RAFFLES BULLETIN OF ZOOLOGY 1992 **40**(2): 221-228

OBSERVATIONS ON THE BIOLOGY OF MIGRATING *EUPLOEA* BUTTERFLIES IN NORTH WEST BORNEO

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ABSTRACT.- In February and March of 1992 large migrations of *Euploea* butterflies occurred in Brunei and in coastal areas of Sabah and Sarawak, coinciding with unusually dry weather. Populations were monitored in and around Bandar Seri Begawan throughout this period and at the peak of the migration in February, over 3000 butterflies per hour passed over a 100 m front, flying east. Seven *Euploea* species were observed migrating, but the dominant species, *E. crameri*, represented 93 percent of all individuals sampled. A majority of the butterflies were relatively fresh and about 70 percent were female, most of which were unmated and exhibited delayed ovarian development. It is suggested that large numbers of individuals emerged in drought conditions in January 1992 and aggregated in sheltered situations, with females entering reproductive diapause, and that environmental factors and/or sexual harassment by males of unreceptive, reproductively inactive females triggered the migratory response.

INTRODUCTION

Unlike their temperate counterparts in which mass migrations can be a regular seasonal event (Brower, 1977; Urquhart & Urquhart, 1978), butterflies of the perhumid tropics migrate infrequently, unpredictably and often on a very local scale (Poulton, 1921). In West Malaysia species most often recorded as migrating include various Pieridae and Nymphalidae, especially Danainae (Batchelor, 1960; Low, 1960; Marsh, 1964; Corbet & Pendlebury, 1978). In drier parts of southern Papua and in tropical and subtropical eastern Queensland, Australia, members of the danaine genus *Euploea* form large, multispecific aggregations in sheltered humid gullies or forest patches during dry or cold periods (Orr, 1980; Kitching & Zaluki, 1981; Monteith, 1982; Scheermeyer, 1985, 1987). Aggregating females are mostly reproductively inactive and may exhibit delayed ovarian development, presumably because of a shortage of oviposition sites under these conditions.

As a rule aggregations disperse and butterflies resume reproductive activity following rain and the production of new growth by the hostplants (species of Apocynaceae, Asclepiadaceae and Moraceae) (Scheermeyer, 1987). However aggregations also quite frequently break up

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without the stimulus of rain and the butterflies suddenly appear, apparently from nowhere, and migrate in a definite direction, sometimes in huge numbers (Williams, 1930; Brayby, 1991), only to disappear just as mysteriously after a few days.

From mid February to April 1992, several migrations of *Euploea crameri* Lucas, a species which occurs frequently but not abundantly in mangrove and swamp forest and to a lesser extent in a variety of secondary forest types, occurred throughout Brunei Darussalam and in neighbouring areas of North Borneo. Relatively small numbers of six other *Euploea* species were also present. At the peak of the migration the density of butterflies was so spectacular as to attract considerable attention from the national press (Stephen, 1992a, b & c).

During this time I monitored *E. crameri* populations on a regular basis in and around Bandar Seri Begawan, and made casual observations in other parts of Brunei, collecting data on:

1. Phenology, magnitude and direction of migration,
2. Population sex ratios and age structure and
3. Mated status and ovarian development of females.

METHODS

Abundance was usually measured daily at around 1400 hours at a fixed station in open country near the campus of the Universiti Brunei Darussalam (UBD). The number of butterflies flying across a 100 m front in 20 minutes was counted and the direction of flight recorded. To determine the overall pattern of migration, on the 5th and 6th of February this exercise was repeated for 10-20 minutes, at 20 similar locations around Bandar Seri Begawan (BSB). To determine species composition and sex ratios large samples of dead butterflies were collected from beside the highway (Lebuhraya Sultan Hassanal Bolkiah) where they lay in hundreds after being struck by cars. Age was determined by the degree of scale loss from the wings and butterflies were ranked as fresh (0% scale loss), slightly worn (1-5% scale loss), and worn (>5% scale loss), determined by microscopic examination of the wing membranes. Throughout the study period samples of butterflies were netted, graded for scale loss, and held alive in glassine envelopes for dissection. Freshly killed butterflies were dissected in 70% alcohol. Female mating record was determined by the presence of spermatophores or spermatophore stalks in the bursa copulatrix (Burns, 1968). Ovaries were examined and graded as mature (some chorionated eggs), or immature (all eggs very small and lacking chorion), intermediate stages not being present. The fat body of both sexes was examined and graded as extensive, slightly depleted and depleted, and this served chiefly as a cross-check on estimated age using wing-wear classes. To determine the extent of normal activity, weekly excursions were made to mangrove areas near Muara, and to a patch of secondary forest near Lamunin, where various *Euploea* species are normally common and where the larval hostplants *Hoya* and *Parsonsia* are abundant.

RESULTS

Geographical extent of migrations.- Throughout much of February 1992 *Euploea* butterflies were observed migrating throughout coastal areas in Brunei (including Bandar Seri Bagawan, Bangar, Muara, Tutong, Lamunin, Seria and Kuala Belait). Outside Brunei migrations were reported from Kota Kinabalu in Sabah, from Lambir Hills in Sarawak (S. Davies, pers

comm), and probably extended well into northern Sarawak, but not as far as Kuching, which received heavy rain during this period (I. Stephen, pers. comm.). This suggests that the butterflies were migrating along a coastal strip at least 300km long, and probably considerably longer.

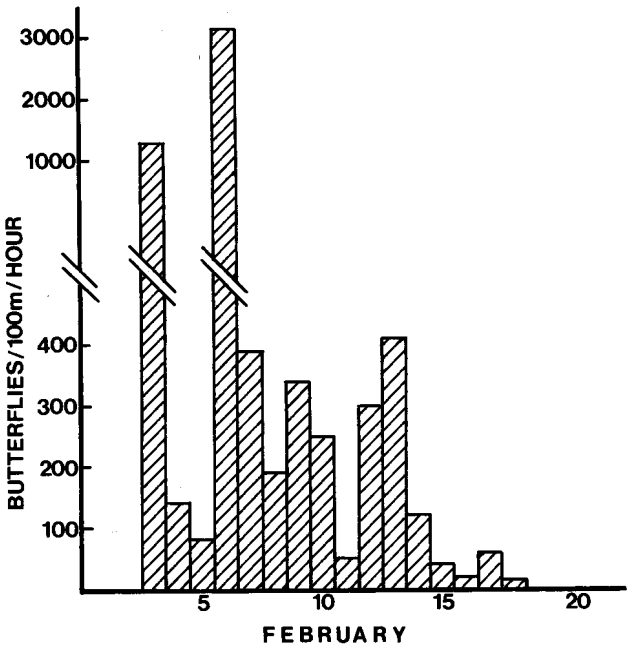

Fig. 1. Relative abundance of migrating butterflies, measured as number crossing a 100m front per hour, during February.

Phenology and general behaviour.- Figure 1 illustrates the phenology of appearance of butterflies in Bandar Seri Begawan. The initial migration began on 3 Feb 92 and lasted for about 20 days. Maximum numbers were recorded on the fourth day when over 3000 butterflies per hour were observed flying at about 8 km/h across a 100m front. The flight was steady, more or less in a straight line and always heading east, against the prevailing wind (records supplied for Brunei International Airport, courtesy of Department of Civil Aviation, Brunei). Butterflies were frequently seen flying in pairs with a male following a female but no other courtship behaviour was observed. The butterflies tended to be concentrated into streams following the line of valleys or open areas hence the density of the migration varied considerably at different localities around BSB (Fig. 2). Butterflies were on the wing from about 0900 hours to 1600 hours with maximum activity between 1000 and 1500 hours. A similar pattern occurred throughout coastal Brunei, with butterflies always flying east to north-east, although local variation did occur. For example on 5 Feb 92 relatively few butterflies were seen in BSB but many were reported at Serasa beach 20 kilometers away (W. E. Booth, pers comm). Each night the butterflies disappeared, presumably to form communal roosts in the mangroves and other favourable areas as is normal in the genus (Ackery & Vane-Wright, 1984). On the 22 Feb 92 heavy rain fell briefly over most of Brunei (Fig. 3) and migratory behaviour ceased. Almost no butterflies were to be seen in the open areas through which they had previously been flying but moderate numbers were observed for the next five days in patches of mangrove and secondary forest, actively flying, mating, searching and ovipositing.

Dry conditions returned and prevailed for the remainder of February and all of March (Figure 3) and, a week after the Febuary 22nd rain very few butterflies were to be seen anywhere. During March several minor eastward migrations occurred, lasting for one to three days, and during this period no mating or ovipositing butterflies were to be found in secondary forest. On the first and second of April there was once more widespread rain and this also resulted in considerable *Euploea* activity with many present in gardens and open areas, but no consistent directional migration was evident. At the same time numerous butterflies were observed at Lamunin and normal courtship and oviposition behaviour were observed.

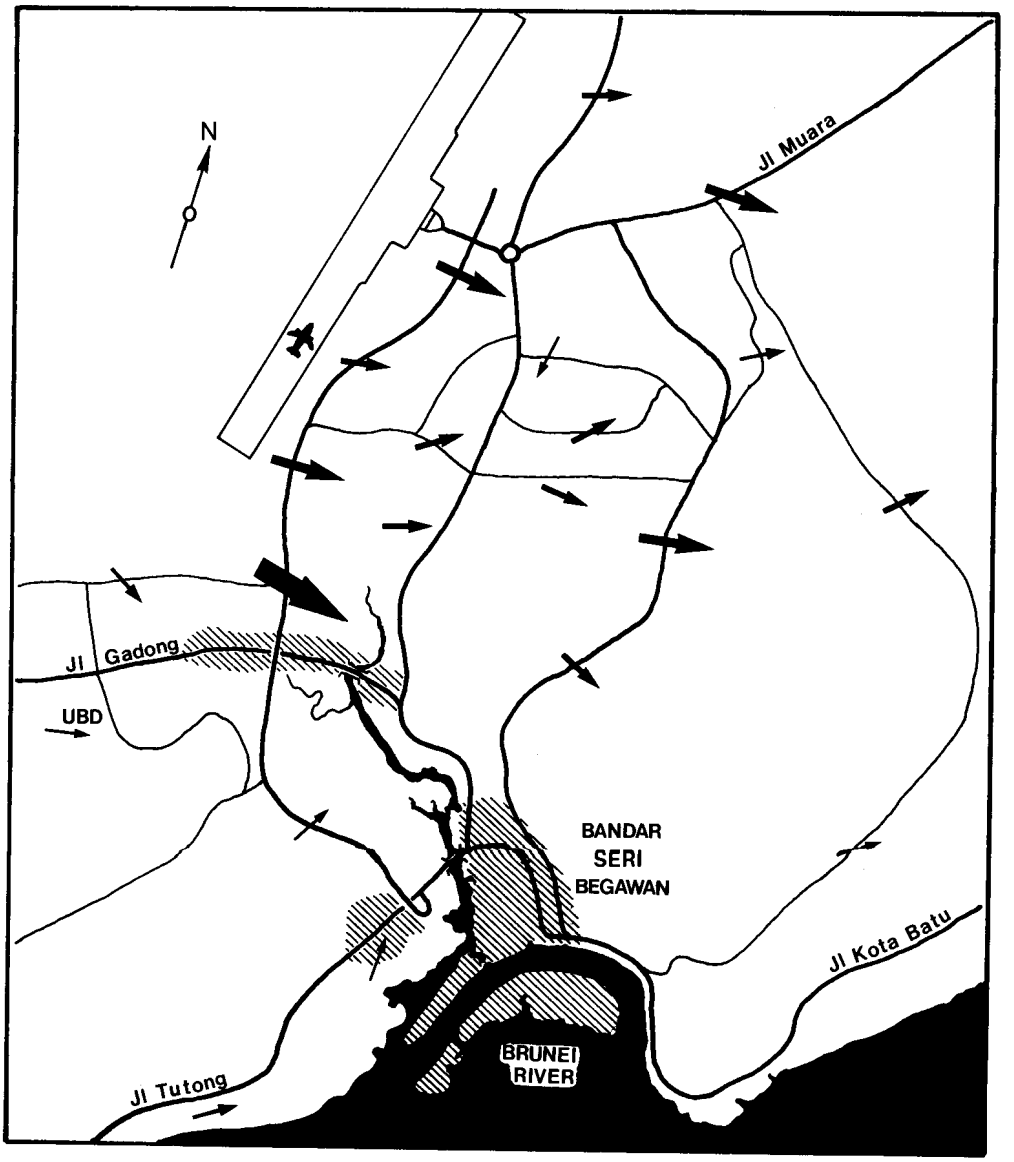

Fig. 2. Pattern of migration of butterflies around Bandar Seri Begawan on February 6th and 7th with arrows indicating direction of flight and arrow area approximately proportional to abundance. Hatching indicates heavily built up areas.

Sex ratios.- A preponderance of females was present in all migratory flights. At the beginning of the migration in February 73% of the migrating population was female (n=221) and the proportion of females in later samples remained high (67% on 13 Feb 92, n=180, 71% throughout March, n=105). The situation was reversed, however, immediately after brief periods of rain. The proportion of females in a small sample taken in secondary forest at Lamunin on 24 Feb 92, two days after rain was 41% (n=37), and the proportion of females in a sample taken in a garden in BSB on 5/4/92 was 39% (n=28). Neither of these differs significantly from 50%.

Age structure.- Age structure was estimated from the same samples using the scale loss index. On 6 Feb 92 most specimens were fresh or slightly worn with males on average being older than females. Over the study period the average age of both sexes tended to increase but there was always a substantial proportion of fresh or slightly worn individuals indicating a steady recruitment of newly eclosed butterflies (Fig. 4).

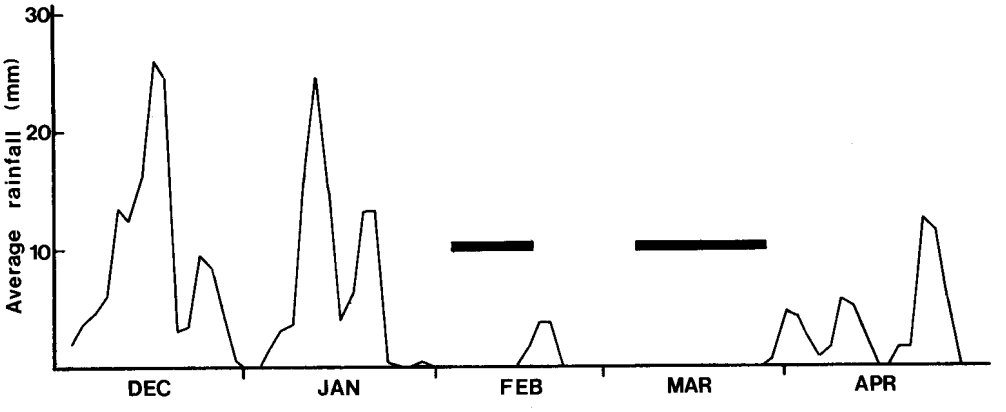

Fig. 3. Trends in rainfall in BSB from December 1991-April 1992. (Two point averages from a five point moving average, computed from daily rainfall records supplied by the Department of Civil Aviation, Negara Brunei Darussalam.) Horizontal bars indicate periods in which migratory behaviour was recorded.

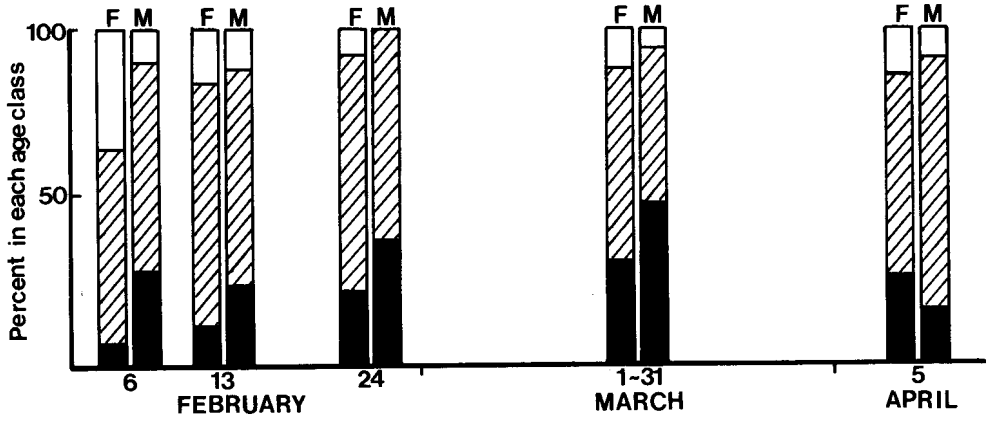

Fig. 4 Percentages of females (F) and males (M) in the age classes fresh (unhatched), slightly worn (hatched) and worn (solid), for each of the sampling periods.

Mated status and reproductive condition of females.- In general unmated females showed no ovarian development whatsoever, whereas mated females always had some chorionated eggs. Most migrating female butterflies sampled on 6 Feb 92 and 13 Feb 92 were unmated (Table 1) but the two exceptions, both captured on 13 Feb 92 were both mated twice and had depleted fat bodies and very worn wings. Females sampled in secondary forest on 24 Feb following rain were mostly mated, but never more than once, and the spermatophore was fresh, suggesting that mating had recently occurred. Three unmated individuals were in very fresh condition. Migrating females sampled throughout March included almost equal numbers of mated and unmated individuals. Mated females were all slightly worn to worn and were mated once only. Unmated females were either fresh or slightly worn. On 5 Apr 92, following a second period of rain all 10 females sampled were mated at least once, two were mated twice and two three times.

Table 1. The frequencies of mated females and females mated more than once in subsamples taken throughout the period of study.

date	6 Feb 92	13 Feb 92	25 Feb 92	March	5 Apr 92
sample size	20	20	11	15	10
number mated	0	2	8	7	10
number mated more than once	0	2	0	0	4

Other species involved.- In addition to *E. crameri* which accounted for 93 percent of migrating *Euploea*, there were small numbers of *E. algea* (Godart), *E. sylvester* (Fabricius), *E. rhadamanthus* (Fabricius), *E. mulciber* (Cramer), *E. eyndhovii* Felder& Felder and*E. phaenareta* (Schaller). Sample sizes were too small to say how closely these species paralleled *E. crameri* in reproductive biology and age structure but at least some differences were present. For example seven migrating female *E. mulciber* captured on 6 Feb 92 were all worn, mated at least once and with mature ovaries.

DISCUSSION

The results indicate two clear trends. Firstly, migratory behaviour was correlated with drought conditions (Fig. 3). Migratory behaviour ceased following rain, and although rain in April stimulated considerable activity this was definitely non-migratory as it did not involve concentrated directional flight. It is also apparent that short periods without rain such as occurred in early January and mid April do not induce migration and this is only observed after about ten days of little or no rain. There was no clear relationship between migratory behaviour and relative humidity which ranged from 75% to 91% throughout the study period.

Secondly migrating females were in reproductive diapause. Lack of ovarian development cannot be attributed to the fact that most of the females were obviously young. When development is not arrested female danaines exhibit some ovarian growth two days after eclosion and mature eggs are present five to seven days later (Orr, 1988). Thus if the female *E. crameri* were not in reproductive diapause the results of 2 Feb 92 and 13 Feb 92 would only have been obtained if the females sampled had all emerged within the last two or three days prior to sampling. This is highly unlikely, especially as several of the unmated females were distinctly

worn and were probably at least two weeks old. Moreover *Euploea* are known to live several months in the field (Orr, 1980) and it is possible that at least some of the butterflies observed in early April were alive in early February.

Once females have mated, reproductive diapause is probably broken, as they apparently continue to produce eggs despite the return of dry conditions. This was evidenced by a number of mated females with mature eggs in their ovarioles migrating in March. It seems more likely that mating, rather than rain per se breaks diapause, since older virgins in diapause were still present in March following rain, but rain probably triggers mating.

It is not certain what factors triggered migratory behaviour. However adult butterflies emerging in mid to late January would have encountered dry conditions and, like their congeners in New Guinea and tropical Australia, probably formed dense aggregations in sheltered humid refuges. Either environmental cues, or sexual harrasment of unreceptive females by males, or a combination of both could caused the break up of aggregations leading to migration to new refuges or to more favourable environments.

Acknowledgements.- I would like to thank Dr W.E. Booth, Dr J.K. Charles, Mstr Daniel Knowles, Mrs J.K. Orr, Mr I. Stephen and Mr S. Davies, for assistance in the field and for providing useful information. Climatological data were kindly provided by Haji Abdul Kadir bin Tengah of the Brunei Department of Civil Aviation, Meteorological service.

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