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Yukawa, Junichi

Partomihardjo, Tukirin

Yata, Osamu

Hirowatari, Toshiya

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An Assessment of the Role of Sebesi Island as a Stepping-stone for the Colonisation of the Krakatau Islands by Butterflies¹⁾

Junichi YUKAWA²⁾

Entomological Laboratory, Faculty of Agriculture,
Kyushu University, Fukuoka, 812-8581 Japan

Tukirin PARTOMIHARDJO

Herbarium Bogoriense, Botanical Division, Center for R & D in Biology,
Indonesian Institute of Sciences, Bogor, 16122 Indonesia

Osamu YATA

Biosystematics Laboratory, Graduate School of Social and Cultural
Studies, Kyushu University, Fukuoka, 810-8560 Japan

and

Toshiya HIROWATARI

Entomological Laboratory, College of Agriculture, Osaka Prefecture
University, Sakai, Osaka, 599-8531 Japan

Abstract. Thirty-three butterfly species were collected in July 1993 from Sebesi and Sebuku Islands, Indonesia. Most of them were identified at the subspecies level, except several lycaenids. Fourteen species (42.4%) out of the 33 have never been recorded from the Krakataus. This proportion is distinctly higher than 4 to 8 (13.3 to 26.7%) of 30 species recorded from Sebesi in 1989. When these data were taken together, the percentage becomes 32.7 to 40.4% (17 to 21 of 52 species recorded from Sebesi-Sebuku). Comparison between Javanese and Sumatran subspecies in the rate of common species on Sebesi-Sebuku and the Krakataus indicates that the butterfly fauna of the Krakataus have been chiefly derived from Java rather than from Sumatra even though the 2 stepping-stone islands exist between the Krakataus and Sumatra.

Key words: Krakatau Islands, Sebesi Island, butterfly, derivation of fauna, colonisation, stepping-stone.

1) Contribution from the Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka (Ser.5, No.42).

2) To whom all correspondence should be addressed at: Fax: +81-92-642-2837, E-mail: jyukawa@agr.kyushu-u.ac.jp

Introduction

The Krakatau Islands are situated in the Sunda Strait, Indonesia, about 40 km away from the coast of Java and 35 km from Sumatra and now consist of 4 islands, Rakata, Panjang, Sertung, and Anak Krakatau (Fig. 1). As is well known, the first 3 islands were effectively sterilized by the 1883 catastrophic eruption of Krakatau Island, of which Rakata is the remnant. Anak Krakatau appeared above the sea in the 1930s as a result of submarine volcanic activity. Since the eruption, special attention has been paid to the ecological succession on the Krakatau Islands and various faunistic and floristic data have been accumulated (see Thornton, 1996a for literature).

There have been 2 opinions as to the derivation of fauna on the Krakataus (e.g., Dammerman, 1948; Thornton, 1996a, 1996b; Yukawa, 1984). One is that the fauna has been derived chiefly from Sumatra via 2 stepping-stone islands, Sebesi and Sebuku. Another is that it has been derived mainly from Java. The latter opinion has been supported by the relative abundance of Javanese forms over Sumatran ones in the insect groups of aculeata Hymenoptera (Sk. Yamane, 1983), butterflies (Yukawa, 1984), and termites (Sk. Yamane *et al.*, 1992).

Thus, the provision of data indicating the proportions of species deriving from Sumatra and from Java is an appropriate way of contributing to the aforementioned discussion. However, further entomofaunal data are still required, particularly from Sebesi and Sebuku Islands, which are much less well known entomologically than the Krakataus in spite of several previous surveys (e.g., Dammerman, 1922, 1948; Docters van Leeuwen, 1923; Bush *et al.*, 1990) and the role of Sebesi and Sebuku Islands as stepping-stones for the colonisation of the Krakatau Islands by various insect groups needs to be assessed more precisely.

In order to calculate the relative abundance of species of Sumatran and Javanese origin and the ratio of species that occur both on the Krakataus and on Sebesi and Sebuku, insects must be identified at the subspecies level and distributional information on the species concerned is required. Butterflies are suitable for such a faunistic survey since they can be more easily identified, frequently at the subspecies level, than other insect groups. Their host plants and distributional range are also relatively well known. In addition, the butterfly fauna of the Krakataus has been surveyed intensively on many occasions, particularly during the period from 1982 to 1999 (Yukawa, 1984; Bush, 1986; New *et al.*, 1988; Bush *et al.*, 1990; Bush & Whittaker, 1991; New & Thornton, 1992). In the light of these considerations, the butterfly fauna of Sebesi and Sebuku Islands was surveyed in 1993 in order to assess the role of these islands as stepping-stones for the colonisation of the Krakatau Islands by butterflies.

Materials and Methods

Sebesi Island is almost circular, with a diameter of from 6 to 8 km. The summit is 844 m high. The island is about 16 km from the nearest coasts of both Krakatau and Sumatra (Fig. 1). It has been extensively deforested and converted to coconut and banana plantations since the 1970s. Sebuku is a low island with about the same area as Sebesi and is about 2.5 km north of Sebesi and about 2.3 km south of Sumatra. The native forest of Sebuku has been largely eradicated.

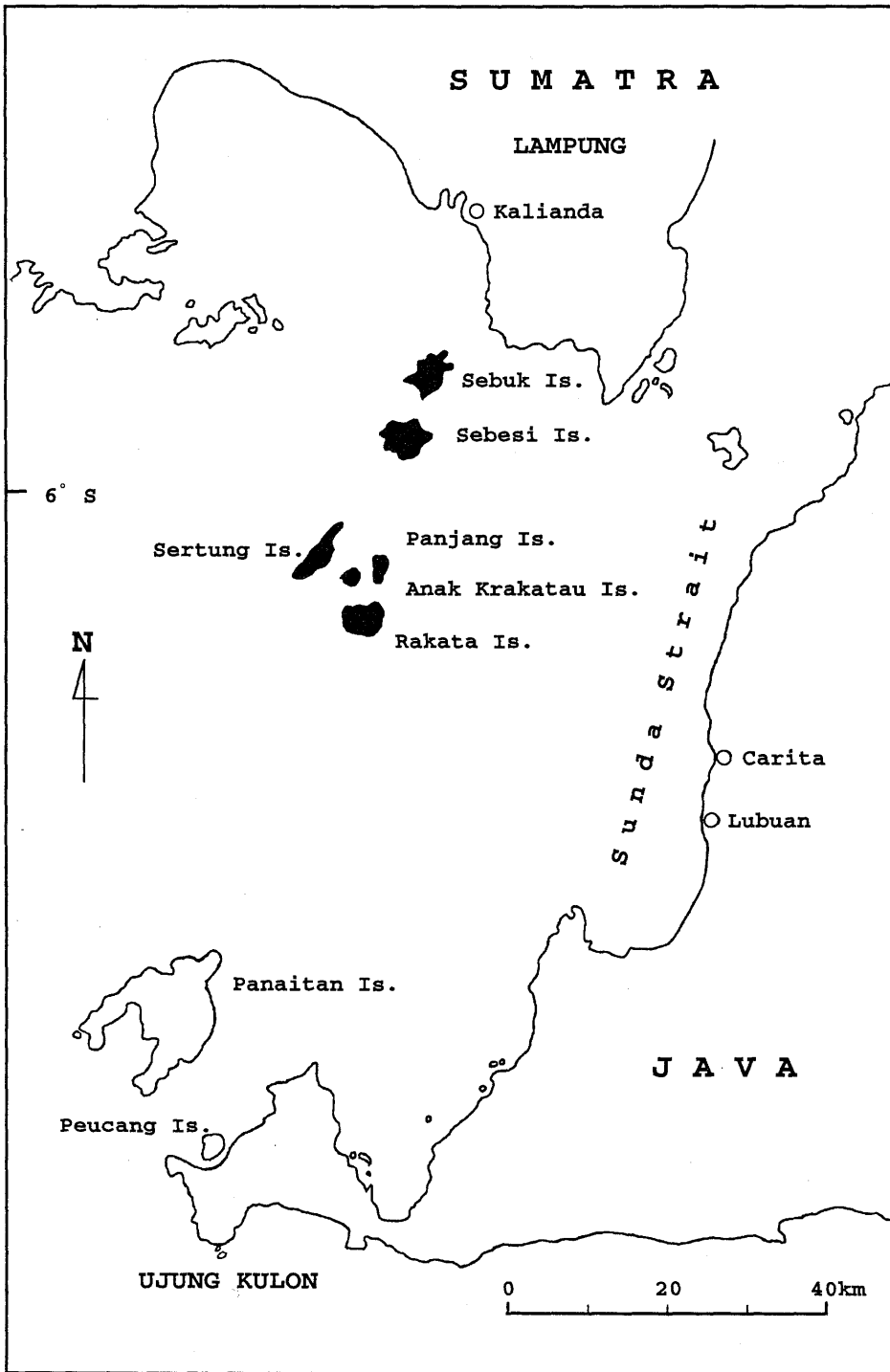


Fig. 1. Map of the Krakatau Islands and surroundings.

Butterflies were netted randomly by Junichi Yukawa and Tukirin Partomihardjo on Sebesi for fully 1 day on 11 July 1993 and on Sebukú for half day on 12 July 1993. On Sebesi the collection was undertaken in villages, around beach vegetation, and along field boundaries, not in the high uplands. Since the collection on Sebukú was restricted to beach vegetation owing to the limited time of stay, the role of Sebukú as a stepping-stone could not be assessed independently. Therefore the collection data from Sebesi and Sebukú are taken together in the following assessment.

The butterflies were identified by Osamu Yata and Toshiya Hirowatari to the subspecies level, as many species as possible to the subspecies level. The identified subspecies were divided into 3 categories: Javanese, Sumatran, and widely distributed, of which the last category includes species distributed both in Java and in Sumatra.

Further distributional information on the butterfly taxa was obtained from Evans (1949), Corbet & Pendlebury (1978), Tsukada (1980-1991), Otsuka (1988, 1991), Yata (1995). Records of butterflies from the Krakataus in the 1980s-1990s were taken from Yukawa (1984), Bush & Whittaker (1991), and New & Thornton (1992). Records of butterflies known in recent years on Sebesi and Sebukú were obtained from Bush *et al.* (1990).

Results

Butterflies on Sebesi-Sebukú and the Krakatau Islands

In 1993, 29 and 16 butterfly species were collected from Sebesi and Sebukú, respectively (Table 1), totalling 33 species in 26 genera belonging to 5 families. Prior to the 1993 survey, 30 butterfly species, including 4 unidentified and 1 temporarily identified species were collected from Sebesi in 1989 (Bush *et al.*, 1990) (Table 2). Of these 11 were found also in 1993. As a result, butterflies recorded from Sebesi-Sebukú in 1989-1993 totalled 52 species.

On the Krakatau Islands, 92 butterfly species, including 5 unidentified and 3 temporarily identified species, were recorded during the period from 1984 to 1992 (Yukawa, 1984; Bush & Whittaker, 1991; New & Thornton, 1992) (Table 2).

Common species on Sebesi-Sebukú and the Krakataus

Fourteen species (42.4%) out of the 33 that were collected in 1993 on Sebesi-Sebukú have never been recorded from the Krakataus (Table 2). This proportion is distinctly higher than 4 (13.3%; 4 unidentified species were excluded) or 8 (26.7%) of the 30 species that had been collected in 1989 from Sebesi (Table 1). When the 1989 and 1993 data were taken together, 17 to 21 (32.7 to 40.4%) of 52 species that had been recorded from Sebesi-Sebukú in 1989-1993 were not known on the Krakataus.

Distribution of subspecies

Among 33 species that were collected in 1993 on Sebesi-Sebukú, 5 lycaenids could not be identified at the subspecies level, but the remaining 28 were classified into subspecies and the distributional range of each subspecies was obtained from the literature (Table 1). In order to determine the source area from which these subspecies came to Sebesi-Sebukú, they were divided, based on their distributional range, into 3 categories: Javanese, Sumatran, and Wide (Table 1). The Javanese category comprises species with

Table 1. Butterflies collected in 1993 from Sebesi and Sebuksu Islands, and category of each species based on distributional information.

	Sebesi	Sebuku	Category based on distribution range ¹⁾
Papilionidae			
<i>Graphium agamemnon agamemnon</i> (Linnaeus, 1758)	1♂	--	W: N.India-Indo China-Sundaland
<i>Papilio memnon memnon</i> Linnaeus, 1758	2♂	--	J: Borneo, Java, Bali
<i>Papilio polytes javanus</i> C.Felder, 1862	1♂	--	J: Java
Pieridae			
<i>Appias lyncida hippo</i> (Cramer, 1779)	--	1♂	S: W.Sumatra
<i>Catopsilia pyranthe pyranthe</i> (Linnaeus, 1758)	1♀	--	W: India-Indo China-Sundaland-Sulawesi
<i>Eurema blanda blanda</i> (Boisduval, 1836)	3♂	1♀	W: Malay Pen., Sumatra, Borneo, Java
<i>Eurema hecabe hecabe</i> (Linnaeus, 1758)	2♂	1♀	W: China-Indo China-Sundaland
Lycaenidae			
<i>Flos apidanus</i> (Cramer, 1777)	1♀	--	?: Subspecific identification impossible ²⁾
<i>Hypolycaena erylus</i> (Godart, 1824)	1♂	--	?: Subspecific identification impossible ³⁾
<i>Jamides aratus</i> (Stoll, 1781)	1♀	--	?: Subspecific identification impossible ⁴⁾
<i>Jamides celeno</i> (Cramer, 1775)	6♂1♀	1♂	?: India-New Guinea, Solomons ⁵⁾
<i>Miletus symethus</i> (Cramer, 1779)	2♀	--	?: Subspecific identification impossible ⁶⁾
<i>Zizula hylax</i> (Fabricius, 1795)	5♂1♀	1♂	W: Old World tropics
Nymphalidae (Danainae)			
<i>Ideopsis juvena robinsoni</i> (Rothschild, 1920)	2♂2♀	--	S: W. & S.Sumatra
Nymphalidae (Nymphalinae)			
<i>Ariadne ariadne pallidior</i> Fruhstorfer, 1899	--	1♂1♀	S: India-Indo China-Malay Pen., Sumatra
<i>Chersonesia rahria rahria</i> (Moore, 1857)	1♂	1♂	W: Sundaland
<i>Cupha erymanthis erymanthis</i> (Drury, 1773)	1♂	--	S: India-Indo China-Malay Pen., Sumatra
<i>Hypolimnas bolina bolina</i> (Linnaeus, 1758)	3♂	1♀	J: Java, L.Sundas, Sulawesi-Australia
<i>Junonia atlites atlites</i> (Linnaeus, 1758)	2♂1♀	4♂	W: India-Sundaland
<i>Junonia iphita horsfieldi</i> (Moore, 1899)	--	2♂2♀	J: Java, Bali
<i>Neptis hylas papaja</i> Moore, 1874	3♂	1♂	S: Malay Pen., Sumatra
<i>Neptis ilira cindia</i> Eliot, 1969	1♂	1♀	S: Indo China-Malay Pen., Borneo, Sumatra
Nymphalidae (Satyrinae)			
<i>Amathusia phidippus phidippus</i> (Linnaeus, 1763)	1♂	--	W: Indo China-Sundaland
<i>Elymias nesaea nesaea</i> (Linnaeus, 1758)	--	1♂	J: W.Java
<i>Melanithis leda lacrima</i> Fruhstorfer, 1908	2♂1♀	--	J: Java, Bali, L.Sundas
<i>Mycalesis mineus micromalayana</i> Fruhstorfer, 1911	1♀	1♂2♀	W: Sundaland
<i>Orsoyriaena medus medus</i> (Fabricius, 1775)	2♂4♀	1♀	W: Indo China-Sundaland-New Guinea
<i>Ypthima baldus moerus</i> Fruhstorfer, 1911	1♂	1♂	S: Sumatra
<i>Ypthima philomela philomera</i> (Linnaeus, 1763)	6♂	--	W: Sumatra, Java, Bali
Hesperiidae			
<i>Parnara apostata apostata</i> (Snellen, 1886)	1♀	--	S: C.Sumatra
<i>Parnara naso bada</i> (Moore, 1878)	1♂	--	W: Oriental Region
<i>Pelopidas mathias mathias</i> (Fabricius, 1798)	2♀	--	W: Oriental Region
<i>Taractrocer ziclea tissara</i> Fruhstorfer, 1910	2♂2♀	--	S: Sumatra

1) J: Javanese category; distribution range including Java, but not Sumatra.

S: Sumatran category; distribution range including Sumatra, but not Java.

W: Wide distribution category; distribution range including both Java and Sumatra.

?: Distribution range unknown since butterflies were not identified to the subspecies level.

2) ssp. *apidanus* (Java), ssp. *saturatus* (Malay Pen., Borneo, Sumatra).

3) ssp. *erylus* (Java), ssp. *teatus* (Malay Pen., Borneo, Sumatra).

4) ssp. *tryphiodorus* (Java), ssp. *adana* (Malay Pen., Borneo, Sumatra).

5) ssp. *celeno* (Sumatra), ssp. *ruvana* (Java, Bali, Lombok).

6) ssp. *symethus* (E. Java), ssp. *nuctus* (C. & S. Sumatra).

Table 2. A list of butterfly species recorded from the Krakatau in 1984-1992, from Sebesi in 1989, and from Sebesi-Sebuk in 1993.

Family	Species	Krakatau 1984-1992	Sebesi 1989	Sebesi-Sebuk 1993
PAPILIONIDAE	<i>Graphium agamemnon agamemnon</i> (Linnaeus)	+	+	+
	<i>Graphium doson evemonides</i> (Honrath)	+	-	-
	<i>Graphium sarpedon</i> (Linnaeus)	+	-	-
	<i>Pachliopta aristolochiae adamas</i> (Zinken)	+	-	-
	<i>Pachliopta aristolochiae antiphus</i> (Fabricius)	+	-	-
	<i>Papilio helenus engarius</i> Doherty	+	-	-
	<i>Papilio peranthus</i> Fabricius	+	-	-
	<i>Papilio polytes javanus</i> C. Felder	-	-	+
	<i>Papilio memnon memnon</i> Linnaeus	+ ¹⁾	+ ¹⁾	+
	<i>Troides helena helena</i> (Linnaeus)	+	+	-
	Subtotal	8 ²⁾	3	3
PIERIDAE	<i>Appias indra leptis</i> (C. & R. Felder)	+	-	-
	<i>Appias lyncida hippo</i> (Cramer)	-	-	+
	<i>Appias lyncida lyncida</i> (Cramer)	+	-	-
	<i>Appias nero nero</i> (Fabricius)	+	-	-
	<i>Appias paulina leis</i> (Hübner)	+	-	-
	<i>Belenois java java</i> (Sparman) ³⁾	+	-	-
	<i>Catopsilia pomona pomona</i> (Fabricius)	+	-	-
	<i>Catopsilia pyranthe pyranthe</i> (Linnaeus)	-	-	+
	<i>Cepora iudith iudith</i> (Fabricius)	+	-	-
	<i>Eurema alitha sankapura</i> (Fruhstorfer)	+	-	-
	<i>Eurema blanda blanda</i> (Boisduval)	+	+	+
	<i>Eurema hecabe hecabe</i> (Linnaeus)	+	+	+
	<i>Gandaca harina harina</i> (Horsfield)	+	-	-
	<i>Pareronia valeria leona</i> (Fruhstorfer)	+	-	-
	Subtotal	12	2	4
	LYCAENIDAE	<i>Allotinus felderi</i> Semper	+	-
<i>Allotinus unicolor</i> Felder		+	-	-
<i>Anthene emolus</i> Godart		+	-	-
<i>Arhopala pseudocentaurus pseudocentaurus</i> (Doubleday)		+	+	-
<i>Arhopala</i> sp.		-	+	-
<i>Catochrysops panormus</i> (C. Felder)		+	+	-
<i>Catochrysops strabo</i> (Fabricius)		+	+	-
<i>Catopylops ancyra</i> (C. Felder)		+	-	-
<i>Deudorix jarbas dekaiarchus</i> Fruhstorfer		+	-	-
<i>Euchrysops cnejus cnejus</i> (Fabricius)		+	+	-
<i>Everes lacturnus</i> Godfrey		-	+	-
<i>Flos apidanus</i> (Cramer)		-	-	+
<i>Hypolycaena erylus erylus</i> (Godart)		+	-	+ ¹⁾
<i>Hypolycaena ithna</i> Hewitson		+	-	-
<i>Jamides aratus</i> (Stoll)		+	-	+
<i>Jamides bochus</i> (Stoll)		+	+	-
<i>Jamides celeno celeno</i> (Cramer)		+ ¹⁾	+ ¹⁾	+
<i>Jamides elpis</i> (Godart)		+	-	-
<i>Jamides malaccanus</i> (Röber)		+	-	-
<i>Jamides pura</i> Moore		+	-	-
<i>Lampides boeticus</i> (Linnaeus)		+	+	-
<i>Loxura atymnus</i> (Stoll)		+	-	-
<i>Megisba malaya malaya</i> (Horsfield)		+	-	-
<i>Miletus boisduvalii</i> Moore		+	-	-
<i>Miletus symethus</i> (Cramer)		+	-	+
<i>Miletus</i> sp.		+	-	-
<i>Nacaduva beroe</i> Felder		+	-	-
? <i>Nacaduba pactolus</i> (C. Felder)		+	-	-
<i>Petrelaea dana dana</i> (de Nicéville)		+	-	-
<i>Prosotas dubiosa</i> (Semper)		+	+	-
<i>Prosotas lutea</i> (Martin)		+	-	-
<i>Rapala iarbus</i> Fruhstorfer		+	-	-
<i>Spalgis epius</i> Westwood		+	-	-
<i>Zizeeria karsandra</i> Moore		-	+	-
<i>Zizina otis lysizone</i> (Snellen)		+	+	-
<i>Zizula hylax</i> (Fabricius)		+	-	+
Subtotal		32	12	6

Table 2. A list of butterfly species recorded from the Krakataus in 1984-1992, from Sebesi in 1989, and from Sebesi-Sebuk in 1993. (continued)

NYPHALIDAE	<i>Danaus chrysippus bataviana</i> Moore	+	+	-
(DANAINAE)	<i>Danaus genuita intensa</i> Moore	+	-	-
	<i>Danaus genuita sumatrana</i> Moore	+	-	-
	<i>Danaus melanippus melanippus</i> (Cramer)	+	-	-
	<i>Euploea crameri</i> Lucas	+	-	-
	<i>Euploea modesta</i> Butler	+	-	-
	<i>Euploea</i> sp.	+	-	-
	<i>Ideopsis juvena robinsoni</i> (Rothschild)	+ ¹⁾	+ ¹⁾	+
	<i>Tirumala septentrionis septentrionis</i> Butler	+	-	-
	Subtotal	8 ²⁾	2	1
(NYPHALINAE)	<i>Ariadne ariadne pallidior</i> Fruhstorfer	-	+ ¹⁾	+
	<i>Cethosia hypsea</i> Doubleday	+	-	-
	<i>Charaxes</i> sp.	+	-	-
	<i>Chersonesia rahria rahria</i> (Moore)	+ ¹⁾	-	+
	<i>Cirrochroa tyche</i> C. & R. Felder	+	-	-
	<i>Cupha erymanthis erymanthis</i> (Drury)	-	-	+
	<i>Euthalia mahadeva</i> (Moore)	+	-	-
	<i>Hypolimnas anomala</i> (Wallace)	+	+	-
	<i>Hypolimnas bolina bolina</i> (Linnaeus)	+	+	+
	<i>Junonia palmada javana</i> (Felder & Felder)	+	-	-
	<i>Junonia atlites atlites</i> (Linnaeus)	+	-	+
	<i>Junonia iphita horsfieldi</i> (Moore)	-	-	+
	<i>Junonia orithya</i> (Linnaeus)	+	-	-
	<i>Modusa procris minoe</i> Fruhstorfer	+	-	-
	<i>Neptis hylas papaja</i> Moore	+ ¹⁾	+ ¹⁾	+
	<i>Neptis ilira cindia</i> Eliot	-	-	+
	<i>Neptis</i> sp.	-	+	-
	<i>Phalanta phalantha</i> (Drury)	+	-	-
	Subtotal	13	5	8
(SATYRINAE)	<i>Amathusia phidippus phidippus</i> (Linnaeus)	-	-	+
	<i>Elymnias hypermnestra</i> Linnaeus	+	-	-
	<i>Elymnias nesaea nesaea</i> (Linnaeus)	-	-	+
	<i>Melanitis leda lacrima</i> Fruhstorfer	+ ¹⁾	+ ¹⁾	+
	<i>Mycalesis horsfieldii horsfieldii</i> (Moore)	+	-	-
	<i>Mycalesis janardana janardana</i> Moore	+	-	-
	<i>Mycalesis mineus micromalayana</i> Fruhstorfer	-	-	+
	<i>Mycalesis</i> sp.	-	+	-
	<i>Orsotriaena medus medus</i> (Fabricius)	+ ¹⁾	+ ¹⁾	+
	<i>Ypthima baldus moerus</i> Fruhstorfer	-	-	+
	<i>Ypthima horsfieldii</i> Moore	+	+	-
	<i>Ypthima philomela philomera</i> (Linnaeus)	+	-	+
	? <i>Ypthima striata</i> (Hampson)	-	+	-
	Subtotal	7	5	7
HESPERIIDAE	<i>Borbo cinnara</i> (Wallace)	+	-	-
	<i>Hasora taminatus</i> Hübner	+	-	-
	<i>Notocrypta curvifascia</i> C. & R. Felder	+	-	-
	<i>Notocrypta</i> sp.	+	-	-
	<i>Parnara apostata apostata</i> (Snellen)	-	-	+
	<i>Parnara</i> cf. <i>guttata</i> (Bremer et Grey)	+	-	-
	<i>Parnara naso bada</i> (Moore)	-	-	+
	? <i>Pelopidas agna</i> (Moore)	+	-	-
	<i>Pelopidas conjunctus</i> (Herrich-Schäffer)	+	-	-
	<i>Pelopidas mathias mathias</i> (Fabricius)	+ ¹⁾	-	+
	<i>Polytremis lubricans</i> (Herrich-Schäffer)	+	-	-
	<i>Potanthus confucius</i> (C. & R. Felder)	+	-	-
	<i>Potanthus</i> sp.	-	+	-
	? <i>Tagiades japetus enganicus</i> Fruhstorfer	+	-	-
	<i>Tagiades</i> sp.	+	-	-
	<i>Taractrocera ziclea tissara</i> Fruhstorfer	-	-	+
	<i>Telicota augias</i> (Linnaeus)	+	-	-
	Subtotal	13	1	4
	Total	93	30	33

+ Existence of collection records.

- No collection records.

1) Butterflies that could not be identified to the subspecies level on the island.

2) Conspecific subspecies regarded as one species.

3) = *Anaphaeis java coronea* Cramer

a distributional range including Java, but not Sumatra, and the Sumatran category includes species with Sumatra, but not Java in the distributional range. For species in the third category, the range covers a wide area, including both Java and Sumatra.

Six subspecies out of the 28 were referable to the Javanese and 9 to the Sumatran category, whilst the remaining 13 were put into the Wide distribution category and were not available for analysis of the place of derivation (Table 1). The Sumatran category naturally includes more subspecies than the Javanese category, since Sebesi and Sebuku are closer to Sumatra than to Java (Fig. 1). However, the ratio of subspecies that were common to both Sebesi-Sebuku and the Krakataus was distinctly higher for species in the Javanese category (50.0%) than for those in the Sumatran category (22.2%) (Table 3).

Conspecific Javanese and Sumatran subspecies have been recorded to coexist on the Krakataus in *Pachliopta aristrochiae* (Papilionidae) and *Danaus genuita* (Nymphalidae: Danainae) (Table 2). On Sebesi-Sebuku, however, there was no example of the coexistence of conspecific Javanese and Sumatran subspecies. In addition, in the case of *Appias lyncida* (Pieridae), the Javanese subspecies, *A. l. lyncida* was found on the Krakataus (Table 2), whilst the Sumatran subspecies, *A. l. hippo* was on Sebuku (Table 1).

Table 3. Comparison between subspecies belonging to Javanese and Sumatran categories in the proportion of subspecies common to Sebesi-Sebuk and the Krakataus.

Distributional category	Recorded on Sebesi-Sebuku	Recorded also on the Krakataus
Javanese	6	3 (50.0%)
Sumatran	9	2 (22.2%)
Total	15	5 (33.3%)

Discussion

The present data indicate that 32.7 to 40.4% of 52 butterfly species collected recently on Sebesi-Sebuku have never been recorded from the Krakataus and that there are more Javanese subspecies on Sebesi and Sebuku than Sumatran subspecies. According to Yukawa (1984), 9 of 10 butterfly species on the Krakataus consisted of Javanese subspecies and only 1 was represented by Sumatran subspecies. A similar tendency was also noted for aculeata Hymenoptera (Sk.Yamane, 1983), in which 4 species were considered to be derived from Java and 1 from Sumatra. In termites, 2 species of Javanese origin were recognized, and 1 of Sumatran origin (Sk.Yamane *et al.*, 1992). In addition, Toxopeus (1950) found that the butterfly and moth fauna of the Lampung district of southern Sumatra, including Sebuku and Sebesi, contains Javanese species as well as true Sumatran elements.

The aforementioned evidence suggests that there have been more frequent movements of butterfly species from Java to the Krakataus and Sebesi-Sebuku, and then to southern

Sumatra rather than in the opposite direction. However, as Dammerman (1948) warned, we must keep in mind that some, probably not many, Javanese representatives on Sebesi-Sebuku and on the Krakataus possibly derived from southern Sumatra, since we cannot distinguish between Javanese representatives from Java and Sumatra. The existence of conspecific Javanese and Sumatran subspecies on the Krakataus may suggest the possibility of derivation from both Java and Sumatra.

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References

- Bush, M. B., 1986. The butterflies of Krakatoa. *Ent. Month. Mag.*, **122**: 51-58.
- Bush, M. B., D. J. B. Bush & R. D. Evans, 1990. Butterflies of Krakatau and Sebesi: New records and habitat relations. pp. 35-41, In Whittaker *et al.* (eds.) Krakatau Research Project 1989 Expedition Report. 62pp., School of Geography, University of Oxford, Oxford.
- Bush, M. B. & R. J. Whittaker, 1991. Krakatau: Colonization patterns and hierarchies. *J. Biogeogr.*, **18**: 341-356.
- Corbet, A. S. & H. M. Pendlebury, 1978. *The Butterflies of the Malay Peninsula* [3rd edn, revised by J. N. Eliot]. xiv+578pp., 35pls., Malayan Nature Society, Kuala Lumpur, Malaysia.
- Dammerman, K. W., 1922. The fauna of Krakatau, Verlaten Island and Sebesy. *Treubia*, **3**: 61-112.
- Dammerman, K. W., 1948. The fauna of Krakatau 1883-1933. *Verhandl. Koninkl. Ned. Akad. Wetenschap. Afdel. Natuurk.*, (2), **44**: 1-594.
- Docters van Leeuwen, W. M., 1923. The vegetation of the island of Sebesy, situated in the Sunda-Strait, near the islands of the Krakatau group, in the year 1921. *Ann. Jard. Bot. Buitenzorg*, **32**: 135-192.
- Evans, W. H., 1949. *A Catalogue of the Hesperidae from Europe, Asia and Australia in the British Museum (Natural History)*. 502pp., 53pls., The British Museum (Natural History), London.
- New, T. R., M. B. Bush, I. W. B. Thornton & H. K. Sudarman, 1988. The butterfly fauna of the Krakatau Islands after a century of recolonization. *Philosoph. Trans. Roy. Soc. London B*, **322**: 445-457.
- New, T. R. & I. W. B. Thornton, 1992. The butterflies of Anak Krakatau, Indonesia: Faunal development in early succession. *J. Lep. Soc.*, **46**: 83-96.

- Otsuka, K. (ed.), 1988/1991. *Butterflies of Borneo. Vols. I-II. Vol.I (Papilionidae, Pieridae, Danaidae, Satyridae)*, 1988, xx+61pp.+80pls.; *Vol.II (No.1 Lycaenidae, x+139pp., 72pls.; No.2 Hesperiiidae & Addendum of Vol.I, xiii+89pp., 48pls.)*. Tobishima Co. Ltd., Tokyo.
- Thornton, I. W. B., 1996a. *Krakatau, The Destruction and Reassembly of an Island Ecosystem*. 345pp. Harvard Univ. Press, Cambridge, Massachusetts, and London.
- Thornton, I. W. B., 1996b. The origins and development of island biotas as illustrated by Krakatau. pp. 67-90, In Keast, A. & S. G. Miller (eds.). *The Origin and Evolution of Pacific Island Biotas. New Guinea to Eastern Polynesia: Patterns and Processes*. SPB Academic Publishing, The Netherlands.
- Toxopeus, L. J., 1950. Over de pioneer-fauna van Anak Krakatau, met enige beschouwingen over het onstaat van de Krakatau-fauna. *Chronica Nat.*, **106**: 27-34.
- Tsukada, E. (ed.), 1980-1991. *Butterflies of South East Asian Islands. Vol.I. Papilionidae*, 1980, 459pp., 166pls. Plapac Co. Ltd., Tokyo; *Vol.II. Pieridae & Danaidae*, 1981, 628pp., 162pls. Plapac Co. Ltd., Tokyo; *Vol.III. Satyridae & Amathusiidae*, 1982, 500pp., 152pls. Plapac Co. Ltd., Tokyo; *Vol.IV. Libytheidae & Nymphalidae 1*, 558pp., 157pls. Azumino-chorui-kenkyusho, Matsumoto; *Vol.V. Nymphalidae 2*, 1991, 576pp., 238pls. Azumino-chorui-kenkyusho, Matsumoto.
- Yamane, Sk., 1983. The aculeate fauna of the Krakatau Islands (Insecta, Hymenoptera). *Rep. Fac. Sci., Kagoshima Univ. (Earth Sci. & Biol.)*, (16): 75-107.
- Yamane, Sk., T. Abe, & J. Yukawa, 1992. Recolonization of the Krakataus by Hymenoptera and Isoptera (Insecta). *GeoJournal*, **28**: 213-218.
- Yata, O., 1995. A revision of the Old World species of the genus *Eurema* Hübner (Lepidoptera, Pieridae). V. Description of the *hecabe* group (part). *Bull. Kitakyushu Mus. Nat. Hist.*, (14): 1-54, pls. 1-35.
- Yukawa, J., 1984. Geographical ecology of the butterfly fauna of the Krakatau Islands, Indonesia. *Tyô to Ga*, **35**: 47-74.