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Sri Wulan, S. Ikom.

Layout:
Liana Astuti

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Yaheita Yokoi

Callidiopini beetles (Coleoptera: Cerambycidae) in the collection of Museum Zoologicum Bogoriense, Indonesia

TREUBIA, December 2019, Vol. 46, pp. 1–20.

Callidiopini species in the collection of Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI) were examined. Three new species of the genus *Ceresium* Newman, 1842, are described, i.e. *C. clytinioides* sp. nov., *C. sugiartoi* sp. nov., both from Kalimantan, and *C. emarginatum* sp. nov. from Papua. One new species of the genus *Examnes* Pascoe, 1869, from Kalimantan, *E. subvermiculatus* sp. nov. is described.

(Yaheita Yokoi, Hiroshi Makihara and Woro A. Noerdjito)

Keywords: Asia, Kalimantan, longhorn beetle, New Guinea, taxonomy

UDC: 595.78.001.03(594.81)

R.I. Vane-Wright

The identity of *Euploea tulliolus goodenoughi* Carpenter, 1942, a crow butterfly (Lepidoptera: Nymphalidae, Danainae) from Papua New Guinea

TREUBIA, December 2019, Vol. 46, pp. 21–34.

The nominal taxon *Euploea tulliolus goodenoughi* Carpenter, 1942, based on a unique crow butterfly collected on Goodenough Island in 1913, is shown to represent a small, aberrant female of the locally common *Euploea leucostictos eustachius* (Kirby, 1889). This new synonymy invalidates the only previous record of the Purple Crow, *Euploea tulliolus* (Fabricius, 1793), from the islands of Milne Bay Province, Papua New Guinea. However, two female *Euploea tulliolus* collected from islands in the Louisiade Archipelago during 2010 are reported here, constituting the first valid records of the Purple Crow from the Milne Bay islands.

(R.I. Vane-Wright)

Keywords: *tulliolus* species complex, new synonymy, new records, Milne Bay islands, *Euploea leucostictos*

UDC: 595.762(594.31)

Raden Pramesa Narakusumo

Four new species of *Epholcis* Waterhouse (Coleoptera: Scarabaeidae: Melolonthinae: Maechidiini) from the Moluccas, Indonesia

TREUBIA, December 2019, Vol. 46, pp. 35–50.

Here, we provide the first record of the chafer beetle genus *Epholcis* Waterhouse, 1875 from the Moluccas, Indonesia. We describe four new species: *E. acutus* sp. nov., *E. arcuatus* sp. nov., *E. cakalele* sp. nov., and *E. obiensis* sp. nov. A lectotype is designated for *Maechidius moluccanus* Moser, 1920, which is redescribed and transferred to the genus *Epholcis* as *E. moluccanus* (Moser) comb. nov.

(Raden Pramesa Narakusumo and Michael Balke)

Keywords: Coleoptera, *Epholcis*, Maechidiini, Melolonthinae, Moluccas

UDC: 597.82(594.17)

Mediyansyah

A new tree frog of the genus *Kurixalus* Ye, Fei & Dubois, 1999 (Amphibia: Rhacophoridae) from West Kalimantan, Indonesia

TREUBIA, December 2019, Vol. 46, pp. 51–72.

Kurixalus absconditus sp. nov., a new species of tree frog of the genus *Kurixalus,* described from West Kalimantan on the basis of molecular phylogenetic and morphological evidence. The new species can be distinguished from its congeners by a combination of following morphological characters: having smaller body size, more prominent of mandibular symphysis, skin smooth on throat, vomerine odontophores two oblique series touching anterior corner of choanae and widely separated, vomerine teeth thick, buccal cavity narrow and deep, choanae with teardrop shaped, single vocal slit, weakly crenulated dermal fringe on fore- and hindlimbs.

(Mediyansyah, Amir Hamidy, Misbahul Munir and Masafumi Matsui)

Keywords: *Kurixalus absconditus* sp. nov., new species, West Kalimantan

UDC: 594.34.001.03(594.11)

Mulyadi

New records and redescription of *Labidocera rotunda* Mori, 1929 (Copepoda, Calanoida, Pontellidae) from Sebatik Island, North Kalimantan, Indonesia, with notes on its species-group

TREUBIA, December 2019, Vol. 46, pp. 73–84.

During a plankton trip around Sebatik Island, North Kalimantan, a copepod *Labidocera rotunda* Mori, 1929 (Calanoida, Pontellidae) was collected for the first time in Indonesian waters. Both sexes are redescribed and compared to previous descriptions. The geographical distribution of the species confirms that it is of Indo-Pacific origin. There has been a mix-up between *L. rotunda* described by Mori (1929) from Pusan, Korea and *L. bipinnata* from Sagami Bay, described by Tanaka (1936). Fleminger et al. (1982) have argued that the minor difference is based on the presence or absence of cephalic hooks and had synonymized *L. bipinnata* with *L. rotunda*.

(Mulyadi)

Keywords: copepods, Indonesia, *Labidocera rotunda*, new record, Pontellidae

UDC: 595.78:57.01(594.53)

Djunijanti Peggie

Biological aspects of *Papilio peranthus* (Lepidoptera: Papilionidae) as observed at Butterfly Research Facility - LIPI, Cibinong, Indonesia

TREUBIA, December 2019, Vol. 46, pp. 85–102.

Papilio peranthus is endemic to Indonesia, where it occurs on several islands and island groups. This beautiful butterfly is extensively traded, thus efforts to breed this species are very desirable. Captive breeding research was conducted on *P. peranthus* during September 2016 to December 2018. In total, 221 individuals were available for observation. Data on the life cycle of the species, together with observations on females being approached for mating, and female oviposition after mating, are presented. The result demonstrate that *P. peranthus* is not monogamous. Observations on other biological aspects are also reported.

(Djunijanti Peggie)

Keywords: egg-laying, mating, life cycle, *Papilio peranthus*, parent stocks

UDC: 599.41:001.891(594)

Susan M. Tsang

Review - Indonesian flying foxes: research and conservation status update

TREUBIA, December 2019, Vol. 46, pp. 103–113.

Flying foxes are important ecological keystone species on many archipelagoes, and Indonesia is home to over a third of all flying fox species globally. However, the amount of research on this clade belies their importance to natural systems, particularly as they are increasingly threatened by anthropogenic development and hunting. Here, we provide a review of the literature since the publication of the Old World Fruit Bat Action Plan and categorize research priorities as high, medium, or low based on the number of studies conducted. A majority of the research priorities for Indonesian endemics are categorized as medium or high priority. Low priority ratings were in multiple categories for widespread flying fox species found throughout Southeast Asia, though much of the data were from outside of the Indonesian extent of the species range. These research gaps tend to highlight broader patterns of research biases towards western Indonesia, whereas significant research effort is still needed in eastern Indonesia, particularly for vulnerable island taxa.

(Susan M. Tsang and Sigit Wiantoro)

Keywords: bats, conservation, Pteropodidae, *Pteropus*, threats

Treubia 46: 85–102, December 2019

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BIOLOGICAL ASPECTS OF *PAPILIO PERANTHUS* (LEPIDOPTERA: PAPILIONIDAE) AS OBSERVED AT BUTTERFLY RESEARCH FACILITY - LIPI, CIBINONG, INDONESIA

Djunijanti Peggie*

Zoology Division (Museum Zoologicum Bogoriense), Research Center for Biology,
Indonesian Institute of Sciences (LIPI), Jl. Raya Jakarta-Bogor Km. 46, Cibinong, Bogor 16911, Indonesia
*e-mail: kupu2indonesia@gmail.com

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ABSTRACT

Papilio peranthus is endemic to Indonesia, where it occurs on several islands and island groups. This beautiful butterfly is extensively traded, thus efforts to breed this species are very desirable. Captive breeding research was conducted on *P. peranthus* during September 2016 to December 2018. In total, 221 individuals were available for observation. Data on the life cycle of the species, together with observations on females being approached for mating, and female oviposition after mating, are presented. The result demonstrate that *P. peranthus* is not monogamous. Observations on other biological aspects are also reported.

Keywords: egg-laying, mating, life cycle, *Papilio peranthus*, parent stocks

ABSTRAK

Papilio peranthus merupakan spesies endemik Indonesia yang dijumpai di beberapa pulau di Indonesia. Spesies kupu-kupu yang indah ini diperdagangkan dalam jumlah besar sehingga diperlukan upaya penangkaran spesies ini. Penelitian penangkaran terhadap *P. peranthus* dilakukan dalam kurun waktu September 2016 hingga Desember 2018. Secara keseluruhan ada 221 individu yang diamati. Data mengenai siklus hidup spesies, dan pengamatan mengenai kupu-kupu betina didekati untuk kawin dan betina meletakkan telur setelah kawin dipaparkan di sini. Hasil studi ini menunjukkan bahwa *P. peranthus* bukan monogamous. Pengamatan terhadap aspek biologi lainnya juga dilaporkan.

Kata kunci: peletakan telur, kawin, siklus hidup, *Papilio peranthus*, induk

INTRODUCTION

Papilio peranthus Fabricius, 1787, which belongs to the *peranthus*-group of the subgenus *Achillides*, occurs in lowland areas of southern Sumatra (Hasanah et al., 2006; Nukmal et al., 2017), Java, Bawean, Bali, Nusa Tenggara, and Sulawesi (Tsukada & Nishiyama, 1982). Specimens deposited at Entomology Laboratory, Museum Zoologicum Bogoriense also confirm this geographical coverage for the species. This butterfly flies along streams and forest edges (Peggie & Amir, 2006). Many species of *Papilio* are highly sought after by collectors because of their beautiful wing colors, especially members of the subgenus *Achillides.* They have magnificent green or blue patches on forewings and hindwings, except *Papilio paris* and *P. karna*, which lack the patches on the forewings.

The high demands on trade of *P. peranthus* will put significant pressures on populations if they are taken directly from the habitat. To fulfil the demands, it is desirable to

have the butterflies harvested from captive breeding stocks, instead of capturing from wild populations. To achieve a better captive breeding operation for sustainable utilization of butterflies, various biological aspects need to be understood (Peggie, 2018). It is crucial to have the knowledge of the host plants (New et al., 1995) and how the species thrives in captivity. Previous detailed knowledge of the biology of *P. peranthus* is limited. The pre-adult stages were illustrated by Igarashi & Fukuda (2000), and observations of the mating behavior and male mate-locating strategy presented by Lukvitasari (2016) and Nukmal et al. (2017), respectively.

Each butterfly species has a close relationship with its hosts. The majority are oligotrophic, being limited to a few species of hosts. A female butterfly which has mated and is ready to lay eggs will search carefully for suitable plants and will not lay eggs if she cannot find the appropriate plants for her offspring (Vane-Wright, 2003; Ghosh et al., 2019). Eggs laid on inappropriate plants will usually hatch, but the larvae will either not feed, be poisoned, or develop very slowly, if at all. Igarashi & Fukuda (2000) recorded *Micromelum minutum*, which belongs to the family Rutaceae, as the host plant for *Papilio peranthus*. Nukmal et al. (2017) used another member of the Rutaceae, *Clausena excavata*, to rear *P. peranthus* at Lampung, southern Sumatra. *C. excavata* is known as the host plant for several other swallowtails, including *Papilio demoleus*, *P. polytes*, *P. palinurus*, and *P. daedalus* (Igarashi & Fukuda, 2000).

With the increasing need to know the life history and biological aspects of many Indonesian butterfly species, a butterfly research facility was built and established at Cibinong in August 2016, through the Biovillage program of the Indonesian Institute of Sciences (see below). To obtain life history data, observations on pre-adult stages were conducted in the rearing room. Observations on the adult behavior were made in the butterfly flight enclosure. Results from observations on flower visiting (nectaring), mating, oviposition, and other biological aspects of *Papilio peranthus*, are presented and discussed.

MATERIALS AND METHODS

Study area

The research was conducted at the Butterfly Research Facility of the Indonesian Institute of Sciences, located at Cibinong Science Center, Cibinong, Bogor, Indonesia. The butterfly facility includes a 10x20 sq. m. butterfly enclosure, a 4x6 sq. m. rearing room, and surrounding area for planting. Various plants have been grown inside and outside the butterfly enclosure to support butterflies, including larval host plants, nectar-producing plants, and shade plants. Rearing and research observations were conducted at ambient temperatures of 28–34^{0}C.

Materials

Parent stocks (Fig. 1) for the research were obtained from several sources at different time, as follows:

(I). The parent stocks on the first batch were pupae of *Papilio peranthus transiens* Fruhstorfer, 1897 from a butterfly supplier in Bali, a total of 29 pupae received on 21 September 2016.

(II). Parent stocks on the second batch were pupae from a butterfly supplier in Bali, a total of 19 pupae received on 10 February 2017.

(III). Parent stocks of the Javan subspecies, *Papilio peranthus peranthus,* were obtained from Citayam, Bogor, a total of 11 pupae received between 25 April – 14 May 2017.

(IV). Parent stocks from naturally arriving individuals of subspecies *peranthus* were obtained from outside the butterfly enclosure. To obtain more data on the biology of this species, they were caught and put into the butterfly enclosure (individual numbers 9188, 9315, 9347, and 9351).

Methods

Upon arrival of the parent stocks, each pupa was numbered by means of a label attached to the twig on which the pupa was hanging. The pupae were then put inside large plastic containers each with a mesh opening lid. When the adult butterfly emerged and its wings had fully expanded and dried, usually a few hours after emerging, the individual was marked using paint markers (Hagler & Jackson, 2001). The application of paint marker pens used in this research was developed to fulfil the need to recognize individuals. The dot marking was given on the underside of left forewing for easy handling (Fig. 2a). Paint marker pens with 10 different colors were used and applied consistently to indicate separate color for each number. White was used to indicate number 1, yellow = 2, purple = 3, brown = 4, red = 5, green = 6, blue = 7, orange = 8, silver = 9, gold = 0. This combination of 10 different colors proved effective. After being marked, the date of emergence and sex were noted in a data book. Males and females can readily be distinguished by the male androconial brand on the upperside of the forewings, and examination of the external genitalia at abdominal tip. Males have a pair of claspers or valves, while females have a rounded abdominal tip with a ventral opening between the 7^{th} and 8^{th} abdominal segments, the ostium bursae (Scoble, 1992, p. 103). Females of this species are slightly paler and, on average, larger than males (Tsukada & Nishiyama, 1982). Butterflies were released into the butterfly enclosure on the day of their eclosion. Observations were then commenced on the butterflies flying in the enclosure. Mating individuals were photographed whenever possible and the individual numbers recorded. Flower-visiting individuals were also noted or photographed. Other behavior such

as egg-laying was recorded whenever possible during the rearing period. To determine the life span of adults, regular searching for wings (Fig. 2b) was conducted as well as recording the activity of flying individuals.

After mating, or whenever ovipositing females were observed, the host plants were searched for eggs. Each day, the eggs were collected into a petri dish and brought to the rearing room for observation. After hatching, each first-instar caterpillar was placed in an individual plastic container. Fresh leaves of the host plants were added daily and excreta removed. Observation was conducted on the caterpillars as they grew and molted into subsequent instars, pupated, and the adults eclosed. All observations were recorded in the data book.

Figure 1. Pupae, as parent stocks of *Papilio peranthus*, obtained from several sources. The pupae were hung inside the wired pupal cabinet using cloth pins. (photograph: D. Peggie)

a b

Figure 2. Marking of *Papilio peranthus* was done using paint marker pens (a) to indicate the individual number. The color combinations enabled individual butterflies to be recognized on inspection. Dead individuals were searched for daily to determine the life span of adults (b). (photograph: D. Peggie)

RESULTS

The rearing room observations gave data on the early stages of *Papilio peranthus*, whereas observations in the butterfly enclosure provided information on adult behavior. The observations of this butterfly species were conducted within the period of September 2016 through December 2018, encompassing 221 observed adults in total.

(I). The parental stock of the first batch of *P. peranthus transiens* from Bali all successfully eclosed between 25 September 2016 and 1 October 2016, to give 18 males and 11 females. Male number 238, which emerged on 26 September, was found at 10:00 mating with newly emerged female 239 on 27 September. Male 240, which emerged on 27 September, was found mating with newly emerged female 251 on 28 September. From this first batch, data on duration of adult life were obtained for five individuals, which ranged from 2–17 days. Ovipositing females were not observed for this first batch, but eggs were obtained from leaves of the host plant, *Micromelum minutum*. It was not possible to locate all eggs, determine which eggs were had been laid by particular females, or ascertain exactly when the eggs were laid. Most eggs were found on the underside of young leaves or young shoots (Fig. 3), glued with secretion from the colleterial glands (Chew & Robbins, 1984). Eggs were checked and taken every afternoon but some eggs might have been missed. The eggs were brought to the rearing room to rear the early stages. Thirty-seven eggs were obtained on 27 September, 104 eggs on 28 September, and some further eggs up to 9 October. At the same time, *Papilio polytes* individuals were in the enclosure, using the same host plants, so it was not easy to determine the eggs. The hatchlings were then moved to individual plastic jars and were given individual numbers. There were 81 individual F1 *P. peranthus*, 38 of which failed

to develop into adulthood: 1 died at third instar, 4 died at fourth, 10 died at fifth, 10 failed at prepupal stage, 12 failed at pupal stage, and 1 failed to eclose. The 28 male and 15 female F1 individuals which emerged 29 October – 8 November did not manage to found a successful F2 generation. This was so despite F1 female 805 that emerged on 5 November mating almost immediately with F1 male 822.

(II). The parental stock of the second batch of *P. peranthus transiens* comprised 19 pupae obtained on 10 February 2017 from Bali. Ten males and 1 female emerged between 13–19 February, 8 pupae failing at eclosion. No mating was observed, and no F1 generation resulted from this second batch.

(III). A stock of the Javan subspecies, *P. peranthus peranthus*, from Citayam, Bogor, comprised 11 pupae obtained between 25 April and 14 May 2017. Six males and four females emerged, over the period 25 April to 27 May, with one pupa failing to eclose. No observations were obtained from this batch, and they did not produce an F1 generation.

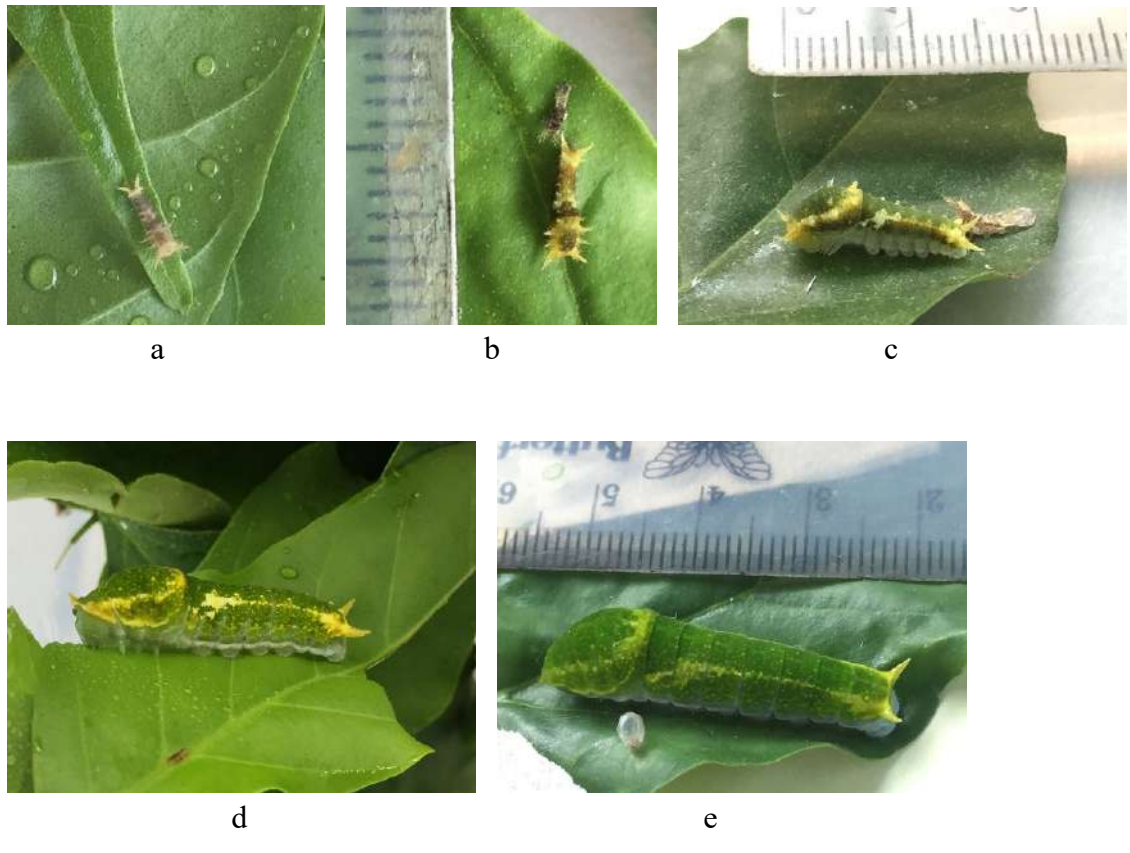
(IV). Parent stocks from naturally arriving individuals of subspecies *peranthus*. Local individuals of *P. peranthus* were observed outside the butterfly enclosure from time to time, visiting the host plants. On 3 June 2018 a male, numbered 9188, was put into the enclosure but there was no female present during the following days, so this male could not mate. On 6 July 2018 a female was seen outside and it was caught and numbered 9315. The activity of the butterfly seemed uninterrupted upon being put inside the enclosure, as it fed on available nectar plants and laid eggs on *Micromelum minutum*. This female, numbered 9315, laid eggs which resulted in 25 larvae. These produced an F1 generation of 12 male and 11 female adults which emerged 6–15 August 2018; 2 failed at pupal stage.

Table 1. Duration of each life stage of *Papilio peranthus* reared in captivity at the butterfly research

	egg	**L1**	**L2**	**L3**	**L4**	**L5**	**prepupa**	**pupa**	**adult**
Number individuals observed	156	155	155	153	148	138	128	107	20
Average (days)	4.45	3.04	3.35	3.12	2.78	2.90	1	10.58	6.8
Maximum (days)	7	4	4	4	4	4	1	12	21
Minimum (days)	1	2	2	2	2	2	1	8	2

a b c

Figure 3. Examples of eggs of *Papilio peranthus* obtained during this research: (a) eggs on the underside of the host plant, (b) eggs laid on a young shoot of the host plant, (c) eggs taken to the rearing room for captive breeding. (photograph: D. Peggie)



a b c

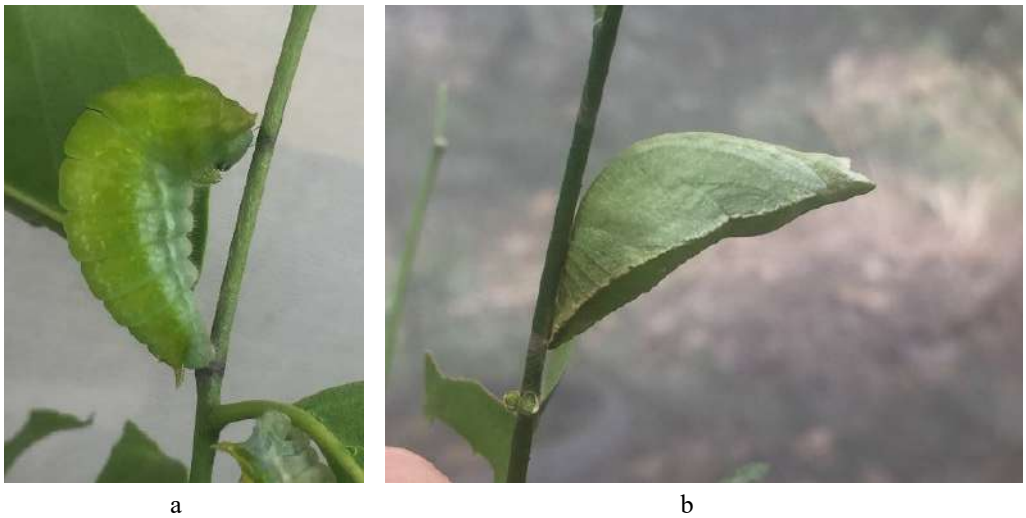
d e

Figure 4. Larvae of *Papilio peranthus*: (a) L1 – first instar, average length 3 mm, (b) L2 – second instar, average length 5–6 mm, (c) L3 – third instar, average length 12 mm, (d) L4 – fourth instar, average length 19 mm, and (e) L5 – fifth instar, average length 28 mm. (photograph: D. Peggie)

There were 32 F2 larvae resulting from the F1: 13 males and 10 females emerged 8–21 September 2018, and 9 failed (2 at L1, 3 at pupal stage, and 4 at eclosion). The F2 generation produced 13 F3 individuals, 7 males and 6 females emerging 20 October 2018 to 1 November 2018. The F3 resulted in 4 F4 individuals: 3 males and 1 female which emerged 28 November 2018 to 2 December 2018. Female 9315 had no further descendants.

Two more local *P. peranthus peranthus* females arrived on 28 August 2018, and were numbered 9347 and 9351. Eggs obtained on 31 August produced two females (9416 and 9417) which emerged on 30 September and 1 October 2018, respectively; another pupa failed at eclosion. These F1s did not produce offspring.

Based on daily observations of each individual and molting events to the next instar of larva, the duration period of each life stage is presented (Table 1), showing the average duration from eggs to adults is 31 days. However, it should be noted that the date of the eggs obtained might not necessarily mean the date of egg laying. The larval stage consists of 5 instars (Fig. 4), and each instar lasts about 3 days on average, giving a total of 15 days (see Table 1). For comparison, the larval duration of *Papilio polytes* reared at Nilgiri Hills, India was 14.41 days (Rajeswari & Jeyabalan, 2017). The process from prepupal to pupal stage (Fig. 5) takes one day. Pupal development lasts about 10 days. Observation in the butterfly enclosure showed that some adults could live over 2 weeks and one individual (number 9326) was recorded still alive for 21 days, but many of them lived only about a week. The



a b

Figure 5. prepupa (a) is ready for pupal ecdysis (moult), which usually takes place within a day, to reveal the pupa (b). (photograph: D. Peggie)

determination of the life span of adults was obtained through finding broken wings (Fig. 2b) as well as recording the activity of flying individuals daily during the research period.

Adults eclosing from the pupal cases crept out and needed time to expand their wings. These processes would take 1–2 hours. When the butterflies were considered ready, with wings fully expanded and dried, they were marked with paint on the underside of left forewing, and then released into the enclosure. Some newly emerged butterflies were observed to perch on plants for a few minutes, others were ready to fly (Fig. 6).

Daily observations inside the enclosure revealed that newly emerged butterflies of this species do not visit flowers for nectar on the day of emergence. Subsequently, the butterflies visited *Jatropha integerrima* (Euphorbiaceae), *Impatiens hawkeri* (Balsaminaceae) (Fig. 8b), *Ixora* spp. (Rubiaceae), *Caesalpinia pulcherrima* (Fabaceae), *Cuphea hyssopifolia* (Lythraceae), *Pseuderanthemum reticulatum* (Acanthaceae), *Zinnia* sp. (Asteraceae), *Cosmos caudatus* (Asteraceae), *Lantana camara* (Verbenaceae), *Jatropha podagrica* (*Euphorbiaceae*), and *Bougainvillea* sp. (Nyctaginaceae). Later, after 3 days, the butterflies also visited *Aloysia virgata* (Verbenaceae). *Clerodendrum paniculatum* (Lamiaceae) is known also as a nectar plant for *P. peranthus*, as seen in some butterfly gardens, but during the period of research this plant species was not in bloom. *Antigonon leptopus* (Polygonaceae) was not visited.

Observations showed that males did not mate on the first day of emergence (Table 3, Fig. 7). Most females, on the other hand, were approached by males within minutes of their entrance to the enclosure and were then mated (Table 3). Some females were also observed mating on days 2 and 3 after emergence. One female (number 9400) was observed mating with two different males in the same morning. One male (number 9386) mated 3 times, with 3 different females on days 2, 3, and 6. Thus males and females of this species can be polygamous, mating multiple times with different individuals. This contradicts the conclusion drawn by Lukvitasari (2016) based on a very brief observation in a butterfly enclosure in Lampung. Of course, in nature some males and some females will not get the opportunity to mate more than once, if at all.

Mated females were seen laying eggs usually a day after mating (Table 2, Fig. 7b). These ovipositing females fluttered around the host plant, *Micromelum minutum*, several times before laying eggs on the underside of leaves or flower buds. Some females were observed visiting flowers between episodes of ovipositing activity.

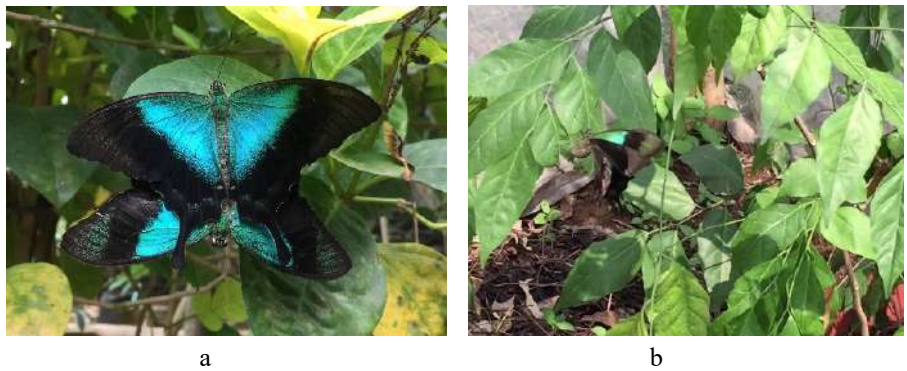
'Mud-puddling' and urinating behavior was also seen (Table 3, Fig. 8b). Similar behavior was observed in *Papilio karna* at Cikaniki research station, Gunung Halimun-Salak National Park, April 2016.

Table 2. Adult activities of *Papilio peranthus* as recorded during the research in the butterfly enclosure

No.	Individual number	Date emergence	M/F	Observed mating	Other activities
1	239	27 September 2016	female	27 September 2016 at 10:00 with 238	
2	240	27 September 2016	male	28 September 2016 with 251	
3	805	5 November 2016	female	5 November 2016 with 822	
4	822	4 November 2016	male	5 November 2016 with 805	
5	9315	6 July 2018	female		laid eggs 6 July 2018
6	9319	8 August 2018	male	9 August 2018 at 8:50 with 9322	puddled 9 August 2018 at 12:00
7	9320	8 August 2018	male	9 August 2018 at 8:30 with 9323	puddled 9 August 2018 at 12:10
8	9322	9 August 2018	female	9 August 2018 at 8:50 (30 mins. upon release) with 9319 until 10:00	
9	9323	9 August 2018	female	9 August 2018 at 8:30 (10 mins. upon release) with 9320 until 10:50	laid eggs 10 August 2018
10	9327	10 August 2018	female	10 August 2018 at 10:20 with 9319, still in copula at 11:35	
11	9328	11 August 2018	male	13 August 2018 at 12:00 with 9335	
12	9326	10 August 2018	male		puddled 13 August 2018; still seen alive 31 August 2018
13	9335	13 August 2018	female	mated at 12:00 (10 mins. upon release) with 9328	
14	9339	14 August 2018	male	15 August 2018 with 9341	
15	9340	15 August 2018	female		laid eggs16 August 2018; laid 26 eggs in small cage 17 August 2018
16	9341	15 August 2018	female	15 August 2018 with 9339	
17	9385	12 August 2018	female	12 August 2018 with 9382	laid eggs 13 August 2018
18	9386	12 September 2018	male	13 September 2018 with 9389; 14 September 2018 with 9393; 17 September 2018 with 9400	
19	9387	13 September 2018	male	17 September 2018 with 9400	
20	9389	13 September 2018	female	4 minutes upon entering with 9386	
21	9393	14 September 2018	female	14 September 2018 at 9:50 with 9386	laid eggs 17 September 2018
22	9400	17 September 2018	female	17 September 2018 at 9:30 – 10:30 mated with 9387 and at 11:05 with 9386	
23	9401	17 September 2018	male	18 September 2018 with 9402	
24	9402	18 September 2018	female	18 September 2018 at 9:40 – 10:30 with 9401	laid eggs 20 September 2018

a b

Figure 6. *Papilio peranthus* male (a) can be distinguished by the androconial brand on the upperside of the forewings; the female (b) is a little paler and lacks the androconia. (photograph: D. Peggie)



a b

Figure 7. Mating of *Papilio peranthus* is shown here (a) with the female is usually above the male in position; when they needed to move, the female would take flight carrying the male trailing in the same position. An ovipositing female flutters around *Micromelum minutum* (b) to lay eggs singly on the underside of the leaves or young buds. (photograph: D. Peggie)

a b

Figure 8. Puddling behavior (a) and flower visiting (b) of *Papilio peranthus* were observed in this research. (photograph: D. Peggie)

DISCUSSION

A total of 61 individuals (59 pupae and two adults) served as parental stocks in this investigation. Not all stocks were successful. From the first batch all pupae eclosed successfully and produced a first generation. From the second batch, eight pupae failed. From the Citayam parental stock, only one pupa failed to develop. However, the success rate for producing descendants was not only influenced by the number of potential parents, but also by the timing of emergence. The first batch of pupae eclosed within a few days (Fig. 9), so fresh males and females were available together to mate. The second batch only produced one female, which emerged very late compared to the males, which had emerged up to 6 days earlier (Fig. 10), so mating was unlikely. The stock from Citayam also failed to reproduce, even though there were 6 males and 4 females, most likely for the same reason, i.e. the time of emergence was too widely separated (Fig. 11).

The stock derived from naturally arriving individual 9315 was the most successful. Upon being captured and marked, this female resumed her activities – visiting flowers and laying eggs. Within that week, eggs were obtained from the leaves of the host plants. Ten days after the female was taken into the enclosure and laid eggs, first instar larvae started to hatch, and they grew well to adulthood. In exactly 31 days after the founder female was brought in, F1 individuals emerged. This cycle continued to a fourth generation.

Data on the life cycle of *Papilio peranthus* gave, at the ambient temperatures experienced, an average duration from egg to adult of 31 days. Apparent duration of egg development varied greatly. This was because the date of the eggs obtained might not necessarily represent the date at which the eggs were laid. Efforts had been taken to get all available eggs each day, but some eggs were almost certainly overlooked, and then gathered on subsequent days. Eggs were laid singly, as commonly observed for most species of Papilionidae (Stamp, 1980). The number of eggs that can be laid by a single female butterfly during her life time cannot be determined from the present data as there was only one enclosure available at the time. It was likewise not possible to know which eggs were laid by which female during the project. Therefore, no meaningful assessment of the fecundity of female *P. peranthus* can yet be made. It is hoped that further data will be presented at a later date as two small enclosures have been built recently. The success and survival rates of each larval instar also needs further research.

The host plant used by *P. peranthus* for this project was *Micromelum minutum*. Another member of the Rutaceae successfully used by *P. peranthus* is *Clausena excavata*: Nukmal et al. (2017) employed this species to rear *P. peranthus* at Lampung. *Clausena excavata* is also a known host for other species of *Papilio*, including *P. demoleus*, *P. polytes*, *P. palinurus* and *P. daedalus* (Igarashi & Fukuda, 2000). Studies on food plant preferences could be conducted in future, as additional enclosures are now available.

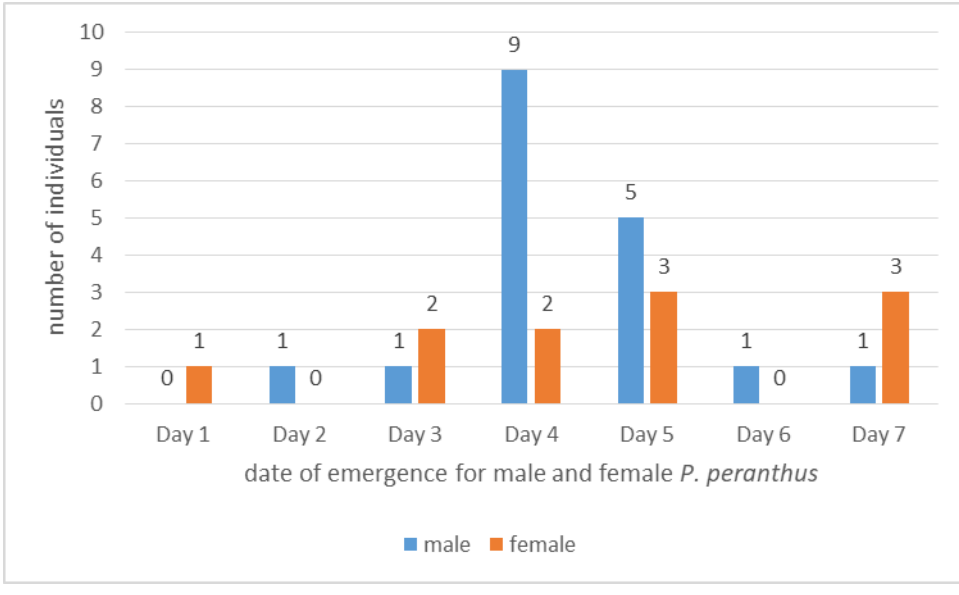


Figure 9. Adult emergence of parent stocks batch I of *Papilio peranthus*.

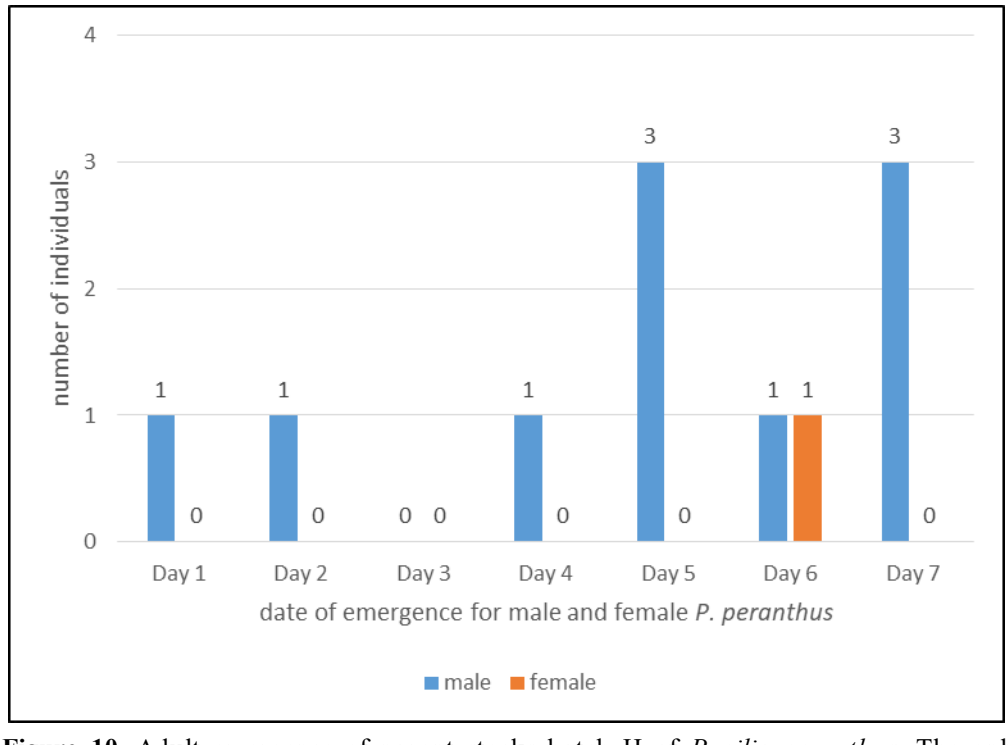


Figure 10. Adult emergence of parent stocks batch II of *Papilio peranthus*. The only female failed to mate.

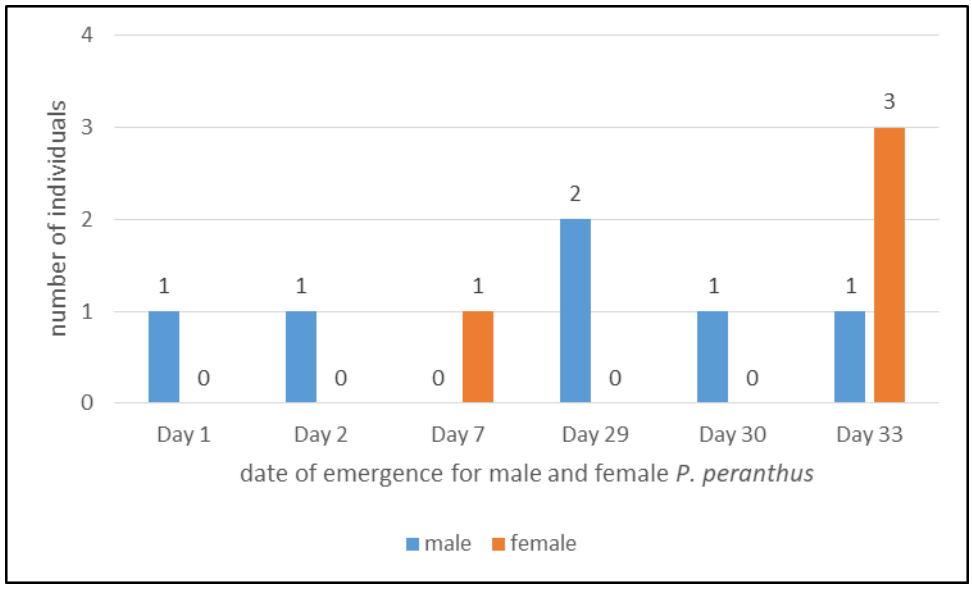


Figure 11. Adult emergence of parent stocks from Citayam, Bogor, of *Papilio peranthus*. No second generation was produced because the time of emergence of males and females was too widely separated.

The observations demonstrate that both males and females of this species are not monogamous (Table 2). They can mate multiple times with different individuals. Males approached newly emerged females relatively quickly, as little as four minutes after a female was released into the enclosure. Many female Lepidoptera release sex pheromones that can be recognized by the males conspecifics (Roelofs & Carde, 1974). Although there is evidence that this occurs in butterflies, details are sparse and the phenomenon is not well established for many butterflies (Boppré, 1984). The receptivity of female butterflies to males is influenced by various factors, including male pheromones (Boppré, 1984; Andersson et al., 2003; Wedell, 2005). Male pheromones can be dispersed from androconial scales, as suggested by an experiment with *Heliconius melpomene* in Panama, in which the specialized wing area with androconial scales was covered by a nail varnish, resulting in loss of receptivity by females (Darragh et al., 2017).

At the time of observation of *P. peranthus*, some other butterfly species were also inside the enclosure. At certain times the presence of *P. polytes* might have been a nuisance for *P. peranthus* as they were both making use of the same host plant. However, further study will need to be conducted to check any assumption or potential of competition. The presence of *Troides helena* (Papilionidae) and *Idea blanchardii* (Nymphalidae) did not seem to affect *P. peranthus*, neither of which feed on Rutaceae, as they continued to thrive. More quantitative assessments on the interactions among butterfly species co-existing in the enclosures could be undertaken. Daily activity patterns of the butterfly species co-occurring

within the enclosure could also be investigated, as Peixoto & Benson (2009) discussed for satyrine butterflies in a forest fragment in Brazil.

The associations of adult butterflies with plants for nectar are generally far less specific (Courtney, 1986; Shreeve, 1992). This research showed that adult butterflies would go to most flowers available for nectar. An exception was *Antigonon leptopus*, in which the small flower opening perhaps limits the ability of this butterfly species to obtain nectar. However, *Papilio polytes* and several other butterfly species have been recorded to take nectar from this plant (Raju et al. 2001, table 1) as observed also with other butterfly species in the enclosure. Flower preference by *P. peranthus* was not investigated in detail as the adults in general would visit almost any flowers with corolla depth that could be reached by the proboscis (Corbet, 2000; Tiple et al., 2009). Based on daily observations inside the enclosure, newly emerged butterflies of this species do not visit flowers for nectar on the day of emergence. This corresponds to observations on *Tirumala limniace* by Li et al. (2015). At times when there were many butterflies of different species in the enclosure, additional 10% sugar solution was placed on *Hibiscus* flowers, and *P. peranthus* would also feed on that.

Other behavior observed included "mud-puddling" (drinking) and urinating. Similar behavior was observed in *Papilio karna* at Cikaniki research station, Gunung Halimun-Salak National Park, April 2016. Many butterflies showed puddling behavior perhaps to obtain supplementary diet like sodium as suggested by Adler & Pearson (1982). The time of puddling observed here was between 12:00 – 12:20 and Patwardhan (2019) reported that puddling happened between 8:00 – 13:00 with peak activity at 11:30. This behavior was recorded only on three male individuals, two of which were observed to have mated that morning. This behavior may warrant further study.

Understanding the biology of this butterfly species and how it thrives in captivity may lead to a better captive breeding operation for sustainable utilization of the butterflies. Further study regarding the fecundity of female *P. peranthus*, the success and survival rates of each life stages will be useful. Observations on the effect of parasitoids and predators will complement the understanding toward better management of a butterfly facility.

CONCLUSION

The mean duration of life cycle of *Papilio peranthus* demonstrated in this study was 31 days. The success rates of each life stage needs to be further assessed. Adults can live over 21 days. The male and female of this species are not monogamous. Males exhibit water -puddling behavior. The adults used most available flowers as nectar sources except *Antigonon leptopus*.

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