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PAPILIO DEMOLEUS L. AND *PAPILIO POLYTES* L. (LEPIDOPTERA: PAPILIONIDAE) REARED ON SOME HOST PLANTS AT BUTTERFLY RESEARCH FACILITY, LIPI - CIBINONG, WEST JAVA, INDONESIA

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ABSTRACT

Papilio demoleus L. and *P. polytes* L. are common butterflies and distribute almost throughout Indonesia. Both species are attractive in butterfly gardens, but may be considered as pests in *Citrus* plantations. This research aimed to obtain data on their biology, on how the species thrive in captivity, and to assess the alternative host plants. Captive breeding research on these two species was conducted at the butterfly research facility within the period of September 2016 to February 2019, with 482 individuals of *P. demoleus* and 2,334 individuals of *P. polytes* reared, of which 292 individuals of *P. demoleus* and 560 individuals of *P. polytes* have complete informative data. The average duration of eggs was 3.7 days for *P. demoleus* on *Citrus* spp., 3.68 days for *P. polytes* on *Citrus* spp., and 3.48 days for *P. polytes* on *Micromelum minutum*. The duration of larvae varied between 13–19 days for both species. Prepupal stage lasted for 1 day for all observed individuals. Incidental observation at home during the pandemic COVID-19 added some insights that the pupation happened between 18:00-19:00. The duration of pupae varied between 9–14 days for both species. The total duration of pre-adult stages for both species was between 26–38 days. Adults at the butterfly dome could live up to 19 days for *P. demoleus* and 39 days for *P. polytes*. Recognition of alternative host plants is very useful for the improvement of species management in butterfly gardens and in *Citrus* plantations.

Key words: butterfly dome, observation, *Papilio demoleus, P. polytes*, rearing

INTRODUCTION

Papilio demoleus Linnaeus, 1758 is a common butterfly species which occurs in Asia from Arabia (Larsen, 1984), India, Indo-China, Malay Peninsula, Indonesia, Philippines, and Australia (Tsukada & Nishiyama, 1982; Peggie & Amir, 2006), with recent invasion to Dominican Republic (Guerrero et al., 2004), Puerto Rico (Homziak & Homziak, 2006), Caribbean (Garraway et al., 2009), to Papua New Guinea (Tennent et al., 2011), also to Syria (Benyamini et al., 2007) and Seychelles Islands (Kolosova & Bolotov, 2020). In Indonesia this species has now distributed almost throughout the archipelago with establishment in Java (Kato, 1989; Moonen, 1991), Kalimantan (Matsumoto, 2002), and Papua (Moonen, 1999). In many areas, *P. demoleus* is regarded as a pest to *Citrus* plantations as the subspecies *P. demoleus demoleus* and *P. demoleus*

malayanus feed on *Citrus* spp. On the other hand, *P. demoleus sthenelus*, the subspecies in Australia, is not considered a pest, as it uses Fabaceae as the host plants and only occasionally use *C. australis*, *C. aurantium*, and *C. aurantifolia* (Braby, 2004). Therefore, Australian government has put a strict measure to prevent the entrance of other subspecies into the country (Nielsen, 2017). Nonetheless, *P. demoleus malayanus* was detected from Dauan Island, Torres Strait (Lambkin, 2017), and Nielsen (2017) presented additional diagnostic features to distinguish the subspecies.

Papilio polytes Linnaeus, 1758 is distributed in India, China, Ryukyu Islands, Indo-China, Malay Peninsula, Indonesia, Philippines (Tsukada & Nishiyama, 1982; Corbet & Pendlebury, 1992, 2020). In Indonesia it distributes in Sumatra, Kalimantan, Java, Bali, Nusa Tenggara, Sulawesi, and Maluku (Tsukada & Nishiyama, 1982; Peggie & Amir, 2006).

Each butterfly species has a close relationship with its host plants, which can be very limited to a few species of plants (Vane-Wright, 2003; Ghosh et al., 2019). Both *P. demoleus* and *P. polytes* have quite a wide range of host plants, compared to other butterfly species, which explain their common occurrence. The known host plants for *P. demoleus* are *Citrus* spp. and *Clausena excavata* of Rutaceae family (Igarashi & Fukuda, 2000). The host plants for *P. polytes* in the forest are *Murraya*, *Triphasia*, *Glycosmis*, *Aegle*, *Zanthoxylum*, *Toddalia*, *Euodia*, *Clausena*, *Atalantia* and *Poncirus* of Rutaceae (Corbet & Pendlebury, 1992, 2020). In urban areas, it also feed on *Citrus* spp. (Corbet & Pendlebury, 1956, 1992, 2020) which was also reported by Igarashi & Fukuda (2000), in addition to *Cl. excavata*, and *Micromelum minutum* of Rutaceae. The adaptation of *P. polytes* to *Citrus* spp. in urban areas (Corbet & Pendlebury, 1956) has made it a potential pest to *Citrus* plantation. On the other hand, these two butterfly species are common in butterfly houses due to their attractive coloration and the ease of production and supplies. It is therefore desirable to understand various biological aspects of the species (Peggie, 2018). Knowledge on the pre-adult stages of *P. demoleus* and *P. polytes* is quite readily available (Igarashi & Fukuda, 2000; Tan, 2011a, b).

Study of the oviposition preference of *P. demoleus* was carried out (Yasmin & Suwarno, 2006) on *C. nobilis* (Indonesian: jeruk siam), *C. mitis* (Indonesian: jeruk peras / jeruk kasturi), or *C. aurantifolia* (Indonesian: jeruk nipis). The results showed that females laid more eggs on *C. nobilis* but not significantly different than on the other two *Citrus*. Research on larval food preference of *P. polytes* on three species of *Citrus* and on *Mu. koenigii* revealed that *P. polytes* consistently consumed less *Mu. koenigii* perhaps due to the tough texture of the leaves (Suwarno et al., 2007; Suwarno, 2010).

This research on these two species aimed to obtain data on their biology, which include the duration of the life cycles and on how the species thrive in captivity, and to assess the alternative host plants in relation to potential pest concern. To obtain data on life cycles, observation on pre-adult stages was conducted in the rearing room. To understand the biological aspects, observation of the adult stage was conducted inside the butterfly dome.

MATERIALS AND METHODS

Time and place of the research:

The research was conducted within the period of September 2016 through February 2019, at the Butterfly Research Facility of LIPI, located at Cibinong Science Center, Cibinong, Bogor, Indonesia. The butterfly facility includes a 10x20 sq. m. butterfly dome, a 4x6 sq. m. rearing room, and surrounding area for planting the plants associated with butterflies. Various plants were grown inside and outside the butterfly dome to support butterflies which include the larval host plants, the nectar-producing plants, and the shade plants. Rearing and research observations were conducted at ambient temperature of 25–35^{0}C.

Materials:

Parent stocks of both butterfly species for the research were obtained from incoming individuals to the area of Butterfly Research Facility and from several other sites nearby.

Methods:

The individual was marked with paint marker pens in the case of adult or labelled on the plastic container in the case of pre-adult stage to indicate the individual number for data (see Peggie, 2019), using paint markers on the surface of the wings (Hagler & Jackson, 2001). The dot marking was given on the underside of left forewing for easy handling and recognition. Paint marker pens with 10 different colors were used and applied consistently to indicate separate color for each number. In this study, white is used to indicate number 1, yellow number 2, purple number 3, brown number 4, red number 5, green number 6, blue number 7, orange number 8, silver number 9, gold number 0. This combination of 10 different colors has been proved to be effective in numbering the butterflies for research purpose. After being marked, the date of emergence and sex were noted on the data book. Male and female of *P. demoleus* can be distinguished by the paler black stripes in the female (Tsukada &Nishiyama, 1982), the size of black spot above the red spot in space 1b of the hindwing, which is narrow in male and large in female (Tan, 2011b), and by looking at the external genitalia at the end of abdomen. Male and female of *P. polytes* are easily distinguishable. The female *P. polytes* has two forms (Corbet & Pendlebury, 1992, 2020; Tan, 2011a): the male-like *cyrus* form and the *stichius* form which resembles *Pachliopta adamas*; but in this research all female individuals were of the *stichius* form. The newly-emerged butterflies of the day (Fig. 1a) were released into the butterfly dome. Observation was then started on the butterflies flying in the dome, including mating (Fig. 2). To know the life span of adults, search for leftover wings (Fig. 1b) was conducted every day.

After mating butterflies or egg-laying female were observed, the search for eggs on the host plants was conducted. The eggs of the day were collected into a petri dish and brought to the rearing room to be observed. When the eggs hatched into small caterpillars or larvae, they were individually placed into plastic containers. Fresh leaves of the host plants were added daily and excreta were removed. In this research, the larvae were fed the leaves of the host plants which the female butterflies laid the eggs on. Not differentiations were made between the *Citrus* spp. and

the larvae which eggs were laid on *Citrus* spp. were fed on leaves of either *C. nobilis*, *C. mitis*, or *C. aurantifolia* available within the butterfly research facility. Observation was conducted on the larvae as they grew and molted into next instars, pupated, and emerged. In this research, no emphasis was given on separate instars as the molting time was not monitored closely for each. All data were recorded in the data book.

Figure 1. Adult butterflies of: (**a**) *P. polytes* just eclosed at the rearing room to be released into the butterfly dome; and (**b**) *P. polytes* and other species including *P. peranthus* which were found dead to be noted for the data of adult duration.

Figure 2. Mating individuals of: (**a**) *P. demoleus*; and of (**b**) *P. polytes* with the female is usually above the male in position. When they needed to move, the female would take the male flying still in the position.

RESULTS

The observations of *P. demoleus* and *P. polytes* covered 482 individuals of *P. demoleus* and 2,334 individuals of *P. polytes* reared during the period of 2.5 years. We did not have complete data for all of these individuals due to the time constraint and limitation, as we also reared other species during the same time period. We presented here data of 292 individuals of *P. demoleus*, and 560 individuals of *P. polytes* which are complete and continuous so as to give informative data on duration of eggs, larval stages, pupal stage, adult stage, including adult mating.

Immature Stages

Eggs of both species are laid singly, usually at the edge of a leaf of the host plants on the underside surface. Based on daily observations to each individual and molting events to the next stage, the duration period of each life stage is presented (Tables 1–3). Table 1 showed the average duration of eggs of *P. demoleus* was 3.7 days, and that of *P. polytes* on *Citrus* spp. was 3.68 days and on *M. minutum* was 3.48 days.

The duration of larval stage of *P. demoleus* and that of *P. polytes* varied between 13–19 days (Table 2). The process from prepupal to pupal stage, or known as pupation, lasts for only one day on all individuals observed for both species. Incidental observation at home during the pandemic COVID-19 added some insights about the time of pupation, which happened between 18:00-19:00. However, one individual of *P. polytes* (#1038) went into pupation in the afternoon. Pupal development of *P. demoleus* and that of *P. polytes* varied between 9–14 days (Table 3). The total duration of pre-adult stages for both species ranged between 26–38 days.

Table 1. Duration of egg stage of *P. demoleus* and *P. polytes* laid on leaves of the host plants at the butterfly research facility

Duration of egg stage	3 days	4 days
Number of eggs of *P. demoleus* on leaves of *Citrus* spp.	6	14
Average: 3.7 days		
Number of eggs of *P. polytes* on leaves of *Citrus* spp.	19	40
Average: 3.68 days		
Number of eggs of *P. polytes* on leaves of *M. minutum*	67	61
Average: 3.48 days		

Table 2. Duration of larval stages of *P. demoleus* and *P. polytes* fed on the host plants in captivity at the butterfly research facility

Duration of larval stage (L1–L5)	13 days	14 days	15 days	16 days	17 days	18 days	19 days
Number of larvae of *P. demoleus* fed on leaves of *Citrus* spp.	32	60	54	27	31	15	5
Number of larvae of *P. demoleus* fed on leaves of *Cl. excavata*	2	3	1	5	0	0	2
Number of larvae of *P. demoleus* initially on *Cl. excavata* then were moved to *Citrus* spp.	0	6	0	1	1	0	0

Duration of larval stage (L1–L5)	13 days	14 days	15 days	16 days	17 days	18 days	19 days
Number of larvae of *P. polytes* fed on leaves of *Citrus* spp.	19	15	47	27	21	12	5
Number of larvae of *P. polytes* fed on leaves of *M. minutum*	22	30	26	37	26	14	17
Number of larvae of *P. polytes* fed on leaves of *Cl. excavata*	0	2	3	2	0	2	0

Table 3. Duration of pupal stage of *P. demoleus* and *P. polytes* to emerge as adults at the butterfly research facility

Duration of pupal stage	9 days	10 days	11 days	12 days	13 days	14 days
Number of pupae of *P. demoleus* on *Citrus* spp.	6	22	74	97	49	10
Number of pupae of *P. demoleus* on *Cl. excavata*	0	0	2	4	3	2
Number of pupae of *P. polytes* on *Citrus* spp.	22	67	71	49	9	6
Number of pupae of *P. polytes* on *M. minutum*	10	65	85	67	14	0
Number of pupae of *P. polytes* on *Cl. excavata*	0	4	3	1	0	1

Mature Stage

Based on daily observations inside the dome, newly emerged butterflies do not visit flowers for nectar on the day of emergence. Both species would go to all available flowers inside the butterfly dome, i.e., *Antigonon leptopus* (Polygonaceae), *Aloysia virgata* (Verbenaceae), *Bougainvillea* sp. (Nyctaginaceae), *Caesalpinia pulcherrima* (Fabaceae), *Clerodendrum paniculatum* (Lamiaceae), *Cosmos caudatus* (Asteraceae), *Cuphea hyssopifolia* (Lythraceae), *Impatiens hawkeri* (Balsaminaceae), *Ixora* spp. (Rubiaceae), *Jatropha integerrima* (Euphorbiaceae), *Jatropha podagrica* (Euphorbiaceae), *Lantana camara* (Verbenaceae), *Pseuderanthemum reticulatum* (Acanthaceae), and *Zinnia* sp. (Asteraceae). Adults *P. demoleus* visited *Zinnia* flowers the most, whilst *P. polytes* visited *A. leptosus* the most.

Data on mating individuals and on adult duration (Tables 4–5) showed that adults of *P. demoleus* at the butterfly dome could live up to 19 days and one individual of *P. polytes* reached 39 days, but many of them lived only about a week. The determination of the life span of adults was obtained through finding broken wings (Fig. 1b).

Table 4. Data on mating and adult duration of *P. demoleus* as recorded during the research in the butterfly dome

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
1	87	17-Oct-16	male		02-Nov-16	16
2	103	17-Oct-16	male		31-Oct-16	14
3	322	30-Sep-16	female		06-Oct-16	6
4	338	26-Sep-16	female	mated 28 Sept 2016		
5	342	28-Sep-16	male	mated 30 Sept 2016		

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
6	385	30-Sep-16	male		12-Oct-16	12
7	425	02-Oct-16	male		21-Oct-16	19
8	871	26-Oct-16	male		04-Nov-16	9
9	937	29-Oct-16	male		09-Nov-16	11
10	938	27-Oct-16	female		04-Nov-16	8
11	1210	24-Oct-16	male		01-Nov-16	8
12	1211	24-Oct-16	male		04-Nov-16	11
13	1212	24-Oct-16	male		09-Nov-16	16
14	1629	31-Oct-16	male		04-Nov-06	4
15	1630	31-Oct-16	female		05-Nov-16	5
16	1775	23-Nov-16	male		04-Dec-16	11
17	1790	23-Nov-16	male		06-Dec-16	13
18	1791	24-Nov-16	female		01-Dec-16	7
19	1795	23-Nov-16	female		12-Dec-16	19
20	3295	31-Jan-17	male		14-Feb-17	14

Table 5. Data on mating and adult duration of *P. polytes* as recorded during the research in the butterfly dome

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
1	17	30-Sep-16	male		12-Oct-16	12
2	23	03-Oct-16	male		12-Oct-16	9
3	24	03-Oct-16	female		04-Oct-16	1
4	28	30-Sep-16	male		12-Oct-16	12
5	29	30-Sep-16	male		14-Oct-16	14
6	33	02-Oct-16	female		04-Oct-16	2
7	37	03-Oct-16	female		12-Oct-16	9
8	42	04-Oct-16	male		07-Oct-16	3
9	52	06-Oct-16	female		30-Oct-16	24
10	53	06-Oct-16	female		19-Oct-16	13
11	57	05-Oct-16	female		01-Nov-16	26
12	62	06-Oct-16	female		25-Oct-16	19
13	77	01-Oct-16	female		12-Oct-16	11
14	286	26-Sep-16	male	mated 27 Sept 2016 (1 day) with female # 289		
15	288	26-Sep-16	female		12-Oct-16	16
16	289	26-Sep-16	female	mated 27 Sept 2016 (1 day) with male # 286		
17	290	26-Sep-16	female	mated 28 Sept 2016 (2 day) with male # 298		
18	292	27-Sep-16	male		12-Oct-16	15
19	293	27-Sep-16	female	mated 28 Sept 2016 (1 day) with unclear number	12-Oct-16	15
20	298	27-Sep-16	male	mated 28 Sept 2016 (1 day) with female # 290		

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
21	308	29-Sep-16	male		16-Oct-16	17
22	313	30-Sep-16	male		16-Oct-16	16
23	314	30-Sep-16	male		13-Oct-16	13
24	366	29-Sep-16	female		16-Oct-16	17
25	368	29-Sep-16	female		12-Oct-16	13
26	369	29-Sep-16	female	emerged after 13:00	13-Oct-16	14
27	375	30-Sep-16	female		04-Oct-16	4
28	376	30-Sep-16	female		17-Oct-16	17
29	384	30-Sep-16	female		13-Oct-16	13
30	389	01-Oct-16	female		18-Oct-16	17
31	391	01-Oct-16	male		13-Oct-16	12
32	392	01-Oct-16	male		18-Oct-16	17
33	397	01-Oct-16	male		16-Oct-16	15
34	398	01-Oct-16	female		13-Oct-16	12
35	403	01-Oct-16	female		13-Oct-16	12
36	408	01-Oct-16	male		12-Oct-16	11
37	422	02-Oct-16	male	mated 5 Oct 2016 with unclear number		
38	427	02-Oct-16	male		17-Oct-16	15
39	442	03-Oct-16	female		13-Oct-16	10
40	443	03-Oct-16	female		13-Oct-16	10
41	444	03-Oct-16	male		18-Oct-16	15
42	495	07-Nov-16	male		16-Nov-16	9
43	504	09-Nov-16	female		22-Nov-16	13
44	507	09-Nov-16	male		17-Nov-16	8
45	516	08-Nov-16	male		24-Nov-16	16
46	522	09-Nov-16	female		17-Nov-16	8
47	524	07-Nov-16	male		21-Nov-16	14
48	584	10-Nov-16	male		24-Nov-16	14
49	585	10-Nov-16	female		30-Nov-16	20
50	591	28-Oct-16	female		31-Oct-16	3
51	598	28-Oct-16	male		05-Nov-16	8
52	600	29-Oct-16	female		06-Nov-16	8
53	601	28-Oct-16	male		10-Nov-16	13
54	631	27-Oct-16	female		04-Nov-16	8
55	632	27-Oct-16	female		04-Nov-16	8
56	635	29-Oct-16	female		04-Nov-16	6
57	636	28-Oct-16	male		04-Nov-16	7
58	639	28-Oct-16	male		07-Nov-16	10
59	640	28-Oct-16	male		07-Nov-16	10
60	643	30-Oct-16	female		11-Nov-16	12
61	651	29-Oct-16	male		01-Nov-16	3
62	676	31-Oct-16	male		10-Nov-16	10

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
63	677	31-Oct-16	male		02-Nov-16	2
64	678	01-Nov-16	male		06-Nov-16	5
65	683	27-Oct-16	male		05-Nov-16	9
66	684	25-Oct-16	male		06-Nov-16	12
67	685	25-Oct-16	male		31-Oct-16	6
68	705	02-Nov-16	female		07-Nov-16	5
69	710	31-Oct-16	male		10-Nov-16	10
70	715	30-Oct-16	female		04-Nov-16	5
71	719	03-Nov-16	male		07-Nov-16	4
72	727	05-Nov-16	female		14-Nov-16	9
73	737	02-Nov-16	female		05-Nov-16	3
74	738	02-Nov-16	male		10-Nov-16	8
75	740	02-Nov-16	male		06-Nov-16	4
76	760	04-Nov-16	female		11-Nov-16	7
77	761	05-Nov-16	female		24-Nov-16	19
78	762	05-Nov-16	male		07-Nov-16	2
79	763	05-Nov-16	male		10-Nov-16	5
80	825	02-Nov-16	male		05-Nov-16	3
81	836	27-Oct-16	female		04-Nov-16	8
82	839	27-Oct-16	male		10-Nov-16	14
83	857	27-Oct-16	female		11-Nov-16	15
84	862	29-Oct-16	female		05-Nov-16	7
85	863	28-Oct-16	male		09-Nov-16	12
86	866	26-Oct-16	male		4-Nov-16	9
87	872	26-Oct-16	male		02-Nov-16	7
88	876	28-Oct-16	female		10-Nov-16	13
89	877	30-Oct-16	male		20-Nov-16	21
90	939	03-Nov-16	female		7-Nov-16	4
91	950	28-Oct-16	female		11-Nov-16	14
92	951	28-Oct-16	female		11-Nov-16	14
93	985	28-Oct-16	male		06-Nov-16	9
94	986	28-Oct-16	female		07-Nov-16	10
95	988	27-Oct-16	female		07-Nov-16	11
96	991	26-Oct-16	male	emerged afternoon at 15:00	11-Nov-16	16
97	1003	02-Nov-16	female		17-Nov-16	15
98	1014	02-Nov-16	male		07-Nov-16	5
99	1022	02-Nov-16	male		05-Nov-16	3
100	1038	30-Oct-16	male	pupate afternoon 18 Oct 2016	11-Nov-16	12
101	1086	29-Oct-16	female		06-Nov-16	8
102	1097	01-Nov-16	male		04-Nov-16	3
103	1154	31-Oct-16	male		03-Nov-16	3
104	1160	31-Oct-16	male		06-Nov-16	6
105	1161	31-Oct-16	male		17-Nov-16	17

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
106	1172	03-Nov-16	female		12-Dec-16	39
107	1174	02-Nov-16	female		07-Nov-16	5
108	1180	01-Nov-16	female		24-Nov-16	23
109	1185	03-Nov-16	male		06-Nov-16	3
110	1192	30-Oct-16	female		04-Nov-16	5
111	1205	04-Nov-16	female		07-Nov-16	3
112	1222	03-Nov-16	male		09-Nov-16	6
113	1225	05-Nov-16	female		21-Nov-16	16
114	1228	04-Nov-16	male		10-Nov-16	6
115	1253	03-Nov-16	male		08-Nov-16	5
116	1262	05-Nov-16	male		06-Nov-16	1
117	1264	05-Nov-16	female		24-Nov-16	19
118	1265	05-Nov-16	female		30-Nov-16	25
119	1266	05-Nov-16	male		06-Nov-16	1
120	1295	05-Nov-16	female		17-Nov-16	12
121	1298	05-Nov-16	male		10-Nov-16	5
122	1302	05-Nov-16	male		11-Nov-16	6
123	1305	04-Nov-16	male		08-Nov-16	4
124	1308	04-Nov-16	male		07-Nov-16	3
125	1309	04-Nov-16	female		17-Nov-16	13
126	1319	04-Nov-16	male		07-Nov-16	3
127	1328	05-Nov-16	female		17-Nov-16	12
128	1337	07-Nov-16	female		10-Nov-16	3
129	1348	08-Nov-16	male		17-Nov-16	9
130	1352	10-Nov-16	female		22-Nov-16	12
131	1361	06-Nov-16	female		10-Nov-16	4
132	1363	06-Nov-16	female		22-Nov-16	16
133	1364	07-Nov-16	male		09-Nov-16	2
134	1372	07-Nov-16	female		14-Nov-16	7
135	1378	16-Nov-16	male		27-Nov-16	11
136	1406	05-Nov-16	female		11-Nov-16	6
137	1434	10-Nov-16	female		14-Nov-16	5
138	1438	12-Nov-16	female		28-Nov-16	16
139	1452	12-Nov-16	male		16-Nov-16	4
140	1455	15-Nov-16	male		16-Nov-16	1
141	1466	19-Nov-16	male		01-Dec-16	12
142	1479	07-Nov-16	female		25-Nov-16	18
143	1489	07-Nov-16	female		16-Nov-16	9
144	1491	07-Nov-16	male		10-Nov-16	3
145	1499	09-Nov-16	female		24-Nov-16	15
146	1501	09-Nov-16	male		17-Nov-16	8
147	1502	09-Nov-16	male		25-Nov-16	16
148	1504	09-Nov-16	male		27-Nov-16	18

no.	individual number	emerged as adult	male or female	notes	found dead	adult duration (days)
149	1522	17-Nov-16	female		12-Dec-16	25
150	1526	12-Nov-16	female		17-Nov-16	5
151	1566	08-Nov-16	male		21-Nov-16	13
152	1592	28-Oct-16	female		11-Nov-16	14
153	1593	28-Oct-16	male		04-Nov-16	7
154	1636	10-Nov-16	female		17-Nov-16	7
155	1660	12-Nov-16	female		24-Nov-16	12
156	1662	13-Nov-16	male		28-Nov-16	15
157	1672	12-Nov-16	female		24-Nov-16	12
158	1676	11-Nov-16	male		17-Nov-16	6
159	1683	11-Nov-16	male		29-Nov-16	18
160	1690	11-Nov-16	female		22-Nov-16	11
161	1701	02-Nov-16	female		10-Nov-16	8
162	1703	02-Nov-16	female		30-Nov-16	28
163	1704	02-Nov-16	male		06-Nov-16	4
164	1706	02-Nov-16	female		03-Nov-16	1
165	1707	02-Nov-16	male		04-Nov-16	2
166	1712	13-Nov-16	female		30-Nov-16	17
167	1727	28-Nov-16	female		15-Dec-16	17
168	1814	03-Nov-16	female		17-Nov-16	14
169	1815	03-Nov-16	male		10-Nov-16	7
170	4745	21-Apr-17	female		12-May-17	21
171	5178	16-May-17	male	mated 30 May 2017 (14 days old) with female # 5313		
172	5313	30-May-17	female	mated 30 May 2017 (just emerged) with male # 5178		

DISCUSSION

Eggs were laid singly as common for species of family Papilionidae (Stamp, 1980; Revathy & Mathew, 2014). The duration of eggs of both species was between 3–4 days, which was the same as reported in Singapore by Tan (2011a, b). It was 3 days for both species reared in Bengkulu, Sumatra (Helmiyetti et al., 2012). It was 3–5 days for *P. polytes* in Kerala, India (Revathy & Mathew, 2014). It was 3.1–6.1 days for *P. demoleus* reared in laboratory condition in Saudi Arabia (Badawi, 1981).

Larval duration of *P. demoleus* and of *P. polytes* varied between 13–19 days. In this paper, no emphasis was given on separate instars because the molting time was not monitored closely for each. The distinction between instars can be seen in the excellent work of Tan (2011a, b). For comparison, the larval duration was between 12–16 days for *P. demoleus* and 11–15 days for *P. polytes* reared on *C. hystrix* in Bengkulu, Sumatra (Helmiyetti et al., 2012). The average larval duration of *P. polytes* reared in Nilgiri Hills, India was 14.41 days (Rajeswari & Jeyabalan, 2017), and it was 21.64 days in Kerala, India (Revathy & Mathew, 2014). The larval

duration of *P. demoleus* reared in Saudi Arabia was 12.9–22.7 days (Badawi, 1981). Based on our observation, we would point out that often times individuals that hatched at the same time from eggs into L1 would take different paces at the larval stages.

We had the larval host plant *Cl. excavata* later in the research, in January 2018, also in limited numbers which made it necessary to transfer some larvae to *Citrus* leaves (Table 2). This plant species is known to be used by *P. demoleus*, *P. peranthus*, *P. polytes*, *P. palinurus*, and *P. daedalus* (Igarashi & Fukuda, 2000). Our data showed that larvae of *P. demoleus* thrived well on *Citrus* spp. and *Cl. excavata* but did not eat *M. minutum*. Larvae of *P. polytes* thrived well on *Citrus* spp., *Cl. excavata* and *M. minutum*. This research revealed that recognition of alternative host plants for both butterfly species is very useful for the improvement of management of the species in butterfly gardens and for management of populations where they might be considered as pests of *Citrus* plantations. This brings up the potential benefit of non-economical plants, which will be explored further. The knowledge of alternative host plants is essential to minimize attack on economically important plants (Portillo et al., 1996).

Pupal duration of *P. demoleus* and of *P. polytes* varied between 9–14 days. For comparison, it was between 9–11 days for *P. demoleus* and 8–10 days for *P. polytes* reared in Bengkulu, Sumatra (Helmiyetti et al., 2012). It was 12–15 days for *P. polytes* in Kerala, India (Revathy & Mathew, 2014), and between 8–22.4 days for *P. demoleus* in Saudi Arabia (Badawi, 1981). The eclosion into adults usually happen early in the morning, but our data showed at least two individuals emerged late in the afternoon.

Previous reports on *P. demoleus* and *P. polytes* were conducted using small numbers of observed individuals. For example, it was only 13 individuals of *P. demoleus* and 14 individuals of *P. polytes* observed in Bengkulu (Helmiyetti et al., 2012). Our study covered 482 individuals of *P. demoleus* and 2,334 individuals of *P. polytes* reared in 2.5 years, with 292 individuals of *P. demoleus* and 560 individuals of *P. polytes* have complete informative data. The total duration of pre-adult stages for both species ranged between 26–38 days, with great variations in larval and pupal stages.

The observation showed that adults *P. demoleus* visited *Zinnia* flowers the most, whilst *P. polytes* visited *A. leptosus* the most. Preference on flowers visited by both butterfly species was not observed in much detail as adult butterflies in general would take almost any flowers (Courtney, 1986; Shreeve, 1992) with corolla depth that can be reached by the proboscis (Corbet, 2000; Tiple et al., 2009). At a particular time when there were so many butterflies of different species in the dome, additional 10% sugar solution was placed on *Hibiscus* flowers and both butterfly species would also take it.

Data of both species showed that mating mostly occurred one or two days after the eclosion. However, data of *P. polytes* also showed that a 14-days old male mated a newly emerged female. These finding shows that they were capable of mating even at that age of two weeks old, while many individuals have died within two weeks. The marking method has helped us gain more knowledge of the species.

The data on the life span of adults was obtained based on the leftover wings which were checked every day throughout the butterfly dome. However, many were not detected perhaps because ants or spiders have unfortunately devoured them before we found them, or because some of them were caught in between layers of the insect net at the upper corners of the dome. At least we know that two individuals of *P. demoleus* lived for 19 days and one individual of *P. polytes* lived for 39 days. The adult longevity of *P. demoleus* reared in Saudi Arabia was only 4–6 days in spring time (Badawi, 1981). Further study on the reproductive capacity, feeding preference on the host plants, and other factors such as natural enemies will be useful.

CONCLUSION

This research showed that P. *demoleus* uses *Citrus* spp. and *Cl. excavata*, and *P. polytes* uses *Citrus* spp., *M. minutum* and *Cl. excavata* as the larval host plants. This knowledge of the alternative host plants is very useful for species management in butterfly gardens and for the management of potential pests. The total duration of pre-adult stages for both species was between 26–38 days. The data on adult longevity at the butterfly dome showed that both species thrived well in captivity during the 2.5 years of rearing program.

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