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MATINGS WITHOUT SPERMATOPHORE TRANSFER AND WITH TRANSFER OF TWO SPERMATOPHORES IN *CALLOPHRYS XAMI* (LYCAENIDAE)

Additional key words: spermatophore production, copulation, sexual selection.

In Lepidoptera, males normally transfer one spermatophore during copulation (Drummond 1984). However, some studies indicate that in some matings no spermatophore is transferred (although this does not necessarily means that the female is not inseminated; Drummond 1984). There are several possible explanations for this fact: (a) exhaustion of substances necessary for building spermatophores as a result of frequent mating (Drummond 1984); (b) male or female disabilities, such as deformations in the genitalia or in the reproductive tract resulting from disease or defective development; or (c) mate choice (rejection) after initiation of copulation by females (i.e., females somehow inhibit or prevent the transfer of spermatophores by certain males; Eberhard 1996) or by males (i.e., males avoid to transfer spermatophores to certain females). Mate rejection could be achieved by interrupting copulations before successful spermatophore transfer; in this case copulations are expected to be of short duration (Cordero 1993).

On the other hand, it has been found that sometimes males transfer more than one spermatophore in one copulation (Drummond 1984). This type of mating may be a male adaptation to sperm competition if the transfer of multiple spermatophores decreases female receptivity during a longer period (in several species there is a negative correlation between female receptivity and the degree of distention of the corpus bursa) (Drummond 1984) or if permits the transfer of more sperm (for example, if spermatophores can contain only a certain maximum amount of sperm). However, the transfer of multiple spermatophores may be disadvantageous for many species, since the last spermatophore needs to be at least partially digested before re-mating because sperm migration to the spermatheca requires proper alignment of the spermatophore tube with the ductus seminalis and this alignment is more difficult in the presence of another spermatophore (Drummond 1984, Simmons & Siva-Jothy 1998). Thus, an alternative hypothesis is that the transfer of more than one spermatophore in one copulation is result of a male disability.

The multiplicity of explanations, and the theoretical relevance of many of them, indicates that to report matings in which no spermatophore is transferred and in which multiple spermatophores are transferred, as well as its possible causes, is important. During the course of three laboratory experiments on spermatophore production by males of the lycaenid butterfly *Callophrys xami* (Reakirt) (Cordero 1998), in which I observed 199 copulations, I recorded five copulations in which no spermatophore was transferred and four in which more than one spermatophore was deposited in the female corpus bursa. I report these observations in Table 1.

My observations suggest two possible causes of failure in spermatophore transfer. First, three of the four timed copulations lasted less (between ~7 and 15 min) than the average duration (±standard error) of first copulations of the day recorded in the field (32.3 ± 4.9 min; Cordero 1993) or in the laboratory (26.2 ± 7.1 min, 32.9 ± 9.8 min and 35.9 ± 10.2 min, considering each experiment separately; Cordero 1998), suggesting possible "interrupted copulations" (Cordero 1993). However, only in one case I observed the female behavior associated with such copulations. I have discussed the possibility that mate choice (by females or males) after mating began may be the cause of interrupted copulations (Cordero 1993). Second, female deformation of the ductus bursa and corpus bursa may have precluded the transfer of a spermatophore in case D (Table 1). Lifelong male disabilities may be discarded in all cases since the virgin male (case A) transferred one spermatophore in a posterior copulation, and the four previously mated males (cases B–E) had transferred one spermatophore in a previous mating and two of them in subsequent matings (Table 1). Although the possibility of male exhaustion of substances necessary for building a spermatophore cannot be discarded in the case of the male that mated twice in a day (case C), we have observed several second matings of the day and in all cases one spermatophore was transferred. From my observations, I cannot suggest possible causes for the cases in which two spermatophores were transferred during one copulation.

It is unlikely that the "abnormal" matings reported in Table 1 are purely a product of laboratory conditions. Experimental matings were performed in cylindrical mesh cloth cages (58 cm height and 26 cm diameter) hung outdoors in the natural habitat of *C. xami*, by individuals born in captivity. These conditions are artificial because territorial behavior (matings in the field are always performed by territorial males; Cordero & Soberón 1990, Cordero et al. 2000) and the initial aerial components of courtship (Cordero 1993) were prevented by the experimental method. However, in captivity all the non-aerial phases of courtship and copulation itself are, as far as I can tell, similar to those of occurring in the wild (Cordero 1993). Furthermore, the duration of matings in captivity and in the wild was very similar (see previous paragraph). Finally, the 190 experimental "normal" matings in which one spermatophore was transferred and the nine "abnormal" copulations occurred under apparently similar conditions (in fact, all "abnormal" copulations occurred in days in which "normal" matings were also observed).

TABLE 1. Male mating status previous to relevant copulation and mating duration (MD) in which no spermatophore was transferred and in which two spermatophores were transferred by male *Callophrys xami*.

Male mating status	MD (min)	Comments
Copulation without spermatophore transfer (n = 5)		
A. Virgin	15	We tried to re-mate this male the same day without success; the next day he mated (31 min) and transferred two spermatophores (see case G); in a third mating he transferred one spermatophore
B. Mated once	10	Previous mating seven days before; male transferred one spermatophore in his first mating
C. Mated once	?	Previous mating the same day; male transferred one spermatophore in his first and in three subsequent matings
D. Mated once	~7	During four min the female was moving as in the "interrupted copulations" reported in Cordero (1993); this male mated the previous day during 20 min and transferred an spermatophore
E. Mated once	38	The female had deformed ductus bursa and corpus bursa; this male transferred an spermatophore in his first (two days before) and in a subsequent mating
Copulation with transfer of two spermatophores (n = 4)		
F. Virgin (n = 3)	~18, ~25, ?	These males transferred an spermatophore in their two, two and four posterior matings, respectively
G. Mated once	31	Male of case A

Although matings without spermatophore transfer and matings in which more than one spermatophore is transferred may be adaptive for males or females, they have negative effects on the fitness of at least one of the sexes (see above). The strength of the selective pressures exerted by the causes of these types of copulations is correlated with the frequency of such copulations. The nine "abnormal" copulations reported in Table 1 correspond to 4.5% of all copulations observed during the three experiments (n = 199); and the eight males involved correspond to 10.5% of all experimental males (n = 76).

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PAPILIO DEMOLEUS (PAPILIONIDAE) IN BORNEO AND BALI

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

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

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

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

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

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

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