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Earthworms newly from Mongolia (Oligochaeta, Lumbricidae, *Eisenia*)

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Abstract

Two new megadrile earthworms from the steppes, the first species wholly from Outer Mongolia, are ascribed to the partially parthenogenetic *Eisenia nordenskioldi* (Eisen, 1879) species-complex. Taxonomic justification of sympatric *Eisenia nordenskioldi mongol* and *E. nordenskioldi onon* **ssp. n.** are supported by mtDNA COI barcodes. The unreliability of molecular differentiation based on voucher names compared to definitive types is again demonstrated, as pertains to the ultimate *Eisenia andrei* Bouché, 1972 synonym of the *E. fetida* (Savigny, 1826) sibling species-complex composed of more than a dozen prior names. Similar species described from Northeast China [formerly Manchuria] and North Korea are briefly considered, albeit they are intermittently held in synonymy of cosmopolitan *Aporrectodea rosea* (Savigny, 1826) along with many other taxa including some exotic lumbricids initially found in India. Japanese and North American lumbricids are also mentioned. Distributions are discussed and an annotated checklist of all nine Siberian/sub-arctic *E. nordenskioldi* ssp. is appended.

Keywords

Far eastern Asian biodiversity, soil fauna, endemic vs. exotic invertebrates, Megadrilacea, climate extremes

Introduction

Holarctic family Lumbricidae continues to be refined, now providing approx. 670 valid taxa (plus ca. 55 uncertain species) from a total of 1,130 names in ca. 63 genera – or about 10% of all known megadrile earthworms – and contributing just 33 (or ~22%) of the 150 or so globally ubiquitous cosmopolitan species (Blakemore 2008a, 2010, 2012b). Natural distribution is from Vancouver Island in Canada, throughout Europe and Central Asia to Korea and Japan. Stephenson (1925) noted that no native species were known from Tibet or Mongolia, whereas Gates (1967 p. 172) concluded: "*In Manchuria, Kobayashi (1940) found that an annual rainfall of less than 400 mm (ca 16 inches) was unfavourable to earthworms. He likewise was mainly interested in native taxa. 'In the region where the amount of annual rainfall is less than 400 mm, no endemic species can exist.' (p. 308). Some at least, if not all, of the supposed endemics, when revised, will fall into synonymies of more or less widely spread anthropochores. Probably no single megadrile will prove to be autochthonous (evolved in, and not found elsewhere) in either Manchuria and Mongolia*".

Prior to the current work, the only previous Mongolian record the author is aware of was for the giant *Eisenia magnifica* (Svetlov 1957: 183), formerly in genus *Allolobophora*, from the north-western Altai mountains bordering several countries thus its distribution is not restricted to Mongolia. A national report on sustainable development cites vermicompost production since 2005 by Ulziin Gol LLC a local company in Selenge Province, presumably using mundane compost-worm, *Eisenia fetida* (Savigny, 1826) that for the last 30 yrs, and currently, includes as its ultimate of 15 subsequent synonyms *Eisenia andrei andrei* Bouché, 1972 as determined by Easton (1983), Blakemore (2003, 2004 p. 97, 2006, 2008a, b, 2010, 2012a, b, 2013a, b), Csuzdi and Zicsi (2005 p. 143), Blakemore et al. (2010), Blakemore and Grygier (2011), and Csuzdi (2012).

Materials and methods

Specimens, fixed in 75–80 % ethanol, lodged in National Institute of Biological Resources are available for transfer to a suitable Mongol national institute if regulations require. Description is in the author's usual style (e.g. Blakemore 2010). Cytochrome c oxidase subunit 1 (COI barcode) sequences (Hebert et al. 2003) obtained using methods similar to those provided in Blakemore et al. (2010) are appended with analyses via megaBLAST (www.blast.ncbi.nlm.nih.gov/BLAST.cgi) and MEGA 5.1 (wwww.megasoftware.net) (Tamura et al. 2011). A checklist of boreal Palaearctic / Siberian *Eisenia nordenskioldi* species-complex, revised from those of Perel' (1979, 1997), Easton (1983) and Blakemore (2004, 2008a, b), is presented in Appendix 2. Abbreviations are rhs- right hand-side, lhs – left hs; TP – tubercula pubertates; DP – dorsal pore; mid-D = mid-dorsal line.

Systematic results

Order Megadrilacea Benham, 1890
Family Lumbricidae Rafinesque-Schmaltz, 1815
Genus *Eisenia* Malm, 1877 [type-species *Enterion fetidum* Savigny, 1826]

***Eisenia fetida* (Savigny, 1826) species-complex. *s.* Blakemore (2010)**
http://species-id.net/wiki/Eisenia_fetida
Fig. 1

Note. *Eisenia fetida* is the earliest representative of the genus, originally *Enterion fetidum* Savigny, 1826: 182 (type locality Paris; types in Muséum national d'histoire naturelle, Paris according to Stöp-Bowitz, 1969: 172); its 15 progressive synonyms, lastly including *Eisenia andrei andrei* Bouché, 1972: 381 (with types in Sully, France, OECO79-1388-4321), are fully presented in Blakemore (2008a, 2010, 2012, 2013a, b).

Material examined. Puce, semi-mature specimen S1 from Hamdeok Sewoobyong beach, Jeju Island, collected 15th Feb., 2012 by RJB NIBRIV0000249915 (dissected and figured, Fig. 1, providing DNA sample WM18 – nil results, resampled as WO12 and as w11 to recheck); S2 mature, posterior amputee specimen with same collection data. S3-4 two uniformly pale Jeju specimens, collected 16th Feb., 2012 by RJB (one posterior amputee dissected and figured, Fig. 1, providing DNA WO7 that was mixed in the genetics laboratory, resampled as w62 with data pending). S5 is a single deep-red, very weakly striped mature from Gangreung, Yongok stream, eastern S. Korea collected 4th April, 2012 by RJB (IV0000249930 providing DNA sample WO18 – see Appendix 1). Three matures, pale with pink clitella, S6-8 from Incheon, Seogu, Gyeongseo-dong, 20th April, 2000 (IV0000215368 mislabeled as "*Perionyx excavatus*"; note other *P. excavatus* Perrier, 1872 proper confirmed in NIBR collection). Eight mature specimens, darkly striped with pale intersegments, otherwise compliant (IV0000261280 labeled "20110609//5/A" their jar also contains four *Amynthas* sp.). Other NIBR specimens labeled "*E. foetida*" e.g., IV0000213769/214062, were not inspected here.

Description of current specimens. Body not especially flattened. Lengths 50-80 mm, segments 110–140. First dorsal pore small in 3/4, open from 4/5 onwards. Setae closely paired, *ab* slightly tumid in some or all of 9-12, 22, 23 and 25,26-32; distinctly paler around *cd* in just 9 or in some of 9-11,12. Dorsum to below *c* lines a reddish or pinky puce (sometimes much darker or much paler); ventrum pale with clitellum darker buff, saddle-shaped in 24,25,26,27-31,32,33. TP ½28,28-½31,31. Spermathecae nearly mid-dorsum in 9/10/11. Female pores small on 14 lateral to *b*. Male pores in slightly tumid pads on 15 lateral of *b* setae. Nephropores visible sporadically intersegmentally above *b* lines (alternatively in *d*?).

Internally, spermathecae spherical in 9 & 10. Testis small in 10 & 11, seminal vesicles in 9–12. Last hearts in 11. Calciferous glands annular in 11 & 12. Ovaries in

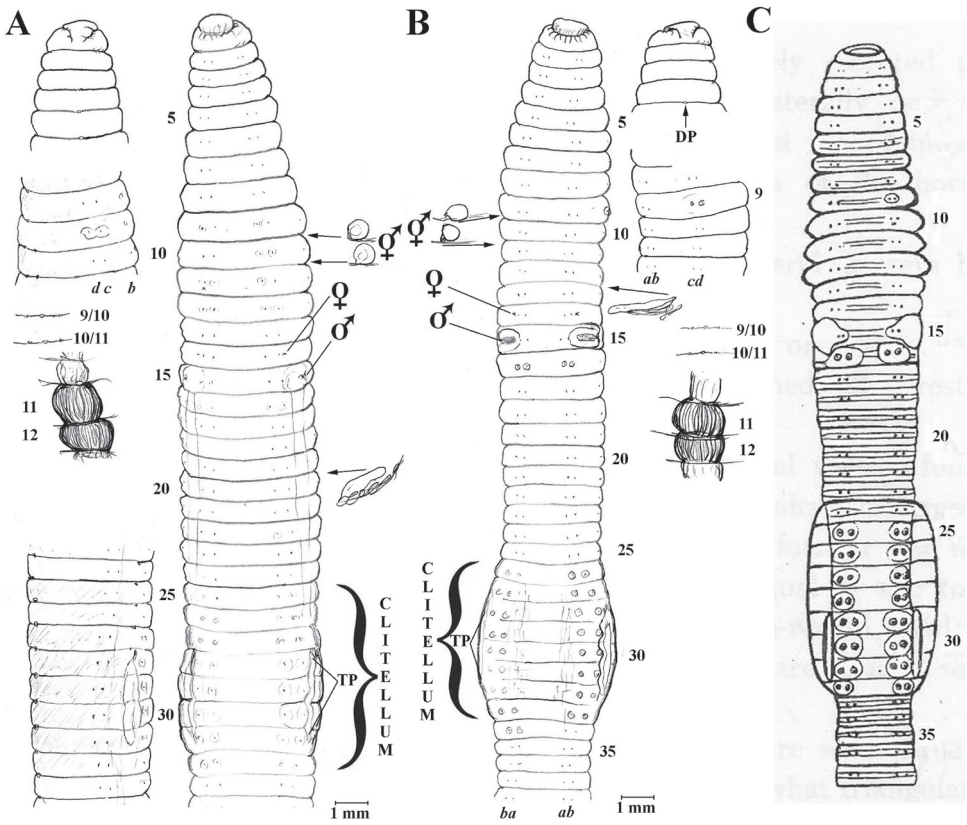

Figure 1. A *Eisenia fetida* specimen S1 from Jeju Isl., Korea; anterio-ventral and lateral views, dorsal prostomium; spermathecae and calciferous glands *in situ*, nephridium from 20lhs **B** *E. fetida* S3 ditto with nephridium in 13lhs **C** Athecal *Allolobophora hataii* Kobayashi, 1940: fig. 5 (*incertae sedis*) for comparison.

13. Nephridia sausage-shaped. Crop in 16 and gizzard large in 17-18, with intestine proper after 19; a low, wide typhlosole present from about 26.

Remarks: The Jeju specimens lack the supposedly characteristic broad striped appearance while specimen S5 is brick red (mtDNA barcodes show 99% agreement). It seems remarkable that S3-4 would agree as they lack pigment. Other specimens with much darker, almost black, segments and contrasting paler intersegment also comply superficially. The whole species-complex requires evaluation with consideration of ICZN compliance as noted in the Discussion.

Eisenia nordenskioldi (Eisen, 1879) species-complex. *s.* Blakemore (2010)

(see Appendix 2)

***Eisenia nordenskioldi mongol* ssp. n.**
http://species-id.net/wiki/Eisenia_nordenskioldi_mongol
Fig. 2, Tab. 1

Material examined. Holotype (H), NIBR IV0000261274 (dissected and figured, Fig. 2, providing DNA - wo63); label details "*2012-7-22 Balji Riverside Coll. T-S Park*" (possibly near Onon-Balji Conservation Area) at Dadal (ca. 49°1'2.16"N, 110°37'18.49"E), Khentii Province NE of Ulaanbaatar, Mongolia. Paratype P1, IV0000261275 (dissected, providing DNA - wo64) plus six other specimens (P2-7, four mature, two sub-matures, IV0000261276) all labeled "*2012-7-21 Dadal*".

Etymology. Nominative singular noun in apposition, after natives of Mongolia.

Description. Body substantial and only slightly trapezoid, posterior barely flattens. Pigment pinkish-grey dorsally in alcohol with ventrum and 9-11 paler laterally; clitellum buff. Lengths 80-110 mm (holotype H 60+50 = 110, paratype P1 80). Segments H 75+67 = 142, P1 131. Prostomium open epilobic (first thought tanylobic in H). Dorsal pores from 3/4 (minute), open from 4/5. Setae closely paired. Tumescences around setae *ab* on 7 & 11rhs plus 26lhs,27-32 (H); on 7 plus 27-33 (Ps); tumid and pale around lateral setae *cd* on 8-11 (H, P1). Clitellum saddle-shaped 26-33 (slightly encroaching onto 25 dorsally in some Ps). Tubercula pubertates faint, 29-31 lateral of setal *b* lines. Nephropores sporadically visible above *b* or *d* setal lines, e.g. above *d* in 9, 13, 14, 23-26, 34, 37, 38, 40, 41; or above *b* setal lines in some other segments in H. Spermathecal pores paired in 9/10/11 close to mid-D. Female pores in 14 lateral of *b*. Male pores small in 15 lateral of *b* just wider than female pores.

Internally, septa 8/9-10/11 slightly thickened. Spermathecae spherical on thin tapering stalks in 9 & 10. Testis and funnels non-iridescent (atrophied?) in 10 & 11. Seminal vesicles paired in 9-12 (smaller in 10). Ovaries compact in 13. Ovisacs vestig-

Table 1. Characters of *Eisenia nordenskioldi* sub-species after Kobayashi (1940), Perel' (1969), Zicsi (1972) and pers. obs (cf. other sub-species in Appendix 2).

	***E. n. mongol* ssp. n.**	***E. n. polypapillata***	***E. n. nordenskioldi*** (*)
Length (mm)	80–110	55–80	25–45 (44–120*)
Segments	131–142	102–137	106–125 (101–176*)
Colour	Pink-grey	Pale	Dark puce to pale
Setae *aa:ab* ratio	Ca. 8–9:1	?	(7–8:1*)
Spermathecae	9/10/11 in mid-D	9/10/11 above *d*	9/10/11 mid-D
Papillae in *ab*	7(11), 25, 26–32	16–18, 21–23(24), 26 & 32–34	16, 22–34 (or 16, 22–34, 35 or just some*)
Paler tumid *cd*	8–11	Not noted	(10–12,13*)
Clitellum	½25,26–33	26,27–32	26,27–33
TP	29–31	½28,29-½31,31	29–31
Neph. bladders	Sausage-shaped	?	?
Typhlosole	Small T-shaped	?	?

*Features from Kobayashi's (1940, 1941) descriptions compared to Zicsi's.

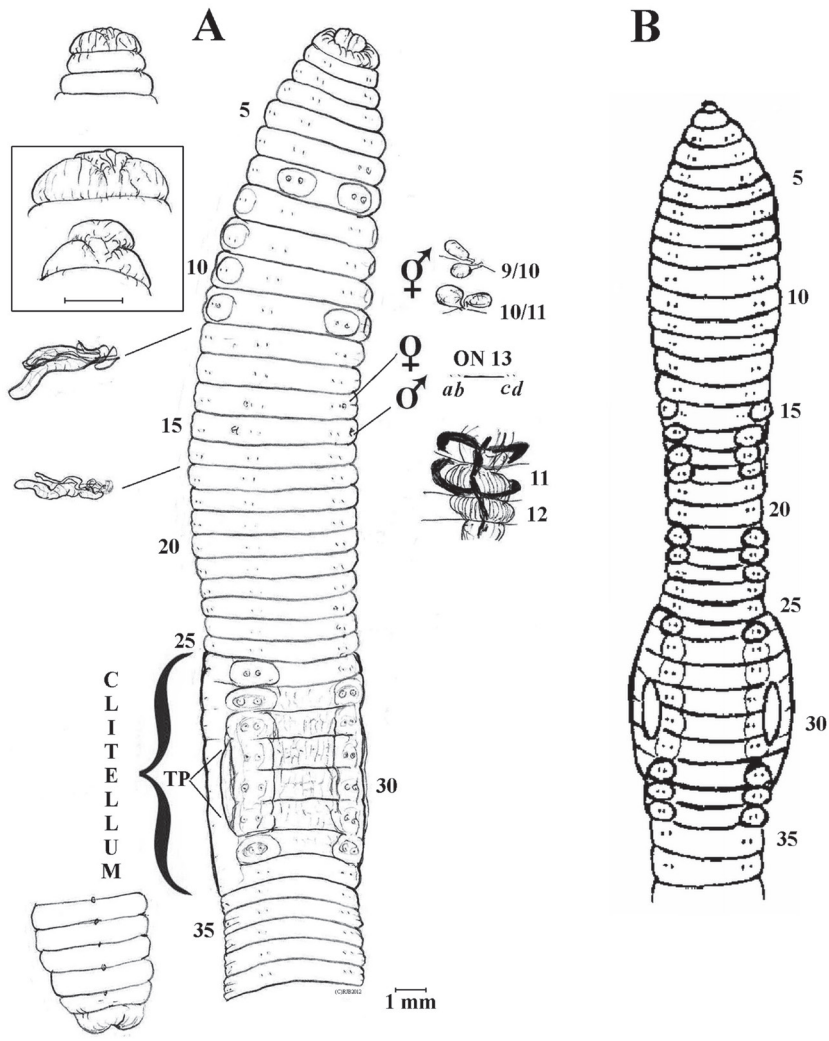

Figure 2. A *Eisenia nordenskioldi mongol* ssp. n. Holotype anterio-ventral view, dorsal prostomium [plus enlargements with that of P1 boxed], posterior, plus actual setal ratios on 13; spermathecae and calciferous glands *in situ*, nephridia in 12 & 17 **B** *E. n. polypapillata* after Perel' (1969: text-fig) for fair use comparison.

ial anteriorly in 14. Hearts in 7-11. Nephridial bladders simple, sausage-shaped (in all segments inspected). Calciferous glands large and moniliform in 11 & 12. Crop in 15-16; muscular gizzard in 17-18 with septum 17/18 to midriff. Intestine proper from 19; slight typhlosole noticeably developing to inverted T-shaped from about 27,28. Gut contents mixed coarse organic material and some soil with mica flakes (i.e., a topsoil species). Apart from some loose gregarines, no parasites were observed in the coelom.

Remarks. Lack of spermatozoal iridescence indicates parthenogenesis. *Eisenia nordenskioldi mongol* sub-sp. n. compares to the nominal subspecies and to *E. n. poly-*

papillata Perel', 1969 differing from both due, at least, to its arrangement of setal tumescences. Kobayashi (1940 p. 282, 1941 p. 148) redescribed *E. nordenskioldi* from Manchuria [=Northeast China] and northern Korea, while Zicsi (1972 p. 131) summarized *E. nordenskioldi* from Pyongyang, North Korea. These taxa are compared in Table 1. Additionally, the DNA barcodes in Appendix 1 help define new and old taxa.

***Eisenia nordenskioldi onon* ssp. n.**
http://species-id.net/wiki/Eisenia_nordenskioldi_onon
Fig. 3

Material examined. Holotype (H) NIBR IV0000261277 (mature, dissected, providing DNA sample - wo65) plus six sub-adults provisionally listed as paratypes (IV000061278) and a 'tail', all poorly-preserved in same batch from "*2012-7-20 Dadal*". Unidentifiable were ca. 20 specimens (IV0000261279) some having clitella ca. 24-33 and TP ca. 28-30, also poorly-preserved from crowding in a single tube, labelled "*2012-7-21 Dadal*". All specimens collected by NIBR's Mr T.-S. Park.

Etymology. Nominative noun in apposition after sample region where Dadal and the upper Onon River are supposed birthplace and likely final resting place of Temüjin (otherwise known as Genghis Khan).

Description. Body medium sized, H 100 mm. Segments 170. Reddish pink anterior-dorsum to segment 15 otherwise unpigmented. Epilobous. Pale laterally around *cd* in 8-11 and slightly tumid *ab* on 11-12 and possibly somewhat on clitellum. First dorsal pore 4/5. Spermathecal pores in 9/10/11 mid-dorsally. Female and male pores slight, lateral of *b* setae on 14 and 15, respectively. Nephridia sporadically visible lateral of *b* lines near intersegments (at least on clitellum) otherwise near *d* lines? Clitellum, pale from 24 dorsally or laterally 25-33, i.e., 24,25-33 . TP longitudinally lenticular lateral of *b* 28-31. External features rather unclear due to poor preservation.

Internally similar to nominal subspecies. Seminal vesicles in 9-12. Testis iridescent, free in 10 & 11. Calciferous glands in 11 & 12, vascularized and extending slightly into adjacent segments. Nephridial bladders sausage-shaped. Gizzard 17-18 and thin inverted T-shaped typhlosole present. Soil with coarse organic debris in gut. No parasites were noted.

Remarks. The current taxon differs from previously described subspecies (Tab. 1 and Appendix 2) on its clitellum, TP and tumescences; moreover it appears fertile. Fresher and better preserved material should confirm this analysis. In the meantime, although physically closest to *E. n. mongol*, it is clearly separated objectively on mtDNA data (Appendix 1). This compares to its sibling species-complex: European *Eisenia fetida* (Savigny, 1826) *vs*. *E. andrei* Bouché, 1972 that is claimed to differ molecularly on enzyme gel electrophoresis, e.g. by Jaenike (1982) based on material from New York, but never yet on respective types of either taxon (see Appendix 1 and Discussion).

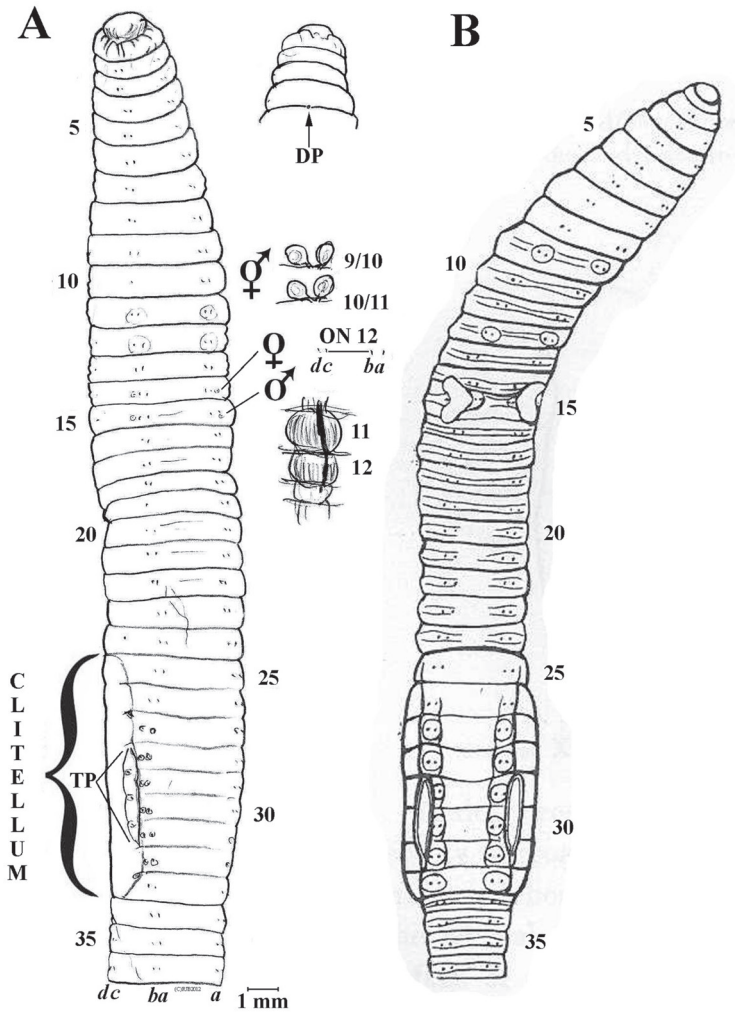

Figure 3. A *Eisenia nordenskioldi onon* ssp. n. Holotype sketched as for Figs **1–2 B** *Allolobophora harbinensis* Kobayashi, 1940: fig. 6 (*incertae sedis*) for comparison.

Discussion

Interest in natural and acquired species ranges intensifies with global climate concerns. Specific responses to extreme physico-chemical factors are also of interest. Lee (1985 p. 44) reports Ghilarov's claim that *Eisenia nordenskioldi* revives after long periods of being frozen, with freeze tolerance down to -30°C recorded for *E. nordenskioldi* (subspecies?) by Holmstrup and Petersen (1997) and Berman and Leirikh (1985). Berman et al. (2002) further report on adaptation to arid conditions. Its sibling species, *Eisenia fetida*, common at altitude in the Himalayas (Stephenson 1925), may be found in Spitzbergen or Siberia wandering on or under snow (some reports possibly misidentifications of *E. nordenskioldi*?); and it is also found in deserts (e.g. of Arizona by

Gates 1967) and Csuzdi and Pavlicek (2005a, b) recently report it from Mar Saba and Samaria, Israel and Jordan. *Eisenia fetida* was further located at hot springs on subarctic Iceland and a fumarole at subtropical Raoul Island, N.Z.; its experimental temperature range is given as -2° to +40°C (Lee 1985 tab. 2).

Regarding natural distributions of lumbricid earthworms and species identities, after synonymy of *Helodrilus* (*Bimastus*) *indicus* Michaelsen, 1907, Gates (1958 p. 6, 1972 p. 108) delineated the natural southern boundary of Lumbricidae in Asia north of the Hindu Kush and Karakorum ranges and from Baluchistan west to the Pacific. He thought endemicity of any lumbricid south of Tian Shan and Altai Mts (where giant *Eisenia magnifica* occurs) into Mongolia or Northeast China would be quite unexpected. Gates (1972 p. 108) said that his synonymy (in *Aporrectodea rosea*) was not accepted by all authors, indeed Easton (1983 p. 478) resurrected Michaelsen's taxon as *Dendrobaena indica*, and whereas transfer was questioned by others (cf. genus *Healyella*), Dr Cs. Csuzdi (2003 pers. comm.) informed that "*I have seen the two type specimens. It seems a distinct species with unknown origin*". Regardless of its generic status, *De. indica* or *He. indicus* can no longer be thought to have been endemic to India, and neither is athecal Kashmiri *Al. prashadi* (Stephenson, 1922) as noted below.

Although Perel' (1969 p. 62) thought it likely that *Allolobophora harbinensis* Kobayashi, 1940 belonged in synonymy of *Eisenia nordenskioldi*, the characters Kobayashi (1940) provided showed similarity to his other three new species that were comparable to *Helodrilus* (*Allolobophora*) *prashadi* Stephenson, 1922: 440, another non-native from India and, after Gates (1958), usually placed in synonymy of *Ap. rosea*. Kobayashi's data are given in Table 2, albeit all five taxa are currently held in the extensive (four page!) synonym list of *Aporrectodea rosea* (Savigny, 1826) (e.g., by Gates 1974, Easton 1983, Blakemore 2008a, 2010, 2012; cf. Tab. 2). Quoting the generic definition by Michaelsen (1900 p. 471), Kobayashi (1940) presumably attributed his taxa to *Eisenia* as then defined only when the spermathecae were present and in or near the median-dorsal line, otherwise he put them into *Allolobophora* (including parthenogens?).

Possibly *Al. harbinensis* is a sexual morph (and therefore an invalid synonym) of *Al. hataii*. Alternatively, it may represent the amphimixic form of a separate taxon or, equally possible, they are subspecies of either of *E. fetida* (most likely) or *E. nordenskioldi* but with spermathecal pores more lateral in *cd* lines. Nothing of substance separates Kobayashi's *Al. jeholensis* from his page prior *Al. dairenensis* so it, at least, should be subsumed. Both have the flared clitella in 29-31 characteristic of *Ap. rosea* and neither are superficially distinguishable from *Aporrectodea rosea* itself defined with clitellum in 25,26-31,32 and TP 29-½31,31 or thereabouts, plus several combinations of setal tumescences. Internally *Ap. rosea* has spermathecae absent or in 9/10/11 dorsally; calciferous glands in 10; U-shaped nephridial bladders and it has a compound typhlosole – see Blakemore (2010, 2012). Thus possibly some or all of Kobayashi's taxa, as well as athecal *Al. prashadi*, may either be Northeast China candidates for *Ap. rosea* or for parts of the *E. fetida* and *E. nordenskioldi* spp.-complexes. Interestingly, Kobayashi (1940 pp. 282-287) describes *Eisenia nordenskioldi* sub-species as well as both *E. rosea* and *E. fetida* from Northeast China! But, since he omits crucial morphological

Table 2. Similar *Allolobophora* species (or rather parthenogenetic morphs?) as described by Kobayashi (1940) with characters he used for separatation bolded.

	***Al. bataii* Kob., 1940: 288**	***Al. harbinensis* Kob., 1940: 290**	***Al. dairenensis* Kob., 1940: 291 (*)**
Length (mm)	78–97	76–96	80–111 (41–53*)
Segments	134–142	134–144	137–139 (132–140*)
Prostomium	Pro-epilobous	Pro-epilobous	Pro-epilobous
Colour	Grey	Grey	**Pinkish** (**Pale***)
Setae *aa:ab* ratio	96:7 (post-clit.)	93:7.5	83:8 (40:3.8*)
1st dorsal pore	4/5/6	4/5	4/5
Spermathecae	**Absent**	9/10/11 in *cd*	**Absent**
Papillae in *ab*	(9)15, 16, 25–32	9, 12, 27–32	9, 15, 16, 23–33
Paler tumid *cd*	10–12	9, 10, 12	10–12 (9–12*)
Clitellum	24–32,33	25,26–32,33	**23–33** (23–32,33*)
TP	29–31	29–31	29–31
Male pores	Prominent	**Horseshoe-shape**	Prominent
Neph. Bladders	?	?	?
Ca Glands	?	?	?
Typhlosole	?	?	?

*For *Al. jeholensis* Kob., 1940: 293 that differs inconsequentially from *Al. dairenensis*.

information ("?s" in Tab. 2), more work is therefore required for resolution of all Kobayashi's taxa – extending to DNA analysis of primary types, if locatable and their DNA viable. More probably (topotypic) neotypes will be required – as per Blakemore et al. (2010) – to permit objective comparison with complete and correct identifications on GenBank notwithstanding. Such tasks far exceed the brief of the present study.

For *Eisenia nordenskioldi* spp-complex, Perel' (1969) separated her *E. n. polypapillata* from the nominal type and a similarly unpigmented, *E. n. pallida* (Malevic, 1956) on the basis of its numerous papillae between the male pores and clitellum, and on the wider distance separating the spermathecal pores from the mid-dorsal line (Tab. 1). Dr Perel (pers. comm. Dec. 2012) now suspects both subspecies are variations of the same taxon, however this too would require reference to the earlier *pallida* and *acystis* types (if locatable).

As with *E. fetida*, mere colour differentiation is probably inadequate. Kobayashi (1940), whose taxa were subsequently combined irrespective of their pigmentation, said typical *E. nordenskioldi* somewhat resembled *E. fetida* but were not quite so banded intersegmentally. In contrast, Zicsi (1972) noted his *E. nordenskioldi* specimens reddish in life, when preserved were colourless. Thus wide intraspecific colour variations seem permissible in parts of *E. nordenskioldi* too.

Some possibly similar species from the Siberian region are *Dendrodriloides grandis perelae* (Kvavadze, 1973) [syn. *Eisenia perelae polysegmentica* Kvavadze, 1979 (non Kvavadze, 1973)], *E. sibirica* Perel & Graphodatsky, 1985, *E. tracta* Perel, 1985, *E. ventripapillata* Perel, 1985 and *Eisenia angusta* Perel, 1994. In the opinion of its author, *E.*

ventripapillata is certainly a separate species to *E. nordenskioldi*; however, it is perhaps closer to *E. acystis* (T. Perel pers. comm. via Anna Leirikh, 27th Feb. 2013). The diagnostic comparison of *E. ventripapillata* given was as an unpigmented worm with clitellum extending to 32/33 and TP occupying three segments at least from ½28 or 28, whereas in *E. nordenskioldi* the TP is always from segment 29 (and clitellum to 33/34).

Another Siberian species claimed to be similar but separate from *E. nordenskioldi* is *Eisenia atlavinyteae* Perel & Graphodatsky 1984: 611 (sometime spelt "*atlavynteae*", "*atlaviniteae*" or "*atlavyntae*" and authored "Perel, Graf., 1985"). Vsevolodova-Perel and Bulatova (2008a, b) commented on polyploidy: "*Amphimictic autopolyploid races of two species of the Asian genus* Eisenia, E. nordenskioldi *and* E. atlaviniteae [sic, lapsus]*, are widespread in Siberia, from its southern boundary to the arctic region, while polyploid Lumbricidae in the East-European plain, except for the Volga region, are represented mainly by parthenogenetic forms of other genera*."

Polyploidy is often associated with parthenogenetic species complexes. Sexual forms of the *Eisenia nordenskioldi* species-complex are reported to have even ploidy levels (orthoploids with 2× being equal to 36 rather than 24 according to Bulatova et al., 1987) ranging from 2n-8n, while the only previously recorded parthenogen is a deep-burrowing and athecal septaploid (7n), *E. nordenskioldi acystis* (Michaelsen, 1903) (with 10× = 110-l15) found in the Talasskii Alatau mountains (Perel and Grafodatsky 1983) that Viktorov (1997) called a "*race*" (and, if so, an invalid taxon). Other taxa like *E. nordenskioldi pallida* may be di- or tetraploid, and ecological differences of polyploid vs. diploid morphs shows wide distribution and variation: the more wide, the higher the ploidy level (Perel' 1987, Grafodatsky et al. 1982, Perel and Bulatova 2008a, b).

Regarding distribution of the species-complex, Kobayashi (1940, 1941) found *E. nordenskioldi nordenskioldi* to be prevalent in the DongBei Region of China and North Korea; differentiating his more darkly pigmented *E. nordenskioldi manshurica* subspecies (Appendix 2 cf. Tab. 1) that he also thought similar to Caucasian *E. n. lagodechiensis* (Michaelsen, 1910) but lacking its glandular male pores, as do all the other sub-species. Dr Perel's *E. n. polypapillata* is from the Dzungarian Alatau mountain range at Almaty Province of south-eastern Kazakhstan. The current species are from much further east in Mongolian river tributaries flowing from the Khentii Mountains to the steppes.

Perel' (1987) states: "..Eisenia nordenskioldi *in southern Kazakhstan, Siberia and the Far East is represented by the poorly pigmented form* pallida*. The typical form is significantly more widespread, in Siberia reaching the regions of the far north and also occurring in the eastern and south-eastern parts of the European USSR"* and Perel' (1997 p. 22) gives the location of dubious *Eisenia nordenskioldi pallida* morph or subspecies in "..Китая и на севере Корея." (= China and in northern Korea). These citations by Perel (1979 pp. 75, 267, 1997 pp. 69, 70) may be mistaken if priority yields to *Eisenia acystis* (Michaelsen, 1903), thus leaving *Eisenia nordenskioldi pallida* Malevics, 1956 as *species inquirendum*. Historical reports of the nominal taxon from the Azores and Hawaii are probable misidentifications with *E. fetida* (as noted by Michaelsen, 1900 p.

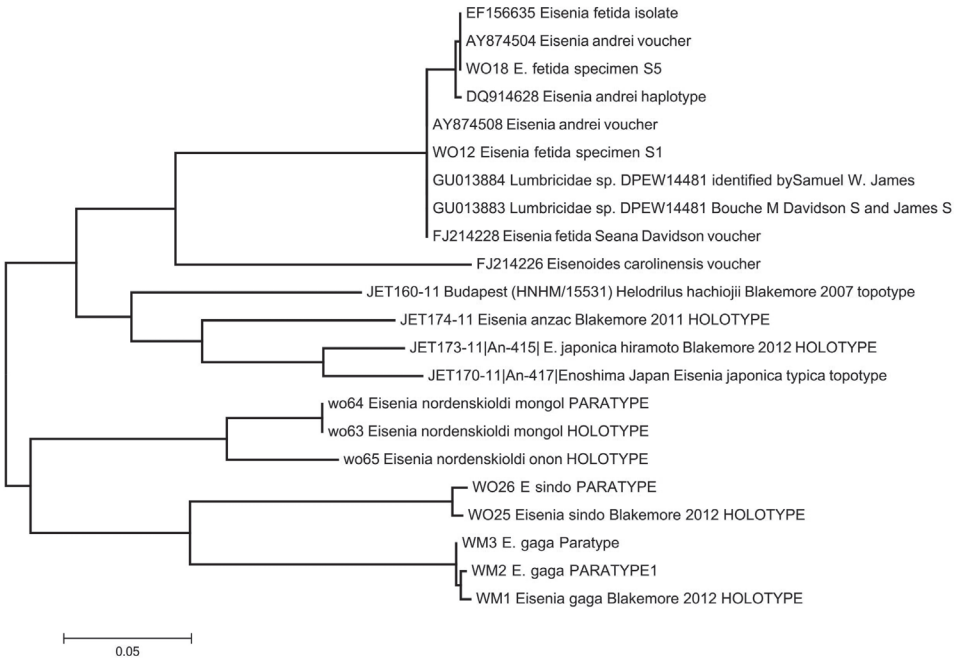

Figure 4. MEGA 5.1 default NJ-ML phylotree of COI barcodes (with sequences aligned using the Clustal X option defaults and S1 (WO12), S5 (WO18) and *E. gaga* complements reversed) showing unreliability of GenBank (blast.ncbi.nlm.nih.gov/genbank) and/or Bold Systems (boldsystems.org) voucher names compared to eloquent power of barcoding definitive ICZN 1° types. Cf. data in Appendix 1.

476); while Garman (1888 p. 73) said that *E. nordenskioldi* was: "*Obtained by Eisen in Siberia; credited to North America by Vejdovsky*", i.e., its USA credit was mistaken too.

Confusion between these sibling species may have been common. Both Michaelsen (1903, 1910) and Gates (1972 p. 103) recognized variability of (parthenogenetic and/or polyploidal) morphs and close relationships of Siberian *Eisenia nordenskioldi* (Eisen, 1879) with European *E. fetida* (Savigny, 1826), Gates saying they were "*indistinguishable specifically from each other by any of the characters of the classical system*" and differing substantially only in the number of atyphlosolate posterior segments. The whole *Eisenia fetida* species-complex yet requires evaluation with consideration of ICZN compliance. For example, as noted above, Jaenike (1982) avoided types and overlooked the synonyms with priority over *E. andrei*, the first being *E. semifasciatus* (Burmeister, 1835) which has not yet been tested and neither have any of Kobayashi's species as noted herein. Moreover, at least Stop-Bowitz (1969, tab. V) maintains Scandinavian *E. fasciata* Backlund, 1948 which is often included in *E. fetida* synonymy by most authors along with ca. 14 other names, but more often than not (especially in chemical/molecular studies by non-taxonomists) these available synonyms are completely overlooked (see also the discussion in Blakemore et al. 2010).

This notion, that components of the *E. fetida* and *E. nordenskioldi* spp. complexes are indistinct, is gradually being falsified by refined genetic information complementing the morphology of taxa under rules of ICZN (1999) that disallows nomenclatural availability to varietal forms, morphs or races. However, further considerations are, firstly, that genetics only reveals a part of the information on a taxon while a morphological character is often controlled and manifest from interplay of several genes throughout the organism's ontogeny and phylogeny (with ontogeny defined as the history of structural change in any biotic entity whether a cell, an organism, or a population of organisms, i.e., a species). Secondly, regardless of data being based on DNA or morphology, or on both of these, it is only the condition pertaining to the ICZN (1999) defined type-specimen that defines the scientifically-named species. Hence a chronic confusion of all *E. fetida/andrei* results – see Blakemore (2006, 2010, 2012b, 2013a, b) and Blakemore et al. (2010), the latter while also providing a model from the first COI barcode of an earthworm's neotype, comments on the shortcomings of all previous molecular studies. Just as Blakemore (2011) observed regarding a New Zealand paper: "*as with several previous molecular phylogenetic works, the only errors in their otherwise informative study are the names*".

The genus is a contrivance itself defined by its type-species' type; ditto a family.

Despite morphological limitations (Tabs 1–2), objective DNA data (Appendix 1) and regulated ICZN taxonomy (Appendix 2) complement comfortably herein (Fig. 4).

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Appendix 1

DNA COI and BLAST analysis

Confidently proven barcode results will eventually be uploaded to GenBank (www.blast.ncbi.nlm.nih.gov/genbank) and/or Bold Systems (www.boldsystems.org).

[>WO7 *Eisenia fetida* specimen S3 from Jeju Island, Korea. Sample mixed/contaminated – megaBLAST result 99–100% *A. trapezoides*, or an unidentified French "*Lumbricidae sp. DPEW31891*" No. GU013952; this result identical with samples WO13 & WO14 I identified as *Bimastos parvus* from Jeju and *A. trapezoides* species-complex specimens from NZ, respectively; these obviously require redoing as noted in Blakemore (2013a)].

>WO12 *Eisenia fetida* specimen S1 from Jeju Island, Korea collected by RJB.

ATAAATGTTGGTAGAGAATAGGGTCGCCACCTCCAGCAGGGT-
CAAAGAATGAGGTATTTAGGTTTCGATCTGTCAATAGTATAGTGA-
TAGCTCCCGCAAGTACTGGAAGAGATAAAAGTAGTAACACCACGG-
TAATAACTACAGCTCATACAAATAGGGGGATTCGTTCTAGTCGAAGC-
CCACTTCATCGTATGTTAATAACTGTAGTAATGAAGTTAATTGCCC-
CTAAAATTGAGGAGGCACCTGCTAAATGGAGGGAAAAAATAGCCAG-
GTCCACTGAGGGCCCCGCGTGCGCTAAGTTACTGGATAGGGGTGGG-
TAAACTGTCCACCCTGTTCCAGCACCCTTTTCCACTGCAGCAGAG-
GATACTAGGAGAATTAGGGAAGGGGGCAGAAGTCAAAATCTTATGTT-
GTTGAGACGTGGAAAGGCTATGTCTGGAGCTCCTAGTATAAGAGG-
TAGAAGTCAGTTTCCAAATCCACCAATAAATACAGGTATTACCAGAAA-
GAAAATTATTACAAATGCATGGGCTGTAACAATTGTATTATATAGTTG-
GTCCCTTCCTAGGAAGGCACCTGGTTGCCTTAGCTCGATTCGAATGA-
GAAGGCTTATACCAGCACCAACCATACCTGCTCAGACCCCGAGAAT-
GAAATAGAG

megaBLAST – 100% for "*DNA barcodes for soil animal taxonomy: transcending the final frontier*" by Bouche & James as unidentified "*Lumbricidae sp*."!, or 100% *E. fetida*, or 100% *E. andrei* by Perez-Losada, *et al.* 2005; GenBank Nos. , GU013883.1, FJ214228.1, AY874508.1, none being based on valid types; or 99% for "*Eisenia andrei* haplotype" DQ914628.1 this again not an ICZN valid type designation.

Recheck analysis as w11 yielded exactly same - nBLAST Id = 617/617 (100%). QED.
>WO18 *E. fetida* specimen S5, 4th April, 2012 mainland Korea collected by RJB.

TCAGAATAAATGTTGGTAGAGAATAGGATCGCCACCTCCAGCAGGGT-
CAAAGAATGAGGTATTCAGGTTTCGATCTGTCAATAGTATAGTGA-
TAGCTCCCGCAAGTACTGGAAGAGATAAAAGTAGTAACACCACGG-
TAATAACTACAGCTCATACAAATAGGGGGATTCGTTCTAGTCGAAGC-
CCACTTCACCGTATGTTAATAACTGTAGTAATGAAGTTAATTGCCC-
CTAAAATTGAGGAGGCACCTGCTAAATGGAGGGAAAAAATAGCCAG-
GTCCACTGAGGGCCCCGCGTGCGCTAAGTTACTGGATAGGGGTGGG-
TAAACTGTCCACCCTGTTCCAGCACCCTTCTCCACTGCAGCAGAGGA-
TACTAGGAGAATTAGGGAAGGGGGCAGAAGTCAAAATCTTATGTTGTT-
GAGACGTGGAAAGGCTATGTCTGGAGCTCCCAGTATAAGAGGTAGAA-
GTCAGTTTCCAAATCCACCAATAAATACAGGCATAACCAGAAAGAAAATT-
ATTACAAATGCATGGGCTGTAACAATTGTATTGTATAGTTGGTCCCTTC-
CTAGGAAGGCACCTGGTTGCCTTAGCTCGATTCGAATGAGAAGGCT-
TATACCAGCACCAACCATACCTGCTCAGACCCCGAGAATGAAATAGAGA

megablastBLAST –100% *Eisenia andrei* by Perez-Losada et al. 2005, or 100% *E. fetida* from USA, or 99% "*DNA barcodes for soil animal taxonomy: transcending the final frontier*" by Bouche & James an unidentified French "*Lumbricidae sp*." with GenBank Nos. AY874504.1, EF156635.1, GU013884.1 – none valid ICZN types.
nBLAST WO12 vs. WO18 Id = 644/652 (99%), i.e., tolerably the same taxon.
>wo63 *Eisenia nordenskioldi mongol* H.

CATAGTAGGTGCAGGAATAAGACTTCTCATCCGAATTGAATTAA-
GTCAGCCGGGTGCCTTCCTAGGTAGAGATCAACTATACAACACAATT-
GTCACAGCTCACGCCTTTGTGATAATCTTCTTCTTAGTTATACCTG-
TATTTATTGGGGGATTTGGAAACTGACTCCTTCCTCTAATACTAG-
GTGCCCCTGACATAGCCTTTCCTCGTCTTAATAACATAAGCTTCT-
GACTTCTACCCCCCTCCCTAATCCTACTAGTATCCTCTGCCGCAGTA-
GAAAAAGGAGCTGGCACAGGATGAACTGTATACCCTCCCTTATCTAG-
GAATATTGCCCATGCTGGCCCTTCAGTAGATTTAGCAATTTTTTC-
CCTACATTTAGCTGGAGCTTCATCAATTCTTGGTGCTATTAACTT-
TATCACCACAGTAATTAATATGCGGTGAACAGGTATACGTCTC-
GAACGAATCCCTCTATTTGTCTGAGCTGTAATTATCACAGTGGTCT-
TACTTCTTCTTTCTCTTCCGGTTCTTGCAAGAGCCATTACCAT-
ACTTCTGACAGACCGAAACCTCAATACTTCATTTTTTGATCCTGCTG-
GAGGGGGGGACCCTATCCTTTACCAGCA

megaBLAST max id for random lumbricids =<83%, *i.e.*, new relative to GenBank.
nBLAST wo63 *vs*. WO12 *E. fetida* Id = 497/617 (81%), i.e., clearly different spp.
>wo64 *Eisenia nordenskioldi mongol* P.

GTACTCTTTACTTTATTCTAGGCGTCTGGGCCGGCATAGTAGGTGCAG-
GAATAAGACTTCTCATCCGAATTGAATTAAGTCAGCCGGGTGCCTTC-
CTAGGTAGAGATCAACTATACAACACAATTGTCACAGCTCACGCCTTT-
GTGATAATCTTCTTCTTAGTTATACCTGTATTTATTGGGGGATTTG-
GAAACTGACTCCTTCCTCTAATACTAGGTGCCCCTGACATAGCCTTTC-
CTCGTCTTAATAACATAAGCTTCTGACTTCTACCCCCCTCCCTAATC-
CTACTAGTATCCTCTGCCGCAGTAGAAAAAGGAGCTGGCACAGGAT-
GAACTGTATACCCTCCCTTATCTAGGAATATTGCCCATGCTGGCC-
CTTCAGTAGATTTAGCAATTTTTTCCCTACATTTAGCTGGAGCTTCAT-
CAATTCTTGGTGCTATTAACTTTATCACCACAGTAATTAATATGCGGT-
GAACAGGTATACGTCTCGAACGAATCCCTCTATTTGTCTGAGCTGTAAT-
TATCACAGTGGTCTTACTTCTTCTTTCTCTTCCGGTTCTTGCAAGAGC-
CATTACCATACTTCTGACAGACCGAAACCTCAATACTTCATTTTTT-
GATCCTGCTGGAGGGGGGGACCCTATCCTTTACCAGCACT

nBLAST "H" *vs*. "P" Id = 618/618 (100%), i.e., ostensibly the same taxon. QED.
>wo65 *Eisenia nordenskioldi onon* H.

GTTTGGGCCGGCATAGTGGGTGCCGGAATAAGACTTCTTATCCGAATT-
GAGTTAAGTCAGCCGGGAGCCTTTCTAGGCAGAGATCAACTATATAATA-
CAATTGTTACAGCTCACGCCTTTGTAATAATCTTCTTCTTAGTTATAC-
CTGTATTTATTGGAGGATTTGGAAACTGACTTTTACCTCTAATACTAG-
GTGCCCCTGATATAGCCTTTCCTCGTCTAAATAACATAAGCTTTT-
GACTTCTACCCCCCTCCCTAATCCTCCTAGTTTCCTCTGCCGCAGTT-
GAGAAAGGAGCTGGCACAGGATGAACTGTATACCCCCCCCTATCTA-
GAAATATTGCCCATGCTGGCCCTTCCGTAGATTTAGCAATTTTTTCGC-
TACATTTAGCCGGAGCTTCATCAATTCTTGGAGCTATTAACTTCAT-
CACCACAGTAATTAATATACGATGAGCAGGTATACGTCTTGAAC-
GAATCCCTTTATTTGTCTGAGCTGTGATTATTACAGTAGTCTTACTTC-
TACTTTCTCTCCCGGTGCTGGCAGGAGCTATTACCATACTTCTAACA-
GACCGAAACCTTAATACTTCATTTTTTGATCCTGCTGGTGGGGGGGAC-
CCTATCCTATATCAACACCTTTTT

megaBLAST max. alignment for random lumbricids =<84%, i.e., again nothing similar yet on GenBank but future comparisons with this definitive type now possible.
nBLAST wo65 *vs*. wo63 Id = 562/609 (92%), i.e., ostensibly different (sub-)species.
All above sequences and megaBLAST results are compared in a MEGA 5.1 default phylotree (Fig. 4) against Japanese *E. japonica* (Michaelsen, 1892) plus some of its sibling species, and against FJ214226 *Eisenoides carolinensis* (Michaelsen, 1910) from USA as the author discusses in Blakemore and Park (2012). Specifically, all *Eisenia andrei* Bouché, 1972 records may be dismissed or falsified in favour of any of the 14–15 prior synonyms of *E. fetida* (Savigny, 1826) that are thoroughly detailed in Blakemore (2004, 2008, 2010, 2013) and are cogently discussed in

Blakemore et al. (2010). As Blakemore (2011) observed in relation to a New Zealand study: "as with several previous molecular phylogenetic works, the only errors in their otherwise informative study are the names."

Appendix 2

Annotated checklist of *Eisenia nordenskioldi* species-complex (chronological)

1. *E. nordenskioldi nordenskioldi* (Eisen, 1879: 6). [Emend. corr. from *nordenskiöldi* e.g. by Blakemore (2008a p. 39); Perel (1979 p. 218) originally included *Allolobophora acystis* in synonymy; but she later stated (Perel 1997 pp. 69–71) that the previous "*E. acystis* Michaelsen, 1903" synonym was erroneous. Miscited as "*nordenskioeldi*" by Blakemore (2004 p. 98) after Easton (1983 p. 480) from original spelling of "*nordenskiöldi*" and as per Michaelsen (1900 p. 476), since it is named after the famous explorer – Baron Nils Adolf Eric Nordenskiöld (1832–1901) – the 'ö' is Finnish and not a German umlaut so was corrected under ICZN (1999 Art: 32.5.2.1) with just the diacritic removed. Alternate original spelling "*nordenskiöldii*" Eisen (1879: 46). Name sometimes misspelt "*nordenskioeldii*", "*nordenskjoldii*", "*nordenscioldi*", "*nordenskiöldii*", or "*nordenskjöldi*" e.g. by Reynolds and Cook (1976 p. 145); misquoted as "Eisen, 1873" in Perel' (1997 p. 69)]. Furthermore, Reynolds and Cook (1976 p. 85) cite a taxon: "*Eisenia nordenskjöldi* var. *caneasia* Mich., 1907: 82" (sic), probably a mistake for *Eisenia nordenskioldi caucasica* that they omit].
2. *E. nordenskioldi caucasica* Michaelsen, 1903: 38 ***species inquirendum*** [non *Dendrobaena caucasica* Kulagin, 1889 (= *D. veneta*)]. [Often misdated "1902" as with *acystis*. From Transcaucases, to 2,500 m altitude (Michaelsen, 1903 p. 39) found also in association with *E. fetida*; its clitellum is 24,25-33 and TP 27,28-31 or 28-½32 . Although Michaelsen has types in St. Petersberg they are listed in Hamburg (6959) by Reynolds and Cook (1976 p. 85) for their "*Ei. nordenskjöldi caneasia* Mich., 1907: 82" (sic, lapsus pro *caucasica*) in a 1907 Georgian publication that seems not to exist. Easton (1983 p. 480) at least placed *caucasica* in synonymy of *E. fetida*, although this placement requires re-evaluation with the benefit of recent taxonomic advances (e.g., DNA and IBM)].
3. *E. nordenskioldi acystis* (Michaelsen, 1903: 43) ***species inquirendum***. [Originally *Helodrilus acystis*; ?non "*Haplotaxis acystis* Michaelsen, 1903: 43" (lapsus?) – this taxon, often repeated on species databases, has the same publication data and is likely a mistake]. [A parthenogenetic sub-species of some part of the species-complex lacking spermathecae (and spermatophores?); it was unpigmented, described with clitellum in 26-33 and TP in 29-½31; seminal vesicles in 9-12; *cf. E. n. pallida*. From Turkestan with types in St. Petersburg Museum. Dr T. Perel (pers. comm. via A. Leirikh 27th Feb. 2012) now considers it a separate taxon from *E.*

nordenskioldi. Note: Its publication date is confirmed as 1903 since the journal states "*Augegeben am 27. Mai 1903*" rather than "1902" as scheduled].

4. *E. nordenskioldi lagodechiensis* (Michaelsen, 1910: 18) ***species incertae sedis***. [Originally in *Helodrilus*; returned to separate species level by Kvavadze (1993) because its developed male pores are apparently distinctive (cf. Kobayashi's, 1940 taxa). From Georgia, the types probably in St Petersburg].
5. *E. nordenskioldi manshurica* Kobayashi, 1940: 284 ***species inquirendum.*** [Sometimes included as a synonym of nominal sub-species, its characters probably justify its separation: Dark pigment. Length 111-144 mm, segments 154-175), clitellum in 26,27-34 and TP 29-32. Type-locality is likely Anshan, where two clitellate specimens were found (August, 1938) along with two aclitellate specimens; other semi-clitellates from Chinhsien and Mutanchiang but all syntypes are now lost following Pacific and Korean wars].
6. *E. nordenskioldi pallida* (Malevic, 1956: 439) ***species inquirendum*** (non *Allolobophora pallida* Bretscher, 1900: 41). [Cited in Perel' (1969 p. 62, 1979 pp. 75, 267) and Vsevolodova-Perel (1997 pp. 69-71) as *E. nordenskiöldi pallida* Malevic, 1956 latterly with restoration of synonym *E. acystis* (Michaelsen, 1903) - this possibly a mistake as the priority would yield to *E. acystis* with *acystis* itself possibly remaining a synonym of the nominal subspecies. Both taxa overlooked by Reynolds and Cook (1976) and by Easton (1983). The original reference (listed as "Ucs. Zapisk. M. Gor. Ped. Inst. 61: 439-448" on www.earthworm.uw.hu) was inaccessible at time of current submission].
7. *E. nordenskioldi polypapillata* Perel, 1969: 61 ***species inquirendum***. [Its papillae and position of spermathecae, as originally described, are perhaps definitive (Tab. 1). Collected in May, 1967 from "*Dsungar-Ala-Tau, Bezirk Sarkand, Försterei Topolevskoje*" (a forestry station in Sarkand district of the Dzungarian Alatau mountain range at Almaty Province of south-eastern Kazakhstan); found in Apple and Fir forest at 1,200–1,500 m altitude. Holotype and Paratype from ten poorly-preserved specimens in Zoological Museum of Moscow University, No. W-10. Dr Perel now suspects it is synonymous (pers. comm. via Anna Leirikh Dec. 2012) "*She also now suppose that* E. n. polypapillata *in fact is* E. n. pallida*, and some authors considers* E. n. pallida *as separate species*"; however the relationship of both to prior *E. n. acystis* remains unclear as noted above].
8. *E. nordenskioldi mongol* Blakemore, 2013 ssp. n. with its DNA data provided.
9. *E. nordenskioldi onon* Blakemore, 2013 ssp. n. with its DNA data provided.

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Genus *Promalactis* Meyrick (Lepidoptera, Oecophoridae) from China: Descriptions of twelve new species

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Abstract

Sixteen species of the genus *Promalactis* Meyrick, 1908 from China are described. Among them, twelve species are described as new: *P. bifurciprocessa* **sp. n.**, *P. convexa* **sp. n.**, *P. papillata* **sp. n.**, *P. quadratitabularis* **sp. n.**, *P. quadriloba* **sp. n.**, *P. ramispinea* **sp. n.**, *P. scorpioidea* **sp. n.**, *P. serpenticapitata* **sp. n.**, *P. similiconvexa* **sp. n.**, *P. spinosicornuta* **sp. n.**, *P. strumifera* **sp. n.** and *P. uncinispinea* **sp. n.**; the previously unknown male of *P. dimolybda* Meyrick, 1935 and female of *P. flavescens* Wang, Zheng & Li, 1997 are described for the first time; *P. albipunctata* Park & Park, 1998 and *P. dierli* Lvovsky, 2000 are newly recorded for China. Adults and genitalia are illustrated.

Keywords

Lepidoptera, Oecophoridae, *Promalactis*, new species, China

Introduction

The genus *Promalactis* was established by Meyrick (1908). It currently comprises 179 valid species worldwide, distributed mainly in the Palaearctic and Oriental regions. China has the greatest diversity, with 101 recorded species (Wang et al. 2006, 2009, 2011). This paper presents the results of our recent study of *Promalactis* based on

specimens deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing (IOZ), with some additional specimens from the Insect Collection, College of Life Sciences, Nankai University, Tianjin (NKU). Sixteen species have been identified, including twelve species new for science, and two species new for China.

Promalactis is represented by the combination of the following characters: the smooth head with metallic lustre, the lanceolate forewings with various dark or white markings against yellow to deep ochreous brown ground colour; the variously shaped symmetrical or asymmetrical valvae and a narrow to very broad sacculus in the male genitalia; and a developed to ill-defined lamella postvaginalis and an elongate thin ductus bursae in the female genitalia.

Little is known about the biology of this genus. Meyrick (1922) reported that larvae of *Promalactis* fed on rotten wood or bark of Pinaceae and other trees.

Material and methods

Specimens examined in this study were collected in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hunan, Jiangxi, Sichuan, Zhejiang Provinces and Xizang Autonomous Region by light traps. Genitalia dissections and slide mounting methods followed Li (2002). Photographs of adults were taken with a Nikon D300 digital camera plus macro lens, and the genitalia were photographed with an Olympus C-7070 digital camera. All the studied specimens, including the types, are deposited in the Insect Collection, the Institute of Zoology, Chinese Academy of Sciences, Beijing, and the Insect Collection of the College of Life Sciences, Nankai University, Tianjin, China.

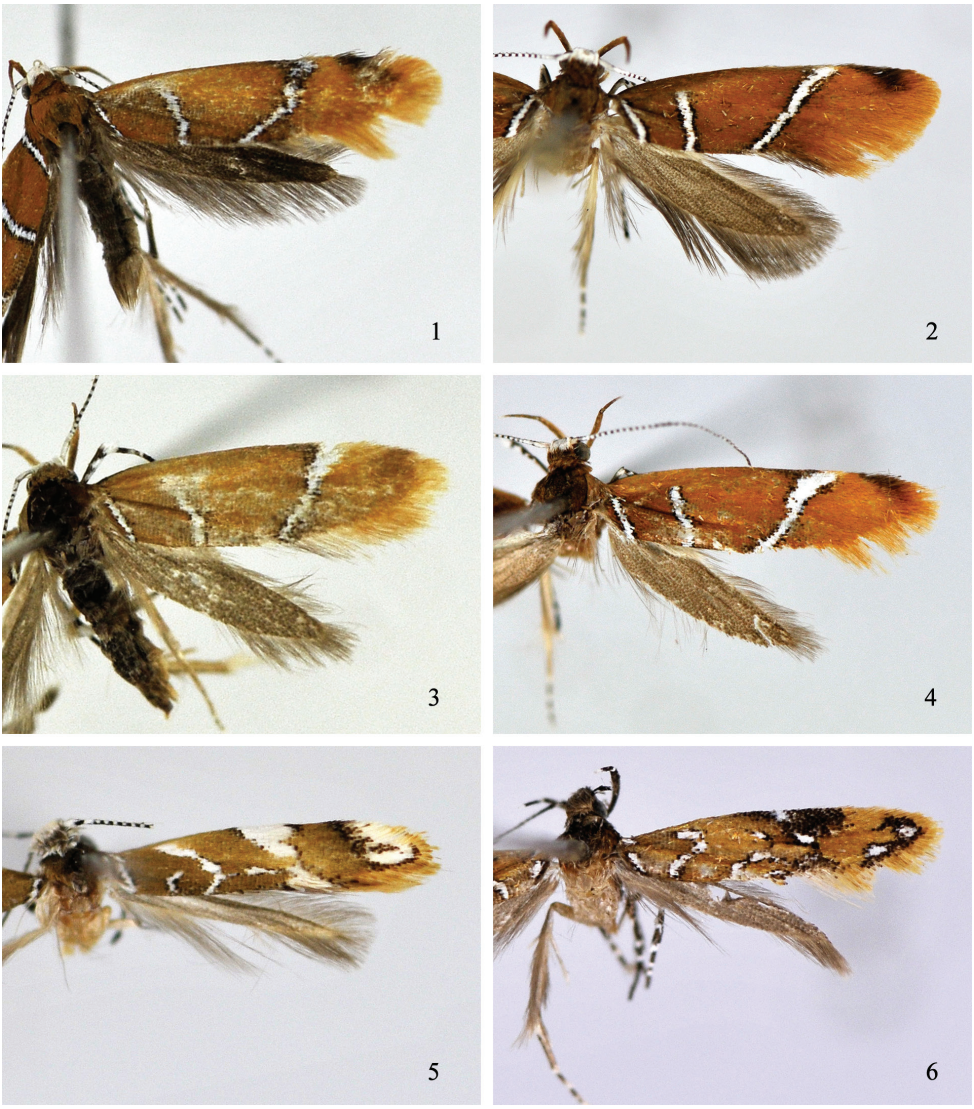
Taxonomic accounts

***Promalactis bifurciprocessa* sp. n.**
urn:lsid:zoobank.org:act:333A38C0-615C-4B6D-90D1-594C4C567610
http://species-id.net/wiki/Promalactis_bifurciprocessa
Figs 1, 17

Type material. Holotype ♂ – **China, Anhui Province:** Yungusi, Mt. Huang (30°07'N, 118°11'E), 15.V.1978, coll. Sizheng Wang, genitalia slide No. DZH12198 (IOZ).

Diagnosis. The new species is similar to *P. manoi* Fujisawa, 2002. It can be separated by the left sacculus with distal process bifurcate, the right sacculus with distal process slender and curved ventrad, and the aedeagus with one cornutus in the male genitalia. In *P. manoi*, the distal process of the left sacculus is not bifurcate, the distal process of the right sacculus is broad and curved dorsad, and the aedeagus has two cornuti.

Description. Adult (Fig. 1). Wingspan 13.5 mm. Head with vertex shining white, frons dark brown, occiput ochreous brown. Labial palpus with basal and second segments dark orange on outer surface, basal segment light yellow on inner surface, sec-



Figures 1–6. Adults of *Promalactis* species. **1** *P. bifurciprocessa* sp. n., holotype, male **2** *P. convexa* sp. n., holotype, male **3** *P. papillata* sp. n., paratype, female **4** *P. quadratitabularis* sp. n. , holotype, male **5** *P. quadriloba* sp. n., holotype, male **6** *P. ramispinea* sp. n., paratype, female.

ond segment ochreous yellow on inner surface; third segment dark ochreous brown, white at apex, almost same length as second. Antenna with scape white except dark brown on anterior and posterior margins; flagellum white and dark brown on dorsal surface, dark brown on ventral surface. Thorax and tegula ochreous brown. Forewing orange; a narrow white fascia edged with dense black scales from beyond costal 2/3 to before lower angle of cell, then obliquely straight inwards to 3/4 of dorsum, its anterior1/4 widened and densely diffused with black scales; costal margin with an apical

blackish brown spot; two white streaks arising from dorsal margin, edged with dense black scales: basal streak from dorsal 1/5 to above base of fold, straight, second streak from dorsal 2/5 to basal 1/3 of upper margin of cell, sinuate, area between two streaks ochreous brown; cilia orange yellow, dark brown along distal part of costal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 17). Uncus heavily sclerotized, nearly trapezoidal, broad at base, slightly narrowed to blunt apex, laterally folded inward and with sparse setae. Gnathos heavily sclerotized, about 3/5 length of uncus, bluntly rounded at apex; lateral arm band shaped, almost same length as gnathos. Tegumen branched from about middle, narrowed anteriorly, blunt apically. Valva asymmetrical; left valva long, slightly narrowed basally, widened distally, rounded apically; costa slightly concave basally, projected distally, rounded apically; sacculus broadened medially, narrowed distally, distal process free, heavily sclerotized, setose, bifurcate distally, forming two spine-like processes: dorsal process curved straight dorsad, apically reaching dorsal 1/4 of valva, ventral process almost straight, apically slightly exceeding end of valva; right valva short, subtriangular, pointed apically, concave inward ventro-distally; costa projected distally; sacculus broad oval, distal process free, very long, curved ventrad, arched inward, far exceeding end of valva, setose distally, acute apically. Saccus short, about 3/5 length of uncus, subtriangular, narrowly rounded at apex. Juxta small, weakly sclerotized, subtriangular. Aedeagus curved, about 1.3 times length of left valva, broad basally, narrowed distally, with a curved, thin apical spine; cornutus spine-like, about 1/4 length of aedeagus, situated near middle of aedeagus.

Female. Unknown.

Distribution. China (Anhui).

Etymology. The specific name is derived from Latin *bifurcus* (= bifurcate) and *processus* (= process), referring to the bifurcate distal process of the left sacculus in the male genitalia.

***Promalactis convexa* sp. n.**
urn:lsid:zoobank.org:act:A53C143D-3AE2-496E-8B69-75E5CE0D542C
http://species-id.net/wiki/Promalactis_convexa
Figs 2, 18

Type material. Holotype ♂ – **China, Sichuan Province:** Mt. Qingcheng (30°58'N, 103°31'E), 25.V.1979, genitalia slide No. DZH12027 (IOZ).

Diagnosis. The new species is similar to *P. ermolenkoi* Lvovsky, 1986, but can be separated by the left valva with a beak-like dorso-apical process and the right valva with a hooked dorso-apical process, the left sacculus with a leaf-like distal process and the right sacculus with a spine-like distal process, and the aedeagus with one large cornutus in the male genitalia. In *P. ermolenkoi*, the valva has no dorso-apical process, the left sacculus has a papillary distal process and the right sacculus with an elongate

club-shaped distal process, and the aedeagus has two small cornuti. This species is also similar to *P. quadratitabularis* sp. n and *P. similiconvexa* sp. n. The differences between them are stated under each of the latter two species.

Description. Adult (Fig. 2). Wingspan 15.0–16.0 mm. Head with vertex shining white, frons brown, occiput ochreous brown. Labial palpus with basal and second segments orange on outer surface, basal segment light yellow on inner surface, second segment yellow on inner surface; third segment ochreous, slightly shorter than second. Antenna with scape white; flagellum with basal several flagellomeres white, remaining flagellomeres white and black on dorsal surface, black on ventral surface. Thorax and tegula ochreous brown. Forewing ground colour ochreous brown; markings white edged with black scales; a narrow fascia from beyond costal 2/3 extending obliquely inwards to dorsal 3/4, its anterior 2/5 slightly broad; two streaks arising from dorsum: basal streak from dorsal 1/5 extending obliquely to above base of fold, second streak from dorsal 1/3 to above upper margin of cell at basal 1/3; costal margin with a dark brown apical spot; cilia dark orange, dark brown basally at apex, forming a large ill-defined quadrangular spot together with costal spot. Hindwing and cilia dark grey.

Male genitalia (Fig. 18). Uncus heavily sclerotized, nearly square, lateral margin arched outward, with sparse setae, posterior margin concave at middle, protruded laterally. Gnathos heavily sclerotized, very short, narrowly banded, distally curved ventrad, with small triangular lateral processes; lateral arm long, heavily sclerotized, about 2/3 length of uncus, band shaped. Tegumen branched from posterior 1/5, slightly narrowed anteriorly. Valva broad, sclerotized, setose distally, asymmetrical; left valva rounded at apex, with a heavily sclerotized, curved, beak-like dorso-apical process, which directs dorsad and bears three teeth distally on outside; sacculus strongly convex dorso-basally, reaching costa posteriorly, then conspicuously narrowed to narrowly rounded apex, with a heavily sclerotized, nearly leaf-like subapical process, which is curved upright, margined with dense teeth, pointed at apex, and reaches middle of dorso-apical process; right valva truncate at apex, with a heavily sclerotized, hooked dorso-apical process, which is upright and pointed at apex; sacculus with basal 3/5 roundly protruding dorso-basally, exceeding costa posteriorly, abruptly narrowed to 3/5, almost same width from 3/5 to 4/5, with a large spine-like process at distal 1/5, distal 1/5 tapered to apex, edged with teeth dorsally. Vinculum nearly triangular, protruding outward latero-medially. Saccus about 3.5 times length of uncus, basal 2/5 broader than distal 3/5, rounded at apex. Juxta roughly oval, weakly sclerotized. Aedeagus curved, about twice length of valva, with a sclerotized, quadrate apical plate; cornutus consisting of some almost coalesced, short, fine spines, forming a large spine, about 1/5 length of aedeagus, situated basally.

Female. Unknown.

Distribution. China (Sichuan).

Etymology. The specific name is derived from Latin *convexus* (= convex), referring to the sacculus strongly convex dorso-basally.

***Promalactis papillata* sp. n.**
urn:lsid:zoobank.org:act:EE5F3D8B-F17C-4C49-A750-C8FF6D610523
http://species-id.net/wiki/Promalactis_papillata
Figs 3, 19, 31

Type material. Holotype ♂ – **China, Zhejiang Province:** Zhonglieci, Mt. Tianmu (30°19'N, 118°27'E), 400 m, 27.VII.2011, coll. Linlin Yang & Na Chen, genitalia slide No. DZH12147 (NKU); Paratypes – 1 ♂, 3 ♀, same data as holotype except dated 25–27.VII.2011 (NKU). **Anhui Province:** 1 ♀, Julongsi, Mt. Jiuhua, 23.VII.1979, coll. Sizheng Wang (IOZ), genitalia slide Nos. DZH11097 ♀, DZH12137 ♀, DZH12196 ♀, DZH12206 ♂.

Diagnosis. This species is similar to *P. scorpioidea* sp. n. It can be separated by the uncus with two small lateral papillary processes at distal 1/3, and the left sacculus having a strong spine-like process at distal 2/5; the lamella postvaginalis produced to a trapezoidal or quadrangular process on the dorsal surface and to a short quadrangular process on the ventral surface. In *P. scorpioidea* sp. n., the uncus is trilobed distally, the left sacculus has a subrectangular process at distal 1/3; the lamella postvaginalis lacks the process posteriorly. This species is also similar to *P. brevivalvaris* Wang, Li & Zheng, 2000, but the latter can be distinguished by the uncus without papillary process at basal 2/3, with three pointed processes on the posterior margin which are absent in the new species, and the short cornutus about 1/3 the length of the aedeagus, which is 3/5 the length of the aedeagus in the new species.

Description. Adult (Fig. 3). Wingspan 9.0–12.0 mm. Head with vertex shining white, frons and occiput yellowish brown. Labial palpus with basal and second segments ochreous brown on outer surface, light yellow on inner surface; third segment dark ochreous brown, almost same length as second. Antenna with scape white except dark brown on anterior and posterior margins; flagellum white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula ochreous brown. Forewing dark orange yellow, markings white edged with black scales; narrow fascia from costal 2/3 obliquely inwards to end of fold, its anterior 1/2 broad subtriangular; orange yellow from outer margin of fascia to termen; two streaks arising from dorsal margin: basal streak from dorsal 1/5 to base of fold, straight, second streak from dorsal 1/2 to basal 1/3 of upper margin of cell, sinuate; cilia yellow. Hindwing and cilia dark grey.

Male genitalia (Fig. 19). Uncus with basal 2/3 broad and parallel sided, with a small, setose, papillary process at basal 2/3 laterally, distal 1/3 narrowed, posterior margin emarginate or narrowly rounded. Gnathos about 3/5 length of uncus, narrow tongue shaped, scobinate, apex narrowly rounded; lateral arm band shaped, slightly shorter than gnathos. Tegumen branched from posterior 1/3, triangularly narrowed anteriorly. Valva with costa slightly concave at base, apex blunt, asymmetrical; left valva almost parallel dorso-ventrally, slight longer than right valva; sacculus broad at base, gradually narrowed to pointed apex, exceeding end of valva, setose medially, strongly dentate and setose along distal 2/5 dorsally, with a heavily sclerotized, strong spine-like

process at distal 2/5, which is oblique toward basad; right valva broad basally, slightly narrowed distally; sacculus almost same width except narrowed distally, setose medially, dentate and setose along distal 1/4 dorsally, with a heavily sclerotized, upright, triangular process at distal 1/4, with a small apical spine. Saccus about twice length of uncus, broad at base, slightly narrowed to basal 1/3, distal 2/3 nearly finger-like, rounded at apex. Juxta sclerotized, a large quadrangular plate. Aedeagus curved, about 1.6 times length of left valva, sclerotized distally; cornutus long and curved, spine-like, about 3/5 length of aedeagus.

Female genitalia (Fig. 31). Apophysis anterioris about 1/2 length of apophysis posterioris. Lamella postvaginalis large and heavily sclerotized, columniform, sometimes narrowed anteriorly; posteriorly produced to a trapezoidal or quadrangular process on dorsal surface and a short quadrangular process on ventral surface: dorsal process rounded on posterior margin, or concave in V shape at middle and forming two small hill-like lateral processes; ventral process about 2/5 length of dorsal one, slightly concave on posterior margin. Antrum nearly funnelform. Ductus bursae long and coiled, about four times length of corpus bursae, sclerotized except small membranous posterior and anterior sections, dorsally with a sclerotized quadrate plate bearing four curved long spines on right side at posterior 1/6, ventrally with a cluster of short spines at posterior 1/6; ductus seminalis arising from near posterior end of ductus bursae. Corpus bursae rounded, membranous, with dense granules; signum absent.

Distribution. China (Anhui, Zhejiang).

Etymology. The specific name is derived from Latin *papillatus* (= having papillary process), referring to the uncus having a small papillary process at basal 2/3 laterally.

***Promalactis quadratitabularis* sp. n.**
urn:lsid:zoobank.org:act:86F99BA5-E995-4CE2-A1F7-0B4A781C9720
http://species-id.net/wiki/Promalactis_quadratitabularis
Figs 4, 20

Type material. Holotype ♂ – **China, Sichuan Province:** Wanniansi, Mt. Emei (29°32'N, 103°19'E), 14.VI.1979, genitalia slide No. DZH12037 (IOZ). Paratypes – 2 ♂, same data as holotype, genitalia slide Nos. DZH12181, DZH12205 (IOZ).

Diagnosis. This species is very similar to *P. convexa* sp. n., but can be separated by the left valva with an apical spine and a triangular dorso-apical process, the right valva dorsally projected and serrate on distal 1/4, and the sacculus with a triangular distal process on the left and with some distal teeth on the right in the male genitalia. In *P. convexa* sp. n., the left valva lacks the apical spine and has a beak-like dorso-apical process, the right valva has a hooked dorso-apical process, the sacculus has a leaf-like distal process on the left and a spine-like distal process on the right. *Promalactis pulchra* Wang, Zheng & Li, 1997, *P. similipulchra* Wang, 2006, and *P. zhejiangensis* Wang & Li, 2004 *et al* are externally similar to this new species, but their valva lacks the dorso-

apical process on the left, and their narrow sacculus is not strongly convex and does not reach costa posteriorly.

Description. Adult (Fig. 4). Wingspan 14.0–15.0 mm. Head with vertex shining white, frons brown, occiput dark ochreous yellow. Labial palpus with basal and second segments ochreous yellow on outer surface, basal segment light yellow on inner surface, second segment yellow on inner surface; third segment ochreous yellow mixed with dark ochreous brown, almost same length as second. Antenna with scape white except dark brown on anterior and posterior margins; flagellum with basal three flagellomeres white, remaining flagellomeres white and black on dorsal surface, dark brown on ventral surface. Thorax, tegula and forewing dark orange yellow. Forewing with white markings edged with black scales; narrow white fascia from about costal 3/4 obliquely inwards to dorsal 3/4, curved, its anterior 2/5 broadened, with dense diffused dark brown scales on inner margin anteriorly; two streaks arising from dorsum: basal streak from dorsal 1/5 to above base of fold, straight, second streak parallel with basal streak, from dorsal 1/2 to upper margin of cell at basal 1/3, slightly sinuate; costal margin with a apical blackish brown spot; cilia orange yellow, dark ochreous brown basally around apex. Hindwing and cilia ochreous grey.

Male genitalia (Fig. 20). Uncus sclerotized, nearly quadrate, shallowly concave at middle on posterior margin, with two small, directing ventrad, triangular processes near posterior margin. Gnathos heavily sclerotized, very short, apically concave at middle, forming two small, triangular lateral processes, curved ventrad; lateral arm about 1.5 times length of gnathos, band shaped. Tegumen branched from posterior 1/4, slightly narrowed anteriorly. Valva broad, sclerotized, setose distally, asymmetrical; left valva having a larger, upright apical spine, with a heavily sclerotized, triangular dorso-apical process directing obliquely basad and serrate dorsally; sacculus strongly convex dorso-basally, slightly exceeding costa posteriorly, conspicuously narrowed to rounded apex, with a heavily sclerotized, serrate, triangular distal process directing obliquely basad, almost same length as and parallel to dorso-apical process of valva; right valva having a smaller, upright apical spine, its distal 1/4 dorsally projected and serrate; sacculus with basal 3/5 roundly protruding, slightly exceeding costa posteriorly, then abruptly narrowed to 3/5, distal 2/5 free, with many heavily sclerotized, ragged dorso-distal teeth, apex narrowly rounded. Vinculum with anterior 1/2 broadened, having a broad transverse band joining lateral sides anteriorly, forming a very short sac antero-ventrally. Saccus elongate, about three times length of uncus, broad at base, gradually narrowed to 2/3, distal 1/3 parallel laterally, rounded at apex. Juxta roughly oval, weakly sclerotized. Aedeagus gently curved, about twice length of valva, slightly dilated basally, with a sclerotized, irregular quadrate plate apically; cornutus consisting of some clustered, almost coalesced fine spines, forming a large, gently curved spine, about 1/5 length of aedeagus, situated basally.

Female. Unknown.

Distribution. China (Sichuan).

Etymology. The specific name is derived from Latin *quadratus* (= quadrate) and *tabularis* (= plate shaped), referring to the quadrate apical plate of the aedeagus.

***Promalactis quadriloba* sp. n.**
urn:lsid:zoobank.org:act:8AE3931A-B02B-4B84-B3DA-1187D5150666
http://species-id.net/wiki/Promalactis_quadriloba
Figs 5, 21

Type material. Holotype ♂ – **China, Guizhou Province:** Sanchahe (27°31'N, 106°54'E), Xishui County, 300–500 m, coll. Chunsheng Wu, genitalia slide No. DZH12032 (IOZ).

Diagnosis. This new species is similar to *P. tricuspidata* Wang & Li, 2004, but can be separated by the ventral lobe of the valva having a slender spine-like ventrobasal process, the saccus about the same length as the uncus, the juxta without lateral processes at basal 1/3, the aedeagus without hooked distal process, and the very small cornutus shorter than 1/10 length of the aedeagus in the male genitalia. In *P. tricuspidata*, the ventral lobe of the valva lacks ventral process, the saccus is about four times the length of the uncus, the juxta has lateral processes at basal 1/3, the aedeagus has a hooked distal process, and the long cornutus is about 1/4 length of the aedeagus in the male genitalia.

Description. Adult (Fig. 5). Wingspan 9.0–9.5 mm. Head milk white, occiput white tinged with ochreous brown. Labial palpus with basal and second segments grey on inner surface, brown on outer surface, second segment black at apex; third segment yellow mixed with black except white at base and apex, slightly shorter than second. Antenna with scape white, pecten yellowish brown; flagellum white and black on dorsal surface, black on ventral surface. Thorax and tegula dark yellowish brown. Forewing ground colour yellowish brown; markings white edged with black scales; costal margin black along basal 1/4, with a slender fascia from base extending to dorsal margin, with a broad streak extending from subcostal 1/6 obliquely to middle of fold, with a large patch at costal 1/2 extending downward to near end of cell, contracted lateromedially, bearing dense black scales antero-laterally; dorsal margin with a V-shaped pattern extending from before 1/3 to before 2/5 of fold, with a L-shaped pattern from 1/2 straight outward to middle of fold, then curved outward to before lower angle of cell; apex with a large ovate spot, mixed with black scales, edged with dense black scales except on anterior margin; an irregular spot before tornus, extending upward to lower angle of cell; cilia ochreous yellow. Hindwing and cilia grey.

Male genitalia (Fig. 21). Uncus with basal 3/5 slightly wide, sclerotized laterally, distal 2/5 sclerotized, compressed laterally, apex pointed and curved ventrad; laterally with a long, strong setae at basal 2/5. Gnathos rectangular, straight at apex, about 3/5 length of uncus; lateral arm broad, subtriangular, about same length as gnathos. Tegumen broad posteriorly, branched from near posterior margin, rounded anteriorly. Valva narrowed basally, broadened distally; apex with three slender lobes: dorsal lobe heavily sclerotized, curved, with an apical tuft of setae directing ventrad; median lobe with basal 3/4 slender, distal 1/4 expanded and setose, slightly exceeding end of dorsal lobe, directing obliquely dorsad, close to dorsal lobe at base; ventral lobe with basal 3/5 broad triangular, distal 2/5 slender digitate, bearing a spine-like process ventro-

basally, with tufted hairs apically, slightly shorter than median lobe. Costa sclerotized, broad at base, gradually narrowed distally. Sacculus indistinct. Saccus broad at base, gradually narrowed to rounded apex, about same length as uncus. Juxta very narrow at base, gradually broadened to about middle, sclerotized laterally; distal half bilobed, heavily sclerotized, arched outwards, obliquely truncate at apex, reaching anterior 2/5 of tegumen. Aedeagus slightly arched, about 1.3 times length of valva, triangular distally; cornutus very small, shorter than 1/10 length of aedeagus, spine-like, situated at about middle of aedeagus.

Female. Unknown.

Distribution. China (Guizhou).

Etymology. The specific name is derived from the Latin prefix *quadri-* (= four), and the suffix *-lobus* (= lobe), referring to the three apical lobes and the ventral process of the valva.

***Promalactis ramispinea* sp. n.**
urn:lsid:zoobank.org:act:9DB7D7E5-27D1-4912-83E5-52D0362CA290
http://species-id.net/wiki/Promalactis_ramispinea
Figs 6, 22, 32

Type material. Holotype ♂ – **China, Jiangxi Province:** Mt. Lu (26°30'N, 115°58'E), 382.8 m, 1.VIII.1975, coll. Youqiao Liu, genitalia slide No. DZH11025 (IOZ). Paratypes – 1 ♀, same data as holotype except dated 9.VII.1975; 4 ♂, 5 ♀, same data as holotype except dated 28.VII–1.VIII.1975. **Jiangxi Province:** 2 ♂, 1 ♀, Xingguo County (26°19'N, 115°20'E), 4, 19, 21.VII.1976; 1 ♀, Mt. Wuyi, 670 m, 2.VIII.1980, genitalia slide Nos. DZH12012 ♂, DZH12013 ♀ (IOZ). **Hunan Province:** 3 ♀♀, Cangxi Town, Xinhua County (27°44'N, 111°18'E), 8–9.VIII.2004, coll. Yunli Xiao. **Fujian Province:** 1 ♀, Guadun (27°44'N, 117°38'E), Mt. Wuyi, 1100 m, 29.VII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai. **Guangdong Province:** 1 ♀, NanLing (23°20'N, 115°23'E), Shaoguan City, 7–14.VII.2007, coll. Min Wang *et al.*, genitalia slide Nos. DZH12043 ♀, DZH12044 ♀, DZH12045 ♀ (NKU).

Diagnosis. This species is similar to *P. trapezia* Wang, 2006, but can be separated by the forewing with a white spot on termen; the tongue-shaped gnathos, the valva with a thick, curved digitate dorso-apical process, and the cornutus distally bearing four to five strong spines in the male genitalia. In *P. trapezia*, the forewing has no white spot on termen; the gnathos is somewhat trapezoidal, the valva has some strong dorso-apical spines and the cornutus is a single spine.

Description. Adult (Fig. 6). Wingspan 10.0–12.0 mm. Head shining greyish brown. Labial palpus with basal and second segments yellowish grey on inner surface, dark brown on outer surface; third segment with basal 1/4 and distal 1/4 white, middle 1/2 black, about 3/5 length of second. Antenna with scape black mixed with white on dorsal surface, yellow on ventral surface, pecten dark brown; flagellum white

and black on dorsal surface, yellow on ventral surface. Thorax and tegula ochreous brown. Forewing ground colour orange yellow; costal margin with an inverted triangular black blotch at basal 3/5, posteriorly crossing half wing, with a small white spot at middle within black blotch; cell with a very short, longitudinal white streak at 1/3 on upper margin, with a small white spot at 3/4 and near outer margin; fold with a short white streak at base, a rectangular spot above 1/3 sometimes connected with the white streak at 1/3 of cell, and a L-shaped white streak above 2/3; dorsal margin with three white streaks arising from basal 1/6, 1/3 and 1/2 reaching obliquely to fold respectively, median streak sometimes joined with the spot above 1/3 of fold, third streak sometimes connected with L-shaped streak, with a sinuate weak white line from distal 1/3 to end of fold; tornus with a diffused triangular black spot, extending upward to lower angle of cell; apex and termen with a white spot respectively, surrounded with dense black scales; cilia yellow, tinged with white scales at tornus. Hindwing and cilia dark grey.

Male genitalia (Fig. 22). Uncus elongate triangular, broad at base, narrowed to narrowly rounded apex. Gnathos tongue shaped, about same length as uncus, distal 1/3 scobinate; apex rounded, with a small papillary process; lateral arm short, band shaped. Tegumen branched from posterior 2/5, triangularly narrowed anteriorly. Valva almost parallel dorso-ventrally; apex obliquely truncate, dorso-apical process thick digitate, curved ventrad, forming a right angle with apex, with sparse setae distally, blunt at apex; costa straight except slightly projected subapically. Sacculus about 2/5 width of valva, slightly narrowed to a short free distal process, distal 2/3 setose. Saccus broad, triangular, about same length as uncus. Juxta weakly sclerotized, extremely broad, nearly oval, reaching anterior 1/5 of tegumen, with a small saccate basal process, with digitate lateral processes at distal 2/5. Aedeagus strong, almost straight, nearly as long as valva, basal 3/5 membranous, distal 2/5 heavily sclerotized; cornutus strong and curved, about 1/2 length of aedeagus, slightly dilated near base, slender medially, distal 1/4 with four to five strong spines.

Female genitalia (Fig. 32). Apophysis anterioris about 1/2 length of apophysis posterioris, apophyses anterioris and posterioris expanded distally. Eighth sternum very short, rounded posteriorly. Seventh sternum slightly concave medially on posterior margin, posterior 1/5 sclerotized, laterally produced to a sclerotized, curved, gradually narrowed band. Antrum concave at middle on posterior margin, protruded in a short triangle postero-laterally, heavily sclerotized laterally; left side with anterior half concave inward, produced to a broad folded band stretching to ductus bursae. Ductus bursae long and curved, about 2.5 times length of corpus bursae, with a sclerotized shield-like plate at middle; posterior 2/5 sclerotized, with fourteen small spines posteriorly; anterior 3/5 membranous; ductus seminalis arising from posterior 1/4 of ductus bursae. Corpus bursae membranous, nearly rounded; two signa small, irregular oval.

Distribution. China (Fujian, Guangdong, Hunan, Jiangxi).

Etymology. The specific name is derived from the Latin prefix *rami-* (= ramus), and Latin *spineus* (= spine-like), referring to the strong spines in the distal 1/4 of the cornutus.

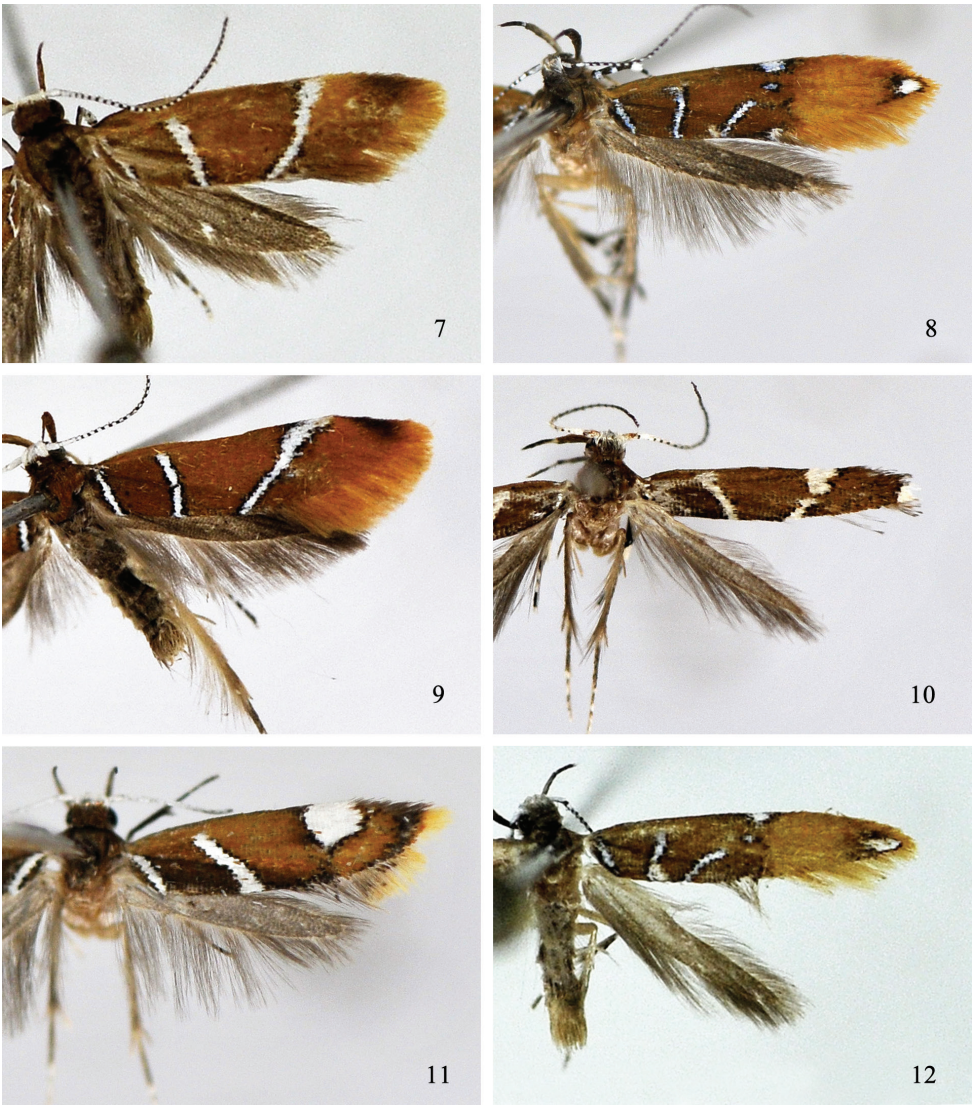
***Promalactis scorpioidea* sp. n.**
urn:lsid:zoobank.org:act:6261C8FD-0583-4A6B-9776-B437CB0C59A1
http://species-id.net/wiki/Promalactis_scorpioidea
Figs 7, 23, 33

Type material. Holotype ♂ – **China, Jiangxi Province:** Mt. Lu (26°30'N, 115°58'E), 335 m, 1.VII.1975, coll. Youqiao Liu, genitalia slide No. DZH12188 (IOZ). Paratypes – 1 ♂, same data as holotype; 1 ♂, 1 ♀, same data as holotype except dated 26.VI.1975; 1 ♀, same data as holotype except dated 30.VI.1975; 1 ♂, 1 ♀, same data as holotype except dated 28.VII.1975, genitalia slide Nos. DZH12030 ♂, DZH12187 ♂, DZH12189 ♀, DZH12190 ♀, DZH12191 ♀, DZH12192 ♂ (IOZ).

Diagnosis. This species is similar to *P. tridentata* Wang & Li, 2004, but can be separated by the sacculus distally curved like a scorpion tail and the cornutus about 1/2 the length of the aedeagus in the male genitalia; and the columniform lamella postvaginalis in the female genitalia. In *P. tridentata*, the sacculus is nearly straight distally and the cornutus is about 1/3 the length of the aedeagus in the male genitalia; and the lamella postvaginalis is bell shaped in the female genitalia. This species is also similar to *P. papillata* sp. n. The differences between them are stated under the latter species.

Description. Adult (Fig. 7). Wingspan 11.5–13.5 mm. Head with vertex shining white, frons yellowish brown, occiput ochreous brown. Labial palpus with basal and second segments ochreous brown on outer surface, basal segment yellowish white on inner surface, second segment yellow on inner surface; third segment dark ochreous brown except white at apex, almost same length as second. Antenna with scape white except dark brown on anterior margin; flagellum white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula ochreous brown. Forewing ochreous brown to ferrugineous, costal margin black along basal 1/4; markings white edged with black scales; a narrow white fascia from costal 2/3 obliquely inwards to end of fold, broadened anteriorly, inner margin with diffused dense black scales anteriorly; two white streaks arising from dorsal margin: basal streak from dorsal 1/5 to above base of fold, second streak parallel with basal streak, from dorsal 2/5 to above basal 1/3 of upper margin of cell, widened; cilia dark orange, dark ochreous brown along distal part of costal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 23). Uncus short, narrow at base, broadened slowly, trilobed distally: lateral lobes digitate, setose, middle lobe thicker and longer than lateral lobes. Gnathos almost same length as uncus, very narrow, scobinate, apex rounded; lateral arm band shaped, broad at base, about 4/5 length of gnathos. Tegumen narrowed posteriorly, branched from posterior 1/3, blunt anteriorly. Valva irregularly rectangular, setose distally, apex blunt; costa slightly concave at base. Sacculus broadened near base, narrowed distally, distal 1/5 free, curved dorsad in a right angle, like tail of a scorpion; slightly asymmetrical: left sacculus with distal 1/3 heavily sclerotized, dentate on dorsal margin, with a large heavily sclerotized subrectangular process at distal 1/3, which directs basad and bears some teeth on dorsal margin; right sacculus with distal 3/10 heavily sclerotized, dentate on dorsal margin, with a heavily sclerotized subtriangular



Figures 7–12. Adults of *Promalactis* species. **7** *P. scorpioidea* sp. n., holotype, male **8** *P. serpenticapitata* sp. n., paratype, female **9** *P. similiconvexa* sp. n., holotype, male **10** *P. spinosicornuta* sp. n., holotype, male **11** *P. strumifera* sp. n., holotype, male **12** *P. uncinispinea* sp. n., holotype, male.

process at distal 3/10, which directs basad and bears large teeth dorsally. Saccus about twice length of uncus, broad at base, slightly narrowed to basal 1/3, distal 2/3 nearly finger-like, rounded at apex. Juxta weakly sclerotized, roughly oval. Aedeagus slightly curved, about twice length of valva, sclerotized distally; cornutus long and curved, spine-like, about 1/2 length of aedeagus.

Female genitalia (Fig. 33). Apophysis anterioris about 1/2 length of apophysis posterioris. Lamella postvaginalis large and heavily sclerotized, columniform, narrowed

anteriorly, broadened posteriorly, posterior margin sinuate, anterior margin heavily concave medially and expanded laterally on dorsal surface. Ostium bursae large. Antrum very short. Ductus bursae long and coiled, about four times length of corpus bursae, sclerotized except small membranous posterior and anterior sections, dorsally with a sclerotized quadrate plate bearing five curved long spines on right side at posterior 1/6, ventrally with a cluster of short spines at posterior 1/6; ductus seminalis arising from near posterior end of ductus bursae. Corpus bursae rounded, membranous, with dense granules; signum absent.

Distribution. China (Jiangxi).

Etymology. The specific name is derived from Latin *scorpioideus* (= like tail of a scorpion), referring to the sacculus curved distally like the tail of a scorpion.

***Promalactis serpenticapitata* sp. n.**
urn:lsid:zoobank.org:act:DCB54EEC-278B-459D-9C12-06978B25B493
http://species-id.net/wiki/Promalactis_serpenticapitata
Figs 8, 24, 34

Type material. Holotype ♂ – **China, Fujian Province**: Sangang (27°45'N, 117°40'E), Mt. Wuyi, 740 m, 25.VII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai, genitalia slide No. DZH12055 (NKU). Paratypes – 6 ♂, 18 ♀, Guadun (27°44'N, 117°38'E), Mt. Wuyi, 1100 m, 28.VII–2.VIII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai. **Zhejiang Province:** 2 ♀, Qingliang Peak (30°07'N, 118°51'E), Linan City, 900 m, 8, 12.VIII.2005, coll. Yunli Xiao; 1 ♀, Sanmuping, Mt. Tianmu (30°26'N, 119°34'E), 1000 m, 29.VII.2011, coll. Linlin Yang & Na Chen, genitalia slide Nos. W04148 ♀, DZH12046 ♂, DZH12047 ♀, DZH12048 ♀ (NKU). **Jiangxi Province:** 1 ♀, Xiaoxidong II (26°28'N, 114°11'E), 5.VII.1978, genitalia slide No. DZH12038 ♀ (IOZ).

Diagnosis. This new species is similar to *P. maculosa* (Wang & Li, 2001), but can be separated by the forewing without white streak on the cell from basal 1/3 to middle; the distal process of the sacculus nearly L shaped and far exceeding the tip of the costa, the nearly rod-like juxta without lateral lobes and the aedeagus with a heavily sclerotized distal process and one cornutus in the male genitalia. In *P. maculosa*, the forewing has a white streak on the cell from basal 1/3 to middle, the distal process of the sacculus is digitate and not exceeding the tip of the dorso-apical process, the juxta has strong lateral lobes and the aedeagus has no distal process and has two cornuti in the male genitalia. This species is also similar to *P. uncinispinea* sp. n. The differences between them are stated under the latter species.

Description. Adult (Fig. 8). Wingspan 10.5–13.0 mm. Head dark brown, vertex white or lateral sides white only. Labial palpus with basal and second segments dark brown on outer surface, basal segment pale white on inner surface, second segment yellowish grey on inner surface; third segment black except white at base and apex, about same length as second. Antenna with scape white except black on anterior and

posterior margins; flagellum black, with white annuli on dorsal surface. Thorax and tegula dark ochreous brown, tinged with dark brown scales. Forewing with basal 3/5 ochreous brown, distal 2/5 ochreous yellow; markings silvery white or white, edged with dense black scales; costal margin with a semicircular or quadrate silvery white spot at middle; cell with a small silvery white dot on upper margin under costal spot; three silvery white streaks arising from dorsal margin: basal streak to base of fold, second streak from dorsal 1/3 straight to basal 1/3 of cell, third streak from dorsal 3/5 obliquely to distal 1/4 of cell on lower margin; fold with a white dot at end; apex with an elliptic white spot, edged with dense black and ochreous brown scales; cilia ochreous yellow, grey along distal part of dorsal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 24). Uncus subtriangular, broad at base, gradually narrowed to rounded apex, with a subapical tooth. Gnathos about 3/5 length of uncus, broad at base, gradually narrowed to 2/3, distal 1/3 broadened and rounded, ventrally with a small, snake head-shaped subapical process; lateral arm band shaped, about 2/3 length of gnathos. Tegumen narrow posteriorly, convex laterally at posterior 1/3, branched from posterior 2/3, anterior 1/3 nearly parallel sided, rounded apically. Valva sclerotized except an ovate membranous area medially before apex; basal 2/3 almost parallel dorso-ventrally, distally produced to a setose papillary process; costa concave basally and distally, slightly projected at middle. Sacculus broad at base, slightly narrowed distally, concave between 1/2–2/3 dorsally, distal 1/3 produced to a free, setose, L-shaped distal process, directing dorsad, apically serrate and far exceeding tip of costa. Vinculum widened anteriorly, with a slender transverse band joining left and right sides, forming a fan-shaped area between this band and posterior margin of saccus. Saccus short and broad, about 3/4 length of uncus, subtriangular, pointed at apex. Juxta long, nearly rod-like, slightly curved, with a short digitate basal process, distal 7/10 with a bundle of setae on dorsal surface, with longer setae on distal 2/3, apically with dense spinules or teeth, reaching near middle of uncus. Aedeagus straight and strong, about 4/5 length of valva; with two pieces of dense microtrichia and a heavily sclerotized plate distally, basal half of the plate thick and somewhat conical, distal half spine-like and curved; cornutus spine-like, situated at middle, about 1/3 length of aedeagus, with three short spines and one triangular plate basally.

Female genitalia (Fig. 34). Apophysis anterioris stronger than and about 1/2 length of apophysis posterioris. Eighth abdominal segment very short, sternum heavily sclerotized postero-medially, rounded on posterior margin. Seventh abdominal segment sclerotized. Antrum large, inverted trapezoidal, sclerotized except an oval membranous area anteriorly on left side, slightly convex at middle on posterior margin ventrally, lateral margin sinuate. Ductus bursae membranous, slightly longer than corpus bursae, with some short spines posteriorly; ductus seminalis arising from near antrum. Corpus bursae large, nearly rounded, membranous; signum absent.

Distribution. China (Fujian, Jiangxi, Zhejiang).

Etymology. This specific name is derived from the Latin prefix *serpent-* (= snake-like), and the adjective *capitatus* (= having a head), referring to the small, snake head-shaped subapical process on the ventral surface of the gnathos.

***Promalactis similiconvexa* sp. n.**
urn:lsid:zoobank.org:act:B883343D-DAE4-4B08-AB08-48058EEBFF5D
http://species-id.net/wiki/Promalactis_similiconvexa
Figs 9, 25

Type material. Holotype ♂ – **China, Sichuan Province:** Mt. Qingcheng (30°58'N, 103°31'E), 24.V.1979, genitalia slide No. DZH12178 (IOZ).

Diagnosis. This species is extremely similar to *P. convexa* sp. n. It can be separated by the left valva with a small hill-like apical process, the left sacculus with distal process reaching basal 1/4 of dorso-apical process of the valva; the right valva with a large quadrate dorso-apical process dentate apically, and the right sacculus with a small subtriangular distal process in the male genitalia. In *P. convexa* sp. n., the left valva is rounded at apex and lacks the apical process, the distal process of the left sacculus reaches the middle of the dorso-apical process of the valva; the right valva has a hooked dorso-apical process and the right sacculus has a spine-like distal process. This species is also externally similar to *P. baotianmanensis* Wang, Li & Zheng, 2000, *P. guangxiensis* Wang, 2006 and *P. parki* Lvovsky, 1986 *et al.*, but can be easily separated by the valva having a dorso-apical process, which is absent in each of the latter three species.

Description. Adult (Fig. 9). Wingspan 15.5 mm. Head with vertex shining white, frons brown, occiput dark ochreous brown. Labial palpus with basal and second segments ochreous brown on outer surface, basal segment light yellow on inner surface, second segment ochreous yellow on inner surface; third segment dark ochreous brown, white at apex, shorter than second. Antenna with scape white except dark brown on anterior and posterior margin; flagellum with basal three flagellomeres white, remaining flagellomeres white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula ochreous brown. Forewing ochreous brown; markings white edged with black scales; a narrow white fascia from costal 3/4 obliquely inwards to dorsal 3/4, anterior 2/5 broadened, inner margin with diffused dense black scales anteriorly; two white streaks arising from dorsal margin: basal streak from dorsal 1/5 to above base of fold, second streak from dorsal 2/5 to basal 1/3 of upper margin of cell, slightly arched, area dark ochreous brown between these two streaks; costal margin black along basal 1/4, with a blackish brown apical spot; cilia ochreous brown, dark brown along distal part of costal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 25). Uncus heavily sclerotized, nearly square, lateral margin arched outward, with sparse setae, posterior margin concave at middle, protruded laterally. Gnathos heavily sclerotized, about 1/2 length of uncus, apex curved ventrad, concave at middle, forming two small triangular lateral processes; lateral arm subtriangular, almost same length as gnathos. Tegumen branched from posterior 1/5, triangularly narrowed anteriorly. Valva sclerotized, setose distally, asymmetrical; left valva with apex dentate, with a small hill-like apical process, with a heavily sclerotized, broad beak-like dorso-apical process, which directs obliquely dorsad and is serrate dorsomedially; sacculus strongly protruding basally, reaching costa posteriorly, with a heavily sclerotized, nearly thorn-like subapical process directing dorsad and slightly curved

inward, serrate marginally, apically pointed and reaching basal 1/4 of dorso-apical process of valva; right valva quadrate and slightly curved inward distally, apex dentate, with two larger teeth; sacculus with basal 2/3 roundly protruding dorsad, exceeding costa posteriorly, abruptly narrowed to 2/3, almost same width from 2/3 to 5/6, distal 1/6 gradually narrowed to narrowly rounded apex, with a small, heavily sclerotized, subtriangular process at distal 1/6, which is dentate on inner margin. Vinculum nearly triangular, widened latero-medially. Saccus about 2.7 times length of uncus, basal 2/5 broader than distal 3/5, rounded at apex. Juxta roughly oval, weakly sclerotized. Aedeagus slightly curved, about twice length of valva, apex with a sclerotized, quadrate plate; cornutus consisting of some almost coalesced, short, fine spines, forming a large curved spine, shorter than 1/5 length of aedeagus, situated basally.

Female. Unknown.

Distribution. China (Sichuan).

Etymology. The specific name is derived from the Latin prefix *simili-* (= similar), and the species name *convexa*, referring to the similarity of the two species.

***Promalactis spinosicornuta* sp. n.**
urn:lsid:zoobank.org:act:51545D2D-88D5-4CA1-B8E9-148D445AD89C
http://species-id.net/wiki/Promalactis_spinosicornuta
Figs 10, 26

Type material. Holotype ♂ – **China, Xizang Autonomous Region:** Motuo County (29°13'N, 95°18'E), 1080 m, 21.VIII.2006, coll. Fuqiang Chen, genitalia slide No. DZH12011(IOZ). Paratype – 1 ♂, same data as holotype, genitalia slide No. DZH12009 (IOZ).

Diagnosis. This new species is similar to *P. ruiliensis* Wang, 2006, but can be separated by the forewing without white dot on termen; the bifurcate part of the uncus curved ventrad, the costa without strong distal spines, and the aedeagus with numerous short spinose cornuti. In *P. ruiliensis*, the forewing has a white dot at middle of termen; the bifurcate part of the uncus is straight, the costa has a bundle of strong spines along distal 1/4, and the cornuti are absent.

Description. Adult (Fig. 10). Wingspan 9.0 mm. Head with vertex shining white, frons shining leaden, occiput dark ochreous brown. Labial palpus with basal segment dark ochreous brown on outer surface, light yellow on inner surface; second segment dark ochreous brown on outer surface, basal 2/5 light yellow, distal 3/5 dark yellow on inner surface; third segment black except white at base and apex, slightly shorter than second. Antenna with scape white, pecten dark brown; flagellum white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula dark ochreous brown. Forewing ochreous brown, sporadically with black scales; markings white sparsely edged with black scales; costal margin black along basal 1/4, with a large spot at 2/3 crossing 3/5 width; three white streaks arising from dorsum: basal streak relatively thin, from dorsal 1/5 to near costal margin, interrupted anteriorly, second streak from

dorsal 1/3 to basal 1/3 of upper margin of cell, third streak from dorsal 3/4 extending to before lower angle of cell; apex white; cilia greyish brown, white on apex. Hindwing and cilia greyish brown.

Male genitalia (Fig. 26). Uncus with basal 1/2 nearly quadrate; distal 1/2 bifurcate, forming two horn-shaped lateral processes, curved ventrad, sinuate, tapering to pointed apex. Gnathos subtriangular, membranous, sclerotized laterally. Tegumen broad, branched from posterior 1/3, narrowed anteriorly. Valva subtriangular; costa concave at base, projected at 1/5; apex pointed, directing dorsad; ventral margin densely setose on distal 1/2. Sacculus broad at base, gradually narrowed to distal end. Saccus triangular, about 1/2 length of uncus. Juxta broad, with a small saccate basal process; lateral lobes short and broad, somewhat semicircular, reaching near middle of tegumen. Aedeagus gently curved, about 1.5 times length of valva; numerous short spinose cornuti present along 3/5 distal part of the aedeagus.

Female. Unknown.

Distribution. China (Xizang).

Etymology. The specific name is derived from Latin *spinosus* (= spinose), and *cornutus*, referring to the numerous cornuti.

***Promalactis strumifera* sp. n.**
urn:lsid:zoobank.org:act:E07B58C0-2BEA-423A-B7F8-09608A6305C7
http://species-id.net/wiki/Promalactis_strumifera
Figs 11, 27, 35

Type material. Holotype ♂ – **China, Zhejiang Province:** Mt. Jiulong (28°21'N, 118°52'E), 400 m, 5.VIII.2011, coll. Linlin Yang & Na Chen, genitalia slide No. DZH12050 (NKU). Paratypes – 1 ♂, same data as holotype except dated 4.VIII.2011; **Zhejiang Province,** Wuyanling (27°42'N, 119°39'E), Taishun County: 1 ♂, 400 m, 1.VIII.2005, coll. Yunli Xiao; 4 ♂, 680 m, 28.VII–2.VIII.2005, coll. Yunli Xiao; 2 ♂, 790 m, 2, 3.VIII.2007, coll. Qing Jin. **Guangdong Province:** 2 ♂, 1 ♀, Nanling (23°20'N, 115°23'E), Shaoguan City, 7–14.VII.2007, coll. Min Wang *et al.* **Fujian Province:** 9 ♂, 4 ♀, Sangang (27°45'N, 117°40'E), Mt. Wuyi, 740 m, 26, 27.VII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai. **Guangxi Zhuang Autonomous Region:** 3 ♀, Qinmu village, Yongfu County (24°59'N, 109°59'E), 160 m, 5.V.2008, coll. Li Zhang & Hui Zhen; 1 ♀, Hongqi Forest Farm, Shangsi County (22°09'N, 107°58'E), 260 m, 2.IV.2002, coll. Shulian Hao & Huaijun Xue; 1 ♀, Fubo Forest Farm, Pingxiang City (22°07'N, 106°44'E), 550 m, 1.VIII.2011, coll. Bingbing Hu *et al.*, genitalia slide Nos. W05010 ♂, W05028 ♂, DZH11063 ♀, DZH12051 ♀, DZH12052 ♂ (NKU). **Jiangxi Province:** 1 ♂, Dayu County (25°23'N, 114°22'E), 15.VI.1976; 1 ♀, Dayu County, 14.VIII.1976; 1 ♂, Xingguo County, 19.VII.1976. **Hunan Province:** 1 ♂, Suoxiyu (29°35'N, 110°57'E), 17.X.1988, genitalia slide Nos. DZH12033 ♂, DZH12034 ♀(IOZ).

Diagnosis. This species is similar to *P. fascispinata* Du, Li & Wang, 2011, but can be separated by the rectangular gnathos, the dorsal lobe of the valva bifurcate distally

and the ventral lobe with two digitate distal processes, and the juxta without spines in the male genitalia. In *P. fascispinata*, the gnathos is tongue shaped, the dorsal lobe of the valva is not bifurcate and the ventral lobe has two elongate ovate distal processes, and the juxta has an ovate cluster of fine spines distally in the male genitalia.

Description. Adult (Fig. 11). Wingspan 8.0–11.5mm. Head with vertex shining white, frons shining leaden, occiput dark ochreous brown. Labial palpus with basal and second segments yellow on inner surface, ochreous brown on outer surface; third segment black, almost same length as second. Antenna with scape white; flagellum white except several distal flagellomeres dark brown on dorsal surface, dark brown on ventral surface. Thorax and tegula dark ochreous brown. Forewing ground colour ochreous brown tinged with dark ochreous brown, sometimes scattered with black scales on lower angle of cell; costal margin greyish black along basal 3/4, with a large rounded white spot at distal 1/4, slightly across middle of wing, edged with dense black scales except on anterior margin; two parallel oblique white streaks arising from dorsum, edged with dense black scales: basal streak from dorsal 1/5 to base of fold, second streak from beyond middle of dorsum to basal 1/3 of upper margin of cell, area ferrugineous between two streaks; dense black scales extending from apex along termen to tornus, forming a narrow black apical band; cilia yellow, dark greyish brown along distal part of costal margin, dark grey along distal part of dorsal margin. Hindwing and cilia grey.

Male genitalia (Fig. 27). Uncus stout, heavily sclerotized, sinuate marginally, with a heavily sclerotized, short, triangular apical process at middle; basal 2/3 open ventrally. Gnathos heavily sclerotized, rectangular, densely with warts, blunt at apex: right side concave in U shape near apex; lateral arm almost same length as gnathos, broad, nearly semicircular basally. Tegumen narrowly elongate, almost parallel laterally, branched from posterior 3/10, blunt anteriorly. Valva narrow, almost parallel dorso-ventrally; costa projected at middle, concave near apex; apex bilobed: dorsal lobe short and sclerotized, bifurcate distally, forming two thick spines, dorsal spine short, about 1/3 length of ventral spine, with a brush of setae between two spines; ventral lobe elongate, about 1.4 times length of dorsal lobe, weakly sclerotized, very narrow basally, broadened gradually, distally setose, bifurcate, forming two slender, digitate processes: dorsal process straight, ventral process slightly shorter than dorsal process, curved dorsad distally. Sacculus with basal 3/5 broad and almost parallel sided, distal 2/5 gradually narrowed to base of ventro-apical lobe of valva. Saccus slightly shorter than uncus, somewhat semi-oval. Juxta strong, rod-like, curved dorsad at basal 1/3, with a small awl-shaped process at base, apex narrowly rounded or bluntly pointed, reaching near posterior margin of tegumen; diaphragm with large sclerotized rumples dorsally, enlarged and protruded leftward. Aedeagus almost straight, basal 2/9 slender, slightly curved at 2/9; distal 7/9 broad, uniformly thick, apex pointed; cornutus absent.

Female genitalia (Fig. 35). Apophysis anterioris stronger, about 1/3 length of apophysis posterioris. Eighth tergum sclerotized, nearly trapezoidal, convex anterolaterally, sinuate and with sparse long setae on posterior margin. Seventh abdominal segment sclerotized, laterally with a nodular process at anterior 2/5, posterior margin

serrate, sometimes with large lateral tooth. Ostium bursae heavily sclerotized and large. Lamella postvaginalis with dorsal part broad leaf-like, posterior margin serrate and with sparse setae, produced to a sclerotized, ovate process at middle, margined with small teeth; ventral part with two lateral processes: left process with basal 1/3 narrow, distal 2/3 abruptly broadened, with ten spines of varied length; right process nearly spine-like, slightly curved at base. Lamella antevaginalis heavily sclerotized, very short, nearly band shaped, anterior and posterior margin convex at middle. Antrum very short, nearly funnel shaped. Ductus bursae curved, slightly longer than corpus bursae, membranous, posterior 3/5 thin, with discontinuous, weakly sclerotized bands, anterior 2/5 enlarged, with a weakly sclerotized, thin ring at anterior 2/5; ductus seminalis arising from anterior 2/5 of ductus bursae. Corpus bursae nearly oval, membranous, with dense granules; a small and rounded signum bearing one larger and one smaller conical spines, with a shield-like, weakly sclerotized plate at base.

Distribution. China (Fujian, Guangdong, Guangxi, Jiangxi, Zhejiang).

Etymology. This specific name is derived from Latin *strumifer* (= nodular), referring to the lateral nodular process at anterior 2/5 of the 7th abdominal segment in the female genitalia.

***Promalactis uncinispinea* sp. n.**
urn:lsid:zoobank.org:act:265C422D-84CB-4DC5-9193-C6567821B93E
http://species-id.net/wiki/Promalactis_uncinispinea
Figs 12, 28

Type material. China: Sichuan Province: Holotype ♂, Mt. Qingcheng (30°58'N, 103°31'E), 16.vii.1980, genitalia slide No. DZH12185 (IOZ).

Diagnosis. This species is extremely similar to *P. serpenticapitata* sp. n. It can be separated by the gnathos with a triangular subapical process ventrally, the distal process of the sacculus with a small dentate dorso-medial process, the juxta with a bundle of setae and short spines in distal 1/3, and the cornutus about 2/3 length of aedeagus in the male genitalia. In *P. serpenticapitata* sp. n., the gnathos has a snake head-shaped subapical process ventrally, the distal process of the sacculus lacks the dorso-medial process, the juxta has a bundle of setae and short spines in distal 7/10, and the cornutus is about 1/3 the length of the aedeagus. This species is also superficially similar to *P. dierli* Lvovsky, 2000, but can be easily separated by the male genitalia with a symmetrical valva and the aedeagus with one cornutus. In *P. dierli*, the valva is asymmetrical and the aedeagus has no cornutus in the male genitalia.

Description. Adult (Fig. 12). Wingspan 11.0 mm. Head with vertex and frons silvery white mixed with brown, occiput dark brown. Labial palpus with basal and second segments dark brown; third segment black except white at base and apex, slightly shorter than second. Antenna with scape white except black on anterior and posterior margins; flagellum white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula dark ochreous brown. Forewing with basal 3/5 ochreous brown,

distal 2/5 ochreous yellow; markings silvery white or white, edged with dense black scales; costal margin with a semicircular silvery white spot at middle; cell with a small silvery white dot under costal spot; three silvery white streaks arising from dorsal margin: basal streak to base of fold, second streak from dorsal 1/3 straight to basal 1/3 of upper margin of cell, third streak from dorsal 2/5 obliquely to distal 1/4 of cell on lower margin; fold with a white dot at end; apex with an elliptic white spot, edged with dense black scales; cilia yellow, grey along distal part of dorsal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 28). Uncus subtriangular, broad at base, narrowed to pointed apex, with a subapical tooth ventrally. Gnathos almost same length as uncus, slender, distal 1/4 scobinate and curved ventrad, apex narrowly rounded, ventrally with a small, triangular subapical process; lateral arm band shaped, about 1/4 length of gnathos. Tegumen narrow posteriorly, convex laterally at posterior 1/3, branched from posterior 2/3, rounded apically. Valva sclerotized; basal 2/3 almost parallel dorso-ventrally, distally produced to a setose triangular process; costa with basal 3/5 straight, distal 2/5 concave. Sacculus broad at base, slightly narrowed distally, dorsal margin concave between basal 2/5–2/3, distal 1/3 produced to a free, setose distal process, which bears a small, heavily sclerotized, dentate process dorso-medially, apex pointed and directing dorsad, far exceeding tip of costa. Vinculum widened anteriorly, with a slender transverse band joining left and right sides, forming a fan-shaped area between this band and posterior margin of saccus. Saccus short and broad, slightly shorter than uncus, subtriangular, narrowly rounded at apex. Juxta long, nearly rod-like, slightly curved, broad basally, with a short digitate basal process, distal 1/3 with a bundle of setae and short spines on dorsal surface, apically with dense short spines, reaching near posterior margin of tegumen. Aedeagus straight and short, about 3/5 length of valva; with two pieces of dense microtrichia and a heavily sclerotized hooked spine distally; cornutus slightly curved, basal half weakly sclerotized and rod-like, distal half heavily sclerotized and spine-like, situated at middle, about 2/3 length of aedeagus, with several short spines medially.

Female. Unknown.

Distribution. China (Sichuan).

Etymology. The specific name is derived from the Latin prefix *uncin-* (= hooked), and Latin *spineus* (= spine-like), referring to the hooked distal spine in the aedeagus.

***Promalactis albipunctata* Park & Park, 1998**
http://species-id.net/wiki/Promalactis_albipunctata
Figs 13, 29 , 36

Promalactis albipunctata Park & Park, 1998: 58. Type locality: Korea (South).

Material examined. China, Jiangxi Province: 1 ♂, 1 ♀, Dayu County, 18.VI.1976; 1 ♀, Mt. Jiulian, 23.V.1977, genitalia slide Nos. DZH12176 ♂, DZH12203 ♀

Figures 13–16. Adults of *Promalactis* species. **13** *P. albipunctata* Park & Park, female **14** *P. dierli* Lvovsky, female **15** *P. dimolybda* Meyrick, male **16** *P. flavescens* Wang, Zheng & Li, female.

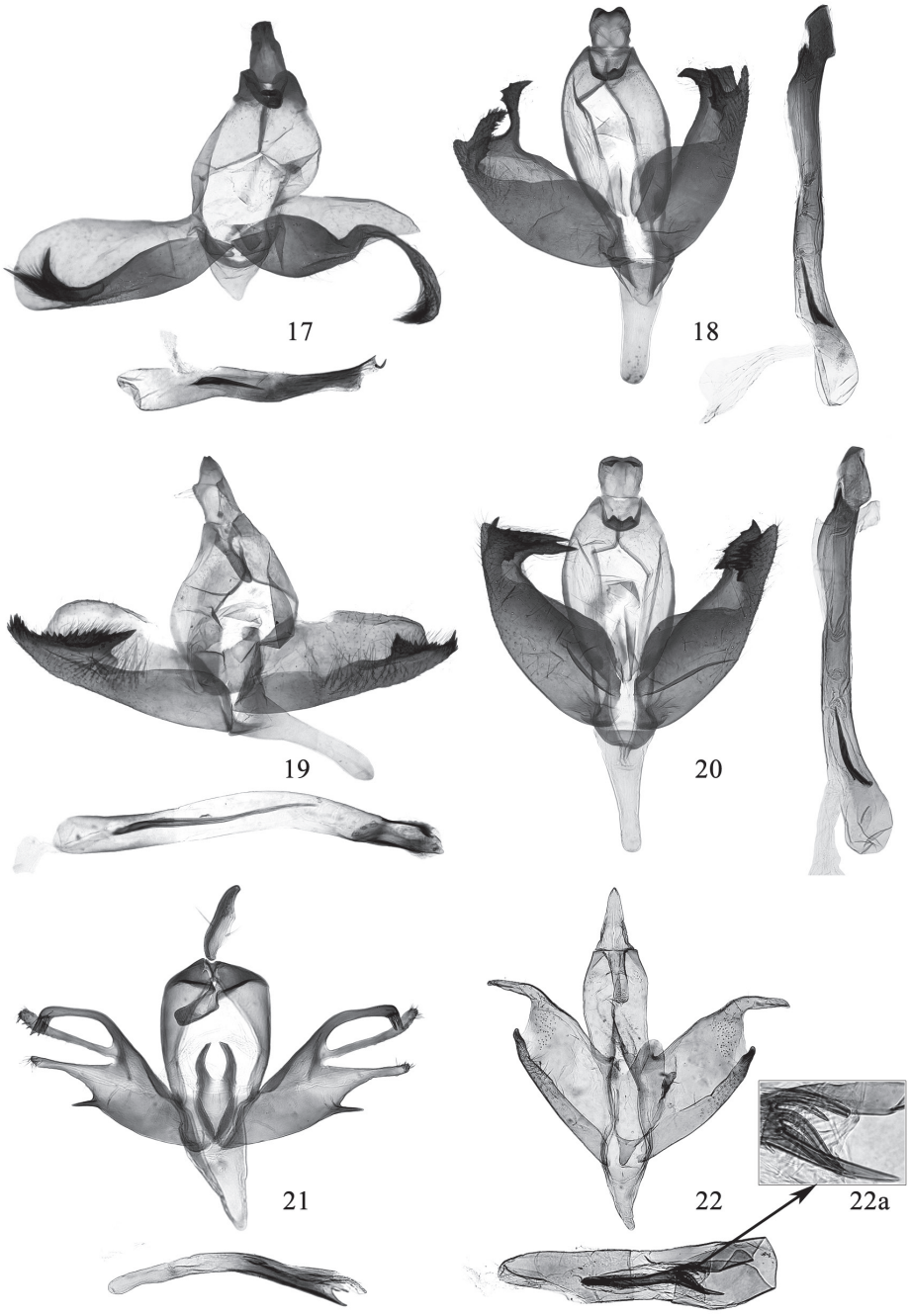
(IOZ). **Fujian Province:** 1 ♂, Sangang, Mt. Wuyi, 740 m, 27.VII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai. **Zhejiang Province:** 1 ♀, Mt. Jiulong, 400 m, 5.VIII.2011, coll. Linlin Yang & Na Chen, genitalia slide Nos. DZH12053 ♂, DZH12054 ♀ (NKU).

Diagnosis. Adult with wingspan 11.0–14.0 mm. This species is similar to *P. parasuzukiella* Wang, 2006, but can be separated by the sacculus with a digitate apical process, the slender rod-like saccus and the aedeagus with two spine-like apical processes in the male genitalia (Fig. 29); the M-shaped lamella postvaginalis and the oval signum in the female genitalia (Fig. 36). In *P. parasuzukiella*, the sacculus has no digitate apical process, the saccus is semi-oval and the aedeagus has no apical process; and the lamella postvaginalis is absent and the signum is cross shaped.

Remarks. *Promalactis albipunctata* was described by Park and Park (1998) on the basis of six female specimens from Korea. *Promalactis akaganea* Fujisawa, 2002 was described from three male and seventeen female specimens from Japan. By checking the photographed adult and both male and female genitalia of *P. albipunctata*, we suspect that *P. akaganea* is a synonym of *P. albipunctata*, which can be confirmed only after checking the types of *P. akaganea*.

Distribution. China (Jiangxi); Korea.

Note. This species is recorded from China for the first time.



Figures 17–22. Male genitalia of *Promalactis* species. **17** *P. bifurciprocessa* sp. n., holotype, slide No. DZH12198 **18** *P. convexa* sp. n., holotype, slide No. DZH12027 **19** *P. papillata* sp. n., holotype, slide No. DZH12147 **20** *P. quadratitabularis* sp. n., holotype, slide No. DZH12037 **21** *P. quadriloba* sp. n., holotype, slide No. DZH12032 **22** *P. ramispinea* sp. n., holotype, slide No. DZH11025 **22a** enlarged distal part of cornutus.

Promalactis dierli **Lvovsky, 2000**
http://species-id.net/wiki/Promalactis_dierli
Figs 14, 37

Promalactis dierli Lvovsky, 2000: 667. Type locality: Nepal.

Material examined. China, Xizang autonomous Region: 1 ♀, Zhangmu Port, 11.VIII.1981, coll. Shengyuan Hu, genitalia slide No. DZH12003 (IOZ).

Diagnosis. Adult with wingspan 14.5 mm. This species is very similar to *P. jezonica* (Matsumura, 1931), but can be separated by the forewing without the white dot at end of the fold (Fig. 14); the uncus having a triangular process at basal 3/5 ventrally, the broad leaf-like juxta, and the aedeagus with a short spine extending from dorsal side at distal 1/4 in the male genitalia (Lvovsky 2000, Fig. 5), and further the mound-like lamella postvaginalis in the female genitalia (Fig. 37). In *P. jezonica*, the forewing has a white dot at end of the fold, the uncus lacks the triangular process, the juxta is very slender, and the aedeagus has no distal spine; and the lamella postvaginalis is nearly crown shaped.

Distribution. China (Xizang); Nepal.

Note. This species is recorded from China for the first time.

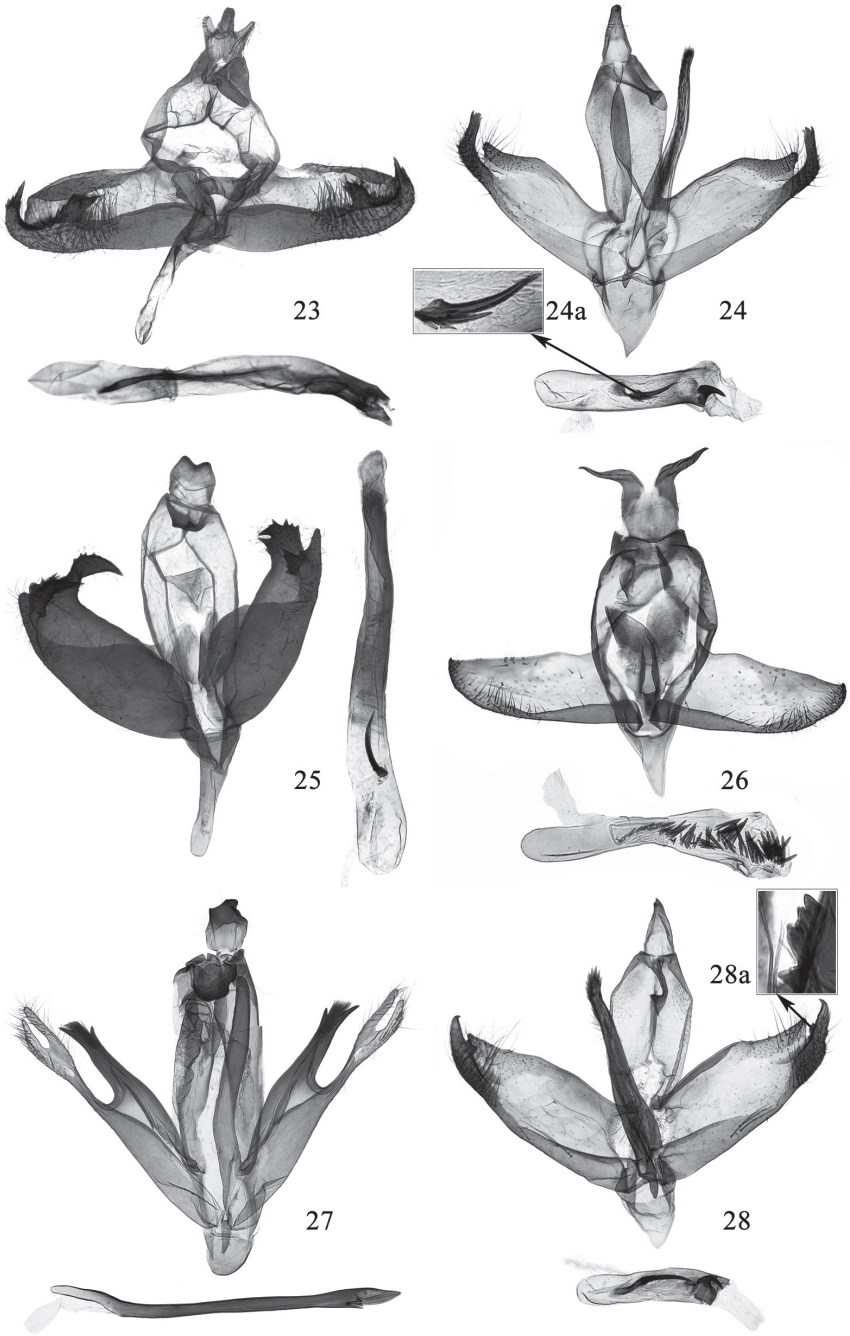
Promalactis dimolybda **Meyrick, 1935**
http://species-id.net/wiki/Promalactis_dimolybda
Figs 15, 30, 38

Promalactis dimolybda Meyrick, 1935: 78. Type locality: China (Tien-Mu-Shan).

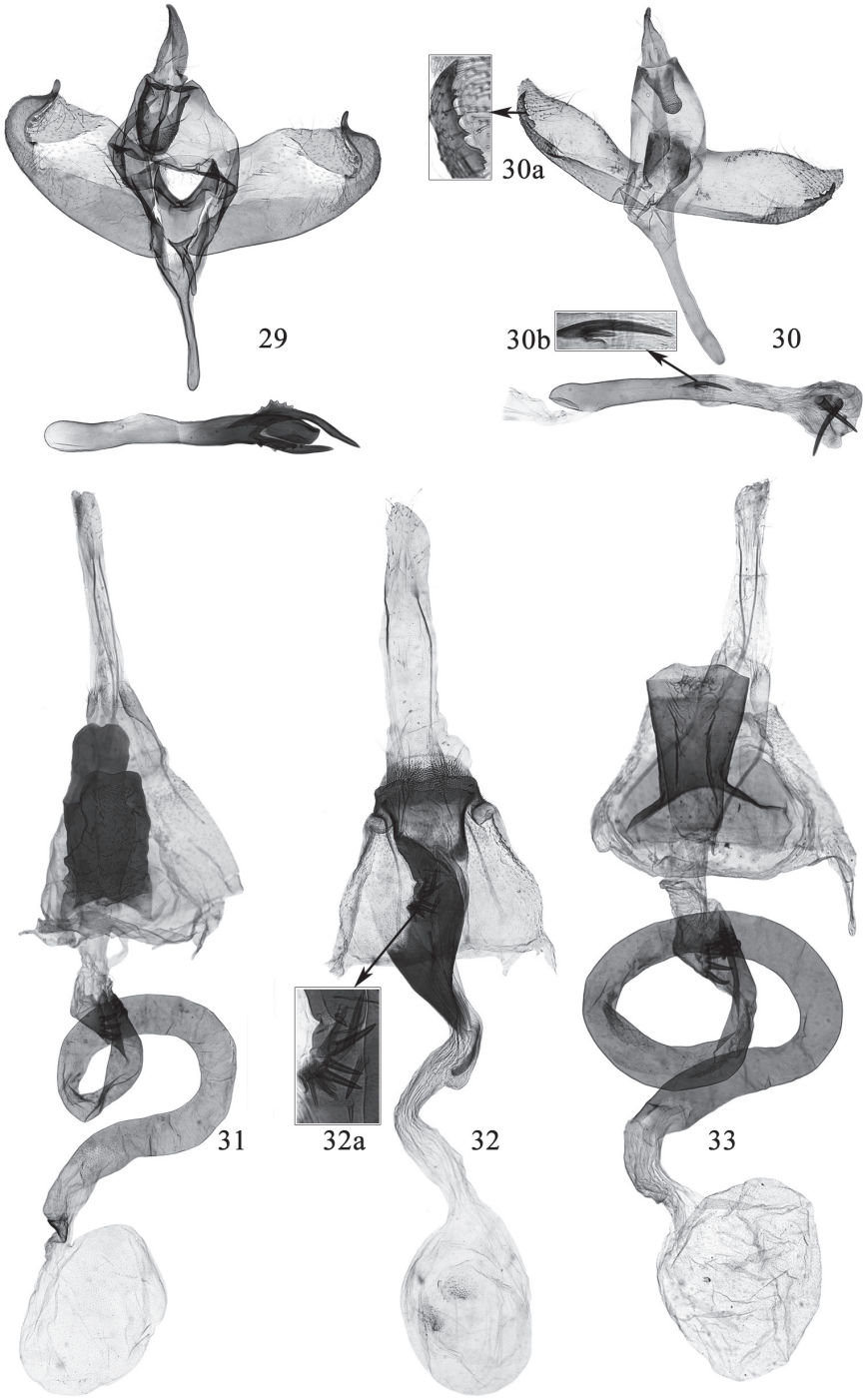
Material examined. China, Zhejiang Province: 2 ♂, 33 ♀, Mt. Fengyang, Lishui City, 1470 m, 25–30.VII.2007, coll. Qing Jin. **Fujian Province:** 19 ♀, Guadun, Mt. Wuyi, 1100 m, 28.VII–2.VIII.2008, coll. Weichun Li, Yongling Sun & Haiyan Bai. **Hubei Province:** 1 ♀, Houhe, Wufeng County, 1100 m, 11.VII.1999, coll. Houhun Li *et al.*, genitalia slide Nos. W00106 ♀, ZL08133 ♂, DZH08042 ♀, DZH08043 ♀, DZH08044 ♂, DZH08046 ♀, DZH12039 ♀, DZH12040 ♀, DZH12112 ♀ (NKU); **Sichuan Province:** 3 ♂, 3 ♀, Wanniansi, Mt. Emei, 14.VI.1979, genitalia slide Nos. DZH12007 ♀, DZH12008 ♂, DZH12041 ♂ (IOZ).

Diagnosis. This species is similar to *P. taibaiensis* Wang, Zheng & Li, 1997, but can be separated by the aedeagus with two apical spines and two cornuti in the male genitalia; the ductus bursae concave ventrally at middle on posterior margin and membranous between posterior 3/5–3/4, and the signum with small distinct or indistinct teeth on posterior end in the female genitalia. In *P. taibaiensis*, the aedeagus has four apical spines and one cornutus; the ductus bursae is slightly convex ventrally on posterior margin and entirely sclerotized, and the signum has dense teeth.

Redescription. Adult (Fig. 15). Wingspan 9.5–11.5 mm. Head with vertex shining white, frons shining leaden grey, occiput yellowish brown. Labial palpus with basal



Figures 23–28. Male genitalia of *Promalactis* species. **23** *P. scorpioidea* sp. n., paratype, slide No. DZH12012 **24** *P. serpenticapitata* sp. n., paratype, slide No. DZH12046 **24a** enlarged cornutus **25** *P. similiconvexa* sp. n., holotype, slide No. DZH12178 **26** *P. spinosicornuta* sp. n., slide No. DZH12011 **27** *P. strumifera* sp. n., paratype, slide No. DZH12052 **28** *P. uncinispinea* sp. n., holotype, slide No. DZH12185 **28a** enlarged dentate dorsal process of sacculus.



Figures 29–34. 29–30 Male genitalia of *Promalactis* species. **31–33** Female genitalia of *Promalactis* species **29** *P. albipunctata* Park & Park, slide No. DZH12176 **30** *P. dimolybda* Meyrick, slide No. DZH12041 **31** *P. papillata* sp. n., slide No. DZH12196 **32** *P. ramispinea* sp. n., slide No. DZH12013 **32a** enlarged spines of ductus bursae **33** *P. scorpioidea* sp. n., slide No. DZH12189.

and second segments yellow, third segment dark brown, almost same length as second. Antenna with scape white; flagellum white and black on dorsal surface, dark brown on ventral surface. Thorax and tegula ochreous brown. Forewing ground colour ochreous yellow; a narrow white fascia from costal 1/4 to dorsal 2/5, its inner margin edged with dense black scales, area ochreous brown from inner margin to base; a broad dark grey fascia at 3/5, tinged with black scales, its inner margin straight, outer margin sinuate; a wedge-shaped dark grey fascia from apex of costal margin along termen to end of fold, tinged with black scales; a narrow dark grey band along dorsal margin between two dark fasciae and connected them; cilia yellow, dark grey along distal part of costal margin, grey along distal part of dorsal margin. Hindwing and cilia dark grey.

Male genitalia (Fig. 30). Uncus nearly bell shaped, broad at base, gradually narrowed to 3/5, distal 2/5 slender, rounded at apex, laterally with setae. Gnathos tongue shaped, about 2/3 length of uncus, distal 1/2 scobinate, apex broadly rounded; lateral arm short, band shaped, about 1/3 length of gnathos. Tegumen branched from posterior 1/2, very narrow anteriorly. Valva narrowed and setose distally, apex narrowly rounded and directing dorsad; costa sinuate, concave at base and before apex, projected at middle. Sacculus narrow, slightly concave at basal 3/5 on dorsal margin, distal 2/5 setose; distal 1/5 free, serrate dorsally; apex pointed, directing dorsad, not reaching end of valva. Saccus slender, rod-like, slightly broader at base, rounded at apex, almost as long as valva. Juxta weakly sclerotized, short, with a small, slender awl-shaped basal process; lateral lobes broad, irregularly quadrate, rounded at apex, reaching middle of tegumen. Aedeagus gently curved, dilated distally, with two curved, basally joined distal spines; two joined or separate, spine-like cornuti present at middle: one very small, the other larger, sometimes deciduate.

Female genitalia (Fig. 38). Apophysis anterioris stronger than and about 1/2 length of apophysis posterioris. Ductus bursae about twice length of corpus bursae, posterior margin ventrally concave at middle and protruded laterally, posterior 3/5 sclerotized and sinuate, with some spinules at posterior 3/5, posterior 3/5–3/4 membranous and expanded, anterior 1/4 sclerotized, curved in semi-volute or sinuate; ductus seminalis arising from posterior 2/3 of ductus bursae. Corpus bursae rounded; signum small, nearly oval or rhombic, with small distinct or indistinct teeth on posterior end.

Distribution. China (Fujian, Hubei, Sichuan, Zhejiang).

Note. The male is described for the first time.

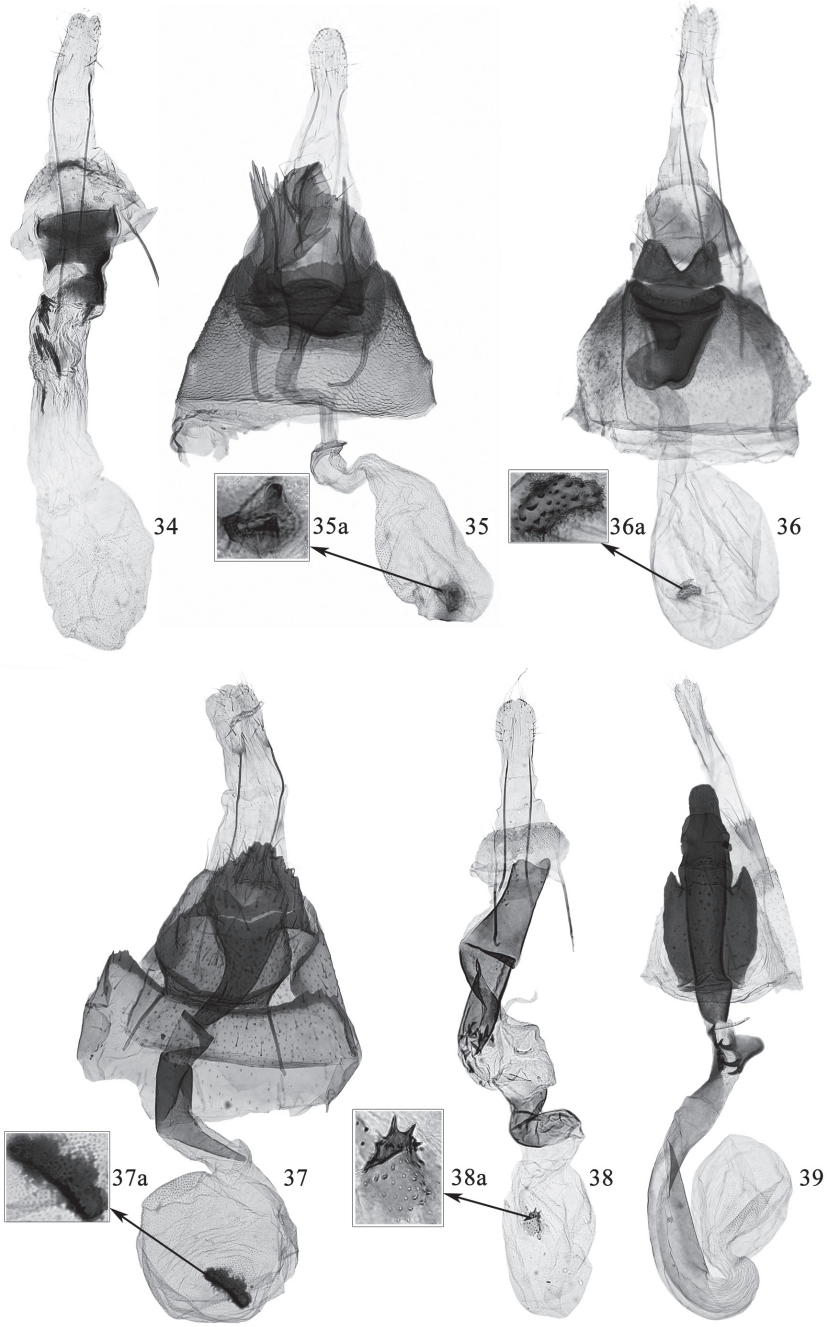
Promalactis flavescens Wang, Zheng & Li, 1997

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

Figs 16, 39

Promalactis flavescens Wang, Zheng & Li, 1997: 202; Wang 2006: 32. Type locality: China (Shaanxi).

Material examined. China, Sichuan Province: 4 ♂, 2 ♀, Mt. Qingcheng, 19–24.V.1979; 1 ♂, 1 ♀, Wanniansi, Mt. Emei, 14.VI.1979, genitalia slide Nos. DZH12042 ♂, DZH12014 ♀ (IOZ).



Figures 34–39. Female genitalia of *Promalactis* species. **34** *P. serpenticapitata* sp. n., slide No. DZH12038 **35** *P. strumifera* sp. n., slide No. DZH12034 **35a** enlarged signum **36** *P. albipunctata* Park & Park, slide No. DZH12203 **36a** enlarged signum **37** *P. dierli* Lvovsky, slide No. DZH12003 **37a** enlarged signum **38** *P. dimolybda* Meyrick, slide No. DZH12039 **38a** enlarged signum **39** *P. flavescens* Wang, Zheng & Li, slide No. DZH12014.

Diagnosis. Adult with wingspan 12.5–14.0 mm. This species is similar to *P. bitaenia* Park & Park, 1998, but can be separated by the forewing with a dark brown fascia (Fig. 16); the sacculus with a bundle of strong setae on the dorsal margin distally, the aedeagus about twice length of the valva and with a small subapical tooth in the male genitalia (Wang 2006, Fig. 40); the lamella postvaginalis with the dorsal part nearly quadrangular and the ventral part trapezoidal in the female genitalia (Fig. 39). In *P. bitaenia*, the forewing has two dark brown fasciae; the sacculus has spines and small teeth on dorsal margin distally, and the aedeagus is slightly longer than the valva and lacks the subapical tooth; and the lamella postvaginalis is irregularly rounded.

Female genitalia (Fig. 39). Apophysis anterioris about 1/2 length of apophysis posterioris. Eighth tergum with sparse long setae on posterior margin. Lamella postvaginalis heavily sclerotized, dorsal part elongate, nearly quadrangular, rounded on posterior margin, ventral part short, about 3/5 length of dorsal part, trapezoidal; lamella antevaginalis large, anterior 3/5 broad and slightly convex laterally, narrowed near anterior margin, anterior margin straight, triangularly protruded backward at anterior 3/5 laterally. Antrum elongate, tubular, posterior 1/3 broader. Ductus bursae weakly sclerotized except basal small portion heavily sclerotized, membranous near corpus bursae, with two plates near middle: one plate hand shaped, protruded, with three strong, curved spines on anterior edge; the other plate subtriangular, with very short spines on anterior edge. Corpus bursae small, rounded and membranous; signum absent.

Distribution. China (Shaanxi, Sichuan).

Note. The female of this species is described here for the first time.

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A taxonomic study of Chinese species of the *alberti* group of *Metaphycus* (Hymenoptera, Encyrtidae)

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Abstract

Ten *alberti*-group species of the genus *Metaphycus* Mercet from China are reviewed. Six species, *M. dorsalis* **sp. n.**, *M. chinensis* **sp. n.**, *M. wui* **sp. n.**, *M. stylatus* **sp. n.**, *M. fusiscapus* **sp. n.**, and *M. fusiformis* **sp. n.** are described as new to science. Four known species from China are redescribed. A key to the females of the Chinese species is given and photomicrographs are provided to illustrate morphological characters of these species. All specimens, unless otherwise specified, are deposited in the National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing.

Keywords

Chalcidoidea, parasitoids, natural enemy, new species, China

Introduction

Metaphycus is a large genus of the family Encyrtidae, including 455 species worldwide (Noyes 2012). All species of *Metaphycus* with known biology are primary endoparasitoids of scale insects, mainly species of Coccidae, Diaspididae, Eriococcidae and Mar-

garodidae (Guerrieri and Noyes 2000; DeBach and Rosen 1991). *Metaphycus* play a role in the control of agricultural and forestry pests, and probably contribute to the population control of potential pests of forest and fruit trees, ornamentals and agricultural crops. In China, *M. parasaissetiae* controls their host *Parasaissetia nigra* at the earlier stage of the egg-laying season (Zhang et al. 2010). It is one of the most successful groups of insects to have been used in the biological control of scale insects (such as *Coccus* and *Saissetia*) (Guerrieri and Noyes 2000; Noyes 2004; Lotfalizadeh 2010).

Due to the economical and particularly the extraordinary diversification of *Metaphycus*, many taxonomic works have been published and a few good keys have been presented for the regional species of *Metaphycus* (Compere 1940; Annecke and Mynhardt 1971, 1972, 1981; Myartseva 1987; Viggiani and Guerrieri 1988; Guerrieri and Noyes 2000; Trjapitzin 1989; Zeya and Hayat 1993). Most of them are based on the distinction of species groups using the palpal formula as suggested by Compere and Annecke (1960). Based on the palpal formula, Compere and Annecke (1960) suggested dividing the genus *Metaphycus* into three species groups: *alberti*-group (Plate I–A) (with 2-segmented maxillary palpi), *insidiosus*-group (Plate I–B) (with 3-segmented maxillary palpi) and *zebratus*-group (Plate I–C) (with 4-segmented maxillary palpi). The *alberti*-group is interpreted here as having 2-segmented maxillary and 2-segmented labial palpi (Anneck and Mynhardt 1971; Guerrieri and Noyes 2000). Graham (1959) used *hederaceus* as the group name, but later he proposed *asterolecanii* for the same group, since *hederaceus* belongs to *Aphycus* rather than *Metaphycus* (Graham, 1969). Tachikawa (1963) was the first author to use *alberti* as the name of this group, and this is widely accepted (Guerrieri and Noyes 2000; Noyes 2004; Zeya and Hayat 1993). Guerrieri and Noyes (2000) described *M. babas* as a new species, with a palpal formula of 2-3. Therefore, they prefer to define these species on the number of segments in the maxillary palpi alone. Noyes (2004) broke with this framework and introduced several other characters (e.g. presence or absence of subapical setae on the 2nd valvifer). These characters are very difficult to observe unless high quality slide-mounted specimens are prepared. In the course of this work, the framework of Compere and Annecke (1960) was followed.

The Chinese fauna of *Metaphycus* is poorly known, though some taxonomic contributions (Jiang 1982; Shi 1986; Xu and Jing 1990) have been made in the later years of past century. But some synonyms and homonyms can be found easily, such as *Metaphycus ericeri* Xu & Jiang, 1990 (renamed *M. xujiangi* by Özdikmen 2011). Recently, several new species and new records have been reported from China (Dang and Wang 2002; Li and Xu 2006; Li and Li 2008; Zhang and Huang 2006; Zhang and Wu 2008; Tan 2008). So far, more than twenty species of *Metaphycus* species have been recorded from China, including four *alberti* group species. To facilitate the accurate identification of this large group of Encyrtidae, systematic study of all species known in China is necessary (Zhang and Wu 2008). The present work is part of this effort.

Accurate identification of *Metaphycus* species is very difficult because of their small size and general appearance (Annecke and Mynhardt 1971; Guerrieri and Noyes 2000). Thus high quality slide preparation is needed, and it is necessary to dissect

the mouthparts and ovipositor parts. The characters (e.g. body coloration, width of frontovertex) used in the keys to species are disputable (Guerrieri and Noyes 2000); however our recent studies using molecular markers show these characters are arguable and can help us to disentangle these species complexes (unpublished data).

Morphological terminology and abbreviations follow those of Noyes (2004). Absolute measurements were used for body length. Relative measurements were used for other dimensions and measured with a Motic SMZ-168 stereomicroscope, under 50x magnification, and the absolute measurement of each unit is 0.02 mm. The following abbreviations are used in the text:

F1, F2, … Fn	Funicle segment number
AOD	Largest diameter of anterior ocellus
HW	Head width measured in facial view
FV	Minimum width of the frontovertex
FVL	Length of frontovertex from occipital margin to top of antennal scrobes as seen in dorsal view
MS	Malar space or the minimum distance between eye and mouth margin
POL	The minimum distance between the posterior ocelli
OCL	The minimum distance between the posterior ocellus and the occipital margin
AOL	The minimum distance between posterior ocellus and anterior ocellus
OOL	The minimum distance between the eye margin and the adjacent posterior ocellus
POD	Largest diameter of posterior ocellus
EL	The maximum diameter of eye
EW	The minimum diameter of eye
SL	The length of the scape
SW	The maximum width of the scape
FWL	Length of fore wing excluding the marginal fringe
FWW	The maximum width of the fore wing excluding the marginal fringe
HWL	Length of hind wing, excluding the marginal fringe
HWW	Width of hind wing, measured at the widest point, excluding the marginal fringe
MT	Length of the mid tibia
OL	Length of ovipositor
GL	Length of the gonostylus
BMNH	Natural History Museum, London, UK
ICZN	International Commission of Zoological Nomenclature
IZCAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, PR China
USNM	United States National Museum, Washington, DC, USA
ZJU	Zhejiang University, Hangzhou, China
SCU	Sichuang University, Chengdu, China
KYUN	Kyoto University, Kyoto, Japan

Taxonomy of *Metaphycus* Mercet

Aenasioidea Girault, 1911: 171. Type species: *Aenasioidea latiscapus* Girault, by original designation. Synonymy by Noyes and Woolley (1994: 1329). Suppressed: *Metaphycus* given precedence over *Aenasioidea* by the International Commission of Zoological Nomenclature (ICZN 1998).

Metaphycus Mercet, 1917: 138. Type species: *Aphycus zebratus* Mercet, by monotypy.

Tyndarichoides Girault, 1920: 189. Type species: *Tyndarichoides mexicanus* Girault, by monotypy. Synonymy by Noyes and Woolley 1994: 1329.

Euaphycus Mercet, 1921: 97. Type species: *Encyrtus hederaceus* Westwood, by subsequent designation of Mercet 1925: 23, as subgenus of *Aphycus* Mayr. Synonymy by Compere and Annecke 1960: 384. *Encyrtus hederaceus* Westwood was misidentified by Mercet; see Graham 1969: 224–225.

Metaphycus Mercet, 1925: 28. Generic status.

Mercetiella Dozier, 1926: 98. Type species: *Mercetiella reticulata* Dozier, by original designation. Synonymy by Trjapitzin and Gordh 1978: 636.

Oaphycus Giraiult, 1932: 5. Type species: *Aphycus sanguinithorax* Girault, by original designation. Synonymy by Noyes and Hayat 1984: 298.

Erythraphycus Compere, 1947: 7. Type species: *Erythraphycus argyrocomus* Compere, by original designation. Synonymy by Noyes and Woolley 1994: 1329.

Melanphycus Compere, 1947: 5. Type species: *Pseudococcobius fumipennis* Timberlake, by original designation. Synonymy by Noyes 1980: 212.

Anaphycus Sugonjaev, 1960: 372. Type species: *Aphycus nitens* Kurdjumov, by original designation. Synonymy by Trjapitzin 1971: 126.

Mesaphycus Sugonjaev, 1960: 370. Type species: *Aphycus picearum* Erdős, by original designation. Synonymy by Guerrieri and Noyes 2000: 148.

Notoencyrtus De Santis, 1964: 211. Type species: *Notoencyrtus guttofasciatus* De Santis, by original designation. Synonymy by Noyes 1980: 212.

Xenaphycus Sharkov & Voynovich, 1988: 826. Type species: *Paraphycus flavovarius* Mercet, by subsequent designation of Trjapitzin (1982: 38). Synonymy by Guerrieri and Noyes 2000: 148.

Aenigmaphycus Sharkov & Voynovich, 1988: 826. Type species: *Aenigmaphycus paluster* Sharkov and Voynovich, by monotypy. Synonymy by Guerrieri and Noyes 2000: 148.

Diagnosis. Length 0.7–1.8 mm; robust and squat species; body largely orange, yellow to brown or black (the latter at maximum shiny), never with metallic luster, antenna usually with black and white or yellow segments, fore wing hyaline or partially infuscate, legs mostly yellowish, sometimes tibiae with dark rings. Head with occipital margin sharp; mandible mostly broad with 3 short, subequal teeth. Pronotum short, mesoscutum wider than long, notaular lines variable in length from virtually absent to reaching about 0.7× across mesoscutum; fore wing generally about 2.1–2.7× as long

as broad and with uniform setation, postmarginal vein very short, stigmal vein well developed, longer than marginal and postmarginal vein together; linea calva usually closed and interrupted in posterior third by a few setae. Female: antenna almost always 11-segmented (formula 1163: 1 scape, 1 pedicel, 6 funicle, 3 clava). Gaster with hypopygium reaching half way along gaster to more or less reaching its apex; ovipositor sheath free, in most cases not exserted or only slightly exserted in *M. stylatus* sp. n. Male: generally darker and with more uniform colour in respect to that of corresponding female. Antenna 9-segmented (formula 1161: 1 scape, 1 pedicel, 6 funicle, 1 clava).

Key to *Metaphycus* species of *alberti*-group (females) from China

1 Scape (Figs 39, 58) not distinctly flattened and expanded, about or more than 4× as long as broad **2**

– Scape (e.g. Figs 15, 63, 77) distinctly flattened and expanded, less than 3.5× as long as broad **3**

2 Fore wing (Fig. 42) hyaline, without a small infuscate area beneath stigma vein; ovipositor sheath strongly exserted and about 0.4× as long as ovipositor (Fig. 47)..... ***M. stylatus* sp. n.**

– Fore wing (Fig. 62) hyaline, with a small infuscate area beneath stigma vein; ovipositor sheath clearly exserted but only about 0.25× as long as ovipositor (Fig. 61) ..... ***M. nadius* (Walker, 1838)**

3 Scape (Figs 1, 8, 15) 2.6–3.5× as long as broad..... **4**

– Scape (e.g. Figs 23, 48, 77) not more than 2.5× as long as broad 6

4 Scape (Fig. 8) with a completely pale yellow dorsal margin, usually 3× as long as broad ..... ***M. alberti* (Howard, 1898)**

– Scape (Fig. 1) with dorsal margin not completely pale yellow **5**

5 Mesoscutum and scutellum with a longitudinal dark brown strip medially (Plate I–D) ..... ***M. dorsalis* sp. n.**

– Mesoscutum and scutellum without a dark brown longitudinal strip..... .....***M. dispar* (Mercet, 1925)**

6 Scape (Fig. 70) with completely pale yellow dorsal margin, usually 2.4× as long as broad ..... ***M. fusiformis* sp. n.**

– Scape (e.g. Figs 23, 48, 77) without completely pale yellow dorsal margin...**7**

7 Ovipositor longer than mid tibiae..... **8**

– Ovipositor shorter than mid tibiae..... **9**

8 Mid and hind tibiae with distinct dark brown brown marking (Fig. 67); scape (Fig. 63) about 2× as long as broad..... ***M. fusiscapus* sp. n.**

– Mid and hind tibiae immaculate (Fig. 36), at most with a fuscous spot near base of mid tibiae; scape (Fig. 30) 2.3× as long as broad ..... ***M. wui* sp. n.**

9 F1–F3 subquadrate, not distinctly transverse; clava clearly shorter than scape, about 0.6× as long as scape (Fig. 77)..... ***M. xujiangi* Özdikmen, 2011**

– F1–F3 distinctly transverse; clava about as long as scape (Figs 23, 48) **10**

10 Fore wing 2.4× as long as broad (Fig. 53), ocelli forming an angle of about 50°; ovipositor (Fig. 57) about 5.4× as long as ovipositor sheath..... ..... ***M. ericeri*** **Trjapitzin, 1967**

– Fore wing 2.7× as long as broad (Fig. 25), ocelli forming an angle of about 40°; ovipositor (Fig. 29) about 4.8× as long as ovipositor sheath..... ..... ***M. chinensis*** **sp. n.**

Metaphycus dorsalis **sp. n.**
urn:lsid:zoobank.org:act:486A67C0-EE88-4D7C-988A-47ABE6CB1712
http://species-id.net/wiki/Metaphycus_dorsalis
Plate 1D, Figs 1–7

Holotype. ♀, China, Yunnan, Xishuangbanna: 2009.XI.9, Coll. G. Tang (IZCAS).

Paratypes. 2♀♀, the same as holotype; 2♀♀, 1♂, Sichuan, Chengdu, 1961. VII.1–5, Coll. D. X. Liao (IZCAS).

Female: Body length, including ovipositor about 1mm. Frontovertex orange; orange in ocellar area, pale orange between occipital margin and posterior ocelli; immaculate with yellow from occiput to base of mandible; mouth margin medially yellow below torulus; rest of head, except occiput, white; antenna (Fig. 1) with radicle dark brown; scape with both faces dark brown, blackish, only base and apex white; pedicel dark brown in proximal one third, otherwise white; F1–F3 dark brown, F4 very pale brown, F5–F6 white, clava dark brown, becoming slightly paler towards apex, apex very pale brown; occiput with a brown area above foramen, rest white; neck of pronotum dark brown, posterior margin white, lateral spots relatively large and distinct; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae conspicuously bordered brown, mesoscutum and scutellum (Plate I–D) with brown line from front edge of mesoscutum to apex of scutellum; setae translucent pale brown, silvery in most lights; tegula white with apex pale brown; metanotum orange; mesopleuron yellow; prosternum and mesosternum pale yellow; legs (Figs 5–7) pale yellow; fore wing (Fig. 4) hyaline and with linea calva interrupted; venation yellow-brown; hind wing hyaline; propodeum medially orange-brown, laterally pale yellow; gaster orange and ovipositor sheath orange.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; frontovertex about one-fourth head width; ocelli forming an acute angle about 30°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel and from anterior ocellus slightly wider anteriorly; scrobes shallow and U-shaped; antenna with scape about 3–3.1× as long as broad; funicle with F1–F4 smallest, F5 a little larger than F4 but transverse, F6 largest and slightly wider than long; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2

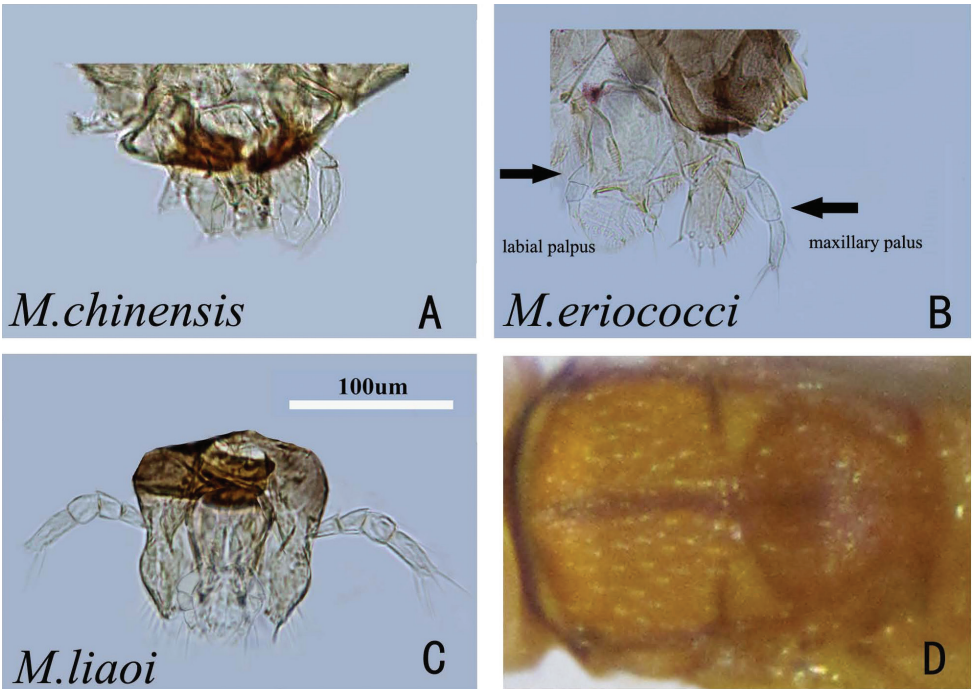


Plate 1. A palpal formula 2-2 (*Metaphycus chinensis* sp. n.) **B** palpal formula 3-3 (*Metaphycus eriococci*) **C** palpal formula 4-3 (*Metaphycus liaoi*) **D** thorax of *Metaphycus dorsalis* sp. n. in dorsal view.

(Fig. 3), notaular lines reaching about 0.4× across mesoscutum; fore wing venation and setation as in Fig. 4; ovipositor (Fig. 2) slightly exserted, about 5.6× as long as ovipositor sheath.

Relative measurements: HW 13, FV 3, FVL 7, POL 1.5, AOL 3.5, OOL 0.5, OCL 2, POD 1, AOD 1, EL 9, EW 6, MS 5, SL 6, SW 2, FWL 35, FWW 14, HWL 23, HWW 5, OL 10, GL 2, MT 10.

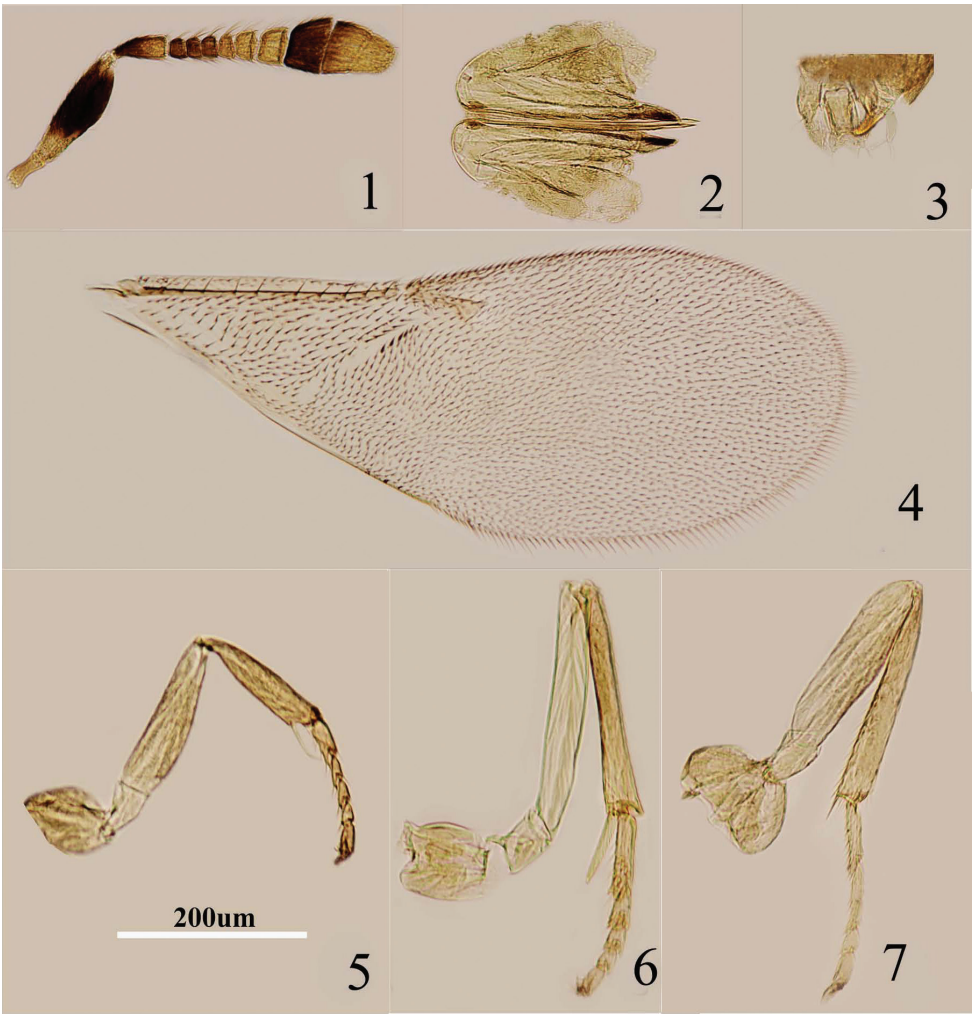
Male. Unknown.

Host. Unknown.

Distribution. China (Sichuan, Yunnan).

Etymology. The specific epithet of this new species refers to the medial longitudinal dark brown strip on the mesoscutum and scutellum.

Diagnosis. Antenna with scape about 3–3.1× as long as broad; mesoscutum and scutellum with brown line running from front edge of mesoscutum to apex of scutellum; legs pale yellow; fore wing hyaline and with linea calva interrupted. Using the keys of Trjapitzin (1989) and Guerrieri and Noyes (2000), this species runs to *M. dispar* (keys couplet 11 and 15). It can be separated from *dispar* as follows: mesoscutum and scutellum with a longitudinal dark brown strip in the middle (in *dispar*, mesoscutum and scutellum without a longtitudinal dark brown strip). Scape about 3× as long as broad (in *dispar*, scape about 3.3× as long as broad). Ovipositor about 5× as long as



Figures 1–7. *Metaphycus dorsalis* sp. n. Female: **1** antenna **2** ovipositor **3** palpal formula **4** fore wing **5** fore leg **6** mid leg **7** hind leg.

ovipositor sheath (in *dispar*, ovipositor about 4.3× as long as ovipositor sheath). The colour of the radicle is dark brown, and the metanotum is orange (in *dispar*, radicle with yellow, and metanotum is brown).

***Metaphycus alberti* (Howard, 1898)**
http://species-id.net/wiki/Metaphycus_alberti
Figs 8–14

Aphycus alberti Howard, 1898: 247. Syntypes ♀♂, Australia (New South Wales), USNM, examined (part).

Metaphycus alberti (Howard); Compere 1957: 222, 224.
Metaphycus aurantiacus Annecke & Mynhardt, 1981: 60–61. Synonymized with *alberti* by Noyes 2004: 254.

Female. Body length, including ovipositor, 0.72–1.1 mm. Frontovertex pale orange; orange in ocellar area, pale orange between occipital margin and posterior ocelli; immaculate from occiput to base of mandible; occiput with a large dark brown area above foramen, rest white; antenna (Fig. 8) with radicle very pale brown; scape mostly pale yellow and with a dark brown mark in middle, dorsal margin pale yellow; pedicel dark brown in proximal half, otherwise white, F1–F3 brown, F4–F6 white, clava dark brown, becoming slightly paler towards apex, apex pale brown; neck of pronotum brown, posterior margin translucent white, lateral spots relatively small and faint, rest white; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; setae translucent yellow, silvery in most lights; tegula white with apex pale grey-brown; metanotum orange; mesopleuron pale yellow; prosternum and mesosternum pale yellow; legs (Figs 12–14) mainly pale yellow; fore wing (Fig. 11) hyaline and with linea calva interrupted, stigmal vein about 2.3× as long as marginal vein, venation yellow-brown; hind wing hyaline; propodeum medially orange, laterally dark brown, sides white; gaster mostly yellow, sometimes pale brown dorsally from cercal plates to near apex, ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an acute angle less than 35°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex parallel-sided; scrobes shallow and U-shaped; antenna with scape about 2.7–3.5× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger, F6 largest and slightly wider than long; linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 10), notaular lines reaching about 0.4× across mesoscutum; fore wing venation and setae as in Fig. 11; ovipositor (Fig. 9) slightly exserted, about 5.2× as long as ovipositor sheath.

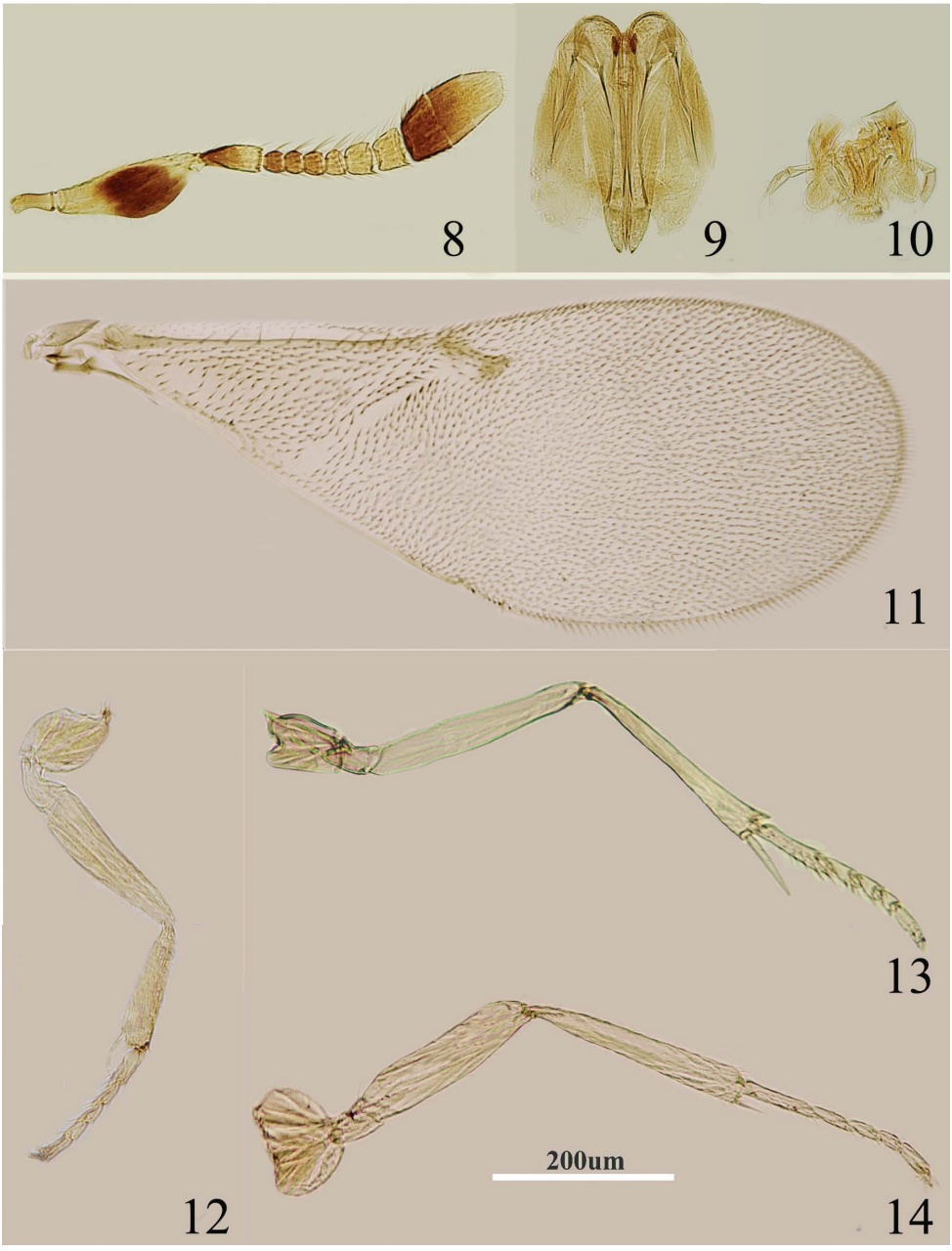
Relative measurements: HW 13, FV 3, FVL 7, POL 2, AOL 4, OOL 1, OCL 2, POD 1, AOD 1.5, EL 8, EW 6, MS 3.5, SL 7, SW 2, FWL 37, FWW 14, HWL 26, HWW 5, OL 10, GL 2, MT 11.

Male. Length 0.7 mm. Generally similar to female but for coloration, structure of clava and genitalia. Frontovertex with ocellar area dark brown; dorsum of thorax and gaster dark brown. Antenna similar to that of female but clava solid and relatively slender; aedeagus about half as long as mid tibia.

Hosts. *Coccus hesperidum* (Annecke & Mynhardt, 1981), *Coccus elongates*, *Coccus longulus* and *Ceroplastes* sp. (Hemiptera: Coccidae) (Noyes 2004).

Distribution. China (Chongqing, Fujian, Guangdong, Sichuan, Zhejiang), Hawaii, USA (California), Costa Rica, South Africa, Swaziland, Australia.

Material examined. China: 5♀♀, Zhejiang, Huangyan, 1964.VII.17, Coll. D. X. Liao (IZCAS); 1♀, Zhejiang, Ningbo, 2012.VII.3, F. Wang (IZCAS); 3 ♀♀, 1♂,



Figures 8–14. *Metaphycus alberti* (Howard) Female: **8** antenna **9** ovipositor **10** palpal formula **11** fore wing **12** fore leg **13** mid leg **14** hind leg.

Sichuan, Chengdu, 1961.VII.10–13, Coll. D. X. Liao (IZCAS); 2♀, Guangdong, Heyuan, 2009.XI.8, F. Yuan and Y. Z. Zhang (IZCAS); 1♀, Fujian, Wuping (Liangye Mt.), 2008.XI.15, Coll. F. Yuan (IZCAS); 1♀, Fujian, Fuzhou, 1998.X, M. Xu (IZ-

CAS); 1♀, Chongqing, Longxi, 1992.VII.15 (BMNH). South Africa: 1♀, Zebediela, 1957–III, Coll. D. P. Annecke (BMNH).

Diagnosis. Antenna with radicle very pale brown; scape mostly pale yellow and with a dark brown mark in middle, dorsal margin pale yellow; legs mainly pale yellow, scape about 2.7–3.5× as long as broad, ovipositor slightly exserted, about 5.2× as long as ovipositor sheath. *Metaphycus alberti* is very similar to *M. dispar* in general coloration and habitus. The female of *alberti* can be identified reliably by the pale yellow dorsal margin of the scape (in *dispar* dorsal margin of the scape medially interrupted by dark brown mark), and the ovipositor about 5.2× as long as ovipositor sheath (in *dispar* ovipositor about 4.3× as long as ovipositor sheath).

Metaphycus dispar (Mercet, 1925)

http://species-id.net/wiki/Metaphycus_dispar
Figs 15–22

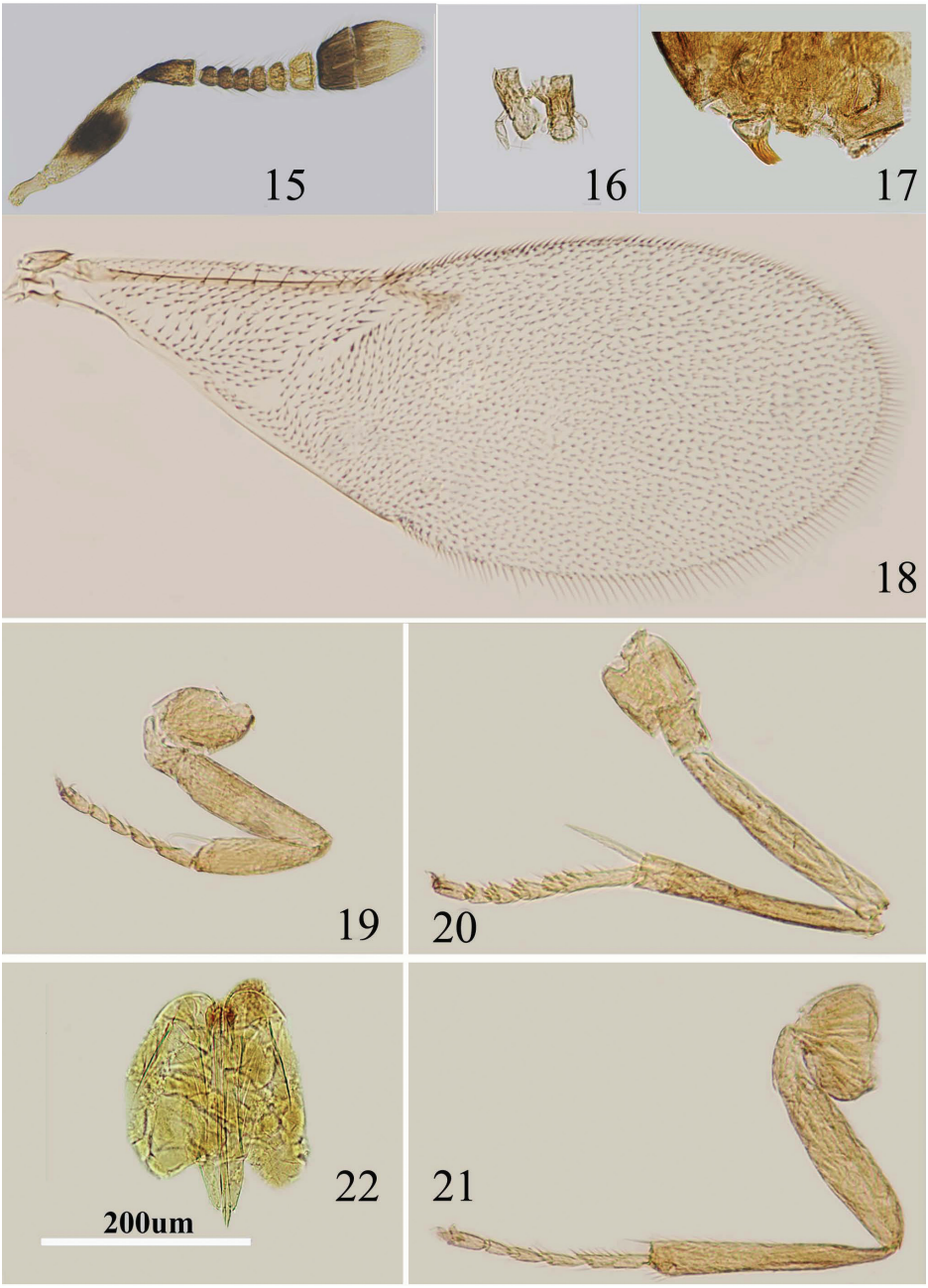
Euaphycus dispar Mercet, 1925: 25–27. Lectotype ♀ (designated by Noyes 1981: 174), Spain, IEE.

Metaphycus tamakatakaigara Tachikawa, 1957: 27–30. Holotype female, Japan, KYUN. Synonymized with *dispar* by Trjapitzin 1989: 232.

Metaphycus dispar (Mercet); Sugonjaev and Babaev 1971: 70–75. Trjapitzin 1978: 314; Trjapitzin 1989: 384; Guerrieri and Noyes 2000: 168.

Female. Body length, including ovipositor, about 0.67mm. Frontovertex orange; orange in ocellar area, pale yellow between occipital margin and posterior ocelli; immaculate from occiput to base of mandible; mouth margin pale yellow below torulus; rest of head, except occiput, white; antenna (Fig. 15) with radicle yellow; scape mostly pale yellow and with a dark brown mark in middle, dorsal margin in middle brown; pedicel in proximal two thirds dark brown and distal one third white, dark brown area extending slightly towards apex externally and internally; F1–F3 dark brown, F4 pale brown, F5–F6 yellow-white, clava dark brown, becoming slightly paler towards apex, apex yellow; occiput with a large dark brown area above foramen, rest white; neck of pronotum black, posterior margin white, lateral spots relatively large and distinct, rest white; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; setae translucent pale orange, silvery in most lights; tegula white with apex pale brown; metanotum brown; mesopleuron white; prosternum and mesosternum white; legs (Figs 19–21) pale yellow; fore wing (Fig. 18) hyaline and with linea calva interrupted, venation yellow-brown; hind wing hyaline; propodeum medially pale brown, brown laterally, sides white; gaster dorsally mainly very pale brown, but basal tergite dark brown, sides and venter white; ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an acute angle less than 35°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; eye margins subparal-



Figures 15–22. *Metaphycus dispar* (Mercet) Female: **15** antenna **16** palpal formula **17** mandible **18** fore wing **19** fore leg **20** mid leg **21** hind leg **22** ovipositor.

lel with frontovertex slightly wider anteriorly; scrobes shallow and U-shaped; antenna (Fig. 15) with scape about 3.1–3.3× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger and F6 largest, linear sensilla only on F5 and

F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth (Fig. 17); palpal formula 2-2 (Fig. 16), notaular lines virtually absent; fore wing venation and setation as in Fig. 18; ovipositor (Fig. 22) slightly exserted, about 4.3× as long as ovipositor sheath.

Relative measurements: HW 9, FV 3, FVL 4, POL 2 AOL 3, OOL 0.5, OCL 1, POD 1, AOD 1, EL 6, EW 4, MS 3, SL 4.5, SW 1.5, FWL 28, FWW 11, HWL 15, HWW 4, OL 7, GL 1.6, MT 8.

Male. Length 0.7–0.8 mm. Very similar to female except for antenna, genitalia and darker coloration; torulus with several pores inside the lower margin. (Guerrieri and Noyes 2000).

Hosts. *Ericerus pela*, *Eulecanium* sp., *Eulecanium douglasi*, *Eulecanium kunoense*, *Eulecanium rugulosum*, *Eulecanium secretum*, *Eulecanium tiliae*, *Parthenolecanium corni*, *Parthenolecanium persicae*, *Pulvinaria* sp., *Pulvinaria vitis*, *Rhodococcus turanicus*.

Distribution. China (Beijing, Xinjiang), Japan, Kazakhstan, Kirgizia, Kyrgyzstan, Mongolia, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Canary Islands, Czech Republic, Finland, France, Greece, Hungary, Italy, Madeira, Russia, Russia-Adygeyskaya, Russia-Altayskiy Kray, Russia-Buryatskaya Respublika, Russia-Sakhalin Oblast, Slovakia, Spain, United Kingdom, United Kingdom-England, former Yugoslavia, Georgia, USA, (Trjapitzin 1989; Guerrieri and Noyes 2000).

Material examined. China: 1♀, Xinjiang, Kurle, 1965.VI.9, Coll. D. X. Liao (IZCAS); 1♀, Beijing, Changping, 2011.IX.23 (IZCAS); 1♀, Jiangsu, Nianjing, 2011. VI. (IZCAS); 1♀, Liaoning, Shenyang, 1991.VI., Coll. J. X. Lou (IZCAS). France: 1♀, Corsica Propriano, 1989.VIII, Coll. J. S. Noyes (BMNH); Greece: 1♀, Corfu Ano Kourakiana, 1987.VIII.30, Coll. J. S. Noyes (BMNH); Japan: 1♀, Tokyo, 1981. VIII.2, Coll. Ikece & Carlson (BMNH).

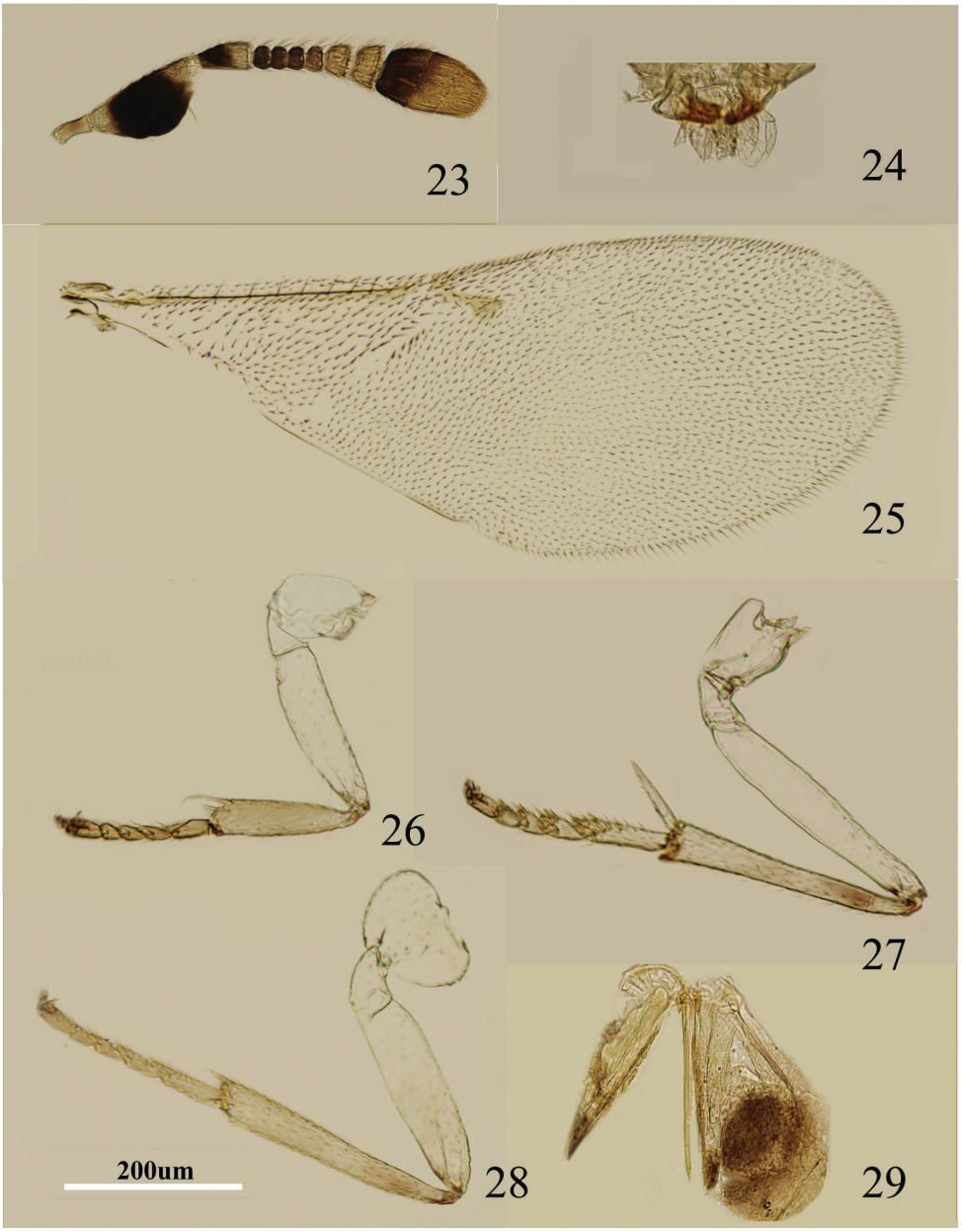
Diagnosis. Scape mostly pale yellow and with a dark brown mark in middle, dorsal margin in middle brown, and about 3.1–3.3× as long as broad; ovipositor slightly exserted, about 4.3× as long as ovipositor sheath. See diagnosis under the *M. alberti*. According to Guerrieri and Noyes (2000), *M. dispar* is very close to *M. kozari* Sugonjaev (1975).

***Metaphycus chinensis* sp. n.**
urn:lsid:zoobank.org:act:0D6FA99A-77F0-4525-83B7-AA1B93277977
http://species-id.net/wiki/Metaphycus_chinensis
Figs 23–29

Holotype. ♀, China, Jiangsu, Nanjing: 2011.VI.1, coll. L. Ding (IZCAS).

Paratypes. 2♀♀, the same as holotype (IZCAS).

Female: Body length, including ovipositor, 0.7mm. Frontovertex orange; orange in ocellar area, yellow between occipital margin and posterior ocelli; immaculate from occiput to base of mandible; rest of head, except occiput, white; antenna (Fig. 23) with radicle brown; scape with both faces blackish, extreme base and apex yellow; pedicel



Figures 23–29. *Metaphycus chinensis* sp. n. Female: **23** antenna **24** palpal formula **25** fore wing **26** fore leg **27** mid leg **28** hind leg **29** ovipositor.

dark brown in proximal half, otherwise white; F1–F3 dark brown, F4 pale brown, F5–F6 white, clava dark brown, becoming paler towards apex, apex paler brown; occiput with a large dark brown area above foramen, rest white; neck of pronotum black, posterior margin translucent brown, lateral spots relatively large and distinct, rest white;

dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered pale brown; setae translucent orange, silvery in most lights; tegula white with apex pale grey-brown; metanotum pale brown; mesopleuron pale yellow; prosternum and mesosternum white; legs (Figs 26–28) mainly pale yellow, occasionally mid and hind tibiae with faint brown marking; fore wing (Fig. 25) hyaline and with linea calva interrupted, venation yellow-brown; hind wing hyaline; propodeum medially dark brown, laterally white; dorsum of gaster brown but T8 white, sides and venter white; ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 40°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel-sided; scrobes shallow and U-shaped; lateral antennal groove absent; antenna (Fig. 23) with scape about 2.3× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 larger but transverse, F6 largest, linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 24), notaular lines virtually absent; fore wing venation and setation as in Fig. 25; ovipositor (Fig. 29) hardly exserted, about 4.8× as long as ovipositor sheath.

Relative measurements: HW 11, FV 3, FVL 6, POL 1.5, AOL 3, OOL 0.5, OCL 1, POD 1, AOD 1, EL 7, EW 5, MS 3.5, SL 5, SW 2.2, FWL 30, FWW 11, HWL 19, HWW 3, OL 9, GL 1.9, MT 11.

Male. Unknown.

Host. Unknown**.**

Distribution. China (Jiangsu).

Etymology. The specific epither of this new species is derived from the type locality "China".

Diagnosis. Antenna with radicle brown; scape with both faces blackish, extreme base and apex yellow; scape about 2.3× as long as broad; dorsum of gaster brown but T8 white, sides and venter white; ovipositor sheath yellow; ovipositor hardly exserted, about 4.8× as long as ovipositor sheath. This species is close to *M. ericeri* in appearance. It can be separated from the latter as follows: fore wing 2.7× as long as broad (Fig. 25), ocelli forming an angle of about 40°; ovipositor (Fig. 29) about 4.8× as long as ovipositor sheath (in *ericeri*, fore wing 2.4× as long as broad (Fig. 53), ocelli forming an angle of about 50°; ovipositor (Fig. 57) about 5.4× as long as ovipositor sheath).

***Metaphycus wui* sp. n.**
urn:lsid:zoobank.org:act:9C8CB15E-29C7-40C1-8CAD-DA6EBAEA2AE6
http://species-id.net/wiki/Metaphycus_wui
Figs 30–38

Holotype. ♀, China, Guangxi, Chongzuo 2011.IV.22, ex. *Ceroplastes* sp., coll. S. A. Wu (IZCAS).

Paratypes. 2♀♀, same as holotype (IZCAS).

Female: Body length, including ovipositor, 0.7–0.8mm. Frontovertex orange; orange in ocellar area, orange between occipital margin and posterior ocelli; gena with brown-yellow from occiput to base of mandible; mouth margin yellow below torulus; rest of head, except occiput, white; antenna (Fig. 30) with radicle very pale brown; scape mostly black only extreme base and apex white; pedicel dark brown in proximal half otherwise white, F1–F4 dark brown, F5–F6 white, clava dark brown, becoming slightly paler towards apex, apex paler brown; occiput with a large black area above foramen, rest white; neck of pronotum black, posterior margin brown, lateral spots relatively large and distinct, rest brown; dorsum of thorax brown-yellow; sides and posterior margin of mesoscutum and axillae inconspicuously bordered yellow-brown (Fig. 34); setae translucent yellow, silvery in most lights; tegula white only apex pale brown; metanotum dark brown; mesopleuron pale yellow; prosternum and mesosternum white; legs (Figs 35–37) mainly pale brown-yellow; fore wing (Fig. 32) hyaline, venation yellow-brown; hind wing hyaline and with linea calva interrupted; propodeum medially dark brown; gaster dorsally brown, side and venter white; ovipositor sheath pale yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 45°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; eye margins subparallel with frontovertex slightly wider anteriorly; scrobes shallow and U-shaped; antenna (Fig. 30) with scape about 2.3× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger, F6 largest and quadrate, linear sensilla only on F5 and F6; clava 3-segmented, its apex rounded; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 31), notaular lines reaching about 0.5× across mesoscutum (Fig. 33); fore wing venation and setation as in Fig. 32; ovipositor (Fig. 38) slightly exserted, about 4.7× as long as ovipositor sheath.

Relative measurements: HW 12, FV 3, FVL 6, POL 2, AOL 3, OOL 1, OCL 1, POD 1, AOD 1, EL 8, EW 5, MS 2, SL 7, SW 3, FWL 36, FWW 17, OL 16, GL 3.4, MT 12.

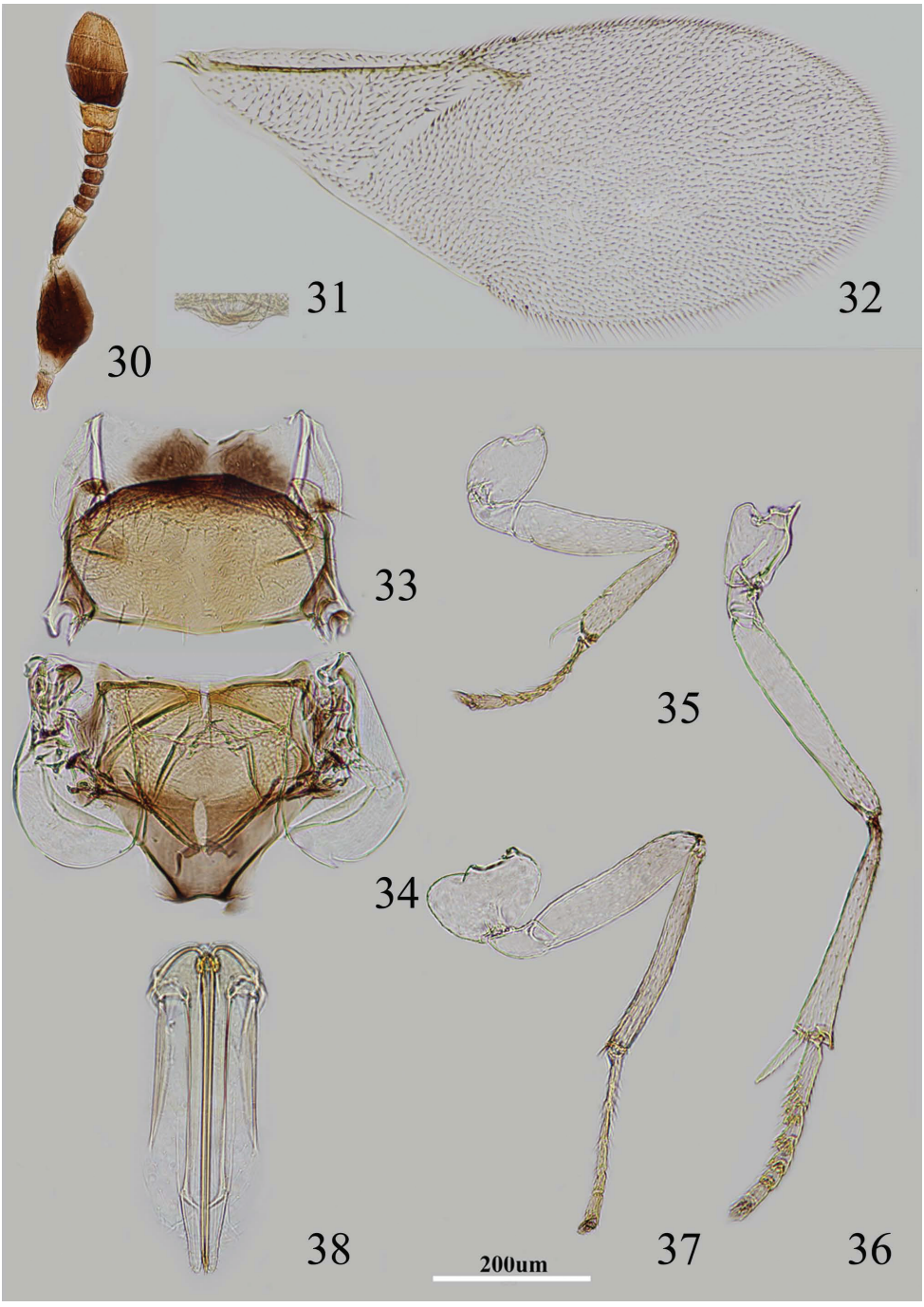
Male. Unknown.

Host. *Ceroplastes* sp. on *Pinus*.

Distribution. China (Guangxi).

Etymology. The species is named after Professor Sanan Wu, who helped to identify many hosts of Encyrtidae.

Diagnosis. Antenna with radicle very pale brown; scape mostly black, only extreme base and apex white, about 2.3× as long as broad; legs mainly pale brown-yellow; ovipositor slightly exserted, about 4.7× as long as ovipositor sheath. This species is similar to *M. fusiscapus* in colour and size. It can be separated from the latter as follows: scape about 2.3× as long as broad (in *fusiscapus*, scape about 2× as long as broad); mid and hind tibiae immaculate (Fig. 36), at most with a fuscus spot near base of mid tibiae (in *fusiscapus* mid and hind tibiae with distinct dark brown marking).



Figures 30–38. *Metaphycus wui* sp. n. Female: **30** antenna **31** palpal formula **32** fore wing **33** mesoscutum **34** scutellum **35** fore leg **36** mid leg **37** hind leg **38** ovipositor.

***Metaphycus stylatus* sp. n.**
urn:lsid:zoobank.org:act:B8D8DF2C-283E-447F-9776-E361F4A669C0
http://species-id.net/wiki/Metaphycus_stylatus
Figs 39–47

Holotype. ♀, China, Beijing: 2011.VII.1 (IZCAS).

Paratypes. 2♀♀, same as holotype (IZCAS).

Female: Body length, including ovipositor about 0.8mm. Frontovertex orange; orange in ocellar area, orange between occipital margin and posterior ocelli; gena with a fairly broad, oblique, pale brown-yellow from occiput to base of mandible; mouth margin narrowly pale brown below torulus; rest of head, except occiput, white; antenna (Fig. 39) with radicle yellow; scape mostly dark brown and base white; pedicel dark brown in proximal half, otherwise white, F1–F4 dark brown, F5–F6 pale brown-grey, clava dark brown, becoming slightly paler towards apex, apex paler brown; occiput with a large dark brown area above foramen, rest white; neck of pronotum pale black, posterior margin brown, lateral spots relatively large and distinct, rest white; dorsum of thorax yellow-brown; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; setae translucent yellow, silvery in most lights; tegula white and apex grey-brown; metanotum dark brown; mesopleuron pale yellow; prosternum and mesosternum white; legs (Figs 43–45) mainly pale yellow but tibiae at knees narrowly dark brown, mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×; fore wing (Fig. 42) hyaline and with linea calva interrupted, venation yellow-brown; hind wing hyaline; propodeum medially brown, laterally yellow; gaster dorsally brown, sides and venter white; ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 60°; eye not quite reaching occipital margin, separated by one diameter of a facet; eye margins subparallel with frontovertex slightly wider anteriorly; scrobes shallow and U-shaped; antenna with scape about 5.5× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 and F6 largest, subequal; linear sensilla only on F5 and F6; clava 3-segmented, its apex rounded; mandible relatively broad with three subequal, apical teeth (Fig. 41); palpal formula 2-2 (Fig. 40), notaular lines reaching about 0.6× across mesoscutum (Fig. 46); fore wing venation and setation as in Fig. 42; ovipositor (Fig. 47) strongly exserted, the exserted part about 2.6× as long as mid tibial spur, ovipositor length about 2.8× as long as ovipositor sheath.

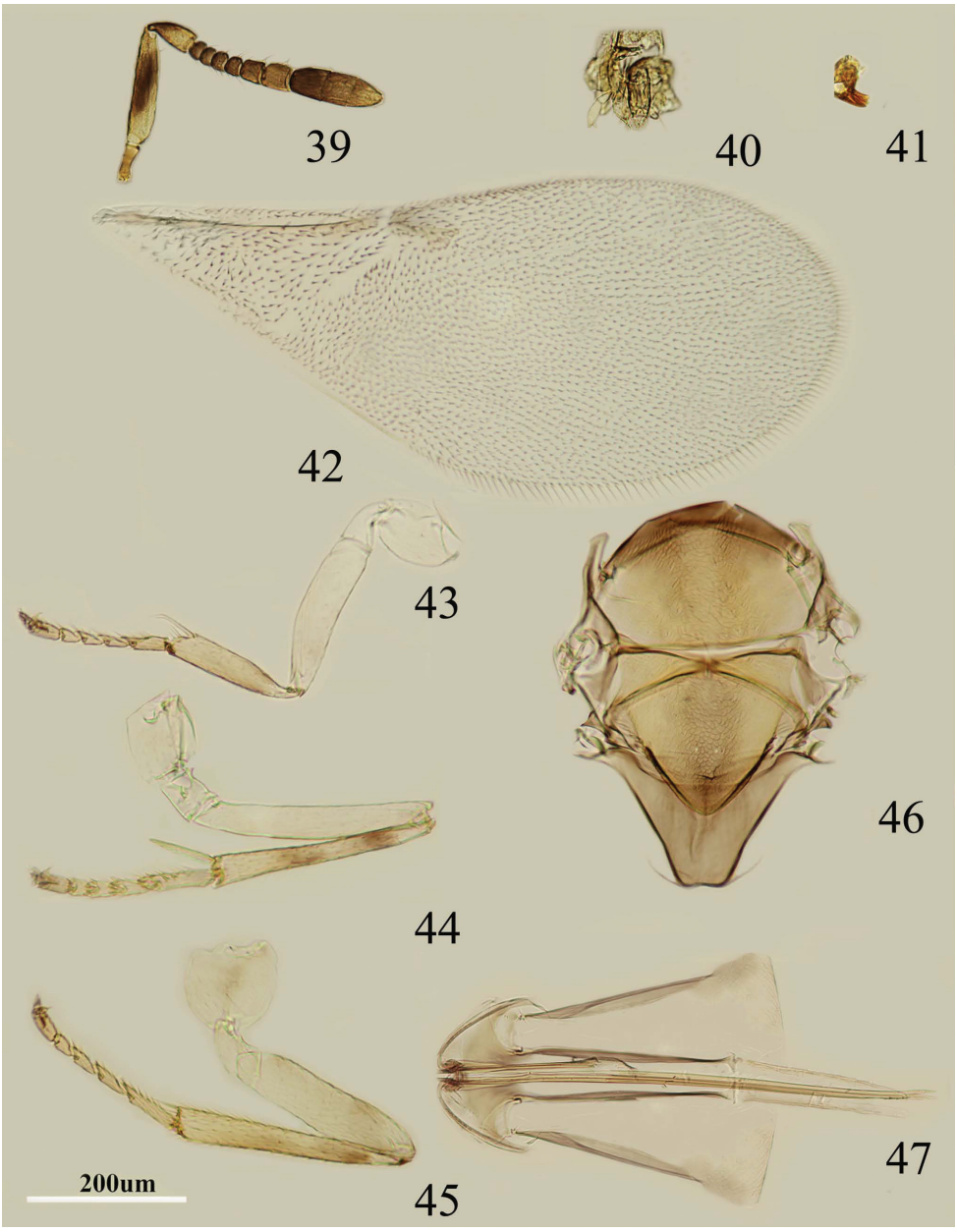
Relative measurements: HW 11, FV 4, FVL 5, POL 2, AOL 2, OOL 1, OCL 1, POD 1, AOD 1, EL 7, EW 4, MS 3, SL 5.5, SW 1, FWL 31, FWW 12, HWL 20, HWW 3.5, OL 15, GL 5.4, MT 9.

Male. Unknown.

Host. Unknown.

Distribution. China (Beijing).

Etymology. The specific epithet is derived from the latin word “stylatus” referring to the long ovipositor sheath of the new species.



Figures 39–47. *Metaphycus stylatus* sp. n. Female: **39** antenna **40** palpal formula **41** mandible **42** fore wing **43** fore leg **44** mid leg **45** hind leg **46** mesothorax **47** ovipositor.

Diagnosis. Scape mostly dark brown and base white and about 5.5× as long as broad; legs mainly pale yellow but tibiae at knees narrowly dark brown, mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×; gaster dorsally brown, sides and venter white; ovipositor sheath strongly exserted, the exserted

part about two thirds gaster length; ovipositor length about 2.8× as long as ovipositor sheath.

Metaphycus stylatus differs from other species studied here by the strongly exserted ovipositor sheath, which is about two thirds gaster length. In other species, the ovipositor sheath is less than one fifth the gaster length. Using the key of Guerrieri and Noyes (2000), this species runs to *M. asterolecanii* (key couplet 12). It can be separated from *asterolecanii* as follows: scape about 5.5× as long as broad; head about 3× as broad as frontovertex, and ocelli forming an angle of about 60°; ovipositor (Fig. 47) strongly exserted, about 1.7× as long as mid tibia (in *asterolecanii*, scape about 3× as long as broad; head about 4× as broad as frontovertex, and ocelli forming an angle of clearly less than 60°; ovipositor hidden and nearly as long a mid tibia).

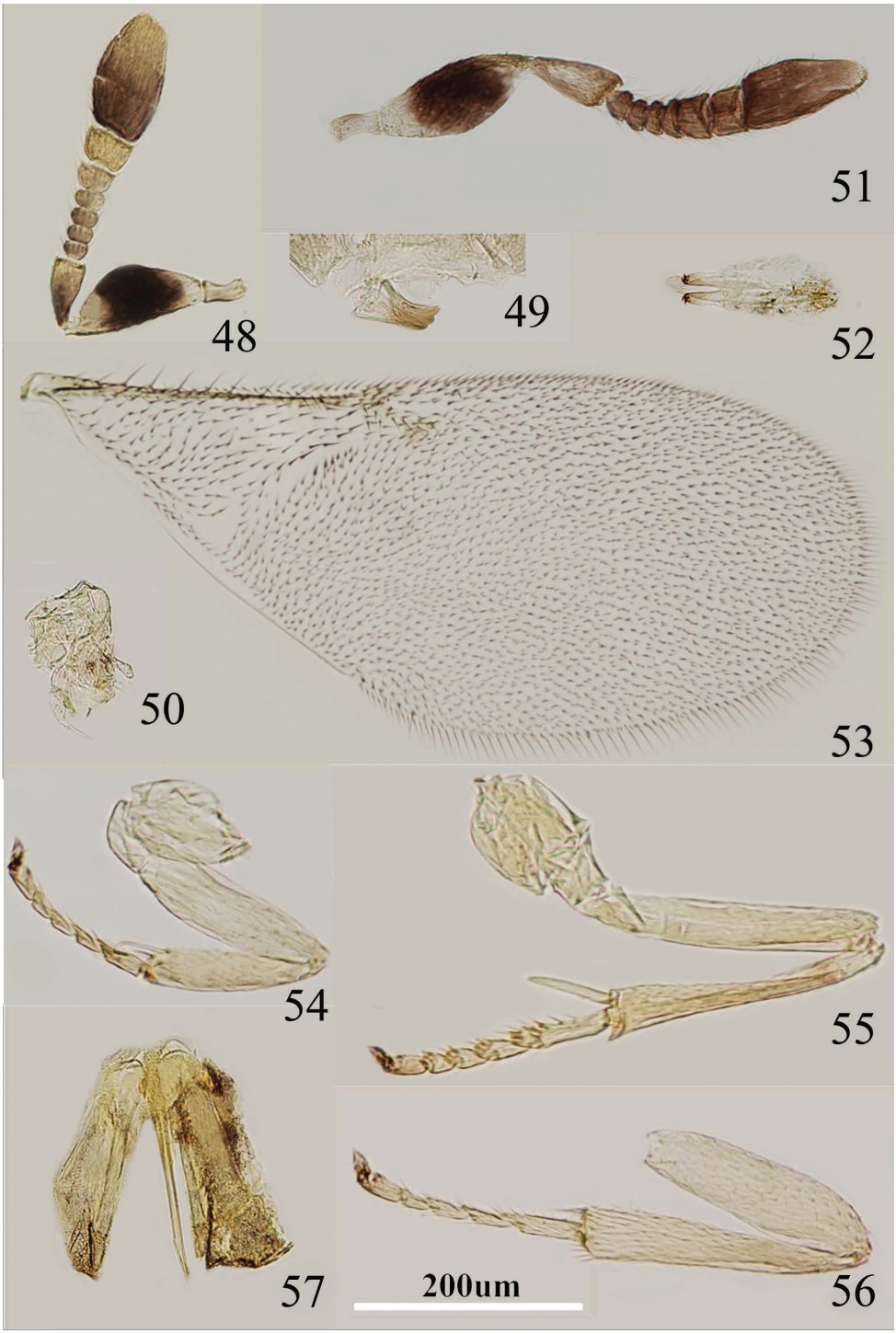
Metaphycus ericeri Trjapitzin, 1967

http://species-id.net/wiki/Metaphycus_ericeri
Figs 48–57

Metaphycus ericeri Trjapitzin, 1967: 185. Holotype ♀, Russia–Primor'ye Kray.
Metaphycus ericeri Trjapitzin: Trjapitzin 1975: 10; Trjapitzin 1989: 345.

Female. Body length, including ovipositor about 0.8 mm. Frontovertex pale orange; pale brown in ocellar area, yellow between occipital margin and posterior ocelli; immaculate from occiput to base of mandible; rest of head, except occiput, white; antenna (Fig. 48) with radicle brown-yellow; scape with both faces blackish, only extreme apex and extreme distal yellow, dorsal margin pale black; pedicel dark brown in proximal half, otherwise white; F1–F4 dark brown, F5–F6 white, clava dark brown, becoming paler towards apex, apex paler brown; occiput with a large dark brown area above foramen, rest white; neck of pronotum dark brown, posterior margin translucent white, lateral spots relatively large and distinct, rest white; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered pale brown; setae translucent orange, silvery in most lights; tegula white with apex pale grey-brown; metanotum orange; mesopleuron pale yellow; prosternum and mesosternum pale yellow; legs (Figs 54–56) mainly pale yellow and mid tibia with a faint brown marking; fore wing (Fig. 53) hyaline and with linea calva interrupted, venation yellow-brown; hind wing hyaline; propodeum medially orange; gaster mostly orange but brown dorsally from cercal plates to near apex, ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 50°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex not parallel-sided, becoming slightly broader anteriorly from the narrowest point which is slightly in front of posterior ocelli; scrobes shallow and U-shaped; antenna with scape about 2.3× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger but transverse, F6 largest, linear sensilla only on F5 and F6; clava 3-segmented, its apex



Figures 48–57. *Metaphycus ericeri* Trjapitzin Female: **48** antenna **49** mandible **50** palpal formula **53** fore wing **54** fore leg **55** mid leg **56** hind leg **57** ovipositor. Male: **51** antenna **52** genitalia.

more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth (Fig. 49); palpal formula 2-2 (Fig. 50), thorax dorsally with notaular lines present only anteriorly; fore wing venation and setation as in Fig. 53; ovipositor (Fig. 57) hardly exserted, about 5.4× as long as ovipositor sheath.

Relative measurements: HW 14, FV 4, FVL 9, POL 2, AOL 3, OOL 1, OCL 1, POD 1, AOD 1, EL 8, EW 6, MS 5, SL 7, SW 3, FWL 36, FWW 15, HWL 24, HWW 5, OL 8, GL 1.5, MT 13.

Male. Length 0.65–0.70mm, almost identical to female but for genitalia and antenna, coloration of gaster. Pedicel white and with clava relatively more slender and solid, funicle brown (Fig. 51); genitalia (Fig. 52) with digitus long and slender apically with two hooks; aedeagus sharply pointed at apex.

Distribution. China (Liaoning), Russia.

Host. *Ericerus pela*.

Material examined. China: 3 ♀♀, 6 ♂♂, Liaoning, Xiuyan, 2010.VI, Coll. Y. Q. Xi (IZCAS); 2 ♀♀, 1 ♂, Liaoning, Shenyang, 2009.VI.12, Coll. Y. Q. Xi (IZCAS).

Diagnosis. Scape about 2.3× as long as broad; legs mainly pale yellow and mid tibia with a faint brown marking; gaster mostly orange but brown dorsally from cercal plates to near apex, ovipositor sheath yellow; ovipositor about 5.4× as long as ovipositor sheath.

This species is similar to *M. helvolus* in appearance. It can be separated from *M. helvolus* as follows: dorsal margin of scape pale black; linear sensilla on F5 and F6 (in *helvolus* dorsal margin of scape yellowish, linear sensilla absent on F5), head is about 3.5× as broad as frontovertex, the ovipositor about 0.6× as long as mid tibia (in *helvolus* head about 3× as broad as frontovertex, and the ovipositor about as long as mid tibia).

Metaphycus nadius (Walker, 1838)

http://species-id.net/wiki/Metaphycus_nadius
Figs 58–62

Encyrtus nadius Walker, 1838: 423. Lectotype ♀ (BMNH, examined), designated by Bouček and Graham (1978: 230), England.

Encyrtus syllaeus Walker, 1838b: 426. Lectotype ♂ (designated by Bouček and Graham 1978: 230), England, BMNH, examined. Synonymized by Guerrieri and Noyes 2000: 158.

Aphycus pinicola Mercet, 1917: 135. Lectotype ♀ (designated by Noyes 1981: 168), Spain, IEEM. Synonymized with *nadius* by Guerrieri and Noyes 2000: 158.

Aphycus (*Euaphycus*) *pinicola* Mercet; Mercet 1921: 205.

Euaphycus intermedius Mercet, 1925: 24. Synonymized with *nadius* by Guerrieri and Noyes 2000: 158.

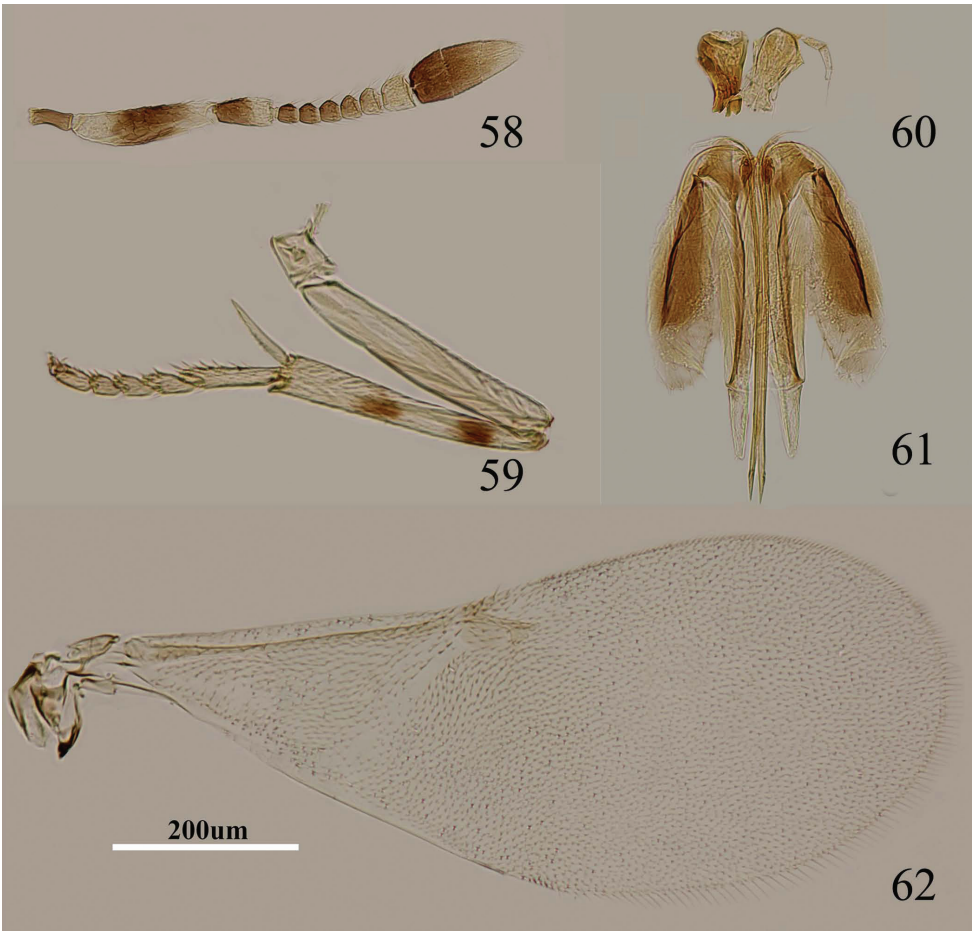
Euaphycus callunae Alam, 1957: 433. Holotype ♀, England, BMNH. Synonymized with *nadius* by Guerrieri and Noyes 2000: 158.

Euaphycus duplus Chumakova, 1961: 324. Synonymized with *nadius* by Guerrieri and Noyes 2000: 158.
Metaphycus intermedius (Mercet): Trjapitzin 1975: 8.
Metaphycus callunae (Alam); Trjapitzin 1975: 13.
Metaphycus pinicola (Mercet); Trjapitzin 1975: 14.
Metaphycus duplus (Chumakova); Trjapitzin 1975: 14.
Metaphycus nadius; Bouček and Graham 1978: 230; Trjapitzin 1989: 246; Li and Xu 2006: 112–113.
Metaphycus syllaeus (Walker); Bouček and Graham 1978: 230.

Female. Body length, including ovipositor, 0.7–0.8mm. Frontovertex dark orange; brown in ocellar area, brown between occipital margin and posterior ocelli; dark brown from occiput to base of mandible; mouth margin narrowly dark brown below torulus; rest of head, except occiput, brown; antenna (Fig. 58) with radicle dark brown; scape with both faces dark brown and base of scape white; pedicel in proximal half dark brown, distal half white, dark brown area extending slightly towards apex externally and internally; F1–F4 pale brown, F5–F6 white, clava dark brown, becoming slightly paler towards apex, apex paler brown; occiput with a large dark brown area above foramen; neck of pronotum black, posterior margin translucent brown; dorsum of thorax dark brown; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; setae translucent pale brown, silvery in most lights; tegula pale brown with apex pale darker; metanotum dark brown; mesopleuron pale brown; prosternum and mesosternum brown; legs (Fig. 59) mainly pale yellow but tibiae at knees narrowly dark brown and each with a pair of dark brown rings at about 0.2× and 0.5× (fore tibia at about 0.5×); fore wing (Fig. 62) hyaline with a small infuscate area beneath stigmal vein, and with linea calva interrupted; venation yellow-brown; hind wing hyaline; propodeum dark brown; gaster dorsally and venter dark brown, sides very pale brown to white; ovipositor sheath pale brown.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 45°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; eye margins subparallel; scrobes shallow and U-shaped; antenna with scape about 4.5× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger but transverse, F6 largest and quadrate; linear sensilla only on F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad, with three subequal, apical teeth; palpal formula 2-2 (Fig. 60), gaster with ovipositor slightly exserted, notaular lines reaching about 0.7× across mesoscutum; fore wing venation and setation as in Fig. 62; ovipositor (Fig. 61) clearly exserted, about 4.3× as long as ovipositor sheath.

Relative measurements: HW 12, FV 3, FVL 4, POL 1.5, AOL 2, OOL 1, OCL 0.5, POD 1, AOD 1, EL 9, EW 5, MS 3, SL 6, SW 2, FWL 32, FWW 15, HWL 22, HWW 4, OL 11, GL 2.5, MT 10.



Figures 58–62. *Metaphycus nadius* (Walker) Female: **58** antenna **59** mid leg **60** palpal formula **61** ovipositor **62** fore wing.

Male. Almost identical to female in general structure, habitus and coloration except for solid clava, genitalia.

Hosts. *Asterolecanium* sp.; *Asterolecanium minus*; *Chionaspis pinifoliae*; *Diaspidiotus bavaricus*; *D. gigas*; *D. zonatus*; *Phenacaspis pinifoliae*; *Quadraspidiotus bavaricus*; *Quadraspidiotus gigas*; *Quadraspidiotus perniciosus*; *Quadraspidiotus zonatus*; *Sphaerolecanium prunastri*.

Distribution. China (Heilongjiang, Inner Mongolia, Qinghai); Croatia, Czech Republic, England, Finland, France, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Wales, Russia, Slovakia, Spain, United Kingdom.

Material examined. China: 1♀, Inner Mongolia: Darhan Maomingan Allied county, 1979.VIII.1 (IZCAS); 7♀♀, 13♂♂, Qinghai Geermu, 2007.VII.4–5 (IZCAS), England: 1♀, 1985, Coll. S. M. Alam (BMNH); 1♀, Richmond Park, Surrey, 1996.VII.18, Coll. J. Noyes (BMNH).

Diagnosis. Antenna with radicle dark brown; scape with both faces dark brown and base of scape white; scape about 4.5× as long as broad; legs mainly pale yellow but tibiae at knees narrowly dark brown and each with a pair of dark brown rings at about 0.2× and 0.5× (fore tibia at about 0.5×); fore wing hyaline with a small infuscate area beneath stigmal vein. The female of *M. nadius* can be identified reliably from other Chinese species in this group by the brown mark under the stigmal vein and the two rings on the mid tibia, antenna with linear sensilla on F6 and clava only. According to Guerrieri and Noyes (2000), it is also similar to *M. hubai*, both with a small infuscate area below marginal and stigma veins.

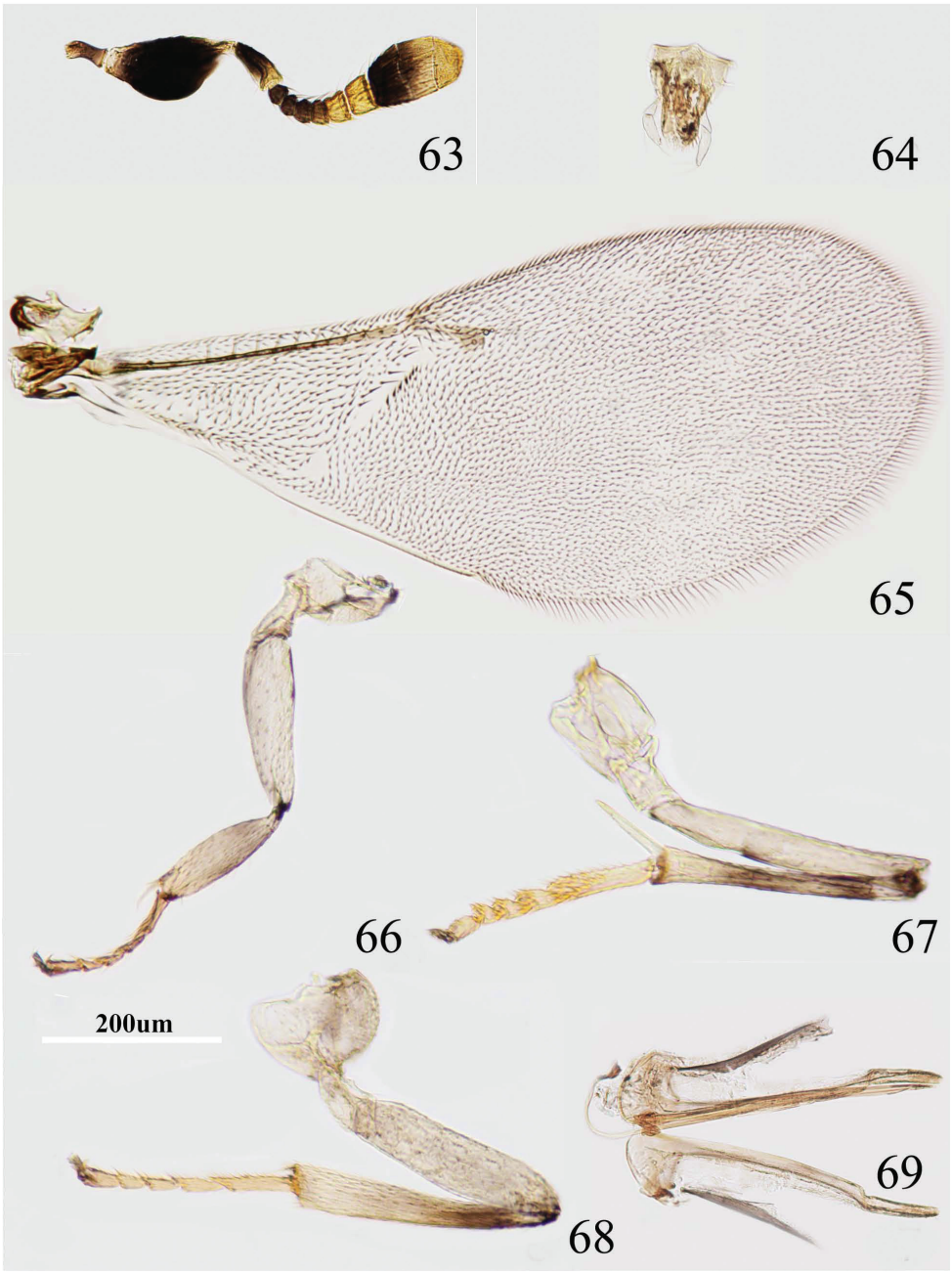
***Metaphycus fusiscapus* sp. n.**
urn:lsid:zoobank.org:act:A309BC1D-C062-460D-B0CA-5BDB716D77F2
http://species-id.net/wiki/Metaphycus_fusiscapus
Figs 63–69

Holotype. ♀, China, Sichuan, Chengdu: 2012.VI.30, ex. *Ceroplastes floridensis*, coll. J. Deng (IZCAS).

Paratypes. 3♀♀, same as holotype. 1 ♀, Fujian, Shaowu, 2012.IV.17, ex. *Ceroplastes floridensis*, coll. A. K. Deng (IZCAS).

Female: Body length, including ovipositor, 0.9–1mm. Frontovertex orange; very pale brown in ocellar area, pale brown between occipital margin and posterior ocelli; gena with brown-grey; mouth margin narrowly pale brown below torulus; rest of head, except occiput, white; antenna (Fig. 63) with radicle dark brown; scape with both faces black, dorsal margin black, extreme apex white; pedicel in proximal four fifths dark brown, distal one fifth white, dark brown area extending slightly towards apex externally and internally; F1–F3 dark brown, F4 pale brown to pale yellow, F5–F6 white, clava proximal half dark brown, becoming white towards apex; neck of pronotum dark brown, posterior margin translucent brown, lateral spots relatively large and distinct, rest white; dorsum of thorax dark orange; sides and posterior margin of mesoscutum and axillae inconspicuously bordered brown; scutellum slightly darker in center; setae translucent pale brown, silvery in most lights; tegula white with apex brown; metanotum black; mesopleuron white; prosternum and mesosternum pale brown; legs (Figs 66–68) with insides white, and outsides very pale brown, coxae white, but tibiae at knees narrowly dark brown and fore tibia with faint brown rings, mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×; fore wing (Fig. 65) hyaline and venation brown; hind wing hyaline, and with linea calva interrupted; propodeum medially black, laterally white; gaster dorsally black, sides and venter white; ovipositor sheath pale brown.

Head ocelli forming an angle of about 40°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex parallel-sided; scrobes shallow and U-shaped; antenna (Fig. 63) with scape about 2× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger, F6 largest and quadrate;



Figures 63–69. *Metaphycus fusiscapus* sp. n. Female: **63** antenna **64** palpal formula **65** fore wing **66** fore leg **67** mid leg **68** hind leg **69** ovipositor.

linear sensilla only on F5 and F6; clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 64). notaular lines reaching about 0.5× across

mesoscutum; fore wing venation and setation as in Fig. 65; ovipositor (Fig. 69) hardly exserted, about 4.1× as long as ovipositor sheath.

Relative measurements: HW 11, FV 4, FVL 6, POL 2, AOL 2.5, OOL 1, OCL 1, POD 1, AOD 1, EL 7, EW 5, MS 3, SL 6, SW 3, FWL 40, FWW 15**,** HWL 22, HWW 6, OL 14, GL 3.5, MT 12.

Male. Unknown.

Host. *Ceroplastes floridensis*.

Distribution. China (Sichuan, Fujian).

Etymology. This specific epither of this new species is referring to the dark brown scape.

Diagnosis. Scape with both faces black, dorsal margin black, extreme apex white, and about 2× as long as broad; legs (Figs 66–68) with inner sides white, and outer sides very pale brown, coxae white, but tibiae at knees narrowly dark brown and fore tibia with faint brown rings, mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×; ovipositor hardly exserted, about 4.1× as long as ovipositor sheath.

Using the key of Guerrieri and Noyes (2000), *M. fusiscapus* runs to *M. pretiosus* (key couplet 8), but can be separated from the latter by scape about 2× as long as broad and head 4.1× as broad as frontovertx (in *pretiosus*, scape about 4× as long as broad, head 3× as broad as frontovertex). Using the key of Zeya and Hayat (1993), this species goes to *M. agarwali*. Both of these two species having two dark bands on mid tibiae and scape about 2× as long as broad. It can be separated from *M. agarwali* as follows: dorsal margin of scape black only base apex white, F1–F4 subequal and F5 distinctly larger (in *M. agarwali*, scape dorsal margin white, and F1–F5 subequal). Both of the two species are distributed in Asia, perhaps they are closely related. In China, *M. fusiscapus* is very similar to *M. wui* (see comments under *M. wui*).

***Metaphycus fusiformis* sp. n.**

urn:lsid:zoobank.org:act:7199B2CC-9C8B-4DB7-8680-CE252E87C303

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

Figs 70–76

Holotype. 1♀, China, Shanxi, Li Mt.: 2006.VIII.1, Coll. D. Liu (IZCAS).

Paratypes. 1♀, Beijing, Mentougou, 2011.VIII.30 (IZCAS); 2♀♀, Beijing, Changping, 2009.VIII.7, Coll. F. Yuan (IZCAS), 2♀♀, Beijing, Changping, 2009. VIII.7, Coll. Q. T. Wu (IZCAS), 1♀, Hainan, Danzhou, 2005.I, Coll. T. X Zhang (IZCAS); 1♀, Hainan, Danzhou, 2007.V.16, Coll. Y. Z. Zhang (IZCAS).

Female: Body length, including ovipositor about 0.8–0.9mm. Frontovertex orange; orange in ocellar area, very pale brown to orange between occipital margin and posterior ocelli; gena with a fairly broad, oblique**,** brown mark from occiput to base of mandible; mouth margin narrowly pale brown below torulus; rest of head, except occiput, white; antenna (Fig. 70) with radicle dark brown; scape with both faces dark brown, blackish, dorsal margin narrowly pale yellow, extreme apex white; pedicel base

at most two thirds dark brown, white distally, dark brown area extending slightly towards apex externally and internally; F1–F3 dark brown, F4 brown, F5–F6 white-yellow, clava in proximal 2/3 dark brown, becoming slightly paler towards apex, apex yellow; occiput with a large dark brown area above foramen, rest pale yellow; neck of pronotum dark brown, posterior margin translucent yellow, lateral spots relatively large and distinct, rest orange; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae conspicuously bordered brown; setae translucent pale brown, silvery in most lights; tegula white with apex pale grey-brown; metanotum brown; mesopleuron pale yellow; prosternum yellow and mesosternum white; legs (Fig. 73–75) mainly white but tibiae at knees narrowly dark brown and mid and hind tibiae with a pair of dark brown rings at about 0.2× and 0.5×; fore wing (Fig. 72) hyaline, a faintly infuscate area below marginal and stigmal veins, and with linea calva interrupted, venation yellow-brown; hind wing hyaline; propodeum medially brown, laterally white; gaster mostly brown but dark brown dorsally from cercal plates to near apex, sides and venter white**;** ovipositor sheath yellow.

Head with polygonally reticulate sculpture and mesh size slightly less than that of one eye facet; ocelli forming an angle of about 35°; eye not quite reaching occipital margin, separated by much less than diameter of a facet; frontovertex subparallel-sided; scrobes shallow and U-shaped; antenna (Fig. 70) with scape about 2.4× as long as broad; funicle with F1–F4 smallest, subequal and transverse, F5 a little larger but transverse, F6 largest and quadrate, linear sensilla only on F6, clava 3-segmented, its apex more or less rounded but with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 71); notaular lines reaching about 0.6× across mesoscutum; fore wing venation and setation as in Fig. 72; ovipositor (Fig. 76) slightly exserted, about 5.2× as long as ovipositor sheath, second valvifer without subapical setae.

Relative measurements: HW 14, FV 4, FVL 8, POL 1.5, AOL 3, OOL 1, OCL 1, POD 1, AOD 1, EL 8, EW 6.5, MS 4, SL 6, SW 2.5, FWL 35, FWW 14, OL 10, GL 2, MT 11.

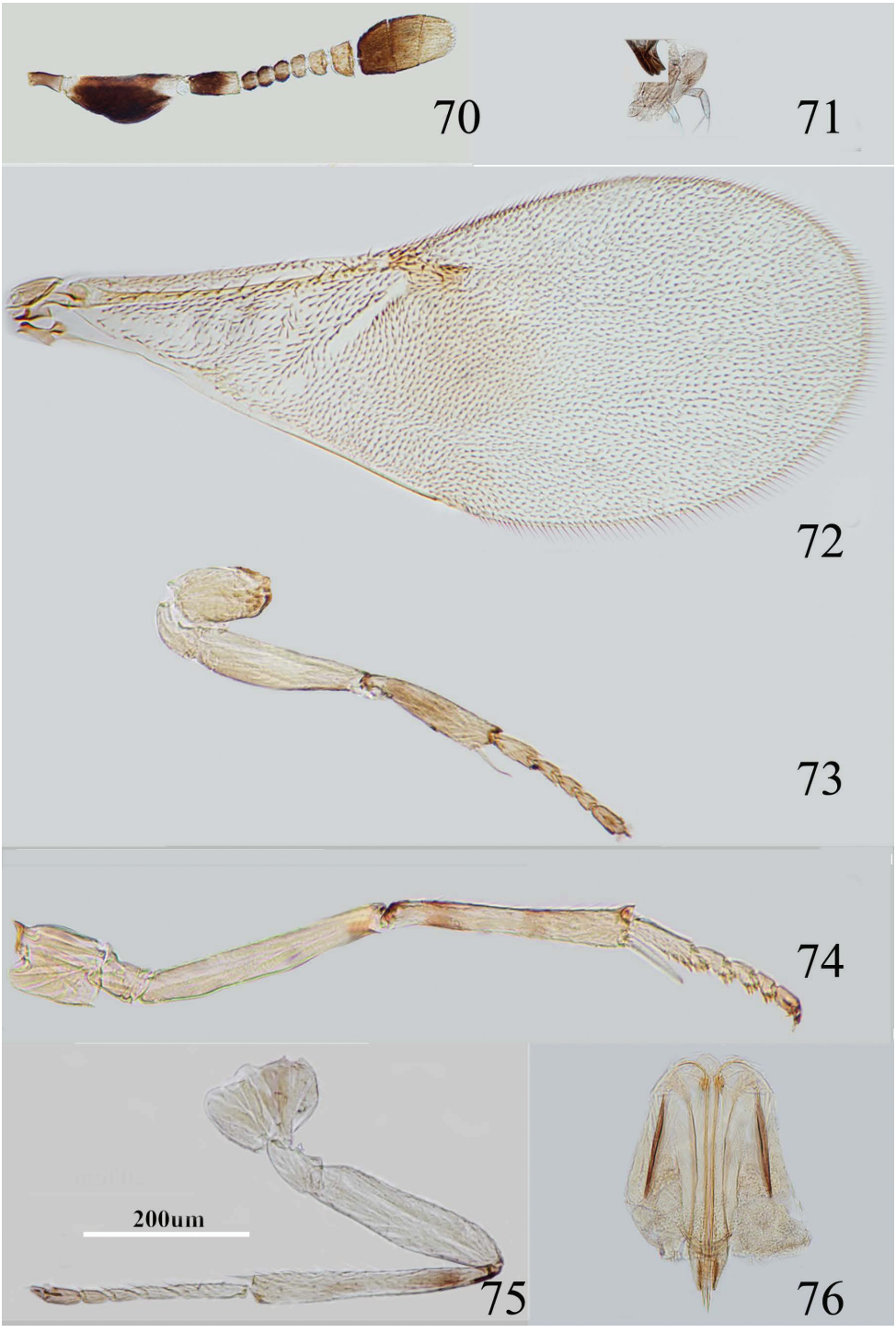
Male. Unknown.

Host. Unknown.

Distribution. China (Beijing, Hainan, Shanxi).

Etymology. The species name 'fusiformis' is derived from the infuscate area of the fore wing.

Diagnosis. Scape with both faces dark brown, blackish, dorsal margin narrowly pale yellow, extreme apex white and about 2.4× as long as broad; fore wing (Fig. 72) hyaline, a faintly infuscate area below marginal and stigmal veins. Using the key of Guerrieri and Noyes (2000), this species runs to couplet 10 and is similar to *M. ibericus* in having a uniformly weakly infuscate fore wing. It can be separated from the latter as follows: dorsal margin of scape pale orange, not marked brown medially and 2.4× as long as broad (in *ibericus*, dorsal margin of scpae marked brown medially and 3× as long as broad); ovipositor about as long as mid tibia (in *ibericus* with ovipositor about 0.8× as long as mid tibia).



Figures 70–76. *Metaphycus fusiformis* sp. n. Female: **70** antenna **71** palpal formula **72** fore wing **73** fore leg **74** mid leg **75** hind leg **76** ovipositor.

***Metaphycus xujiangi* Özdikmen, 2011**
http://species-id.net/wiki/Metaphycus_xujiangi
Figs 77–83

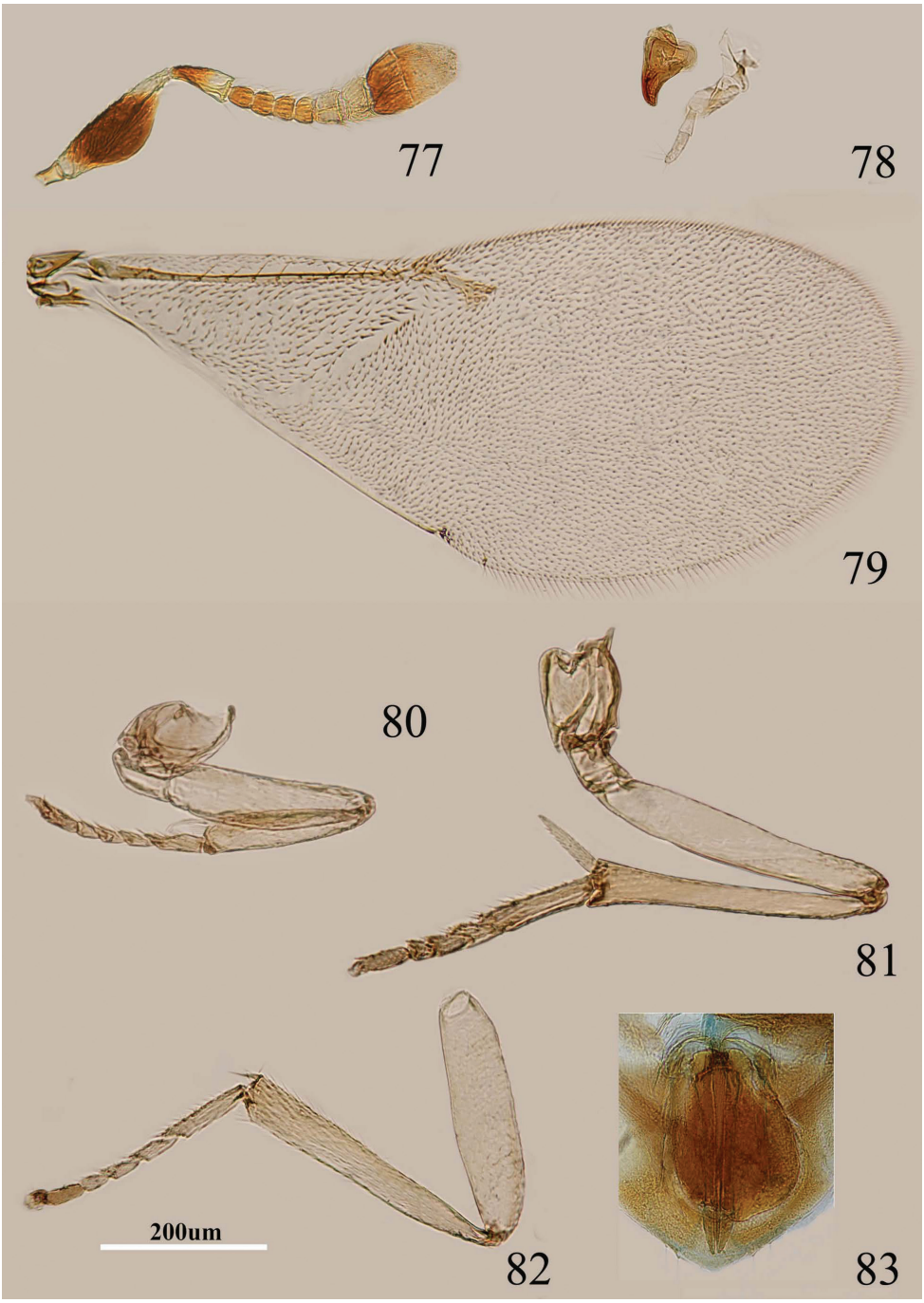
Metaphycus tamakatakaigara Jiang 1982: 7: 182; Jiang 1986: (3):14. Misidentified.
Metaphycus ericeri Xu & Jiang 1990: 203. Holotype ♀, China, ZJU & SCU; Jiao and Zhao 1999: 166-171.
Metaphycus xujiangi Özdikmen, 2011: 802. Replacement name for *Metaphycus ericeri* Xu & Jiang nec Trjapitzin (1967).

Female. Body length, including ovipositor about 1.1mm. Frontovertex orange to dark orange; orange in ocellar area, orange between occipital margin and posterior ocelli; immaculate from occiput to base of mandible; rest of head, except occiput, yellow-white; antenna (Fig. 77) with radicle yellow; scape with both faces blackish, only extreme apex and extreme distal yellow, dorsal margin black; pedicel dark brown in proximal half and apex white; F1–F4 brown, F5–F6 white, clava dark brown, becoming paler towards apex, apex white; occiput with dark brown area above occipital foramen, rest white; neck of pronotum dark brown, posterior margin translucent white, lateral spots relatively small and undistinct, rest white; dorsum of thorax orange; sides and posterior margin of mesoscutum and axillae bordered brown; setae translucent yellow, silvery in most lights; tegula white; metanotum pale brown; mesopleuron yellow; prosternum and mesosternum pale yellow; legs (Figs 80–82) mainly pale yellow; fore wing (Fig. 79) hyaline, and with linea calva interrupted, venation dark yellow; hind wing hyaline; propodeum medially dark orange; gaster dorsally pale brown, becoming paler towards apex, side and venter white; ovipositor sheath yellow.

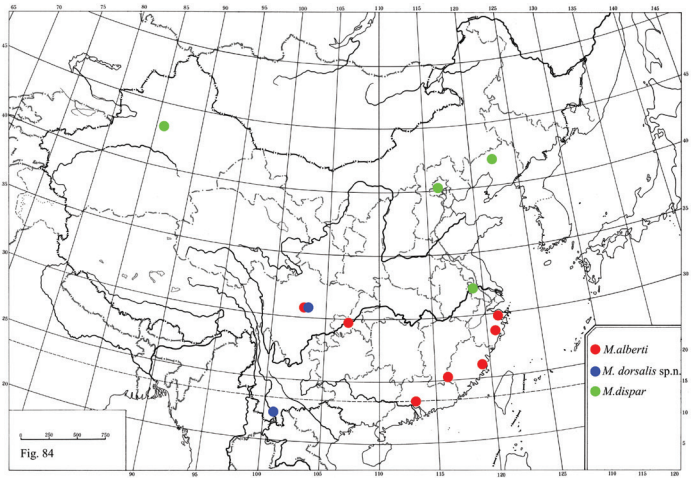
Ocelli forming an angle of about 50°; eye not quite reaching occipital margin, separated by much less than diameter of one facet; frontovertex subparallel-sided, becoming slightly broader anteriorly from the narrowest point which is slightly in front of posterior ocelli; scrobes shallow and U-shaped; antenna with scape about 2–2.5× as long as broad; funicle with F1–F4 smallest, subequal, F4 transverse, F5 a little larger but transverse, F6 largest; clava 3-segmented, its apex more or less rounded and with a short slightly oblique truncation; mandible relatively broad with three subequal, apical teeth; palpal formula 2-2 (Fig. 78), notaular lines reaching about 0.6× across mesoscutum; fore wing venation and setation as in Fig. 79; ovipositor (Fig. 83) hardly exserted, length about 5.4× as long as ovipositor sheath.

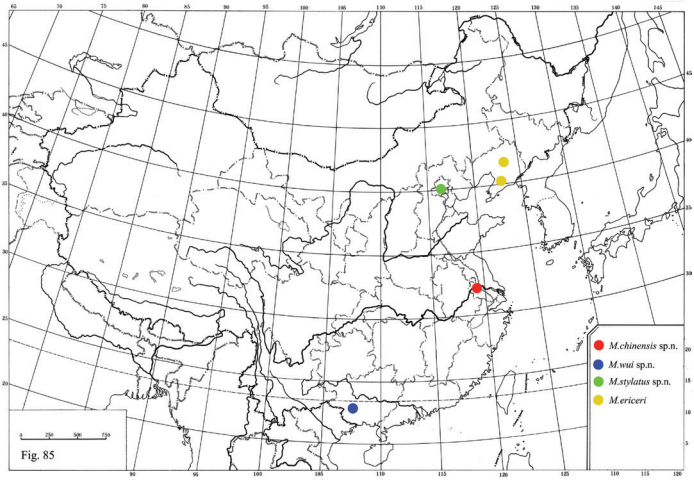
Relative measurements: HW 15.5, FV 3, FVL 7, POL 2, AOL 3, OOL 1, OCL 1, POD 2, AOD 2, EL 9, EW 6, MS 4, SL 7, SW 3, FWL 45, FWW 21, HWL 30, HWW 6, OL 11, GL 2, MT 15.

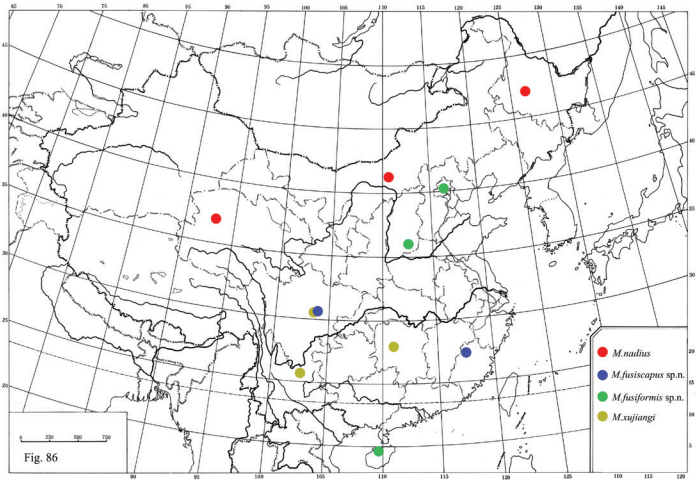
Male. (length 0.8–1.33mm). Thorax black-brown, ocellar area black-brown, antenna yellow-brown, clava solid and as long as F3 to F6. Digitus of genitalia apically with two hooks; aedeagus robust, length about 3× as long as broad. (Xu and Jiang 1990).



Figures 77–83. *Metaphycus xujiangi* Özdikmen. Female: **77** antenna **78** palpal formula and mandible **79** fore wing **80** fore leg **81** mid leg **82** hind leg **83** ovipositor.







Figures 84–86. Distribution of *Metaphycus* spp. in China.

Host. *Ericerus pela*.

Distribution. China (Hunan, Sichuan, Yunnan).

Material examined. China: 9♀♀, Sichuan, E'mei Mt., 1963.X, Coll. D. X Liao (IZCAS).

Diagnosis. Antenna with radicle yellow; scape with both faces blackish, only extreme apex and extreme distal yellow, dorsal margin black, scape about 2–2.5× as long as broad; ovipositor hardly exserted, length about 5.4× as long as ovipositor sheath. Jiang (1982) misidentified this species as *M. tamakatakaigara*, and Xu and Jiang 1990 described it as a new species. *Metaphycus xujiangi* is very similar to *M. ericeri*. It can be separated from *M. ericeri* as follows: head is about 5× as broad as frontovertex, POD=POL and the ovipositor about 0.7× as long as mid tibia (in *M. ericeri*, the head is about 3.5× as broad as frontovertex, 2POD=POL and the ovipositor about 0.6× as long as mid tibia).

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A new genus for a rare African vespertilionid bat: insights from South Sudan

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Abstract

A new genus is proposed for the strikingly patterned African vespertilionid "*Glauconycteris" superba* Hayman, 1939 on the basis of cranial and external morphological comparisons. A review of the attributes of a newly collected specimen from South Sudan (a new country record) and other museum specimens of "*G." superba* suggests that "*G." superba* is markedly distinct ecomorphologically from other species classified in *Glauconycteris* and is likely the sister taxon to *Glauconycteris sensu stricto.* The recent capture of this rarely collected but widespread bat highlights the need for continued research in tropical sub-Saharan Africa and in particular, for more work in western South Sudan, which has received very little scientific attention. New country records for *G.* cf. *poensis* (South Sudan) and *G. curryae* (Gabon) are also reported.

Keywords
Glauconycteris superba, *Glauconycteris poensis, Glauconycteris curryae, Niumbaha* gen. nov., Badger Bat, South Sudan, Description

Introduction

In 1939 Hayman described a new vespertilionid bat from the Belgian Congo (now Democratic Republic of the Congo), noting that it was "one of the most striking discoveries of recent years" (Hayman 1939). He placed this species in the genus *Glauconycteris* Dobson, 1875, aptly erecting the specific name *superba* for its spectacularly bold black and white color pattern. Since that time, only a few specimens of this species have been collected. Our capture of a parous female in July 2012 in southwestern South Sudan represents a new country record for this poorly known bat, extending its range eastward. The only species of *Glauconycteris* previously reported from South Sudan is *G. variegata* (Koopman 1975, McLellen 1986).

Glauconycteris, originally described by Dobson (1875) as a subgenus of *Chalinolobus,* is found in Africa south of the Sahara and is currently recognized as having 12 species (Simmons 2005, Rambaldini 2010). Its species are restricted, more or less, to forested tropical areas and savanna woodlands. While one or two species of *Glauconycteris* are widely distributed, many are poorly known and relatively poorly represented in museum collections. *Glauconycteris* bats are characterized by a highly distinctive combination of traits, including variable patterns of spots and stripes on the body, reticulated wings, and an extremely shortened muzzle and toothrow. Within the large family Vespertilionidae, *Glauconycteris* is classified in the subfamily Vespertilioninae, tribe Nycticeiini (Hoofer and Van Den Bussche 2003) and forms a clade with *Lasionycteris*, *Nycticeius*, *Arielulus*, *Eptesticus*, and *Scotomanes* (Roehrs et al. 2011). Hayman (1939) placed *superba* in *Glauconycteris* on the basis of its boldly patterned markings, dental formula, and properties of the incisors (Rosevear 1965; Rambaldini 2010).

Close examination of our 2012 South Sudan specimen relative to other specimens of *G. superba* and of other *Glauconycteris* species indicates that, while this taxon is probably closely related to species of *Glauconycteris,* it lacks many of the most notable specializations of that genus, and we suggest that it is sufficiently and remarkably different from other vespertilionids as to warrant placement in a unique genus.

Materials and methods

Field work was conducted in Bangangai Game Reserve, Western Equatoria State in the new country of South Sudan in July 2012 (Fig. 1). Bats, including the single "*G.*" *superba* specimen described below and two other species of *Glauconycteris,* were captured in single ground-height or triple-high mist-nets and euthanized by isoflurane overdose. Tissue samples (liver and muscle) were collected and flash frozen in liquid

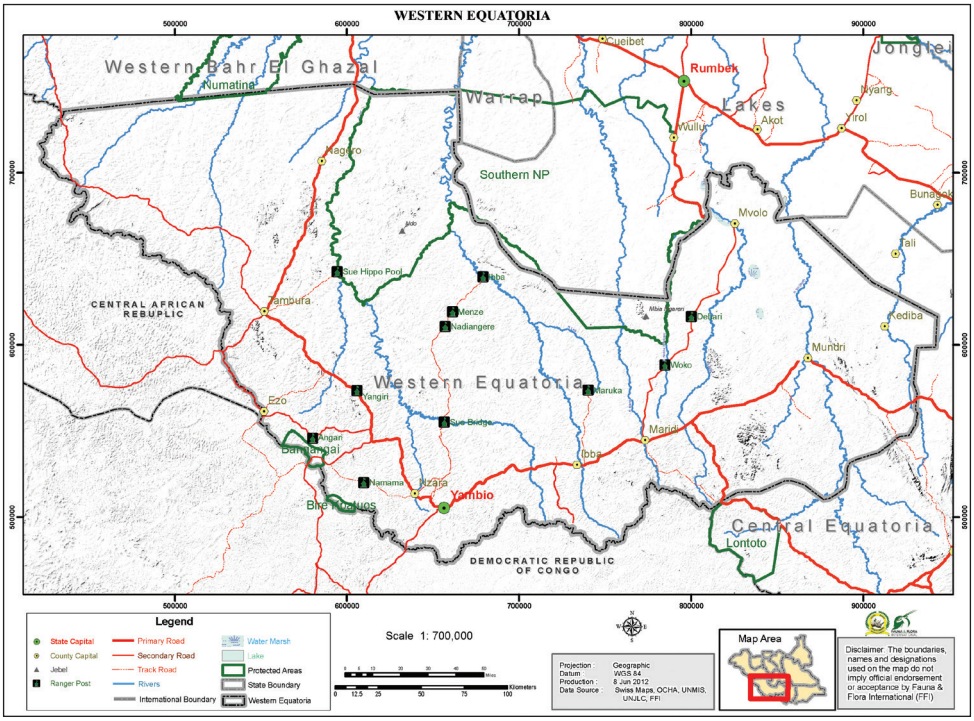

Figure 1. Map of Western Equatoria State, South Sudan. Location of the Bangangai Game Reserve (and the neighboring Bire Kpatuos Game Reserve) and other protected areas shown.

nitrogen. Specimens were either formalin fixed and then transferred to ethanol with skulls extracted or were prepared as skins, skulls, and skeletal material. Field work was approved by the Internal Animal Care and Use Committee of Bucknell University and by the South Sudanese Ministry for Wildlife Conservation and Tourism.

A comparative analysis included data from our 2012 specimens, a few South Sudan specimens from our earlier expeditions, data from the three previously collected specimens of "*G." superba* and data from museum specimens as noted below. Measurements were taken with rulers (ears) or dial calipers (all other measurements). External and osteological characters examined are based largely upon Eger and Schlitter (2001) (see Table 1). Differences in wing-tip length between species of *Glauconycteris* and "*G." superba* were determined with a t-test and both principal components analysis (PCA) and t-tests were performed on cranial and dental data. PCA was performed using the combination of cranial and dental measurements indicated in tables and in the text. All measurement values were transformed to natural logarithms prior to multivariate analysis. Principal components were extracted from a covariance matrix. Variables for multivariate analyses were selected judiciously to maximize sample sizes for comparison by allowing for inclusion of partially broken skulls in some cases. The software programs Statistica 8.0 (Statsoft Inc., Tulsa, Oklahoma, USA) and SPSS Statistics 19.0 @ 2010 (IBM Corporation, Somers, NY, USA) were used for all analytical procedures.

Table 1. Definition of external, craniodental, and mandibular measurements used in this study.

Measurement	Definition
Forearm length (FA)	Distance from the elbow (tip of the olecranon process) to the wrist (including the carpals).
Metacarpal length (ML-III, -IV, -V)	Distance from the joint of the wrist (carpals) with the 3rd metacarpal to the metacarpophalangeal joint of the 3rd digit; same for 4th and 5th digits.
Phalangeal length (1PL, 2PL)	1PL: Distance from the metacarphophalangeal joint of each respective digit (DI, DII, DIII) to the phalangeal joint. 2 PL: Distance from the phalangeal joint to the tip of the bone (cartilage tip not included).
Greatest length of skull (GLS)	Greatest distance from the occiput to the anteriormost point on the premaxilla.
Condyloincisive length (CIL)	Distance between a line connecting the posteriormost margins of the occipital condyles and the anteriormost point on the upper incisors.
Condylocanine length (CCL)	Distance between a line connecting the posteriormost margins of the occipital condyles and the anteriormost surfaces of the upper canines.
Palatal length	Distance from the posterior palatal notch to the anteriormost border of the incisive alveoli.
Zygomatic breadth (ZB)	Greatest breadth across the zygomatic arches.
Mastoid width	Greatest breadth at the mastoid processes.
Breadth of braincase (BBC)	Greatest breadth of the globular part of the braincase, excluding mastoid and paraoccipital processes.
Height of braincase (HBC)	Distance from basisphenoid and basioccipital bones to top of braincase on either side of sagittal crest.
Interorbital width	Distance between orbits measured below lachrymal processes.
Postorbital process width (POP)	Width across postorbital processes.
Postorbital constriction (POC)	Least distance between orbits.
Width across M^3 (M^3-M^3)	Greatest width of palate across labial margins of the alveoli of M^3s.
Maxillary toothrow length (C-M^3)	Distance from anteriormost surace of the upper canine to the posteriormost surface of the crown of M^3.
Width at upper canines (C-C)	Width between labial alveolar borders of upper canines.
Greatest length of mandible	Distance from midpoint of condyle to the anteriormost point of the dentary, including the incisors.
Mandibular toothrow length (c-m_3)	Distance from posterior alveolar border of m_3 to the anterior alveolar border of lower canine.
Height of the upper canine	Greatest height of the upper canine from point immediately dorsal to cingulum to end of tooth (not taken if tooth too worn).
Thickness of the upper canine	Greatest anterior-posterior thickness of the upper canine.
Width M^3 (WM^3)	Greatest lateral-medial width of last tooth (M^3).
Width M^2 (WM^2)	Greatest lateral-medial width of second to last tooth (M^2).
Mid rostrum length (MRL)	Length of a medial line from the inflexion point at the rostrum/braincase to posterior point of emargination in the upper palate.
I-M^2 alv	Length from anterior alveoli of incisors to posterior alveoli of second to last tooth (M^2).

Taxonomy

***Niumbaha* Reeder et al., gen. n.**
urn:lsid:zoobank.org:act:EDF16BEE-0749-41BC-AE19-BAE130BE58F8
http://species-id.net/wiki/Niumbaha
Figures 2–6

Etymology. The name is the Zande word for 'rare/unusual'. This name was chosen because of the rarity of capture for this genus, despite its wide distribution throughout West and Central Africa, and for the unusual and striking appearance of this bat. Zande is the language of the Azande people, who are the primary ethnic group in Western Equatoria State in South Sudan (where our recent specimen was collected). The homeland of the Azande extends westwards into Democratic Republic of the Congo, where *superba* has also been collected (the holotype and another recent capture), and into southeastern Central African Republic. Gender: feminine.

Type species. *Glauconycteris superba* Hayman, 1939; by monotypy.

Diagnosis. Among vespertilionids, *Niumbaha* bears closest comparison with species of *Glauconycteris* (the type species of which is *G. poensis*), to which it is apparently closely related, but it has a considerably larger skull and is more strikingly patterned compared to any member of *Glauconycteris* (its patterning most closely approaching the Asian vespertilionid genus *Scotomanes*). It lacks various of the most exaggeratedly derived traits (specializations) that uniquely unite the species of *Glauconycteris* among African vespertilionids, including the excessively foreshortened rostrum, moderately to highly reduced relative canine size, and very elongate wing tips (second wing phalanxes) of *Glauconycteris* (Rosevear 1965). Externally, *Niumbaha* is immediately distinguished from all other African vespertilionid bats by its distinct coloration pattern, including pale yellow spots and stripes on an otherwise dark black pelage (Fig. 2, Fig. 3, and detailed descriptions below). While Hayman (1939:222) noted that, "in general form *G. superba* does not differ from other *Glauconycteris*," we find that most external features are in fact different from *Glauconycteris sensu stricto*. The ears of *Niumbaha* are more robust and subquadrangular, contain a larger free lobe at the inner margin, and contain a more strongly curved tragus than *Glauconycteris* (Fig. 3). The muzzle of *Niumbaha* is more robust than *Glauconycteris sensu stricto* and contains nostrils that open more to the front than to the side (Fig. 3). The wingtips in *Niumbaha* are longer than in most other African vespertilionids in that phalanx 2 of the third digit is longer than phalanx 1, yet remain considerably shorter than in the characteristically long-wingtipped *Glauconycteris* (ratio of Ph2/Ph1 in *Niumbaha*, at 1.15 ± 0.05 SD, is significantly shorter than *Glauconycteris*, at 1.51 ± 0.12 SD; Fig. 4). *Niumbaha* shares its dental formula with *Glauconycteris*, at 2.1.1.3/3.1.2.3 = 32, but is overall significantly larger than species of *Glauconycteris* in all characters, with a total skull length of greater than 16.0 mm (Table 2; Fig. 5). While the rostrum of *Glauconycteris* is short and generally rises in an even plane from the incisors to the occiput, the frontal region of the skull in *Niumbaha* is excavated or 'hollowed out', with the upper surface of the

Figure 2. Photographs of *Niumbaha superba* live and as a freshly prepared specimen. Top photos show profile and anterior view, with ventral and dorsal images below.

longer rostrum largely flat and roughly parallel to the upper toothrows (see Fig. 5). Additionally, the skull is relatively less broad and less domed and more elongate than in *Glauconycteris* (indicated by ratios of the mastoid width, breadth of the braincase,

height of the braincase, and zygomatic breadth to the greatest length of the skull (Table 2)), although the anterior portion of the rostrum is relatively broader (indicated by the ratio of the width at the upper canines to the width at the last molar (M^3-M^3)).

Material examined. The collection of a new specimen of *N. superba* in South Sudan (USNM 586592) in July 2012 allowed for the examination of a live bat and for the preservation of an intact specimen in fluid. This bat was captured in a single-high ground-level mist net next to a stagnant pool of water on a rocky grasslands plateau. This plateau, located at 04°52.643'N, 027°40.557'E (elevation ~ 720 m) is surrounded by secondary thicket forest and is within the boundaries of Bangangai Game Reserve, Ezo County, Western Equatoria State. Data for previously collected specimens of *N. superba* were taken from Hayman (1939, 1947) and from Randolph L. Peterson's notes, provided by Judith Eger at the Royal Ontario Museum. An additional specimen was recently collected in the Democratic Republic of the Congo and reported by Gembu Tungaluna (2012).

Data for *N. superba* were compared to those of various species of *Glauconycteris,* as summarized in Table 2. Additionally, for the wingtip analysis, comparisons with other, more 'typical' West African vespertilionids of similar size to *N. superba* (*Scotophilus leucogaster* and *S. viridis*) were made. Species/specimens examined: *G. alboguttata* J. A. Allen, 1917 (2): Cameroon (AMNH 236329, USNM 598588); *G. argentata* (Dobson, 1875) (14): Cameroon (AMNH 23624, AMNH 23625, AMNH 23627, AMNH 23628), Democratic Republic of the Congo (AMNH 120328, AMNH 120332, USNM 535398), Kenya (USNM 268759), Tanzania (AMNH 55545, AMNH 55546, AMNH 55548, USNM 297476, USNM 297477, USNM 297478); *G. beatrix* Thomas, 1901 (4): Cameroon (USNM 511928, USNM 511929), Gabon (USNM 584723), Ghana (USNM 420078); *G. curryae* Eger and Schlitter, 2001 (1): Gabon (USNM 584724); *G. humeralis* J.A. Allen, 1917 (3): Democratic Republic of the Congo (AMNH 49014, AMNH 49312, AMNH 49315); *G. poensis* (Gray, 1842) (12): Ivory Coast (USNM 429953, USNM 429954, USNM 429955, USNM 468192), Ghana (USNM 479528, USNM 479529, USNM 479530, USNM 479531, USNM 479533), Nigeria (AMNH 273244), Togo (USNM 437777, USNM 437778); *G.* cf. *poensis* (6): South Sudan (new country record) (USNM 586596, USNM 586597, USNM 586598, USNM 586599, USNM 586600, USNM 586601), *G. variegata* (Tomes, 1861) (27): Benin (USNM 421480, USNM 421481), Botswana (USNM 518696, USNM 518697), Democratic Republic of the Congo (AMNH 49060, AMNH 49061, AMNH 49062, AMNH 49063, AMNH 49066, AMNH 49067, AMNH 49068, AMNH 49070, AMNH 49195, AMNH 49313), Ghana (USNM 420077, USNM 424900), Kenya (AMNH 238490), Mozambique (USNM 304844), Nigeria (USNM 378863, USNM 378864, USNM 378865), South Africa (AMNH 257397), South Sudan (USNM 586593, USNM 586594, USNM 586595, USNM 590905), Uganda (AMNH 184228); *N. superba* (Hayman, 1939) (4): Democratic Republic of the Congo (RMCA 14.765), Ivory Coast (RMCA A9363), Ghana (BMNH 47.10), South Sudan (USNM 586592); *S. leucogaster* (Cretzschmar, 1830) (8): Benin (USNM 421421, USNM 421424, USNM 421425), Burkina Faso (USNM

Table 2. Selected measurements (in mm) of *Niumbaha superba* and several *Glauconycteris* and *Scotophilus* species. Summary statistics (mean and standard deviation), observed range and sample size of measurements are given for each species. See Table 1 for definition of measurement abbreviations and see methods for list of specimens examined.

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
ML-III											
$\bar{X} \pm SD$	44.7 ± 2.3	39.8	41.7 ± 0.7	37.8 ± 1.9	35.0	-	38.4 ± 1.3	42.3 ± 1.1	42.3 ± 1.3	50.8 ± 1.4	46.8 ± 2.5
Min-max	42.0–47.4	-	40.8–42.3	35.2–39.6	-	-	36.4–39.6	40.8–44.3	40.5–44.1	48.6–52.4	41.5–50.1
n	4	1	4	4	1	-	5	5	8	8	9
DIII-1PL											
$\bar{X} \pm SD$	20.4 ± 1.3	16.0	15.6 ± 0.6	13.4 ± 0.9	13.6	-	13.9 ± 0.9	15.6 ± 0.7	16.6 ± 0.6	18.6 ± 0.5	17.1 ± 1.1
Min-max	18.7–22.0	-	15.0–16.3	12.3–14.5	-	-	12.9–15.2	14.9–16.7	15.7–17.4	18.1–19.6	15.7–19.2
n	4	1	4	4	1	-	5	5	8	8	9
DIII-2PL											
$\bar{X} \pm SD$	23.4 ± 1.1	22.0	25.7 ± 0.6	21.3 ± 1.6	19.5	-	21.3 ± 1.0	24.1 ± 0.8	22.8 ± 1.4	14.6 ± 0.8	13.9 ± 1.2
Min-max	22.4–24.3	-	24.8–26.2	19.7–22.9	-	-	20.1–22.9	22.5–25.6	20.7–24.5	13.4–15.5	11.9–15.7
n	4	1	4	4	1	-	5	5	8	8	9
ML-IV											
$\bar{X} \pm SD$	43.4 ± 2.5	35.8	39.1 ± 1.1	34.1 ± 1.8	32.5	-	34.9 ± 1.1	39.3 ± 1.4	40.8 ± 1.3	48.9 ± 1.6	45.6 ± 2.3
Min-max	40.6–46.4	-	37.7–40.3	31.6–36.0	-	-	33.6–36.4	37.0–41.8	39.4–42.5	46.4–50.6	41.4–48.9
n	4	1	4	4	1	-	5	5	8	8	9
DIV-1PL											
$\bar{X} \pm SD$	13.5 ± 1.2	11.8	11.7 ± 0.4	10.1 ± 0.7	8.8	-	11.1 ± 0.4	11.6 ± 0.7	12.7 ± 0.9	13.7 ± 1.1	13.5 ± 1.0
Min-max	12.2–15.0	-	11.4–12.1	9.1–10.8	-	-	10.5–11.4	10.8–12.2	11.2–13.9	11.3–15.1	12.1–14.8
n	4	1	4	4	1	-	5	5	8	8	9
DIV-2PL											
$\bar{X} \pm SD$	10.1 ± 0.9	10.8	11.8 ± 0.6	11.5 ± 1.1	12.0	-	10.8 ± 0.9	11.6 ± 0.8	12.3 ± 0.8	10.2 ± 0.3	9.1 ± 0.9
Min-max	9.0–10.8	-	11.2–12.4	10.1–12.6	-	-	9.9–11.9	10.6–12.5	10.9–13.5	9.8–10.7	7.2–10.2
n	4	1	4	4	1	-	4	5	8	8	9

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
ML-V											
$\bar{X}$ ± *SD*	38.8 ± 2.8	31.2	35.5 ± 0.9	32.5 ± 1.2	29.9	-	32.1 ± 0.8	35.5 ± 0.8	38.6 ± 1.5	47.1 ± 1.6	42.9 ± 1.9
Min-max	35.5–42.0	-	34.3–36.3	31.3–34.2	-	-	30.6–32.8	33.7–37.0	36.1–40.4	43.9–49.4	39.5–45.8
n	4	1	4	4	1	-	5	5	8	8	9
DV-1PL											
$\bar{X}$ ± *SD*	8.8 ± 1.2	9.6	9.6 ± 0.4	9.4 ± 0.4	8.4	-	9.8 ± 0.5	10.3 ± 1.0	10.6 ± 0.6	10.2 ± 0.9	9.0 ± 0.6
Min-max	7.6–10.4	-	9.2–10.2	8.8–9.7	-	-	9.1–10.3	9.1–11.4	9.7–11.4	8.9–11.6	7.9–9.6
n	4	1	4	4	1	-	5	5	8	8	9
DV-2PL											
$\bar{X}$ ± *SD*	7.5 ± 0.7	7.8	8.7 ± 0.6	7.4 ± 0.5	7.6	-	8.1 ± 0.5	7.8 ± 0.4	8.3 ± 0.9	6.4 ± 0.3	6.4 ± 0.7
Min-max	6.8–8.2	-	8.3–9.5	6.8–7.9	-	-	7.5–8.8	6.7–8.4	7.2–9.8	5.9–6.9	5.7- 7.4
n	4	1	4	4	1	-	5	5	8	8	9
DIII-2PL/1PL											
$\bar{X}$ ± *SD*	1.1 ± 0.1	1.4	1.7 ± 0.1	1.6 ± 0.1	1.4	-	1.5 ± 0.1	1.6 ± 0.1	1.4 ± 0	0.8 ± 0.1	0.8 ± 0.01
Min-max	1.1–1.2	-	1.5–1.7	1.5–1.7	-	-	1.4–1.7	1.5–1.6	1.3–1.4	0.7–0.9	0.7–0.9
n	4	1	4	4	1	-	5	5	8	8	9
DIV-2PL/1PL											
$\bar{X}$ ± *SD*	0.8 ± 0.1	0.9	1.0 ± 0.0	1.1 ± 0.1	1.4	-	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	0.8 ± 0.1	0.7 ± 0.1
Min-max	0.7–0.8	-	1.0–1.1	1.0–1.3	-	-	0.9–1.1	0.9–1.1	0.9–1.1	0.7–0.8	0.6–0.8
n	4	1	4	4	1	-	4	5	8	8	9
GLS											
$\bar{X}$ ± *SD*	16.8 ± 0.6**	13.3	12.7 ± 0.3	11.4 ± 0.2	12.2	11.1 ± 0	12.3 ± 0.3	-	13.9 ± 0.3	20.5 ± 0.3	18.0 ± 0.7
Min-max	16.2–17.4	13.2–13.4	12.0–13.3	11.2–11.6	-	11.1–11.1	12.0–12.7	-	13.4–14.4	20.1–20.9	17.0–18.4
n	4	2	12	3	1	3	6	-	23	7	4

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
CIL											
$\bar{X}$ ± *SD*	15.6 ± 0.4**	12.8	12.3 ± 0.3	11.1 ± 0.3	11.1	10.9 ± 0.1	11.9 ± 0.3	-	13.3 ± 0.3	18.0 ± 0.2	16.3 ± 0.5
Min-max	15.4–16.2	12.7–12.9	11.7–12.5	10.9–11.5	-	10.8–11.0	11.5–12.4	-	12.8–13.8	17.7–18.3	15.6–16.6
n	4	2	12	3	1	3	6	-	23	7	4
CCL											
$\bar{X}$ ± *SD*	16.0	12.4	11.9 ± 0.4	10.9 ± 0.3	10.7	10.8 ± 0.3	11.5 ± 0.3	-	12.9 ± 0.3	17.5 ± 0.3	15.8 ± 0.4
Min-max	-	12.4–12.4	11.0–12.2	10.7–11.2	-	10.5–11.0	11.1–12.0	-	12.3–13.4	17.1–17.9	15.3–16.3
n	1	2	13	3	1	3	7	-	24	7	4
Palatal length											
$\bar{X}$ ± *SD*	5.9 ± 0.4**	5.3	4.8 ± 0.2	4.4 ± 0.1	-	4.6 ± 0.2	4.8 ± 0.5	-	5.2 ± 0.3	7.1 ± 0.1	6.5 ± 0.5
Min-max	5.5–6.5	5.1–5.5	4.4–5.3	4.3–4.5	-	4.4–4.8	4.4–5.5	-	4.8– 6.0	6.9–7.3	6.1–7.2
n	4	2	13	3	-	3	4	-	22	7	4
ZB											
$\bar{X}$ ± *SD*	11.4 ± 0.5**	9.5	9.0 ± 0.2	8.3 ± 0.2	8.5	8.2	8.6 ± 0.2	-	10.2 ± 0.3	13.1 ± 0.4	12.0 ± 0.4
Min-max	11.0–11.9	9.4–9.5	8.6–9.2	8.1–8.4	-	8.0–8.3	8.4–8.9	-	9.5–10.9	12.7–13.8	11.5–12.3
n	4	2	10	3	1	2	7	-	23	7	4
Mastoid width											
$\bar{X}$ ± *SD*	9.6 ± 0.2**	8.4	8.2 ± 0.3	7.5 ± 0.1	7.3	7.3 ± 0.2	7.7 ± 0.2	-	8.9 ± 0.2	11.5 ± 1.0	10.2 ± 0.4
Min-max	9.5–9.9	8.4 – 8.4	7.9–8.5	7.4–7.6	-	7.1–7.4	7.5–8.0	-	8.4–9.4	9.3–12.3	9.6–10.5
n	4	2	12	3	1	3	7	-	23	7	4
BBC											
$\bar{X}$ ± *SD*	8.7 ± 0.3**	7.8	7.6 ± 0.2	6.9 ± 0.1	6.8	6.8 ± 0.1	7.2 ± 0.3	-	8.0 ± 0.2	9.2 ± 0.2	8.3 ± 0.2
Min-max	8.5–9.0	7.7–7.9	7.4–8.0	6.9–7.0	-	6.7–6.9	6.8–7.4	-	7.6–8.4	8.8–9.4	8.1–8.5
n	4	2	12	3	1	3	7	-	24	7	4

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
HBC											
$\bar{X}$ ± *SD*	6.9 ± 0.3**	5.8	5.7 ± 0.2	5.1 ± 0.1	4.9	5.1 ± 0.1	5.4 ± 0.2	-	6.0 ± 0.1	8.2 ± 0.3	6.8 ± 0.5
Min-max	6.6–7.3	5.8 – 5.8	5.5–6.0	4.9–5.2	-	5.0–5.2	5.1–5.6	-	5.7–6.2	7.7–8.6	6.1–7.1
n	4	2	11	3	1	3	7	-	23	7	4
Interorbital width											
$\bar{X}$ ± *SD*	6.4 ± 0.2**	5.7	5.4 ± 0.1	4.6 ± 0.1	4.6	4.6 ± 0.2	5.3 ± 0.1	-	6.0 ± 0.3	8.1 ± 0.3	7.1 ± 0.4
Min-max	6.2–6.7	5.6–5.8	5.3–5.6	4.6–4.7	-	4.4–4.7	5.1–5.4	-	5.6–6.9	7.6–8.4	6.5–7.3
n	4	2	12	3	1	3	7	-	23	7	4
POP											
$\bar{X}$ ± *SD*	6.4 ± .3**	5.8	5.5 ± 0.1	4.9 ± 0.1	4.7	4.6 ± 0.3	5.3 ± 0.1	-	6.0 ± 0.2	7.9 ± 0.2	6.9 ± 0.3
Min-max	6.1–6.9	5.8–5.8	5.3–5.8	4.8–5.0	-	4.4–4.9	5.1–5.5	-	5.7–6.4	7.6–8.2	6.5–7.3
n	4	2	12	3	1	3	7	-	23	7	4
POC											
$\bar{X}$ ± *SD*	4.8 ± 0.1**	4.7	4.8 ± 0.4	4.3 ± 0.0	4.4	4.1 ± 0.1	4.2 ± 0.2	-	4.6 ± 0.1	5.0 ± 0.2	4.3 ± 0.2
Min-max	4.7–5.0	4.5–4.8	4.5–5.9	4.3–4.3	-	4.0–4.1	3.9–4.4	-	4.2–4.8	4.6–5.2	4.1–4.5
n	4	2	12	3	1	3	7	-	24	7	4
M^3-M^3											
$\bar{X}$ ± *SD*	8.0 ± 0.3**	6.5	6.0 ± 0.2	5.4 ± 0.3	5.6	5.2 ± 0.1	5.8 ± 0.2	-	6.8 ± 0.2	8.5 ± 0.2	7.7 ± 0.1
Min-max	7.5–8.2	6.4–6.5	5.8–6.2	5.2–5.7	-	5.2–5.3	5.5–6.1	-	6.6–7.2	8.3–8.7	7.6–7.9
n	4	2	12	3	1	3	7	-	23	7	4
C-M^3											
$\bar{X}$ ± *SD*	6.0 ± 0.2**	4.4	4.1 ± 0.1	3.9 ± 0.1	4.0	3.8 ± 0.1	4.1 ± 0.1	-	4.7 ± 0.1	6.6 ± 0.1	5.9 ± 0.2
Min-max	5.8–6.2	4.3–4.4	3.9–4.2	3.8–4.0	-	3.7–3.9	4.0–4.2	-	4.5–5.0	6.5–6.7	5.7–6.0
n	4	2	12	3	1	3	7	-	24	7	4

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
C-C											
$\bar{X}$ ± *SD*	6.0 ± 0.2**	4.8	4.3 ± 0.1	3.9 ± 0.1	3.5	3.7 ± 0.1	4.4 ± 0.2	-	4.8 ± 0.2	6.4 ± 0.2	5.7 ± 0.2
Min-max	5.8–6.2	4.8–4.9	4.1–4.5	3.9–4.0	-	3.6–3.8	4.0–4.6	-	4.4–5.2	6.2–6.6	5.4–5.9
n	4	2	12	3	1	3	7	-	23	7	4
Mandible											
$\bar{X}$ ± *SD*	12.3 ± 0.5**	9.6	9.0 ± 0.2	8.3 ± 0.2	8.2	8.6 ± 0.5	8.7 ± 0.3	-	10.1 ± 0.2	14.1 ± 0.3	12.7 ± 0.2
Min-max	11.6–12.7	9.6–9.6	8.7–9.3	8.2–8.5	-	8.2–9.1	8.4–9.1	-	9.8–10.5	13.6–14.5	12.4–12.9
n	4	2	11	3	1	3	7	-	24	7	4
c-m_3											
$\bar{X}$ ± *SD*	6.7 ± 0.2**	5.0	4.6 ± 0.2	4.1 ± 0.3	4.4	4.3 ± 0.4	4.5 ± 0.2	-	5.3 ± 0.2	7.5 ± 0.2	6.6 ± 0.1
Min-max	6.4–6.9	4.9–5.1	4.3–4.9	3.9–4.5	-	4.0–4.8	4.2–4.7	-	5.1–5.6	7.2–7.7	6.5–6.8
n	4	2	11	3	1	3	7	-	24	7	4
Height of the upper canine											
$\bar{X}$ ± *SD*	2.8	2.2	1.9 ± 0.1	1.3 ± 0.1	1.4	1.2 ± 0.1	1.8 ± 0.1	-	2.2 ± 0.2	3.5 ± 0.4	3.1 ± 0.2
Min-max	-	2.1–2.2	1.7–2.1	1.2–1.4	-	1.1–1.3	1.6–1.9	-	1.8–2.4	2.9–3.9	2.9–3.4
n	1	2	12	3	1	3	6	-	22	7	4
Thickness of the upper canine											
$\bar{X}$ ± *SD*	1.3	0.9	0.8 ± 0.2	0.7 ± 0.1	0.7	0.7 ± 0.1	0.8 ± 0	-	0.9 ± 0.1	1.6 ± 0.2	1.2 ± 0.1
Min-max	-	0.9–0.9	0.5–1.0	0.6–0.8	-	0.6–0.7	0.8–0.8	-	0.7–1.0	1.4–1.9	1.2–1.4
n	1	2	12	3	1	3	6	-	23	7	4
WM^3											
$\bar{X}$ ± *SD*	1.9	1.5	1.4 ± 0.1	1.3 ± 0.1	1.4	1.3 ± 0	1.4 ± 0.1	-	1.4 ± 0.1	2.2 ± 0.2	2.0 ± 0.1
Min-max	-	1.5–1.5	1.4–1.5	1.2–1.4	-	1.3–1.3	1.3–1.4	-	1.6–2.0	2.1–2.5	1.9–2.0
n	1	2	12	3	1	3	7	-	24	7	4

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
WM²											
$\bar{X}$ ± *SD*	2.4	1.7	1.5 ± 0.1	1.3 ± 0.1	1.5	1.3 ± 0	1.5 ± 0.1	-	1.8 ± 0.1	2.3 ± 0.1	2.3 ± 0.2
Min-max	-	1.6–1.8	1.4–1.5	1.2–1.3	-	1.3–1.3	1.4–1.6	-	1.6–2.0	2.1–2.4	2.1–2.4
n	1	2	12	3	1	3	7	-	24	7	4
MRL											
$\bar{X}$ ± *SD*	2.9	2.1	2.1 ± 0.3	1.6 ± 0.3	2.3	1.8 ± 0.3	-	-	2.1 ± 0.2	-	-
Min-max	-	1.9–2.2	1.5–2.4	1.4–1.9	-	1.5–2.0	-	-	1.6–2.5	-	-
n	1	2	12	3	1	3	-	-	23	-	-
I-M² alv											
$\bar{X}$ ± *SD*	6.8	4.9	4.6 ± 0.2	4.3 ± 0.3	4.3	4.3 ± 0.2	4.6 ± 0.1	-	5.2 ± 0.2	7.2 ± 0.2	6.4 ± 0.1
Min-max	-	4.9–4.9	4.2–4.8	4.1–4.6	-	4.1–4.4	4.4–4.8	-	4.7–5.4	6.9–7.5	6.3–6.6
n	1	2	12	3	1	3	7	-	24	7	4
Mastoid width/GLS											
$\bar{X}$ ± *SD*	0.57 ± 0.01**	0.63	0.65 ± 0.01	-	0.60	0.65 ± 0.01	0.63 ± 0.01	-	0.64 ± 0.01	0.56 ± 0.04	0.57 ± 0.00
Min-max	0.56–0.59	0.63–0.64	0.63–0.67	-	-	0.64–0.67	0.62–0.64	-	0.61–0.66	0.46–0.60	0.56–0.57
n	4	2	12	-	1	3	6	-	22	7	4
BBC/GLS											
$\bar{X}$ ± *SD*	0.52 ± 0.00**	0.59	0.60 ± 0.01	-	0.56	0.61 ± 0.01	0.58 ± 0.01	-	0.58 ± 0.01	0.45 ± 0.01	0.46 ± 0.02
Min-max	0.52–0.52	0.58–0.60	0.58–0.63	-	-	0.60–0.62	0.56–0.60	-	0.55–0.61	0.43–0.46	0.46–0.47
n	4	2	12	-	1	3	6	-	23	7	4
HBC/GLS											
$\bar{X}$ ± *SD*	0.41 ± 0.01**	0.44	0.45 ± 0.12	-	0.40	0.46 ± 0.01	0.43 ± 0.01	-	0.43 ± 0.01	0.40 ± 0.01	0.39 ± 0.02
Min-max	0.41–0.42	0.43–0.44	0.43–0.47	-	-	0.45–0.46	0.42–0.45	-	0.41–0.45	0.38–0.41	0.36–0.39
n	4	2	11	-	1	3	6	-	22	7	4

Character	*N. superba**	*G. alboguttata*	*G. argentata*	*G. beatrix*	*G. curryae*	*G. humeralis*	*G. poensis*	*G.* cf. *poensis*	*G. variegata*	*S. leucogaster*	*S. viridis*
ZB/GLS											
$\bar{X}$ ± *SD*	0.68 ± 0.01	0.71	0.71 ± 0.03	-	0.70	0.73	0.70 ± 0.02	-	0.73 ± 0.02	0.64 ± 0.02	0.67 ± 0.01
Min-max	0.67–0.69	0.71–0.71	0.68–0.77	-	-	0.72–0.75	0.67–0.73	-	0.69–0.77	0.62–0.66	0.66–0.68
n	4	2	10	-	1	2	6	-	22	7	4
C-C/M³-M³											
$\bar{X}$ ± *SD*	0.76 ± 0.01**	0.74	0.72 ± 0.02	-	0.63	0.71 ± 0.02	0.76 ± 0.04	-	0.70 ± 0.02	0.76 ± 0.03	0.73 ± 0.03
Min-max	0.74–0.77	0.73–0.76	0.69–0.76	-	-	0.69–0.73	0.69–0.82	-	0.65- 0.75	0.72–0.80	0.70–0.77
n	4	2	12	-	1	3	7	-	23	7	4

* For cranial and dental measurements and ratios, significant size differences (based upon t-tests with $p \leq 0.05$) between *Niumbaha* and *Glauconycteris* (all measured species combined) are indicated with **.

450698, USNM 452887, USNM 452889, USNM 503955), Sierra Leone (USNM 547030); *S. viridis* (Peters, 1852) (9): Ivory Coast (USNM 468194, USNM 468195, USNM 468199), Mozambique (USNM 365411, USNM 365412, USNM 365413, USNM 365414, USNM 365417, USNM 365418). Museum abbreviations and information: USNM: National Museum of Natural History, Smithsonian Institution, (Washington, D.C., USA); AMNH: American Museum of Natural History (New York, USA); BMNH: British Museum of Natural History (London, UK); RMCA: Royal Museum for Central Africa (Tervuren, Belgium).

Notes. Species of *Glauconycteris* are quickly recognized by a variety of distinctive traits, many of which are shared with the monotypic *Niumbaha.* Below we examine each of these traits, highlighting similarities and differences between *Niumbaha* and *Glauconycteris.*

Coloration, pattern, and body size: Hayman (1939) described and illustrated the coloration and patterning of this bat in detail, based upon the first specimen collected in Belgian Congo (now Democratic Republic of the Congo) (RMCA 14.765). He noted the presence of: (1) two sets of stripes on the dorsum - one set of "lanceolate stripes" found on each side of the median dorsal line of the back starting near the base of the neck and tapering to an end near the middle of the back, and one set of longer, narrower stripes on either side of the body, each commencing a little in advance of and lateral to the ends of medial stripes and each terminating just short of the root of the tail; (2) a set of stripes that begin on the dorsal side of each shoulder and run over the shoulder to the venter where they widen and run the lateral length of the venter joining and widening in the perineal region; (3) a wide throat band that connects to the shoulder/venter stripe, and (4) three spots – one roughly circular patch on the top of the muzzle between the eyes and one at each side of the face at the base of each ear.

In 1947, Hayman described the second specimen collected, this time from the Gold Coast (Ghana) (BMNH 47.10). Hayman found the markings of this specimen sufficiently different from the holotype of *superba* that he erected a new subspecies based upon it, *G. superba sheila.* The patterning of this specimen differs in that (1) two white spots are found on each shoulder next to the base of the humerus, (2) the unpigmented areas on the upper surface of the elbow, knee and ankle joints are present, and (3) the ventral interfemoral membrane is a pale gray color. Our newly collected specimen more closely resembles the Ghana specimen, but has only one white spot on each shoulder next to the base of the humerus and lacks an unpigmented area at the base of the ankle (Fig. 2). The recent DRC specimen (Gembu Tungaluna 2012) resembles our South Sudan specimen, but has the unpigmented ankle spots. The only other specimen of *N. superba* is from the Ivory Coast (RMCA A9363) and, while cited by Peterson and Smith (1973), it has not been described in the literature and we have not examined it. However, Peterson, in his museum notes, noted that it corresponds to *G. s. sheila* (Peterson, in litt., Royal Ontario Museum notes). Thus, of the five specimens, four appear to have characteristics attributed to the subspecies *sheila* and only one to the nominate subspecies. However, given the variation seen within the specimens of the subspecies *sheila* and given that the single specimen attributed to the nominate subspecies was

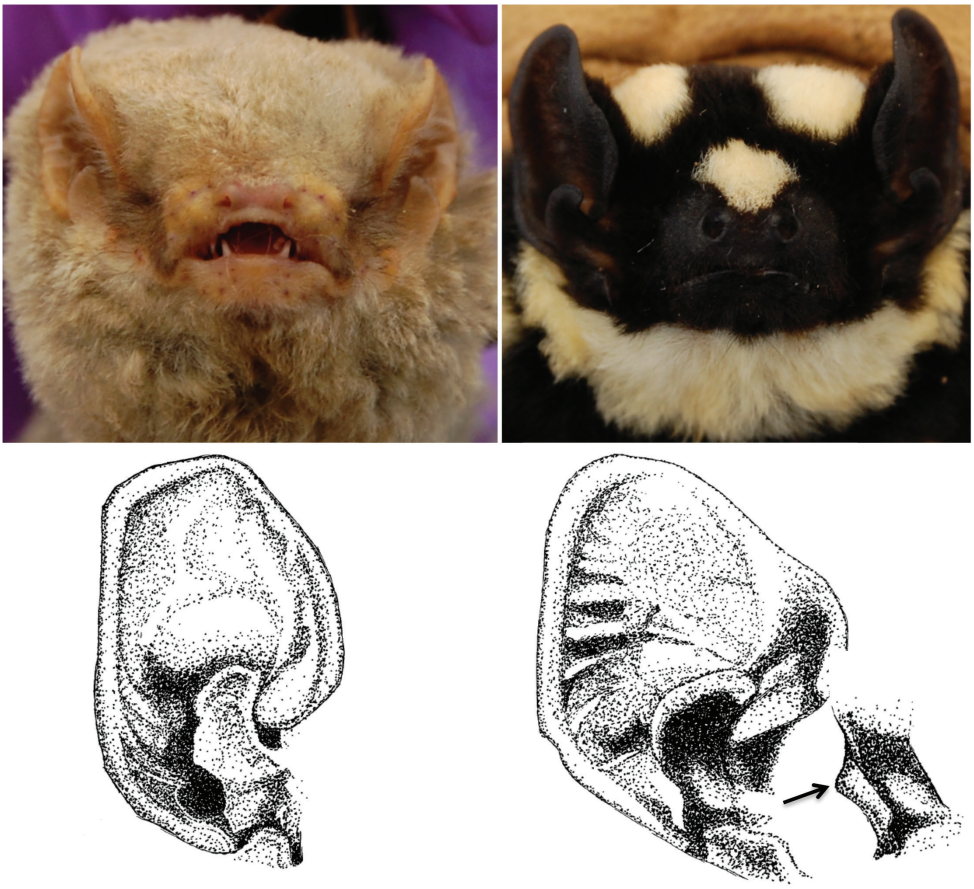

Figure 3. Contrasting facial aspects for *Glauconycteris* cf. *poensis* (left) and *Niumbaha superba* (right). Top panels show differences in nostril shape and orientation from photographs of live bats, bottom drawings show difference in ear and tragus structure. *Glauconycteris poensis* and *Niumbaha superba* are the type species of *Glauconycteris* and *Niumbaha.*

captured in relatively close proximity to two specimens that match more closely the pelage patterning described for *sheila*, we do not recognize *sheila* as a valid subspecies (see also Simmons 2005). Within species of *Glauconycteris*, the tendency to produce patterns of spots, stripes and reticulations is pronounced and variable (Rosevear 1965). In *G. poensis*, for example, Hayman and Jones (1950) described "remarkable" variation in the pattern of white shoulder spots and flank stripes, suggesting that variation is normal for this and related species. Further study, ideally based upon the collection and (morphological and genetic) study of additional material from additional localities, will be needed to ascertain whether clear patterns of geographic variation exist within *N. superba* and whether multiple subspecies can be recognized.

Notably, our specimen of *N. superba* (and that reported by Gembu Tungaluna 2012) was *not* originally black and white when collected, but rather black and

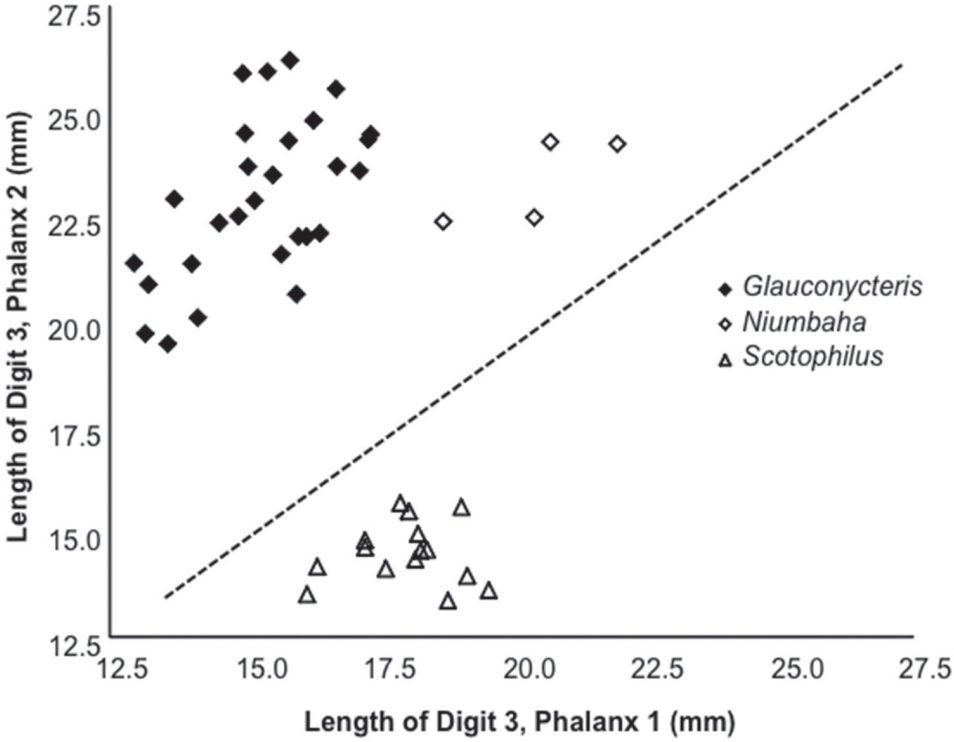

Figure 4. Length of the 2nd phalanx (2PL) of the 3rd digit vs. the 1st phalanx (1PL) of the 3rd digit. Several species of *Glauconycteris* are shown (closed diamond), as is *Niumbaha superba* (open diamond), and for comparison, two species of *Scotophilus* (open triangle; a 'typical' African vespertilionid bat). The ratio of 2PL/1PL is significantly greater in *Glauconycteris* than in *Niumbaha* (with a theoretical 1:1 ratio indicated by the dashed line). Data as reported in Table 2.

cream/buffy yellow. Hayman (1939, 1947) described *superba* from museum specimens, in which we suspect the color had faded (Rosevear [1965] also noted the "pure white hairs" and included a drawing of *G. s. sheila*, taken from a black and white photograph [from which the original color is thus not clear] of the bat on a tree trunk). Indeed, our specimen, fixed in formalin and stored in ethanol, is now black and white, such that the yellow coloration of the paler fur ornamentation has leached from the fur, and only the images of the freshly collected bat indicate its true color.

Finally, *N. superba* is larger than all species of *Glauconycteris*, as noted by Hayman (1939, 1947). Rosevear (1965) subsequently noted the larger body size as well, but also noted that body size measurements are not "very much larger" than *G. variegata* and *G. argentata*, but that the skull is far bigger, with a total skull length greater than 16mm (Table 2; see also discussion below).

Wing morphology: Rosevear (1965) distinguished *Glauconycteris* from other African Vespertilioninae by its distinctive wing morphometry – noting that phalanx 2 (Ph2) on digit 3 (DIII) is longer than Ph1. Within *Glauconycteris, G. variegata* is perhaps the

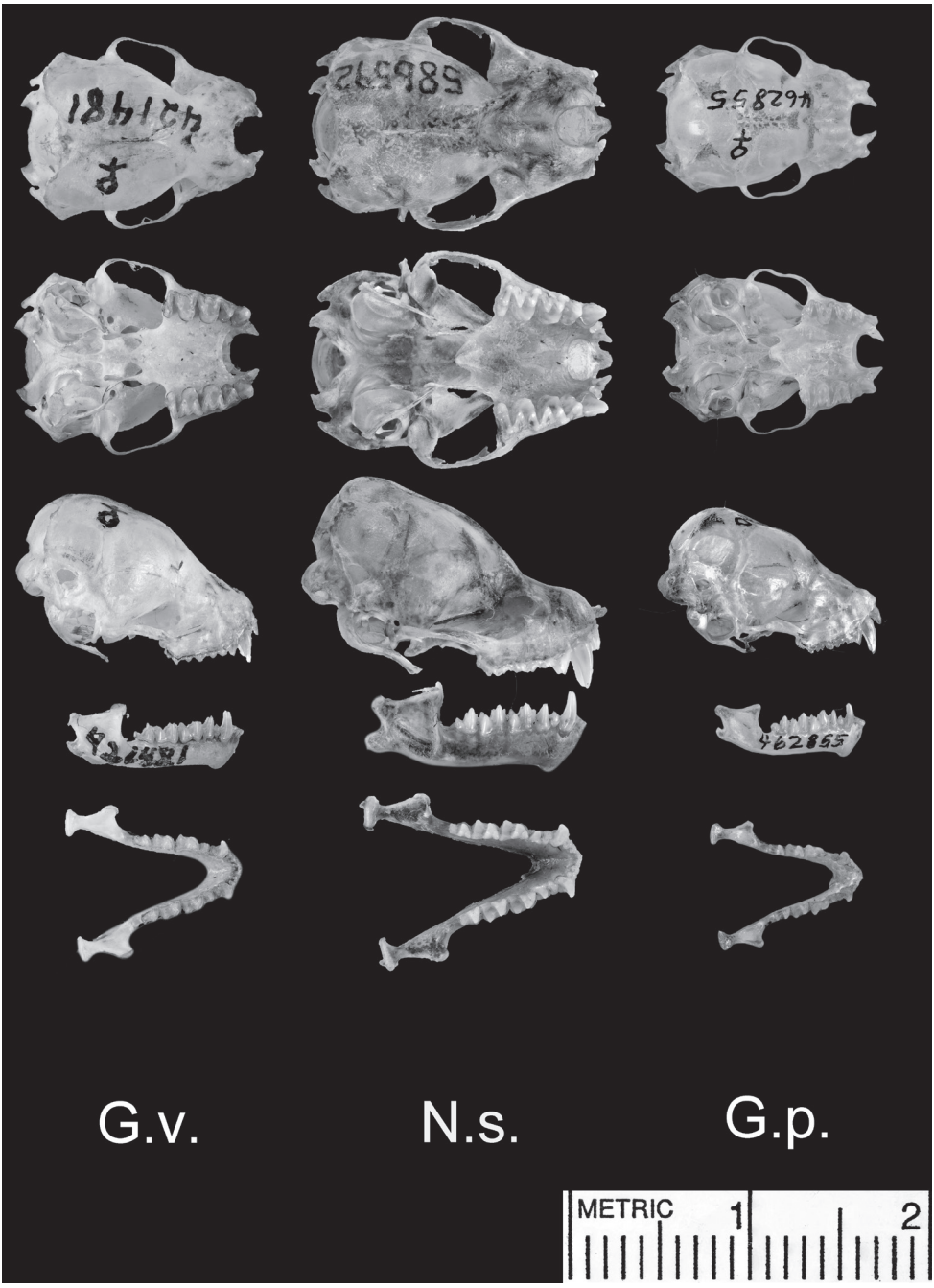

Figure 5. Dorsal and ventral views of the cranium, lateral views of the cranium and mandible, and dorsal view of the mandible. Species shown include *Glauconycteris variegata* (G.v.; a relatively large species of *Glauconycteris,* which nearly matches *Niumbaha superba* in linear body size, but not in skull size); *Niumbaha superba* (N.s.; the type species of *Niumbaha*), and *Glauconycteris poensis* (G.p., the type species of *Glauconycteris*).

best studied species and Findley et al. (1972) described it being among the bat species with the highest aspect ratio (wing length/wing width) and the longest wing tips. Wing size and shape represent a compromise between different (and often conflicting) selective forces and the kinematics of bat flight are complex (Norberg and Rayner 1987). Nevertheless, we can say that the long pointed wingtips and high aspect ratio of *G. variegata* suggest relatively maneuverable, low flight speed that might favor feeding in open areas around, but not within clutter (Norberg and Rayner 1987; and see Obrist et al. 1989, whose examination of echolocation calls also supported this flight/feeding mode). *Niumbaha superba,* while retaining Ph2>Ph1 for DIII, diverges from *Glauconycteris* in that the ratio of Ph2/Ph1 is significantly less extreme (1.15 ± 0.05 SD vs. 1.51 ± 0.12 SD; $t = -6.12$, $df = 31$, $p < 0.0001$; Fig. 4), which has not previously been noted for this taxon. This suggests that *Niumbaha* is perhaps closer to 'typical' vespertilionids in ecomorphological space (for comparison, measurements for *Scotophilus* are also included in Fig. 4). This difference in wing shape may reflect differences in habitat type and feeding mode (see also the discussion of differences in dentition between *Niumbaha* and *Glauconycteris*, below).

Facial features (including the ear): Glauconycteris is distinctive among African vespertilionids in possessing an extremely shortened but broad muzzle in which the nostrils open more or less to the side from a transverse, thick subcylindrical naked pad. On the underlip is found a thickened pair of pads and the lower lip near the corner of the mouth has a fleshy lappet or fold that can be made to extend horizontally (Rosevear 1965). The rostrum is proportionally longer in *N. superba* as compared to *Glauconycteris,* but we have found no mention in the literature of differences in other facial features. We note here that the fleshy lappet is present on the lower lip but that the muzzle appears to be more robust and contains nostrils that open more to the front than to the side (Fig. 3), a more 'typical' vespertilionid configuration.

The ears of *Glauconycteris sensu stricto* are of small to moderate size and rounded with a strong semicircular inner margin that ends basally in a "curiously backwardly projecting lobe" and a pronounced antitragus (Rosevear 1965:273). The tragus is "sickle" or half-moon shaped with a large and broadly triangular basal lobe. In his original description of *N. superba,* Hayman (1939) noted that the ears are less rounded and more subquadrangular than in other *Glauconycteris* (Fig. 3). Rosevear (1965:284-285), noting that his observations were from a dried skin, described the inner margin of the ear of *N. s. sheila* as "terminating in a long almost parallel-sided free lobe", the antitragus as large and semicircular, and the tragus as broader than in other *Glauconycteris* with a "boldly curved" outer margin and a small acute lobule. Based upon examination of the fresh and subsequent fluid specimen from South Sudan, we generally concur. The "free lobe" at the inner margin of the ear is larger in *Niumbaha* than in *Glauconycteris,* but we note that the antitragus is more squared off than semicircular. Additionally, the horizontal cartilaginous ridges in the outer ear margin are pronounced in *Niumbaha* (especially in the fresh specimen; Fig. 3) relative to *Glauconycteris*.

Cranial features: Despite placing this bat in *Glauconycteris,* Hayman (1939:222) noted that the skull was longer and less broad with marked flattening of the rostrum

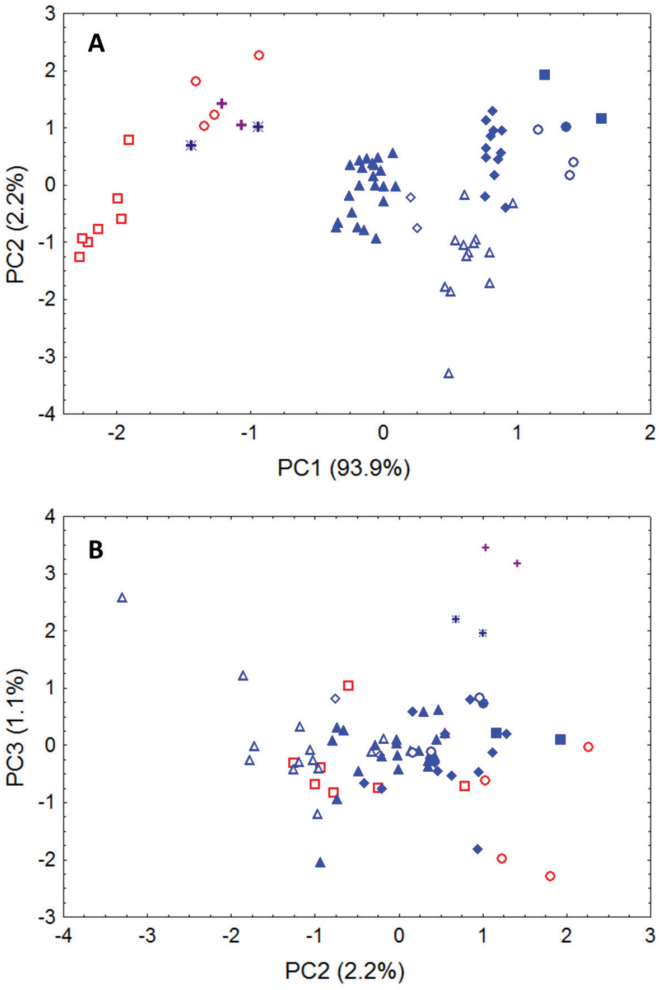

Figure 6. Morphometric separation (first three principal components of a Principal Components Analysis) of 12 cranial and dental measurements. Data are from 70 adult skulls of *Glauconycteris, Niumbaha,* and *Scotophilus* (with measurements following Table 1 and 2). Specimens of *Scotophilus*, included for ecomorphological comparison, are indicated in red (**open red squares**, *S. leucogaster*; **open red circles**, *S. viridis*). Specimens of *Glauconycteris* are indicated in blue (**open blue diamonds**, *G. alboguttata*; **open blue triangles**, *G. argentata*; **open blue circles**, *G. beatrix*, **closed blue circles**, *G. curryae*; **closed blue squares**, *G. humeralis*; **closed blue diamonds**, *G. poensis*; **closed blue triangles**, *G. variegata*). Specimens of *Niumbaha superba* from central Africa (DRC, S Sudan) are marked with **crosses**; specimens of *N. superba* from west Africa (Cote D'Ivoire, Ghana) are marked with **asterisks**. **A** Skulls of *Niumbaha* separate from skulls of species of *Glauconycteris* in combination along the first and second components, suggesting greater overall ecomorphological resemblance of *Niumbaha* with medium-sized, less specialized African vespertilionids such as *Scotophilus*. The first principal component reflects distinctions in overall skull size, which increases from right to left. **B** Separation of skulls of *Niumbaha* from those of *Glauconycteris* and *Scotophilus* in combination along the second and third components indicates the morphological isolation of *Niumbaha* and illustrates consistent differences in skull shape, reflecting (in separation along the third component) the proportionally narrower interorbital dimensions, less dramatic postorbital constriction, longer toothrows, narrowed skull, but widened anterior rostrum in *Niumbaha* relative to *Glauconycteris*.

Table 3. Factor loadings, eigenvalues, and percentage of variance explained by illustrated components (Fig. 6) from Principal Components Analysis of 70 adult skulls of *Glauconycteris*, *Niumbaha*, and *Scotophilus*. Principal components were extracted from a covariance matrix of 12 log-transformed cranial measurements (see Table 1, 2).

Variable	PC1	PC2	PC3
Zygomatic breadth	-0.988	0.003	-0.044
Mastoid width	-0.962	-0.083	-0.098
Breadth of braincase	-0.940	-0.218	0.082
Height of braincase	-0.969	-0.137	-0.020
Interorbital width	-0.970	-0.109	-0.160
Postorbital process width	-0.971	-0.133	-0.146
Postorbital constriction	-0.489	-0.726	0.449
Width at M^3	-0.977	0.035	0.064
Maxillary toothrow length (C-M^3)	-0.985	0.129	0.073
Width at upper canines	-0.966	0.054	0.091
Greatest length of mandible	-0.989	0.077	0.012
Mandibular toothrow length	-0.983	0.130	0.054
Eigenvalues	0.222	0.005	0.003
Percent variance (%)	93.9	2.1	1.1

"so that the profile shows an angle at the junction of the brain-case and the rostrum" and (1947:549) and so that there is "considerable lengthening of the infraorbital foramen"; he also noted the presence of proportionally deeper basisphenoid pits (Fig. 5). Rosevear (1965) noted that the skull is significantly larger and more powerful than *Glauconycteris sensu stricto* and that the upper surface of the rostrum does not rise in an even plane from the incisors to the occiput (as occurs in most *Glauconycteris,* see skull images of *G. variegata* and *G. poensis* in Fig. 5) but rather is flat or roughly parallel to the upper toothrow. This results in an excavation or "hollowing-out" of the frontal region of the skull (Fig. 5). Lastly, while *Glauconycteris* have a domed braincase with virtually no sagittal crest, a low crest is present in *Niumbaha*, where it joins posteriorly with a lambdoidal crest to form a low supraoccipital pyramid (Rosevear 1965).

Niumbaha shares its dental formula and many dental characteristics with *Glauconycteris*. The dental formula is 2.1.1.3/3.1.2.3 = 32, but Hayman (1939) noted a greater proportional difference in size between the lower i_1 and i_3 than in *Glauconycteris sensu stricto* (Fig. 5). As with *Glauconycteris,* the upper incisor is long and pointed and the upper premolar is long, similar in height to the molars. While Hayman (1947) noted a considerably reduced m_3 compared to other (we presume *Glauconycteris*) species, we do not find this to be the case in our South Sudan specimen. The canines, and especially the upper canine, are considerably more robust (unreduced) in *Niumbaha* than in *Glauconycteris.* The size difference between *Niumbaha* and *Glauconycteris* presumably allows *Niumbaha* to take larger, more hard-bodied prey than *Glauconycteris*, an apparent lepidopteran (moth) specialist (Fenton et al. 1977).

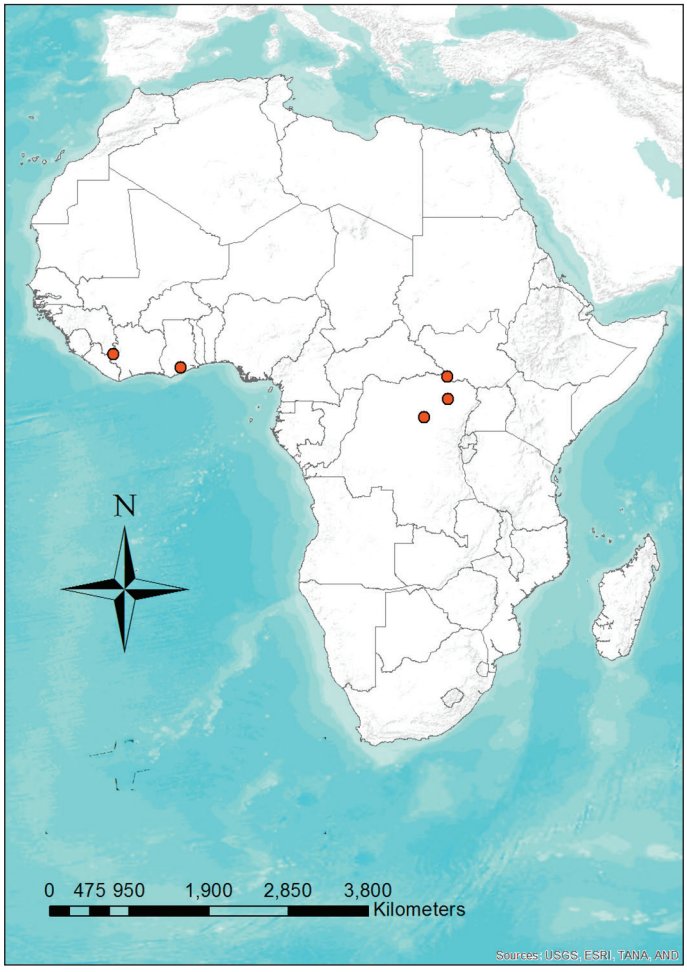

Figure 7. Distribution map showing the locations of the five recorded specimens of *Niumbaha superba*. Given how widely distributed this species is, its rarity in collections is enigmatic.

Our principal components analysis of cranial and dental data (based upon measurements listed in Table 2 from *Niumbaha, Glauconycteris*, and *Scotophilus*) clearly indicates that the skulls of *Niumbaha* separate from skulls of species of *Glauconycteris*, suggesting greater overall ecomorphological resemblance of *Niumbaha* with medium-sized, less specialized African vespertilionids such as *Scotophilus* (Fig. 6). The first principal component reflects distinctions in overall skull size and indeed each of the cranial measurements in this analysis is significantly larger for *Niumbaha* than for *Glauconycteris* (see Table 2). Beyond size, separation of skulls of *Niumbaha* from those of *Glauconycteris* and *Scotophilus* in combination along the second and third components indicates the morphological isolation of *Niumbaha* and illustrates consistent differences in skull shape, reflecting (in separation along the third component) the proportionally narrower interorbital dimensions, less dramatic postorbital constric-

tion, longer toothrows, narrowed skull, but widened anterior rostrum in *Niumbaha* relative to *Glauconycteris*.

Distribution and habitat. *Niumbaha superba* has been rarely captured (only five times) but is apparently widely distributed (Fig. 7), being recorded from Ghana, Ivory Coast, Democratic Republic of the Congo and South Sudan. This broad distribution suggests that it is more common than its collection records indicate. Although most species in its apparent sister genus, *Glauconycteris*, are not well known, at least one species (*G. variegata*) is believed to be a high flier (Obrist et al. 1989), which could translate to poor capture success for *Niumbaha,* especially if it typically flies at even greater heights. *Glauconycteris* are found in a variety of habitats, mostly from moist forest zones (Rosevear 1965). We can only speculate that *Niumbaha* is found in similar habitat types. Neither the description of the first specimen collected in the Democratic Republic of Congo (Hayman 1939) nor that of the second specimen from Ghana, which was "found alive on the ground" (Hayman 1947:550) contain habitat descriptions. However, Rosevear (1965) noted that both locations were in closed forest (though the Ghana location was on the edge of closed forest and a Guinea woodland zone) and Hayman and Hill (1971) noted that both locations are from heavy rain forest. A recent specimen from Democratic Republic of the Congo was mist-net captured in secondary forest (Gembu Tungaluna 2012) and our specimen from South Sudan was mist-net captured on a grassland plateau just above a secondary thicket forest.

Discussion

The generic placement of "*Glauconycteris" superba* has never been critically reviewed. Only four specimens have previously been mentioned in the literature (Hayman 1939, 1947; Peterson and Smith 1973; Gembu Tungaluna 2012), with minimal comment on the distinctness of this species from other *Glauconycteris* in cranial features, nostril and ear anatomy, and wing proportions (in addition to differences in skull size, robusticity, and pelage patterning, which have been noted previously). Very few reviewers of *Glauconycteris* have mentioned first-hand examination of specimens of *superba* or their attributes. Obviously, it is not only on the basis of its ecomorphological distinction from other species of *Glauconycteris*, but especially in its lack of several of the most characteristic morphological properties of *Glauconycteris* (which we take to be synapomorphic for the species of *Glauconycteris sensu stricto*), that we erect a new genus, *Niumbaha*, to house *superba*, one of the most beautiful and rarely collected of Africa's vespertilionids. In lacking the reduced body size, extremely blunt face, characteristic nostril configuration, and extreme wingtip lengthening of *Glauconycteris*, *Niumbaha* superficially reminds us of other medium-sized and less specialized vespertilionid genera, such as *Scotophilus* (Fig. 6). We advocate integrating DNA sequence data for *N. superba*, and for as wide a sampling of species of *Glauconycteris* as possible, into current phylogenetic datasets and frameworks for African vespertilionid bats (Hoofer and Van

Den Bussche 2003; Roehrs et al. 2011), to test our hypothesis that *Niumbaha* lies outside the phylogenetic scope of *Glauconycteris sensu strict*o.

Our naming of a new genus for one of the most extraordinary and rarest-collected bats in Africa highlights a number of issues. *Niumbaha superba* displays one of the most striking pelage patterns known in bats. While species of *Glauconycteris* are known for their spots, stripes, and wing reticulation, none are so boldly patterned as *N. superba*. Similar markings are found in only a small number of vespertilionids, especially the East Asian Harlequin bat, *Scotomanes ornatus,* and the western North American Spotted bat, *Euderma maculata,* as well as in (albeit to a considerably lesser extent) some emballonurids, such as *Saccopteryx bilineata*. Rosevear (1965:285) noted that "though the bold black and white coloring of [*N. superba*] … may appear very conspicuous in the hand it doubtless acts as a concealing pattern in nature in a similar way to that well-established for many other animals with disruptive markings…" Such disruptive coloration may, in part, explain the lack of local and scientific knowledge regarding this bat. In each collection location it was unknown to indigenous peoples, and early scientific collecting of bats was often focused on areas where they could be most obviously located, such as buildings or other conspicuous roost locations. Santana et al. (2011) studied relationships between bat roosting habitats and the presence of stripes, throat bands and spots, and demonstrated the independent evolution of pelage markings in 12 of 19 families of bats studied. In particular, they noted an association between roosting in vegetation (especially tent making) and the evolution of stripes and neckbands. They added that crypsis through disruptive stripes and neck bands could be augmented by facial markings (as occur in several tent-making species) and that this crypsis could be enhanced by blending with the patterns of light and shadows created by sunlight peeking through small gaps in the leaf tents. There are no documented examples of tent-making in African bats, although it has arisen independently on other continents (Santana et al. 2011). The possibility that *N. superba* might be a tent-making bat is intriguing. Another possibility is that the striking pelage pattern of *N. superba* is not disruptive or camouflaging, but rather serves in social signaling. However, the use of pelage markings (outside of epaulettes) as social signals in bats is not well studied (Santana et al. 2011) and the apparent lack of sexual dimorphism in the pattern of *N. superba* suggests that their coloration may not play a social role. Similarly, it is possible that *N. superba's* pattern and coloration is aposematic, but this is otherwise unknown in bats (Caro 2005). Strong chemical defenses are associated with some other boldly patterned black and white mammals (e.g., mephitids, mustelids such as *Ictonyx* and striped possums such as *Dactylopsila*), but we did not detect a strong scent in our specimen. Regarding its common name, *N. superba* was originally described by Hayman (1939) as resembling the spotted skunk *Spilogale* and has had several common names over the years, including the Magpie bat (Hayman 1947), Mrs. Cansdale's bat (Hayman 1947), and Pied bat (Wilson and Cole 2000, as *Chalinolobus superba*). Given that several species of the Australo-Papuan genus *Chalinolobus* are referred to as 'pied bats', we think it best to avoid that name, and propose the use

of 'badger bat' in reference to its tenacious appearance and its bold black and white/cream coloration, both reminiscent of badgers.

The conservation status of poorly known species such as *N. superba* is difficult to assess. Until 2004, the International Union for the Conservation of Nature (IUCN) listed *N. superba* as "Vulnerable". In 2008, it changed the listing to "Least Concern" "in view of its wide distribution, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category" (Fahr et al. 2008). We concur, especially in light of the two 2012 captures. Nevertheless, any detailed understanding of the current status of this bat will require considerable further study.

The capture of this bat in South Sudan (as well as the collection of *G.* cf. *poensis*, a new country record) highlights the need to expand biodiversity surveys and studies in this new nation. These bats were captured in the Bangangai Game Reserve in Western Equatoria State, which resides within a 'tropical belt' along the border with the Democratic Republic of the Congo. It is largely composed of dense tropical/subtropical forest, the type of which is highly restricted in South Sudan. Its placement near the Congo Basin ecoregion sets it apart from the rest of South Sudan and elements of the faunas and floras of West Africa and East Africa overlap here (Linder et al. 2012), creating significant biodiversity. Koopman (1975) in his seminal work on the bats of Sudan, highlighted the need to survey for bats in this unstudied region.

In his original description of *N. superba,* Hayman (1939:223) concluded "that such a conspicuous new species should be found in a region which has received considerable attention from museum collectors of proved ability … is somewhat surprising. It seems that much more collecting needs to be done before we can claim a complete knowledge of the mammalian fauna of tropical Africa." More than 70 years later, this statement still holds, and the biota of many areas of sub-Saharan Africa remains poorly understood, even in vertebrate groups usually considered well studied, such as mammals (Reeder et al. 2007). As an understanding of basic biodiversity is the backbone upon which other studies and conservation programs can be built, we encourage further basic field and museum work in the region; many more surprises no doubt await.

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