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A New Subspecies of Hawkmoth from Lanyu, Taiwan, with a Revised and Annotated Checklist of the Taiwanese Sphingidae (Lepidoptera)

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Shen-Horn Yen, Ian J. Kitching and Chao-Shian Tzen (2003) A new subspecies of hawkmoth from Lanyu, Taiwan, with a revised and annotated checklist of the Taiwanese Sphingidae (Lepidoptera). *Zoological Studies* **42**(2): 292-306. "*Macroglossum lanyuana* Chen" was first recorded from Lanyu (Orchid Island), Taiwan, in 1994, but this manuscript name has not been made available under the International Code of Zoological Nomenclature. We herein describe this taxon as *Macroglossum ungues cheni* ssp. nov. The relationships and biogeography of *M. ungues* Rothschild and Jordan, 1903 are discussed. The occurrence of *M. ungues cheni* on Lanyu corroborates geological evidence for the origin of the island. We also present an annotated checklist of the Taiwanese Sphingidae as an update to the *Lepidoptera* of Taiwan published in 1992.
http://www.sinica.edu.tw/zool/zoolstud/42.2/292.pdf

Key words: Biogeography, Neo-Wallace's Line, Peripheral population.

Hawkmoths (Sphingidae) are one of the few lepidopteran groups to have been well inventoried and documented on every continent (Kitching and Cadiou 2000). Backed by a wealth of information on their biology, life histories, and morphology, the Sphingidae have played significant roles in a variety of research programs. Examples include pollination biology (Inoue 1986, Kato et al. 1991, Willmott and Burquez 1996, Maad 2000, Ando et al. 2001), biogeography (Holloway 1983), and conservation biology (Holloway 1991, Kitching 1996). The sphingid fauna of Taiwan is relatively diverse and has received much attention from heterocerists since the late 19th century. Among those works on Taiwanese sphingids, the thesis of Chen (1994), in which he revised all the recorded taxa in Taiwan, is one of the most recent and comprehensive contributions to our knowledge of this family. In this thesis, Chen described a new species "*Macroglossum lanyuana*" from Lanyu, a small island about 62 km off the southeastern coast of Taiwan. Although this name has been used subsequently by several authors (e.g., Li et al. 1998, Lin 1999, Chang 2001), it is a manuscript name that is not yet available under the rules of the International Code of Zoological Nomenclature. Therefore, it is necessary to formally describe and name this new taxon. We consider that it is best treated as a subspecies of *Macroglossum ungues* Rothschild and Jordan, 1903 and describe it as *Macroglossum ungues cheni* ssp. nov. We also discuss its systematic position within *Macroglossum* as well as the relationships and biogeography of the species-group to which it belongs. In addition, as an update to the information published in the *Lepidoptera* of Taiwan (Inoue and Lin 1992), we also provide a revised and annotated checklist (see Appendix II), incorporating current opinions on sphingid systematics and elucidating all outstanding identification problems relating to the Taiwanese fauna.

MATERIALS AND METHODS

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Adults were usually collected during the day by hand netting or occasionally at night by the use of mercury-vapor and ultraviolet lights. Moths were placed individually into small plastic or glass vials and kept alive in dark and, if possible, cool conditions to reduce their activity, until they were either prepared as specimens or used in rearing experiments. Genitalia were prepared following the general method described by Holloway et al. (1987). Morphological terminology follows Common (1990) for wing venation, Kitching and Cadiou (2000) for wing pattern, and Klots (1970) for genitalia. All illustrations were made using a camera lucida attached to a dissecting microscope (Olympus SZ60). All specimens examined were photographed before dissection. Distribution data were extracted from the following sources: Semper (1896-1902), Rothschild and Jordan (1903), Mell (1922), Dupont and Roepke (1941), Inoue (1973), Chu and Wang (1980 1983), Diehl (1982), Lin (1987 1989 1990 1993 1999), Chen and Yang (1987), Chen et al. (1993), Kishida and Shirakawa (1988), Chang (1989), Tennent (1992), Chen (1994), Kitching and Spitzer (1995), Hogenes and Treadaway (1998), Chao (1999), and Chao et al. (1999). Type specimens are deposited in The Natural History Museum, London, UK (BMNH), the National Museum of Natural Sciences, Taichung, Taiwan (NMNS), and the private collections of Chao-Hsiang Tzen, Taipei, Taiwan (CSTC) and Shen-Horn Yen, Taipei (SHYC). Additional specimens of other species were examined at the Taiwan Forestry Research Institute, Taipei, Taiwan (TFRI), Department of Entomology, National Taiwan University (NTU), and Zoologisches Museum für Naturkunde, Humboldt Universitat, Berlin, Germany (ZMHB).

SYSTEMATIC ACCOUNT

Macroglossum ungues cheni **ssp. nov.**

(Figs. 1a-d, 2a-b, g, 3a-b, 4a-c)

Macroglossum lanyuana Chen, 1994, unpublished manuscript name; Li et al. 1998: 84; Lin 1999: 64; Chang 2001: 372.

Diagnosis: *Macroglossum ungues cheni* differs from the nominotypical subspecies (Fig. 1e-h) primarily in the narrower black marginal band of the hindwing upperside, the extreme reduction of the basal black patch on the hindwing upperside, and the extensive yellow coloration on the hindwing underside. In some specimens of *M. u. ungues*, the basal patch can be reduced in size (in 8 of 56 specimens examined in the BMNH), whereas in others, the underside of the hindwing has a scattering of yellow scales over much of its surface. However, the marginal band is always broad and well developed, with no yellow scaling along the veins. In addition, there are subtle differences in the genitalia. The nominotypical subspecies differs in that the smooth posterior process on the end of the aedeagus is longer and apically slightly recurved posteriorly. Furthermore, the serrate anterior process bears several small teeth basally (Fig. 3c-d), rather than a blunt process (Fig. 3a-b), and the corpus bursae are slightly shorter (Fig. 4d-f). Because the observed differences in genitalia of the Lanyu population are so slight, we consider it to be a subspecies of *M. ungues*, albeit one with a very distinctive color pattern.

Description: Male (Fig. 1a-b). Right forewing length (RFWL): 17-18.5 mm (*n* = 7). Upperside: head, thorax, abdomen and forewings as *M. u. ungues* (Fig. 1e-f). Hindwing with orange-yellow median band extending to wing base; black basal patch very reduced, present only as a narrow band of yellowish brown scales along vein Cu as far as origin of CuA2 and as a very small patch at base of 1A; black marginal band 1/2 as wide as in *M. u. ungues* (2 mm at M2), running to anal wing edge at vein 1A, not distinctly delimited basally with yellow intruding along veins to 1/2 its width. Underside: head, thorax, abdomen, and forewings as in *M. u. ungues*, but with yellow scaling along radial vein and in discal cell. Hindwing with yellow anal patch extended anteriorly across basal 2/3 of wing, obliterating normal pattern of 3 brown transverse lines; dark brown marginal band as on upperside but paler and grayer. Female (Fig. 1c-d): As male but larger, RFWL = 18-20 mm (*n* = 9).

Male genitalia and abdominal segment 8 (Fig. 2a-b, g). Very similar to *M. u. ungues* (Fig. 2c-d, h). Uncus and gnathos truncate; valve somewhat elongate, with rounded apex; stridulatory scales absent; harpe long and needle-like, not reaching apex of valve; transtilla present, weakly linked at middle; fultura superior (dorsal part of manica) setose; juxta somewhat semicircular with upper margin slightly emarginate; apex of aedeagus on right side with 2 curved, sclerotized processes; posterior process short, smooth, acutely pointed, directed dorsally at right angles to longitudinal axis of aedeagus; anterior process longer, recurved somewhat over dorsal surface of aedeagus towards left side, tapering to a fine point, margins

Fig. 1. Adult *Macroglossum* species. (a) *M. ungues cheni*, ♂, holotype, upperside, NMNS; (b) ditto, underside; (c) *M. ungues cheni*, ♀, paratype, upperside, NMNS; (d) ditto, underside; (e) *M. ungues ungues*, ♂, upperside, BMNH; (f) ditto, underside; (g) *M. ungues ungues*, ♀, upperside, BMNH; (h) ditto, underside; (i) *M. sitiene*, ♂, upperside, BMNH; (j) ditto, underside; (k) *M. sitiene*, ♀, upperside, BMNH; (l) ditto, underside; (m) *M. insipida*, "C. Formosa, Suishako", BMNH, upperside; (n) ditto, underside; (o) *M. insipida*, holotype, BMNH, upperside; (p) ditto, underside; (q) *M. sylvia*, Thailand, BMNH, upperside; (r) ditto, underside; (s) *M. sylvia*, "Formosa" (ex Felder Collection), BMNH, upperside; (t) ditto, underside. Scale bar = 10 mm.

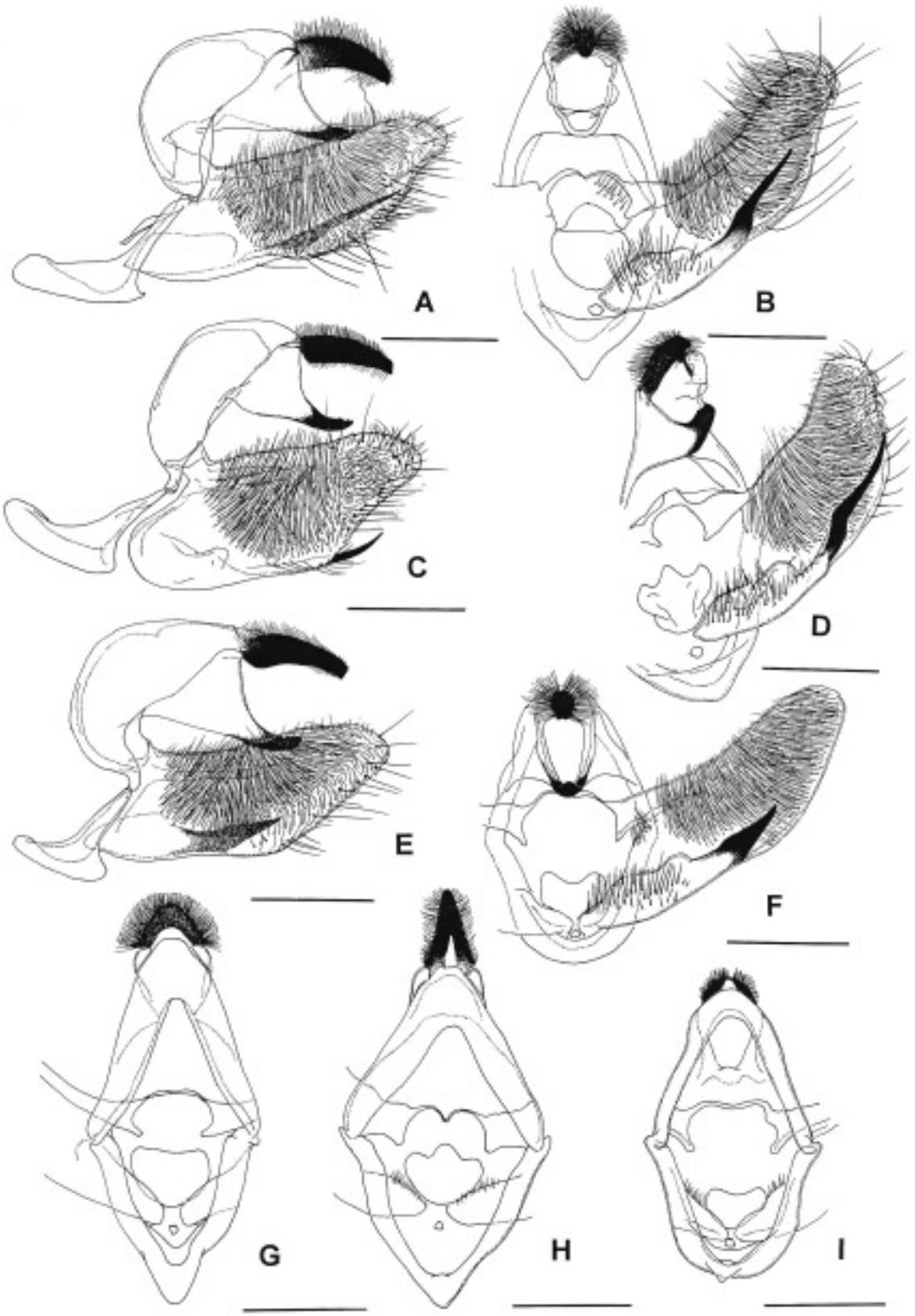

Fig. 2. Male genitalia of *Macroglossum* species. (a, c, e) Lateral view; (b, d, f) Postero-ventral view; (g, h, i) antero-dorsal view; (a, b, g) *M. ungues cheni*; (c, d, h) *M. ungues ungues*; (e, f, i) *M. sitiene*. Scale bar = 1.25 mm.

serrate, with a posterior blunt basal tooth; vesica directed to left; on its ventral surface is a long, thin, sclerotized bar, the right end of which is produced into a short, curved, acutely pointed cornutus; posterolateral surface of vesica produced into a long, ventrally directed, membranous sac, apically bearing a long, straight, sharply pointed cornutus.

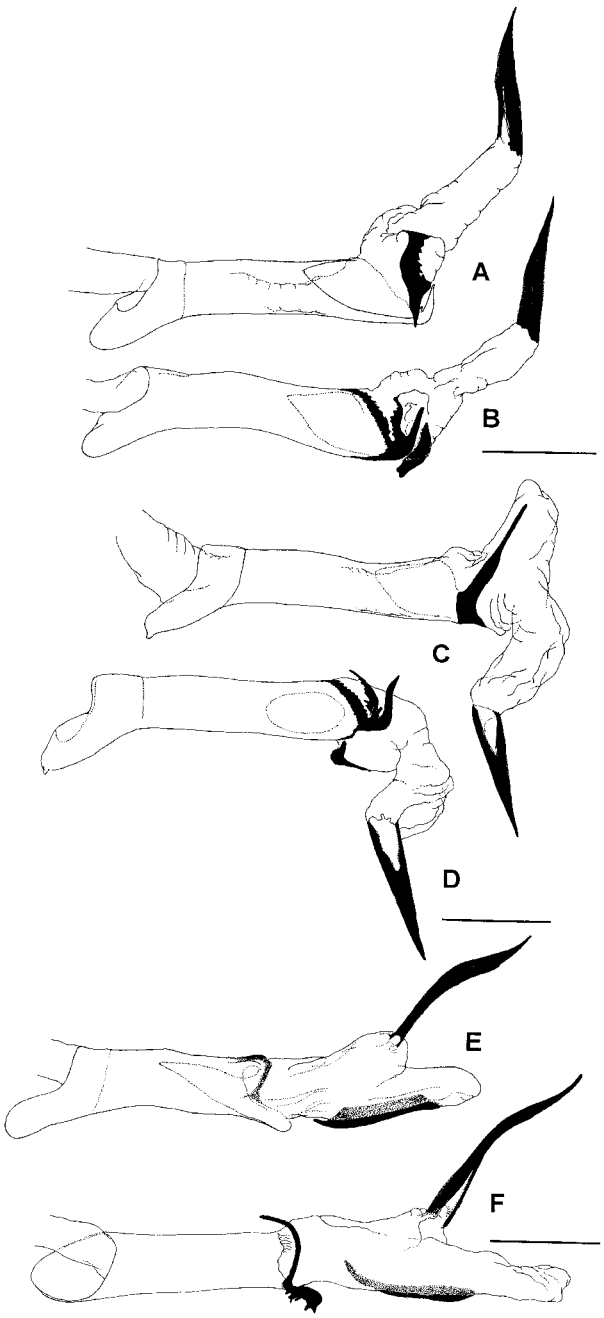

Fig. 3. Aedeagus of *Macroglossum* species. (a, c, e) Left side; (b, d, f) right side; (a, b) *M. ungues cheni*; (c, d) *M. ungues ungues*; (e, f) *M. sitiene*. Scale bar = 1.25 mm.

Female genitalia (Fig. 4a-c). Identical to *M. u. ungues* (Fig. 4d-f). Lamella post-vaginalis narrow, crescentic, connected to convex dorsal edge of antrum medially, laterally produced into thin bars that form the ventral part of anterior apophyses; antrum heavily sclerotized, about twice as long as broad, entrance open, ventral posterior margin shallowly concave, anterior margin with a dorsal invagination appearing in ventral view as a notch; ductus bursae very short, broadly connecting antrum to corpus bursae; corpus bursae elongate, essentially rectangular but broadly rounded anteriorly; signum elongate, posteriorly slightly bifurcate, anteriorly rounded, about 1/2 as long as corpus bursae; corpus bursae ventrally, membranous pleats running longitudinally from ductus bursae and curving around signum anteriorly; dorsally, pleats forming a shallow oval pouch, narrow end of this anteriorly directed and V-shaped.

Type series: Holotype: ♂, Taiwan, Taitung County, Lanyu, Yeongshing [Farm], 13 Nov. 1990 (HY Wang), NMNS (no. 1282-29387 ex BS Chang Collection). Paratypes: 1 ♂, Lighthouse, 9 Oct. 1990 (HY Wang), NMNS (1282-29373, genitalia dissected and pinned with specimen by YH Chen); 1 ♀, Lanyu, 16 June 1990 (HY Wang), NMNS (1282-29211 ex BS Chang Collection); 1 ♂, 1 ♀, Yeongshing Farm, 30 Aug. 1990 (HY Wang), NMNS (1282-29077/genitalia slide no. Yensphingid043 and 1282-29085, ex BS Chang Collection); 3 ♀♀, Weather Station, 31 Dec. 1990 (HY Wang), NMNS (1282-29251, 1282-29440/genitalia slide no. Yensphingid044 and 1282-29469, ex BS Chang Collection); 2 ♀♀, Yeongshing Farm, 15 Nov. 1990 (HY Wang), NMNS (1282-29456 and 1282-29219, ex BS Chang Collection); 3 ♂♂, 1 ♀, Lanyu, 10 Oct. 1988 (CS Tzen), CSTC; 1♀, Lanyu, 1 Sept. 1988 (CST), CSTC; 2 ♂♂, 1 ♀, Lanyu, Lantao, 2 Sept. 1988 (CS Tzen), BMNH (ex CSTC); 1 ♀, Longmen Bridge, 23 July 1993 (SH Yen), SHYC.

Distribution: Known only from Lanyu, Taiwan (Fig. 5).

Etymology: This new subspecies is named after Dr. Yuen-Hong Chen (Institute of Biomedical Sciences, Academia Sinica, Taipei).

Biology: Our observations on Lanyu since 1988 show that adults of *M. u. cheni* are usually active during the day from 06:00 to 18:00, and are also attracted to light at night. They usually fly fast along the margins or above the canopy of coastal forests. The observed nectar sources are *Stachy-*

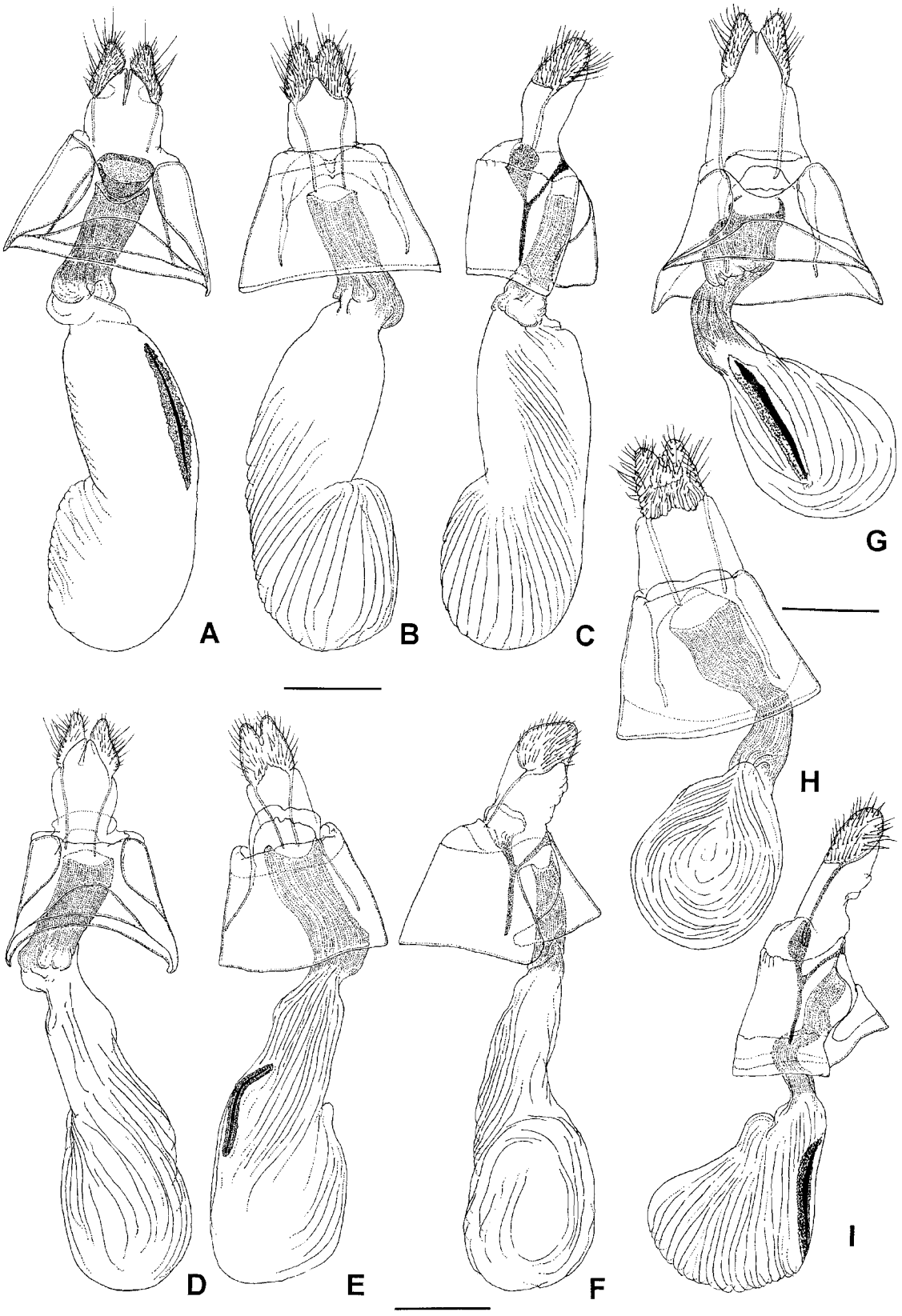

Fig. 4. Female genitalia of *Macroglossum* species. (a, d, g) Ventral view; (b, e, h) dorsal view; (c, f, i) lateral view. (a-c) *M. ungues cheni*; (d-f) *M. ungues ungues*; (g-i) *M. sitiene*. Scale bar = 2.5 mm.

tarpheta jamaicensis (L.) Vahl., *Clerodendrum inerme* (L.) Gaertn. (both Verbenaceae), *Nothapodytes foetida* (Wight) Sleumer (Icacinaceae), *Cerbera manghas* L. (Apocynaceae), *Peucedanum japonicum* Thumb. (Apiaceae) (Chen, 1994), *Tetrastigma lanyuensis* Chang (Vitaceae), *Ehretia philippinensis* A. DC. (Boraginaceae), *Aglaia chittagonga* Miq. (Meliaceae), *Rourea minor* (Gaertn.) Leenhouts (Connaraceae), and *Capparis lanceolaris* DC. (Capparidaceae) (SH Yen, pers. obs.).

The 3rd author has reared larvae on several occasions. We confirm that the larval host plant is *Paederia scandens* (Lour.) Merr. *var. mairei* (Lev.) Hara (Rubiaceae). This plant is widespread throughout Lanyu and is shared with at least 3 other sphingid species, *Neogurelca hyas* (Walker, 1856) (=*Aspledon hyas*), *M. pyrrhosticta* Butler, 1875, and *M. corythus luteata* Butler (Chen 1994, Lin 1999). It is also utilized by *M. sitiene* Walker, 1856 on the main island of Taiwan (Chen 1994). Unlike *M. sitiene* (see Sen and Fan 2001: 60-61), larvae of *M. u. cheni* are not polymorphic but have only a single green color form. The known flight season based on collecting data ranges throughout the entire year except for Jan. to Mar., and thus *M. ungues cheni* is probably multivoltine.

DISCUSSION

Relationships of *Macroglossum ungues*

Many of the 87 described species of *Macroglossum* share very similar color patterns, and misidentifications based solely on this criterion are, unfortunately, very frequent (Inoue et al. 1996). For example, Diehl (1982) purported to give color pattern differences to differentiate *Macroglossum corythus* Walker (1856) from *M. sylvia* Boisduval (1875). However, these features do not hold (Holloway 1987, Tennent 1992) and both specimens he illustrated appear to be *M. corythus*. Fortunately, most *Macroglossum* species have distinctive male genitalia that make identification a simple task (Rothschild and Jordan 1903, Holloway 1987, Tennent 1992, Inoue et al. 1996), although distinguishing features may be restricted to the everted vesica. However, there are few characters that can be used to recognize monophyletic species-groups, and relationships within the genus remain very poorly understood.

As stated by Kitching and Cadiou (2000), Rothschild and Jordan (1903: 644) conjectured that "it is possible that further material of

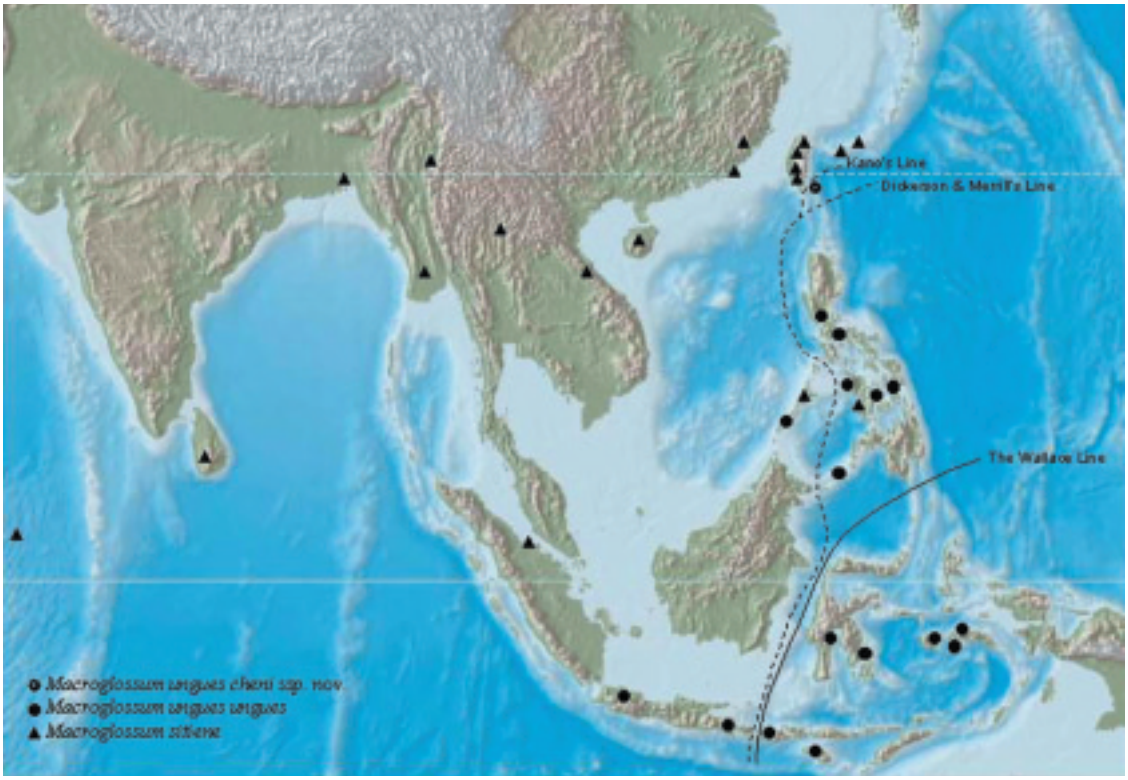

Fig. 5. Distribution map of *Macroglossum ungues cheni* and its allies.

Macroglossum from the larger Sunda Islands will prove *ungues* and *sitiene* (Figs. 1i-l, 2e-f, i, 3e-f, 4g-i) to be forms of the same species". We examined the male genitalia of specimens of *M. sitiene* and *M. ungues* from various localities (see Appendix I). We found that although the harpe of *M. sitiene* is thin and needle-like (Fig. 2e-f, i), it is much shorter than that in *M. ungues* (Rothschild and Jordan 1903: pl. 51, fig. 12). In addition, although the apex of the aedeagus in *M. sitiene* bears 2 processes, the posterior process is very short with a bifurcate tip and has teeth along the inner margin, while the anterior process is unadorned and forms an extremely long, thin hook. These differences are consistent between the 2 species, and thus we cannot concur with Rothschild and Jordan that *M. sitiene* and *M. ungues* are conspecific. However, the double structure of the apical processes of the aedeagus is not yet known in any other *Macroglossum* and is probably a synapomorphy of the 2 species (Holloway 1987).

The needle-like harpe is also present in *M. semifasciata* Hampson, [1893], *M. affictitia* Butler, 1875, *M. gyrans* Walker, 1856 and *M. corythus* Walker, 1856, but their larval morphology and wing patterns do not suggest a close relationship with either *M. ungues* or *M. sitiene*. In addition, *M. limata* Swinhoe, 1892 (=*M. pseudungues* Holloway, 1987), *M. insipida* Butler, 1875 (=*M. troglodytus* Boisduval, [1875]), and *M. alcedo* Boisduval, 1832 are very similar to *M. ungues* and *M. sitiene* in wing pattern, but their genital structures do not suggest an affinity.

Biogeography of *M. ungues*

Macroglossum sitiene is in general a larger species than *M. ungues*. The former is found throughout mainland Southeast Asia, from Sri Lanka, north to Assam, then east through Myanmar, Thailand, Vietnam, SE China (Hainan, Guangdong), and Hong Kong to the main island of Taiwan and the Yayeyama Islands of Japan, and also south through the Tenasserim to northwestern Sumatra (Sumatera Utara). The species is not yet known from Borneo, although it has been taken on Palawan, Dumaran, and Negros (Hogenes and Treadaway 1998). Records of *M. sitiene* from Java (Dupont and Roepke 1941, pl. 20, fig. 1) are misidentifications of *M. ungues* (Kitching and Cadiou 2000). In contrast, *M. ungues* occurs from Java, eastwards through the Lesser Sunda Islands to South Maluku, and northwards through Sulawesi to the Philippine islands of Luzon, Leyte, Marinduque, Cebu, Jolo, Panay, and Dumaran (Semper 1896-1902 but misidentified as *M. sitiene*, Inoue 1996, Hogenes and Treadaway 1998). The subspecies *M. u. cheni* on Lanyu may represent the northernmost peripheral population of *M. ungues*. The distributions of *M. ungues* and *M. sitiene* are shown in figure 5.

Lanyu (also known as Lanhsu, Orchid I., Hongtouyu, Kotosho, and Botel Tobago) is volcanic in origin, with some limestone and coral (Richard et al. 1986). It forms part of the northern extension of the Luzon volcanic arc (Ho 1988), which runs from Luzon to Taiwan, and also includes the Babuyan and Batan Islands, Lutao (Green I., Samasana I.) and the Eastern Coastal Range of Taiwan. This arc is the result of a collision between the Philippine Sea plate and the Eurasian continental margin. Although some rocks on Lanyu have been dated as being more than 25 million years old, most of the island is less than 5 million years old (Richard et al. 1986) and the volcanism that gave rise to Lanyu is of Miocene-Pliocene age (Pelletier and Stephan 1986).

The geological association of Lanyu with the Philippines is corroborated by biogeographical evidence. The flora of Lanyu has more in common with the Philippines than with Taiwan (Chang 1981), while in pachyrrhynchine weevils, and some butterflies and spiders, there is disjunction between Lanyu and Taiwan, with the former possessing Filipino elements in its fauna (Kano 1929 1931a b, Yoshida et al. 2000). On this basis, Kano (1933 1935a b 1936) proposed Neo-Wallace's Line by extending the boundary of Dickerson and Merrill's Line (Dickerson et al. 1928) from northern Luzon to Lanyu through the Bashi Channel, which separates Taiwan from the Philippines. However, Chang (1981) considered that the generic-level distribution knots and distribution type spectra of the woody floras among Taiwan, Lanyu, and Luzon do not support this extended biogeographic line.

Lin (1989 1999) attempted to analyze the sphingid fauna of Lanyu and compare the faunistic similarity with adjacent areas. In 1989, he reported 14 species of sphingids from Lanyu, of which 12 are very widely distributed. The other 2, *Theretra rhesus* (Boisduval) (Greater and Lesser Sunda Is., Sulawesi, and the Philippines) and *Acosmeryx anceus subdentata* Rothschild and Jordan, 1903 (India, south and east through Myanmar, Thailand, Vietnam, and Malaysia, to Java, the Western Lesser Sunda Islands, and the Philippines), are absent from the main island of

Taiwan. In 1999, in his follow-up study, Lin (1999) increased the number of sphingids recorded from Lanyu to 25, of which 19 are shared with Taiwan and 12 are in common with the Philippines (Luzon region). Meanwhile, 14 species are shared by the Taiwanese mainland (80 species) and the Luzon region of the Philippines (77 species). Lin (1999) also compared the faunistic similarity of Lanyu, Lutao, Taiwan, the Philippines, Vietnam, mainland China, and Hong Kong using Simpson's Index. He concluded that the sphingid fauna of Lanyu is more similar to that of Hong Kong then to those of Taiwan, Lutao, Vietnam, the Philippines, and mainland China. However, we doubt this conclusion, because there are numerous misidentifications (especially of *Macroglossum*) in the literature of these areas, and these, together with insufficient faunistic information, can have a significant influence on the similarity index of 2 compared faunas. Nor can we agree with Lin's inference that the sphingid faunal similarity between Lanyu and Hong Kong was caused by an "oceanic island effect" because Hong Kong is not an isolated "land" but has a large proportion of its land area connected to Guangdong Province of mainland China. We suggest that the faunistic similarity between Lanyu and adjacent areas be re-estimated when more-reliable taxonomic revisions and faunistic surveys have been undertaken on Lutao, the Batan Is., and Babuyan Is.

Inoue and Lin (1992) listed 77 species of Sphingidae from Taiwan. Recent research has raised the total to 86 (Chen 1994, and the present study) (see Appendix II). However, of the 62 localities listed (Heppner and Inoue 1992), very few are in the Eastern Coastal Range. This range is also part of the Luzon volcanic arc and, like Lanyu, could possess Philippines elements in its fauna. Future surveys of this range, and of Lanyu and Lutao, could increase the species richness in Taiwan by the addition of further examples of Wallacean taxa.

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Appendix I: Collection data of other *Macroglossum* taxa examined.

Macroglossum ungues Rothschild & Jordan, 1903

Indonesia: Holotype, ♀, Buru (BMNH sphingid genitalia #502); 1 ♂, Celebes [Sulawesi], Boeton Island (BMNH sphingid genitalia #817); 1 ♂, 1 ♀, Sulawesi, Puncak Palopo, Jan. 2000; 1 ♀, Sumba (native collector); 1 ♂, 2 ♀♀, Lombok, Apr. 1896 (H. Fruhstorfer); 2 ♂♂, 3 ♀♀, Ambon, Aug. 1892 (W Doherty) (including 1 ♀ BMNH sphingid genitalia #818); 2 ♂♂, 2 ♀♀. Buru, Mar. 1897 (W Doherty) (including 1 ♂ BMNH sphingid genitalia #421); 1 ♂, Bali, 21 Aug. 1990 (JD Weintraub) (BMNH sphingid genitalia #697); 1 ♂, 1 ♀, Java (BMNH sphingid genitalia #422 and #423); 1 ♂, Ceram [Seram], Manusela, 1912 (E Stresemann). All specimens in BMNH unless otherwise stated.

Macroglossum sitiene Walker, 1856

Taiwan: 1 ♀, Taipei, Yangmingshan, 22 July 1970 (H Toshima. 2 ♂♂, Puli, 1963 (local collector). 5 ♂♂, Tainan, July 1905 (local collector); 2 ♂♂, 1 ♀, Nantou, Hueisun Forest, 24/29 Oct. 1998 (Mey & Speidel), ZMHB; 1 ♂, 1 ♀, Takow [Kaohsiung], July 1905 (local collector); 1 ♀, Songshan, 25 June 1969, NTU; 3 ♂♂, Pingtung, Kenting Botanical Garden, 23 July 1984, TFRI. China: 1 ♂, 1 ♀, Kuangtung [Guangdong] July 1920 (R. Mell); 2 ♂♂, 2 ♀♀, Kowloon, December 1911 (E Wahr); 1 ♂, 1 ♀, Hainan I., Cheng-Mei, July 1902 (local collector). India: 1 ♂, Calcutta, no date (local collector). Thailand: 1 ♂, Doi Suthep, 8-10 July 1966 (Inoue & Okagawa); 1 ♂, Pak Nam Poh, Jan. 1924 (Williamson). Vietnam: 1 ♂, 1 ♀, Central Tonkin, Chien-Hoa, Aug.-Sept. 1911 (H Fruhstorfer). Sri Lanka: 1 ♀, no date (local collector). Burma: 1 ♂, 1 ♀, Mt. Popa, 1-30 Nov. 1937 (G Heinrich). Indonesia: 1 ♂, Sumatra, P. Siantar, 9 Aug. 1995 (EW Diehl) (BMNH sphingid genitalia #736). Maldives: 1 ♀ Gan, 30 Aug. 1958 (WWA Phillips). All specimens are in BMNH unless otherwise stated.

Appendix II: An annotated checklist of the Taiwanese Sphingidae.

All Chinese names adopted here follow Chen (1994) and Wang (1995 1999) except for those indicated by an asterisk (*), which are newly proposed in the present study.

Species name	Chinese name
SPHINGIDAE Latreille, [1802]	天蛾科
Sphinginae Latreille, [1802]	天蛾亞科
Sphingini Latreille, [1802]	天蛾族
Sphinx formosana Riotte, 1970	蓬萊松天蛾*(松天蛾)
Meganoton analis gressitti Clark, 1937	大背天蛾 (粗斜紋天蛾)
Psilogramma menephron (Cramer, 1780)	霜天蛾[1]
Psilogramma increta (Walker, 1865)	霜降天蛾 (霜天蛾、細斜紋天蛾)
Acherontiini Boisduval, [1875]	人面天蛾族
Agrius convolvuli (Linnaeus, 1758)	白薯天蛾(甘薯天蛾、蝦殼天蛾、粉腹天蛾)
Acherontia lachesis (Fabricius, 1798)	人面天蛾(鬼臉天蛾)
Acherontia styx medusa Moore, [1858]	後黃人面天蛾(芝麻鬼臉天蛾、裏黃鬼臉天蛾)[2]
Smerinthinae Grote & Robinson, 1865	短吻天蛾亞科*
Sphingulini Rothschild & Jordan, 1903	絨天蛾族*
Pentateucha inouei Owada & Brechlin, 1997	井上氏絨毛天蛾*(絨毛天蛾)[3]
Dolbina inexacta (Walker, 1856)	白星天蛾 (大星天蛾)
Smerinthini Grote & Robinson, 1865	短吻天蛾族*
Langia zenzeroides formosana Clark, 1936	臺灣鋸翅天蛾 (鋸翅天蛾)
Parum colligata (Walker, 1856)	構月天蛾 (白點天蛾)
Marumba gaschkewitschii gressitti Clark, 1937	桃紅六點天蛾(桃六點天蛾)
Marumba cristata bukaiana Clark, 1937	直翅六點天蛾(楠六點天蛾、缺六點天蛾)
Marumba saishiuana formosana Natsumura, 1927	臺灣六點天蛾(枇杷六點天蛾、黑角六點天蛾)
Marumba dyras (Walker, 1856)	六點天蛾(椴六點天蛾、後橙六點天蛾)
Marumba sperchius (Menetries, 1857)	栗六點天蛾 (後褐六點天蛾)[4]
Cypa enodis Jordan, 1931	單齒天蛾 (臉緣天蛾)[5]
Cypoides chinensis (Rothschild & Jordan, 1903)	楓天蛾(楓小天蛾、凹緣黑天蛾)
Smerinthulus perversa flavomaculatus Inoue, 1990	黃斑索天蛾(黃雲天蛾)[6]
Callambulyx tatarinovii formosana Clark, 1935	榆綠天蛾 (紅裏綠天蛾)[7]
Leucophlebia lineata Westwood, 1847	黃條天蛾(甘蔗天蛾、雙黃帶天蛾)
Clanis bilineata formosana Gehlen, 1941	豆天蛾 (波紋豆天蛾)
Polyptychus chinensis Rothschild & Jordan, 1903	中國齒翅天蛾(三線天蛾、齒翅三線天蛾、三線灰天蛾)
Phyllosphingia dissimilis (Bremer, 1861)	盾斑天蛾(盾天蛾)[8]
Ambulycini Butler, 1876	鷹翅天蛾族
Amblypterus mansoni takamukui (Matsumura, 1930)	芒果天蛾(福木天蛾、臀角斑天蛾)
Ambulyx sericeipennis okurai (Okano, 1959)	臺灣鷹翅天蛾(亞洲鷹翅天蛾、鷹翅天蛾)
Ambulyx ochracea Butler, 1885	鷹翅天蛾 (裂斑鷹翅天蛾)
Ambulyx semiplacida Inoue, 1989	圓斑鷹翅天蛾
Ambulyx japonica angustifasciata (Okano, 1959)	日本鷹翅天蛾 (黑帶鷹翅天蛾)
Ambulyx kuangtungensis (Mell, 1922)	廣東鷹翅天蛾(小鷹翅天蛾)
Macroglossinae Harris, 1839	長喙天蛾亞科
Dilophonotini Burmeister, 1878	隆背天蛾族*
Hemarina Tutt, 1902	透翅天蛾亞族
Cephonodes hylas (Linnaeus, 1771)	大透翅天蛾(咖啡透翅天蛾、透翅天蛾)
Hemaris affinis (Bremer, 1861)	褐緣透翅天蛾(黑邊天蛾、黑邊透翅天蛾)[9]
Macroglossini Harris, 1839	長喙天蛾族
Macroglossina Harris, 1839	長喙天蛾亞族
Daphnis nerii (Linnaeus, 1758)	夾竹桃天蛾 (粉綠白腰天蛾)
Daphnis hypothous (Cramer, 1780)	白腰天蛾(茜草白腰天蛾、暗綠白腰天蛾)
Lepchina obliquifascia baibarana (Matsumura, 1927)	斜帶天蛾(眉原天蛾、灰斑天蛾)
Lepchina taiwana (Brechlin, 1998)	臺灣斜帶天蛾
Dahira rubiginosa Moore, 1888	赭色天蛾 (暗點天蛾)
Ampelophaga rubiginosa myosotis Kitching & Cadiou, 2000	臺灣葡萄天蛾 (葡萄天蛾、背中白天蛾)[10]
Acosmerycoides harterti (Rothschild, 1895)	鋸線天蛾(灰天蛾、鋸紋灰天蛾)[11]
Acosmeryx anceus subdentata Rothschild & Jordan, 1903	姬缺角天蛾
Acosmeryx castanea Rothschild & Jordan, 1903	缺角天蛾 (半緣缺角天蛾)

Appendix II: (Cont.)

Species name	Chinese name
Acosmeryx naga naga (Moore, [1858])	葡萄缺角天蛾 (全緣缺角天蛾)
Acosmeryx formosana (Matsumura, 1927)	臺灣缺角天蛾
Angonyx testacea (Walker, 1856)	褐綠天蛾(絨綠天蛾)
Neogurelca hyas (Walker, 1856)	凹緣天蛾(圓角錐天蛾)[12]
Neogurelca himachala sangaica (Butler, [1876])	三角凹緣天蛾(喜馬錐天蛾、三角錐天蛾)[12]
Macroglossum bombylans (Boisduval, [1875])	青背長喙天蛾 (雙帶長喙天蛾)
Macroglossum belis (Linnaeus, 1758)	淡黃帶長喙天蛾(淡紋長喙天蛾)
Macroglossum pyrrhosticta Butler, 1875	黃斑長喙天蛾(黑長喙天蛾)
Macroglossum neotroglodytus Kitching & Cadiou, 2000	灰紋長喙天蛾 (突帶長喙天蛾、小長喙天蛾)[13]
Macroglossum insipida insipida Butler, 1875	微齒長喙天蛾*[14]
Macroglossum poecilum Rothschild & Jordan, 1903	帶長喙天蛾 (叉帶長喙天蛾)
Macroglossum sitiene (Walker, 1856)	膝帶長喙天蛾(黑長喙天蛾、彎帶長喙天蛾)
Macroglossum ungues cheni ssp. nov.	小斜帶長喙天蛾(蘭嶼長喙天蛾)
Macroglossum heliophila heliophila Boisduval, [1875]	九節木長喙天蛾 (連帶長喙天蛾)[15]
Macroglossum mediovitta Rothschild & Jordan, 1903	玉帶長喙天蛾[16]
Macroglossum saga (Butler, 1878)	北京長喙天蛾 (波斑長喙天蛾)
Macroglossum stellatarum (Linnaeus, 1758)	後黃長喙天蛾[17]
Macroglossum fritzei Rothschild & Jordan, 1903	佛瑞茲長喙天蛾[17]
Macroglossum corythus luteata Butler, 1875	黃紋長喙天蛾(長喙天蛾、平帶長喙天蛾)
Macroglossum faro faro (Cramer, 1779)	法羅長喙天蛾[17]
Macroglossum sylvia (Boisduval, [1875])	木紋長喙天蛾(角斑長喙天蛾、角線長喙天蛾)[18]
Macroglossum passalus (Drury, 1773)	虎皮楠長喙天蛾 (基黑長喙天蛾、石楠長喙天蛾)
Macroglossum mitchellii imperator (Butler, 1875)	背帶長喙天蛾 (背線長喙天蛾)
Choerocampina Grote & Robinson, 1865	線紋天蛾亞族*
Hyles livornica (Esper, 1780)	八字白眉天蛾 (白線紋天蛾)[19]
Hippotion velox (Fabricius, 1793)	斜線天蛾(黑翅斜線天蛾、半黑斜線天蛾)
Hippotion celerio (Linnaeus, 1758)	銀條斜線天蛾
Hippotion rosetta (Swinhoe, 1892)	後紅斜線天蛾(茜草紅後斜線天蛾、裏紅斜線天蛾)
Theretra nessus (Drury, 1773)	綠背斜紋天蛾(青背斜紋天蛾、黃腹斜紋天蛾)
Theretra boisduvalii (Bugnion, 1839)	間斷斜紋天蛾(黑星斜紋天蛾)
Theretra rhesus (Boisduval, [1875])	背帶斜紋天蛾
Theretra clotho (Drury, [1773])	斜紋天蛾
Theretra latreillii lucasii (Walker, 1856)	直翅斜紋天蛾(浙江土色斜紋天蛾、星點多斜紋天蛾)
Theretra alecto (Linnaeus, 1758)	後紅斜紋天蛾(斜紋後紅天蛾、紅裏斜紋天蛾)
Theretra suffusa (Walker, 1856)	背帶後紅斜紋天蛾(白眉斜紋天蛾、紅裏白斜紋天蛾)
Theretra japonica (Boisduval, 1869)	日本斜紋天蛾(雀紋天蛾、黃胸斜紋天蛾)
Theretra oldenlandiae oldenlandiae (Fabricius, 1775)	雙線條紋天蛾(芋雙線天蛾、雙斜紋天蛾)
Theretra silhetensis silhetensis (Walker, 1856)	條紋天蛾(芋單線天蛾、單斜紋天蛾)
Pergesa acteus (Cramer, 1779)	斜綠天蛾
Rhagastis velata (Walker, 1866)	隱紋白肩天蛾(維拉達白肩天蛾、白心點天蛾)
Rhagastis castor formosana Clark, 1925	臺灣白肩天蛾(鋸線白肩天蛾、胸點天蛾)
Rhagastis mongoliana (Butler, 1876)	蒙古白肩天蛾(白肩天蛾、實點天蛾)
Rhagastis binoculata Matsumura, 1909	雙斑白肩天蛾 (雲帶天蛾)
Cechenena minor (Butler, 1875)	背線天蛾(平背天蛾)
Cechenena lineosa (Walker, 1856)	棕綠背線天蛾(條背天蛾)
Cechenena subangustata Rothschild, 1920	泛綠背線天蛾(綠條背天蛾)
Excluded and uncertain species	
Agrius luctifera (Walker, [1865])	粉帶白薯天蛾*[20]
"*Clanis litura Fabricius*"[21]	
Sphinx caligineus (Butler, 1877)	暗色松天蛾*[22]
Smerinthus jamaicensis (Drury, 1773)	北美眼紋天蛾*[23]
Macroglossum nycteris (Kollar, [1844])	暮色長喙天蛾*[24]
Deilephila elpenor (Linnaeus, 1758)	紅天蛾[25]
Hipportion rafflesii (Butler, 1877)	拉氏斜線天蛾*[26]
Theretra gnoma Fabricius, [1775]	印度斜紋天蛾*[27]
Rhagastis trilineata Matsumura, 1921	三線白肩天蛾*[28]

Appendix II: (Cont.)

[1]This species was first recorded from Taiwan by Chen (1994: 25).

[2]The author and year of this subspecies have long been cited as "Butler, 1876" by many authors (e.g., Inoue and Lin 1992, Chen 1994). According to Kitching and Cadiou (2000), the correct authorship is Moore [1858].

[3]This species was misidentified as *Pentateucha curiosa* Swinhoe, 1908 (e.g., Inoue and Lin 1992, Chen 1994) until it was correctly recognized as being a separate species (Kitching et al. 1997).

[4]Until recently, the Taiwanese population of this species was accorded subspecies status as *Marumba sperchius horiana* Clark, 1937. However, Kitching and Cadiou (2000: 58) found no consistent differences between the Taiwanese, Japanese, and continental Asian populations of *Marumba sperchius* and thus synonymized *horiana* with the nominotypical subspecies.

[5]This species was long regarded as a subspecies of *Cypa pallens* Jordan, 1926 (e.g., Inoue and Lin 1992, Chen 1994). However, Kitching and Cadiou (2000) noted that *pallens* Jordan, 1926 from NE India is better treated as a subspecies of *Cypa uniformis* Mell, 1922, and that *enodis* Jordan, 1931 is a distinct species. *Cypa enodis* is distributed from Nepal to Taiwan, south through Thailand and Vietnam to peninsular Malaysia.

[6]Kitching and Cadiou (2000) considered that *Smerinthulus flavomaculatus* Inoue, 1990 from Taiwan, and *Smerinthulus pallidus* Mell, 1922 from China (Guangdong), are conspecific, but with slight morphological differences in the male genitalia.

[7]Sometimes regarded as a subspecies of *Callambulyx poecilus* (Rothschild, 1898), Kitching and Cadiou (2000) noted that the male genitalia of *formosana* agree better with those of *C. tatarinovii* (Bremer & Grey, 1853).

[8]The name *Phyllosphingia dissimilis hoenei* Clark, 1937, described from China (Zhejiang) and applied to SE Chinese and Taiwanese populations, was synonymized with the nominotypical subspecies by Kitching and Cadiou (2000) because the variation in wing pattern is not correlated to geographical distribution but rather is under environmental control.

[9]Kato (1934: pl. 27) published the 1st record of *H. fuciformis* from Taiwan (see Chen 1994: 170). Later, Kishida (1977) reported 1 individual (as *H. fuciformis affinis*) from Sun-Moon Lake, central Taiwan (26 June 1976, M Kibota leg.). Following Chistyakov and Belyaev (1984), Inoue (1990) considered that all records of *H. fuciformis* from Taiwan were misidentifications of *H. affinis*. In addition, *H. affinis* was erroneously included in the subfamily Sphinginae by Inoue and Lin (1992).

[10]The Taiwanese population of *Ampelophaga rubiginosa* Bremer & Grey, 1853 was described as a new subspecies by Kitching and Cadiou (2000) based on consistent differences between the Taiwanese and continental populations.

[11]This species was until recently referred to as *Acosmerycoides leucocraspis* (Hampson, 1910) (e.g., Inoue and Lin 1992, Chen 1994). However, by examination of the relevant types, Kitching and Cadiou (2000) proved that the senior name was correctly *Ampelophaga harterti* (Rothschild, 1895).

[12]The 2 species, *Neogurelca hyas* (Walker, 1856) and *N. himachala* (Butler, 1876) have generally been included in either *Gurelca* Kirby, 1880 or *Aspledon* Boisduval, [1875] (e.g., Chang 1989, Inoue and Lin 1992, Chen, 1994, Wang 1995). However, Fletcher and Nye (1982) pointed out that *Gurelca* was proposed as an objective replacement name for the homonymous *Lophura* Herrich-Schäffer [1854]. They also designated the type species of this genus, *Lophura zantus* Herrich-Schäffer ([1854]), as the type species of *Aspledon*, by which *Gurelca* thus fell as a junior synonym. *Lophura zantus* is currently placed in *Temnora* Walker, 1856 (Rothschild and Jordan 1903, Kitching and Cadiou 2000), to which both Aspledon and *Gurelca* are therefore junior synonyms. Consequently, Hogenes and Treadaway (1993) erected *Neogurelca* to accommodate *hyas* (Walker, 1856), and to which Inoue et al. ([1996]) later added *himachala*.

[13]The genitalia of the lectotype of *Macroglossum troglodytus* Boisduval, [1875] were found to agree with those of *M. i. insipida* Butler, 1875, which led Kitching and Cadiou (2000) to synonymize *troglodytus* with *insipida*. They then proposed a new name, *M. neotroglodytus*, for the species that had been until then referred to as *troglodytus*.

[14]Although d'Abrera (1986: 160) listed this species as occurring in Taiwan, Chen (1994: 171) stated that no Taiwanese specimens have ever been collected. However, there is a specimen in the BMNH labelled "Centr. Formosa, Suishako, 1907" (Fig. 1m, n).

[15]Zhu and Wang (1997) treated *Macroglossum fringilla* Boisduval, [1875] as the senior name for the species now referred to as *Macroglossum heliophila* Boisduval, [1875]. However, under the Principle of the First Reviser, Rothschild and Jordan (1903) had already established the seniority of *heliophila*.

[16]Both Chao (1999) and Chao et al. (1999) announced *Macroglossum mediovitta* as a new record for Taiwan. However, Chen (1994: 117) had already reported this species.

[17]Chen (1994) first reported these species from Taiwan.

[18]*Macroglossum sylvia* is widely distributed in Southeast Asia, from Sri Lanka and Thailand (Fig. 1q, r), east through Vietnam, Malaysia, and China to Japan, the Philippines and the Moluccas. Rothschild and Jordan (1903: 658) listed the species from Taiwan, a record that was accepted by Inoue and Lin (1992). However, Chen (1994) doubted the existence of *M. sylvia* in Taiwan because no further specimens had been found. We have examined the Taiwanese specimen seen by Rothschild and Jordan (which originated in the Felder collection and is labeled simply "Formosa", Fig. 1s, t) and confirmed that it is correctly identified as *M. sylvia*. We also found the specimen figured by Wang (1999: 102). This is another individual of *M. sylvia*, but from Sulawesi not Taiwan.

[19]Matsumura (1905: 30) recorded this species from Taiwan (as *Deilephila* (*Celerio*) *lineata* var. *livornica*) but there have been no further records (Chen 1994: 171). However, the specimen illustrated by Matsumura is clearly this species. Furthermore, *H. livornica* is a well-known migrant, and stray specimens have been recorded from northern Thailand, and Hokkaido, Honshu, and the Ryukyu Islands, Japan. Thus, a stray specimen captured on Taiwan is not beyond the bounds of possibility.

[20]Riotte (1970: 13) listed this species as received in a collection of specimens from Taiwan. Later, he gave the distribution as "Taiwan, Sulawesi, Maluku Is. Halmahera, Ambon, and New Guinea, and probably also occurring in the Philippines, although it is not yet known from there in collections" (Riotte 1984: 339). The confirmed range of *A. luctifera* is from Sulawesi and Tanimbar, through the Moluccas, to New Guinea and the Bismarck Archipelago. Inoue (1990) considered the Taiwanese moths to be misidentified worn specimens of *Agrius convolvuli*, a conclusion with which we concur. The predicted occurrence of *A. luctifera* in the Philippines was then unsubstantiated speculation aimed at filling the apparent distribution gap between Taiwan and Sulawesi/Maluku.

[21]Tsai (1965: 120) first recorded this name, and was then followed by Wang and Yang (1980: 146). However, this "name" does not match any known available name in the Sphingidae. It is most likely a typographical error and the intended species may never be correctly ascertained.

[22]Yen (1973: 81) first recorded this eastern Palaearctic species from Taiwan, but there is no voucher specimen available to allow confirmation. We suspect that the record is based on a small misidentified specimen of *Psilogramma increta*.

[23]This North American species was reported from Taiwan by Matsumura (1931: 615) and Kato (1934: pl. 22, fig. 2). However, no subsequent record has been found (Chen 1994: 170), and we consider the presence of *S. jamaicensis* in Taiwan to be extremely unlikely. What species might have been misidentified is a mystery for no Taiwanese sphingids have well-developed hindwing eyespots.

[24]*Macroglossum nycteris* ranges from Afghanistan, across northern India, Nepal, and Myanmar, to northeastern China and the Ryukyu Islands, Japan. Matsumura (1909: 36, pl. 5, fig. 5) reported this species from Taiwan (as *Rhopalopsyche nycteris*) but we have found no evidence to support its presence on the island. The drawing provided by Matsumura could be any one of a number of small *Macroglossum* species.

[25]Nagano (1904) first reported this species from Taiwan (as *Pergesa elpenor* var. *lewisii*). However, no voucher specimens have been located. Although the most frequently used larval host plants of *D. e. elpenor*, *Epilobium* (Onagraceae), and *Galium* (Rubiaceae), are abundant in the subalpine region of Taiwan, this sphingid has never been reported by any entomological expedition. Although the Taiwan population was referred to as *D. e. lewisii* (Butler, 1875) by both Inoue and Lin (1992) and Chen (1994), current taxonomic opinion does not recognize this as distinct from the nominotypical subspecies.

[26]Closs (1915: 2) reported 2 males and 1 female of this species from Taitung (Aug. 1907) and Tainan (July 1912), respectively. However, there have been no further records, and it is possible that Closs misidentified specimens of *H. rosetta* as *H. r. rafflesii*.

[27]The record of this species in Taiwan was also made by Closs (1915: 3), who cited 2 females collected by Hans Sauter from Kosempo (=Jia-Hsien, Oct. 1911) and Chi-shan (June 1912). Chen (1994: 172) doubted this record, suggesting that Closs had in fact misidentified specimens of *Theretra clotho clotho*. We fully endorse this interpretation. *Theretra gnoma* is restricted to peninsular India.

[28]This species was described by Matsumura (1921: 757, pl. 54, fig. 6) from a single specimen purportedly from Taiwan. However, Inoue (1973 1990) stated he had never seen any Taiwanese material apart from the holotype and suspected that Matsumura had mislabeled a Japanese specimen. *Rhagastris trilineatus* remains unknown in Taiwan.