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PAPILIO DEMOLEUS (PAPILIONIDAE) IN BORNEO AND BALI

Additional key words: Malaysia, Indonesia, Malay Archipelago, invasion, deforestation.

Papilio demoleus L. is widely distributed in the tropical and subtropical regions of Asian continent, Australia, and the islands of Taiwan, Hainan, New Guinea, and Lesser Sunda Islands (Sumba, Flores and Alor), but it had been lacking in Sumatra, Java, Borneo, the Philippines, and the Moluccas until its recent invasion of these islands (Corbet & Pendlebury 1978, 1992). Sumatra received ssp. *malayanus* Wallace from the Malay Peninsula and the Philippines ssp. *libanius* Fruhstorfer from Taiwan in the 1960–70's (Jumalon 1968, Hiura 1973, Miyata 1973, Tsukada & Nishiyama 1980). These two subspecies can be easily discriminated based on the wing markings; Fruhstorfer (1908), in his description of ssp. *libanius*, stated that the Taiwanese specimens appear darker than the nominate subspecies specimens from "Tonkin." The dark appearance of ssp. *libanius* is mainly due to the fact that the yellow spots in spaces 1a and 1b of forewing upper surface are always narrow, whereas these spots are always very broad in ssp. *malayanus*, though as was not mentioned in the Wallace's (1865) description of the subspecies (Figs. 1–4).

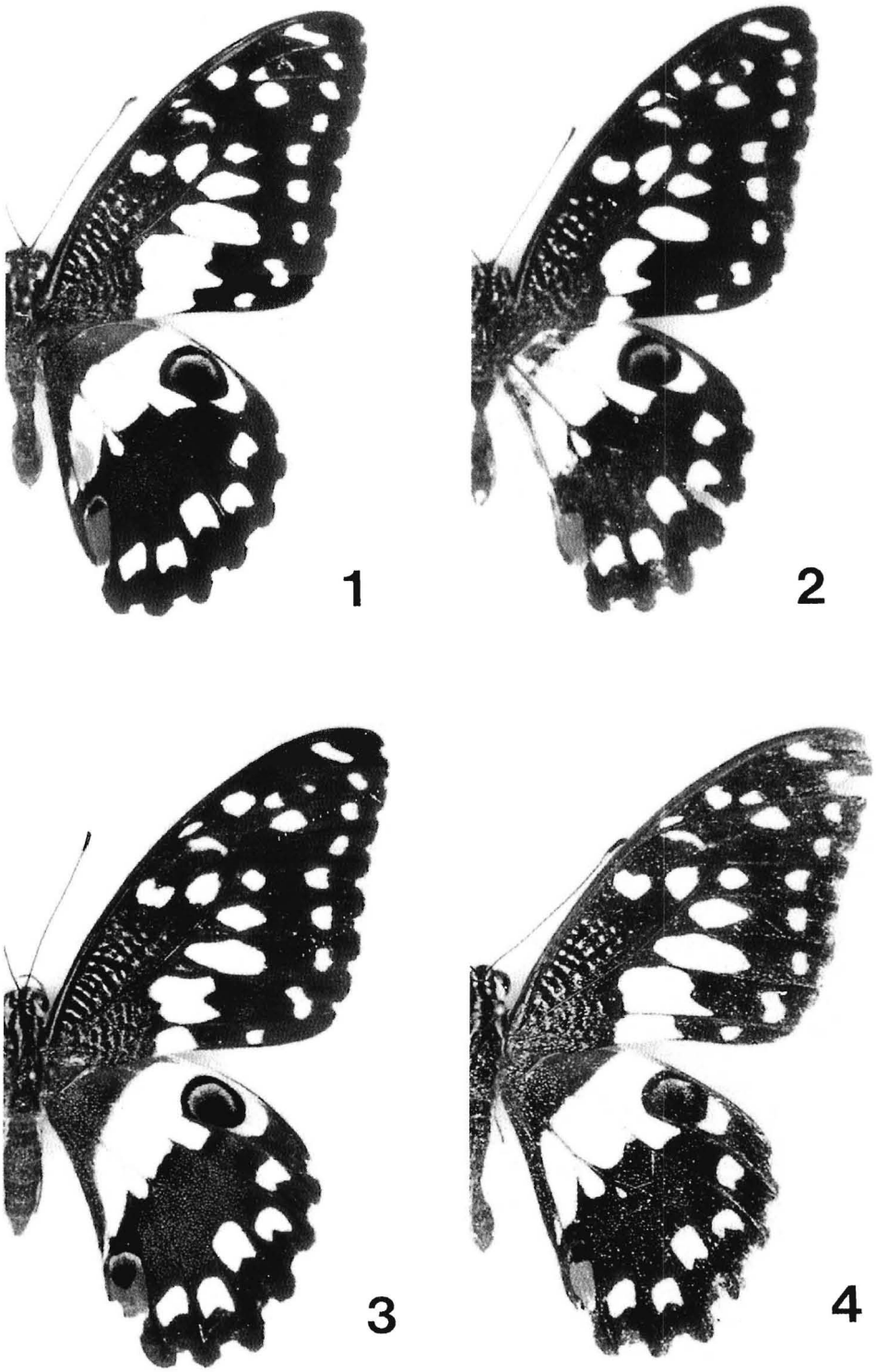
The Malay subspecies was confirmed to have established its population in Java, supposedly having invaded from Sumatra during late 1980's (Kato 1989, Matsumoto & Noerdjito 1996). The species has also been found from Borneo. Otsuka (1988) illustrated a male and a female specimen of *P. demoleus* from Keningau, Sabah, without mentioning that the records were new in Borneo. Although Otsuka (1988) did not identify the subspecies, the illustrated specimens exhibited typical characters of ssp. *libanius*. Ishii (1987, 1991) identified *P. d. libanius* from Sandakan, Sabah, and he mentioned (Ishii 1991) that he saw only a few individuals of this species in 1981, while he found many individuals of the same species in 1983, and suggested that the Taiwanese subspecies may have invaded from the Philippines during the early 1980's.

TABLE 1. Year of first record and presumed origin of the *Papilio demoleus* populations recently established in the Southeast Asian Islands.

Island	Year of first record	Presumed origin	Literature
Luzon	1967*	Taiwan	Jumalon (1968)
Cebu	1968?	Taiwan	Hiura (1973)
Leyte	1968?	Taiwan	Hiura (1973)
Palawan	1969	Taiwan	Hiura (1973)
Negros	1969?	Taiwan	Miyata (1973)
Mindanao	1969	Taiwan	Miyata (1973)
Mindoro	1971	Taiwan	Hiura (1973)
Talaud	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Sangihe	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Sula	Unknown**	Taiwan	Tsukada & Nishiyama (1980)
Borneo	1983	Taiwan	Ishii (1987)
	1996	Malay Peninsula	This study
Sumatra	Unknown**	Malay Peninsula	Tsukada & Nishiyama (1980)
Java	1988*	Malay Peninsula	Kato (1989)
Bali	1991	Malay Peninsula	This study

* Except old sporadic records which are unrelated to the present population (see Jumalon 1968, Moonen 1991 for further details).

** Tsukada & Nishiyama (1980) first stated occurrence of the species in Sumatra without indicating earliest collection data.



FIGS. 1–4. *Papilio demoleus* collected in Borneo and Bali: **1,** a male with characters of ssp. *malayanus* (Bukit Soeharto, East Kalimantan, 16 Nov. 1998); **2,** a male with characters of ssp. *libanius* (Bukit Soeharto, East Kalimantan, 23 Nov. 1998); **3,** a female with intermediate characters between ssp. *malayanus* and ssp. *libanius* (Tawau, Sabah, 11 June 1996); **4,** male *P. d. malayanus* (Nusa Dua, Bali, 17 February 1991).

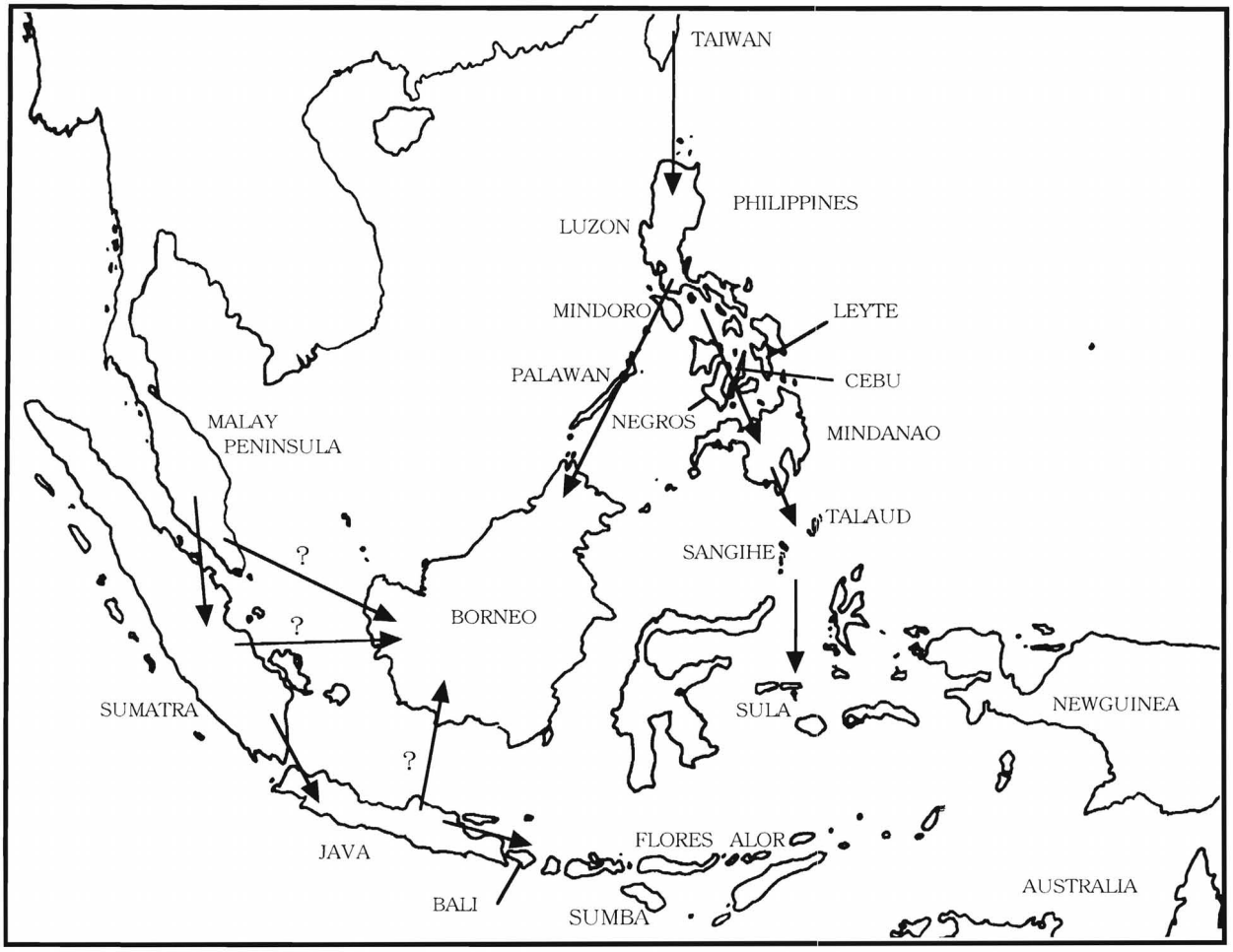


FIG. 5. A map of Southeast Asia, showing islands recently invaded by *Papilio demoleus*. Arrows indicate presumable direction of the invasion.

Furthermore, *P. d. libanius* has been also recorded from Talaud, Sangihe and Sula Islands of the Moluccas (Tsukada & Nishiyama 1980, Corbet & Pendlebury 1992), again suggesting invasion via the Philippines (Table 1, Fig. 5).

Recently, I confirmed *P. d. malayanus* had invaded into Borneo (including Indonesian Kalimantan) and Bali as described below.

***P. demoleus* in Borneo.** I collected four males and one female at Luasong (near Tawau) and one female at Tawau in Sabah, Malaysia, in 1996 (the specimens are kept at Luasong Forestry Centre, Luasong, Sabah). Hiroshi Makihara of Forestry and Forest Products Research Institute (FFPRI), Japan, also collected 18 males and three females at Bukit Soeharto (near Samarinda), East Kalimantan, Indonesia, in 1998 and showed them to me for examination (the specimens are temporarily kept by Makihara and to be kept elsewhere in Indonesia in the future). Ten of these 27 specimens looked like ssp. libanius (1 ♂ Luasong, 19 March 1996; 1 ♀ Tawau, 11 June 1996; 1 ♂ Bukit Soeharto, 6 October 1998; 4 ♂ Bukit Soeharto, 23 November 1998; 2 ♂ Bukit Soeharto, 8 December 1998; 1 ♂ Bukit Soeharto, 30 November 1998), eight looked like ssp. *malayanus* (1 ♂ Luasong, 19 March 1996; 1 ♂ Luasong, 25 May 1996; 1 ♂ Bukit Soeharto, 12 January 1999; 2 ♂ Bukit Soeharto, 6 October 1998; 2 ♀ Bukit Soeharrto, 2 November 1998; 1 ♂ Bukit Soeharto, 9 November 1998), and nine exhibited various intermediate characters between the two (1 ♂ Luasong, 1 June 1996; 1 ♀ Luasong, 28 May 1996; 1 ♂ Bukit Soeharto, 6 October 1998; 1 ♂, 1 ♀ Bukit Soeharto, 6 November 1998; 1 ♂ Bukit Soeharto, 9 November 1998; 1 ♂ Bukit Soeharto, 16 November 1998; 2 ♂ Bukit Soeharto, 23 November 1998), indicating that the population in Borneo is now a mixture of the two subspecies (Figs. 1–3).

***P. demoleus* in Bali.** I found two males of *P. demoleus* collected by Keizi Kiritani at Nusa Dua, Bali, Indonesia, on 17 February, 1991, in the collection of National Institute of Agro-Environmental Sciences

(NIAES), Japan. These specimens had typical characters of ssp. *malayanus* (Fig. 4). To my knowledge, this is the first record of the species from Bali. Although there has been no more information of this species in Bali, it seems likely that the species is established there.

Factors favoring spread of *P. demoleus*. *Papilio demoleus* frequents in and around villages and urban areas. It is originally a species of monsoon regions and prefers open habitats to thick shadowy rain forests as used to dominate in Sumatra, Java, Bali, Borneo and the islands of the Philippines. Hiura (1973) suggested that this habitat preference is the reason why this species had never occurred in the rain forest regions in Sunda Land and the Philippines before, while recent large scale deforestation in the Philippines prepared suitable habitats for the species. I share the same view with him and believe that the same logic applies to the recent establishment of the *P. demoleus* populations in Sumatra and Borneo. In densely human populated Java and Bali, forests have been exploited earlier and suitable habitats for *P. demoleus* have long been prevalent. However, Java and Bali had been far derived from the nearest *P. demoleus* population, until effects of extensive logging and consequent human activities, e.g., fire, shifting cultivation, illegal settlements, cattle breeding, etc. in the forests (or ex-forests) became conspicuous in Sumatra in the 1960–70's. After this stage, Sumatra played a role of stepping stone for *P. d. malayanus* to invade into Java, and then Java played a similar role between Sumatra and Bali. The occurrence of *P. demoleus* in Bali in 1991 indicates that the invasion into Bali took place almost immediately after its establishment in Java. The Malay subspecies in Borneo could have invaded either from Sumatra or Java, or directly from Malay Peninsula (Fig. 5).

Then, a question arises; why the Australian subspecies (i.e., ssp. *sthenelus* Macleay of Australia and Sumba, ssp. *sthenelinus* Rothschild of Flores and Alor and ssp. *novoguineensis* Rothschild of New Guinea) would not spread? Food plant availability could be the factor favoring spread of the Asian subspecies, not the Australian subspecies. The Asian subspecies feed on oranges, *Citrus hystrix* DC., *C. aurantifolia* Swingle, *C. amblyocarpa* Ochse, etc. (Rutaceae; Corbet & Pendlebury 1992, Matsumoto & Noerdjito 1996) which are very commonly planted either as a crop or an ornament in towns, villages and illegal settlements in the forest areas. The Australian subspecies feed on wild leguminous plants of the genus *Psoralea* L.: i.e., *P. tenax* Lindl., *P. patens* Lindl., *P. cinerea* Lindl., *P. leucantha* F. Muell. and *P. pustulata* F. Muell. in Australia (Common & Waterhouse 1981) and *P. badocana* Benth. in Papua New Guinea (Parsons 1999) (no food plant record available for the Lesser Sunda populations). Although *Psoralea* plants occur in the Sunda Islands (Bentham & Mueller 1967), there has been no evidence to indicate increase of these plants favored by recent environmental changes. The *Citrus* feeding Asian subspecies, on the other hand, are now expanding its range in the Malay Archipelago, being favored by increase of habitats with artificially planted *Citrus* hosts.

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