Speciation in *Graphium sarpedon* (Linnaeus) and allies (Lepidoptera: Rhopalocera: Papilionidae)

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Abstract

The relationships between subspecies of *Graphium sarpedon* (Linnaeus, 1758) and closely allied species have been investigated. This group appears to comprise eight sibling species, as follows: *Graphium sarpedon* (Linnaeus, 1758), *G. adonarensis* (Rothschild, 1896) **stat. rev.**, *G. anthedon* (Felder & Felder, 1864), *G. milon* (Felder & Felder, 1865) **stat. rev.**, *G. isander* (Godman & Salvin, 1888) **stat. rev.**, *G. choredon* (Felder & Felder, 1864) **stat. rev.**, *G. teredon* (Felder & Felder, 1864) **stat. rev.**, *G. jugans* (Rothschild, 1896) **stat. rev.** The following new subspecies are described: *G. sarpedon sirkari* **n. subsp.** from N. India and S. China, *G. adonarensis hundertmarki* **n. subsp.** from Bali, *G. adonarensis agusyantoei* **n. subsp.** from Sumatra, *G. adonarensis phyrisoides* **n. subsp.** from Bangka and Belitung, *G. adonarensis toxopei* **n. subsp.** from Lombok, *G. adonarensis septentrionicolus* **n. subsp.** from N. India and E. China.

Keywords: Lepidoptera, Papilionidae, *Graphium sarpedon*, new subspecies.

Zusammenfassung

Die Beziehungen zwischen den Unterarten von *Graphium sarpedon* (Linnaeus, 1758) und anderer nahestehender Arten der Gattung werden untersucht. Diese Gruppe nahe verwandter Arten enthält wahrscheinlich acht Taxa wie folgt: *Graphium sarpedon* (Linnaeus, 1758), *G. adonarensis* (Rothschild, 1896) **stat. rev.**, *G. anthedon* (Felder & Felder, 1864), *G. milon* (Felder & Felder, 1865) **stat. rev.**, *G. isander* (Godman & Salvin, 1888) **stat. rev.**, *G. choredon* (Felder & Felder, 1864) **stat. rev.**, *G. teredon* (Felder & Felder, 1864) **stat. rev.** und *G. jugans* (Rothschild, 1896) **stat. rev.** Die folgenden neuen Unterarten werden beschrieben: *G. sarpedon sirkari* **n. subsp.** aus Nord-Indien, *G. adonarensis hundertmarki* **n. subsp.** aus Bali, *G. adonarensis agusyantoei* **n. subsp.** aus Sumatra, *G. adonarensis phyrisoides* **n. subsp.** aus Bangka und Belitung, *G. adonarensis toxopei* **n. subsp.** aus Lombok und *G. adonarensis septentrionicolus* **n. subsp.** aus Nord-Indien und Ost-China.

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1 Introduction

The Common Bluebottle, or Blue Triangle, is a wide-ranging butterfly found throughout eastern Asia from Japan to Australia. It has long been treated as the single species *Graphium sarpedon* (Linnaeus, 1758) throughout its wide distribution. Murayama (1978) recognised a separate species under the name *Graphium milon* (Felder & Felder, 1865) that included subspecies from the Sula islands and Moluccas. The separation was based on external morphology and differences in the structure of the male genitalia. The external morphological characters were largely defined on the basis of *G. milon* from Sulawesi. The principal characters were: median band uniformly blue and

uniform in width; whitish spot in space 7 more white than in *G. sarpedon*; black radius and cubitus of hindwing cell; submarginal lunules large, prominent and acutely angled. Tsukada & Nishiyama (1982) noted that the Moluccan subspecies do not entirely conform to these characters but that they were nevertheless closer to *G. milon* than to *G. sarpedon*. Moonen (1998) and Vane-Wright (Vane-Wright & De Jong 2003, Peggie et al. 2005) pointed out that *Papilio milon* Felder & Felder was not validly published until 1865 and is thus junior to *Papilio anthedon* Felder & Felder, 1864. These authors transferred all the subspecies assigned to *G. milon* by Tsukada & Nishiyama (1982) to *Graphium anthedon* (Felder & Felder, 1864). The races occurring in the Papuan region and Australia were assigned to *G. sarpedon* by Tsukada & Nishiyama (1982) without discussion of the disjunctive distribution pattern that such assignment creates. Further, Vane-Wright & De Jong (2003) assigned the taxa *monticolus* Fruhstorfer, 1896 and *tetrix* Tsukada & Nishiyama, 1980 to a separate species under the name of *Graphium monticolus* (Fruhstorfer, 1896), and speculated that the taxon *tetrix* Tsukada & Nishiyama, 1980 might be a separate species, based on "superficial examination of museum material". Thus, there exists some uncertainty over the proper affinities of some subspecies in this region.

Re-examination of the external features and anatomy of the male and female genitalia, as well as the available sequence data for the mitochondrial NADH dehydrogenase subunit 5 (ND5) and nuclear 28S rRNA genes, of the races in question suggests a different set of relationships. As described below, there appear to be eight morphologically distinct groups that should be treated as separate species, as follows: *Graphium sarpedon* (Linnaeus, 1758); *G. adonarensis* (Rothschild, 1896) stat. rev., which is sympatric with *G. sarpedon* in N. India and China; *G. milon* (Felder & Felder, 1865) from Sulawesi and Sula; *G. anthedon* (Felder & Felder, 1864), which includes the taxa *monticolus* and *tetrix* and is therefore sympatric with *G. milon*; *G. isander* (Godman & Salvin, 1888) stat. rev., which includes the Papuan subspecies previously assigned to *G. sarpedon*; *G. choredon* (Godman & Salvin, 1888) stat. rev. from Australia; *Graphium teredon* (Felder & Felder, 1864) stat. rev., from S. India and Sri Lanka and *G. jugans* (Rothschild, 1896) stat. rev. from Sumba, Timor and Wetar. Two additional species included in the *G. sarpedon* group, *G. sandawanum* Yamamoto, 1977 from Mindanao in the Philippines, and *G. cloanthus* (Westwood, 1845), are not considered in detail herein as they have been recently been discussed elsewhere (Page & Treadaway 2004, Racheli & Cotton 2009).

2 Methods

The male and female genitalia were dissected by removing the terminal abdominal segments and digesting these with 10 % (w/v) aqueous NaOH for 24 hr at room temperature. The preparations were washed in several changes of water and the soft tissues were removed to expose the external features. After thorough washing and clarifying by passage through 70 % ethanol, preparations were stored in 20 % (v/v) glycerol. Additional preparations of the female genitalia from specimens of *G. sarpedon* and *G. adonarensis* were made using a slower digestion, in 0.5 % NaOH, with gentle agitation. It took several days to soften the tissue, but undue swelling of the cartilaginous structures was avoided. Clarified specimens were examined unmounted using a Zeiss STEMI DV4 stereomicroscope. Digital images were recorded at 32× magnification and normalized using the dorsal and ventral ends of the chitinized rim of the clasper as fixed points for morphometric analysis (Fig. 33). The shape of the clasper was compared using the coordinates of the six points shown in Fig. 33: (a) maximum dorsal extent, (b) apex of the dorsal lobe, (c) maximum extent of the invagination of the clasper rim, (d) maximum lateral extent of the ventral lobe, (e) base of the principal spur of the brachium subcostale, (f) tip of the brachium costale. The similarity between the sets of measurements was assessed using STATISTICA 10 (StatSoft, USA).

Nucleotide sequences deposited in the National Center for Biotechnology Information (NCBI) database (http://www.ncbi.nlm.nih.gov/nuccore/) were aligned and compared using NCBI BLAST (Zhang et al. 2000, Morgulis et al. 2008) using default settings.

Under "Material examined", we list only type material and those specimens that have been available for measurement and dissection. Apart from the type material held in the collection of the Linnaean Society of London [LSLO] and the British Museum (Natural History) [BMNH], the specimens examined are currently located in the collections of the authors: Treadaway collection (part of the Senckenberg Museum, Frankfurt a. M. [CGT]) or the Page collection, Basel [MGP]. All the holotypes of the new subspecies described herein will be deposited in the Senckenberg Museum, Frankfurt a. M., Germany [SMF]. Pictures of some of the types referred to herein, marked with * in the material list, are available at http://globis.insects-online.de/species&tree_h=.Papilionidae.Papilioninae.Leptocircini.Graphium.Graphium.71&sub=no&tree_status=minus&tree_seq=23 and some of the Linneaen types, including the lectotype of *G. sarpedon*, are available at http://www.linnean-online.org/14322.

3 Morphological analysis

Visually, the *G. sarpedon* group species fall into two subgroups, according to the blue-green colour of the discal band, which is due to the different complexation state of the sarpedobilin pigments embedded in the wing membrane and of the scales overlying the pigmented wing areas (Barbier 1981, 1990, Stavenga et al. 2010). The *G. sarpedon* sub-group has green to bluish-green markings whereas the *G. anthedon* sub-group typically has turquoise-blue markings (See Figs. 1–32). Individuals may vary, and frequently one finds that bred specimens that have not had time for the bilin pigments to mature naturally (Barbier 1981), have white, or pale green markings.

The clasper (valva) of the male genitalia of the *G. sarpedon* group species has an irregular outline with distal portion of the rim divided into dorsal and ventral lobes by an invagination (Fig. 33). The dorsal lobe is relatively thick and carries the brachium subcostale (Niculescu 1977), which differs significantly between the various species (Fig. 43). The distal portion of the

ventral lobe of the clasper has a serrate or dentate rim. The harpe is degenerate, with just a raised ridge discernible in the body of the clasper and a setose projection, pointing into the cavity of the clasper, near the dorsal limit of this ridge.

Morphometric analysis demonstrates that there is relatively little variation within a species, but there is marked delineation between the species (Fig. 33). The *G. sarpedon* species group is divided into four major clusters, comprising (1) *G. teredon*, (2) *G. cloanthus*, (3) *G. adonarensis*, and (4) *G. sandawanum*, *G. sarpedon*, *G. anthedon*, *G. milon*, *G. isander* and *G. choredon*.

G. teredon is distinguished by its strongly elongated clasper, which is unlike any other species. It is strongly elongated, with a small circular invagination between the lobes (Fig. 42). The brachium subcostale has two dentate processes of unequal size, the larger spur is relatively short and has a round end that lies close to the apex of the dorsal lobe (Fig. 43). The dorsal lobe of the clasper is small and narrow, while the ventral lobe is strongly produced. The serration on the rim is coarse and strongly chitinized at the apex of the lobe, but weakens sharply away from this point.

G. cloanthus is distinguished largely by the rather square profile of the clasper and the atrophied brachium subcostale, which is represented only by a short dentate spur (Racheli & Cotton 2009).

G. adonarensis is distinguished by the relatively round profile of the clasper and long, curved brachium subcostale. The clasper of *G. adonarensis* is rounded, and the invagination between dorsal and ventral lobes is relatively shallow (Fig. 35). The brachium subcostale is a single, dentate process that curves away from the dorsal margin and crosses the rim of the clasper ventrally with respect to the distal extremity of the dorsal lobe (Fig. 43). The rim of the clasper is notched at the point where the brachium subcostale crosses it and there is additional chitinization of the rim around this point. The proximal portion of the brachium subcostale is broader than that of *G. sarpedon* and is produced to form a large serrate or dentate ridge projecting into the cavity of the clasper. The brachium subcostale curls markedly at its distal end which is, however, not as strongly dentate as in *G. sarpedon*. The serration of the ventral lobe is fine and is restricted to the distal portion of the lobe.

All the species comprising the fourth cluster have moderately elongated claspers, due to the development of the ventral lobe, and a variable brachium subcostale, whose form largely drives the sub-clustering. The clasper of *G. sarpedon* is elongated, and the invagination between dorsal and ventral lobes is relatively deep (Fig. 34). The brachium subcostale is a single, dentate process running nearly parallel to the dorsal margin of the dorsal lobe. It is straight for most of its length, with relatively small teeth, and curls slightly at its distal end which may bear several knobs or small teeth. The brachium subcostale reaches the rim of the clasper dorsally with respect to the distal extremity of the dorsal lobe, and may project slightly beyond the rim (Fig. 43). The serration of the ventral lobe is quite coarse and extends more than half way to the base of the clasper.

The clasper of *G. anthedon* is rounded, and the invagination between dorsal and ventral lobes is relatively deep (Figs. 36, 37). The brachium subcostale has two spurs of unequal size (Fig. 43). The larger spur is strongly chitinized and curves upward, crossing the margin of the clasper dorsally with respect to the distal extremity of the dorsal lobe and projecting considerably beyond it. At the base of this spur there is a smaller dentate ridge that projects into the cavity of the clasper. The dorsal lobe is quite broad and has a rounded apex. The ventral lobe is strongly chitinized and has a sharp, well-defined apex. The serration on the rim is coarse and heavily chitinized. The clasper of *G. milon* is elongated, and the invagination between dorsal and ventral lobes is relatively deep (Fig. 38). The brachium subcostale has two dentate processes of similar size (Fig. 43). One spur is oriented towards the dorsal lobe of the clasper and just crosses it at the apex. The other spur is directed perpendicular to the first and projects into the cavity of the clasper. It has a broad, dentate head which is considerably larger than the equivalent structure found in *G. anthedon* (Felder & Felder, 1864). The dorsal lobe is slender in comparison to all other species. The ventral lobe is strongly chitinized and has its apex extended as a coarsely dentate spur. The serration on the rim is coarse and strongly chitinized. The clasper of *G. isander* is rounded, and the invagination between dorsal and ventral lobes is relatively shallow (Figs. 39, 40). The brachium subcostale has two dentate processes of unequal size that are greatly reduced compared to all other species (Fig. 43). The dorsal lobe of the clasper has a rounded apex and a corrugated inner surface. The ventral lobe of the clasper is strongly chitinized with coarse serration on the rim and an angular apex. The clasper of *G. choredon* is elongated, and the invagination between dorsal and ventral lobes is relatively narrow but deep (Fig. 41). The brachium subcostale has two spurs of unequal size, similar to the structure observed in *G. anthedon* but much more slender in construction (Fig. 43). The upper spur is directed towards the dorsal lobe and reaches the clasper rim dorsally of its apex. The dorsal lobe of the clasper is broad and has a rounded apex. The ventral lobe of the clasper is also broad and the serration on the rim is relatively fine but the serrate portion of the rim is raised from the line of the clasper rim. The clasper of *G. jugans* is rounded, with a deep, almost circular invagination between the lobes (Fig. 33). The brachium subcostale has two spurs of unequal size (Fig. 43). The major spur is directed towards the dorsal lobe and crosses the rim dorsally of its apex. The second spur originates from the main spur and not its base as in the other species that have this structure. The dorsal lobe of the clasper has a pointed, chitinized apex. The apex of the ventral lobe is produced as a dentate spur. The clasper of *G. sandawanum* is intermediate between *G. sarpedon* and *G. anthedon*. It is relatively elongated by extension of the ventral lobe, but this is not heavily chitinized (Page & Treadaway 2004). The brachium subcostale has two spurs of unequal size, as in *G. anthedon*, but the major spur is long and straight as in *G. sarpedon*.

The female genitalia of the *G. sarpedon* group (Fig. 44) conform to the general structure of *Graphium*. Thus, the ostium bursae opens, via a sclerotized, bilobed structure, into a cup-like vestibulum (Van Son 1949) closed dorsally by a canopy-like lamella postvaginalis (posterior labia of Smith & Vane-Wright 2001) presumed to derive from the 8th sternite (Miller 1987) and ventrally by the lamella antevaginalis formed from sclerotized ridges and a cartilaginous fold produced from the 7th tergite (lateral lobes of Smith & Vane-Wright 2001).

The female genitalia of *G. sarpedon* sensu stricto are difficult to analyse because of the highly cartilaginous inner structure of the organ. During the standard preparation using strong alkali, the cartilage absorbs water and swells up, resulting in considerable distortion and even extrusion of the internal structure of genital orifice. Thus, the preparation illustrated by Smith & Vane-Wright (2001) has undergone nearly complete eversion of the upper part of the vestibulum such that the lamella postvaginalis is not readily detectable, which led Smith & Vane-Wright

(2001) to describe it as a "simple ridge without clear homology to structures in other species of *Graphium*". PAGE & TREADAWAY (2004) illustrate a less distorted preparation in which the lamella postvaginalis is readily detected and clearly homologous to that found in other *Graphium*. Nevertheless, the structure surrounding the ostium bursae has partially swollen so that it protrudes significantly beyond the lamella antevaginalis. It is necessary to use rather dilute alkali and to monitor the progress of the digestion to avoid such distortion. In undistorted specimens, the lamella postvaginalis is domed and the rim has a small central lobe (Fig. 45). The margin of the lamella antevaginalis is smooth and weakly bilobed.

The female genitalia of *G. adonarensis* are similar to those of *G. sarpedon* but not so highly cartilaginous (and therefore not prone to the swelling usually observed with *G. sarpedon* specimens). The lamella postvaginalis is flatter than that of *G. sarpedon*, and there is no central lobe (Fig. 45). The margin of the lamella antevaginalis is slightly dentate and more strongly bilobed than that of *G. sarpedon*.

In *G. anthedon*, the lamella postvaginalis is very large but is only strongly chitinized along its ventral rim. The rim has a small central protrusion that weakly divides the rim into two lobes (Fig. 45). The lamella antevaginalis is strongly bilobed and is highly cartilaginous. On the outer surface, the two lobes are separated by a corrugated keel-like structure. Anterior to this latter structure is a pair of lateral folds that are strongly chitinized.

In *G. milon*, the lamella postvaginalis is very large and is strongly chitinized. The rim is smooth, without a central protrusion (Fig. 45). The lamella antevaginalis is strongly bilobed with the central keel marking a cleft between the lobes. The rim of the lobes is finely dentate and its surface is marked with corrugations. Anterior to this latter structure is a pair of lateral folds that are sclerotized, but not to the extent seen with *G. anthedon*.

In *G. isander*, the lamella postvaginalis is large, bilobed with a large central division and is only sclerotized along its rim (Fig. 45). The lamella antevaginalis is bilobed with a weakly represented central keel. The outer surface of this structure is more extensively corrugated than seen with other species.

In *G. choredon* the lamella postvaginalis is large, heavily chitinized and relatively flat (Figs. 44, 45). It has a central protrusion from the ventral rim. The lamella vaginalis is bilobed, with a marked central process and the whole structure is relatively strongly chitinized.

The female genitalia of *G. teredon* and *G. jugans* have not been examined. In *G. sandawanum*, the lamella postvaginalis is very large but is only strongly chitinized along its ventral rim as in *G. anthedon*. The rim has a small central protrusion this weakly divided into two lobes (PAGE & TREADAWAY 2004).

The differences in morphology of the male and female genitalia that exist between *G. sarpedon* and *G. adonarensis*, *G. anthedon* and *G. milon* and *G. isander* and *G. choredon* are more profound than observed between *Arisbe doson* (Felder & Felder, 1864) and *A. eurypylus* (Linnaeus, 1758), which differ in the shape of the harpe in the male genitalia and hardly at all in the female genitalia (PAGE & TREADAWAY 2004).

4 Sequence analysis

YAGI et al. (1999) and MAKITA et al. (2003) reported sequence fragments from the mitochondrial ND5 genes for a number of species of Leptocircini, including several isolates of *G. sarpedon* (from Japan, Malaysia and Taiwan), *G. adonarensis* from Bali (as *G. sarpedon*), *G. anthedon* (from Buru, as *G. milon*) and *G. milon* (from Sulawesi). MAKITA et al. (2003) described the results of phylogenetic analyses by clustering using neighbour-joining, or unweighted pair-group with arithmetic averages and by maximum parsimony analysis. They recognized two species, *G. sarpedon* and *G. milon*, with *G. adonarensis* (Bali) included in the *G. sarpedon* cluster but evidently less closely related to the other isolates. The topology of the trees constructed by either method was very similar to that shown in Fig. 46 for the BLAST analysis of the protein sequences. The isolates of *G. sarpedon* sensu stricto were highly homologous at the nucleotide level, differing not at all, or only in single nucleotide substitutions in the 381 base-pair fragment that was common to all sequences, as is typical for isolates representing different subspecies within the Leptocircini (MAKITA et al. 2003). The *G. adonarensis* sequence (AB059518) differed in six nucleotide substitutions from the consensus *G. sarpedon* sequence. This is more than typical for isolates representing different subspecies and is about the same degree of difference that is observed between the sequences of closely related pairs of species of Leptociricini. For example, *Arisbe bathycles* (Zinken, 1831) and *Arisbe chironides* (Honrath, 1884) differ by only four nucleotide substitutions, while isolates of *Arisbe doson* and *Arisbe eurypylus* differ by four to six nucleotide substitutions (MAKITA et al. 2003). The *G. anthedon* sequence (AB059528) differed in 14 nucleotide substitutions from the consensus *G. sarpedon* sequence and the *G. adonarensis* sequence. The *G. milon* sequence (AB059527) differed in 16 nucleotide substitutions from the consensus *G. sarpedon* sequence and in 17 nucleotide substitutions the *G. adonarensis* sequence. There was more similarity between the *G. anthedon* and *G. milon* sequences with 14 nucleotide differences. The difference between the nucleotide sequences of *G. sarpedon*, *G. anthedon* and *G. milon* are considerably greater than observed within any of the species of Leptocircini studied by MAKITA et al. (2003), and is about the same degree of difference as seen between distinct members of a species group, such as *Arisbe doson* and *A. evemon* (Boisduval, 1836) or *A. mandarinus* (Oberthür, 1879) and *A. tamerlanus* (Oberthür, 1876). At the protein level, which is more significant for the organism than the nucleotide sequences, *G. anthedon* differs from *G. milon* at only one position in the corresponding amino acid sequence, whereas both differ from all *G. sarpedon* isolates in conservative substitutions at three loci: position 17 (methionine in *G. sarpedon* isolates, leucine in *G. milon* & *G. anthedon*), position 235 (valine in *G. sarpedon* isolates, isoleucine in *G. milon* & *G. anthedon*), and position 236 (methionine in *G. sarpedon* isolates, valine in *G. milon* & *G. anthedon*). Thus, *G. anthedon* appears to be significantly more similar to *G. milon* than it is to *G. sarpedon*.

The nuclear 28S rRNA sequences analysed by MAKITA et al. (2003) revealed a similar pattern, with the topology of the phylogenetic trees being identical to the BLAST analysis (Fig. 47). The *G. sarpedon* isolates from Japan, Taiwan, Laos, and Malaysia had few, if any, substitutions. The sequence of the *G. adonarensis* isolate from Bali was somewhat less similar, being no more similar to *G. sarpedon* than was *G. milon* from Sulawesi.

In conclusion, the available nucleotide sequence data places *G. adonarensis* at approximately the same level of differentiation from *G. sarpedon* as one observes between established, closely related, pairs of species and places *G. anthedon* at approximately the same level of differentiation from *G. milon* as one observes between well-differentiated species within a species group.

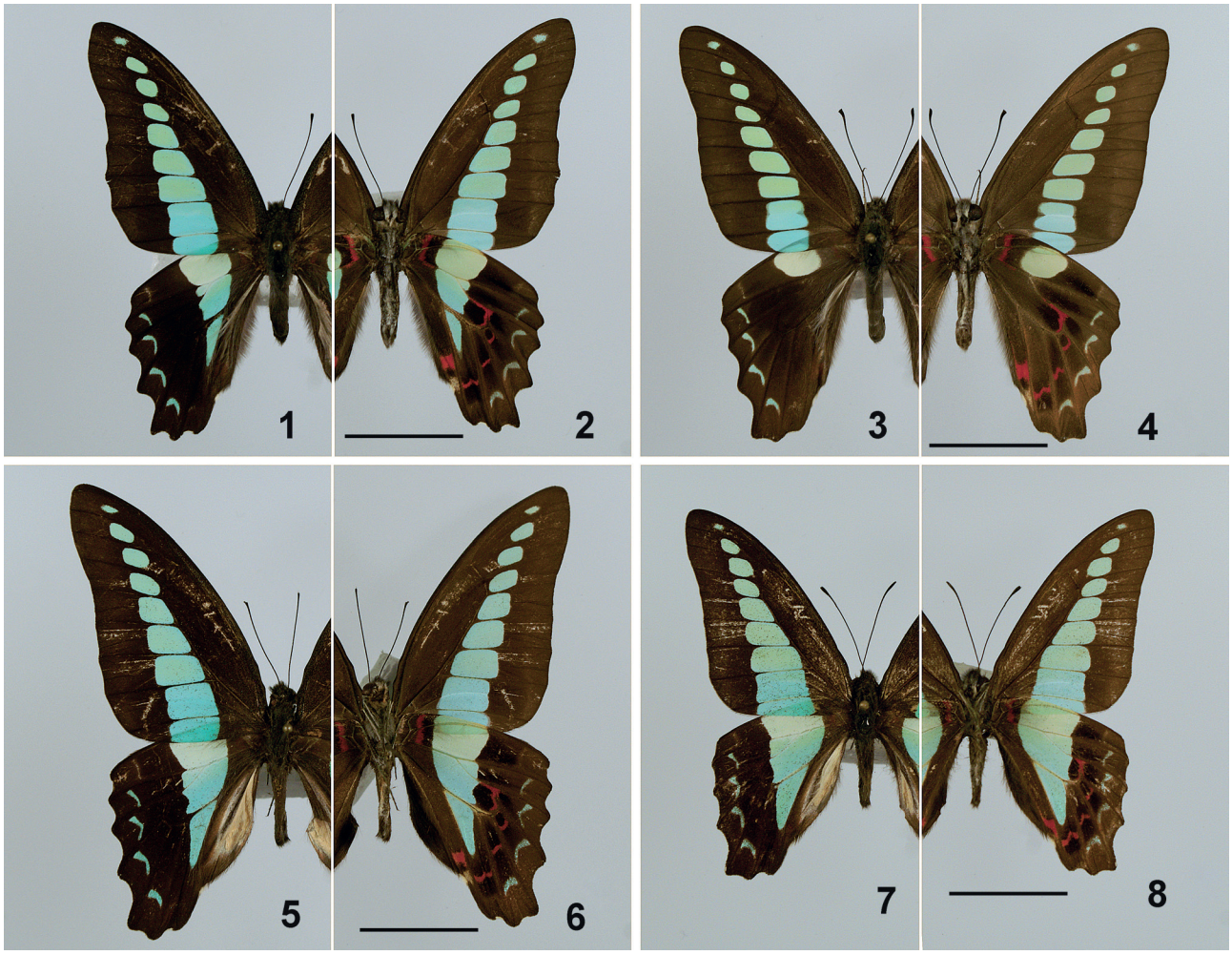
5 Taxonomy

5.1 *Graphium sarpedon* (Linnaeus, 1758)

Papilio Eques Trojanus sarpedon LINNAEUS, 1758. Type locality: Asia [China, Canton].

The type specimen and its origin were discussed by CORBET (1942) and TOXOPEUS (1951), who concurred that the authentic type is a specimen in the Linnaean cabinet originating from China and not, as suggested by AURIVILLIUS (1882), a specimen in the collection of Queen Louisa Ulrica of Sweden. The origin of the latter specimen may also be China (TOXOPEUS 1951), although it was assumed to be Java by ROTHSCHILD (1895) because of its similarity to Javanese specimens (AURIVILLIUS 1882). The lectotype in the Linnaean collection was designated by HONEY & SCOBLE (2001). HEMMING (1935) placed *Papilio protensor* Gistel, 1857, as a junior synonym of *P. sarpedon* Linnaeus, 1758.

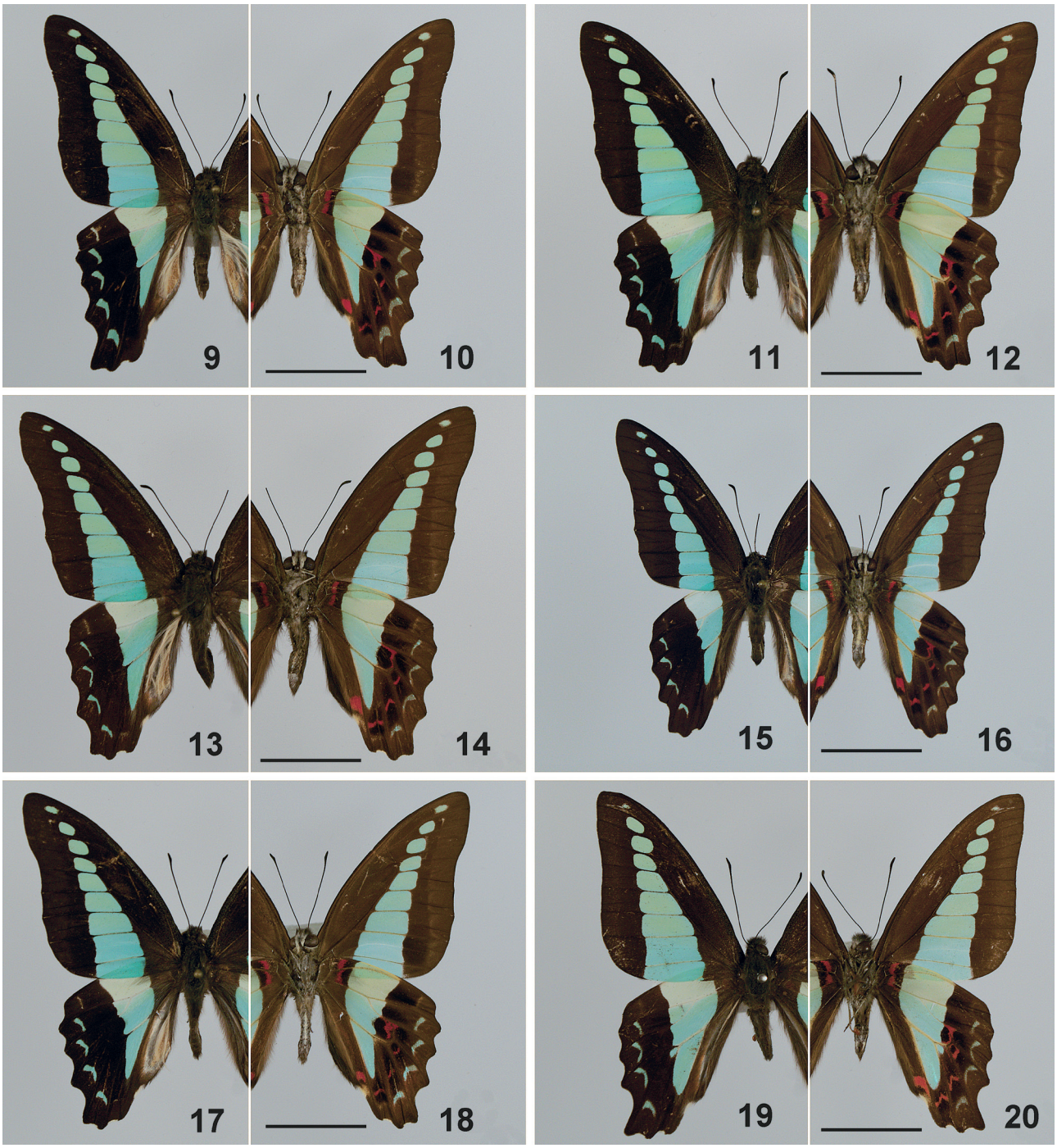
G. s. sarpedon (Figs. 1, 2) has a single band of green markings on both surfaces of the forewing that starts at the costal margin close to the apex of the cell and extends through the discal area to the anal margin. The apical four green markings are isolated round spots but the markings are more extensive in cells CuA2 to M3. In the typical form, the veins separating these cells are marked with black, breaking the discal band into discrete rectangular spots. The hindwing upperside has a tapered discal band that is white at the costal margin and green towards the anal tornus of the wing. There is also a sub-marginal band of green (or white) spots. The markings on the underside of the wings resemble those on the upperside except that the



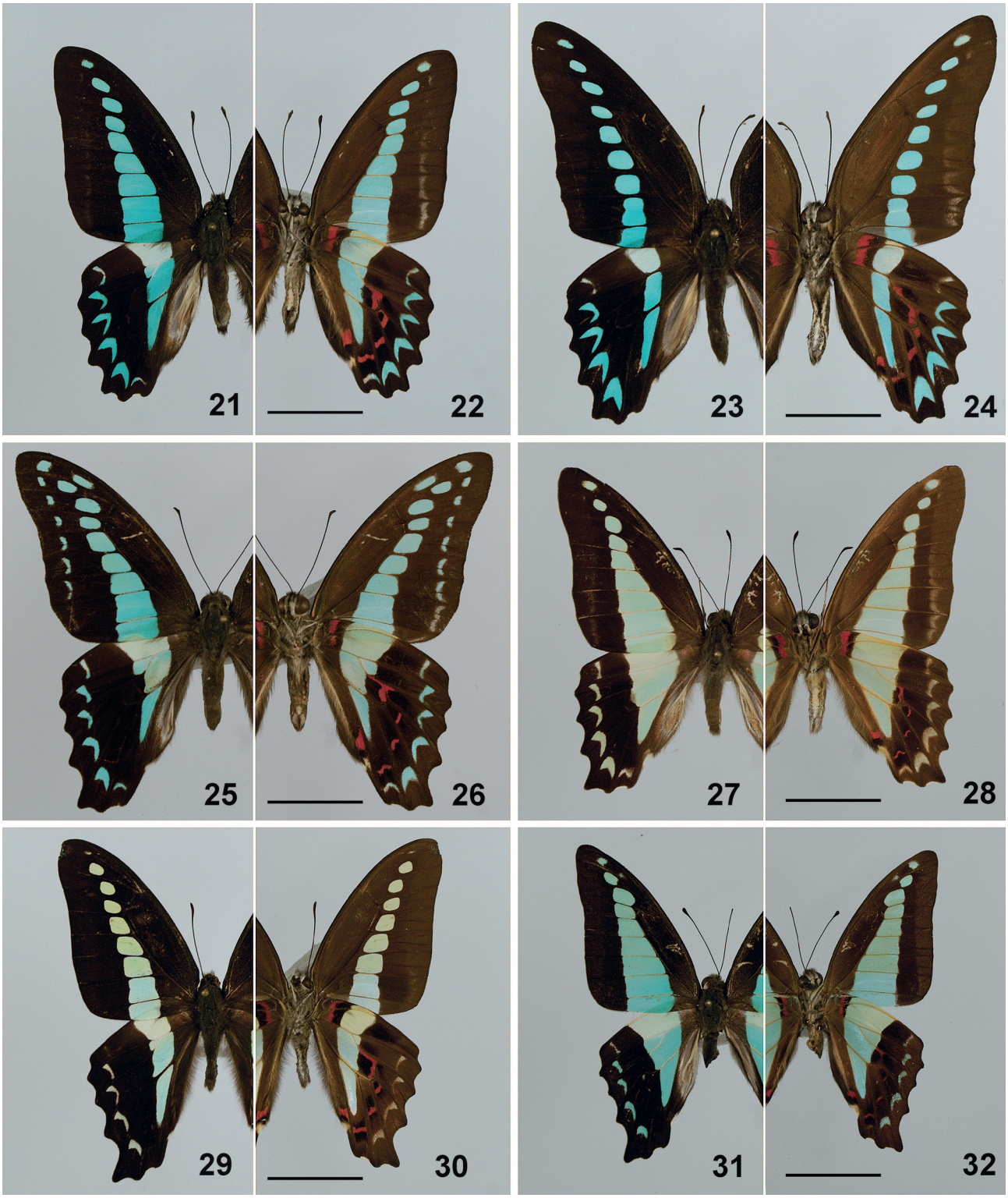
Figs. 1–8. Males of *Graphium sarpedon*. – **1**. *G. s. sarpedon* (Linnaeus, 1758), China, typical form. **2**. Same specimen as before, underside. **3**. *G. s. sarpedon*, f. *semifasciatus*, China. **4**. Same specimen as before, underside. **5**. *G. s. sirkari* n. subsp. Holotype, N. India. **6**. Same specimen as before, underside. **7**. *G. s. sirkari* Paratype, N. India, early season form. **8**. Same specimen as before, underside. – Scales: 2 cm.

green areas are covered with a layer of opalescent scales on both wings and that there is a discal band of red spots lying between the green markings of the discal band and the submarginal row of spots.

Distribution of the species: China, Indonesia (Kalimantan), Japan, Malaysia, Philippines, Taiwan.



Figs. 9–20. Males of *Graphium adonarensis*. – **9**. *G. a. adonarensis* (Rothschild, 1896), Sumbawa. **10**. Same specimen as before, underside. **11**. *G. a. hundertmarki* n. subsp. Holotype, Bali. **12**. Same specimen as before, underside. **13**. *G. a. agusyantoei* n. subsp. Holotype, Sumatra. **14**. Same specimen as before, underside. **15**. *G. a. phyrisoides* n. subsp. Holotype, Belitung. **16**. Same specimen as before, underside. **17**. *G. a. toxopei* n. subsp Holotype, Lombok. **18**. Same specimen as before, underside. **19**. *G. a. septentrionicolus* n. subsp Holotype, N. India. **20**. Same specimen as before, underside. – Scales: 2 cm.



Figs. 21–32. Males of *Graphium anthedon*, *G. milon*, *G. isander*, *G. choredon*, *G. teredon* and *G. jugans*. – **21**. *G. a. anthedon* (Felder & Felder, 1864), Seram. **22**. Same specimen as before, underside. **23**. *G. m. milon* (Felder & Felder, 1865), Sulawesi. **24**. Same specimen as before, underside. **25**. *G. i. isander* (Godman & Salvin, 1888), Guadalcanal. **26**. Same specimen as before, underside. **27**. *G. choredon* (Felder & Felder, 1864), Australia. **28**. Same specimen as before, underside. **29**. *G. teredon* (Felder & Felder, 1864), Sri Lanka. **30**. Same specimen as before, underside. **31**. *G. j. wetterensis* Okano, 1993, Wetar. **32**. Same specimen as before, underside. – Scales: 2 cm.

Graphium sarpedon sarpedon (Linnaeus, 1758)

= *Papilio protensor* Gistel, 1857. Type locality: probably China. [Synonym].
= *Papilio semifasciatus* Honrath, 1888. Type locality: Kiukiang, China. [Synonym].

Material examined

Type material: Lectotype ♂ *Papilio sarpedon* Linnaeus, 1758 [LSLO]; Holotype ♂* *Papilio semifasciatus* Honrath, 1888 [BMNH]. – Additional material: 4♂♂ Hong Kong [CGT]; 61♂♂ from China (Anhui, Hubei, Fujian, Guangxi, Sichuan, Yunnan provinces and Hong Kong, 6♀♀ from Anhui and Sichuan provinces, China [MGP].

Diagnostic characters

A moderately sized subspecies with the range in ♂ FW length 34–42 mm in early season and 40–48 mm in the late season. It shows some variation in size across its range and between seasons. Specimens from the northern part of the range are smaller (Anhui, June–July, average ♂ FW length 41.7 mm, N = 23) than those from the southern part of the range (Fujian, June–July, average ♂ FW length 44.8 mm, N = 11). The early season ("Spring") forms are smaller than those of the late season ("Summer") brood (Sichuan, April–May, average ♂ FW length 37.4 mm, N = 6, compared to July–August average ♂ FW length 45.5 mm, N = 6). The early season forms have complete bands of green spots on the uppersides of both wings. The spots towards the anal margin of the forewing are scarcely separated by black marking along the veins. The hindwing discocellular CuA1 is constantly marked by heavy black scaling. The late season specimens have the FW spots separated by black scaling along the veins (Fig. 1). The black marking along the HW discocellular shows a tendency to be enlarged across the discal cell leading to reduction of the tapering discal band green markings, which may be reduced to a single spot in cell Sc+R1 (Fig. 3). These examples with reduced markings (= *semifasciatus* Honrath 1888) were identified as being extreme wet season forms by Toxopeus (1951). The type specimen has a complete discal band on the hindwing and was suggested to be a normal summer form.

Distribution

Distributed throughout most central and southern China, with the exception of Hainan and those parts of southern Yunnan bordering onto Myanmar and Laos.

Graphium sarpedon nipponus (Fruhstorfer, 1903)

Papilio sarpedon nipponus Fruhstorfer, 1903. Type locality: In original description: Okinawa, Ishigaki, Nagasaki; later restricted to Nagasaki (Fruhstorfer 1908).
= *Papilio sarpedon sarpedonides* Fruhstorfer 1908. Type locality: Oshima. [Synonym].
= *Papilio sarpedon intermedium* Kato, 1940. Type locality: Hachijo Is. [Homonym, nec. *Papilio intermedia* Stichel, 1910].
= *Papilio sarpedon hachijoinsulanum* Kato, 1942. Replacement name for *intermedium* Kato, 1940. [Synonym].

Material examined

Type material: Syntype ♂ *Papilio sarpedon sarpedonides* [BMNH]. – Additional material: 3♂♂, 1♀ [CGT], 8♂♂, 5♀♀ [MGP] from various localities on Honshu Island, Japan.

Diagnostic characters

A relatively large subspecies: average ♂ FW length 45.7 mm in the early season, to 46.7 mm in late season. The discal band of green spots on the upperside of the wings is narrow, with most spots of the FW being separated by black lines along the veins. Specimens from Korea are traditionally included under this subspecies, but examination of museum and photographic material suggests this needs further investigation. Both seasonal forms from Korea appear to have consistently broader green discal bands, with the veins not heavily marked with black. The difference between the late summer forms is strongest.

Distribution

Japan (Honshu, Kyushu, Shikoku, Hachijo), Korea.

Graphium sarpedon connectens (Fruhstorfer, 1908)

Papilio sarpedon connectens Fruhstorfer, 1908. Type locality: Formosa.
= *Papilio sarpedon surusumi* Matsumura, 1909. Type locality: Formosa. [Synonym].

Material examined

Type material: Syntype ♂ [BMNH]. – Additional material: 4♂♂ [CGT], 5♂♂, 4♀♀ [MGP] from Taiwan.

Diagnostic characters

A small subspecies: average ♂ FW length 41.1, females slightly larger. There is no detectable seasonal variation. Similar in phenotype to *G. s. nipponus*, but with heavier black markings along the veins of the forewing.

Distribution

Taiwan.

Graphium sarpedon luctatius (Fruhstorfer, 1907)

Papilio sarpedon luctatius Fruhstorfer, 1907. Type locality: in the original description syntypes were listed from Natuna (Borneo, Singapore, Malay Peninsula). The syntype held in the BMNH labelled as a "Type" is from North Borneo.

= *Papilio sarpedon melas* FRUHSTORFER, 1907. Type locality: In original description: Tonkin and Tenasserim. "Type" in BMNH: Chiem-Hoa, C. Tonkin. [Homonym, nec. *Papilio melas* Herbst, 1796].
= *Graphium sarpedon corbeti* TOXOPEUS, 1951. Proposed as a replacement name for *Papilio sarpedon melas* Fruhstorfer, 1907. [**n. syn.**].

Material examined

Type material: Syntypes *Papilio sarpedon luctatius* Fruhstorfer, 1907 (♂*), *Papilio sarpedon melas* Fruhstorfer, 1907 (♂*) [BMNH]. – Additional material: 10♂♂ from Malaysia, Thailand and Indonesia (Kalimantan including Karimata island) [CGT]; 44♂♂ from Cambodia, China (Hainan), Indonesia (Kalimantan, including Karimata and Natuna Islands), Laos, Malaysia (including Balambangan and Banggi islands), Singapore, Thailand, and Vietnam, 18♀♀ from Indonesia (Kalimantan), Laos, Malaysia, Thailand, and Vietnam [MGP].

Diagnostic characters

This is a small subspecies with a range in ♂ FW length of 36–46 mm (average ♂ FW length 41.9 mm). There is some variation in size across its range, with specimens from eastern Thailand, Laos, Vietnam and Hainan tending to be a bit larger (average ♂ FW length 42.8 mm) than those from southern Thailand, Malaysia and Indonesia (average ♂ FW length 41.3 mm). Very small specimens (♂ FW length < 36 mm) with sharply pointed wings and narrow green markings on both sets of wings occur in all parts of the range. These do not, however, appear to correspond to seasonal forms, as they may occur at different times of the year. The markings do not vary greatly over the range, except that a few specimens from N. Vietnam and Hainan have the HW discocellular marked with black as it traverses the green discal band, as is usual in *G. s. sarpedon* spring form. This suggests there may be some introgression of genes from southern China into the Vietnamese and Hainan populations of *luctatius*.

TOXOPEUS (1951) proposed the replacement name for *melas* Fruhstorfer, 1908 because this name is preoccupied by *Papilio melas* Herbst 1796. He assumed that *melas* Fruhstorfer, 1908 was the wet season form of *G. sarpedon* Linnaeus, 1758 to be found in Sikkim as well as Tonkin (= Vietnam) and Tenasserim (= Myanamar). However, the description of *melas* Fruhst. reads thus: "Die Flügel werden noch schmaler und spitzer als bei *luctatius*, die Hinterflügelbinde verengt sich mehr, und fast alle Flecke der Vorderflügel stehen durch breiten schwarzen Aderbezug weit getrennt. Uebergang zu *semifasciatus* Honr. von China. Patria: Tonkin, Juni bis September; Tenasserim, Mai". In describing specimens that have narrower and more pointed wings than *G. s. luctatius* Fruhstorfer, 1907 and a narrow discal band with well-separated spots, FRUHSTORFER (1907) was describing a different butterfly to the wet season form of *G. sarpedon* found in Sikkim, which is a significantly larger form than *G. s. luctatius*, and has rounded forewings. The description by FRUHSTORFER corresponds to specimens found sporadically within the range of *G. s. luctatius* and we therefore place *G. s. corbeti* Toxopeus, 1951 as a synonym of *G. s. luctatius* Fruhstorfer, 1907.

Distribution

Cambodia, China (southern Guangdong and Guanxi: Hainan), Indonesia (Kalimantan, Kep. Natuna, Kep. Pul. Karimata), Laos, Malaysia, Singapore, Thailand, Vietnam.

Graphium sarpedon colus (Fruhstorfer, 1907) **stat. rev.**

Papilio sarpedon colus FRUHSTORFER, 1907. Type locality: Palawan.

Material examined

Type material: Syntype ♂* [BMNH]. – Additional material: 11♂♂, 1♀ [CGT], 55♂♂, 12♀♀ [MGP] from Palawan and Balabac.

Diagnostic characters

This is a moderately sized subspecies, with average ♂ FW length 42.1 mm, lacking significant seasonal variation. In the discal band of green spots on the FW upperside, the spot in cell M1 is characteristically enlarged relative to those in the cells above and below.

PAGE & TREADAWAY (2003) treated this population as belonging to *G. s. sarpedon*. However, after examining a larger number of specimens from China and the Philippines, including Palawan, it is clear that there are consistent differences that warrant treating the populations on Palawan and Balabac as a separate subspecies, for which the name *colus* Fruhstorfer, 1907 is available. Melanic specimens, in which part or even all of the green markings are absent (PAGE & TREADAWAY 2003), seem to be more frequent in the Palawan population than in any other race.

Distribution

Philippines (Balabac, Palawan).

Graphium sarpedon pagus (Fruhstorfer, 1907) **stat. rev.**

Papilio sarpedon pagus FRUHSTORFER, 1907. Type locality: Philippinen Bazilan, Mindoro.

Material examined

Type material: Syntype ♂* from Philippinen, Bazilan [BMNH]. – Additional material: 31♂♂, 7♀♀ [CGT], 151♂♂, 23♀♀ [MGP] from Bohol, Catanduanes, Cebu, Leyte, Luzon, Marinduque, Mindanao, Mindoro, Negros, Panay, Polillo, Samar, Siasi, Sibuyan, Tawi Tawi group (including Sibutu and Sanga Sanga).

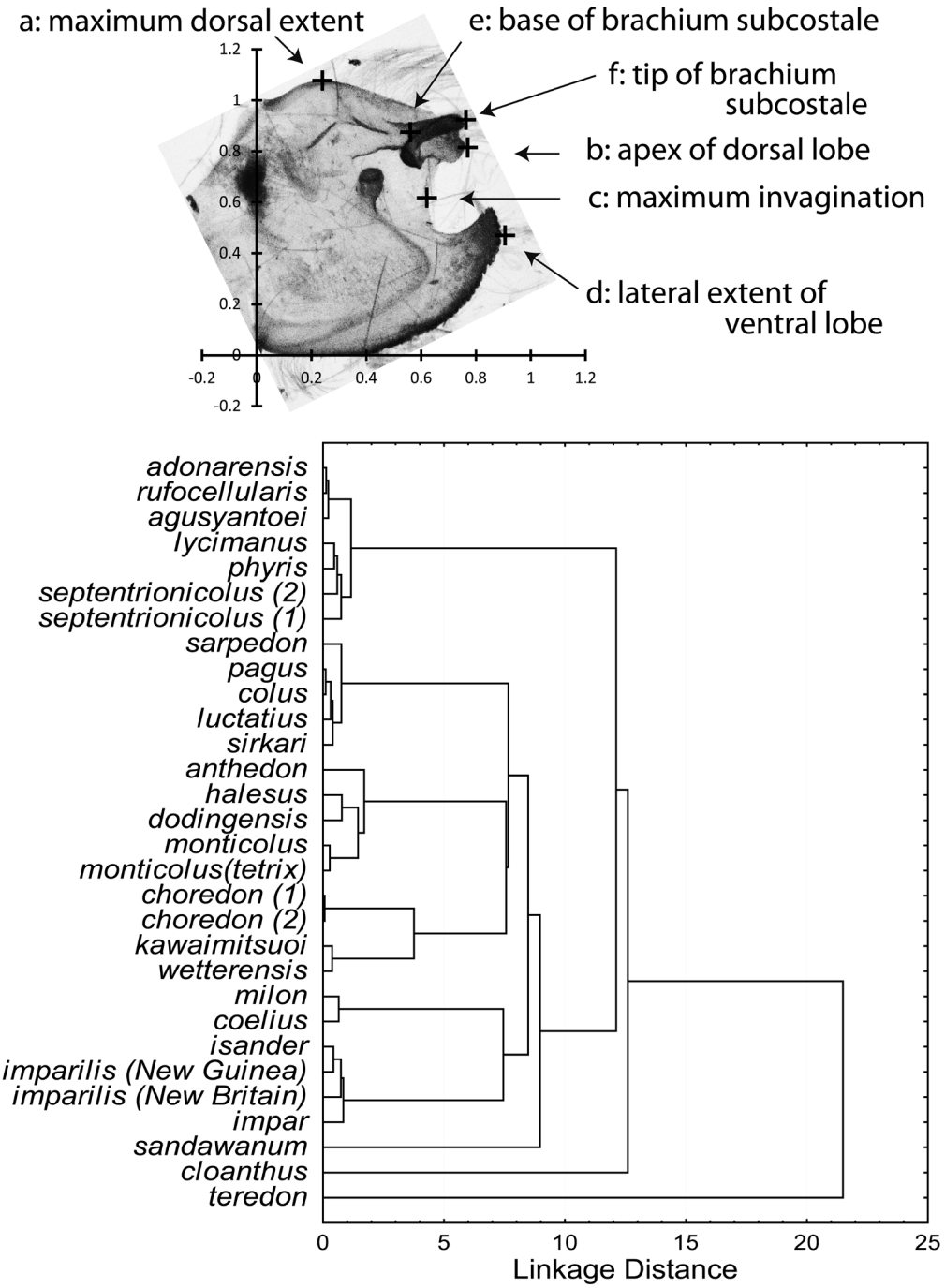
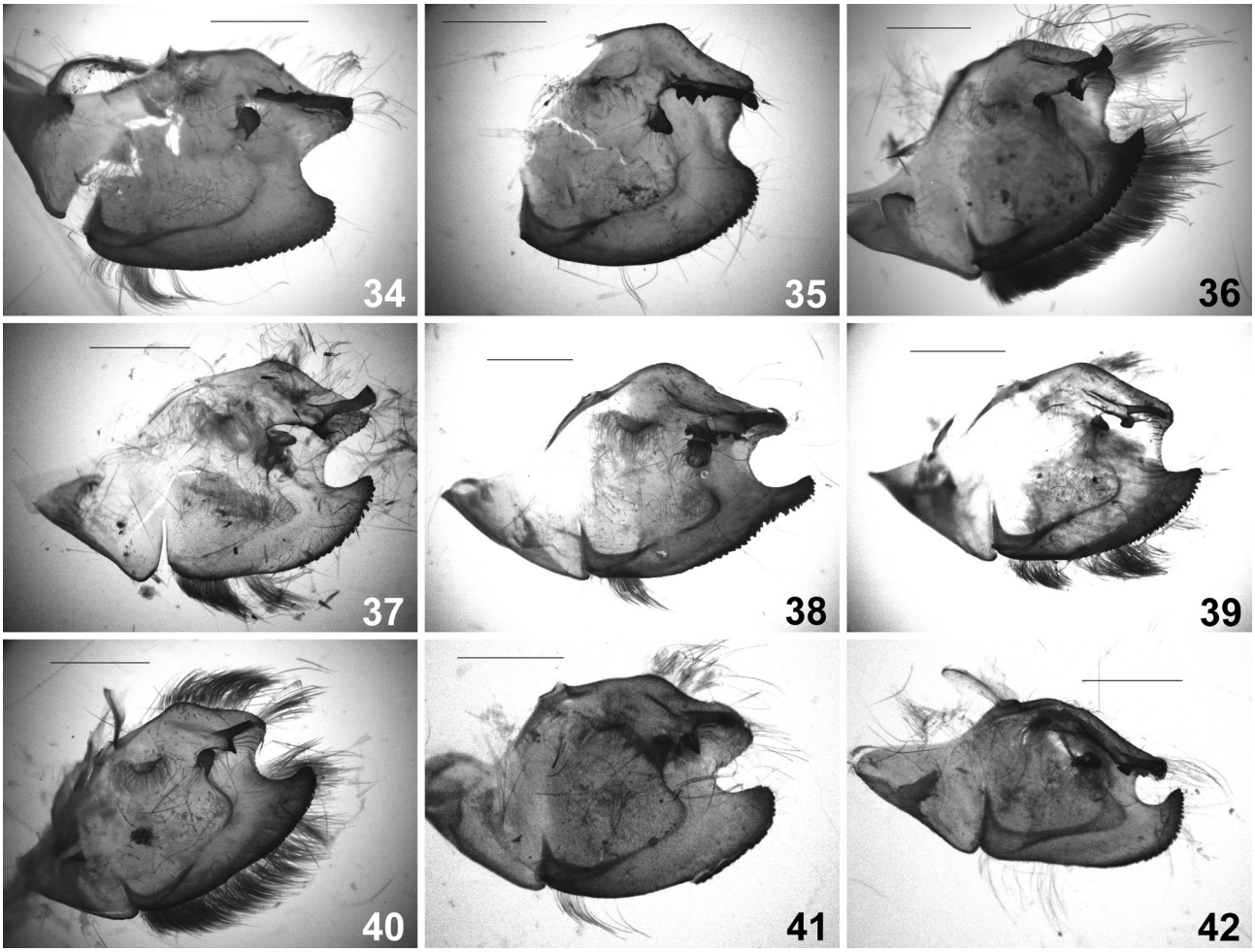


Fig. 33. Morphometric analysis of the male genitalia of the *Graphium sarpedon* species group. – The clasper of *G. jugans wetterensis* is shown aligned in the coordinate system used for morphometric analysis with the measurement points marked. A neighbouring group linkage diagram using squared euclidean distances is shown for representative samples of the prinicipal taxa.

Diagnostic characters

This is a large subspecies, with average ♂ FW length 44.4 mm, that does not display significant seasonal variation. The discal band of green spots on the FW upperside is narrower than in *G. s. sarpedon* and neither the veins near the FW anal margin nor the HW discocellular vein are lined with black.

As remarked above, Page & Treadaway (2003) treated the Philippines population as belonging to *G. s. sarpedon*, but this arrangement is not supported by more extensive



Figs. 34–42. Male claspers of *Graphium* spp. – **34**. *G. sarpedon sarpedon* (Linnaeus, 1758), China. **35**. *G. adonarensis adonarensis* (Rothschild, 1896), Sumbawa. **36**. *G. anthedon anthedon* (Felder & Felder, 1864), Seram. **37**. *G. anthedon monticolus* (Fruhstorfer, 1896), Sulawesi. **38**. *G. milon milon* (Felder & Felder, 1865), Sulawesi. **39**. *G. isander isander* (Godman & Salvin, 1888), Guadalcanal. **40**. *G. isander imparilis* (Rothschild, 1895), Papua New Guinea. **41**. *G. choredon* (Felder & Felder, 1864), Australia. **42**. *G. teredon* (Felder & Felder, 1864), Sri Lanka. – Scales: 1 mm.

studies, including series from multiple locations within the Philippines. It is now clear that the population of the greater part of the Philippines should be referred to a separate subspecies, for which the name *pagus* Fruhstorfer, 1907 is available. Despite the wide range of climatic conditions in the Philippines, this subspecies shows little or no variation over most of its range or through the seasons (Treadaway & Schröder 2012). The exception may be in the small islands lying at the end of the Sulu archipelago, close to Borneo. We have examined 1 ♂ from Sibutu and 1 ♂, 1 ♀ from Sanga Sanga, in the Tawi Tawi group, which all have a markedly narrower green discal band, with the veins strongly marked with black, unlike the specimens from Tawi Tawi Island itself, which are typical of *G. s. pagus* Fruhstorfer, 1907. The status of the population of this small island group needs further investigation.

Distribution

Philippines, except Balabac and Palawan.

Graphium sarpedon morius (Fruhstorfer, 1908) **stat. rev.**

Papilio sarpedon morius Fruhstorfer, 1908. Type locality: Ishigaki Is.

Material examined

Type material: Syntypes (♂*, ♀*) [BMNH]. – Additional material: 5 ♂♂, 2 ♀♀ Iriamote and Ishigaki Islands [MGP].

Diagnostic characters

Intermediate in size between *G. s. connectens* and *G. s. nipponus* (average ♂ FW length 44.0 mm). The green

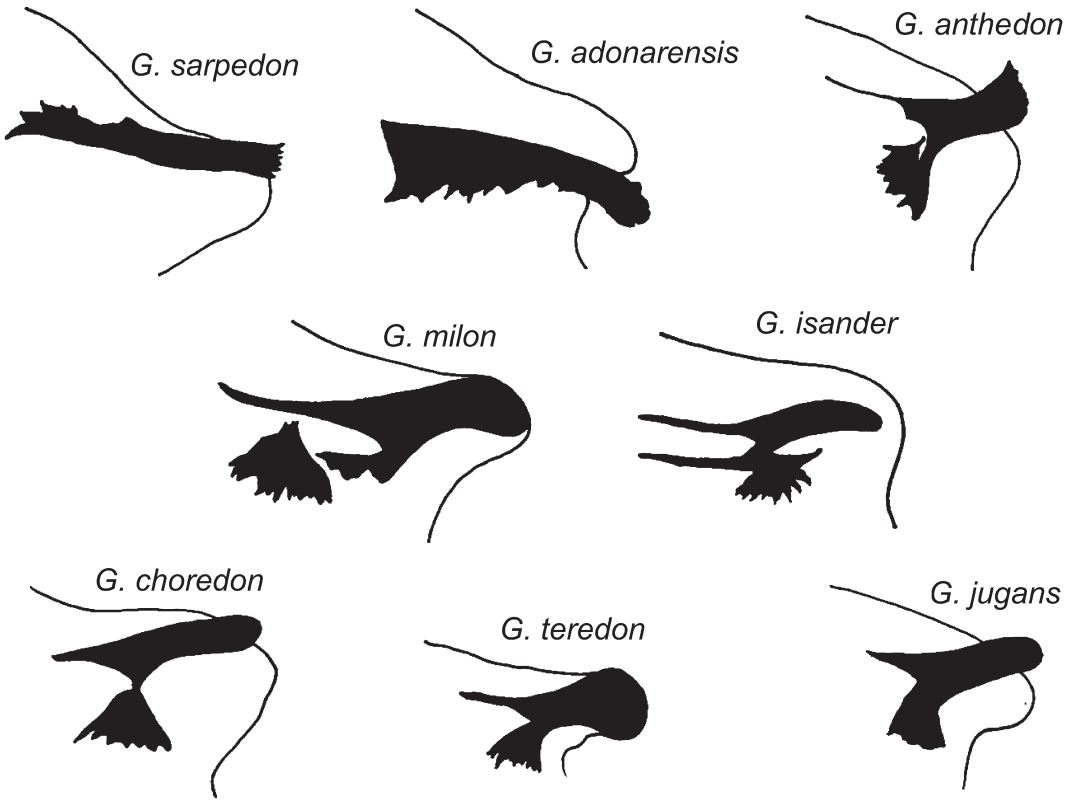


Fig. 43. Diagrams showing the outline of the brachium costale and apex of the dorsal lobe of *Graphium sarpedon* species group members.

discal band of spots is narrower than in *G. s. nipponus* and the FW spots are well separated by black along the veins, as in *G. s. connectens*.

Racheli & Cotton (2009) placed *G. s. morius* as a synonym of *G. s. nipponus* Fruhstorfer, 1903, but this is not correct. The Yaeyama Islands population is intermediate between *G. s. nipponus* from Honshu and *G. s. connectens* from Taiwan.

Distribution

Japan (Yaeyama Islands [Iriomote-jima, Ishigaki-jima]).

Graphium sarpedon sirkari **n. subsp.**

= *Papilio (Graphium) sarpedon corbeti* f. *gemmatus* Toxopeus, 1951. Type locality: Sikkim. "Trockenzeit" (form name).

Holotype: ♂, Shillong, Khasi Hills, Assam, N. India, April–June 1968, leg. S. K. Sirkar [SMF]. FW length 44.0 mm. (Fig. 5, Fig. 6 underside).

Paratypes: 38♂♂ Assam, N. India April–June 1968, leg. S. K. Sirkar [CGT]; 1 ♂ Nowgong Assam, N. India, 7 April 1949 [CGT]; 1 ♂ Khasi Hills, Assam, India 9 July 1956 [CGT]; 1 ♂ Jowai, Assam, N. India, 28 April 1966 [CGT]; 1 ♂ Shillong, Khasi Hills, N. India, May 1965, leg. S. K. Sirkar [CGT]; 1 ♂ Mengsu, S. W. Yunnan, May 1968 [CGT]; 35♂♂ Khasi Hills, N. India, April–June 1968, leg. S. K. Sirkar [MGP]; 6♂♂ Khasi Hills, Meghalaya, India, 1300 m, 10 July 2001 [MGP]; 1 ♂ Donggan, Mengallan, S. W. Yunnan, China, July 2008 [MGP]; 2♂♂ Donggan, Mengallan, S. W. Yunnan, China, April 1999 [MGP]; 1 ♂ Dongchuan, N. E. Yunnan, China, July 2008 [MGP]; 8♂♂ Ping Bian (Geiju), Yunnan, China, 900–1200 m, 21 June–17 July 1996, leg. R. Westphal [MGP]; 10♂♂ Yunnan, China, July 2008 [MGP]; 1 ♂ Chudu Razi Hills, 30 miles east of Kawnglaghpa, Kachin State, Burma, 23 June 2005 [MGP]; 1 ♂ Chudu Razi Hills, 30 miles east of Kawnglaghpa, Kachin State, Burma, 15 July 2005 [MGP]; 1 ♂ Chudu Razi Hills, 30 miles east of Kawnglaghpa, Kachin State, Burma, 18 July 2005 [MGP]; 1 ♂ Chudu Razi Hills, 30 miles east of Kawnglaghpa, Kachin State, Burma, 20 July 2005[MGP].

Derivatio nominis

This subspecies is named after the collector S. K. Sirkar.

Diagnostic characters

A relatively large subspecies with the range in ♂ FW length 35–43 mm (average 38.7 mm) in early season and 41–50 mm (average 44.8 mm) in the late season. It is

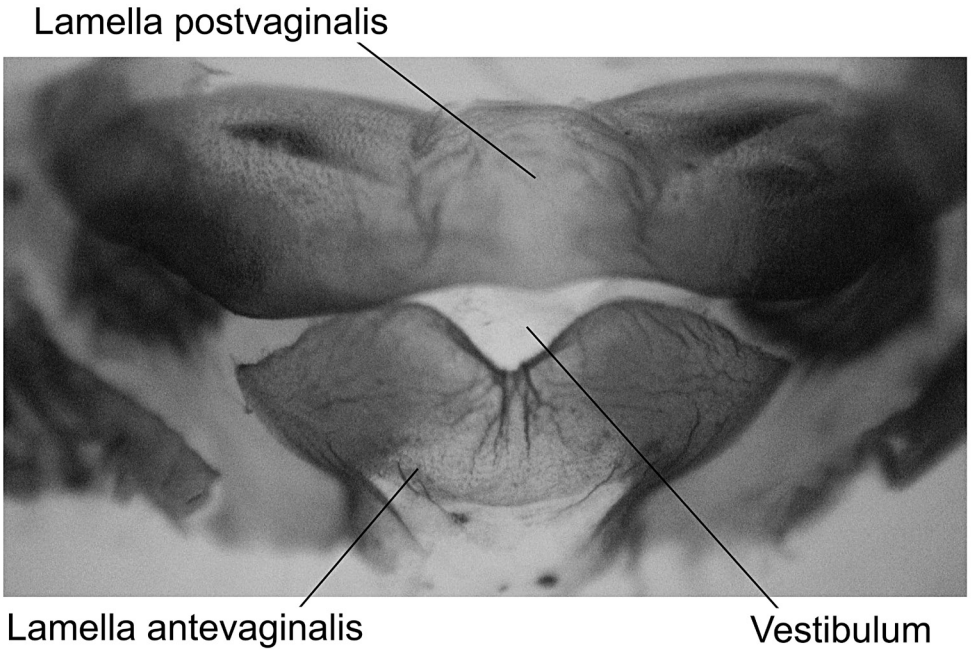


Fig. 44. External morphology of the female genitalia of *Graphium choredon*.

clearly larger than the neighbouring *G. s. luctatius* Fruhstorfer 1758 (average late season ♂ FW length 41.5 mm), under which name it has sometimes been treated. The green spots in the upperside discal bands towards the anal margin of the forewing are scarcely separated by white (or black, particularly in the late season form) marking along the veins. The tapering discal band of the HW is entire, with the discocellular CuA1 marked with a fine black line, if at all. The early season form (Figs. 7, 8) has broader discal bands on both sets of wings than does the late season form.

Distribution

China (S. W. Yunnan), India (Northern provinces), Myanmar (Kachin State).

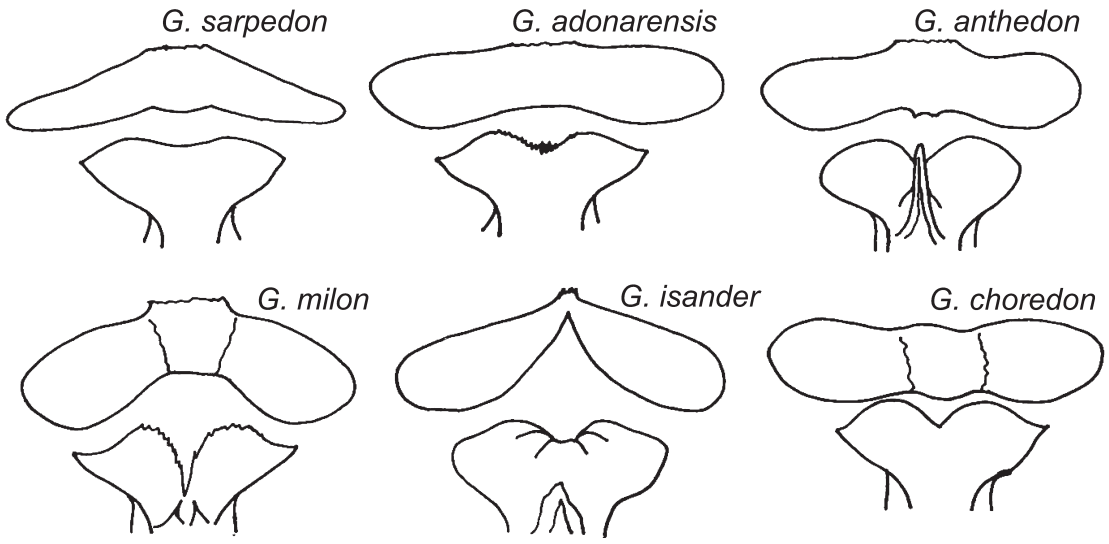


Fig. 45. Diagrams showing the outlines of the lamella postvaginalis and lamella antevaginalis of *Graphium sarpedon* species group members.

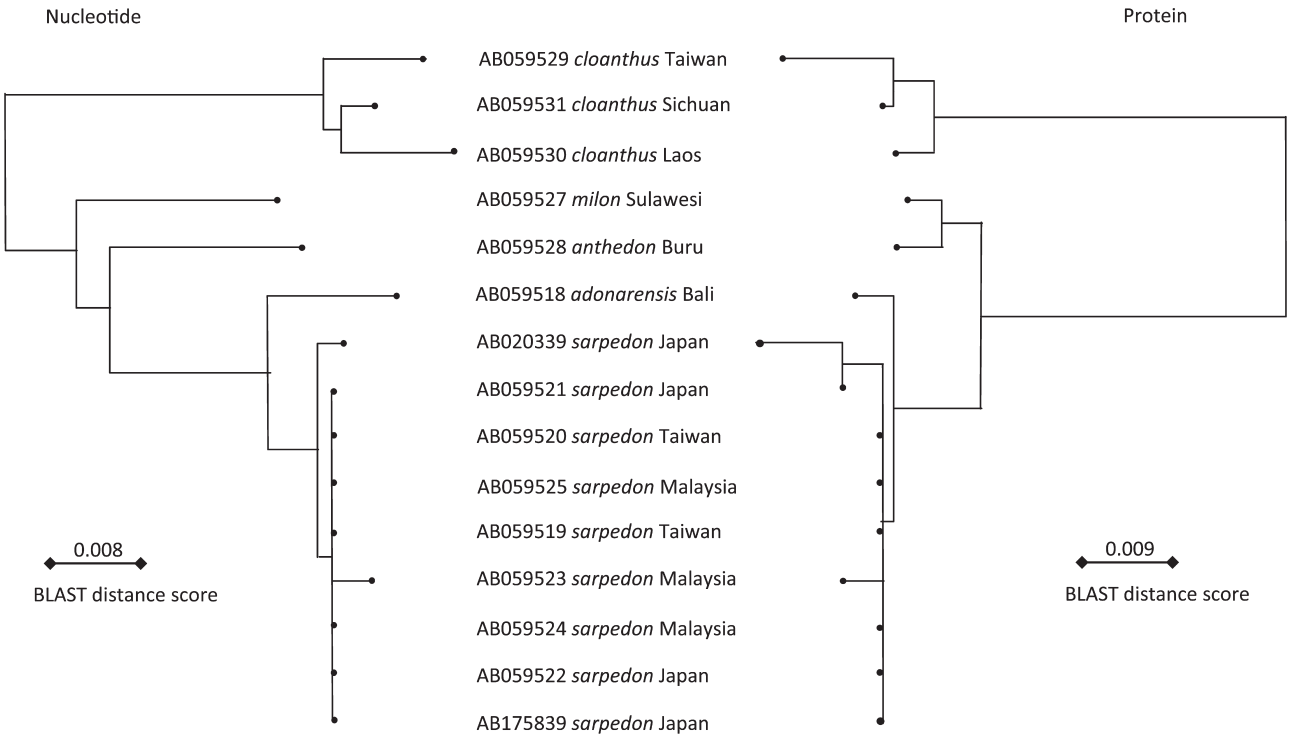


Fig. 46. Distance tree diagram from BLAST showing homology between ND5 nucleotide and translated protein sequences of *Graphium cloanthus*, *G. anthedon*, *G. milon*, *G. adonarensis* and *G. sarpedon* isolates.

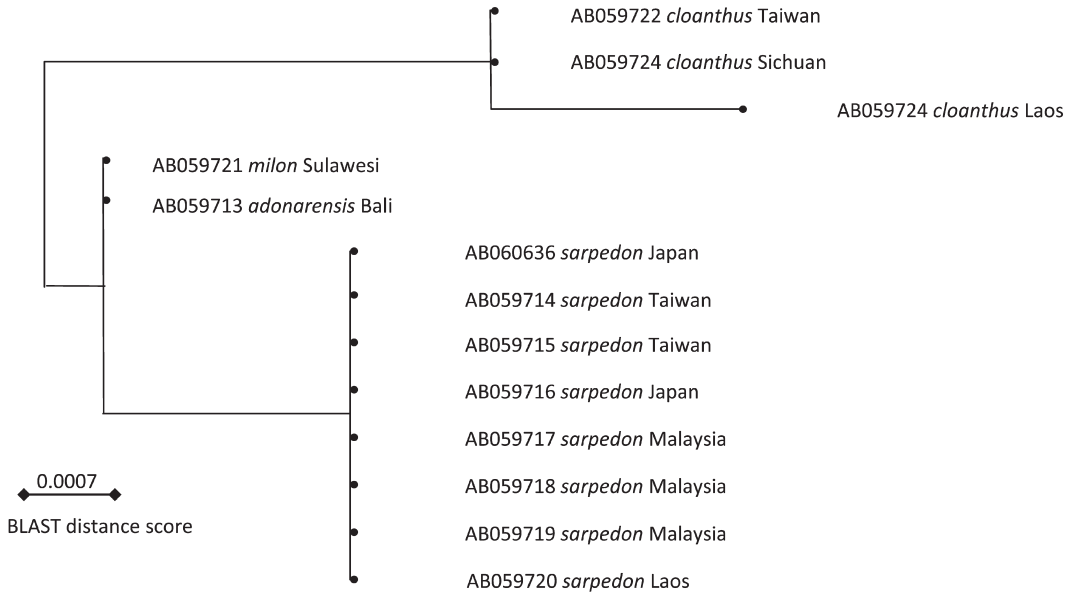


Fig. 47. Distance tree diagram from BLAST showing homology between 28S rRNA nucleotide sequences of *Graphium cloanthus*, *G. milon*, *G. adonarensis* and *G. sarpedon* isolates.

5.2 *Graphium adonarensis* (Rothschild, 1896) **stat. rev.**

Papilio sarpedon adonarensis ROTHSCHILD, 1896. Type locality: Adonara.

The discal band is broader than in *G. s. sarpedon* and the markings in cells CuA2 and CuA1 are not usually separated by broad black lines along the veins (Fig. 9). Instead these veins are often dusted with white scales. There are significant differences in the anatomy of the male and female genitalia (see section 4 above).

Distribution of the species: China (Fujian, Hubei), India (Meghalaya), Indonesia.

Graphium adonarensis adonarensis (Rothschild, 1896)

Material examined

Type material: Holotype ♂ [BMNH]. – Additional material: 5 ♂♂ Sumbawa, 5 ♂♂ Flores, 1 ♂ Adonara [MGP].

Diagnostic characters

Small (average ♂ FW length 41.6 mm), with sharply pointed FW and narrow, elongated HW, produced to a small, sharply pointed tail at M3. The discal band of green spots is relatively broad at the anal margin of the FW and the veins traversing it are marked with white. Only the apical 3–4 spots of the band are separated by black.

Distribution

Indonesia (Sumbawa, Flores, Adonara).

Graphium adonarensis rufofervidus (Fruhstorfer, 1897) **n. comb.**

Papilio sarpedon rufofervidus FRUHSTORFER, 1897. Type locality: Nias.

Material examined

Type material: Syntype ♂ [BMNH]. – Additional material: 1 ♂ Nias [MGP].

Diagnostic characters

Similar to *G. a. adonarensis*, except that the red spots of the HW underside are greatly enlarged.

Distribution

Indonesia (Nias).

Graphium adonarensis rufocellularis (Fruhstorfer, 1905) **n. comb.**

Papilio sarpedon rufocellularis FRUHSTORFER, 1905. Type locality: Bawean.

Material examined

Type material: Syntype ♂ [BMNH]. – Additional material: 1 ♂, 1 ♀ Bawean [MGP].

Diagnostic characters

Larger than *G. a. adonarensis* (FW length 44.1 and 45.6 for ♂ and ♀, respectively). The green discal band of the upperside is narrower and most of the spots on the FW are separated by black markings along the veins. The red spots of the HW underside are greatly enlarged.

Distribution

Indonesia (Bawean).

Graphium adonarensis phyris (Jordan, 1937) **n. comb.**

Papilio sarpedon phyris JORDAN, 1937. Type locality: Sipora.

Material examined

Type material: Holotype ♂ [BMNH]. – Additional material: 3 ♂♂ Sipora, 1 ♂ Pagai [MGP].

Diagnostic characters

Smaller than *G. a. adonarensis* (average FW length 40.1 mm). The green discal band of the upperside is narrow and most of the spots on the FW are separated by black markings along the veins. Only those towards the anal margin of the wing are confluent: vein CuA2 is marked with white.

Distribution

Indonesia (Sipora, Pagai).

Graphium adonarensis lycianus (Toxopeus, 1951) **n. comb.**

Papilio sarpedon lycianus TOXOPEUS, 1951. Type locality: Java.

Material examined

5 ♂♂, 2 ♀♀ [CGT], 6 ♂♂, 1 ♀ [MGP] from Java.

Diagnostic characters

Smaller than *G. a. adonarensis* (average FW length 40.8 mm). The green discal band of the upperside is broader than *G. a. adonarensis* and only the apical three spots on the FW are separated by black. The veins CuA2 to M3 are marked with white.

Distribution

Indonesia (Java).

Graphium adonarensis hundertmarki **n. subsp.**

Holotype: ♂, Bedegul, Bali, Indonesia, April 2003, leg. H. AGUSYANTO [SMF]. FW length 41.4 mm. (Fig. 11, Fig. 12 underside).

Paratypes: 1 ♂ Den Pasar, Bali, Indonesia, 6 April 1958, leg. C. G. TREADAWAY [CGT]; 4 ♂♂ Bali, Indonesia, April 2003, leg. H. AGUSYANTO [MGP]; 1 ♂ Bedegul, Bali, Indonesia, April 2003, leg. H. AGUSYANTO [MGP]; 1 ♂ Bali, Indonesia, October 2007, leg. M. PAGE [MGP]; 1 ♂ Bali, Indonesia, October 2002, leg. H. AGUSYANTO [MGP]; 1 ♂ Bali, Indonesia, November 2002, leg. H. AGUSYANTO [MGP]; 6 ♂♂ Bali, Indonesia, December 2002, leg. H. AGUSYANTO [MGP]; 1 ♀ Gilimanuk, Bali, Indonesia, December 2002, leg. H. AGUSYANTO [MGP].

Derivatio nominis

This subspecies is named after B. HUNDERTMARK, an enthusiastic student of the butterflies of Bali, in recognition of his help while exploring the island, and other parts of Indonesia.

Diagnostic characters

Larger than *G. a. adonarensis*, with more rounded FW and less elongated HW. The tail on M3 is not so pronounced. The green discal band is broader on both wings than that of *G. a. adonarensis* or even *G. a. lycianus*. The wing shape is similar to that of *G. a. lycianus*, but the forewing is broader with a more convex distal margin.

The paratype males agree well with the holotype (average FW length 39.4 mm, range 37.1–41.9 mm), except that those from October through to December tend to have narrower green discal bands than those from April, or *G. a. lycianus*. The single female, caught in December, is large (FW length 45.8 mm) and a pale form. The discal band is narrow, as in the contemporary males and is narrower than observed with females of *G. a. lycianus*.

Distribution

Indonesia (Bali).

Graphium adonarensis agusyantoei **n. subsp.**

Holotype: ♂, Aceh, Sumatra, Indonesia, December 1997, leg. H. AGUSYANTO [SMF]. FW length 43.5 mm. (Fig. 13, Fig. 14 underside).

Paratypes: 4 ♂♂ Same data as holotype [MGP]; 1 ♂ Brastagi, Sumatra, Indonesia, June 2008, leg. M. PAGE [MGP]; 3 ♂♂, 1 ♀ Mt Dempo, Sumatra, Indonesia, July 2008, leg. M. PAGE [MGP].

Derivatio nominis

This subspecies is named after H. AGUSYANTO for his considerable help in providing information and with obtaining some of this material.

Diagnostic characters

Larger than *G. a. adonarensis*, with more rounded FW and less elongated HW. The tail on M3 is scarcely produced. The green discal band is broader on both wings than that of *G. a. adonarensis* but not as broad as in *G. a. lycianus*. The wing shape is similar to that of *G. a. lycianus*, except that the hindwing margin is more regular.

The paratype males agree well with the holotype (average FW length 41.2 mm, range 40.1–43.6 mm). The single female is similar in size to the males (FW length 40.4 mm). The discal band is narrow, as in the males and is narrower than observed with females of *G. a. lycianus*.

Distribution

Indonesia (Sumatra).

Graphium adonarensis phyrisoides **n. subsp.**

Holotype: ♂, Belitung, Indonesia, September 2008, leg. M. PAGE [SMF]. FW length 37.1 mm. (Fig. 15, Fig. 16 underside).

Paratypes: 1 ♀ lower slopes of Mt Samak, Belitung, Indonesia, 7 April 1953 [CGT]; 1 ♂ Mt Bantau, Belitung, Indonesia, 5 March 1958 [CGT]; 2 ♂♂ Belitung, Indonesia, September 2008, leg. M. PAGE [MGP]; 2 ♂♂ Bangka, Indonesia, April 1982 [MGP].

Derivatio nominis

This subspecies is named for its resemblance to *G. a. phyris* Jordan, 1937.

Diagnostic characters

This is a small subspecies, with sharply pointed FW and elongated HW. The tail on M3 is scarcely produced: the hindwing margin is more regular than in *G. a. adonarensis*. The green discal band is narrow on both wings and the apical three spots of the FW band are separated by black. The veins CuA2 to M3 are marked by fine black lines, with some white along CuA2.

The paratype males agree well with the holotype (average FW length 38.3 mm, range 36.4–40.0 mm). The single female is similar in size to the males (FW length 40.4 mm). The discal band is narrow, as in the males and is narrower than observed in the female from Sumatra.

Distribution

Indonesia (Bangka, Belitung).

Graphium adonarensis toxopei **n. subsp.**

Holotype: ♂, Lombok, Indonesia, December 1997 [SMF]. FW length 40.7 mm. (Fig. 17, Fig. 18 underside).

Paratypes: 5 ♂♂ Lombok, Indonesia, December 1997 [MGP]; 1 ♂ Lombok, Indonesia, January 2005 [MGP].

Derivatio nominis

This subspecies is named after J. TOXOPEUS in recognition of his contributions to the understanding of *Graphium sarpedon* and its races.

Diagnostic characters

A relatively small butterfly, with sharply pointed FW and elongated HW. The tail on M3 is slightly produced but

sharply pointed. The green discal band is narrow on both wings and the apical three spots of the FW band are separated by black. The veins CuA2 to M2 are marked by fine black lines, with some white along CuA2.

The paratype males agree well with the holotype (average FW length 40.9 mm, range 39.3–42.0 mm). The green FW band is narrower than that of *G. a. hundertmarki* or *G. a. adonarensis*. The FW is broader than that of *G. a. adonarensis* and the HW not so strongly elongated.

Distribution

Indonesia (Lombok).

Graphium adonarensis septentrionicolus **n. subsp.**

Holotype: ♂, Nowgang, Assam, India, 14 April 1964, leg. C. G. Treadaway [SMF]. FW length 40.6 mm. (Fig. 19, Fig. 20 underside).

Paratypes: 7♂♂ Khasi Hills, Meghalaya, India, April–June 1962, leg. S. K. Sirkar [CGT]; 5♂♂ Khasi Hills, Meghalaya, India, April–June 1962, leg. S. K. Sirkar [MGP]; 1♂ Central Fujian, April 2006, leg. Pan Yang [MGP]; 2♂♂ Central Fujian, April 2008, leg. Pan Yang [MGP]; 1♂ Shennongija, W. Hubei, June 1998, leg. Pan Yang [MGP].

Derivatio nominis

This subspecies is named for is northerly distribution (Latin: *septentrion* north, *colus* dweller).

Diagnostic characters

A small butterfly, with sharply pointed FW and elongated HW. The tail on M3 is strongly produced. The green discal band is very broad on both wings and only the apical spot of the FW band is clearly separated by black. The apical spot is very small. The veins CuA2 to M3 are marked with white and veins M2 and M1 are marked with black. The veins of the HW are marked with white where they traverse the discal band. The male genitalia (dissections of five specimens from Khasi Hills, two from Hubei and one from Fujian) have the distinguishing characters of *G. adonarensis*, as described above. They are readily distinguishable from those of sympatric, synchronous specimens of *G. sarpedon*.

The paratype males agree well with the holotype (average FW length 39.4 mm, range 36.8–42.4 mm).

Distribution

India (Assam, Meghalaya), China (Fujian, Hubei).

5.3 *Graphium anthedon* (Felder & Felder, 1864)

Papilio anthedon Felder & Felder, 1864. Type locality: Amboina.

G. anthedon (Felder & Felder, 1864) is a medium-sized species that typically has a deeper, blue-green colour than the preceding species (Fig. 21), but the colour varies considerably between the subspecies. Specimens of *G. a. dodingensis* Rothschild, 1896 from Morotai, Halmahera and Bacan exhibit an intense blue-green colour. The colour is somewhat less intense in specimens of *G. a. halesus* from Buru and can be greenish in some specimens of *G. a. anthedon* from Seram. The veins of the forewing are lined with black as they cross the band, except in *G. a. halesus* Fruhstorfer, 1907 from Buru and some specimens of *G. a. anthedon*, where those closer to the hind margin are lined with white. Specimens of the Sulawesi subspecies *G. a. monticolus* Fruhstorfer, 1896 have greenish-blue markings that are more similar to *G. sarpedon*. The veins are lined with white, as in *G. a. anthedon*. The width of the band decreases from the anal margin of the wing towards the tip of the cell. At the anal margin the width varies between subspecies: it is narrowest in *G. a. dodingensis* and broadest in *G. a. anthedon* and *G. a. monticolus*. Traces of a sub-marginal are encountered in specimens of *G. anthedon* from Seram and the *tetrix*-form of *G. a. monticolus* Fruhstorfer, 1896 has a full sub-marginal row of lunules. The full row of sub-marginal lunules is present on the underside of the forewing in some specimens of *G. anthedon* from Seram but not from any other island, amongst which it is normally restricted to one or two spots.

The band on the hindwing upperside has a white area in the cell Sc+R1 and is blue-green with some white highlighting in the other spots, especially in the small spot in cell Rs and along the adjacent veins. The vein CuA1 may be marked with black or white.

There are 4–6 blue-green lunules in the sub-marginal band, those in cells Rs, M1, M2 and M3 always being well marked. The lunules in cells Sc+R1 and CuA1 are weak and usually whitish: the lunule in cell CuA1 is absent in some specimens, especially of *G. a. dodingensis* and *G. a. halesus*. The lunule in cell M3 is usually weak in *G. a. monticolus* Fruhstorfer, 1896 and may be absent. The lunules in cells M1, M2 and M3 are strongly bent forming C- or <-shaped marks except in *tetrix*, where the angle formed at the outer margin of the spot is less acute. Specimens of *G. anthedon*, especially of the subspecies *G. a. anthedon*, *G. a. halesus*, and *G. a. monticolus* have an irregular hindwing margin produced by elongation of the veins Rs and M1–M3. The hindwing is otherwise rather broad and rounded towards the anal tornus.

Graphium anthedon anthedon (Felder & Felder, 1864)

Material examined

1♂, 1♀ [CGT], 12♂♂ [MGP] from Seram and Ambon.

Diagnostic characters

Relatively large (average ♂ FW length 44.0 mm) with rounded FW and HW. The blue-green band of the upperside is relatively broad, towards the anal margin of the FW.

Distribution

Indonesia (Kelang, Seram, Ambon).

G. anthedon dodingensis (Rothschild, 1896)

Papilio sarpedon dodingensis ROTHSCHILD, 1896. Type locality: Halmahera.

Material examined

Type material: Syntypes (♂*, ♀*) *Papilio sarpedon dodingensis* Rothschild, 1896 [BMNH]. – Additional material: 1 ♂ Bacan [CGT]; 17 ♂♂ Bacan, Morotai and Halmahera, 3 ♀♀ Bacan and Halmahera [MGP].

Diagnostic characters

Relatively large (average ♂ FW length 44.0 mm) with very rounded FW and HW. The blue-green band of the upperside is narrow. Specimens from Bacan and Morotai are somewhat smaller than those from Halmahera (♂ FW length range 40.0–45.0 mm for Bacan and Morotai compared to range 44.3–46.0 for Halmahera), but there is little difference in pattern. The females are somewhat larger (46.1–48.0 mm).

Distribution

Indonesia (Bacan, Morotai and Halmahera).

G. anthedon monticolus (Fruhstorfer, 1896) **n. comb.**

Papilio sarpedon monticolus FRUHSTORFER, 1896. Type locality: Bua Kraeng, S. Celebes.

= *Graphium sarpedon tetrix* TSUKADA & NISHIYAMA, 1980. Type locality: Celebes. [Synonym].

Material examined

Type material: Syntypes (♂*,♀*) *Papilio sarpedon monticolus* Fruhstorfer, 1896 [BMNH]. – Additional material: 1 ♂ central Sulawesi [CGT]; 1 ♂ Bantimurung, Macassar district, south Sulawesi, 7 ♂♂ Maros, Macassar district, south Sulawesi, 9 ♂♂ various locations in central Sulawesi [MGP].

Diagnostic characters

Relatively large (average FW length 43.5 mm, range 41.1–45.0 mm). The green discal band is yellowish green, close to that of *G. sarpedon*, rather than the blue-green usual in *G. anthedon*. The type specimen in the BMNH has only a few sparsely marked chevrons in the submarginal band TSUKADA & NISHIYAMA (1980) separated *G. s. tetrix* from *G. s. monticolus* by the appearance of a strong submarginal band of green chevrons on the forewing. D'ABRERA (1982) regarded *tetrix* as a straight synonym of *monticolus*, whereas VANE-WRIGHT & DE JONG (2003) reported that "superficial examination of museum material even suggests that the two taxa could represent separate species". Examination of these two forms collected at various locations on Sulawesi suggests that the distinguishing characteristic is quite variable. Specimens from the central part of Sulawesi always have the submarginal band, whereas those in the south are more variable with some having a very strong submarginal band and others having only indistinct markings. This is not a sufficiently stable character to warrant separation and we follow D'ABRERA in regarding *G. s. tetrix* Tsukada & Nishiyama, 1980 as a junior synonym of *G. a. monticolus* Fruhstorfer, 1896. TSUKADA & NISHIYAMA (1982) were incorrect in showing that the *tetrix*-form only occurs in central Sulawesi. The male genitalia of *G. a. monticolus* Fruhstorfer, 1896 (Fig. 37) are very similar to those of *G. anthedon* (Fig. 36) clearly indicating that it should be treated as a subspecies of the latter. There is no difference in the male genitalia between *monticolus*-forms and *tetrix*-forms that would support specific separation.

Distribution

Indonesia (Sulawesi).

Graphium anthedon crudus (Rothschild, 1898)

Papilio sarpedon crudus ROTHSCHILD, 1898. Type locality: Obi.

Material examined

Type material: Holotype ♂ [BMNH]. – Additional material: 1 ♂ Obi [MGP].

Diagnostic characters

Smaller than typical for *G. a. anthedon* (FW length 42 mm) with a narrower blue-green discal band.

Distribution

Indonesia (Obi).

Graphium anthedon halesus (Fruhstorfer, 1907)

Papilio sarpedon halesus FRUHSTORFER, 1907. Type locality: Buru. [Homonym, nec. *Papilio halesus* Cramer, 1777, currently *Atlides halesus* (Lycaenidae)].

Material examined

Type material: Syntype ♂ *Papilio sarpedon halesus* Fruhstorfer, 1907 [BMNH]. – Additional material: 5 ♂♂ [CGT], 7 ♂♂ [MGP] from Buru.

Diagnostic characters

Relatively large (average ♂ FW length 43.2 mm) with rounded FW and HW. The blue-green band of the upperside is broad at the anal margin of the FW but tapers strongly towards the apex.

Distribution

Indonesia (Buru).

5.4 *Graphium milon* (Felder & Felder, 1865) **stat. rev.**

Papilio milon FELDER & FELDER, 1865. Type locality: Celebes.

G. milon (Figs. 23, 24) is the largest of the *G. sarpedon* group species. The band on the forewing upperside is narrow with an intense blue-green colour similar to that of *G. anthedon*. The veins of the forewing are broadly lined with black as they cross the band. The band is very narrow and uniform in width up to the tip of the cell. There are no sub-marginal markings. The discal band on the hindwing upperside has a white area in the cell Sc+R1 and is blue-green with little or no white highlighting in the other spots. The spot in cell Rs is absent. The veins M1 and CuA1 are strongly marked with black. There are 4–5 blue-green lunules in the sub-marginal band, those in cells Rs, M1, M2 and M3 always being well marked. The lunule in cell Sc+R1 is weak and usually whitish: the lunule in cell CuA1 is absent in most specimens. The lunules in cells M1, M2 and M3 are strongly bent forming C- or <-shaped marks. *G. milon* stands apart from all the other species in having the elongated and strongly bowed costal margin of the forewing found in many papilionids originating on Sulawesi. The hindwing is also rather elongated and produced towards the anal tornus, presumably in order to compensate for the elongated forewing.

Graphium milon milon (Felder & Felder, 1865)

Material examined

5 ♂♂ Sulawesi [CGT]; 18 ♂♂, 5 ♀♀ from Butung, Peleng, Muna and Sulawesi [MGP].

Diagnostic characters

Large (average ♂ FW length 49.8 mm) with the costal margin of the FW strongly bowed and falcate wing tip. The blue-green band of the upperside is narrow and the spots are clearly separated by black markings along the veins. Specimens from Muna (range ♂ FW length 46.7–49.9 mm) and Butung (range ♂ FW length 47.7–49.6 mm) are smaller than those from Sulawesi and Peleng (range ♂ FW length 47.0–52.6 mm) but there is no significant difference in pattern.

Distribution

Indonesia (Sulawesi, Kep. Talaud, Kabaena, Butung, Muna, Kep. Banggai [Peleng]).

Graphium milon sulaensis (Lathy, 1899)

Papilio sarpedon sulaensis LATHY, 1899. Type locality: Sula Is.
= *Papilio sarpedon coelius* FRUHSTORFER, 1899. Type locality: Sula Is. [Synonym].

Material examined

Type material: Syntypes *Papilio sarpedon sulaensis* Lathy, 1899 (♂*), *Papilio sarpedon coelius* Fruhstorfer, 1899 (♂*) [BMNH]. – Additional material: 1 ♂ Sula [CGT]; 6 ♂♂ from the Sula islands [MGP].

Diagnostic characters

Relatively large (average ♂ FW length 47.7 mm) with the costal margin of the FW strongly bowed and falcate wing tip. The blue-green band of the upperside is narrow and the spots are clearly separated by black markings along the veins. Smaller, and with a narrower discal band than *G. m. milon*.

Distribution

Indonesia (Kep. Sula [Mangole, Sanana]).

5.5 *Graphium isander* (Godman & Salvin, 1888) **stat. rev.**

Papilio isander GODMAN & SALVIN, 1888. Type locality: Aola, Guadalcanal I.

G. isander (Figs. 25, 26) has blue-green markings similar in intensity to *G. anthedon* from Seram. The veins of the forewing are highlighted with white as they cross the band in *G. i. imparilis* from New Guinea. The population of the central Solomon Islands (*G. i. isander*) appears to have the most primitive pattern, in retaining submarginal spots on the forewing upperside. Specimens from New Britain, New Ireland and New Guinea have male genitalia that are very similar to those of *G. isander* (Figs. 39, 40) and they are therefore included in this species.

Graphium isander isander (Godman & Salvin, 1888)

= *Papilio impar shortlandica* RIBBE, 1900. Type locality: Fauro, Shortlands.

Material examined

Type material: Holotype ♂ *Papilio impar shortlandica* Ribbe, 1900 [BMNH]. – Additional material: 5 ♂♂, 3 ♀♀ from Malaita and Guadalcanal, Solomon Islands [MGP].

Diagnostic characters

A large subspecies (average ♂ FW length 45.1 mm), with the blue-green discal band of similar colour and intensity to *G. anthedon*. There is a spot at the base of FW cell R2, which is rarely represented in other species, and well-formed submarginal spots. The latter are rectangular towards the apex of the wing and chevron-like towards the anal margin. They are homologous to the markings found in some subspecies of *G. anthedon*.

Distribution

Papua New Guinea (Bougainville), Solomon Islands (Choiseul, Florida, Guadalcanal, Malaita, Russell, Santa Isabel, Shortland Is.).

Graphium isander impar (Rothschild, 1895) **n. comb.**

Papilio sarpedon impar Rothschild, 1895. Type locality: Solomon Islands, New Georgia.

Material examined

Type material: Syntype ♀ [BMNH]. – Additional material: 1 ♀ [CGT], 1 ♂ [MGP] from Ghizo.

Diagnostic characters

Smaller than *G. i. isander* (FW length 43.6 mm) with a broader blue-green band. The submarginal spots are absent but the spot at the base of cell R2 is retained.

Distribution

Solomon Islands (Ghizo, New Georgia, Rubiana).

Graphium isander imparilis (Rothschild, 1895) **n. comb.**

Papilio sarpedon imparilis Rothschild, 1895. Type locality: New Britain, New Ireland, Duke of York.
= *Papilio sarpedon messogis* Fruhstorfer, 1907. Type locality: Key, Aru. [**n. syn.**].
= *Papilio sarpedon temnus* Fruhstorfer, 1907. Type locality: Deutsch Neu Guinea, Friederich Wilhelms Hafen, Dorey, Kapaur, Hattam, Britisch Neu Guinea (Milne Bai). [**n. syn.**].
= *Papilio sarpedon corycus* Fruhstorfer, 1907. Type locality: Waigiu. [**n. syn.**].

Material examined

Type material: Syntypes *Papilio sarpedon imparilis* Rothschild, 1895 (♂) [BMNH], *Papilio sarpedon corycus* Fruhstorfer, 1907 (♂*) [BMNH], *Papilio sarpedon messogis* Fruhstorfer, 1907 (♂*, ♀*) [BMNH], *Papilio sarpedon temnus* Fruhstorfer, 1907 (♂*, ♀*) [BMNH], the syntype ♂ held in the BMNH and identified as "Type" is from Neu Guinea, Fri. Wilh. Hafen. – Additional material: 1 ♂ Papua New Guinea [CGT]; 11 ♂♂, 5 ♀♀ from New Britain, New Guinea, New Ireland, Waigeo [MGP].

Diagnostic characters

Smaller than *G. i. isander* (average ♂ FW length 44 mm) and completely lacks the submarginal band of spots as well as the basal spot in cell R2. There is no significant difference between specimens from New Britain, New Ireland and New Guinea and these should all be treated as the same subspecies, for which the name *imparilis* Rothschild, 1895 is available. The subspecies described from Key and Aru (*messogis* Fruhstorfer, 1907), New Guinea (*temnus* Fruhstorfer, 1907) and Waigeo (*corycus* Fruhstorfer, 1907) are all thus placed as junior synonyms of *G. i. imparilis* (Rothschild, 1895).

D'Abrera (1971) included this subspecies in *G. choredon* saying that he could not find any differences. However, the male and female genitalia, as well as similar blue-green colour of the wings, clearly place this taxon in *G. isander* rather than *G. choredon*.

Distribution

Indonesia (West Papua, Key, Aru, Waigeo), Papua New Guinea (Provinces on New Guinea island, New Britain, New Ireland, Duke of York I.).

5.6 *Graphium choredon* (Felder & Felder, 1864) **stat. rev.**

Papilio choredon Felder & Felder, 1864. Type locality: Australia; New Guinea; Waigeu; Woodlark.

Material examined

2 ♀♀ from Queensland, Australia [CGT]; 2 ♂♂, 2 ♀♀ from Queensland, Australia [MGP].

Diagnostic characters

A small species (♂ FW length 38.8, 42.1 mm), *G. choredon* has a variable green to yellowish-green colour with considerable highlighting in white of the veins and frequently has short tails at M3 on the hindwing (Figs. 27, 28). The more yellowy green colour and the short pointed tails are the most distinctive external features separating *G. choredon* from *G. i. imparilis* from New Guinea and Waigeo.

Distribution

Eastern coast of Australia (Queensland–New South Wales).

5.7 *Graphium teredon* (Felder & Felder, 1865) **stat. rev.**

Papilio teredon Felder & Felder, 1865. Type locality: Ceylon.
= *Delchina thermodusa* Swinhoe, 1885. Type locality: Matheran.

Material examined

1 ♂ Sri Lanka [CGT]; 1 ♂ South India (Kerala), 1 ♂ Sri Lanka [MGP].

Diagnostic characters

A small species (♂ FW length 38.0, 39.6 mm), *G. teredon* usually has blue-green spots, similar to *G. anthedon*, but individuals with yellowish-green colour (Figs. 29, 30) are not uncommon.

Distribution

Southern India and Sri Lanka.

5.8 *Graphium jugans* (Rothschild, 1896) **stat. rev.**

Papilio sarpedon jugans ROTHSCHILD, 1896. Type locality: Sumba.

The smallest of the *G. sarpedon* group species, *G. jugans* (Figs. 31, 32) typically has blue-green markings similar in intensity to that seen in *G. isander* and considerable highlighting in white as in that species but not as extensive as is observed in *G. choredon*.

Distribution of species: Indonesia (Sumba, Timor, Wetar).

Graphium jugans jugans (Rothschild, 1896)

Material examined

Type material: Syntype ♂ [BMNH]. – Additional material: 1 ♂ Sumba [MGP].

Diagnostic characters

A small subspecies (♂ FW length 36.0 mm) with sharply pointed FW and elongated HW produced in a sharp stubby tail at M3. The discal band of green spots is relatively broad, similar to *G. adonarensis*, but with a more bluish hue.

Distribution

Indonesia (Sumba).

Graphium jugans wetterensis Okano, 1993 **n. comb.**

Graphium sarpedon wetterensis OKANO, 1993. Type locality: Wetar.

Material examined

2 ♂♂ Wetar [MGP].

Diagnostic characters

A small subspecies (♂ FW length 35.8, 37.3 mm) with sharply pointed FW and elongated HW produced in a sharp stubby tail at M3. The discal band of green spots is broader than *G. j. jugans* and distinctly blue-green, rather than green.

Distribution

Indonesia (Wetar).

Graphium jugans kawaimitsuoi Fujioka, 1997 **n. comb.**

= *Papilio sarpedon timorensis* ROTHSCHILD, 1896. Type locality: Timor. [Homonym, nec. *Papilio polytes timorensis* Felder & Felder, 1864].

Graphium sarpedon kawaimitsuoi FUJIOKA [in FUJIOKA, TSUKIYAMA & CHIBA] 1997. Proposed as a replacement name for *Papilio sarpedon timorensis* Rothschild, 1896.

= *Graphium sarpedon cesa* KOÇAK & KEMEL, 2000. Proposed as a replacement name for *Papilio sarpedon timorensis* Rothschild, 1896. [**n. syn.**].

Material examined

Type material: Holotype ♂ *Papilio sarpedon timorensis* Rothschild, 1896 [BMNH]. – Additional material: 2 ♂♂, 1 ♀ Timor [MGP].

Diagnostic characters

A small subspecies (♂ FW length 35.5, 37.5 mm) with sharply pointed FW and elongated HW produced in a sharp stubby tail at M3. The discal band of green spots is narrower than in *G. j. wetterensis* but similar in colour.

Distribution

Indonesia (Timor).

6 Discussion

Graphium adonarensis is separated from *G. sarpedon* and raised to species rank on the basis of significant differences in the male and female genitalia as well as in the sequences of the mitochondrial ND5 and nuclear 28S rRNA genes. It is sympatric and synchronous with *G. sarpedon* in N. India and parts of China. *G. anthedon* is separated from *G. milon* on the basis of significant differences in the male and female genitalia as well as in the sequences of the mitochondrial ND5 genes. Both have previously been recognized as species distinct from *G. sarpedon* (MURAYAMA 1978, TSUKADA & NISHIYAMA 1982, MOONEN 1998, VANE-WRIGHT & DE JONG 2003, PEGGIE et al. 2005). *G. monticolus* is placed as a subspecies of *G. anthedon* on the basis of the very similar male genitalia. Thus, *G. anthedon* and *G. milon* are sympatric on Sulawesi. *G. isander* is separated from *G. sarpedon* and raised to species rank on the basis of significant differences in pigmentation/scale structure as well as in the male and female genitalia. *G. choredon* is separated from *G. sarpedon* and raised to species rank on the basis of significant differences in pigmentation/scale structure as well as in the male and female genitalia. *G. choredon* differs from *G. isander* in the structure of both male and female genitalia and the two are accordingly recognized as separate species. *G. jugans* is separated from *G. sarpedon* and raised to species rank on the basis of significant differences in pigmentation/scale structure and structure of the male genitalia. There are some similarities between *G. jugans* and *G. choredon* and further investigation is necessary to clarify their relationship. *G. teredon* is separated from *G. sarpedon* and raised to species rank on the basis of significant differences in pigmentation/scale structure and structure of the male genitalia.

7 Check list of the *Graphium sarpedon* species group

Graphium sarpedon (Linnaeus, 1758)
- *G. sarpedon sarpedon* (Linnaeus, 1758)
  = *Papilio protensor* Gistel, 1857 = *Papilio semifasciatus* Honrath, 1888
- *G. sarpedon nipponus* (Fruhstorfer, 1903)
  = *Papilio sarpedon sarpedonides* Fruhstorfer, 1908 = *Papilio sarpedon intermedium* Kato, 1940 = *Papilio sarpedon hachijoinsulanum* Kato, 1942
- *G. sarpedon connectens* (Fruhstorfer, 1906)
  = *Papilio sarpedon surusumi* Matsumura, 1909
- *G. sarpedon luctatius* (Fruhstorfer, 1907)
  = *Papilio sarpedon melas* Fruhstorfer, 1907 = *G. sarpedon corbeti* Toxopeus, 1951
- *G. sarpedon colus* (Fruhstorfer, 1907)
- *G. sarpedon pagus* (Fruhstorfer, 1907)
- *G. sarpedon morius* (Fruhstorfer, 1908)
- *G. sarpedon sirkari* n. subsp.

Graphium cloanthus (Westwood, 1845)
- *G. cloanthus cloanthus* (Westwood, 1845)
- *G. cloanthus clymenus* (Leech, 1893)
  = *G. cloanthus nyghmat* Koçak & Kemal, 2000
- *G. cloanthus kuge* (Fruhstorfer, 1908)
- *G. cloanthus sumatranum* (Hagen, 1894)

Graphium anthedon (Felder & Felder, 1864)
- *G. anthedon anthedon* (Felder & Felder, 1864)
- *G. anthedon dodingensis* (Rothschild, 1896)
- *G. anthedon monticolus* (Fruhstorfer, 1896) n. comb.
  = *G. sarpedon tetrix* Tsukada & Nishiyama, 1980
- *G. anthedon crudus* (Rothschild, 1898)
- *G. anthedon halesus* (Fruhstorfer, 1907)

Graphium choredon (Felder & Felder, 1864)

Graphium milon (Felder & Felder, 1865)
- *G. milon milon* (Felder & Felder, 1865)
- *G. milon sulaensis* (Lathy, 1899)
  = *Papilio sarpedon coelius* Fruhstorfer, 1899

Graphium teredon (Felder & Felder, 1865)
  = *Delchina thermodusa* Swinhoe, 1885

Graphium isander (Godman & Salvin, 1888)
- *G. isander* (Godman & Salvin, 1888)
- *G. isander impar* (Rothschild, 1895)
- *G. isander imparilis* (Rothschild, 1895)
  = *Papilio sarpedon messogis* Fruhstorfer, 1907 = *Papilio sarpedon temnus* Fruhstorfer, 1907 = *Papilio sarpedon corycus* Fruhstorfer, 1907

Graphium adonarensis (Rothschild, 1896)
- *G. adonarensis adonarensis* (Rothschild, 1896)
- *G. adonarensis rufofervidus* (Fruhstorfer, 1897)
- *G. adonarensis rufocellularis* (Fruhstorfer, 1905)
- *G. adonarensis phyris* (Jordan, 1937)
- *G. adonarensis lycianus* (Toxopeus, 1951)
- *G. adonarensis hundertmarki* n. subsp.
- *G. adonarensis agusyantoei* n. subsp.
- *G. adonarensis phyrisoides* n. subsp.
- *G. adonarensis toxopei* n. subsp.
- *G. adonarensis septentrionicolus* n. subsp.

Graphium jugans (Rothschild, 1896)
- *G. jugans jugans* (Rothschild, 1896)
- *G. jugans wetterensis* Okano, 1993
- *G. jugans kawaimitsuoi* Fujioka, 1997 n. comb.
  = *Papilio sarpedon timorensis* Rothschild, 1896 = *G. sarpedon cesa* Koçak & Kemel, 2000

Graphium sandawanum (Yamamoto, 1977)
- *G. sandawanum sandawanum* (Yamamoto, 1977)
- *G. sandawanum joreli* (Nuyada, 1994)

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