Two New Yellow-Banded Sister Species of Syntomaula Meyrick (Lepidoptera: Gelechioidea: Cosmopterigidae) from Papua New Guinea Associated with Rubiaceae

Authors: Adamski, David, and Miller, Scott E.

Source: The Journal of the Lepidopterists' Society, 69(4) : 307-316

Published By: The Lepidopterists' Society

URL: https://doi.org/10.18473/lepi.69i4.a6

Journal of the Lepidopterists' Society
69(3), 2015, 307–316

TWO NEW YELLOW-BANDED SISTER SPECIES OF *SYNTOMAULA* MEYRICK (LEPIDOPTERA: GELECHIOIDEA: COSMOPTERIGIDAE) FROM PAPUA NEW GUINEA ASSOCIATED WITH RUBIACEAE

DAVID ADAMSKI AND SCOTT E. MILLER

Department of Entomology; National Museum of Natural History;
P.O. Box 37012, MRC–168; Smithsonian Institution; Washington, D.C. 20013–7012

ABSTRACT. Two new species, *Syntomaula xanthofasciata* **n. sp**. and *S. flavoangulata* **n. sp.** (Lepidoptera: Gelechioidea: Cosmopterigidae) are described from Papua New Guinea and are associated with *Neonauclea obversifolia* (Valeton) Merr. & L.M. Perry, *Uncaria appendiculata* Benth., and *Uncaria cordata* (Lour.) Merr. (Rubiaceae). Macromorphological features and DNA barcodes provide corroborative evidence to diagnose these similarly patterned species. Illustrations of the wing pattern, wing venation, and male and female genitalia are provided. The distinctive yellow and brown forewing coloration is discussed with regard to potential mimicry.

Additional key words: Cosmopterigidae, DNA barcode, Gelechioidea, Malesia, Papua New Guinea, Rubiaceae, Mimicry, Taxonomy

The genus *Syntomaula* was established by Meyrick (1914) with the description of its type species, *S. tephrota* from Sri Lanka. *Syntomaula* contains seven described species: one species is from southeast Asia and the other six species are from Sri Lanka, Japan, and New Guinea. Walker (1864) described *Cryptolechia simulatella* and *C. niveosella* from Sarawak. Later Meyrick (1916) transferred *C. simulatella* to *Bathraula*. And Diakonoff (1968) transferred *Bathraula simulatella* to *Syntomaula* (Scaeosophinae) and synonymized *Cryptolechia niveosella* with *S. simulatella*. Diakonoff (1968) also synonymized *Bathybalia* Diakonoff, 1954 with *Syntomaula*, transferring *B. microsperma* Diakonoff, 1954 to *Syntomaula*. Later Sinev (2002) synonymized *Protorhiza* Diakonoff, 1968 with *Syntomaula*, transferring *Protorhiza cyanosticta* Diakonoff, 1968 to *Syntomaula*. Moriuti (1977) described *Syntomaula cana* from Yakusima Island in Japan, documenting the first known host associations (Rubiaceae) for the genus.

Meyrick (1914) initially treated *Syntomaula* as part of the Oecophoridae. He (1932) later reconsidered the genus part of the Scaeosophidae, but Clarke (1955) transferred it to the Cosmopterigidae. Diakonoff (1968) agreed with Clarke's placement of the genus in Cosmopterigidae but recognized Meyrick's (1922) "*Scaeosophides*-group", which *Syntomaula* originally was part of, and upgraded its status to Scaeosophinae.

Currently, there is no phylogenetic analysis that defines the Scaeosophinae or the genera within. Meyrick (1922), Sinev (2002), and Li et al (2012) defined the Scaeosophinae by the synapomorphy, hindwing with an elliptical unscaled area on both surfaces posterior of the cell. This feature is not present in all *Syntomaula* but this genus shares several features of the male and female genitalia with other scaeosophine genera, i.e., *Scaeosopha* (Li et al., 2012) that we consider important enough to keep the genus in the Scaeosophinae. These features include; tegumen with two elongate, opposable dorsolateral lobes; valvae basally bearing an elongate spinelike or digitate process; female with a sclerotized margin of ostium; and corpus bursae with paired signa. We tentatively define *Syntomaula* as having asymmetrical valvae, elongate asymmetrical basal processes of the valvae, imbricate cornuti in a row within the vesica of the phallus, a shortened part of the ductus bursae posterior to the bulla, and a widened part of the ductus bursae (possibly the corpus bursae) anterior to the bulla.

The two new species of *Syntomaula* described herein originated from a massive program of rearing caterpillars in Papua New Guinea, with an international group of collaborators focusing on the ecology of herbivorous insects, their host plants, and their parasitoides (Miller et al. 2003, Craft et al. 2010, Novotny et al., 2007, 2010, Hrcek et al., 2011, Hrcek et al. 2013). These new taxa were found during a project at Wanang, in lowland rainforest in the Sepik River Basin, near Madang, Papua New Guinea. These species are known only from reared adult specimens, and we are not able to find specimens collected as adults in major collections of New Guinea moths.

The purpose of this study is to: 1) describe two new species of *Syntomaula* from Papua New Guinea using collaborative techniques such as macromorphology and DNA barcode data from Cytochrome c Oxidase I sequences, 2) to hypothesize relationships of these two new taxa not only by morphology but by associations from host-plant data, and 3) to discuss the distinctive forewing color pattern relative to other sympatric moths in Papua New Guinea.

MATERIALS AND METHODS

Field and laboratory studies follow Basset et al. (2000, 2004), Miller et al. (2003, 2013) and Craft et al. (2010). Cytochrome c Oxidase I ("DNA barcode") sequences were prepared by the Biodiversity Institute of Ontario, University of Guelph, following the protocols in Craft et al. (2010) and Wilson (2012). Data for 30 sequences have been deposited in GenBank as accession numbers HM906298, HM900661-4, HQ946812-33, JF847961, including the standard fields for the BARCODE data standard (Benson et al. 2012) and more data, including images and host plants, are available in the Barcode of Life Database (BOLD, www.boldsystems.org; Ratnasingham and Hebert, 2007, 2013), in a dataset accessible using a DOI (dx.doi.org/10.5883/DS-NGSYNTOM). Neighbor-joining (NJ) trees were generated from nucleotide sequences using the BOLD aligner as implemented in BOLD (Ratnasingham and Hebert, 2007, 2013).

Morphological observations and measurements of the wings were made using a Leitz RS dissecting microscope with a calibrated ocular micrometer. Genitalia were dissected as described by Clarke (1941), except mercurochrome and chlorazol black were used as stains. The Methuen Handbook of Colour (Kornerup and Wanscher, 1978) was used as a color standard. Holotypes are deposited in the National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC. Paratypes are distributed among USNM, the Papua New Guinea National Agriculture Research Institute (NARI), and the Natural History Museum (NHM), London, United Kingdom. Data of all specimens examined in this study are summarized in Table 1.

In addition to the morphological differences noted in the descriptions below, DNA barcode sequences from the two new species described here differ from each other by 6.222–6.908% (calculated using the BOLD aligner as implemented in BOLD), clearly indicative of species level divergence in Lepidoptera (Craft et al. 2010, Ratnasingham and Hebert 2013).

RESULTS

Syntomaula xanthofasciata Adamski, **n. sp.**
(Figs. 1–2, 4–6, 10)

Diagnosis. *Syntomaula xanthofasciata* is similar to *S. flavoangulata* in acies but differs from the latter by having a more deeply emarginate posterior margin of the eighth tergum, a wider apical part of the dorsolateral processes of the tegumen of the genital capsule, a broader apical part of the valva, more asymmetrically shaped basal processes of the valvae, a longer part of the phallus with cornuti, a wider membranous space between ventral parts of the eighth tergum in the female, and a more reticulated bulla and corpus bursae in the female.

FIG. 1. *Syntomaula xanthofasciata* Adamski (Paratype, USNM ENT 00697920).

Description. *Head*: vertex and frontoclypeus yellow; outer surface of labial palpus yellow except, basal segment pale brown, inner surface pale yellow; scape basal 1/3 flagellum brown, distal 2/3 pale brown; proboscis pale yellow.

Thorax: Tegula brown; mesonotum brown, demarcated posteriorly by a narrow, transverse, dark-brown band adjacent to a yellow-tufted, posterolateral margin. Femur and tibia of foreleg pale brown, brown, or with brown scales with distal margin pale brown; tarsomeres 1 and 4–5 dark brown on dorsal surface, pale yellow beneath; tarsomeres 3–4 pale yellow; basal 1/2 of midfemur pale yellow, distal 1/2 brown; midtibia as above except, with a suffused pale-yellow band near midlength; tarsomeres as above; femur and tibia of hindleg pale brown, tarsomeres pale yellow except, dorsal surfaces of tarsomeres 3–5 dark brown. Forewing (Fig. 1): Length 5.1–7.9 mm (n = 11), with a broad, median, and oblique, yellow band, juxtaposed basally by a brown fascia, extending anterodiagonally with 2–3 irregular crenulations to 1/3 costal length; median fascia juxtaposed distally at 2/3 length by a brown band; each band demarcated by a narrow row of dark-brown scales; submarginal and fringe scales with basal 1/2 pale brown, distal 1/2 brown. Undersurface brown, gradually darkening from midlength of radial and medial veins to submarginal line; radial and medial veins pale brown along subapical length, appearing as narrow streaks; area posterior to CuP pale yellowish brown. Venation (Fig. 2) with M_2 about equidistant from M_1 and M_3; CuA_1 about 3× as divergent distally than from base. Hindwing: translucent pale brown, apical fringe scales brown. Venation (Fig. 2) with frenulum with a single acanthus in males, 4 acanthae in females; M_2 about 2.5× as divergent distally than from base, and closer to M_1 than from M_3; M_3 and CuA_1 basally connate, CuA_2 absent.

Abdomen (Fig. 6): with eighth tergum deeply emarginate posteriorly forming two long posteriolateral subtriangular processes, and widely emarginate anteriorly forming two subparallel digitate processes. **Male Genitalia** (Figs. 4–5): Tegumen with two elongate, opposable dorsolateral lobes; lobes widened basally, gradually narrowed to slightly beyond 1/2, deeply notched along inner margin of a clavate apical part. Vinculum broad, U-shaped. Valvae basally parallelsided, apiclly elliptical, asymmetrical, with right valva slightly less emarginate than left; right valval base bearing a large, elongate, setose, digitate process; left valval base bearing a large setose, outwardly curved spinelike process. Juxta thin, apically rounded, setose. Phallus bulbous basally, produced into a tubular, single-coiled apical process; vesica with many imbricate cornuti in a narrow row about as long as 1/2 length of tubular part. **Female Genitalia** (Fig. 10): Papillae anales lobelike, setose. Ovipositor telescopic with 3 membranous subdivisions; apophysis posterioris slightly longer than 1.5× length of apophysis anterioris. Eighth segment ringlike extending ventrally, forming two free, broadly rounded parts. Ostium demarcated by a widened rim with a posteriorly produced narrow process, within membrane, flanked by large triangular plates formed by a mesially emarginate seventh sternum. Ductus bursae smooth posteriorly, dilated near posterior end of corpus bursae, forming a large reticulated bulla; inception of ductus seminalis on posterior end of bulla. Corpus bursae reticulated throughout, gradually widening from posterior end to near 1/2 length, ovoid on anterior end, with two opposable subequal signa; signa elongate, wider anteriorly than posteriorly, each with a mesolongitudinal ridge, produced into a single spinelike process on anterior end.

Holotype ♂, "Papua New Guinea, Madang Province, Wanang Village, 05°15'S, 145°16'E"; "Manumbor, Sau, Isua, Mogia, Sosanika, Idigel, Keltim, Kua, Bito"; "Sp. 125, WP-3D-0734 [*Neonauclea obversifolia* (Valeton) Merr. & L.M. Perry (Rubiaceae)], CATX 087, 23 Jan[uary] 2007"; "USNMENT: PNG, Madang Ecology Project, 00659673"; "♂ Genitalia Slide by DA, USNM 84164"; "DNA" [USNM].

Paratypes (5 ♂, 5 ♀): 1 ♂, 3 ♀, same data as holotype except, "00659672", "♀ Genitalia Slide by DA, USNM 84165; "00659666", "00659674", "00659677" [specimens not dissected]: 1 ♂, same data as above except, "WP-5B-1122, CATX 291, 9 Oct[ober] 2007"; "00667632"; "♂ Genitalia Slide by DA, USNM 83527": 1 ♂, 1 ♀, same data as above except, "WP-3E-0807, CATX 103, 24 Oct[ober] 2006"; "00659676", [specimen not dissected], "00659671"; "♀ Genitalia Slide by DA, USNM 84166": 1 ♂, 1 ♀, same data as above except, "Auga, Molem, Tamtiai, Lilip, Ibalim, Posman, Rimandai, Brus, Novotny, Hrcek lgt"; "WP-3C-0663, CATX 075, 23 Apr[il] 2007"; "00697920" [specimen not dissected]; "05°15'S, 145°17'E"; WP-3A-574, CATX 469, 14 Jul[y] 2007"; "00667636"; "♀ Wing Slide by DA, USNM 83520"; "DNA 2010" [specimen not dissected]: 1 ♂, same data as above except, "05°15'S, 145°17'E"; "WP-5C-1098, CATX 185, 20 Jun[e] 2007"; "00669354" [specimen not dissected, abdomen in gelatin capsule].

Etymology. The species epithet, *xanthofasciata*, is a compound word formed from the Greek *xantho* meaning yellow and the Latin *fascia* meaning banded, referring to the large median yellow band of the forewing.

Biology. *Syntomaula xanthofasciata* is known only to feed on *Neonauclea obversifolia* (Valeton) Merr. & L.M. Perry (Rubiaceae).

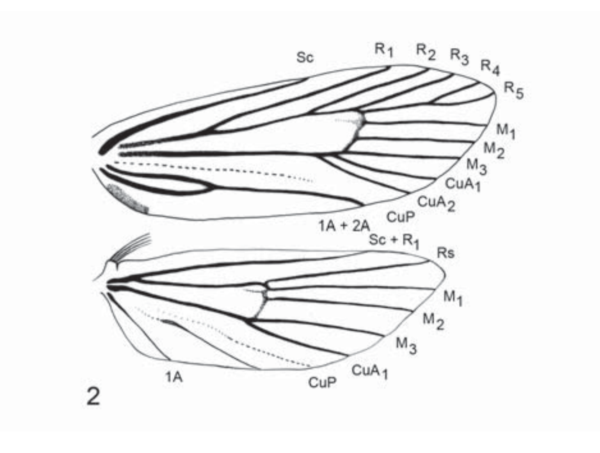


FIG. 2. Forewing and Hindwing venation of *Syntomaula xanthofasciata* Adamski (USNM 83520).

FIG. 3. *Syntomaula flavoangulata* Adamski (Paratype, USNM ENT 00697223).

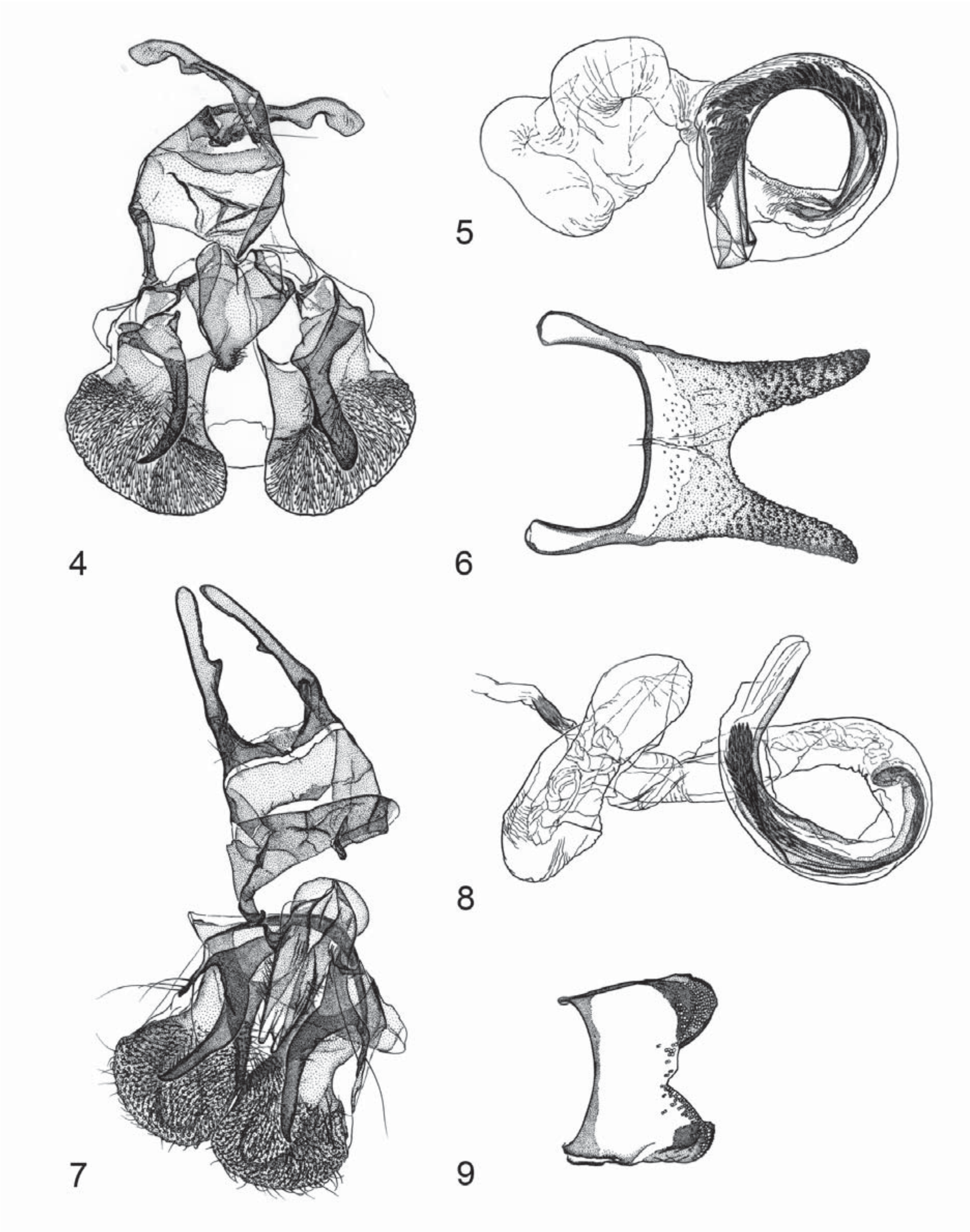
Syntomaula flavoangulata Adamski, **n. sp.**
(Figs. 3, 7–9, 11)

Diagnosis. *Syntomaula flavoangulata* is similar to *S. xanthofasciata* in facies but differs from the latter by having a more shallowly emarginate posterior margin of the eighth tergum, a narrower apical part of the dorsolateral processes of the tegumen of the genital capsule, a narrower apical part of the valva, less asymmetrically shaped basal processes of the valvae, a shorter part of the phallus with cornuti, a narrower membranous space between ventral parts of the eighth tergum in the female, and a less reticulated bulla and corpus bursae in the female.

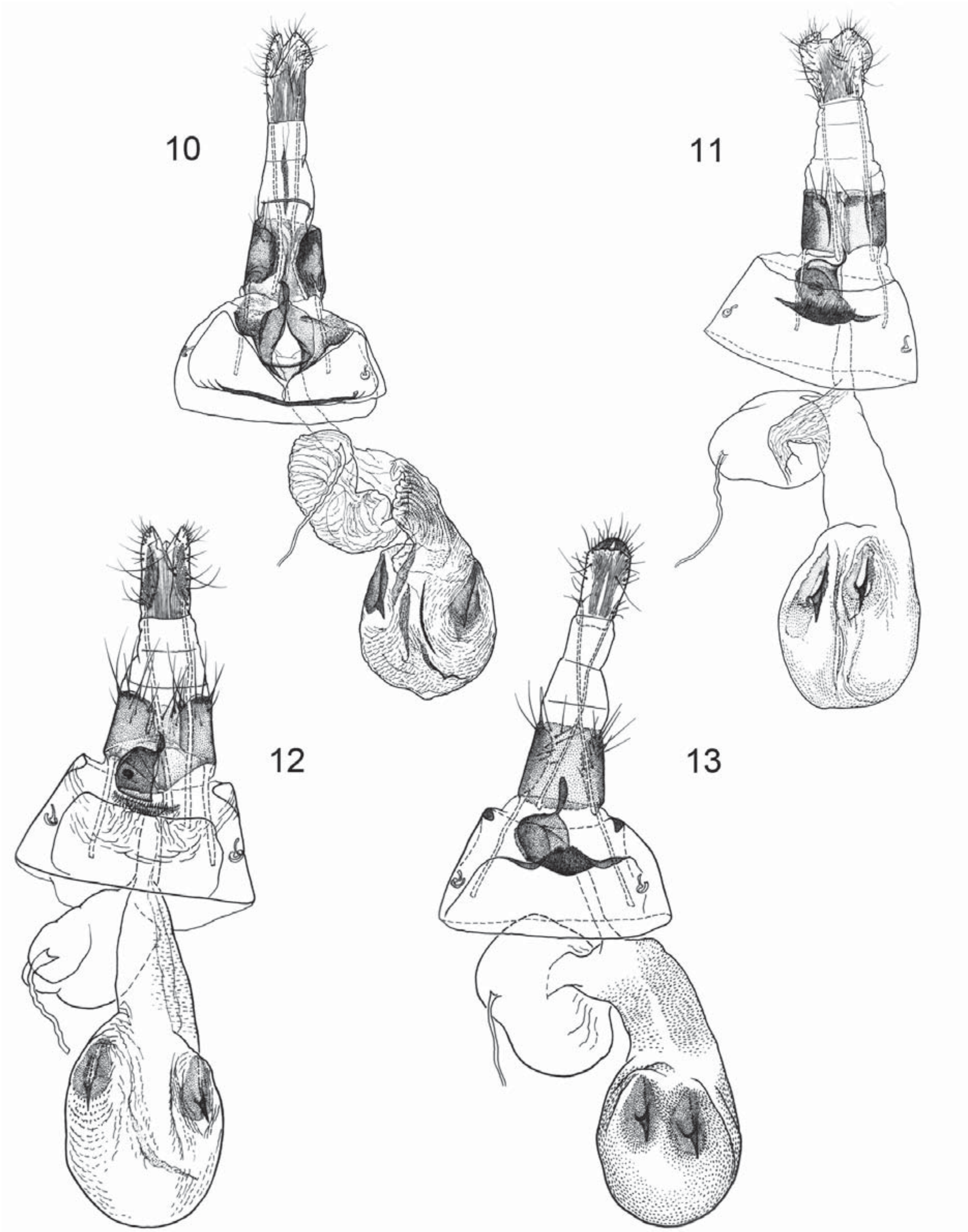
Description. *Head*: Vertex and frontoclypeus yellow; outer surface of labial palpus yellow except, basal segment pale brown, inner surface pale yellow; scape basal 1/3 flagellum brown, distal 2/3 pale brown; proboscis pale yellow.

Thorax: Tegula brown; mesonotum brown, demarcated posteriorly by a narrow, transverse, dark-brown band adjacent to a yellow-tufted, posterolateral margin. Femur and tibia of foreleg pale brown, brown, or with brown scales with distal margin pale brown; tarsomeres 1 and 4–5 dark brown on dorsal surface, pale yellow beneath, tarsomeres 3–4 pale yellow; basal 1/2 of midfemur pale yellow, distal 1/2 brown; midtibia as above except, with a suffused pale-yellow band near midlength; tarsomeres as above; femur and tibia of hindleg pale brown, tarsomeres pale yellow except, dorsal surfaces of tarsomeres 3–5 dark brown. Forewing (Fig. 3): Length 6.2–8.1 mm (n = 14), with a broad, median, and oblique, yellow band, juxtaposed basally by a brown fascia, extending anterodiagonally with 2–3 irregular crenulations to 1/3 costal length; median fascia juxtaposed distally at 2/3 length by a brown band; each band demarcated by a narrow row of dark-brown scales; submarginal and fringe scales with basal 1/2 pale brown, distal 1/2 brown. Undersurface brown, gradually darkening from midlength of radial and medial veins to submarginal line; radial and medial veins pale brown along subapical length, appearing as narrow streaks; area posterior to CuP pale yellowish brown. Venation similar to *S. xanthofasciata*. Hindwing as in *S. xanthofasciata*.

Abdomen (Fig. 9): with eighth tergum shallowly emarginate medioposteriorly forming two short posteriolateral lobelike extensions, and broadly emarginate anteriorly between two short lateral processes. **Male Genitalia** (Figs. 7–8): Tegumen with two elongate, opposable dorsolateral lobes; lobes nearly parallelsided from a widened base, each bearing a large toothlike process near 2/3 length. Vinculum broad, U-



FIGS. 4–9. Male genitalia and eighth tergum of *Syntomaula* spp. Figs. **4–6,** *S. xanthofasciata* Adamski (Holotype; USNM 84164). **4,** Genital capsule. **5,** Phallus. **6,** Eighth tergum. Figs. **7–9**, *S. flavoangulata* Adamski (Holotype; USNM 84167). **7,** Genital capsule. **8,** Phallus. **9,** Eighth tergum.



FIGS. 10–13. Female genitalia of *Syntomaula* spp. **10**, *S. xanthofasciata* Adamski (USNM 84165). **11,** *S. flavoangulata* Adamski (USNM 83532). Figs. **12–13,** Varients of *Syntomaula flavoangulata* or singletons of one or two additional *Syntomaula* (USNM 84168 and USNM 83533).

TABLE 1. Summary of specimen data.

Specimen	Species	Status	Sex	Genitalia Slide	Plant Number
USNM ENT 00659677	*xanthofasciata*	paratype	M		WP-3D-0734
USNM ENT 00659676	*xanthofasciata*	paratype	M		WP-3E-0807
USNM ENT 00697920	*xanthofasciata*	paratype	M		WP-3C-0663
USNM ENT 00659673	*xanthofasciata*	holotype	M	USNM 84164	WP-3D-0734
USNM ENT 00659674	*xanthofasciata*	paratype	F		WP-3D-0734
USNM ENT 00659671	*xanthofasciata*	paratype	F	USNM 84166	WP-3E-0807
USNM ENT 00659666	*xanthofasciata*	paratype	F		WP-3D-0734
USNM ENT 00659672	*xanthofasciata*	paratype	F	USNM 84165	WP-3D-0734
USNM ENT 00667632	*xanthofasciata*	paratype	M	USNM 83527	WP-5B-1122
USNM ENT 00669354	*xanthofasciata*	paratype	M		WP-5C-1098
USNM ENT 00667636	*xanthofasciata*	paratype	F	USNM 83520	WP-3A-574
USNM ENT 00697223	*flavoangulata*	paratype	F		WS-1Z-3445
USNM ENT 00659464	*flavoangulata*	holotype	M	USNM 84167	WS-4A-2163
USNM ENT 00667869	*flavoangulata*	paratype	M		WS-4A-2163
USNM ENT 00659467	*flavoangulata*	paratype	F	USNM 83534	WS-4A-2137
USNM ENT 00667861	*flavoangulata*	paratype	F	USNM 83509	WS-4A-2163
USNM ENT 00667822	*flavoangulata*	paratype	M	USNM 83507	WS-4A-2163
USNM ENT 00667853	*flavoangulata*	paratype	M	USNM 125655	WS-4A-2163
USNM ENT 00697222	*flavoangulata*	paratype	F		WS-1Z-3445
USNM ENT 00667857	*flavoangulata*	paratype	M	USNM 83506	WS-4A-2163
USNM ENT 00667806	*flavoangulata*	paratype	F	USNM 83535	WS-4A-2163
USNM ENT 00659466	*flavoangulata*	paratype	F		WS-4A-2163
USNM ENT 00659465	*flavoangulata*	paratype	F	USNM 83532	WS-4A-2163
USNM ENT 00667849	*flavoangulata*	paratype	F	USNM 83508	WS-4A-2163
USNM ENT 00667865	*flavoangulata*	paratype	F		WS-4A-2163
USNM ENT 00704492	BIN AAL8374	larva	-		WP-4W-0849
USNM ENT 00667894	BIN AAN2759	adult	F	USNM 84168	WS-4A-2163
USNM ENT 00667873	BIN AAN2760	adult	F	USNM 83533	WP-2D-0340
ZMA.INS.765353	BIN ACD3489	adult	?		
ZMA.INS.765354	BIN ACD3571	adult	?		

TABLE 1. Summary of specimen data.(continued)

Plant species	Date	Genbank	Locality	Lat	Lon	Elev
Neonauclea obversifolia	23-Jan-2007	HQ946816	Wanang	-5.25	145.27	115
Neonauclea obversifolia	24-Oct-2006	HQ946814	Wanang	-5.25	145.27	115
Neonauclea obversifolia	23-Apr-2007	HQ946813	Wanang	-5.25	145.27	115
Neonauclea obversifolia	23-Jan-2007	HQ946812	Wanang	-5.25	145.27	115
Neonauclea obversifolia	23-Jan-2007	HQ946822	Wanang	-5.25	145.27	115
Neonauclea obversifolia	24-Oct-2006	HQ946820	Wanang	-5.25	145.27	115
Neonauclea obversifolia	23-Jan-2007	HQ946823	Wanang	-5.25	145.27	115
Neonauclea obversifolia	23-Jan-2007	HQ946825	Wanang	-5.25	145.27	115
Neonauclea obversifolia	09-Oct-2007	HM900661	Wanang	-5.25	145.27	115
Neonauclea obversifolia	20-Jun-2007	HQ946815	Wanang	-5.25	145.27	115
Neonauclea obversifolia	14-Jul-2007	JF847961	Wanang	-5.25	145.27	115
Uncaria caudata	30-Apr-2008	HQ946818	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946827	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946832	Wanang	-5.25	145.27	115
Amomum aculeatum	12-May-2006	HQ946830	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946828	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HM900663	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HM900664	Wanang	-5.25	145.27	115
Uncaria cordata	30-Apr-2008	HQ946826	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HM900662	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946833	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946819	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946829	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946817	Wanang	-5.25	145.27	115
Uncaria appendiculata	12-May-2006	HQ946824	Wanang	-5.25	145.27	115
Neonauclea obversifolia	28-Oct-2006	HM906298	Wanang	-5.231	145.182	100
Uncaria appendiculata	12-May-2006	HQ946821	Wanang	-5.25	145.27	115
Uncaria appendiculata	08-Aug-2006	HQ946831	Wanang	-5.25	145.27	115
	19-Nov-2011	KR736046	Maripi	-0.91667	133.967	112
	26-Oct-2008	KR736047	Lelambo	-4.01667	139.783	900

shaped (not shown). Valvae slightly asymmetrical, basally parallelsided, apically subtrapezoidal; base of valvae bearing from base a large, subequal forklike process, inner part much larger than outer part; inner part setose. Juxta thin, apically rounded, setose. Phallus bulbous basally, produced into a tubular, single-coiled apical process; vesica with many imbricate cornuti in a wide row about as long as 1/5 length of tubular part. **Female Genitalia** (Fig. 11): Papillae anales lobelike, setose. Ovipositor telescopic with 3 membranous subdivisions; apophysis posterioris about 2X length of apophysis anterioris. Eighth segment ringlike extending ventrally, forming two free, closely opposable parts. Ostium demarcated by a widened, twisted rim with a posteriorly produced broadly produced, narrow process, within membrane, posterior to entire, seventh sternum. Seventh sternum with a densely setose elongate ridge on posterior 1/3. Ductus bursae smooth, dilated near posterior end of corpus bursae, forming a large bulla; inception of ductus seminalis on posterior end of bulla. Corpus bursae, gradually widening from posterior end to near 1/2 length, ovoid and finely reticulate on anterior end, with two opposable subequal signa; signa elongate, wider anteriorly than posteriorly, each with a mesolongitudinal ridge, produced into a single spinelike process on anterior end.

Holotype ♂, "Papua New Guinea, Madang Province, Wanang Village, 05°15'S, 145°16'E"; "Manumbor, Sau, Isua, Mogia, Sosanika, Idigel, Keltim, Kua, Bito"; "Sp. 125, WS-4A-2163 [*Uncaria appendiculata* Benth. (Rubiaceae)], CATX 263, 12 May 2006"; "USNMENT: PNG, Madang Ecology Project, 00659464"; "♂ Genitalia Slide by DA, USNM 84167"; "DNA" [USNM].

Paratypes (4 ♂, 9 ♀): 2 ♂, 4 ♀, same data as holotype except, "00667857"; "♂ Genitalia Slide by DA, USNM 83506"; "00667869", [*Uncaria appendiculata* [specimen not dissected]; "00659465", "♀ Genitalia Slide by DA, USNM 83532"; "00659467", [ex. *Amomum aculeatum* Roxb. (Zingiberaceae)]; "♀ Genitalia Slide by DA, USNM 83534"; "00667865", "00659466" [ex. *Uncaria appendiculata*]; [specimens not dissected]; 2 ♀, same data as above except, "WS-1Z-3447, CATX 0469, 30 Apr[il] 2008", "00697222", "00697223", [ex. *Uncaria cordata* (Lour.) Merr. (Rubiaceae)]; [specimens not dissected]; 2 ♂, 3 ♀, same data as above except, "Auga, Molem, Tamtiai, Lilip, Ibalim, Posman, Rimandai, Brus, Novotny, Hrcek"; "00667822"; [ex. *Uncaria appendiculata*]; "♂ Genitalia Slide by DA, USNM 83507"; "00667853"; [ex. *Uncaria appendiculata*]; "♂ Genitalia Slide by LEH, USNM 125655"; "00667849"; [ex. *U. appendiculata*]; "♀ Genitalia Slide by DA, USNM 83508"; "00667861"; [ex. *Uncaria appendiculata*]; "♀ Genitalia Slide by DA, USNM 83509"; "00667806"; [ex. *Uncaria appendiculata*]; "♀ Genitalia Slide by DA, USNM 83535."

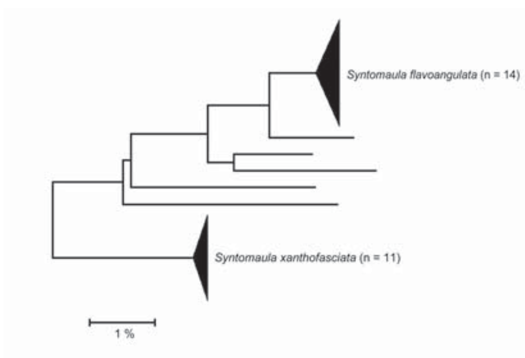


FIG. 14. A compressed subtree sequence data of *Syntomaula xanthofasciata* Adamski and *S. flavoangulata* Adamski taken from 25 samples, and *Syntomaula* spp. taken from 5 samples of 4 adults and one larva based upon neighbor-joining analysis. Subtrees are compressed into triangles with a vertical scale of 10 pixels per specimen; the horizontal scale corresponds to divergence. Two female specimens (HQ946821 and HQ946831) are very similar morphologically to the above described species. They are illustrated in Figs. 12–13.

Etymology. The species epithet, *flavoangulata*, is a compound word formed from the Latin *flavus* meaning yellow and the Latin *angulatus* meaning angled, referring to the large angular median yellow band of the forewing.

Biology. Most specimens of *Syntomaula flavoangulata* have been reared from *Uncaria appendiculata*, but it has also been reared twice from *U. cordata* (Lour.) Merr. (Rubiaceae), and once from *Amomum aculeatum* Roxb. (Zingiberaceae). The *Amomum* record may be a mistake.

Remarks: Macromorphological evidence is corroborated by a compressed subtree of DNA sequence data (Fig. 14), showing over a 1 per cent difference between samples of *Syntomaula xanthofasciata* and *S. flavoangulata*, in addition to other *Syntomaula* spp. (see Table 1).

DISCUSSION

Forewing coloration and mimicry

Syntomaula xanthofasciata and *S. flavoangulata* have a distinctive forewing color pattern shared by many other small moths of New Guinea. This pattern is characterized by the upper side of the forewing having the distal 1/3–1/2 brown, and the basal 2/3–1/2 yellow or orange, and most of the body brown. Some species have the base of the forewing brown. The hindwing is usually brown, although it can be paler in some species. In addition to Cosmopterigidae (*Syntomaula*), we have observed this color pattern in at least four other moth families:

Erebidae: Arctiinae: Lithosiini: Many species in many genera, not listed here because the generic concepts need revision, but examples are illustrated in Draudt (1914). *Trischalis splendens* de Vos and van Mastrigt (2007) is a recently described species that appears to fit this pattern.

Oecophoridae: Stathmopodinae: Several species in the genus *Stathmopoda*, including *Stathmopoda aurifera* Walker (Robinson et al. 1994:55), which may be a species complex (Miller et al. 2014).

Tineidae: Several species of the genus *Edosa* (Perissomasticinae), see Robinson 2008:320, 366; 2009: Figs. 287–288, and several species of the genus *Opogona* (Hieroxestinae), see Robinson and Tuck (1997).

Tortricidae: Olethreutinae: Several species of *Loboschiza*, including *Loboschiza mediana* (Walker) (Horak 2006:266), and an unidentified *Loboschiza* also reared at Wanang (project morphospecies TORT204).

Some species of *Idiophantis* (Gelechiidae: Anacampsinae) are similar in pattern, although the basal brown coloration is more dominant than the distal brown coloration. These include *Idiophantis thiopeda* Meyrick, *Idiophantis pandata* Bradley (1961: pl. 5, fig. 13), and *Idiophantis* n. sp. (project morphospecies XXXX124).

We suspect that this yellow and brown pattern in moths may be mimicry of Chrysomelidae that may be distasteful. When the wings of these moths are closed at rest, the patterns resemble those of some beetles, and some of the moths even fold the angles of the wings to yield a more oval (beetle-like) shape when at rest. Chrysomelidae with similar patterns in New Guinea include members of three subfamilies (some illustrated in Gressitt and Hornabrook 1977): Chrysomelinae: *Promechus* species (Gressitt and Hart 1974); Galerucinae: *Aulacophora* species such as *Aulacophora pallidifasciata* Jacoby (Gressitt and Hornabrook 1977:62); and Hispinae: *Hispodona chapuisi* Gestri (Gressitt and Samuelson 1988), *Callistola* species (Gressitt 1960), and *Promecotheca* species. While collecting on flowers at Wau in 1983, Miller (unpublished) netted what he thought was a microlepidopteran, and it turned out to be a chrysomelid, so evidently vertebrates can be tricked by these color patterns. Mimetic relationships between beetles and moths have been described elsewhere by Linsley et al. (1961) and Balsbaugh and Fauske (1991).

Meyrick (1938: 503) and Diakonoff (1955: 183; 1956) have commented on the frequent occurrence in New Guinea of moths with a white ground color and black markings of particular patterns, and suggested that it could have a protective function, but we are not aware of previous discussion of the yellow and brown color pattern in New Guinea.

The yellow and brown color pattern appears to be a subset of the "*Damias* type" of mimetic pattern characterized by Holloway (1984) and Yen et al. (2005:198) by "several large bright colour patches (red, yellow, white) with black or white background colour." In New Guinea we have also found a pattern of red, yellow, and black in a new genus of Oecophorinae (reared as morphospecies TORT144, being described by Vitor Becker, Scott Miller and Shen-horn Yen), a new species of *Lactura* (Lacturidae), *Spoladea mimetica* Munroe (illustrated by Munroe 1974:23; Crambidae: Spilomelinae), and *Bursadella anticeros* (Meyrick) and *B. proceros* (Meyrick) (illustrated by Clarke 1969:103, 148; Immidae). This pattern differs from that in our two new *Syntomaula* by including red, and the moths are often larger. Beetle models have not yet been associated with the mimetic pattern that includes red, although similar chyrsomelid beetles are a possibility.

Related species

We have two reared females that appear, based on DNA and genitalia, to be additional undescribed species, but we refrain from describing them based on single females, because they may represent variation. One is specimen USNM ENT 00667894, genitalia slide 84168 (figure 12) and the other is USNM ENT 00667873, genitalia 83533 (figure 13), both reared from *Uncaria appendiculata.*

We are also aware of three additional specimens with unique DNA sequences that might also represent undescribed species. One is known only from a larva collected on *Neonauclea obversifolia* (Rubiaceae) (plant WP4E0849) at Wanang, specimen USNM ENT 00704492, our morphospecies CATX469 (Miller et al., 2013), Genbank accession HM906298. The other two are specimens collected at light in Indonesian New Guinea, now in the Naturalis Biodiversity Center, Leiden. We have seen images of the wings, but have not examined the genitalia. They are ZMA INS 765354 from Lelambo, Jayawijaya Mountains, and ZMA INS 765353 from Maripi, Arfak Mountains (Genbank accessions KR736047 and KR736046).

ACKNOWLEDGMENTS

Field work at Wanang was supported by US National Science Foundation grants DEB 0211591 and 0515678. Field assistance was provided by the Binatang Research Center parataxonomist team and the people of Wanang Village. George Weiblen and Tim Whitfeld identified host plants. DNA barcodes were provided by Paul Hebert, Biodiversity Institute of Ontario, with funding from Genome Canada. Miller first noticed the yellow-brown color pattern on a trip to Wau Ecology Institute, Papua New Guinea in 1983, supported by the Bache Fund and Smithsonian Institution. G. Allen Samuelson, Bishop Museum, provided advice on beetles.

We thank Klaus Sattler, Natural History Museum, London, for his assistance with the generic placement of the study specimens; Kevin Tuck, Natural History Museum, for the loan of additional specimens of *Syntomaula*; Rob de Vos, Naturalis, for access to data on additional *Syntomaula* specimens; Karolyn Darrow, Lauren Helgen, and Margaret Rosati, National Museum of Natural History, for expert assistance; and Kuniko Arakawa, Mizukino Moriya-shi, Japan, for the male and female illustrations.

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Submitted for Publication 19 February 2015; revised and accepted 30 April 2015.