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A new species of genus *Cypoides* Matsumura, 1921 (Lepidoptera, Sphingidae) from Sulawesi Island, Eastern Indonesia

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**Abstract**
A new species of genus *Cypoides* Matsumura, 1921 from Sulawesi is described and illustrated. The description is based on a comparison of genetic and morphological features of the new species with those of its closest relatives, *Cypoides parachinensis* Brechlin, 2009 and *Cypoides chinensis* (Rothschild & Jordan, 1903). The female and preimaginal instars of the new taxon remain unknown.

**Keywords:** *Cypoides*, China, Lepidoptera, Myanmar, Sphingidae, Sulawesi.

**Introduction**
The genus *Cypoides* Matsumura, 1921 currently consists of two species, placed in the informal “*Cypa* genus-group” tribe of the subfamily Smerinthinae (Kitching, 2016). This informal genus-group comprises the group of genera related to *Cypa* identified by Kitching & Cadiou (2000: 17) as forming a putatively monophyletic group. They are distributed in south-eastern Asia and Indonesia. Within the genus, the species form morphologically relatively uniform species-group characterized by relatively small size with wingspans of between 38 – 60 mm; orange-brown in colour. Wings with the outer margin dentate.

The two species currently recognized with *Cypoides* are:

*Cypoides chinensis* (Rothschild & Jordan, 1903), originally described as *Smerinthulus chinensis*, from China. Type locality: China, [Fujian, Qingliu County,] Léou-Pang <<Léou Fang>> [Liufang].

**Subjective synonym:** *Cypa formosana* Wileman, 1910, described from Taiwan [Taiko].

*Enpinanga transtriata* Chu & Wang, 1980, described from China. Type locality: Fujian, Chong’an, 740m.

**Unavailable infrasubspecific synonym:** *Amorphulus chinensis* f. *fasciata* Mell, 1922, described as a cold season form from S. China.

*Cypoides parachinensis* Brechlin, 2009, described from Burma [Myanmar, ZimYar Dam, 65 km E Putao, 1250m, 27°50’N, 97°01’E.] (holotype deposited in coll. Museum Witt, Munich).
Material & Methods
The determination of species status is based on both genetic and morphological data. All specimen data is taken verbatim from the labels. The holotype and comparative material was DNA barcoded and the final sequence of mitochondrial DNA (Cytochrome Oxidase subunit I) analysed. Wingspans were measured, and the male genitalia examined and compared, using an STM 723 (3241) stereomicroscope. Photographs were taken using a Canon EOS 60D digital camera.

Abbreviations
The following abbreviations are used in the text:
Bold: Barcode of Life Data Systems
CEITEC: Central European Institute of Technology, Mendel University in Brno, Czech Republic
gen.: genitalia preparation number
SMCR: Sphingidae Museum, Czech Republic

_Cypoides celebensis_ Melichar & Řezáč & Ilčíková sp. nov.

Type material:
**Holotype** (Fig. 1): 1 ♂, S. Sulawesi, Mt. Sampuraga, [2.10° S, 120.45° E] sic!, 1400 m, 11.–12. II. 1995, leg. Siniaev & Tarasov, BOLD BC–Mel 0219, CEITEC F. 212, gen. 1494, coll. SMCR.

Description (Figs. 1–2):
Wingspan: 58 mm. Antennae fasciculate, light brown with an acuminate tip to the flagellum. Upperside of head, thorax and abdomen brown, without any distinct pattern. Forewing upperside: Ground colour grey-brown. Forewing underside: Ground colour light brown; area between postmedial band and outer margin darker brown; subbasal, antemedial, postmedial and submarginal bands distinct. Hindwing upperside: Ground colour ochre; submarginal band thin, dark brown, turning sharply into the white fringe, not very distinct. Hindwing underside: brown-orange; postmedial and antemedial bands dark brown and distinct; submarginal band more distinct at the apex, gradually fading away towards the inner margin.

Male genitalia (Fig. 3)
Uncus sclerotized, long; basal half much broader than distal half, apex sharply pointed. Gnathos also apically sharply pointed. Harpe broad and short, distally with a sharp tooth-like protrusion ventrally and a ridge of smaller teeth along its distal edge. Valvae short, sole-shaped, symmetrical with long setae and hairs on the inner surface and around the outer edge; apex rounded. Harpe stout as a bulge on basal V-shape; narrowing gradually into a tube and ending in the apical dentate area with a blunt process in the lower part.
**Ethology:** Unknown.

**Etymology:** The name refers to its origin, the Indonesian island of Sulawesi, formerly known as Celebes.

**Comparative material**
All specimens in SMCR unless otherwise stated.

*Cypoides chinensis*

1 ♂, China, Wuyi Shan, Jiangxi-Fujian border, 50 km SE from Yingtan, 1600 m, IV.–V. 2002, 27°56′ N, 117°25′ E, leg. local coll., BOLD BC–Mel 0114, gen. 1497;
1 ♂, China, Wuyi Shan, Jiangxi-Fujian border, 50 km SE from Yingtan, 1600 m, IV.–V. 2002, 27°56′ N, 117°25′ E, leg. local coll., BOLD BC–Mel 0111;
1 ♂, China, Hunan, Nanling Mts., Shikengkong mt., 1300 m, IV. 2006, 24°54′ N, 112°57′ E, BOLD BC–Mel 0113, gen. 1496;
1 ♂, China, Hunan, Nanling Mts., Shikengkong mt., 1300 m, IV. 2006, 24°54′ N, 112°57′ E, BOLD BC–Mel 0220, gen. 1495;
1 ♂, China, Hunan, Nanling Mts., Shikengkong mt., 1300 m, IV. 2006, 24°54′ N, 112°57′ E, BOLD BC–Mel 0112;
1 ♂, China, Wuyi Shan, Jiangxi-Fujian border, 50 km SE from Yingtan, 1600 m, IV. 2002, 27°56′ N, 117°25′ E, leg. V. Siniaev & local coll., BOLD BC–Mel 0109;
1 ♂, China, Fujian, Wuyi Shan, 1400 m, V.–VII. 2006, 27°41′ N, 117°33′ E, leg. team of V. Siniaev, BOLD BC–Mel 0218;
1 ♂, China, Guangxi, Dayao Shan, Jingxiu, 100 km SE Liuzhou, 1200 m, VIII. 2005, 23°45′ N, 109°45′ E, leg. team of V. Siniaev, BOLD BC–Mel 0110;
1 ♀, China, Jiangxi, Wuyi Shan, Xipaihe vil., 1500 m, V. 2005, 27°54′ N, 117°20′ E, leg. V. Siniaev & C;
1 ♂, Taiwan, prov. Nan-Tou, 15 km N of Puli, 500 m, 23. IV. 1997, leg. Gy. Fábián & S. T. Kovács, BOLD BC–Mel 2271;
1 ♂, Taiwan, Nan-Ta-Wo, 300 m, 24°28′ N, 120°57′ E, VI. 2005, ex. coll. Schnitzler, gen. 1566;

**Diagnosis** (Figs. 1–5):
*Cypoides celebensis sp. nov.* is visibly larger (more robust) in comparison to the *Cypoides chinensis* and *Cypoides parachinensis*. There is a considerable degree of individual variation in the shape of the harpe (specimens collected in the same locality can have a totally different distal edge). *Cypoides chinensis* (Rothschild & Jordan, 1903) is similar to *Cypa decolor*, but the forewings are broader. Hindwing upperside rusty red and brighter in colour. It’s known from southern China and Taiwan, south to mountainous northern Vietnam and northeastern Thailand. In the male genitalia, uncus
single, similar to that of *Cypa decolor* but narrowing more gradually. Gnathos with a sharply pointed, narrow medial process. Valva sole-shaped, narrow. Harpe dilated and very strongly sclerotised proximally, with a single distal process. Aedeagus curved. *Cypoides parachinensis* Brechlin, 2009 is slightly smaller than *Cypoides chinensis* from northern Vietnam and southern China, but about the same size as those from Taiwan (Brechlin, 2009).

**Geographical distribution:** *Cypoides celebensis* sp. nov. is only known from the type locality.

**Habitat:** The Wallacea region is a group of islands separated by deep water straits from the Asian and Australian continental shelves. It is separated from the Sundaland on the west by the Wallacea Line, and from the Near Oceania (including Australia and New Guinea) on the east and south by the Lydkeker’s Line. Wallacea is a famous and essential biogeographical island group in eastern Indonesia, which includes Sulawesi Island (which is about 178,700 km²). Because of its tropical climate, its numerous islands, and complex geological history, Wallacea has high biodiversity, with numerous species found nowhere else in the world. Its total number of species is estimated at 11,400 and holds a high probability of undiscovered species due to the area’s isolation and inaccessibility. The Island of Sulawesi is the largest in the Wallacea region, occupying about 53% of the island group located in the northwestern part. *Cypoides celebensis* sp. nov. was collected some 2,800 km southerly than its closest relatives, *Cypoides parachinensis* Brechlin, 2009 and *Cypoides chinensis* (Rothschild & Jordan, 1903).

**Discussion (Fig. 1–5):**
The members of “*Cypa* genus group” share very similar colour patterns, and misidentification based solely on this criterion are very frequent. Morphological differences between the species can be quite small and subtle. Fortunately, most have distinctive male genitalia.
The results of genetic analysis using DNA barcoding performed by the Central European Institute of Technology, Mendel University in Brno, showed that there is a minimum distance of 7% between *Cypoides celebensis* sp. nov., and its closest relative, *Cypoides parachinensis*. There is the minimum distance of 3.74 between *Cypoides parachinensis* and *Cypoides chinensis*. These results, together with the differences in the habitus and male genitalia described above, confirm that species status is justified for *Cypoides celebensis* sp. nov.

**Acknowledgements**
The authors are grateful to Dr Ian Kitching (Natural History Museum, London, UK) for his valuable and very helpful comments and suggestions on the manuscript.
References


Figure 1: *Cypoides celebensis* sp. nov. holotype ♂; S. Sulawesi, Mt. Sampuraga, [2.10° S, 120.45° E] sic!, 1400 m, 11.–12. II. 1995, leg. Siniaev & Tarasov, BOLD BC–Mel 0219, CEITEC F. 212, gen. 1494, coll. SMCR: a – recto; b – verso.

Figure 2: Male habitus. a – *Cypoides chinensis*, China; b – *Cypoides chinensis*, Vietnam; c – *Cypoides chinensis*, Taiwan; d – *Cypoides celebensis* sp. nov., holotype.
Figure 3: *Cypoides celebensis* sp. nov., holotype; male genitalia: a – genital capsule; b – harpe.
Figure 4: *Cypoides chinensis*, male genitalia, genital capsule: a – China, gen. 1495; b – China, gen. 1496; c – China, gen. 1497; d – Vietnam, gen. 1567; e – Taiwan, gen. 1566.
Figure 5: *Cypoides chinensis*, male genitalia, harpe: a – China, gen. 1495; b – China, gen. 1496; c – China, gen. 1497; d – Vietnam, gen. 1567; e – Taiwan, gen. 1566.
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The taxonomy of Indian Endoclita C. & R. Felder, 1874 fauna is very poorly known and this study is the first account since the work of Tindale (1958). The description of an Endoclita sp. presented here of a male specimen collected from Kodaikanal in southwestern India may represent E. malabaricus (Moore, 1879) or E. magus (Tindale, 1942), which are recorded from nearby localities and have a similar external appearance. Conclusive determination is not possible until the type specimens of these species have been dissected and described. Comparative illustrations of E. malabaricus and E. magus are also presented. The genitalia of this southwestern Indian specimen represent a derived condition within the Hepialidae and may be associated with at least a subclade of Endoclita. The specimen also exhibits a specialized arrangement of basal forewing veins known only within Endoclita. It is hoped that this study will encourage further discovery and research on Indian Endoclita species.

Keywords: Description, fauna

Introduction
The southern subcontinent of India is home eight endemic species of Endoclita Felder, 1874, a genus of about 60 species with a combined distribution range extending over much of southern and eastern Asia (Grehan 2011). All species with recorded larval stages are stem borers of live trees and shrubs and this habit is likely to apply to the entire genus (Grehan & Ismavel 2017). The monophyly of Endoclita has yet to be substantiated, although it is likely that most, if not all species comprise a monophyletic entity based on the presence of a distinctive configuration of the female lamella antevaginalis and a specialized arrangement of basal forewing veins (cf. Grehan & Mielke2016).

A loan of Hepialidae specimens from the Michigan State University, East Lansing, USA, was found to include a specimen of Endoclita from southern India. With the kind agreement of the curator, Gary Parsons, we availed ourselves of this opportunity to provide the first description of Endoclita from this region since the taxonomic works of Tindale (1941, 1942, 1958). His studies represent the only comprehensive review of Endoclita taxonomy, but the descriptions are not always sufficient for precise identification, particularly because the genital descriptions and illustrations are almost entirely restricted to externally visible features. This limitation remains a major
impediment to the current taxonomy and the identification of many *Endoclita* species, and this situation will likely persist until types are dissected and redescribed.

**Materials & Methods**
The abdomen was removed and treated in a cold solution of 5% KOH. The external and internal genitalia were dissected. Terminology follows that of Mielke & Casagrande (2013).

**Abbreviations**
HT (holotype), FW (forewing), HW (hindwing),

*Endoclita* nr. *malabaricus* (Moore, 1879)

♂ (Figs. 1-5). FW apical region damaged, length estimated; wingspan approximately 100 mm; FW length: 50 mm, width: 18 mm, ratio 2.7: 1; HW length: 40 mm, width: 20 mm, ratio 2: 1 (Fig. 1 a-b). Eyes prominent, antennae missing. Mouthparts: prelabium pentagonal with convex anterior facets; labial palp elongate, cylindrical, single segmented with apical sensory pit; maxillary palp three segmented; mandible reduced to lobe basal to prelabium (Fig. 2b). Clypeus bilobate. Scales over mouthparts short, reddish brown, frons and vertex yellowish brown (Fig. 2b). Thorax yellowish brown; posterior dorsal and lateral scales of the mesothorax not covering metathorax anteriorly; scutum III iridescent chocolate brown free of scales other than posterior and medial regions (Fig. 3a); FW costal margin slightly convex and widely separated from Sc at H, width narrowing towards apex, outer and posterior margins convex, no sharp anal angle. Venation ‘hepialine’ (Dumbleton 1966) with Rs1+Rs2 + Rs3 not stalked at base and Rs3 joining Rs4 basal to cross vein r-m (in this specimen forming a triple junction with Rs1+2 and Rs4 on right FW); Sc1 absent; four basal cells labelled by Roman numerals I-IV (Fig. 3b); cell IV edged by narrow vein about half diameter of other veins; 1A and 2A fused beyond cell III; 3A thin, distally terminating beyond jugum.

FW dorsal ground colour pale yellowish brown. Six dark brown patches along costal margin, first five as paired spots, each with dark brown canter edged with pale greyish brown. Wing pattern (Fig. 3c) with basal and distal stigmas of discal cell silver white, edged with dark brown. Basal stigma ‘L’ shaped, distal stigma sub-rectangular, slightly curved, from Rs4 to M1, and angled anteriorly towards Rs4. Darker yellowish brown triangular region bounded anteriorly by R, posteriorly by CuA2, and distally in the vicinity of cross veins between CuA2 and R, with pale, almost white, posteriorly convex patch wide from distal edge of basal stigma, and distally narrowing toward R. FW ventral ground colour pale reddish to yellowish brown, ornamentation between Sc and costal margin same as for dorsal surface; Sc lined with row of posterior projecting grayish-brown hairs. Costal pocket present, with longitudinal ribbing over anterior surface (Fig. 3d). HW dorsally pale grayish brown. Sc and R distally parallel, separated by twice width of R. Sc1 absent; Rs1 terminating just before the apex; two anal veins, 3A very
short; CuP extends to anal margin. HW ventrally pale grayish brown with orangish brown tint. Legs: metatibial with orangish-brown androconia (Fig. 3e).

Abdomen yellowish brown; tergum I membranous, broadly rectangular, anterior-posteriorly short, length/width ratio 1: 3.4; tergesternal bar (Fig. 4a) fused to intermediate zone, anterior edge at junction with intermediate zone almost right angled, ventrally rectangular with posterior edge rotated to junction of lateral lobe of sternum II; tergal brace weakly angled between lateral and vertical arms, posterior edge of intermediate zone fused with sclerotized pleural region below sinus (invagination behind dorsal arm of tergal brace), intermediate zone without tergal knob; tergum II rectangular, lateral and anterior margins strongly sclerotized (Fig. 4b); pleurum II with curved recess forming internal pocket (partially visible in Fig. 4b); sternum II laterally convex with anterior and posterior lateral arms (Fig. 4c); tergum VII and VIII rectangular; sternum VII lateral margin indented and posterior margin broadly U-shaped with narrow postero-lateral edges, sternum VIII strongly sclerotized, triangular, wider posteriorly with convex posterior margin (Fig. 4d).

Genitalia (Figs. 5a-e). Tegumen rectangular, slightly curved inward ventrally. Saccus V-shaped with lateral edges projected posteriorly and inwardly curved apically, base of the V as a triangular plate with the posterior margin inclined downwards mesally with a central and conspicuous projecting spatula, apically convex, and a posterior semi-circular expansion each side. Tergal lobes (uncus) triangular with dorsal corner pointed; plates not fused mesally although connected by a thick membrane, ventrally fused in a fold to the pseudotegumen (gnathos); a small membrane spot present on the lateral portion between both structures. Pseudotegumen as a ring not fused dorsally, ventral portion strongly angled mesally forming an inverted V-shaped notch; posterior margin with a conspicuous narrow, rectangular process mesally each side that come almost into contact with each other apically when phallus retracted. Fultura superior an irregular rhombus, concave and fused to the pseudotegumen. Valve digitiform, slightly elbowed, with fine, short setae at the wider base. Fultura inferior with a trapezoidal base and its distal portion rounded with an invagination mesally. Phallus membranous.

Geographical record:
Locality label: Kodai, India, 30 mi w Madurai, Julian Donahue [leg.]. This specimen was collected in the town of Kodaikanal (elevation about 1,333 m) in 1957-1958, either within the grounds of the Kodaikanal International School or possibly around street lights in the town (Julian Donahue, pers. comm.).

Taxonomic notes
Seven *Endoclita* species are recorded from southern India: *E. albofasciatus* (Moore, 1879), *E. magnus*, *E. malabaricus*, *E. microscripta* Tindale, 1941, *E. salsattensis* (Moore, 1879), *E. strobilanthes* (Tindale, 1942), and *E. viridis* (Swinhoe, 1892). Only *E. malabaricus* (Fig. 6-7) and *E. magnus* (Fig. 8-9) exhibit wing patterns similar to
that of the Kodaikanal specimen. Tindale (1942: 154) described *E. magnus* from a single male from the Palni Hills, which are located very near Kodaikanal. The type was considered distinctive for its large size and dull golden-yellow forewings and pink tinged hindwings. The external posterior margin of the eighth sternite was characterized as being evenly concave. The externally visible posterior pseudotegumen was described as strongly sclerotized, evenly notched and fused across the median, and the posterdorsal pseudotegumen supported a broad and long spine-like process [= dorsal lobe] with the apex pointing to the median and almost in contact with its opposite counterpart (Tindale, 1942: Fig. 7).

Moore (1879: 413) described *E. malabaricus* having forewings with broad pale grayish “chalybeate” streaks, with dark-brown borders on the costa, a triangular space in the cell, narrow streaks on hind margin from the base, and transverse discal and submarginal band formed of quadrate marks; a yellow lunule ascending obliquely from end, and a longitudinal narrow mark near base of the cell: hindwing ochreous-brown along costa, grayish at base. The female was characterized as pale brownish ochreous; with markings as in male, except that the yellow mark at the end of the cell has the shape of a teardrop.

The distribution of *E. malabaricus* was documented by Tindale (1942) as several localities between the state of Goa in the north and the Nilgiri Hills in the south (Fig. 11). The elevational distribution ranged between 400’ (~ 122 m) and 4,000’ (~ 1200 m). The male type from ‘Sircy’ (*recte* Sirsi) could not be located by Tindale (1942), but a female from Ootacomund was designated as an allotype, and a male from Coorg was designated as the neotype. A genital dissection was illustrated (Fig. 12) and characterized as having a strongly and evenly concave eighth sternite, a triangular saccus, a strongly sclerotized median prolongation of the pseudotegumen extending in an oblique direction towards the midline (= pseudotegumenal process) that was externally visible as a keeled ridge obliquely directed towards the middle and bearing a series of “minute and obscure serrations”, and a posteriorly directed spine (= dorsal lobe) at the posterior extremity of the pseudotegumen.

In the absence of a detailed illustration of the male genitalia of *E. malabaricus* and *E. magnus*, it is not possible to conclusively identity the Kodaikanal specimen. In general external appearance it most closely resembles *E. malabaricus*. The shape of sternum VIII also appears to conform more closely to *E. malabaricus*, but only in comparison with the generalized diagrams presented by Tindale (1942). The Kodaikanal specimen lies just outside the currently recorded range of *E. malabaricus* while being close to the Palni Hills location of *E. magnus* (Fig. 11). The illustration of male genitalia by Tindale (1942) appears to show a posterior central projection of the saccus that is much shorter and wider than in out specimen, but his diagram is too generalized to provide a definitive comparison with the Kodaikanal specimen. In addition, his illustration of the labial palps for *E. malabaricus* shows two, almost subsquare, cylindrical segments in contrast to the single elongate cylindrical segment in the Kodaikanal specimen. Minute serrations
observed on the pseudotegumen ventral edge of *E. malabaricus* by Tindale (1942) are also lacking. In addition to *E. magnus* of the Palni Hills there is also an unidentified specimen (Fig. 10) from that locality that may represent a further unnamed species.

**Systematic notes**

It is not possible to fully assess the relationships of the Kodaikanal specimen, other than to suggest that it is either conspecific or a close relative of *E. malabaricus*, *E. magnus* or another species in the same region. The medially oriented process of the pseudotegumen represents a uniquely derived character state within the Hepialidae that is at present known only from the Kodaikanal specimen and *E. malabaricus*. The generalized external illustration of genitalia for *E. magnus* may suggest that the feature is also present in that species, but this will require confirmation. The feature is absent from various other *Endoclita* species as illustrated by Tindale (1941, 1942, 1958). The elongate tooth shape of the pseudotegumen of the Kodaikanal specimen may represent a variant of a character that ranges in structure from a parallel pseudotegumen flange, to an inflated region as large as the subtending pseudotegumen (Fig. 13). Our description also confirms the presence of four basal cells on the FW as described by Tindale (1942) for *E. malabaricus* and subsequently reported for *E. fahringeri* Grehan & Mielke, 2016 (Grehan & Mielke 2016). This feature is absent from the forewing of *E. davidi* (JRG, pers. obs.), suggesting that the four basal cells may only define an *Endoclita* subclade.

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We are very grateful to John Rawlins (Carnegie Museum of Natural History, Pittsburgh for providing access to research facilities, and to Jane Hyland and Vanessa Verdecia (Carnegie Museum of Natural History, Pittsburgh) for photography and assistance with photographic facilities respectively. We also greatly appreciate the kind support of David Lees and Geoff Martin (Natural History Museum, London) for photos of type specimens, the staff of the New Zealand Arthropod Collection (New Zealand) for loan of dissections used in this study, and we thank Julian Donahue (Natural History Museum of Los Angeles County, Los Angeles) for his interest and information regarding his collecting of this specimen.

**References**


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**Fig. 1.** *Endoclita* nr. *malabaricus* ♂: dorsal view (1a), ventral view (1b) – (scale line=10 mm). Photo by Jane Hyland.

**Fig. 2.** *Endoclita* nr. *malabaricus* ♂, head: mouthparts, “cp” clypeus, “lp” labial palps, “m” mandible, “mp” maxillary palps (2a), labial scale tuft (2b). Photos by John Grehan.
Fig. 3. *Endoclita* nr. *malabaricus* ♂, thorax: scutum III dorsal view (3a), FW basal cells and veins (nomenclature modified from Mielke & Casagrande, 2013) (3b), FW colour pattern (3c), ventral FW costal pocket with ribbed anterior and posterior half with short, pilose scales (3d), metatibial androconia, ventral view (3e). Photos by John Grehan.
Fig. 4. *Endoclita* nr. *malabaricus* ♂, abdomen: tergosternal bar (4a), tergum II, with portion of internal pleural pocket visible on one side (4b), sternum II (4c), segment VII and VIII (4d) – unscaled. Photos by John Grehan.
**Fig. 5.** *Endoclita* nr. *malabaricus* ♂, genitalia: sternite VIII and pseudotegumenal process “pp” (5a), anterior (internal) view (5b), ventral view (5c), lateral view (5d), ventro-lateral view of the terminal segment and genitalia *in situ*, “pp” pseudoteguminal process, “tl” tergal lobes (5e) – scale bar = 1 mm.
Fig. 8

Fig. 9
Fig. 6–10. *Endoclita* species from southeastern India: *Endoclita malabaricus* – females, Ooty (6, 7), *E. magnus* – type male, Palnis (8), *E. magnus* male, Shembaganur, Palnis, 1830 m (9), *Endoclita* sp. Palnis (10). Photos courtesy of Thomas Witt. © Natural History Museum, London, reproduced by permission.
Fig. 11. Distribution records for *Endoclitia malabaricus* (yellow circles), *E. mangus* (blue circle), and *E. nr. malabaricus* (green circle).
Fig. 12–13. Male genitalia: *E. malabaricus* (from Tindale (1942: Fig. 3), reproduced by permission (12), *E. excrescens*, Japan. JSD dissection 606 (13).
A preliminary list of the Sphingidae of Miandam, Khyber Pakhtunkhwa, North Pakistan
(Lepidoptera Sphingidae)

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Abstract
Fifteen species of Sphingidae are reported from the village of Miandam, north Pakistan, all collected by the second author. Two of these, Dolbina inexacta (Walker, 1856) and Rhagastis olivacea (Moore, 1872), represent further confirmation of their occurrence in the country following first records from Pakistan by Rafi et al. (2014).

Keywords: Lepidoptera, Sphingidae, hawkmoths, Pakistan, biogeography, fauna.

The Sphingidae fauna of Pakistan is largely known from three publications. The first by Bell & Scott (1937) dealt with the Sphingidae of the former “British India” and described the early stages of many of the species, and is still the most comprehensive contribution to our knowledge of the biology of this family of moths in this region. Additional information can be found in Pittaway (1993), but that only covered the Palearctic part of Pakistan. Most recently, Rafi et al. (2014) provided the first comprehensive checklist of the Sphingidae of the whole country, reporting 60 species and subspecies, of which 14 were recorded for the first time. They also discussed the very special biogeographical position of the Pakistan fauna, which shows both Palearctic and Oriental elements.

For the two last years, the second author has undertaken intensive investigations of the moth fauna in the area of Miandam village. Miandam is located in Khyber Pakhtunkhwa province, Swat District, in the foothills of Hindu Kush mountains, a geographic area known also as the Swat Valley.

The average elevation of the collecting localities was 1800m, in a picturesque landscape of terraced fields surrounded by the typical vegetation of middle to high altitude northern Pakistan. The main tree species are Pinus wallichiana (Peoch), Abies pindrow (Achar) and Cedrus deodara (Ranzra), all Pinaceae, together with Diospyros lotus (Tor Amlok) and the introduced and commonly cultivated Diospyros kaki (Sor Amlok), Ebenaceae. Juglans regia (Ghuz) Juglandaceae is also frequent in this valley, either as cultivated or sub-spontaneous established trees. The level of anthropogenic change in Swat district is high, with significant agricultural pressures. The region is famous for medicinal plants,
but potatoes, peaches, plums and apricots are also produced in very large amounts. Every year, 113,000 tons of fruit are produced in Swat Valley, forming 30% of all fruit supplied to the national market. Consequently, the local entomological richness is not very high, due to a combination of deforestation and the use of pesticides on the 35,000 acres of land under fruit cultivation. Despite that, 15 species of Sphingidae were collected, three of which represent interesting records for the Pakistani fauna.

All the moths illustrated here are from Miandam, except for *Daphnis nerii*, for which a moth from Gabon (Africa) because the Miandam moth is still in Pakistan, in the collection of the second author.

*Clanidopsis exusta* (Butler, 1875)
Distribution: A classic moth of the southern Himalaya, flying from northern Pakistan to central Nepal and Tibet.
Status in Miandam: A very common moth, flying from early spring to the end of August; 6 males.
Early stages: The larva was reared and described in the western Himalayas at Mussooree by J. D. Campbell, from eggs found on *Indigofera* sp. (Fabaceae) (Bell & Scott 1937: 209). In the same book, the authors also mention *Populus* sp. (Salicaceae) as a possible hostplant, but only in the appendix page 511 and 530. They do not mention that hostplant in the text dealing with the life history of the species. This record originates from the original description of the taxon and is probably an error (Ian J. Kitching *pers. comm.*)
The European Entomologist, Vol. 9, No. 1

Clanis deucalion (Walker, 1856)
Distribution: from Pakistan to Nepal. Never common.
Status in Miandam: Only two specimens of this rare moth were collected in the village, a male on 13 June 2016 and a female on 22 June 2012. The species was previously reported from Khyber Pakhtunkhwa province by Rafi et al. (2014: 395).
Early stages: The larva has been reared and described by Bell & Scott (1937:149). It feeds on Robinia pseudoacacia, one of the most widespread species of Fabaceae.
Dolbina inexacta (Walker, 1856)
Distribution: From Pakistan and north India to southeast Asia (Thailand, Laos, Vietnam) and north to central China.
Status in Miandam: Only one specimen was collected on 21 May 2016. We have also received a large series of this insect (13 males) from Bagh, Azad Jammu and Kashmir, 1300m, collected on 29-30 June 2014, confirming the occurrence in Pakistan of a moth first reported for the country by Rafi et al. (2014: 398), from the Islamabad and Azad Jammu and Kashmir. Specimens from Pakistan are generally smaller and lighter than those from southeast Asia.
Early stages: The larva was described by Bell & Scott (1937: 96-98), feeding on various species of Oleaceae (*Olea dioica, Ligustrum robustum, Fraxinus* sp., *Liniocera malabarica*).
Psilogramma dillerorum (Eitschberger, 2001)
Distribution: SE Afghanistan and northern Pakistan, and probably southern Iran. Status in Miandam: Only a single female was collected in the village in June 2016. Early stages: The larva of the related species, *P. increta*, is known to feed on various species of Pedaliaceae, Verbenaceae, Oleaceae, Scrophulariaceae and Caprifoliaceae throughout its range. No doubt *P. dillerorum* feeds on similar families of plants.
Acherontia lachesis (Fabricius, 1798)
Distribution: From Pakistan to Japan, all of south Asia, the Philippines and New Guinea. Status in Miandam: Only one large female was collected on 2 September 2012. Early stages: The very large larva of *A. lachesis* feeds mostly on Solanaceae and Verbenaceae, but has been found on some 18 different families of plants, and more than 43 genera (Inoue *et al.* 1997).
*Agrius convolvuli* (Linnaeus, 1758)
Distribution: All of the Ethiopian region, almost all of Europe and tropical/subtropical Asia (migrant in the northern Europe and northern Asia).
Status in Miandam: A very common moth flying from April to July. 3 males and 6 females.
Early stages: The larva feeds mostly on various species of Convolvulaceae, but also Fabaceae and Polygonaceae.
Acosmeryx naga naga (Moore, [1858])
Distribution: The nominotypical subspecies flies from north Pakistan to Taiwan and Japan crossing all tropical and subtropical Asia. The moth flies at mid to high altitudes. Status in Miandam: Only known from 3 males collected on 7 and 9 May 2016.
Early stages: The genus is well known for its close relationship with plants of the family Vitaceae (genus Vitis) but A. naga is also found on Actinidiaceae (Saurauia and Actinidia spp.). Even though Vitaceae and Actinidiaceae do not belong to the same order (respectively Vitales and Ericales) and are not closely related phylogenetically, it is well known that many Sphingidae that feed as larvae on Vitaceae also utilize Actinidiaceae (e.g. the genus Eumorpha, J. Haxaire, pers. obs.)
**Daphnis nerii** (Linnaeus, 1758)

Distribution: An African and Asiatic species, flying as a migrant in Europe. Recently collected in Japan (probably natural range extension) and introduced in Hawaii.

Status in Milandam: One specimen, a perfect male, was collected in December 2016. Very probably a migrant specimen.

Early stages: Mostly feeds on Apocynaceae of the genera *Nerium*, *Vinca*, *Catharanthus*, *Tabernaemontana* and *Ervatamia*. 
Macroglossum nyceteris Kollar, [1844]
Distribution: Along the southern Himalaya from Afghanistan to Myanmar and northeast India, thence across China to Beijing and Shandong (Rafi et al. 2014).
Status in Miandam: A day-flying moth, collected on April 23 and May 7 in Miandam. In some places in Pakistan, the moth can be very common during spring and summer.
Early stages: The larval food plant of the very closely related species, M. bifasciata (Butler, 1875) as well as the one of the present species is a species of Rubiaceae, Rubia cordifolia. The early stages are described by Bell and Scott (1937:394-397).
**Nephele hespera** (Fabricius, 1775)

Distribution: A common moth, from Afghanistan/Pakistan to Vietnam, and southern China (Yunnan), thence southeast to Sumatra and Java; a disjunct population occurs in Papua New Guinea and Dauan Island (Australia) (Rafi et al. 2014).

Status in Miandam: A very common moth, flying from May to August. 7 males and 9 females.

Early stages: The larva, described by Bell and Scott (1937:326-327), is known to feed on *Carissa carandas* (Apocynaceae), a very famous plant in the Himalaya used as a condiment in Indian dishes.
Cechenena mirabilis (Butler, 1875)
Distribution: From Pakistan to Sikkim, along the south edge of the Himalaya.
Status in Miandam: As elsewhere within its range, not common, with only a single male collected in June-July 2016.
Early stages: Reared by Bell & Scott (1937:483-485) in the western Himalaya (Simla); the larva feeds on Vitis (Vitaceae).
Deilephila rivularis (Boisduval, [1875])
Distribution: From Afghanistan to central Nepal along the southern slopes of the Himalaya.
Status in Miandam: 3 males collected in June 2016.
Early stages: Very similar to the European Deilephila elpenor (Linnaeus, 1758). The immature stages were described by Bell & Scott (1937: 411-412) on Impatiens sp. (Balsaminaceae), and Arisaema sp. and Amorphophallus (Araceae).
**Hippotion celerio** (Linnaeus, 1758)

Distribution: One of the widest distributions of all Sphingidae: all of Africa, Asia, Australia, as far as New Caledonia and Tahiti. Migrant to most European countries (Haxaire 2015).

Status in Miandam: One of the commonest Sphingidae in Miandam, probably due to its larva accepting a wide range of plant species. Flies from April to August. 9 males and 4 females.

Early stages: Although the larva feeds mostly on Vitaceae, it can be found on a very wide range of plants families, including Rubiaceae, Polygonaceae, Araceae, Chenopodiaceae and Nyctaginaceae.
Theretra oldenlandiae oldenlandiae (Fabricius, 1775)
Distribution: From Pakistan to Korea, Japan and Indo-China, thence through Malaysia, the Philippines and Indonesia, to New Guinea, Australia and the Solomon Islands.
Status in Miandam: Only a single male collected on 22 August 2016.
Early stages: As with the previous species, T. oldenlandiae feeds on a large number of species from the following families: Araceae, Balsaminaceae, Bignoniaceae, Dilleniaceae, Onagraceae, Rubiaceae, Vitaceae, Convolvulaceae and Lecythidaceae.
**Rhagastis olivacea** (Moore, 1872)
Distribution: From Pakistan to northern Vietnam and southern China.
Status in Miandam: A rare sphingid in Pakistan. Two males were collected in June and July 2016, representing only the second record of the species in Pakistan following the work of (Rafi et al. 2014).
Early stages: The larva was described and reared by Bell & Scott (1937: 475-477) on *Impatiens* sp. (Balsaminaceae), *Arisaema* sp. and *Amorphophallus* (Araceae), and *Vitis* sp. (Vitaceae).
Discussion
Fifteen species of Sphingidae were collected at Miandam, which represents only a small beginning, and further species are sure to be discovered. The most significant moths collected were *Rhagastis olivacea*, with two specimens that confirm the occurrence of the species in Pakistan, and *Dolbina inexacta*, which proved to be very common in some places in Pakistan following its first mention for the country by Rafi & al. (2014). So far, no sphingid species has been reported as an agricultural or horticultural pest in Pakistan, even though the larvae of *Acherontia lachesis*, *Agrius convolvuli*, *Nephele hespera* and *Hippotion celerio* have occasionally been found on cultivated plants.

References
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The Sphingidae Museum performs scientific and research activities in taxonomy and biodiversity in the Czech Republic and abroad.

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Contents:

A new species of genus Cypoides Matsumura, 1921 (Lepidoptera, Sphingidae) from Sulawesi Island, Eastern Indonesia
Tomáš Melichar & Michal Řezáč & Anna Ilčíková ........................ 1 - 9

Morphology and taxonomy of Endoclita nr. malabaricus (Moore, 1879) (Lepidoptera: Hepialidae) from Kodaikanal, India
John R. Grehan & Carlos. G. C. Mielke ................................. 11 - 24

A preliminary list of the Sphingidae of Miandam, Khyber Pakhtunkhwa, North Pakistan (Lepidoptera Sphingidae)
Par Jean Haxaire, Fazlullah Gujjar & Muhammas Saeed ........ 25 - 41

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