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Revision of the classification of *Pachliopta phlegon* (C. & R. FELDER, 1864), *P. buraki* KOÇAK, 1983 and *P. leytensis* MURAYAMA, 1978 (Lepidoptera, Papilionidae)

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Abstract: The systematics of the three taxa *Pachliopta phlegon* (C. & R. FELDER, 1864), *Pachliopta buraki* KOÇAK, 1983 (= *Papilio phegeus* HOPFFER, 1866 nec *P. phegea* BORKHAUSEN, 1788; primary homonymy) and *Pachliopta leytensis* MURAYAMA, 1978 have been investigated. As a result of these studies, *P. phlegon* and *P. strandi* (BRYK, 1930), previously considered to be a subspecies of *P. phlegon*, have been separated as two distinct species. Further, *P. buraki* is now considered to be a synonym of *P. leytensis*. Three **new subspecies** of *P. strandi* are described: *P. s.* ***marinduquensis*** from Marinduque Is., *P. s.* ***nuydaorum*** from Luzon and *P. s.* ***elizabethae*** from Panay and Guimaras. The holotype specimens are in the TREADAWAY collection which is assigned to the Senckenberg-Museum, Frankfurt am Main.

Revision der Klassifikation von *Pachliopta phlegon* (C. & R. FELDER, 1864), *P. buraki* KOÇAK, 1983 und *P. leytensis* MURAYAMA, 1978 (Lepidoptera, Papilionidae)

Zusammenfassung: Die systematischen Probleme der drei Taxa *Pachliopta phlegon* (C. & R. FELDER, 1864), *Pachliopta buraki* KOÇAK, 1983 (= *Papilio phegeus* HOPFFER, 1866 nec *P. phegea* BORKHAUSEN, 1788; primäre Homonymie) und *Pachliopta leytensis* MURAYAMA, 1978 wurden untersucht. Als Resultat werden *Pachliopta phlegon* und *P. strandi* (BRYK, 1930), zuvor als Unterart von *P. phlegon* interpretiert, als zwei getrennte Arten separiert. Weiterhin wird *P. buraki* als Synonym von *P. leytensis* aufgefaßt. Drei **neue Subspecies** von *P. strandi* werden beschrieben: *P. s.* ***marinduquensis*** von Marinduque, *P. s.* ***nuydaorum*** von Luzon und *P. s.* ***elizabethae*** von Panay und Guimaras. Die Holotypen befinden sich in der Sammlung TREADAWAY, die in das Senckenberg-Museum, Frankfurt am Main, gelangen wird.

Abbreviations

CCGT Collection Colin G. TREADAWAY, assigned to the Senckenberg-Museum, Frankfurt am Main, Germany

CMP Collection Macolm G. P. PAGE, Basel, Switzerland

I. *Pachliopta phlegon* (C. & R. Felder, 1864) and *Pachliopta strandi* (Bryk, 1930)

A brief chronology of the taxonomy is as follows:

1861 Felder & Felder gave the name *Papilio annae* to yellow pigmented specimens from Mindoro.

1864 Felder & Felder gave the name *Papilio phlegon* to red specimens from Mindanao.

1909 Jordan[1] named red pigmented specimens from Mindoro as ab. *erythrus*.

1930 Bryk found *Papilio annae* C. & R. Felder, 1861 to be a primary homonym of *Papilio annae* Gistel, 1857 and substituted the name *strandi* for the yellow form from Mindoro.

1980 Tsukada & Nishiyama identified *phlegon* as the species' name, with *strandi* as a subspecies and *erythrus* as a form of this subspecies.

These two butterflies have long been held conspecific. However, close examination shows that *Pachliopta phlegon* from Mindanao differs significantly from the more northerly populations (see map, Fig. 1), which can be grouped under *P. strandi*. Some differences are apparent in wing pattern: the forewing rays of *P. phlegon* (Figs. 12, 13) taper to a point on the inner margin, are less distinct and less heavily scaled than those of *P strandi*, which come to a blunt end on the inner margin (Figs. 6-11, 14, 15). The white scales forming these rays in *P. phlegon* are approximately one half of the width of scales from the equivalent region of the *P. strandi* wings (0.045-0.063 mm for *P. phlegon* and 0.075-0.12 mm for *P. strandi*).

Structural differences are apparent in the genitalia of both sexes. In the males, the clasper of *P. phlegon* is broader than that of *P. strandi* and the socii are more strongly sclerotized (Fig. 2). In the females, the plate formed from operculum and the peri-opercular lamellae of *P. phlegon* is larger and more heavily sclerotized than found in any of the populations assigned to *P. strandi* (Fig. 3). The classification of these butterflies is thus as follows.

[1] According to the publication date printed on these pages, it was published on 29 December 1908; but delivery of these pages was only in April 1909, and Bridges (1988) and others accept 1909 as date.

1. *Pachliopta phlegon* (C. & R. Felder, 1864) (Figs. 12, 13)

Distribution: W. Mindanao

2. *Pachliopta strandi* (Bryk, 1930), stat. nov.

(= *Papilio annae* Felder & Felder, 1861, nec Gistel, 1857; primary homonymy)

Comprising the following 5 subspecies:

a) *Pachliopta strandi strandi* (Bryk, 1930) (Figs. 14, 15)

Distribution: Mindoro

Felder & Felder (1861) originally described a form from Mindoro that had yellow pigmentation on the body as well as the coloured spots of the wing. Jordan (1909) later described the red pigmented form *erythrus* also from Mindoro and noted that "the white area of the hindwing has a yellowish tone". According to Tsukada & Nishiyama (1980) the two forms have a local nature with the red form predominant in E. Mindoro (9 f. *erythrus* 1 f. *strandi*) and the yellow form predominant in N. Mindoro. This would be very interesting if it could be confirmed. Although described as the red form, f. *erythrus* frequently has patches of yellow scaling on the abdomen (see below). This distinguishes the Mindoro *strandi* from all other red subspecies, which may vary in the intensity of colour and shade of red but never have a mixture of red and yellow pigments.

The red pigment found in most of the tribe Troidini was designated type A by Ford (1944: 203-205). It is normally bright pink but turns yellow on exposure to acid (such as the fumes of hydrochloric acid) and readily reverts to its red colour after exposure to a base (such as the fumes of an ammonia solution).

To test whether yellow colour variant of *P. strandi* might repesent stable deposition of the acid form of this pigment, we exposed specimens of *P. strandi* f. *strandi* (yellow) and *P. strandi* f. *erythrus* (red) first to the fumes from ammonia solution and then to fumes from concentrated hydrochloric acid. The yellow colour of the *P. strandi* f. *strandi* specimen was unaffected by either treatment whereas the *P. strandi* f. *erythrus* specimen went first a slightly deeper red with the ammonia and then bright yellow with the hydrogen chloride. Thus, it appears that the yellow pigment is not simply the acid form of the red pigment A. The exposure to base in-

tensified the brick red colour of the abdomen of our f. *erythrus* specimens, turning them mostly pink. It then became obvious that many of our specimens had some patches of scales with the yellow pigment. The mixture of red and yellow pigmented scales then gives the brick-red appearance.

The yellow pigment is not the same as those which give the yellow colour in *Troides* HÜBNER or in *Papilio* LINNAEUS both of which have brilliant fluorescence when illuminated with ultra-violet light, whereas the yellow pigment of *P. strandi* absorbs the ultra-violet light. The possibility that the stable colour shift is produced by complexing with a protein in the scale (such as occurs in many crustaceans) could be eliminated by exposing the specimen to steam. The moist heat would destroy the protein complex restoring the sensitivity to ammonia (crustaceans go from blue to red under such conditions), but this treatment had no effect on the *P. strandi* specimen.

Besides the possibility that the yellow pigment of *P. strandi* is chemically quite divergent, preliminary chemical characterization of alkyline solutions of the red and yellow pigments shows that they have similar compositions. Therefore one possibility that remains is that it is either a biosynthetic precursor or a derivative of the red pigment A. The red pigment A evidently has a functional group that is sensitive to pH, such as the phenolic function found in many natural chromophores (Fig. 4). Modification of this functional group, for example by condensation with a sugar molecule, also often found in natural pigments, would not only eliminate the sensitivity to pH but also lock the pigment in the same colour state as the acid form.

b) *Pachliopta strandi marinduquensis* subsp. nov.

Holotype ♂ (Fig. 6): [Marinduque], Binunga, July, 1973. In CCGT.

Paratypes: In total 23 ♂♂ and 7 ♀♀, all from Marinduque Isl., consisting of:

In CCGT: 1 ♀ ("allotype", Fig. 7), near Boac, 20 February 1973. 11 ♂♂, near Boac (2 ♂♂ Aug. 1973, 2 ♂♂ Sept. 1973, 6 ♂♂ Oct. 1978, 1 ♂ Nov. 1978). 1 ♂, Gasan 26 June 1972. 2 ♂♂ Malibog (1 ♂ June 1972, 1 ♂ June 1984). 2 ♂♂, Malinao (1 ♂ May 1970, 1 ♂ Dec. 1970). 2 ♂♂ "Marinduque" (April 1975, May 1979). 3 ♀♀, Boac (Oct. 1973, Feb. 1972, Sept. 1979). 1 ♀, Gasan, 26 June 1972. 1 ♀, Binunga, June 1972. 1 ♀, "Marinduque", April 1975.

In CMP: 3 ♂♂, Boac, October 1973. 2 ♂♂, "Marinduque", 1978.

Distribution: Marinduque.

This is an extremely well-known butterfly, coming from a major collecting centre in the Philippines. Nevertheless, comparison with the nominotypical form reveals sufficient differences to justify its separation as a new subspecies.

Description, ♂♂: Hair scales on body dull yellow and dark brown to black. FW 44–47 mm. Ground colour black with pronounced white rays. On the hindwing the submarginal spots are narrow, giving the appearance of a dull yellow stripe rather than the squarish spot of the nominate form. The black band between spot and margin is wider than in the other subspecies. The spots in the cell and sub-cellular band are white rather than the cream found in Mindoro specimens. The pseudoveins in the cellular spot are weakly represented. The spots of the subcellular band are relatively small.

Description, ♀♀: Hair scales on body yellow and dark brown to black. FW 49–57 mm. Ground colour black with pronounced white rays on the forewing. On the hindwing, the submarginal spots are small but well marked. There is only light suffusion with black scales. The spots in the cell and sub-cellular band are bright white.

c) ***Pachliopta strandi nuydaorum* subsp. nov.**

Holotype ♂ (Fig. 8): Tanay, C. Luzon, April 1971. In CCGT.

Paratypes: In total 3 ♂♂ and 6 ♀♀, all from C. Luzon, consisting of:

In CCGT: 1 ♀ ("allotype", Fig. 9), Laiya, 11 April 1969. 2 ♂♂, Laiya, Batangas (June 1960, April 1968). 4 ♀♀, Laiya, Batangas (1 ♀ 11 April 1967, 2 ♀♀ 4 Nov. 1968, 1 ♀ 1 April 1969).

In CMP: 1 ♂, Laiya, Batangas 23 April 1970, 1 ♀, Laiya, Batangas, 4 Nov. 1968.

Distribution: Central W. Luzon.

Description, ♂♂: Hair scales on body red and black. FW 45–49 mm in length. Ground colour black with white to grey rays lining the veins and in the cell. The rays in cell CuA2 are fused at the base. Two of the males have the white rays of the FW more suffused with black and those in CuA2 are divided.

HW. All six spots represented, suffused with black scaling. The three spots in the cells closest to the anal tornus (M2, M3 and CuA1) are red. That in CuA1 is the largest and brightest. The white spots around and in the cell are clear of black scaling. There are traces of two pseudo-veins formed by black scaling in the HW cell in three of the males.

Description, ♀♀: Hair scales on body red and black. FW 44-46 mm in length. Ground colour dark brown. The white rays are prominent and those in CuA2 are fused at the base.

HW. Marginal spots large, with a mixture of white and red scaling. There is some suffusion with black scales except in CuA1. The white spots around and in the cell are clear of black scales.

d) *Pachliopta strandi splendida* Schröder & Treadaway, 1984

Distribution: Sibuyan Is.

The red scales of all specimens have bright red to pink, with no admixture of yellow or white scales.

e) *Pachliopta strandi elizabethae* subsp. nov.

Holotype ♂ (Fig. 10): Panay, Aklan, Mt Malindog, 20 May 1993. In CCGT.

Paratypes: In total 20 ♂♂ and 5 ♀♀, consisting of:

1 ♀ ("allotype", Fig. 11), Panay, Aklan, Mt Malindog, 25 May 1993; in CCGT.

In the Semper collection, Senckenberg-Museum: 1 ♂, Nagaba, Guimaras (Semper # 398, SMFL 656, annotation by Semper gives December 1879 as further data; figured by Semper 1891 on pl. 46, fig. 3). 1 ♀, Nagaba, Guimaras (Semper # 398, SMFL 4147, annotation by Semper gives December 1879 as further data).

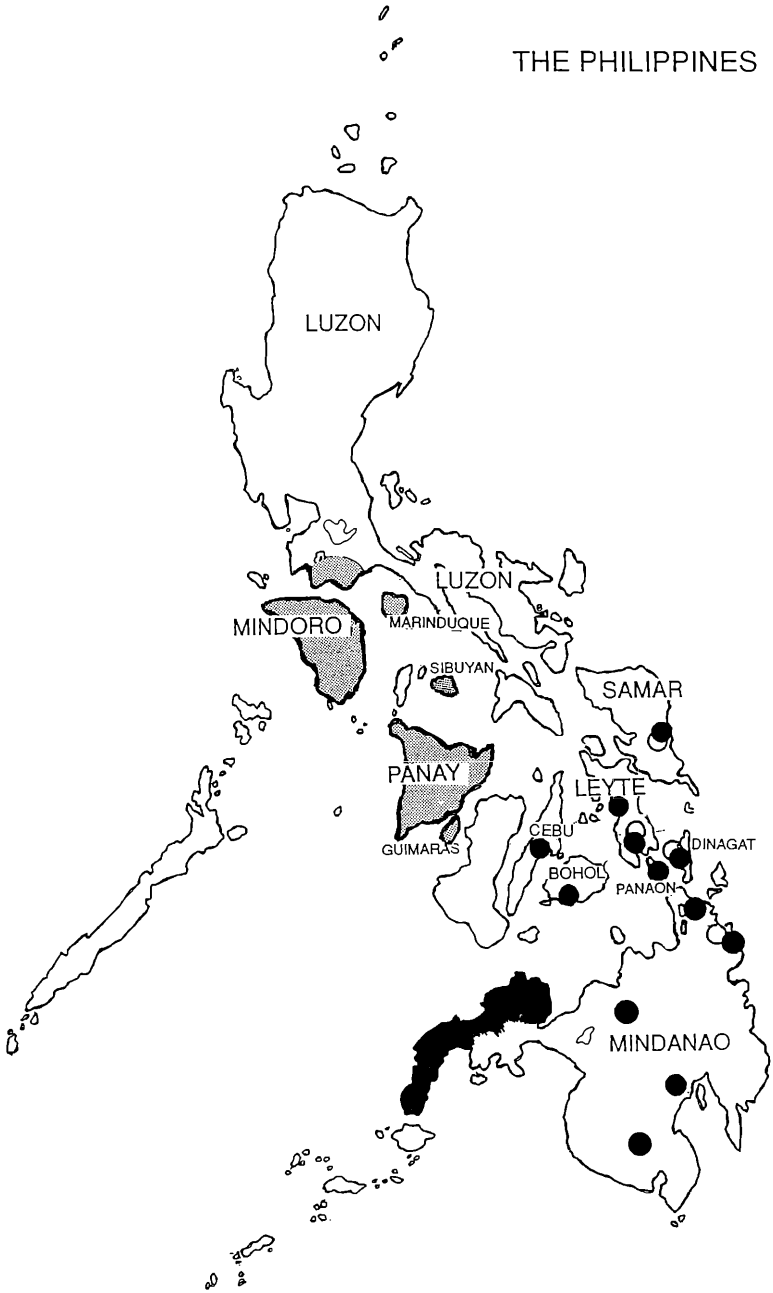
In CCGT: 4 ♂♂, NW Panay, Culasi, Bacong River, 200-300 m (20 March 1980, 21 March 1980, 29 April 1981, 30 April 1981). 6 ♂♂, W Panay, Antique, Mt Madja-as, 100-300 m (21 May 1980, 24 April 1981, 3 February 1982, 9 February 1982, 11 April 1983, 19 January 1993). 8 ♂♂, Panay, Antique, Culasi 100-500 m (11 April 1970, 2 ♂♂ 21 March 1980, 3 May 1981, 16 December 1982, 3 March 1985, 4 March 1985, 5 March 1985). 1 ♀, Panay, near Tibiao, May 1974. 1 ♀, Panay, Antique, Culasi, 100 m, 22 September 1977.

In CMP: 1 ♂, Panay, Antique, Culasi 100-500 m, 21 March 1980. 1 ♀, Panay, Antique, Culasi 100 m, 23 September 1977.

Distribution: W. Panay; Guimaras.

Description, ♂♂: Hair scales on body red and black. Ground colour black with well-marked white rays, divided in CuA2. HW with seven submarginal spots, heavily suffused with black scaling except in cell CuA1. The spots in cells CuA1 and M3 are bright pink. The white cell spot is free of suffusion.

Fig. 1: A map of the Philippines showing the approximate distribution of *P. strandi* (stippled), *P. phlegon* (solid black) and individual records for *P. leytensis* f. *leytensis* (O) and *P. leytensis* f. *buraki* (●).



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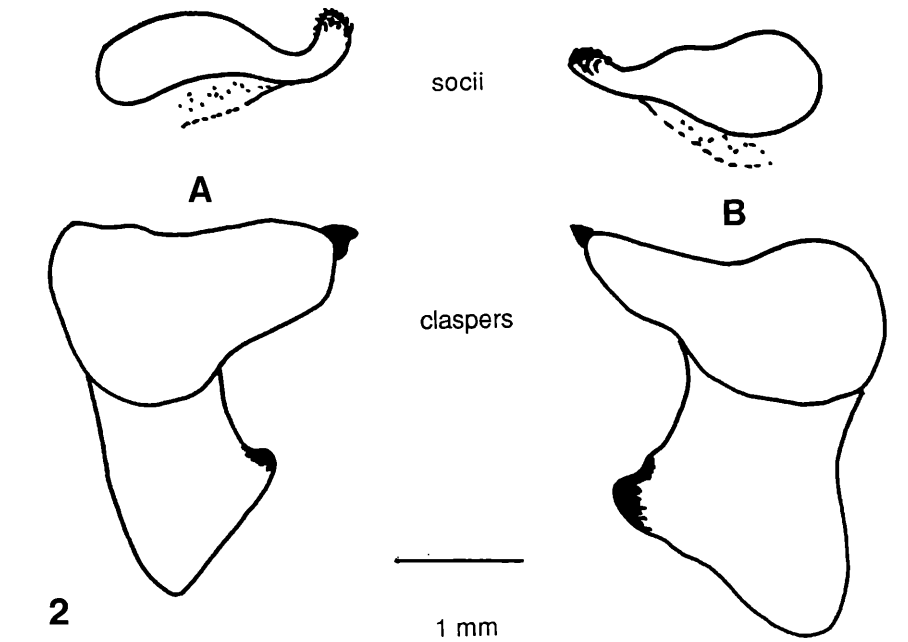


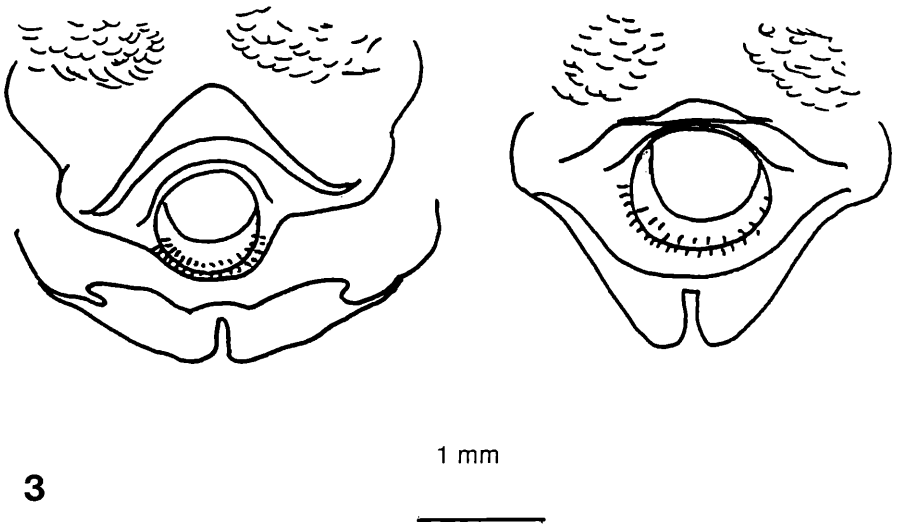


Fig. 2: The male genitalia of (A) *P. phlegon* and (B) *P. s. strandi*. **Fig. 3:** The female genitalia of (A) *P. phlegon* and (B) *P. s. strandi*.

The males are quite uniform in size (FW length 42–50 mm). The red submarginal spots of the hindwing are variable in size and in the amount of white scaling that is present. Three males have very faint pseudo-veins in the hindwing cell. The abdomen of one male is pale brick red. After exposure to ammonia, the colour deepened in some areas while in others the scales were white (perhaps simply lacking a pigment). Thus, the brick-red colour is not a transition to the f. *erythrus* of Mindoro.

Description, ♀♀: Hair scales on body red and black. Ground colour black with well-marked white to grey rays, divided in cell CuA2. HW with six submarginal spots comprised of a mixture of white and red scales, with relatively little black scaling. The white cell spot is free from black scaling.

The females are also quite uniform in size (FW length 48–55 mm). Two of the females have the white rays of the FW fused in CuA2. One female has

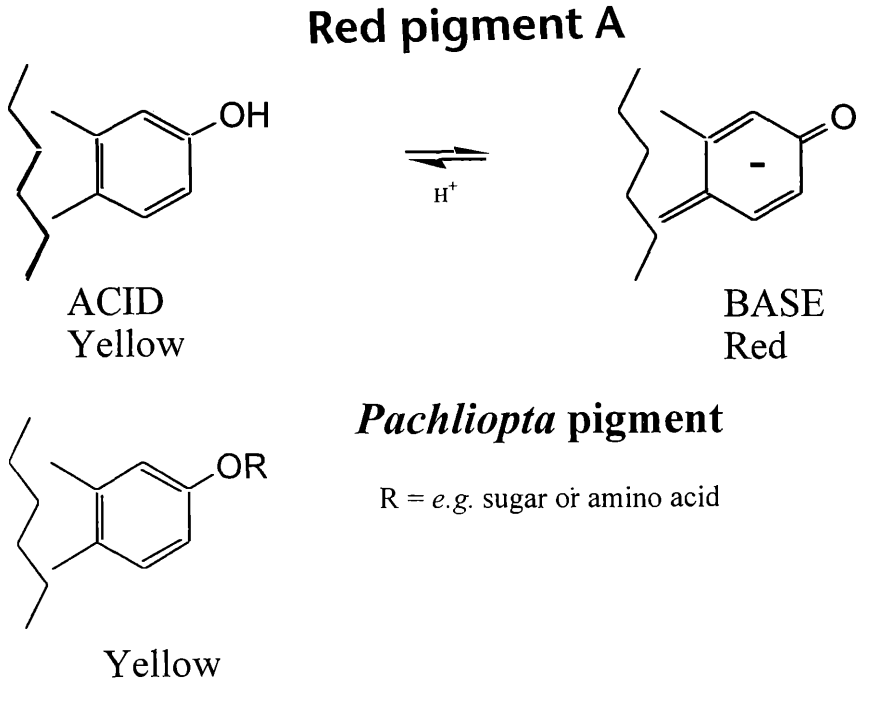


Fig. 4: Suggested reactions occurring during the exposure of pigments to acid or base (following FORD 1944).

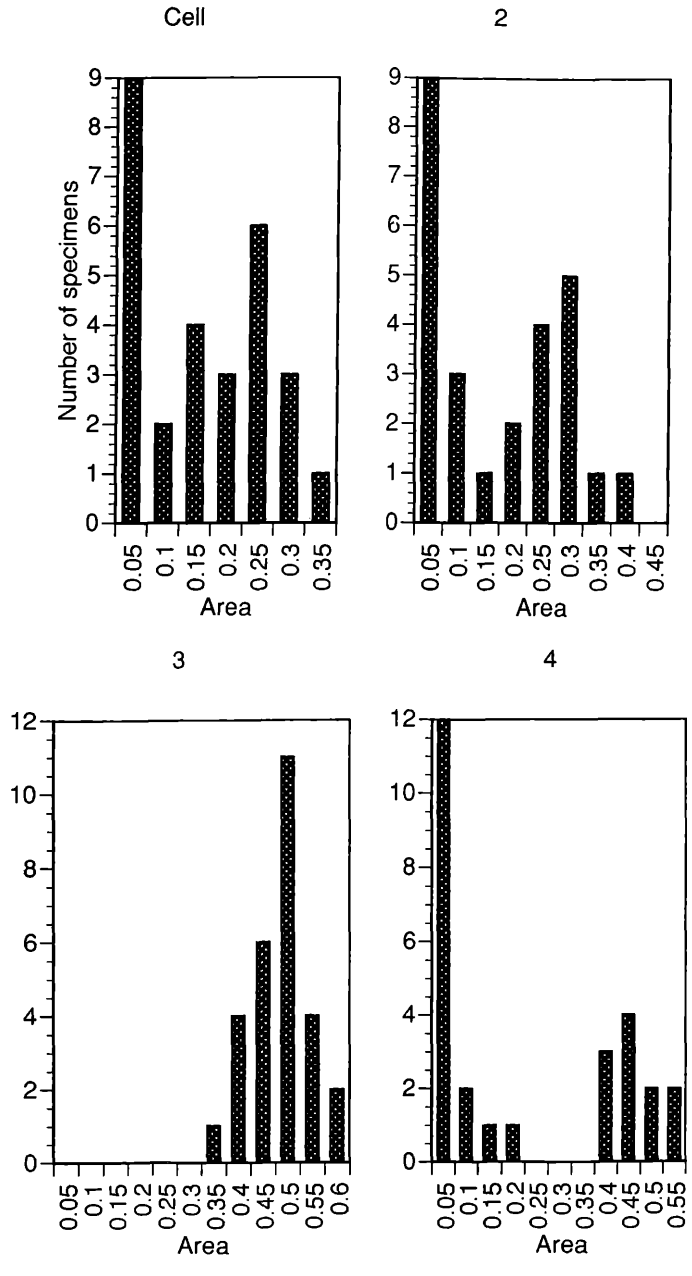


Fig. 5: Histograms showing the distribution in sizes of the subcellular and cellular spots on the hindwing underside of *P. leytensis*. Cell and vein interspaces 2, 3, and 4. Area in cm².

the hindwing spots heavily suffused with black and two pseudo-veins are represented in the hindwing cell. Two females have brick red abdomens and submarginal wing spots.

General remarks

The name *nuydaorum* was given to honour the NUYDA family of Manila, Philippines, who have, over many years, assiduously researched Philippine Lepidoptera. The name *elizabethae* was given to recognize the patience and support of the first author's wife Elizabeth.

All subspecies of *P. strandi* have a tendency to feed at daybreak. For example, *P. s. splendida* was frequently encountered in fairly large numbers shortly after sunrise flying 0.3–0.5 m above the ground in small clearings in the forest where a small blue flower (species unknown) was to be found. By 8.30 a.m., all had disappeared from such areas and during the day occasional specimens only were seen, flying 5–15 m above the ground. Though *P. s. elizabethae* exhibited similar early morning habits to *splendida,* it could more often be located during the day flying lazily at about 0.5–3 m through the secondary forest undergrowth and in clearings. Further, this subspecies was observed feeding on flowering bushes in the late afternoon together with *Atrophaneura semperi lizae* SCHRÖDER & TREADAWAY, 1984.

II. *Pachliopta leytensis* MURAYAMA, 1978 and *Pachliopta buraki* KOÇAK, 1983

A brief chronology of the taxonomy is as follows:

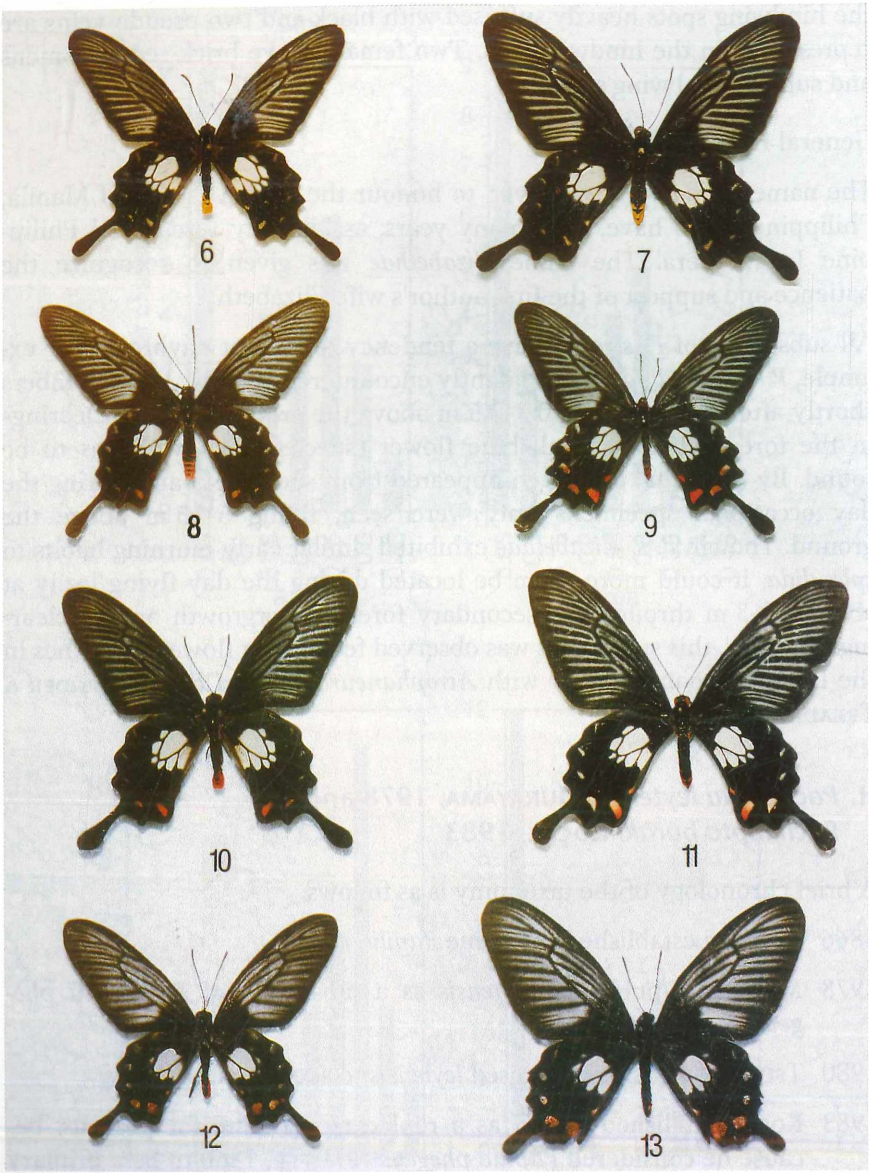
1866 HOPFFER established the name *Papilio phegeus.*

1978 MURAYAMA published *leytensis* as a subspecies of *Pachliopta phegeus.*

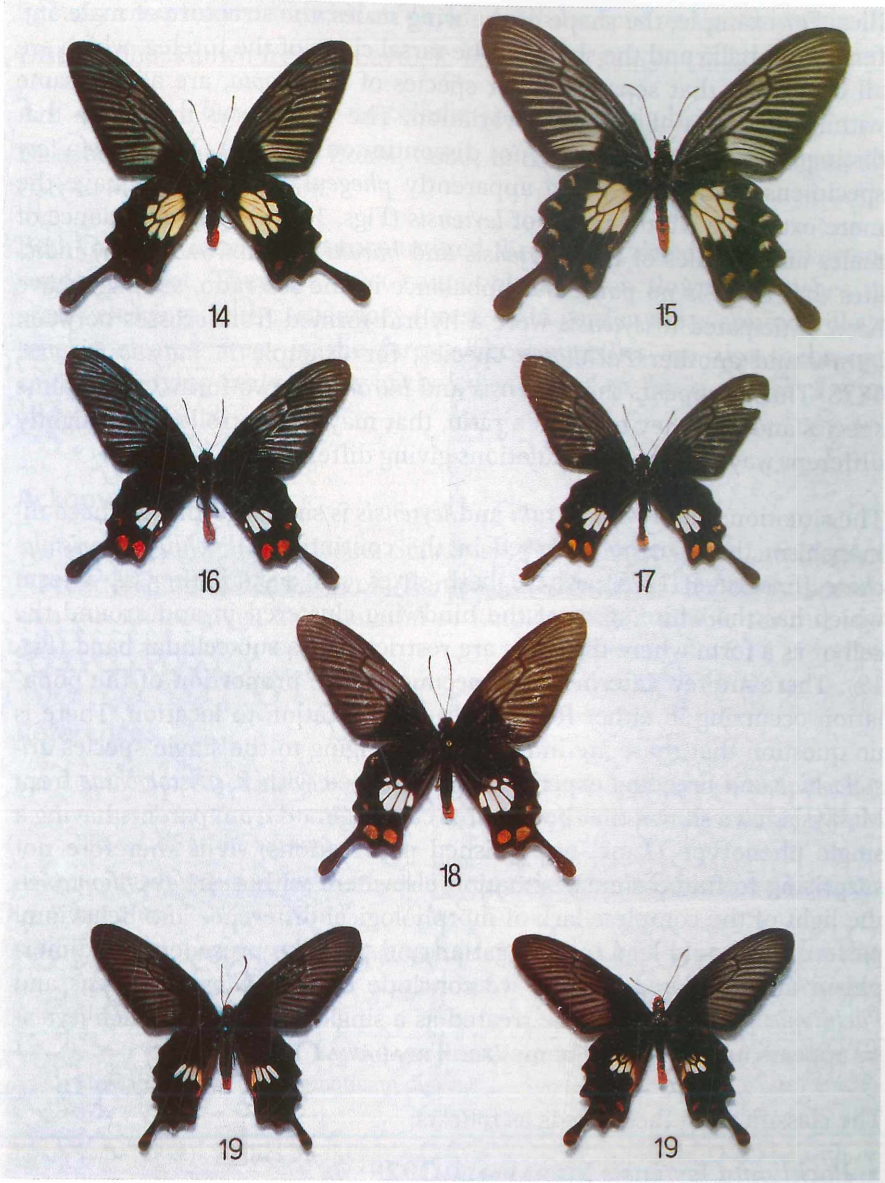
1980 TSUKADA & NISHIYAMA raised *leytensis* to species rank.

1983 KOÇAK published *buraki* as a replacement name for *phegeus,* because he considered *Papilio phegeus* HOPFFER, 1866 to be a primary homonym of *Papilio phegea* BORKHAUSEN, 1788.

Pachliopta leytensis was originally described as a subspecies of *P. phegeus* even though both *leytensis* and *phegeus* forms fly together at the same locality. Structurally, there is no character that separates the two butter-



Colour plate 1: Fig. 6: *Pachliopta strandi marinduquensis* ssp nov. Holotype ♂. Marinduque, Binunga, July, 1973. **Fig. 7:** *P. s. marinduquensis* ssp. nov. Allotype ♀. Marinduque, near Boac, 20 February, 1973. **Fig. 8:** *P. s. nuydaorum* ssp. nov. Holotype ♂. Tanay, C. Luzon, April 1971. **Fig. 9:** *P. s. nuydaorum* ssp. nov. Allotype ♀. C. Luzon, Laiya, 11 April 1969. **Fig. 10:** *P. s. elizabethae* ssp. nov. Holotype ♂. Aklan, Mt Malindog, 20 May 1993. **Fig. 11:** *P. s. elizabethae* ssp. nov. Allotype ♀. Panay, Aklan, Mt Malindog, 25 May 1993. **Fig. 12:** *Pachliopta phlegon*, ♂, W. Mindanao. **Fig. 13:** *P. phlegon*, ♀, W. Mindanao.



Colour plate 2: Fig. 14: *Pachliopta strandi strandi* f. *erythrus* ♂, Mindoro. **Fig. 15:** *P. s. strandi* f. *erythrus* ♀, Mindoro. **Fig. 16:** Typical specimen of *P. leytensis* f. *buraki* ♂, S. Leyte. **Fig. 17:** Intermediate specimen of *P. leytensis* ♂, S. Leyte. **Fig. 18:** Typical specimen of *P. leytensis* f. *leytensis* ♂, S. Leyte. **Fig. 19:** Sibling bred specimens of *P. aristolochiae* from Malaya, showing the forms with and without a cell spot on the hindwing.

flies. For example, the shape of the wing scales, the structure of male and female genitalia and the shape of the tarsal claws of the foreleg, which are all characters that separate other species of *Pachliopta*, are all the same within the limits of indivdual variation. The differences in pattern that distinguish the two forms are not discontinuous (Fig. 5). There are a few specimens that, while being apparently *phegeus*, nevertheless have the more extensive white scaling of *leytensis* (Figs. 16-18). The abundance of males and females of both *leytensis* and *buraki* (TREADAWAY 1995) indicates that there is no particular imbalance in the sex-ratio, as might have been anticipated if *leytensis* were a hybrid formed from crosses between *buraki* and another *Pachliopta* species, for example *P. mariae* SEMPER, 1878. Thus it appears that *leytensis* and *buraki* are two forms of the same species and that they occur in a ratio, that may be controlled in a slightly different way in various populations giving different local ratios.

The situation found with *buraki* and *leytensis* is similar to the balanced dimorphism that can be observed in the contintental *Pachliopta aristolochiae* (FABRICIUS, 1775), where both sexes can occur either as a form which has the white spots of the hindwing clustered in and around the cell or as a form where the spots are restricted to a sub cellular band (Fig. 19). There are few intermediate specimens. The proportion of the population occurring in either form varies from location to location. There is no question that these are individuals belonging to the single species *aristolochiae* and breeding experiments performed with *P. aristolochiae* from Malaysia have shown that both forms can originate from parents having a single phenotype (PAGE, unpublished observations). It is therefore not surprising to find a similar situation elsewhere within the *Pachliopta*. In the light of the complete lack of morphological difference and behavioral pattern that could lead to segregation and with the precedent for dimorphism in the related species, we conclude that *Pachliopta leytensis* and *Pachliopta phegeus* should be treated as a single species, for which *leytensis* appears to be the valid name (see TREADAWAY 1995).

The classification therefore is as follows:

- ***Pachliopta leytensis* MURAYAMA, 1978**
  (Syn. *P. buraki* KOÇAK, 1983 = *P. phegeus* HOPFFER, 1866 nec BORKHAUSEN, 1788, primary homonym)

With two forms:

• *P. leytensis* f. *leytensis:* with an obvious cellular spot on the hindwing

Distribution: known from S. Leyte, E. Mindanao, Samar, Dinagat

• *P. leytensis* f. *buraki:* with no cellular spot on the hindwing

Distribution: known from Bohol, Cebu, C. & S. Leyte, Samar, Dinagat, S.-C. & E. Mindanao, Panaon

Both forms of *leytensis* are encountered throughout the day in broken secondary forest. They are most commonly seen on flowering bushes in grassy clearings in the secondary forest, or in garden areas around village huts in cleared areas in the forest. The butterflies are also to be encountered flying fairly slowly at the edge of broken forested areas 1-4 m above the ground.

Acknowledgement

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