wehrli, 1939), **syn. n.** = B. *panterinaria szechuanensis* (Wehrli, 1939), **syn. n.**). *B. falcata satura* (Wehrli, 1941), **comb. n.** is proposed. A key to Chinese *Biston* and diagnoses for Chinese species are provided. Illustrations of external features and genitalia are presented.

Keywords

Biston, taxonomy, new species, Geometridae, Lepidoptera

Introduction

Leach (1815) established the genus Biston Leach, 1815 with three species, Geometra prodromaria Denis & Schiffermüller, 1775, Phalaena (Geometra) betularia Linnaeus, 1758 and Phalaena hirtaria Clerck, 1759. Geometra prodromaria was designated as the type species of Biston by Westwood (1840) and was later found to be a junior synonym of Phalaena strataria (Hufnagel, 1767) by Prout (1915). Phalaena hirtaria was designated as the type species of Lycia Hübner, 1825 by Hulst (1896). Phalaena betularia is still treated as a member of Biston. Hampson (1895), as the first author, presented a wider concept of Biston and included Eubyjodonta Warren, 1893, Amraica Moore, 1888, Buzura Walker, 1863 and Cusiala Moore, 1887 in the genus Biston. Prout (1915) also included the species of Eubyjodonta in Biston, but did not explicitly state *Eubyjodonta* as a synonym. Subsequently, this genus was considered as a subgenus of Biston by Wehrli (1941). In addition, Prout (1915) treated Buzura as a separate genus, and regarded Amraica and Blepharoctenia Warren, 1894 as different sections of Buzura according to the structure of male antennae, and moved Cusiala to his very broadly defined "genus" Boarmia. Inoue (1982a, 1985) established the broader concept of Biston by examining external and genital characters of the Palaearctic and the East Asiatic species. He treated Buzura as a junior synonym of Biston and raised Amraica to generic level. Sato (1996) also considered Culcula Moore, 1888 as a junior synonym of Biston. Parsons et al. (1999) summarized the previous works, and besides the generic names mentioned above, they also included Epamraica Matsumura, 1910 and Eubyja Hübner, 1825 as junior synonyms of Biston. Rindge (1975, 1985) summerized New World Bistonini and gave a valuable diagnosis for the genus Biston.

Holloway (1994) proposed a very broad concept of the tribe Boarmiini which also subsumed the previously separate tribe Bistonini, and provided the diagnostic characters for the genus *Biston*.

Biston indeed has some typical features in common with the Boarmiini: the postmedial lines of both wings often protrudes outwards between M_1 and M_3 ; in the male genitalia, the socii are usually absent; the valva has a strong cucullus. However, *Biston* also has some features atypical for Boarmiini: a fovea is absent in the male forewing; in the male genitalia, the valva is simple, without any ornamentation (Holloway 1994; Pitkin 2002; Viidalepp et al. 2007; Young 2008).

The species of *Biston* are widely distributed in Holarctic, Oriental and Ethiopian regions. Reviews of the genus are available for some geographical regions, e.g. for Africa (Karisch 2005), for North America (Rindge 1975, 1985) and partly for Asia (Holloway 1994; Viidalepp 1979, 2003; Yazaki 1992; Sato 1996; Inoue 1982a, 1982b, 1985, 1992, 2000; Ghosh 2003). Parsons et al. (1999) listed 50 species and 38 subspecies. Sato (2003) placed *B. praeparva* (Prout, 1937) and *B. semifusca* (Swinhoe, 1902) into the genus *Amraica*. Until now, 54 species and 40 subspecies in the genus *Biston* have been recognized, with 17 species and 14 subspecies record-

ed in China. Major contributions concerned with the Chinese fauna of the genus have been published by Bremer and Grey (1853), Oberthür (1884, 1886, 1910), Leech (1889, 1897), Hampsom (1895), Warren (1899), Bastelberger (1909), Prout (1915), Wehrli (1938–1954), Inoue (1964, 1982b), Zhu (1981, 1982), Heppner and Inoue (1992), Zhu and Xue (1992, 1998), Xue (1992a, 1992b, 1993, 1997, 2001), Sato (1996), Wang (1998), Xue et al. (2002), Han and Xue (2002, 2004), Ades and Kendrick (2004), Hua (2005), Xue and Han (2005). However, it has become apparent that, with the study of the material obtained during recent expeditions and the re-examination of the IZCAS collection, a new species needs to be described, the taxonomy needs to be revised, and the Chinese *Biston* fauna needs to be summarized.

Here, we divide the Chinese *Biston* into three species groups based on morphological characters. Group I includes the "typical" species of *Biston*. Group II includes *B. brevipennata* Inoue, 1982 and the species which were treated in the subgenus *Eubyjodonta* of *Biston* by Wehrli (1941). Group III includes *B. perclara* (Warren, 1899), *B. thibetaria* (Oberthür, 1886) and *B. panterinaria* (Bremer & Grey, 1853) which was considered slightly different from the typical species of *Biston* by Sato (1996).

The purpose of this paper is, to review all known Chinese *Biston* species, to determine their diagnostic characters, to develope a key for their determination and to provide illustrations of external features and genitalia; furthermore, one new species, *B. mediolata* sp. n., will be described, *B. pustulata* (Warren, 1896) will be recorded as new for the fauna of China and several new synonyms and a new combination will be proposed. This results, to our present knowledge, in 17 species and nine subspecies of *Biston* for the fauna of China and 52 species with 33 subspecies worldwide.

Material and methods

Specimens of *Biston* were obtained from Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZCAS) and Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany (ZFMK). The other museums cited here, where types are deposited, are the Natural History Museum, London, United Kingdom (BMNH), the Linnean Society of London, United Kingdom (LSL), the Zoologische Staatssammlung Muenchen, Munich, Germany (ZSM) and the Zoological Institute, Russian Academy of Sciences, Saint-Petersburg, Russia (ZISP). Terminology for wing venation followed the Comstock-Needham System (Comstock 1918) as adopted for Geometridae by Scoble (1992) and Hausmann (2001), and that of the genitalia was based on Pierce (1914), Klots (1970) and Nichols (1989). Photographs of adult moths and their genitalia were taken with digital cameras. Composite images were generated using Auto-Montage software version 5.03.0061 (Synoptics Ltd). The plates were compiled using Adobe Photoshop software.

Taxonomic account

Biston Leach, 1815

http://species-id.net/wiki/Biston

- Biston Leach, 1815, Brewster's Edinburgh Encyclopaedia, 9: 134. Type species: Geometra prodromaria Denis & Schiffermüller, 1775 (= Phalaena strataria (Hufnagel, 1767)), by subsequent designation by Westwood, 1840.
- Dasyphara Billberg, 1820, Enumeratio Insect. Mus. G. J. Billberg: 89. Type species: Geometra prodromaria Denis & Schiffermüller, 1775. [Junior objective synonym of Biston Leach.]
- *Pachys* Hübner, 1822, *Syst.-alphab. Verz.*: 38–44, 46, 47, 49, 50, 52. Type species: *Geometra prodromaria* Denis & Schiffermüller, 1775. [Junior objective synonym of Biston Leach.]
- *Eubyja* Hübner, 1825, V*erz. bekannter Schmett.*: 318. Type species: *Phalaena betularia* Linnaeus, 1758, by subsequent designation by Grote, 1902.
- Amphidasis Treitschke, 1825, in Ochsenheimer, Schmett. Eur., 5 (2): 434. Type species: Geometra prodromaria Denis & Schiffermüller, 1775. [Junior objective synonym of Biston Leach.]
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- Buzura Walker, 1863, List Specimens lepid. Insects Colln Br. Mus., 26: 1531. Type species: Buzura multipunctaria Walker, 1863, by monotypy.
- Culcula Moore, 1888, in Hewitson & Moore, Descr. new Indian lepid. Insects Colln late Mr W.S. Atkinson, (3): 266. Type species: Culcula exanthemata Moore, 1888, by monotypy.
- *Eubyjodonta* Warren, 1893, *Proc. zool. Soc. Lond.*, 1893: 416. Type species: *Eubyjodonta falcata* Warren, 1893, by original designation.
- Blepharoctenia Warren, 1894, Novit. zool., 1: 428. Type species: Amphidasys bengaliaria Guenée, 1858, by original designation.
- *Epamraica* Matsumura, 1910, *Thousand Insects Japan*, (Suppl.) 2: 130. Type species: *Epamraica bilineata* Matsumura, 1910, by monotypy.

Description. Head. Antennae bipectinate in male, rami short, moderately long or long, length tapering towards apex, often the distal part of antennae without rami; filiform in female (Figs 1–3). Frons not protruding, smooth-scaled. Tongue well developed. Labial palpus small, with hair-scales, not extending beyond frons. Compound eyes setose.

Thorax. Legs covered with hair-scales. Hind tibia slightly dilated, with two pairs of spurs in both sexes, without hair-pencil. Frenulum developed. Forewing without basal fovea in male, triangular, outer margin straight or waved, hindwing round, outer



Figures 1–3. Antennae of *Biston*. I bipectinate, with long rami (male of *B. melacron*) **2** bipectinate, with short rami (male of *B. thibetaria*) **3** filiform (female of *B. betularia*). Scale bar = 1 mm.

margin smooth, sometimes concave between M_1 and M_3 or protruding between M_1 and CuA_1 . Wings white, pale yellow or greyish brown, transverse lines black, brown or white. Pattern of forewing: antemedial line slightly waved, often accompanied by a band basally; medial line waved, usually inconspicuous; postmedial line waved or dentate, sometimes protruding outwards between M_1 and M_3 and between CuA_2 and 1A + 2A, often accompanied by a band posteriorly; submarginal line sometimes indistinct; terminal line sometimes appearing as a series of short stripes between veins; discal spot black or grey, shortly strip-like, dot-like or elliptic, pale-centred. Hindwing sometimes with basal line; medial line often indistinct, sometimes double; postmedial line waved or dentate, sometimes protruding outwards between M_1 and M_3 ; terminal line similar to those of forewing; discal spot sometimes smaller and less conspicuous than on forewing. Terminal spots occasionally present on both wings, wedge-shaped. Underside paler, transverse lines often similar to those of dorsal surface.

Venation. Forewing: Sc free, R_1 and R_2 usually stalked (separate in *B. thoracicaria*), diverging before anterior angle of cell; R_2 sometimes connected by a short transverse bar with R_{3-4} or R_{3-5} ; R_{3-5} before or from anterior angle of cell, not stalked with M_1 ; M_1 from anterior angle of cell; M_3 from posterior angle of cell; CuA₁ before posterior angle of cell. Hindwing: Sc+ R_1 close to cell less than onehalf length of cell; Rs before anterior angle of cell; M_1 from anterior angle of cell; M_2 absent; M_3 from posterior angle of cell; CuA₁ before or from posterior angle of cell; M_2 absent.

Abdomen. Dorsum scattered with transverse lines or dots, sometimes with anal tuft. Third sternite of male abdomen without setal patch. Intersegmental membrane between abdomen and genitalia densely covered with elongate scales which partly developed to spines in a few species. Male genitalia. Uncus short and broad, ratio of length to basal width variable, often bifurcate terminally, sometimes bifurcation very shallow or on ventral side below apex, so the latter apparently square or round. Arms of gnathos connected medially, with median process robust or slender, round, acute or square terminally. Valva simple; costa sclerotized, straight or incurved, with terminal half often broadened, bearing long setae from center to apex; sacculus sometimes sinuous. Saccus round or semicircular. Juxta well developed, pointed, or round or flat apically, sometimes elongate, without lateral brushes of long setae, except in *B. melacron* Wehrli, 1941. Aedeagus often cylindrical, sclerotized dorsally; vesica usually wrinkled, scobinate, with or without cornuti; shape of cornuti various.

Female genitalia. Papillae anales covered with dense setae, occasionally elongate. Apophyses posteriores usually very long. Lamella postvaginalis sometimes present, oval or almost triangular. Ostium bursae occasionally weakly sclerotized. Ductus bursae striated longitudinally, sometimes sclerotized. Corpus bursae often long, membranous, sometimes curved medially, swollen anteriorly, often bearing a signum; signum elliptic, bar-like or irregularly shaped, often with marginal spines, sometimes weakly sclerotized around.

Diagnosis. The genus *Biston* resembles *Cusiala* Moore and *Iulotrichia* Warren in: the postmedial lines of both wings often protrudes outwards between M_1 and M_3 ; the apex of the uncus is often bifurcated. But *Biston* differs from *Cusiala* and *Iulotrichia* in the following characters: the forewing fovea of the male is absent in *Biston* but present in *Cusiala* and *Iulotrichia*; in the male genitalia, the aedeagus vesica has numerous, very small, spine-like cornuti, arranged as two pair of longitudinal combs in *Cusiala* and *Iulotrichia*, which is absent in *Biston*. The members of *Biston* also resemble *Lycia* Hübner, 1825 and *Cochisea* Barnes & McDunnough, 1916, both of which belong to the former Bistonini. But both of these genera can be distinguished from *Biston* by the single pair of spurs on the hind tibia, as well as apterous or brachypterous female in *Lycia*, and absence of the tongue in *Cochisea*.

Distribution. Holarctic, Oriental, and Ethiopian regions.

Biological notes. The larva is often twig-like with the characteristic 45 degree resting posture and an obtusely cleft head (Holloway 1994). Singh (1953) recorded the larva of *B. suppressaria* (Guenée, 1858). Issiki et al. (1977) illustrated the larva of *B. robustum* Butler, 1879. Yamamoto et al. (1987) described and illustrated the larva of *B. betularia* (Linnaeus, 1758), *B. robustum, B. regalis* (Moore, 1888) and *B. panterinaria*. Wagner (2001) recorded the larva of *B. betularia*. Sato (2001) described the larva of *B. marginata* Shiraki, 1913. Leong (2009) gave a description of the final instar larva and metamorphosis of *B. pustulata*. Most species are highly polyphagous. The larval host plants have been recorded from the families Aceraceae, Adoxaceae, Anacardiaceae, Apocynaceae, Aquifoliaceae, Celastraceae, Compositae (Asteraceae), Cornaceae, Corylaceae, Cupressaceae, Elaeagnaceae, Ericaceae, Euphorbiaceae, Fagaceae, Ginkgoaceae, Grossulariaceae, Guttiferae (Clusiaceae), Iridaceae, Melianthaceae, Myricaceae, Myrtaceae, Oleaceae, Palmae, Pinaceae, Platanaceae, Rham-

naceae, Rosaceae, Rutaceae, Salicaceae, Sapindaceae, Sterculiaceae, Styracaceae, Solanceae, Theaceae, Tiliaceae, Ulmaceae, Verbenaceae (summarized from Inoue 1965; Holloway 1994; Zhang 1994; Parsons et al. 1999; Sato 2001; Robinson et al. 2004). Patočka (2004) and Patočka and Turcani (2005) construct a key for the pupae of central European species. Nakamura (2004) described and gave a key for the pupae of Japanese species.

Species-group definitions based on morphology

Group I: melacron, marginata, thoracicaria, betularia, robustum, regalis, mediolata, contectaria, bengaliaria, pustulata, suppressaria.

Male antennae bipectinate, with long rami. Forewing outer margin straight, hindwing outer margin usually smooth, sometimes concave between M_1 and M_3 . Postmedial lines of both wings protruding outwards between M_1 and M_3 . Brown terminal spots absent from both wings. Patch of spines absent posterior to 8th tergite on intersegmental membrane. Male genitalia: gnathos with median process acute or round terminally; terminal half of ventral margin of valva not protruding outwards; juxta elongate or not. Female genitalia: ovipositor with apophyses posteriores elongate.

Group II: brevipennata, quercii, falcata.

Male antennae bipectinate, with long rami. Forewing outer margin waved, hindwing outer margin protruding between M_3 and CuA_1 . Postmedial lines of both wings not protruding outwards between M_1 and M_3 . Brown terminal spots present on ends of forewing R_5 , M_1 , M_3 , CuA_1 , CuA_2 , hindwing Rs, M_1 , M_3 , CuA_1 , CuA_2 . Patch of spines absent posterior to 8th tergite on intersegmental membrane. Male genitalia: gnathos median process round terminally; terminal half of ventral margin of valva protruding outwards; juxta elongate. Female genitalia: ovipositor with apophyses posteriores not elongate.

Group III: perclara, thibetaria, panterinaria.

Male antennaebipectinate, with short rami. Postmedial lines of both wings protruding outwards between M_1 and M_3 . Brown terminal spots absent from both forewing and hindwing. Patch of spines present posterior to 8th tergite on intersegmental membrane. Male genitalia: median process of gnathos round terminally; terminal half of ventral margin of valva protruding outwards; juxta not elongate. Female genitalia: ovipositor with apophyses posteriores elongate (Sato 1996).

Key to Chinese Biston species

4	Male antennae bipectinate, with short rami
_	Male antennae bipectinate, with long rami7
5	Discal spots on both wings indistinct
_	Discal spots on both wings distinct
6	Discal spots on both wings black ringed and pale-centred B. thibetaria
_	Discal spots on both wings pale grey, round
7	Antemedial line on forewing almost straight
_	Antemedial line on forewing waved
8	rojection between M_1 and M_2 of hindwing postmedial line round
	<i>B. mediolata</i> sp. n
_	Projection between M ₁ and M ₂ of hindwing postmedial line pointed
	B. contectaria
9	Forewing with R, and R, separate
_	Forewing with R, and R, stalked10
10	Hindwing without basal line
_	Hindwing with basal line
11	Antennae totally bipectinate
_	Antennae partially bipectinate
12	Projection between M, and M, of forewing postmedial line not bilobed
	B. betularia
_	Projection between M ₂ and M ₂ of forewing postmedial line bilobed13
13	Outer margin of hindwing concave between M, and M, B. melacron
_	Outer margin of hindwing not concave between M_1 and M_2 . B. marginata
14	Outer margin of hindwing concave between M, and M,
_	Outer margin of hindwing not concave between M, and M,
15	Discal spots on hindwing black
_	Discal spots on hindwing pale grey
16	Apex of juxta evenly rounded in male genitalia
_	Apex of juxta acute in male genitalia

Biston melacron Wehrli, 1941

http://species-id.net/wiki/Biston_melacron Figs 4–6, 70, 97

Biston melacron Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 430, pl. 35: h. Syntypes 3♂, China: West Tien-Mu-shan, 1600 m. (ZFMK)

Biston exotica Inoue, 1977, Bull. Fac. domestic Sci., Otsuma Woman's Univ., 13: 322, figs 65–67. Holotype ♂, Japan: Kochi Prefecture, Kubokawa. (BMNH) (Synonymized by Heppner and Inoue (1992))

Diagnosis. The external characters of this species are close to those of *B. marginata* as follows: the male antennae are partially bipectinate and filiform at tip; the fore-



Figures 4–20. Adults of *Biston*. 4–6 *B. melacron*. 4 male (holotype 5 male 6 ditto, underside 7–10 *B. marginata*. 7 male 8 ditto, underside 9 female 10 ditto, underside 11–12 *B. thoracicaria*. 11 male 12 female 13–16 *B. betularia parva*. 13 male (holotype of *B. huberaria tienschana*) 14 male (holotype of *B. cognataria sinitibetica*) 15 mal 16 female 17–18 *B. betularia nepalensis*. 17 male 18 female 19–20 *B. robustum*. 19 male (holotype of *B. robustum kiangsua*) 20 male. Scale bar = 1 cm.

wing postmedial line bilobedly protrudes between M_1 and M_3 , and slightly protrudes outwards between CuA₂ and 1A + 2A. But it can be distinguished from *B. marginata* by the following characters: the hindwing outer margin is concave between M_1 and M_3 , whereas it is evenly round in *B. marginata*; the transverse lines are black but dark brown in *B. marginata*; the hindwing postmedial line is waved after M_3 , but straight in *B. marginata*; the transverse lines on the underside of the wings are more conspicuous. The most distinct differences are in the male genitalia: the apex of the uncus is broader and bifurcated, whereas it is narrower and round in *B. marginata*; the median process of the gnathos is broader and round terminally, while in *B. marginata*, it is slenderer and acute apically; the setose area of the valva is much weaker; the juxta is narrower, and sharply pointed apically, while in *B. marginata*, it is broader and round apically; the cornutus is shortly digitiform, but is thornlike in *B. marginata*. In the female genitalia (Inoue 1977), the signum is much longer than in *B. marginata*.

Material examined. CHINA, Chekiang [Zhejiang] (ZFMK): West Tien-Mushan, 1600 m, 27–29.IV.1932, coll. H. Höne, $3\stackrel{\circ}{\circ}$ (Syntypes); same data, 25.IV.1932, $1\stackrel{\circ}{\circ}$; same data, 25.V.1932, $1\stackrel{\circ}{\circ}$; same locality, 400 m, IV.1936, $1\stackrel{\circ}{\circ}$. Fukien [Fujian] (ZFMK): Kuatun, 2300 m, 3–7.IV.1938, 11.IV.1946, coll. J. Klapperich, $1\stackrel{\circ}{\circ}$. Formosa [Taiwan] (ZFMK): Puli, IV.1958, coll. ZSM, $1\stackrel{\circ}{\circ}$. Sichuan (IZCAS): Mt. Emei, Qingyinge, 800–1000 m, 17.IV–1.V.1957, coll. Zhu Fuxing & Huang Keren, $8\stackrel{\circ}{\circ}$.

Distribution. China (Zhejiang, Jiangxi, Fujian, Taiwan, Sichuan), Japan, South Korea.

Biston marginata Shiraki, 1913

http://species-id.net/wiki/Biston_marginata Figs 7–10, 71, 98, 117

- *Biston marginata* Shiraki, 1913, *Spec. Rep. Formosa agric. Exp. Stn*, [Special reports No. 8] Publication no. 68: 433, pl. 44. Syntypes, China: Taiwan.
- *Biston fragilis* Inoue, 1958, *Tinea*, 4 (2): 254, pl. 34, fig. 30. Holotype δ , Japan: Oita Prefecture, Saeki. (BMNH) (Synonymized by Inoue (1965))

Diagnosis. The diagnostic characters of external morphology of the species can be seen in the previous species. The male genitalia of the species are close to those of *B. suppressaria*. But it can be distinguished from the latter by the following characters: the vesica is less strongly sclerotized posteriorly; the cornutus is small and spine-like but absent in *B. suppressaria*. The female genitalia are similar to those of *B. betularia*, but they differ in the following characters: the ductus bursae is shorter and the antrum is absent; the corpus bursae is almost even in width, while in *B. betularia* it is enlarged, wrinkled and weakly sclerotized posteriorly, narrow medially and swollen anteriorly; the signum is oval with several marginal spines, but a transverse bar in *B. betularia*.

Material examined. CHINA, Fukien [Fujian] (ZFMK): Kuatun, 2300 m, 3.IV.1938, coll. J. Klapperich, 1♂. Formosa [Taiwan] (ZFMK): Nantou, SW Tsuifeng, 2100m, 16.III.1996, coll. Csoevari and Steger, 2♂; Puli, IV.1958, coll. ZSM, 2♂. Hunan (IZCAS): Dongan, 24.II.1955, 4♀; Changning, 1981, 1♀. Guangdong (IZCAS): Guangzhou, VIII.1984, 1♂; Yingde, Chayesuo, 1♂. Guangxi (IZCAS):

Bobai, Yunfei, Fenchang, 2–3.I.1986, coll. Wang Jijian, 1♂2♀. **Chongqing** (IZCAS): Beipei, Jinyunshan, 10–12.II.1987, 1♂1♀. **Yunnan** (IZCAS): Suining, VII.1980, 1♂. **VIETNAM** (ZFMK): Tam Dao, 950 m and Fan-si-pan, 1520 m, III.1995, large series of males and a few females.

Distribution. China (Zhejiang, Jiangxi, Hunan, Fujian, Taiwan, Guangdong, Guangxi, Chongqing, Yunnan), Japan, Vietnam.

Biston thoracicaria (Oberthür, 1884)

http://species-id.net/wiki/Biston_thoracicaria Figs 11, 12, 72, 99, 118

- Jankowskia thoracicaria Oberthür, 1884, Études ent., 9: 26, pl. 2, fig. 8. 4 Syntypes 4∂♀, Russia: Sidemi. (ZFMK)
- Lycia tortuosa Wileman, 1911, Trans. ent. Soc. Lond., 1911 (2): 310, pl. 30, fig. 1, pl. 31, fig. 27. Holotype 3, Japan: Oshima, Tobetsu. (BMNH) (Synonymized by Inoue, (1976))

Biston thoracicaria: Prout, 1915, in Seitz, Macrolepid. World, 4: 359, pl. 19: g.

Diagnosis. The external characters of this species are close to those of *B. betularia* as follows: the male antennae are partially bipectinate and filiform at apex; the forewing postmedial line protrudes outwards between M_1 and M_3 and between CuA_2 and 1A + 2A; the discal spots of both wings are stripe-like. But it can be distinguished from *B. betularia* by the following characters: distinctly smaller; the wing colour is dark brown, but greyish black in *B. betularia*; the hindwing basal line is present, but absent in *B. betularia*; the forewing R_1 and R_2 are separate, but stalked in *B. betularia*. In the male genitalia, the apex of the uncus and the median process of the gnathos are more slender than those of *B. betularia*; the valva is more slender and longer; the juxta is much narrower; the cornutus is small and spine-like, whereas *B. betularia* has two kinds of cornuti, one is a large bundle of spines, the other is a small tuft of spines. In the female genitalia, the corpus bursae is curved in the anterior half, while in *B. betularia*, it is expanded posteriorly and narrow medially; the signum is elliptic, with several small marginal spines, whereas it is bar-like and without marginal spines in *B. betularia*.

Material examined. RUSSIA (ZFMK): Sidemi, coll. Oberthür, $2\overline{\circ}$ (Syntypes); Dairen, Mantschourie, coll. H. Höne, $1\overline{\circ}$ (Syntype). CHINA, Shaanxi (ZFMK): Tsinling, Tapaishan, coll. H. Höne, $8\overline{\circ}1\overline{\circ}$. Shantung [Shandong] (ZFMK): Tai-Shan, 1550 m, coll. H. Höne, large series including $3\overline{\circ}$. Jiangsu (ZFMK): Nanking, Lungtan, coll. H. Höne, $3\overline{\circ}$; Zhejiang (ZFMK): East-tien-mu-shan, coll. H. Höne, $3\overline{\circ}$; Yuennan [Yunnan] (ZFMK): Li-kiang, coll. H. Höne, $1\overline{\circ}$. Beijing (IZCAS): 5.VII.1949, $1\overline{\circ}$; VII.1972, coll. Zhang Baolin, $3\overline{\circ}$; Baihuashan, 9.VII.1973, coll. Han Yinheng, $1\overline{\circ}$. Hebei (IZCAS): Yibao, 12.VIII.1972, coll. Zhang Baolin, $3\overline{\circ}$. Henan (IZCAS): Xinyang, Jigongshan, 250 m, 20–21.VII.2002, coll. Han Hongxiang, $1\overline{\circ}$. Shaanxi (IZCAS): Huangbaiyuan, 13.VII.1980, coll. Zhang Baolin, $1\overline{\circ}$. **Gansu** (IZCAS): Wenxian, Bikou, 720 m, 28.VII.1999, coll. Yao Jian, 1∂. **Zhejiang** (IZCAS): Tianmushan, 4.V.1980, coll. Cai Rongquan, 1∂. **Hubei** (IZCAS): Shennongjia, Shouge, 900 m, 18.VI.1981, coll. Han Yinheng, 2∂.

Distribution. China (Beijing, Hebei, Shandong, Henan, Shaanxi, Gansu, Jiangsu, Zhejiang, Hubei, Yunnan), Russia, Japan, North Korea, South Korea.

Biston betularia (Linnaeus, 1758)

http://species-id.net/wiki/Biston_betularia Figs 13–18, 73, 74, 100, 101, 119, 120

- Phalaena (Geometra) betularia Linnaeus, 1758, Syst. Nat., (Ed. 10) 1: 521. Syntype(s), Europe. (LSL)
- Phalaena (Noctua) p-graecum Poda, 1761, Insecta Musei Graecensis: 90. Syntype(s). (Synonymized by Wehrli (1941))
- *? marmoraria* Sepp, 1792, *Nederlandsche Insecten*, 2: pl. 10, pl. 11, Syntype(s), Netherlands. (Treated as a synonym of *B. betularia betularia* by Parsons et al. (1999))
- *Phalaena* (*Geometra*) *ulmaria* Borkhausen, 1794, *Natur. eur. Schmett.*, 5: 181. Syntype(s), Europe. (Treated as a synonym of *B. betularia betularia* by Parsons et al. (1999))
- Eubyja betularia: Hübner, 1825, Verz. bekannter Schmett.: 318.
- Amphidasis huberaria Ballion, 1866, Horae Soc. ent. ross., 4: 29, pl. 1, fig. 1. Syntype(s), Russia: Western Siberia, near Omsk. (ZISP) (Synonymized by Vijdalepp, (1979))
- Amphidasys betularia var. doubledayaria Millière, 1870, Iconogr. Descr. Chenilles Lépid. inédits, 3: 117, pl. 111, fig. 1. Syntypes, including at least 3♂, 4♀, England. (Synonymized by Wehrli (1941))
- *Eurbyjodonta concinna* Warren, 1899, *Novit. zool.*, 6: 50. Holotype *C*, Kazakhstan?: Ili district. (BMNH) (Synonymized by Wehrli (1941))
- Biston betularia: Prout, 1915, in Seitz, Macrolepid. World, 4: 358, pl. 19: g.
- Biston cognataria alexandrina Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 432, pl. 36: a. Syntypes 43, Kirghizstan: Alexander Mountains. (ZFMK) (Treated as a synonym of *B. betularia betularia* by Parsons et al. (1999))
- Biston (Eubyjodonta) huberaria tienschana Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 435, pl. 36: d, g. Holotype ♂, China: Xinjiang, Ürümqi, Tian-shan. (ZFMK) (Treated as a synonym of *B. huberaria* by Parsons et al. (1999))
- Biston cognataria sinitibetica Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 433, pl. 36: a. Syntypes ♂, ♀, China (west): Kangding. (ZFMK) (Treated as a synonym of *B. betularia parva* Leech, 1897 by Parsons et al. (1999))

Diagnosis. See the previous species.

Material examined. CHINA, Xinjiang (ZFMK): Urumtschi, Tian-schan, 1 (Holotype of *B. huberaria tienschana*). **Szetschwan [Sichuan]** (ZFMK): Tachien-lu [Kangding], 1 (Holotype of *B. cognataria sinitibetica* Wehrli, 1941). **Heilongjiang**

(IZCAS): Dailing, 390 m, 3–9.VII.1962, coll. Bai Jiuwei, 3♂; Jiamusi, 23.VIII.1970, coll. Song Shimei, 13; Wuchang, 8–10.VII.1970, 2322. Jilin (IZCAS): Changbaishan, 2–13.VII.1982, coll. Zhang Baolin, 1032; Beipiao, 1984, coll. Liu Jin, 13. In**ner Mongolia** (IZCAS): Wuchagou, 21.VII.1981, 1³; Jiwen, 15–27.VII.1982, 1³1²; Genhe, 4.VII.1983, 1∂1♀; Xilin Gol, 1100 m, 21.VII.1985, coll. Liu Dajun, 2∂; Oragxan, 4.VII.1983, 1♀; Oragxan, 27.VI.1985, coll. Xue Dayong, 1♂; Chen Barag, Bayan Hure, 2–3.VII.1986, 1∂1♀; Orogen, Alihe, 31.VII.1986, coll. Gong Yushan, 1∂; Dayangshu, 20–23.VI.1983, coll. Xue Dayong, 2∂1♀. **Beijing** (IZCAS): Sanpu, 16.VII.1965, 13; Baihuashan, 16.VII-1.VIII.1972, coll. Han Yinheng and Zhang Baolin, 83; Mentougou, Xiaolongmen, 1100 m, 23.VI.2001, coll. Xue Dayong, 13; Mentougou, Liyuanling, 1100 m, 11–12.VIII.2004, coll. Li Hongmei, 13. Hebei (IZCAS): Chengde, 11.VI.1980, 2³; Chicheng, Longmensuo, Liuzhuangzi, 10-11. VIII.2006, coll. Yang Chao, 1012. Shanxi (IZCAS): Yuncheng, Zhongtiaoshan, coll. Cao Tianwen, 4⁽²⁾. **Henan** (IZCAS): Linxian, 1981, 1⁽³⁾; Lingbao, Chuankou, 20.VII.1981, 1 . Shaanxi (IZCAS): Huangbaiyuan, 13.VII.1980, coll. Zhang Baolin, 1♂; Yan'an, 5.VI.1981, 3♂2♀; Taibai, 3.VII.1981, 1♀; Liuba, 1020 m, 18.VII.1998, coll. Zhang Xuezhong, 2⁽²⁾. Ningxia (IZCAS): Jingyuan, 1998–2295 m, 25.VI.–10. VII.2008, coll. Song Wenhui, 32∂1♀; Longde, 2165–2330 m, 3–5.VII.2008, coll. Song Wenhui, 11³2². **Gansu** (IZCAS): Yongdeng, Liancheng Linchang, 20.VII–15. VIII.1985, coll. Meng Feng, 2⁽²⁾; Yongdeng, Tulugou, 2280 m, 25–29.VII.1991, coll. Xue Dayong, 1∂3♀; Yongdeng, Liancheng Linchang, Tulugou, 2600 m, 8.VIII.2005, coll. Li Jing and Han Hongxiang, 23; Zhuoni, 2500 m, 4.IX.1990, coll. Xue Dayong, 13; Kangxian, Baiyunshan, 1250–1750 m, 12.VII.1998, coll. Yao Jian, 13; Zhouqu, Shatan Linchang, 2350 m, 4–5.VII.1998, coll. Wang Hongjian and Wang Shuyong, 18∂2°; Zhouqu, Shatan Linchang, 2357 m, 22.VIII.2001, coll. Cao Xiuwen, 1∂; Diebu, Anzigou, 20.VI-20.VII.2000, 4³; Dangchang, 1800 m, 7.VII.1998, coll. Yao Jian, $3\overline{\circ}$; Wenxian, Qiujiaba, 2350 m, 7–22.VII.1999, coll. Yao Jian, $3\overline{\circ}1\overline{\circ}$; Wenxian, Tielou, 1450 m, 24.VII.1999, coll. Zhu Chaodong, 83. Qinghai (IZCAS): Menyuan, Xianmi, 2800 m, 23–24.VII.1992, coll. Xue Dayong, 1359; Huanglin, 17.VII.1977, coll. Zhang Baolin, 1⁽²⁾; Huzhu, Beishan, 2300 m, 30.VII.1991, coll. Xue Dayong, 1⁽²⁾; Huzhu, Beishan Linchang, Langshidang, 2600 m, 6-7.VIII.2005, coll. Xue Dayong, 432; Tongren, Maixiu, 2950 m, 30.VII–1.VIII.1992, coll. Xue Dayong, 14322; Xining, 6.VII.1981, 1♀. **Xinjiang** (IZCAS): Ürümqi, 21.VI.1965, 2♂; Ürümqi, 1974. VI.22, coll. Chen Yixin, 17; Aksu, 19.VII.1982, 17. Fujian (IZCAS): Mt. Wuyi, Sangang, 5–9.VI.1983, coll. Wang Linyao, 4⁽²⁾. **Sichuan** (IZCAS): Batang, 1974, 8⁽³⁾; Mt. Emei, Qingyinge, 800–1000 m, 1.V.1957, coll. Huang Keren, 1⁽²⁾; Kangding, 30.VI– 6.VII.1979, coll. Chen Tailu, 8∂1♀. **Yunnan** (IZCAS): Deqin, 3250 m, 15.VII.1982, coll. Wang Shuyong, 23; Xiaozhongdian, 3100 m, 31.VII.1984, coll. Chen Yixin, 12; Lijiang, Shiyan Linchang, 2460 m, V.1979, 1⁽²⁾; Lijiang, Yulongshan, 2700–2850 m, 17-27.VII.1984, coll. Chen Yixin and Liu Dayun, 4812; Lijiang, Yuhu, 2700 m, 27.VII.1984, coll. Liu Dayun, 1∂; Lijiang, Gaoshan Zhiwuyuan, 3260 m, 15–18. VI.2009, coll. Qi Feng, 13; Cuishan, Shatanshao, 2300 m, 13.VIII.1980, 13; Kunming, Jinzhusi, 1880 m, 15.VIII.1980, 18; Yongping, Beidou, Qianmatang, 2200 m, 10.VIII.1980, 1 3° . **Tibet** (IZCAS): Qamdo, 19.VIII.1984, coll. Jiang Basang, 1 9° ; Markam, Pula, 23.VII.1984, coll. Jiang Basang, 2 3° ; Nyingchi, Shang Zayü, 1960 m, 21–23.VIII.2005, coll. Wang Xuejian, 6 3° ; Nyingchi, Bayi, 2999 m, 1–3.VIII.2006, coll. Lang Songyun, 2 9° ; Mainling, Pai, Zhuanyunzhan, 2883 m, 4–6.VIII.2006, coll. Lang Songyun, 1 9° ; Yadong, 2800 m, 8.VI.1961, coll. Wang Linyao, 1 3° ; Yadong, 14.VI.1983, coll. Wangjia Tsering, 1 9° . **MONGOLIA** (IZCAS): Batshireet, Hentiy, 1108 m, 29.VI.2009, coll. Chen Fuqiang, 20 3° ; Binder, Hentiy, 1032 m, 29.VI–1. VII.2009, coll. Chen Fuqiang, 20 3° ; Dadal, Hentiy, 944 m, 2.VII.2009, coll. Chen Fuqiang, 10 3° ; Choybalsan, Dornod, 733 m, 6.VII.2009, coll. Chen Fuqiang, 2 3° . More material from Shanxi, Shaanxi, Sichuan, and Yunnan in coll. ZFMK.

Distribution. China (Heilongjiang, Jilin, Inner Mongolia, Beijing, Hebei, Shanxi, Shandong, Henan, Shaanxi, Ningxia, Gansu, Qinghai, Xinjiang, Fujian, Sichuan, Yunnan, Tibet), Russia, Mongolia, Japan, North Korea, South Korea, Nepal, Kazakhstan, Kirghizstan, Turkmenistan, Georgia, Azerbaijan, Armenia, Europe, North America.

Remarks. There are two subspecies of *B. betularia* distributed in China, they are *B. betularia parva* Leech, 1897 (*Biston robustum* var. *parva* Leech, 1897, *Ann. Mag. nat. Hist.*, (6) 19: 323. Syntypes 1° , 2° , China: Kangding. (BMNH)) (Figs 13–16, 73, 100, 119) and *B. betularia nepalensis* Inoue, 1982 (*B. betularia nepalensis* Inoue, 1982, *Bull. Fac. domest. Sci. Otsuma Wom. Univ.*, 18: 175, figs 40a, b. Holotype δ , Nepal: Tukcha, near Daulagiri. (BMNH)) (Figs 17–18, 74, 101, 120). In China, the former is widely distributed in the greater part of the country, the latter is distributed in Yunnan and Tibet, and can be distinguished from the former by the weaker transverse lines and the blunter projections of the postmedian lines on both wings.

Biston robustum Butler, 1879

http://species-id.net/wiki/Biston_robustum Figs 19, 20, 75, 102

- Biston robustum Butler, 1879, Ann. Mag. nat. Hist., (5) 4: 371. Syntype(s), Japan: Yo-kohama. (BMNH)
- Biston robustum kiangsua Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 433, pl. 36: b. Holotype ♂, China: Shanghai. (ZFMK) (Treated as a synonym of *B. robustum robustum* by Parsons et al. (1999))

Diagnosis. The external characters of this species are close to those of *B. porphyria* (Butler, 1889) (India) as follows: the male antennae are bipectinate to tip; greyish brown bands are present basally of the antemedial line of the forewing and distally of the postmedial lines of both wings; the forewing medial line converges with the postmedial line at 1A + 2A; the hindwing postmedial line acutely protrudes between M_1 and M_3 ; the submarginal lines of both wings are dark grey. But the species can be distinguished by the following characters: this species (length of forewing: 28–30 mm in male) is larger than *B. porphyria*; the wings are broader; the hindwing medial line is

more conspicuous. The male genitalia of the species are similar to those of *B. betularia* as follows: the apex of the uncus is bifurcated; the median process of the gnathos is about one-half length of the uncus; the juxta is long, narrow, and acute apically. But it can be distinguished from *B. betularia* by the longer and narrower valva and the absence of cornuti.

Material examined. CHINA, Shanghai (ZFMK): 1♂ (Holotype of *B. robustum kiangsua*). Shandong (IZCAS): Gujiding, 13.IV.1981, 3♂. Jiangsu (IZCAS): Nanjing, Qixiaqu, Yaohuamen, 16.III.2006, coll. Lang Songyun, 3♂. More material from Shaanxi, 2♂ from Taiwan, many from Japan, 2♂ from Korea and many from Vietnam in coll. ZFMK.

Distribution. China (Shandong, Shaanxi, Shanghai, Jiangsu, Jiangxi, Taiwan), Japan, Russia, North Korea, South Korea, Vietnam.

Remarks. There are two Chinese subspecies of *B. robustum*, they are *B. robustum* robustum Butler, 1879 and *B. robustum subrobustum* Inoue, 1964 (*B. robustum subrobustum* Inoue, 1964, *Kontyû*, 32 (2): 338, pl. 8, fig. 3. Holotype \mathcal{J} , Taiwan (central): Puli. (BMNH)). The former is distributed in the mainland China, the latter is distributed in Taiwan. The description of *B. robustum kiangsua* Wehrli was based on a single, rather aberrant specimen, with a single printed label "Shanghai China". Similar forms occur in Japan, as mentioned by Wehrli (1941). So this name very probably does not denote a valid subspecies and it is synonymized correctly.

Biston mediolata sp. n.

urn:lsid:zoobank.org:act:3657C566-2007-4007-B07E-1C3606EF048D http://species-id.net/wiki/Biston_mediolata Figs 21–24, 76, 103, 121

Biston contectaria Walker, sensu Xue, 1992a; in Liu, Iconography of Forest Insects in Hunan China: 880.

Description. Head. Antennae about one-third length of forewing, bipectinate in basal three-fifths, filiform in terminal two-fifths, rami short, length of longest ramus about the same as diameter of antennal shaft; filiform in female. Frons not protruding, smooth-scaled, with basal half white, upper half black. Labial palpus black, small, not extending beyond frons. Vertex white.

Thorax. Dorsum greyish white, scattered with black scales. Patagia and tegulae greyish white, mottled with black scales, pale yellow distally. Posterior margin of metanotum with yellow scales medially. Hind tibia with two pairs of spurs in male, slightly dilated, without hair-pencil. Forewing length: male 32-34 mm; female 42 mm. Forewing outer margin almost straight, hindwing round. Wings white, with pale grey striation. Pattern of forewing: antemedial line black, almost straight anteriorly, distinct, accompanied by a pale yellow band basally; medial line greyish yellow, indistinct; postmedial line black, distinct, acutely protruding outwards between M_1 and



Figures 21–30. Adults of *Biston*. 21–24 *B. mediolata* sp. n. 21 male (holotype) 22 ditto, underside 23 female (paratype) 24 ditto, underside. 25–26 *B. contectaria*. 25 male 26 ditto, underside; 27–30 *B. bengaliaria*. 27 male 28 ditto, underside 29 female 30 ditto, underside. Scale bar = 1 cm.

 M_3 , shallowly protruding outwards between CuA₂ and 1A + 2A, sometimes internally dentate on veins; a pale yellow band distally of postmedial line, diffused with black patches; terminal line black; fringe pale yellow mixed with black; discal spot present as pale grey dot, indistinct. Hindwing with basal line black, distinct; medial line only

distinct near anal margin; postmedial line black, bluntly protruding outwards between M_1 and M_3 , sometimes appearing as black serrations on veins; a pale yellow band distally of postmedial line; terminal line indistinct; fringe and discal spot similar to those of forewing. Underside white; transverse lines dark grey, similar to those of forewing, discal spot black, heavy, on hindwing smaller than on forewing.

Abdomen. First abdominal segment greyish white with black basal margin, remaining segments yellowish brown, scattered with black dots. Setal patch absent on third sternite of male abdomen.

Male genitalia. Uncus somewhat trapeziform, about three-fifths length of basal width. Gnathos with median process short and broad, round terminally, about twofifths length of uncus. Valva simple, broad at base, gradually narrowing apically, about twice as long as basal width; costa sclerotized, incurved medially, expanded with particularly dense setae basally. Saccus round, about one-third length of basal width. Juxta short and broad, almost round. Coremata not developed. Aedeagus cylindrical, sclerotized dorsally; vesica scobinate, cornutus shaped as a narrow band.

Female genitalia. Ovipositor with apophyses posteriores elongate. Lamella postvaginalis small and almost triangular. Ostium bursae sclerotized. Ductus bursae striated longitudinally, short. Corpus bursae long, curved medially, swollen anteriorly, bearing a signum; signum long elliptic with marginal spines.

Diagnosis. The wing pattern of this species is similar to that of *B. contectaria* as follows: the forewing outer margin is almost straight anteriorly; the antemedial line is black, broad and almost straight; the postmedial line acutely protrudes between M₁ and M₃; the medial lines of both wings are greyish yellow and indistinct; pale yellow bands are present basally of the forewing antemedial line and distally of the postmedial line of both wings; the hindwing basal line is black and distinct. But this species is smaller and can be distinguished by the following characters: the postmedial lines of both wings are narrower; the forewing postmedial line weakly protrudes outwards between CuA, and 1A + 2A, while in B. contectaria, it is straight; the protrusion between M_1 and M_3 of the hindwing postmedial line is round but sharply angled in *B*. *contectaria*; the discal spots on the underside of both wings are larger and heavier. In the male genitalia: the much broader uncus and valva of the new species are distinctly different from B. contectaria. The female genitalia are similar to those of B. panteri*naria* as follows: the apophyses posteriores are long; the ostium bursae is sclerotized; the ductus bursae is very short; the corpus bursae is curved medially; the signum is elliptic and narrow. But it can be distinguished from B. panterinaria by presence of the lamella postvaginalis.

Type material. Holotype (IZCAS), \Diamond , **CHINA, Hubei:** Xingshan, Longmenhe, 1200 m, 18.VII.1993, coll. Song Shimei. Paratypes, **CHINA, Shaanxi** (IZCAS): Liuba, Miaotaizi, 1470–1550 m, 1–2.VII.1999, coll. He Tongli, 2 \Diamond . **Gansu** (IZ-CAS): Kangxian, Qinghe Linchang, 1450–1650 m, 15.VII.1998, coll. Yao Jian, 1 \Diamond ; Wenxian, Dianba, 23.VI.1992, coll. Wang Hongjian, 1 \Diamond . **Hubei** (IZCAS): Xingshan, Longmenhe, 1260–1350 m, 17–23.VI., 14–21.VII.1993, coll. Huang Runzhi, Song Shimei and Yao Jian, 11 \Diamond ; Hefeng, 1240 m. 21–31.VII.1989, coll. Li Wei, 4 \Diamond ;

Hefeng, Fenshuiling, 1240 m, 1989.VII.29, coll. Li Wei, 1 \bigcirc ; Badong, 19.V.1989, coll. Li Wei, 1 \bigcirc . **Hunan** (IZCAS): Chenzhou, Guanlisuo, 8.VII.1969, 1 \bigcirc . **Fujian** (IZCAS): Mt. Wuyi, Sangang, 740 m, 25.V.–30.VI.1960, coll. Zhang Yiran, 2 \bigcirc ; Mt. Wuyi, Sangang, 10.V.1981, coll. Wang Jiashe, 1 \bigcirc ; Mt. Wuyi, Sangang, 10.V.1981, coll. Wang Jiashe, 1 \bigcirc ; Mt. Wuyi, Sangang, 14.VI.1983, coll. Wang Linyao, 1 \bigcirc . **Guangxi** (IZCAS): Nanningqu, Linkesuo, 110 m, 17.IV.1984, 1 \bigcirc ; Mao'ershan, 1600 m, 15.VII.1985, coll. Fang Chenglai, 1 \bigcirc ; Jinxiu Shengtangshan, 900–1900 m, 29.VI.2000, coll. Li Wenzhu, 1 \bigcirc ; Jinxiu, Linhai, Shanzhuang, 1000 m, 2.VII.2000, coll. Li Wenzhu, 3 \bigcirc . **Sichuan** (IZ-CAS): Mt. Emei, Qingyinge, 800–1000 m, 22.V., 21–26.VI., 11–16.VII.1957, coll. Huang Keren and Zhu Fuxing, 7 \bigcirc . **Hubei** (ZFMK): Wufeng, Yizhuxiang, 1560 m, VI.1998, coll. Wang and Li 1 \bigcirc . **Fukien** [**Fujian**] (ZFMK): Kuatun, 2300 m, 28.V., 1.VI.1938, coll. J. Klapperich, 2 \bigcirc . **Hainan** (ZFMK): Muzhishan, 1600 m, VII.1998, coll. Yin and Wang, 6 \bigcirc . **VIETNAM** (ZFMK): Mt. Fan-si-pan, 1600–1800 m, 8-29.V.1993, coll. Sinjaev and Simonov, 2 \bigcirc .

Etymology. The specific name is from the Latin prefix *medio-* and the word *latus*, which means medially and broad, refers to the shape of the valva.

Distribution. China (Shaanxi, Gansu, Hubei, Hunan, Fujian, Hainan, Guangxi, Sichuan), Vietnam.

Biston contectaria (Walker, 1863)

http://species-id.net/wiki/Biston_contectaria Figs 25, 26, 77, 104

Amphidasis contectaria Walker, 1863, List Specimens lepid. Insects Colln Br. Mus., 26: 1529. Holotype ♀, India. (BMNH)

Biston (Cusiala) bengaliaria f. contectaria: Hampson, 1895, Fauna Br. India (Moths), 3: 248.

Biston contectaria: Yazaki, 1992, in Haruta, Tinea, 13 (Suppl. 2): 33.

Diagnosis. The external characters of this species are close to those of *B. suppressaria* and *B. inouei* Holloway, 1994 (Borneo), but it can be distinguished from those species by the following differences: this species (length of forewing: 27–28 mm in male) is larger than *B. suppressaria* and smaller than *B. inouei*; the protrusion between M_1 and M_3 of the forewing postmedial line is relatively acute, but blunt or bilobed in *B. suppressaria* and *B. inouei*; the projection between M_1 and M_3 of the the projection between M_1 and M_3 of the the projection between M_1 and M_3 of the the hindwing postmedial line is relatively acute, but blunt in *B. contectaria* and *B. inouei*; the projection between M_1 and M_3 of the the hindwing postmedial line is relatively acute in *B. contectaria* and *B. suppressaria*, but blunt in *B. inouei*. In the male genitalia, the apex of the uncus is broader than that of *B. suppressaria* and *B. inouei*, and is almost not bifurcated; the median process of the gnathos is shorter and round distally, whereas it is longer and pointed in *B. suppressaria* and *B. inouei*; the costa and the ventral margin of the valva are curved, while those of *B. suppressaria* and

B. inouei are less curved or even incurved or concavely curved; the costa is expanded and has dense setae basally, while it is straight in *B. suppressaria* and *B. inouei*; the juxta is shorter and less pointed apically.

Material examined. CHINA, Yunnan (IZCAS): Yunxian, Xingfuzhen, 103 m, 2.VIII.1980, coll. Yang Tianshou, 13; Tengchong, Dahaoping, 2020 m, 24–26.V.1992, coll. Xue Dayong, 63; Tengchong, Heinitang, 1930 m, 28–30.V.1992, coll. Xue Dayong, 13; Dulongjiang, 1500 m, 29.V.2006, coll. Xiao Ningnian, 13. More material from several parts of Yunnan in coll. ZFMK.

Distribution. China (Yunnan), India, Nepal.

Biston bengaliaria (Guenée, 1858)

http://species-id.net/wiki/Biston_bengaliaria Figs 27–30, 78, 105, 122

Amphidasis bengaliaria Guenée, 1858, in Boisduval & Guenée, Hist. nat. Insectes (Spec. gén. Lépid.), 9: 210; ibidem (1858) Atlas; pl. 4, fig. 2. Syntypes 3∂, 1♀, Bengal; India (central). (BMNH)
Blepharoctenia bengaliaria: Warren, 1894, Novit. zool., 1: 428.
Biston (Cusiala) bengaliaria: Hampson, 1895, Fauna Br. India (Moths), 3: 247.

Biston bengaliaria: Yazaki, 1992, in Haruta, Tinea, 13 (Suppl. 2): 33.

Diagnosis. The external characters of this species are close to those of *B. contectaria*, but it can be distinguished from that species by the following differences: the wings are pale yellow but white in *B. contectaria*; the forewing postmedial line is much narrower and protruding outwards between CuA_2 and 1A + 2A, while in *B. contectaria*, it is broader and without such a protrusion; the discal spot on the hindwing upperside is large, round, black, while in *B. contectaria* it is almost absent; the discal spots on the underside of both wings are larger and heavier. The male genitalia are close to those of *B. suppressaria*, but it can be distinguished by the square apex of the juxta, the shorter median process of the gnathos and the presence of a cornutus which is a short spinous patch. The female genitalia are similar to those of *B. suppressaria*. But it differs in that the corpus bursae is coiled anteriorly; the signum is longer and narrower; the ostium bursae is more strongly sclerotized.

Material examined. CHINA, Yunnan (IZCAS): Yuanjiang, 500 m, 12.V.1957, coll. Liang Qiuzhen, 1♀; Cangyuan, 750 m, 22.V.1980, coll. Song Shimei, 1♂; Xishuangbanna, Menglun, 27.V.1964, coll. Zhang Baolin, 1♂; Xishuangbanna, Bubang, 700 m, 14.IX.1993, coll. Cheng Xinyue, 3♂. Tibet (IZCAS): Mêdog, Beibung, 700–800 m, 11.VI.1983, coll. Lin Zai, 2♂; Mêdog, Yarang, 902–1091 m, 14–23. VIII.2006, coll. Lang Songyun, 6♂. More material from several parts of Yunnan in coll. ZFMK.

Distribution. China (Yunnan, Tibet), India, Bengal, Thailand.

Biston pustulata (Warren, 1896), New to the fauna of China

http://species-id.net/wiki/Biston_pustulata Figs 31, 32, 79, 106

Buzura pustulata Warren, 1896, Novit. zool., 3: 401. Holotype A, Peninsular Malaysia: Perak. (BMNH)
Biston pustulata: Holloway, 1994, Malay. Nat. I., 47: 210, pl. 12, fig. 452.

Description. Head. Male antennae about two-fifths length of forewing, bipectinate in basal two-thirds, filiform in terminal one-third, rami long, length of longest ramus about three and half times diameter of antennal shaft. Frons not protruding, smoothscaled, with basal half pale yellow, upper half black. Labial palpus black, small, pale yellow apically, not extending beyond frons. Vertex pale yellow.

Thorax. Dorsum white-dotted with black scales. Patagia and tegulae white, mottled with black scales, yellow apically. Posterior margin of metanotum with two pairs of pale yellow spots. Hind tibia with two pairs of spurs in male, slightly dilated, without hair-pencil. Forewing length: male 29 mm. Forewing outer margin straight, hindwing round. Wings greyish white, dotted with pale grey scales. Pattern of forewing: antemedial line black, slightly waved, distinct, accompanied by a pale yellow band basally; medial line pale yellow, indistinct; postmedial line black, distinct, bilobedly protruding outwards between M, and M₂, then incurved, protruding outwards between CuA₂ and 1A + 2A; a pale yellow band distally of postmedial line; black patches present between M₁ and CuA₁ distally of postmedial line and reaching outer margin between M₁ and M₂; submarginal line white, dentate; terminal line a series of short black strips between veins; fringe yellow mixed with black; discal spot present as grey dot. Hindwing with basal line black; medial line pale yellow, indistinct; postmedial line black, acutely protruding outwards between M₁ and M₂; a pale yellow band distally of postmedial line, scattered with black scales; submarginal line and fringe similar to those of forewing; terminal line less distinct than that of forewing; discal spot smaller. Underside pale yellow, transverse lines dark grey, similar to those of upper side, discal spots black, more distinct than those of upper side.

Abdomen. Dorsum greyish white, dotted with black scales, anal tuft pale yellow. Setal patch absent on third sternite of male abdomen.

Male genitalia. Uncus with bifurcate apex, about two-thirds length of basal width. Gnathos with median process slender, pointed terminally, equal to length of uncus. Valva compressed, about twice as long as basal width; costa sclerotized, straight, bearing long setae from center to apex. Saccus semicircular. Juxta long and broad, terminal half triangular, with pointed apex. Coremata not developed. Aedeagus cylindrical, striated posteriorly; vesica scobinate, without cornuti.

Diagnosis. This species is similar to *B. suppressaria* (see below).

Material examined. CHINA, Hainan (IZCAS): Ledong, Jianfengling, Tianchi, 808 m, 18.V.2009, coll. Chen Fuqiang, 1♂.

Distribution. China (Hainan); S. Thailand, Peninsular Malaysia, Sundaland.



Figures 31–42. Adults of *Biston*. 31–32 *B. pustulata*. 31 male 32 ditto, underside. 33–40 *B. suppressaria*. 33 male (holotype of *B. suppressaria benesparsa*) 34 ditto, underside 35 male (Cili, Hunan) 36 ditto, underside 37 male (Diaoluoshan, Hainan) 38 male (Bawangling, Hainan) 39 female 40 ditto, underside; 41–42 *B. regalis*. 41 male 42 female. Scale bar = 1 cm.

Remarks. The Hainan specimen is different from specimens of Bornean material in the distinct transverse lines and the more acute projection between M_1 and M_3 of the hindwing postmedial line. However, the male genitalia of the Hainan specimen are almost indentical to those of *B. pustulata* from Borneo which were illustrated by

Holloway (1994). Thus we classify the Hainan specimen as *B. pustulata*. If these differences prove constant in a larger number of specimens, the Hainan population should be described as a separate subspecies.

Biston suppressaria (Guenée, 1858)

http://species-id.net/wiki/Biston_suppressaria Figs 33–40, 80, 107, 123

- Amphidasys suppressaria Guenée, 1858, in Boisduval & Guenée, Hist. nat. Insectes (Spec. gén. Lépid.), 9: 210. Syntypes 1∂, 2♀, central India.
- Buzura multipunctaria Walker, 1863, List Specimens lepid. Insects Colln Br. Mus., 26: 1531. Syntypes 3∂♀, Silhet? (BMNH)
- Biston suppressaria: Hampson, 1895, Fauna Br. India (Moths), 3: 247.
- Buzura suppressaria: Prout, 1915, in Seitz, Macrolepid. World, 4: 360, pl. 19: i.
- Buzura suppressaria benescripta Prout, 1915, in Seitz, Macrolepid. World, 4: 360. Holotype ♂, China: Chung-king. (BMNH), syn. n.
- Biston (Buzura) suppressaria: Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 436.
- Biston (Buzura) suppressaria f. benesparsa Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 436, pl. 36: f. Holotype ♂, China: Hunan, Höng-shan. (ZFMK)
- Biston luculentus Inoue, 1992, Bull. Fac. domest. Sci. Otsuma Wom. Univ., 28: 171, figs 59, 60, 62–64. Holotype A, Thailand: Chanthaburi, Khao Soi Dao, 400 m. (UOS), syn. n.

Diagnosis. This species is very close to *B. pustulata*, but we can distinguish it by the following characters: the protrusion between M_1 and M_3 of the forewing postmedial line is shorter, shallowly bilobed and sometimes round; the projection between M_1 and M_3 of the hindwing postmedial line is round. In the male genitalia, it differs in the round apex of the juxta. The diagnostic characters of the female genitalia can be seen in *B. bengaliaria*.

Material examined. CHINA, Hunan (ZFMK): Höng-shan, 900m, 25.V.1933, coll. H. Höne, 1 (Holotype of *B. suppressaria benesparsa*). Henan: Lingshan, 350 m, 25.V.1999, coll. Shen Xiaocheng, 1 **. Shaanxi** (IZCAS): Foping, 900 m, 27.VI.1999, coll. Zhu Chaodong, 1 **. Jiangsu** (IZCAS): 2.VIII.1933, 1 (12. Anhui (IZCAS): Huainan, 19.VII–2.VIII.1981, 2 **. Zhejiang** (IZCAS): Hangzhou, 19.VII–15. VIII.1972, coll. Liu Youqiao, 7 (Hangzhou, 16.VII–1.VIII.1973, coll. Liu Youqiao and Zhang Baolin, 6 (12; Hangzhou, 22.V–17.VI.1976, coll. Chen Yin, 1 (7; Tianmushan, V.1936, 2 ; Tianmushan, 30.VII.1972, coll. Liu Youqiao, 2 ; Tianmushan, 2 , 3 , 2 ; Tianmushan, 2 , 2 ; Tianmushan, 3 , 2 ; Tiashun, Siqianzhen, 2 , 5 , 2 ; 1 ; 1 , 2 ; 1 , 2 ; 1 , 2 ; 1 , 2 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 2 ; 1 , 3 ; 1 , 2 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 , 3 ; 1 ; 1 , 3 ; 1 ; 1 , 3 ; 1 ; 1 ; 1

21.VI–25.VII.1993, coll. Song Shimei and Huang Runzhi, 3∂; Badong, Sanxia Linchang, 180 m, 13-14.V.1994, coll. Li Wenzhu, 23; Dangyang, 1980, 13. Jiangxi (IZCAS): Dayu, 18.VII.1975, coll. Song Shimei and Zhang Baolin, 23; Jiulianshan, 30-31.VII.1975, coll. Song Shimei, 4∂; Dadishan, X.1980, 1∂; Xinyu, VII.1980, 13; Boyang, VII.1980, 13. Hunan (IZCAS): Changsha, Weishengwusuo, 3.V.1979, coll. Gan Yuankai, 13; Yueyang, VI.1981, 13; Cili, IV-17.V.1981, 23; Fenghuang, 16.IX.1988, coll. Song Shimei, 1^Q. Fujian (IZCAS): Mt. Wuyi, Huangxizhou, 500 m, 29.VII.2006, coll. Yang Chao, 1³; Nanjing, 24.VII.1973, coll. Chen Yixin, 1³; Sanming, 13.VII–29.VIII.1981, coll. Xiao Hu, 3³; Jiangle, Longqishan, 10.VIII.1991, coll. Song Shimei, 1∂. Guangdong (IZCAS): Boluo, III.1973, 3∂; Guangzhou, 29.V.1973, coll. Zhang Baolin, 13; Guangzhou, VII.1985, coll. Su Xing, 13; Yingde, Chayesuo, 30.VII.1979, 13; Zhiwuyuan, 13.VI.1978, 13. Hainan (IZCAS): Danzhou, Liangyuan, 130 m, 16.V.2007, coll. Han Hongxiang and Lang Songyun, $3 \stackrel{?}{\triangleleft} 1 \stackrel{\bigcirc}{\downarrow}$; Limushan, 26.V.1984, 1^Q; Qiongzhong, Limuling, 14.V.2007, coll. Han Hongxiang, 1∂; Baisha, Yinggeling, 434 m, 4–5.IV.2008, coll. Lang Songyun, 7∂1♀; Wuzhishan, Shuiman, 730-900 m, 3-8.V.2007, coll. Lang Songyun, 3∂; Tongshi, 340 m, 28.V.1973, coll. Chen Yixin, 1^3 ; Baoting, 80 m, 23.V.1973, coll. Chen Yixin, 1^3 ; Wanning, 60 m, 13.VI–29.VII.1963, coll. Zhang Baolin, 3Å1♀; Wanning, Xinglong, 41 m, 21.III.2008, coll. Lang Songyun, 13; Ledong, Jianfengling, 70-828 m, 17-21.V.2009, coll. Yan Keji, 113; Ledong, Jianfengling, 828 m, 24-27.III.2008, coll. Lang Songyun, $1\sqrt[3]{19}$; Lingshui, Diaoluoshan, 260 m, 5.V.2007, coll. Han Hongxiang and Lang Songyun, $3 \stackrel{?}{\partial} 1 \stackrel{?}{\downarrow}$. **Guangxi** (IZCAS): Longsheng, 10–11.VI.1980, coll. Wang Linyao, 6ð19; Guilin, Yanshan, 19.VII.1976, coll. Zhang Baolin, 1ð; Guilin, 23.VI.1980, coll. Zhang Baolin, 1♂; Yulin, 400 m, 15.X.1983, coll. Luo Zhubiao, 13; Jinxiu, 200–1100 m, 10–20.V.1999, coll. Han Hongxiang et al., 143; Napo, Baihe, 440 m, 7.IV.1998, coll. Wu Chunsheng, 1∂; Qinzhou, 15.IV.1980, coll. Cai Rongquan, 13; Nanning, 13.IV.1980, 23; Pingxiang, 230 m, 8–17.VI.1976, 532Sichuan (IZCAS): Mt. Emei, Qingyinge, 800-1000 m, 20.V.1957, coll. Zhu Fuxing, 1 \mathcal{Q} ; Yibin, Cuipingshan, 13.VIII.1981, coll. Zhang Yuelan, 1 \mathcal{A} . Guizhou (IZ-CAS): Shibing, Ganxi, 690 m, 29.IV.1979, coll. Liu Wanzhao, 19; Jiangkou, Fanjingshan, 500 m, 11.VII.1988, coll. Li Wei, 3∂1♀. **Yunnan** (IZCAS): Baoshan, Bawan, 1100 m, 19–23.V.1992, coll. Xue Dayong, 2♂; Yongshan, 800 m, 30.IV.1979, 1♀; Lushui, 1250 m, 26.IV.1979, 12; Yuxi, Yuanjiang, 4.VII.1978, coll. Jiang Zhaolong, 13; Funing, Boyi, 250 m, 17.IV.1998, coll. Zhu Chaodong, 13; Cangyuan, 750 m, 19–22.V.1980, coll. Li Hongxing et al., 3♂; Ruili, Dengga, 980 m, 11.V–8.VI.1992, coll. Xue Dayong, 3∂; Wanding, 400 m, 10.VI.1992, coll. Xue Dayong, 1∂; Xinping, Mosha, 800 m, 9.VIII.1980, 2³; Jingdong, 1170 m, 21.IV-9.VI.1956, coll. Zagwryyw, 2∂; Xishuangbanna, Damenglong, 650 m, 13.VIII.1958, coll. Zhang Yiran, 13; Xishuangbanna, Mengzhe, 1200 m, 8.IX.1958, coll. Wang Shuyong, 12; Xishuangbanna, 580–700 m, 13–14.IX.1993, coll. Xu Huanli et al, 3⁽²⁾; Yiwu, Banna, Menglun, 650 m, 29.IV–2.V.1964, coll. Zhang Baolin, 2^Q. Tibet (IZCAS): Mêdog, Yarang, 1091 m, 20–23.VIII.2006, coll. Lang Songyun, 18. More material from Zhejiang, Hubei, Guangdong, Sichuan and Yunnan in coll. ZFMK.

Distribution. China (Henan, Shaanxi, Jiangsu, Anhui, Zhejiang, Hubei, Jiangxi, Hunan, Fujian, Guangdong, Hainan, Hong Kong, Guangxi, Sichuan, Chongqing, Guizhou, Yunnan, Tibet); India; Burma; Nepal.

Remarks. Prout (1915) mentioned that *B. suppressaria benescripta* (Prout, 1915) can be distinguished from *B. suppressaria suppressaria* (Guenée, 1858) by the more obvious transverse lines, the absence of the median yellow band and the sparser black dots on the wings. However, after the examination of a long series of material, we find that the form with these variations occurs sympatrically with the nominotypical subspecies, such as in Hunan (Figs 33, 35) and Hainan (Figs 37, 38). And there is no genital difference between the two subspecies. So, we treat *B. suppressaria benescripta* as a junior synonym of *B. suppressaria suppressaria*.

Biston luculentus Inoue, 1992, described from SE. Thailand, is similar to B. suppressaria benescripta, but has the transverse lines even more clearly expressed (e.g. see fig. 37 which is almost identical with B. luculentus). Like B. suppressaria benescripta, also the B. luculentus form occurs sympatrically with typical B. suppressaria suppressaria or with B. suppressaria benesparsa Wehrli, the latter being a rather rare form, at many places. Also at the type locality of B. luculentus (Prov. Chanthaburi, Khao Soi Dao) it occurs together with typical suppressaria (coll. ZFMK) Comparison of the genitalia of the two revealed no differences. Thus we follow Stüning (in litt.) and synonymize B. luculentus with B. suppressaria. Besides, we also believe that the strange, almost patternless female figured by Inoue (1992) as paratype of B. luculentus, belongs to another, still unidentified species.

Biston regalis (Moore, 1888)

http://species-id.net/wiki/Biston_regalis Figs 41, 42, 81, 108, 124

Amphidasys regalis Moore, 1888, in Hewitson & Moore, Descr. new Indian lepid. Insects Colln late Mr W.S. Atkinson, (3): 234. Syntypes ∂♀, India: Darjeeling. (BMNH)
 Biston regalis: Prout, 1915, in Seitz, Macrolepid. World, 4: 359, pl.19: h.

Diagnosis. The wing pattern of this species is similar to that of *B. exalbescens* Inoue, 2000 (Philippines) as follows: the forewing postmedial line is weakly waved, broadly protruding outwards between R_5 and M_3 and below CuA_2 ; the hindwing outer margin is concave between M_1 and M_3 ; the hindwing postmedial line protrudes outwards between M_1 and M_3 ; dark brown bands are present basally of the forewing antemedial line and distally of the postmedial line of both wings, and usually absent at apical area and between M_3 and CuA_1 of the forewing. But the species can be distinguished from *B. exalbescens* by the following characters: the forewing antemedial line is thinner, the dark brown band basally of it is narrower; the medial lines of both wings are less conspicuous. In the male genitalia, it differs in the much stronger central setose area of the valva; the median process of the gnathos is spatulate terminally, but pointed in *B.*

exalbescens; the juxta is longer and narrower; the vesica with two cornuti, a basal, oval plate with a lateral tooth and an elongate, sclerotized, spined fold. The female genitalia of this species are close to that of *B. betularia*, but it has a nearly triangular lamella postvaginalis, which is absent in *B. betularia*; the ductus bursae is broader and sclerotized, without antrum; the corpus bursae is pouched, but enlarged posteriorly and narrow medially in *B. betularia*; the signum is almost oval, but bar-like in *B. betularia*.

Material examined. CHINA, Liaoning (IZCAS): Fengcheng, Sitaizi, 23.VII.1982, coll. Song Shimei, 23. Henan (IZCAS): Nanyang, Baiyunshan, 1300 m, 1.VI.2001, coll. Shen Xiaocheng, 13; Nanyang, Baiyunshan, 1400 m, 21-27. VII.2003, coll. Zhang Dandan, 23; Nanyang, Baotianman, 24.VI.2006, coll. Shen Xiaocheng, 13; Nanyang, Baotianman, 623 m, 12.VIII.2008, coll. Xue Dayong, 13; Yanshi, 21.VI.1981, 13. Shaanxi (IZCAS): Foping, 950 m, 24–25.VII.1998, coll. Yuan Decheng, 4³; Ningshaan, Huoditang, 1580 m, 19.VIII.1998, coll. Yuan Decheng and Zhang Xuezhong, 3⁽²⁾; Liuba, Miaotaizi, 1020–1350 m, 18–21.VII.1998, coll. Yao Jian and He Tongli, 5∂; Zhouzhi, Houzhenzi, 1350 m, 24.VI.1999, coll. Zhu Chaodong, 13; Huangbaiyuan, 1000 m, 13–18.VII.1980, coll. Han Yinheng and Zhang Baolin, 4d. Gansu (IZCAS): Yongdeng, Tulugou, 2280 m, 4.VI.1992, coll. Xue Dayong, 1승; Tianshui, Longmen Linchang, 1990, 1승; Chengxian, Feilongxia, 1020 m, 4.VII.1999, coll. Yao Jian, 2∂; Kangxian, Baiyunshan, 1250–1750 m, 12.VII.1998, coll. Wang Shuyong and Yao Jian, 2³; Kangxian, Qinghe Linchang, 1450–1650 m, 4–8.VII.1999, coll. Yao Jian and Zhu Chaodong, 33; Kangxian, Yangba, 1000 m, 10–11.VII.1999, coll. He Tongli and Zhu Chaodong, 2d; Wenxian, Tielou, 1450 m, 24.VII.1999, coll. Zhu Chaodong, 3♂; Wenxian, Qiujiaba, 2350 m, 22.VII.1999, coll. Yao Jian, 23. Zhejiang (IZCAS): Tianmushan, 21.VII.1973, coll. Zhang Baolin, 1⁽²⁾. **Hubei** (IZCAS): Shennongjia, Songbai, 950 m, 14–18.VII.1980. coll. Yu Peiyu, 3∂; Shennongjia, Dajiuhu, 1800 m, 1.VIII.1981, coll. Han Yinheng, 13; Shennongjia, Jiuchong, 700 m, 1.VII.1998, coll. Ye Chanjuan, 13; Hefeng, Fenshuiling, 1240 m, 29–31.VII.1989, coll. Li Wei and Yang Longlong, 9∂1♀; Xingshan, Longmenhe, 1300-1350 m, 21.VI-18.VII.1993, coll. Song Shimei and Huang Runzhi, 5³; Lichuan, Xingdoushan, 800 m, 21–23.VII.1989, coll. Li Wei and Yang Longlong, 2⁽³⁾. Jiangxi (IZCAS): Guling, 13.VII.1935, 1⁽³⁾; Lushan, 5.VII.1975, coll. Liu Youqiao, 1 d. Hunan (IZCAS): Sangzhi, 8.VII.1981, 2 d. Fujian (IZCAS): Mt. Wuyi, 21.IX.1982, coll. Zhang Baolin, 23. Hainan (IZCAS): Qiongzhong, Limushan, 647 m, 29.XII.2007, coll. Li Jing, 1⁽²⁾; Bawangling, Donger Linchang, 1015 m, 8–10.V.2007, coll. Chen Fuqiang, 1³; Baisha, Yinggeling, Yinggezui, 619 m, 17–19. XI.2009, coll. Yang Chao, 13; Wuzhishan, Shuiman, 730–900 m, 8.V.2007, coll. Lang Songyun, 13; Jianfengling, 18.V.1982, coll. Chen Zhiqing, 12; Ledong, Jianfengling, 934 m, 14–17.XII.2007, coll. Li Jing, 4⁷; Ledong, Jianfengling, 934 m, 14-17.XII.2007, coll. Li Jing, 13; Lingshui, Diaoluoshan, 920 m, 3.V.2007, coll. Lang Songyun, 13; Lingshui, Diaoluoshan, 929 m, 11–12.XII.2007, coll. Li Jing, 2∂. **Sichuan** (IZCAS): Mt. Emei, Qingyinge, 800–1000 m, 29.VI–15.VII.1957, coll. Yu Youcai, 4♂; Xichang, Lushan, 8.VIII.1980, 1♂; Dukou, Pingdi, 28.VI.1981, coll. Zhang Baolin, 23. Yunnan (IZCAS): Weixi, 2320 m, 24.VI.1979, coll. Yan Xiangqun,

13; Baoshan, Bawan, 1100 m, 19–23.V.1992, coll. Xue Dayong, 13; Tengchong, Heinitang, 1930 m, 28–30.V.1992, coll. Xue Dayong, 53; Xiaomenglun, 7.V.1980, 13; Qujing, 7.IX.1982, coll. Fang Chenglai, 13. More material from Shaanxi, Zhejiang, Hubei and Yunnan, in coll. ZFMK.

Distribution. China (Liaoning, Henan, Shaanxi, Gansu, Zhejiang, Hubei, Jiangxi, Hunan, Fujian, Taiwan, Hainan, Sichuan, Yunnan), Russia (Amur, Ussuri), Japan, North Korea, South Korea, India, Nepal, Philippines, Pakistan, United States.

Remarks. The subspecies of *B. regalis* from China is *B. regalis comitata* (Warren, 1899) (*Eubyjodonta comitata* Warren, 1899, *Novit. zool.*, 6: 50. Syntypes 2Å, Russia: Amurland, Sidemi. (BMNH)).

Biston brevipennata Inoue, 1982

http://species-id.net/wiki/Biston_brevipennata Figs 43, 82, 109

Biston brevipennata Inoue, 1982b, Bull. Fac. domestic Sci., Otsuma Woman's Univ., 18: 176, figs 40e, 41b. Holotype ♂, Nepal: Lete, 2400 m near Nilgiri. (BMNH)

Diagnosis. The present species can be distinguished from the other species in group II by the following characters: smaller sized (length of forewing: 23–25 mm in male); the forewing outer margin is less waved; the band basally of the forewing antemedial line is much thinner; the speckles scattered on the wings are dark brown, not black. In the male genitalia, the apex of the uncus is broader and shallowly bifurcated but narrower and round in the others; the juxta is more sharply pointed at tip.

Material examined. CHINA, Tibet (IZCAS): Gyirong, 18.VI.–23.VII.1984, coll. Yan Zhaoxing and Pu Qiongzhi, 2⁽³⁾; Zham, 2200 m, 25.VI.1975, coll. Wang Ziqing, 1⁽³⁾.

Distribution. China (Tibet), Nepal.

Biston quercii (Oberthür, 1910)

http://species-id.net/wiki/Biston_quercii Figs 44, 45, 83, 110

Amphidasis quercii Oberthür, 1910, Études Lépid. comp., 4: 676, pl. 51, fig. 433. Holotype ♀, China: Sichuan, Tien-Tsuen. (ZFMK)

Biston quercii: Prout, 1915, in Seitz, Macrolepid. World, 4: 359.

Biston (Eubyjodonta) quercii: Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 434, pl. 36: f.

Diagnosis. The wing pattern of this species is similar to that of *B. falcata* as follows: the forewing antemedial line is black, slightly waved; the postmedial lines of both wings are black and dentate; broad brown bands are present basally of the forewing anteme-



Figures 43–55. Adults of *Biston.* 43 *B. brevipennata*, male 44–45 *B. quercii.* 44 female (holotype) 45 male 46–53 *B. falcata.* 46 male (holotype of *Amphidasis erilda*) 47 male (holotype of *B. erilda satura*) 48 female (holotype of *B. emarginaria*) 49 female (holotype of *Amphidasis clorinda*) 50 male (Lijiang, Yunnan) 51 female (Gyirong, Tibet) 52 male (Zhouqu, Gansu) 53 female (Zhouqu, Gansu). Scale bar = 1 cm.

dial line and distally of the postmedial lines of both wings; the speckles scattered on the wings are black, and often gather to a black patch basally of the submarginal lines; the hindwing medial line is black and double. But it can be distinguished by the following characters: the outer margins are more undulating, there are distinct marginal processes in the centre of both wings, absent in *B. falcata*; the hindwing discal spot is present. The male genitalia are similar to those of *B. falcata* as follows: the apex of the uncus is round; the median process of the gnathos is broad and round apically; the juxta is long, narrow, acute and with a longitudinal arris apico-ventrally; the cornutus is shaped as a spinous patch. But this species is characterized by the narrower juxta and the longer spines of the cornutus.

Material examined. CHINA, Sichuan (ZFMK): Tien-Tsuen, 1901, coll. native collectors (chasseurs indigènes de feu le P. Déjean), 1° (Holotype). Henan (IZCAS): Baiyunshan, 1300 m, 19.VII.2002, 18.VI.2003, coll. Shen Xiaocheng, 2° . Shaanxi (IZCAS): Ningshaan, Yaquegou, 1580–1750 m, 7.VII.1999, coll. Yuan Decheng, 1° . Gansu (IZCAS): Kangxian, Qinghe Linchang, 1450–1650 m, 15.VII.1998, coll. Yao Jian and Wang Hongjian, 4° . Hubei (IZCAS): Shennongjia, Dajiuhu, 1800m, 1.VIII.1981, coll. Han Yinheng, 1° ; Xingshan, Longmenhe, 1350 m, 14–16. VII.1993, coll. Song Shimei, 4° . Sichuan (IZCAS): Wenchuan, Wolong, 1920 m, 22.VII.1983, coll. Wang Shuyong, 1° . A few males from Shaanxi and Sichuan in coll. ZFMK.

Distribution. China (Henan, Shaanxi, Gansu, Hubei, Sichuan).

Biston falcata (Warren, 1893)

http://species-id.net/wiki/Biston_falcata Figs 46–53, 84–88, 111–113, 125–127

Eubyjodonta falcata Warren, 1893, Proc. zool. Soc. Lond., 1893 (2): 416. Syntypes &, India: Sikkim. (BMNH)

Biston falcata: Hampson, 1895, Fauna Br. India (Moths), 3: 246.

- Biston emarginaria Leech, 1897, Ann. Mag. nat. Hist., (6) 19: 322, pl. 7, fig. 8. Holotype ♀, China: Sichuan, Pu-tsu-fong. (BMNH), syn. n.
- Amphidasis erilda Oberthür, 1910, Études Lépid. comp., 4: 677, pl. 51, fig. 435. Holotype ♂, China: Yunnan, Tse-Kou. (ZFMK), syn. n.
- Amphidasis clorinda Oberthür, 1910, Études Lépid. comp., 4: 677, pl. 51, fig. 434. Syntype(s), China (west): Tse-Kou, syn. n.
- Biston falcata clorinda: Parsons et al., 1999, Geometrid Moths of the World, a Catalogue, 1: 86.

Biston falcata satura Wehrli, comb. n.

Diagnosis. The diagnostic characters of the external mophology and the male genitalia can be seen in the preceding species. In the female genitalia, the species can be distinguished from other congeners by the following characters: the apophyses posteriores are short, about twice the length of apophyses anteriores; the ductus bursae is sclerotized and striated longitudinally, about one-third the length of corpus bursae; the corpus bursae is weakly sclerotized and striated posteriorly; the signum usually consists of two small separate sclerotized patches.
Material examined. CHINA, Yunnan (ZFMK): Tse-kou, coll. R. P. Dubernard, 1895, 1♀ (Holotype of *B. falcata clorinda*); Tse-kou, coll. R. P. Dubernard, 1900, 1♂ (Holotype of Amphidasis erilda); Shaanxi (ZFMK): Tapai-shan im Tsinling, Sued-Shensi, 25.VI.1935, coll. H. Höne, 1 (Holotype of *B. erilda satura*); **Zhejiang** (ZFMK): West-tien-mu-shan, 1&; **Sichuan** (ZFMK): Chasseurs Indigènes de Ta-tsien-lou, Récolte de 1910, 1^Q; **Sichuan** (BMNH): Pu-tsu-fong, 2993 m, VI–VII.1890, coll. Native, 1^Q. (Holotype of Biston emarginaria). Ningxia (IZCAS): Jingyuan, 2052–2084 m, 29.VI.– 2.VII.2008, coll. Sun Wenhui, 3³; Longde, Sutai Linchang, 2165 m, 6.VII.2008, coll. Song Wenhui, 2⁽⁷⁾. Gansu (IZCAS): Zhouqu, Shatan Linchang, 4–7.VII.1998, coll. Yao Jian et al., 17³; Zhouqu, Shatan Linchang, 2400 m, 4–16.VII.1999, coll. Yao Jian et al., $17\sqrt[3]{4}$; Wenxian, Baishuijiang, IX.1986, coll. Wang Hongjian, $1\sqrt[3]{}$; Wenxian, Qiujiaba, 2350 m, 21–29.VII.1999, coll. Chen Jun et al., 9⁽²⁾; Shalin, 2357 m, 25.VI– 28.VII.2002, coll. Cao Xiuwen, 23; Wushan, Tanyu, 26.VII.1990, coll. Deng Lianhai, 13; Kangxian, Qinghe Linchang, 1400 m, 8.VII.1999, coll. Zhu Chaodong, 12; Renmingchi, 2450 m, 30.VII.2002, 1^{\opera}; Baishuijiang, VII.1986, coll. Wang Hongjian, 1^{\opera}. Sichuan (IZCAS): Wenchuan, Wolong, 1920 m, 24–29. VII. 1983, coll. Wang Shuyong et al., 4³; Wenchuan, Wolong, 1900 m, 27.VIII.1982, coll. Chen Yuanqing, 1²; Mt. Emei, Jiulaodong, 1800–1900 m, coll. Huang Keren, 2♂; Gonggashan, Yanzigou, 2350 m, 3.VI.1983, coll. Zhang Xuezhong, 13; Luding, Moxi, Hailuogou, 2821-3155 m, 15–17.V.2009, coll. Li Jing, 2⁽²⁾. Yunnan (IZCAS): Lijiang, Yulongshan, 2700–2800 m, 27.VII.1984, coll. Chen Yixin and Liu Dayun, 3♂; Lijiang, Yulongshan, 2680–3296 m, 15–23.VI.2009, coll. Han Hongxiang et al., 18³; Jizushan, 2500 m, 30.VI.1980, 13; Yiliang, 200 m, 13.VII.1979, 13; Yiliang, 20.VII.1982, coll. Wang Linyao, 13; Diqing, Xiaozhongdian, Linyechang, 3700 m, 28.VII.1979, coll. Yan Baiqun, 19; Xiaozhongdian, 3100 m, 30.VII.1984, coll. Liu Dayun, 1∂; Tengchong, 2500 m, 2-4. VI.1992, coll. Xue Dayong, 33. Tibet (IZCAS): Nyingchi, Pêlung, Mamba, 2115 m, 1–2.IX.2005, coll. Wang Xuejian, 13; Nyingchi, Bayi, 2999 m, 1–3.VIII.2006, coll. Lang Songyun, 23; Mainling, Pai, 2883 m, 4–6.VIII.2006, coll. Lang Songyun, 7∂; Bomi, Yi'ong, 2300–2750 m, 28–31.VIII.1983, coll. Han Yinheng and Lin Zai, 2♂; Bomi, Yi'ong, Tangmai, 2079 m, 29–30.VIII.2006, coll. Lang Songyun, 1♂; Mêdog, 1060–3213 m, 7–13.VIII.2006, coll. Lang Songyun, 33; Cona, Mama, 2900 m, 6.VIII.1974, coll. Huang Fusheng, 19; Nyalam, Zham, 2250 m, 9–20.V.1974, coll. Zhang Xuezhong, 3⁽²⁾; Zham, Qu, 3300 m, 6–7.VII.1975, coll. Huang Fusheng and Wang Ziqing, 23; Gyirong, 2800–3300 m, 26.VII–8.VIII.1975, coll. Wang Ziqing and Huang Fusheng, $3 \stackrel{\circ}{\partial} 3 \stackrel{\circ}{\downarrow}$; Gyirong, Gongshe, 28.VIII.1984, coll. Yan Zhaoxing, $1 \stackrel{\circ}{\partial}$; Yadong, 2800 m, 23.VII.1960, coll. Wang Chunguang, 13; Yadong, 10.VIII.1982, coll. Wangjia Tsering, 23; Yadong, Linchang, 29.VIII.1984, Li Aihua, 12. Large series of material from Yunnan (ssp. falcata) and Shaanxi (ssp. satura Wehrli) in coll. ZFMK.

Distribution. China (Shaanxi, Ningxia, Gansu, Zhejiang, Sichuan, Yunnan, Tibet), India, Nepal.

Remarks. After examinating the types of *Amphidasis erilda* Oberthür, 1910, *Amphidasis clorinda* Oberthür, 1910, *B. emarginaria* Leech, 1897, *B. erilda satura* Wehrli, 1941 and a large series of material from China and the neighbouring regions it became

obvious that B. emarginaria (only females known) and Amphidasis clorinda (female holotype known only) are all females of Amphidasis erilda. The external and genital features of Amphidasis erilda, on the other hand, turned out to be almost identical or fall within the range of variation of B. falcata. Thus we treat B. emarginaria, Amphidasis erilda, Amphidasis clorinda as junior synonyms of B. falcata. B. erilda satura, as described by Wehrli (1941), is treated as a valid subspecies, but has be combined newly with B. falcata, as explained above. Thus, two Chinese subspecies of B. falcata are B. falcata falcata (Warren, 1893) and B. falcata satura (Wehrli, 1941). In China, the former is distributed in Sichuan, Yunnan and Tibet (Figs 46, 48-51, 84-86, 112, 125,126), the latter is distributed in Shaanxi, Ningxia and Gansu (Figs 47, 52, 53, 87, 88, 113, 127). There are some intraspecific variations between individuals of *B. falcata*, for example, in the the male genitalia, the apical part of the valva varies from broad to narrow in the same region, such as Gansu (Figs 87, 88) and Tibet (Figs 85, 86); in the female genitalia, the signum usually consists of two small separate sclerotized patches, sometimes there is only one signum or the signum is very tiny, and the position of the signum is variable individually.

Biston perclara (Warren, 1899)

http://species-id.net/wiki/Biston_perclara Fig. 54

Blepharoctenia perclara Warren, 1899, Novit. zool., 6: 49. Holotype ♂, China: Taiwan, Keelung. (BMNH)

Cusiala bengaliaria cerea Bastelberger, 1909, Dt. ent. Z. Iris, 22: 177. Holotype ♀, China: Taiwan. (Synonymized by Prout (1914))

Epamraica bilineata Matsumura, 1910, *Thousand Insects Japan*, (Suppl.) 2: 130, pl. 28, fig. 1. Syntypes Q, Japan; China: Taiwan. (Synonymized by Prout (1914))

Biston perclara: Prout, 1914, Ent. Mitt., Berlin 3: 264.

Diagnosis. The external characters of this species are similar to those of *B. thibetaria* as follows: the forewing antemedial line and the postmedial lines of both wings are black and thick; black patches are present distally of the forewing postmedial line between M_1 and M_3 , reaching the outer margin; another smaller black patch is present distally of the forewing postmedial line below M_3 . But in this species the broad bands placed basally of the antemedial line of the forewing and distally of the postmedial lines of both wings are pale yellow and indistinct, whereas they are yellowish green and distinct in *B. thibetaria*; the discal spots of both wings are less distinct or have completely vanished; the forewing postmedial line is straight between CuA₂ and 1A + 2A, while it is



Figures 54–63. Adults of *Biston*. 54 *B. perclara*, male 55–57 *B. thibetaria*. 55 male (syntype) 56 male 57 female 58–63 *B. panterinaria panterinaria*. 58 male (syntype of *Culcula panterinaria lienpingensis*) 59 female (syntype of *Culcula panterinaria szechuanensis*) 60 male (Dayu, Jiangxi) 61 male (Jiulianshan, Jiangxi) 62 male (Shixing, Guangdong) 63 male (Pengshui, Sichuan). Scale bar = 1 cm.

slightly excurved in *B. thibetaria*. The male genitalia of the species are almost identical to those of *B. thibetaria*. But the median process of the gnathos of the species is truncate apically and the incision of posterior margin of the juxta is less deep.

Material examined. CHINA, Taiwan (ZFMK): Hueison Forest, Nantou, 570–800 m, 28–29.IX.1992, coll. F. Aulombard and J. Plante, 1 Å. A large series from different localities of Taiwan in coll. ZFMK.

Distribution. China (Taiwan), Japan.

Biston thibetaria (Oberthür, 1886)

http://species-id.net/wiki/Biston_thibetaria Figs 55–57, 89, 114, 128

Amphidasys thibetaria Oberthür, 1886, *Études ent.*, 11: 32, pl. 5, fig. 30. Holotype ♀, China: Sichuan (?), Châpa. (ZFMK)

Buzura thibetaria: Prout, 1915, in Seitz, Macrolepid. World, 4: 360, pl. 19: h.

Buzura (Blepharoctenia) thibetaria: Wehrli, 1941, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 436.

Biston thibetaria: Parsons et al., 1999, Geometrid Moths of the World, a Catalogue, 1: 88.

Diagnosis. This species is very distinct and is easily recognizable by the thick black lines and yellowish green bands placed basally of the antemedial line of the forewing and distally of the postmedial lines of both wings, the large, black ringed and palecentred discal spots on both wings, as well as the black-belted abdomen and the fresh yellow anal tuft. The male genitalia of *B. thibetaria* are close to those of *B. panterinaria*: the apex of the uncus is bifurcated and about four-fifths as long as the basal width; the median process of the gnathos is short and round apically; the valva is broad basally and narrow apically; the ventral margin of the valva is slightly sinuous; the juxta has a deep incision at the middle on the posterior margin; the cornutus is stick-like; a narrow sclerotized band is present on lateral side of the aedeagus. But it can be distinguished from that species by the strongly rounded basal half of the valva. The female genitalia of the species are close to those of B. panterinaria as follows: the ostium bursae is weakly sclerotized; the ductus bursae is very short; the corpus bursae is curved medially, striated in the posterior half and enlarged at tip; the signum is oval and with marginal spines. It differs in having an oval lamella postvaginalis, which is absent in B. panterinaria.

Material examined. CHINA, Sichuan (ZFMK): Sichuan (?), Châpa, 1 $^{\circ}$ (Syntype). Hubei (IZCAS): Shennongjia, 600–700 m, 17–18.VII., 2.VIII.1998, coll. Ye Chanjuan, 3 $^{\circ}$; Xingshan, Longmenhe, 730–1350 m, VI–VII.1993, coll. Song Shimei et al., 11 $^{\circ}$ 1 $^{\circ}$; Zigui, Jiulingtou, 220–250 m, 25.VII.1993, coll. Song Shimei, 2 $^{\circ}$; Badong, 19.V.1989, 1 $^{\circ}$; Hefeng, 650 m, 29.V.1989, coll. Li Wei, 1 $^{\circ}$; Lichuan, Xingdoushan, 860 m, 6.VII.1989, coll. Li Wei, 1 $^{\circ}$; Xianfeng, 800 m, 2.VI.1989, coll. Li Wei, 1 $^{\circ}$. Hunan (IZCAS): Tianpingshan, 12.VIII.1981, 1 $^{\circ}$. Fujian (IZCAS): Mt.

Wuyi, Sangang, 7.VII.1982, coll. Wang Linyao, 1Å. **Guangxi** (IZCAS): Longsheng, 10–13.VI.1980, coll. Song Shimei and Wang Linyao, 4Å. **Sichuan** (IZCAS): Barkam, 2600 m, 21.VIII.1983, coll. Chai Huaicheng, 1Å; Luding, Moxi, 600–1900 m, 11–17.VI.1983, coll. Chai Huaicheng and Wang Shuyong, 3Å; Luding, Guzanjiangju, 1635 m, 21.V.2009, coll. Liang Hongbin and Wang Zhiliang, 1Å2 \bigcirc ; Batang, 1975, 9Å; Dukou, Pingdi, 5–22.VI.1987, coll. Zhang Baolin, 13Å; Huili, 23–29.VII.1974, coll. Han Yinheng, 2Å1 \bigcirc ; Yanyuan, Jinhe, 1230 m, 28.VI.1984, coll. Chen Yixin, 1Å. **Guizhou** (IZCAS): Meiyun, 6.IV.1978, coll. Xia Huai'en, 1 \bigcirc . **Yunnan** (IZCAS): Lijiang, 22–23.V.1980, 7Å1 \bigcirc ; Lijiang, Yushuizhai, 2680 m, 21.VI.2009, coll. Qi Feng, 1Å; Qujing, 3–20.VII.1982, coll. Wang Linyao and Song Shimei, 4Å; Luoci, 21.VI.1982, coll. Song Shimei, 1Å; Yongsheng, Liude, 2250m, 9.VII.1984, coll. Liu Dayun, 1Å. More material from Hubei, Sichuan, Yunnan, Tibet in coll. ZFMK.

Distribution. China (Henan, Zhejiang, Hubei, Hunan, Fujian, Guangxi, Sichuan, Guizhou, Yunnan, Tibet).

Remarks. The female which Oberthür (1886, pl. 5, fig.30) figured, is generally considered to be the holotype of *thibetaria*. However, he indirectly mentioned a larger number of specimens in his original description, by writing: "some specimens have the wings crossed by curved medial lines which cut through the discoidal spots" (translated from French). The female is part of the ZFMK collection, as already mentioned by Wehrli (1941), but all other syntypes are not. It is well possible that they have been transferred to The Natural History Museum, London, which keeps a large part of the Charles Oberthür collection. If these specimens will be found existing, the female will lose its holotype status. Eight specimens of *thibetaria* from several Sichuan localities in the ZFMK collection bearing the typical printed labels of Oberthür have been collected later, in the years following the description of *thibetaria*, thus they do not belong to the syntype series.

Biston panterinaria (Bremer & Grey, 1853)

http://species-id.net/wiki/Biston_panterinaria Figs 58–69, 90–96, 115, 116, 129, 130

- Buzura abraxata Leech, 1889, Trans. ent. Soc. Lond., 1889 (1): 143, pl. 9, fig. 14. Syntype(s) ♀, China: Yangzee River, Kiukiang. (BMNH), syn. n.
- *Culcula panterinaria lienpingensis* Wehrli, 1939, *in* Seitz, *Gross-Schmett. Erde*, 4 (Suppl.): 266, pl. 20: b. Syntype(s), China: Guangdong, Lienping. (ZFMK), syn. n.
- Culcula panterinaria szechuanensis Wehrli, 1939, in Seitz, Gross-Schmett. Erde, 4 (Suppl.): 266, pl. 20: b. Syntype(s), China: Sichuan, Tien-Tsuen. (ZFMK), syn. n.

Culcula panterinaria: Inoue, 1946, Bull. Lepid. Soc. Japan, 1 (2): 37.

Biston panterinaria: Sato, 1996, Trans. lepid. Soc. Japan, 47 (4): 223-236.

Amphidasis panterinaria Bremer & Grey, 1853, *Beitr. Schmett.-Fauna nord. China*: 21, pl. 10, fig. 1. Syntypes, China (north).



Figures 64–69. Adults of *Biston.* **64–65** *B. panterinaria panterinaria.* **64** female (Fangshan, Beijing) **65** female (Yingtaogou, Beijing); **66–69** *B. panterinaria exanthemata.* **66** male **67** ditto, underside **68** female **69** ditto, underside. Scale bar = 1 cm.

Diagnosis. This species is different from other congeners by mimicking the pattern of distasteful or poisonous species of the genus *Abraxas* Leach. The wings are white and scattered with pale grey markings, which are rarely present basally of the hindwing postmedial line; the base of the forewing is grey and has a large brown patch, accompanied by the yellowish brown antemedial line; the postmedial lines of both wings are yellow, narrow and protruding outwards between M_1 and M_3 , and diffused with dark brown oval patches; the discal spots of both wings are large pale grey dots; the discal spots on the underside of the wings are dark brown centrally. The diagnostic characters of genitalia can be seen in the previous species.

Material examined. CHINA, Kwangtung [Guangdong] (ZFMK): Lienping, 1♂ (Syntype of *Culcula panterinaria lienpingensis*). Sichuan (ZFMK): Tien-Tsuen, 1901, coll. native collectors (chasseurs indigènes de feu le P. Déjean), 1♂ (Syntype of *Culcula panterinaria szechuanensis*). Liaoning (IZCAS): Lingyuan, VI.1984, coll. Jin Laiwu, 1♂; Beipiao, VI.1984, coll. Liu Jin, 1♂; Dongling, 2♂. Beijing (IZ-CAS): Xiangshan, 9.VIII.1936, 1♂; Sanpu, 23.VIII.1972, coll. Zhang Baolin, 2♂;

Fangshan, 26–29.VI.1972, coll. Zhang Baolin, 8∂1♀; Baihuashan, 30.VI.1972, 19; Pinggu, 9.VII.1975, 18; Jinshan, 17.VII.1988, 18; Jinshan, 6.VII.1990, 38; Huairou, 10.VII.1981, 1♂; Fengtai, 6.VII.1982, 1♂; Yingtaogou, 29.VI.1990, 1♀. Hebei (IZCAS): Zunhua, Dongling, 1⁽²⁾. Shanxi (IZCAS): Taiyuan, 1⁽²⁾. Shandong (IZCAS): Qufu, Shimensi, 17.VII.1980, 1 d. Henan (IZCAS): Linzhou, Shibanyan, 22.VII.2006, coll. Sun Hao, 1∂; Dengfeng, 8.VII.1981, 1♀; Baiyunshan, 1300 m, 13.VI.2001, coll. Shen Xiaocheng, 13; Baiyunshan, 1400 m, 26–28.VII.2003, coll. Zhang Dandan, 3Å; Baiyunshan, 1550m, 13–15.VIII.2008, coll. Song Wenhui, 1Å; Nanyang, Baotianman, 21.VI.2006, coll. Shen Xiaocheng, 13; Xinyang, Jigongshan, 250 m, 20–21.VII.2002, coll. Han Hongxiang, 13. Shaanxi (IZCAS): Dali, 10.VII.1981, 1³; Ankang, 22.V.1981, 1³; Changqing, Xihan, 9.V.1981, 1³; Liuba, Miaotaizi, 1350m, 19–21.VII.1998, coll. Yao Jian and Zhu Chaodong, 2035; Foping, 890–900 m, 26–27.VI.1999, coll. Yao Jian, 1∂1♀. **Ningxia** (IZCAS): Jingyuan, Hongxia Linchang, 1998 m, 9.VII.2008, coll. Song Wenhui, 1d. Gansu (IZCAS): Zhouqu, Shatan Linchang, 2350 m, 5.VII.1998, coll. Yuan Decheng, 13; Kangxian, Baiyunshan, 1250–1750 m, 12.VII.1998, coll. Wang Shuyong, 1∂; Kangxian, 1000–1400 m, 7–14.VII.1999, coll. Zhang Xuezhong et al., 10∂1♀. **Anhui** (IZCAS): Jiuhuashan, VII.1981, 1 . Zhejiang (IZCAS): Moganshan, 11–12.V.1936, coll. O. Piel, 1Å1; Lin'an, VI.1981, 1Å; Tianmushan, 20–31.VII.1972, coll. Liu Youqiao et al., 11³3²; Lin'an, West Tianmushan, 400 m, 26–30.VII.2003, coll. Han Hongxiang and Xue Dayong, 18Å12; Hangzhou, 18.VII.1973, coll. Chen Ruijin, 1Å; Qingyuan, Fengyangshan, Datianping, 1290 m, 6–10.VIII.2003, coll. Han Hongxiang, 53; Taishun, Siqianzhen, 250–930 m, 31.VII.–4.VIII.2005, coll. Lang Songyun, 143. **Hubei** (IZCAS): Jingshan, 22.VII.1981, 1³; Shennongjia, 950 m, 3–16.VII.1980, coll. Yu Peiyu, 8∂1♀; Shennongjia, 600–700 m, 17–20.VII.–7.VIII.1998, coll. Zhou Hongzhang et al., 113; Xingshan, Longmenhe, 1310 m, 17.VI.1993, coll. Li Wenzhu, 23; Xingshan, Xiaohekou, 700 m, 11.V.1994, coll. Li Wenzhu, 13; Lichuan, Xingdoushan, 800–860 m, 9.VI–23.VII.1989, coll. Li Wei and Yang Longlong, 19³; Xianfeng, 800 m, 4.VI.1989, coll. Li Wei, 23; Hefeng, 1240 m, 28.VII.1989, coll. Li Wei, 1 J. Jiangxi (IZCAS): Fengxin, VIII.1980, 1 ; Yifeng, VIII.1979, 1 ; Jinggangshan, 2.VII.1975, coll. Zhang Baolin, 13; Jiulianshan, 27–31.VII.1975, coll. Song Shimei, 7⁽²⁾; Doushui, 7.VII.1975, coll. Song Shimei, 1⁽²⁾; Lushan, 27.VI-5. VII.1975, coll. Liu Youqiao, 1019; Dayu, 550 m, 15.VIII.1985, coll. Wang Ziqing, 1⁽²⁾. Hunan (IZCAS): Yizhang, 27.VII.1981, 1⁽²⁾; Yizhang, Mangshan, Senlin Gongyuan, 512–770 m, 13–15.VII.2008, coll. Chen Fuqiang, 1♂; Yongshun, Shanmuhe Linchang, 500–600 m, 3–5.VIII.1998, coll. Chen Yixin et al., 834° ; Guidong, Sidu, 714 m, 9–12.VII.2008, coll. Chen Fuqiang, 13; Yanling, Taoyuandong, 631 m, 4–8.VII.2008, coll. Chen Fuqiang, 2∂; Anhua, 22.V.1981, 1∂; Guzhang, Gaowangjie, 850 m, 29.VII.1988, coll. Chen Yixin, 2∂; Fenghuang, 16.IX.1988, coll. Song Shimei, 1 d. Fujian (IZCAS): Mt. Wuyi, Sangang, 10.V–5.VI.1983, coll. Zhang Baolin et al., 133; Mt. Wuyi, 500–700 m, 25–29.VII.2006, coll. Yang Chao et al., 4♂; Mt. Wuyi, Sangang, 704 m, 11–14.VIII.2009, coll. Jiang Nan and Xue Dayong, 8Å; Ninghua, 9.VI.1980, 1Å; Sanming, 1.IX.1981, coll. Xiao Hu, 1Å; Jiangle, Longqishan, 200 m, 10.VIII.1991, coll. Song Shimei, 13; Shaxian, 3.IX.1979, coll. Lin Naiquan, 1⁽²⁾. **Guangdong** (IZCAS): Dinghushan, 16–19.VII.1979, coll. Li Mingjia, 13; Luyuan, Nanling, 1020 m, 16–20.VII.2008, coll. Chen Fuqiang, 33; Shixing, Chebaling, 365-401 m, 22-26.VII.2008, coll. Chen Fuqiang, $15\sqrt[3]{2}$. Hainan (IZ-CAS): Qiongzhong, Limuling, 620 m, 14–15.V.2007, coll. Han Hongxiang and Lang Songyun, 43; Baisha, Yinggeling, 434 m, 5.IV.2008, coll. Lang Songyun, 13; Baisha, Hongkan, Shuiku, 553 m, 3–5.V.2009, coll. Yan Keji, 2∂; Wuzhishan, 29.V.1997, coll. Mai Guoqing, 13; Wuzhishan, Shuiman, 730–900 m, 3.IV–9.V.2007, coll. Han Hongxiang and Lang Songyun, 33; Ledong, Jianfengling, Tianchi, 982 m, 23.XI.2008, coll. Li Jing, 1³; Lingshui, Diaoluoshan, 920 m, 29–30.III.2008, coll. Lang Songyun, 4d. Guangxi (IZCAS): Longsheng, Hongtan, 900 m, 14.VI.1963, coll. Wang Chunguang, 1⁽²⁾; Mao'ershan, Jiuniutang, 1100–1150 m, 6–10.VII.1985, coll. Fang Chenglai, 23; Jinxiu, 400–1100 m, 10–18.V.1999, coll. Han Hongxiang et al., $69\ddot{\partial}4$ \bigcirc . Sichuan (IZCAS): Guanxian, Dujiangyan, 700–1000 m, 4.VI.1979, coll. Shang Jinwen, 13; Mt. Emei, Qingyinge, 800–1000 m, 23.IV–16.VII.1957, coll. Zhu Fuxing, 38³; Jiangjin, Simianshan, 22–26.VI.1981, coll. Zhang Shuli, 2³; Pengshui, Taiyuan, 750 m, 9.VII.1989, coll. Yang Longlong, 2⁽²⁾; Wanxian, Wangerbao, 1200 m, 28.V.1994, coll. Li Wenzhu, 23. Guizhou (IZCAS): Jiangkou, Fanjingshan, 500 m, 11.VII.1988, coll. Li Wei, 123; Leishan, Leigongshan, 1200 m, 3.VII.1988, coll. Yuan Decheng, 12; Shiyun, Jinxing, 700 m, 24.VII.1988, coll. Wang Shuyong, 1 $\bigcirc 1$ $\bigcirc 1$ $\bigcirc 2$. **Yunnan** (IZCAS): Baoshan, Baihualing, 1520 m, 11–13. VIII. 2007, coll. Wu Chunguang and Xue Dayong, 23; Baoshan, Bawan, 1040 m, 8–10.VIII.2007, coll. Xue Dayong, 1♂; Xishuangbanna, Bubang, 700 m, 14.IX.1993, coll. Yang Longlong, 13. Tibet (IZCAS): Zayü, Xia Zayü, 1534 m, 26.VIII.2005, coll. Wang Xuejian, 1∂1♀; Mêdog, 871–2095 m, 10–23.VIII.2006, coll. Lang Songyun, 8∂3♀. A large series from many parts of China in coll. ZFMK.

Distribution. China (Liaoning, Beijing, Hebei, Shanxi, Shandong, Henan, Shaanxi, Ningxia, Gansu, Anhui, Zhejiang, Hubei, Jiangxi, Hunan, Fujian, Guangdong, Hainan, Guangxi, Sichuan, Guizhou, Yunnan, Tibet), India, Nepal, Sikkim, Vietnam, Thailand.

Remarks. For *B. panterinaria* six subspecies have been described: *B. panterinaria* panterinaria (north China), *B. panterinaria abraxata* (Jiangxi, China), *B. panterinaria lienpingensis* (Guangdong, China), *B. panterinaria szechuanensis* (Sichuan, China), *B. panterinaria sychnospilas* (Prout, 1930) (Japan) and *B. panterinaria exanthemata* (Moore, 1888) (India, Nepal, Vietnam and Thailand). Sato (1996) believed that there are geographical variations among *B. panterinaria exanthemata* in India, Nepal, Sikkim, Vietnam and Thailand. These variations can be found in the appearance and in the male genitalia. He also believed that the four Chinese subspecies exhibit intermediate conditions in colour and patches on wings between *B. panterinaria szechuanensis* and *B. panterinaria exanthemata*, and the systematic position of the Chinese populations of *B. panterinaria needs* further study (Sato 1996). According to the descriptions of Wehrli (1939), ssp. *abraxata* has distinct yellow postmedial lines accompanied by distinct dark brown patches as above, ssp. *lienpingensis* has the weak postmedial line accompanied with dark brown



Figures 70–75. Male genitalia of *Biston*. 70 *B. melacron* 71 *B. marginata* 72 *B. thoracicaria* 73 *B. betularia parva* 74 *B. betularia nepalensis* 75 *B. robustum*. Scale bar = 1 mm.

patches, ssp. *szechuanensis* has well developed grey markings. However, we consider these differences to be actually intraspecific individual variations. The yellow postmedial lines, the brown patches and the grey markings vary and are differently developed not only among the different populations, but often occur in the same region. For instance, the yellow postmedial line varies from distinct and complete (ssp. *abraxata*) to incomplete (ssp. *lienpingensis*), and the variation occurred sympatrically in Jiangxi (Figs 60, 61).



Figures 76–81. Male genitalia of *Biston*. 76 *B. mediolata* sp. n. 77 *B. contectaria* 78 *B. bengaliaria* 79 *B. pustulata* 80 *B. suppressaria* 81 *B. regalis.* Scale bar = 1 mm.



Figures 82–88. Male genitalia of *Biston.* **82** *B. brevipennata* **83** *B. quercii* **84–88**. *B. falcata* **84** *B. falcata falcata* (holotype of *Amphidasis erilda*) **85** *B. falcata falcata* (Nyalam, Tibet) **86** *B. falcata falcata* (Mainling, Tibet) **87** *B. falcata satura* (Zhouqu, Gansu) **88** *B. falcata satura* (Shalin, Gansu). Scale bar = 1 mm.



Figures 89–94. Male genitalia of *Biston*. 89 *B. thibetaria*; 90–94. *B. panterinaria panterinaria*. 90 From Sanpu, Beijing 91 From Dayu, Jiangxi 92 From Wuyanling, Taishun, Zhejiang 93 From Taiyuan, Pengshui, Sichuan 94 From Chebaling, Shixing, Guangdong. Scale bar = 1 mm.



Figures 95–104. Male genitalia of *Biston.* **95** *B. panterinaria panterinaria.* From Chebaling, Shixing, Guangdong **96** *B. panterinaria exanthemata.* Scale bar = 1 mm. Aedeagus of *Biston.* **97** *B. melacron* **98** *B. marginata* **99** *B. thoracicaria* **100** *B. betularia parva* **101** *B. betularia nepalensis* **102** *B. robustum* **103** *B. mediolata* sp. n. **104** *B. contectaria.* Scale bar = 1 mm.



Figures 105–116. Aedeagus of Biston. **105** B. bengaliaria **106** B. pustulata **107** B. suppressaria **108** B. regalis **109** B. brevipennata **110** B. quercii **111** B. falcata falcata (holotype of Amphidasis erilda) **112** B. falcata falcata **113** B. falcata satura **114** B. thibetaria **115** B. panterinaria panterinaria **116** B. panterinaria exanthemata. Scale bar = 1 mm.



Figures 117–120. Female genitalia of *Biston* and enlarged view of signum. **117** *B. marginata* **118** *B. thoracicaria* **119** *B. betularia parva* **120** *B. betularia nepalensis.* Scale bar for female genitalia = 1 mm. (s = signum)



Figures 121–124. Female genitalia of *Biston* and enlarged view of signum. **121** *B. mediolata* sp. n. **122** *B. bengaliaria* **123** *B. suppressaria* **124** *B. regalis.* Scale bar for female genitalia = 1 mm. (s = signum)



Figures 125–128. Female genitalia of *Biston* and enlarged view of signum. 125 *B. falcata falcata* (Diqing, Yunnan) 126 *B. falcata falcata* (Gyirong, Tibet) 127 *B. falcata satura* (Zhouqu, Gansu) 128 *B. thibetaria.* Scale bar for female genitalia = 1 mm. (s = signum)



Figures 129–130. Female genitalia of *Biston* and enlarged view of signum. **129** *B. panterinaria panterinaria panterinaria 130 B. panterinaria exanthemata.* Scale bar for female genitalia = 1 mm. (s = signum)

The material with well developted grey markings on the wings (ssp. szechuanensis) and the material without well developted grey markings on the wings (ssp. panterinaria) occurred sympatrically in Beijing (Figs 64, 65). What is more, the similar variation occurs in different localities. For example, the form with distinct and almost continuous yellow postmedial line (ssp. *abraxata*) occurs in Beijing (Fig. 65), besides Jiangxi (Fig. 60); the form similar to the subspecies *lienpingensis* occurs in Guangdong (Fig. 62), as well as in Zhejiang (Fig. 58) and Sichuan (Fig. 63); the form with well developed grey markings (ssp. szechuanensis) occurs in Beijing (Fig. 64), besides Sichuan (Fig. 59). In the male genitalia, the sinuous ventral margins of the valva vary from strongly to weakly among the material from different localities (Figs 90, 91, 92, 93), or even from the same region, such as Chebaling, Shixing of Guangdong (Figs 94, 95). Thus, we regard the variations as intraspecific individual variations, and treat B. panterinaria lienpingensis, B. panterinaria szechuanensis and B. panterinaria abraxata as synonyms of B. panterinaria panterinaria. Besides, we find that the material collected from Yunnan and Tibet is identical with *B. panterinaria exanthemata* which was redescribed and illustrated by Sato (1996). Hence, we classify the material from Yunnan and Tibet as B. panterinaria exanthemata (Figs 66–69, 96, 116, 130) (and new to the fauna of China).

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