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SOME ASPECTS OF MATING BEHAVIOR IN BUTTERFLIES

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Mating butterflies tend to remain nearly motionless. As a result we witness the activity infrequently and our knowledge of it remains extremely limited. Two kinds of mating data, however, are reasonably accessible to the general observer and give promise of increasing value as more records accumulate: the time of day when mating occurs; and the sex of the active (flying) partner. The first requires simply a notation of the time of day. The second is not so simple. In many cases mated pairs must be disturbed deliberately to cause them to fly. The determination of the sex of the one that flies, however, is by no means easy in those species where the sexes closely resemble one another.

For several years each of us has been noting this information as opportunity presented during the course of collecting. In January, 1966, when we went to Mexico as the Carnegie Museum-Catholic University of America Expedition, gathering additional records was on our agenda. Our accumulated observations are given in the present paper. We have added such published records as we have been able to find, but we have made no intensive literature search.

The absolute necessity for accurate reporting (which includes admission of doubt or deletion of a questionable datum) is underscored by the curious paper of Pronin (1964) on this subject. We cite his records, but we consider all of them uncertain and several, which we indicate, are highly questionable. The latter (cf. *Aporia crataegi*, Pieridae; *Danaus plexippus*, Danaidae) contradict several to many others, and cast doubt on the rest of his records. This opinion is reinforced by his numerous unwarranted conclusions and unsupported categorical statements. For example, he gives (p. 40) a table of the mating times of ten species of butterflies, all periods of an hour or less (and no indication of how many pairs of each species were observed). Immediately following the table he states, "Thus, each species of butterfly . . . has its own definite mating time." The conclusion is certainly not legitimately derivable from his data and is, furthermore, incorrect (see records below of *Pieris rapae, Euptychia cymela, Erynnis juvenalis*).

In the following list we use these abbreviations: DC, District of Columbia and vicinity; PNR, Powdermill Nature Reserve (9 miles south of Ligonier, Westmoreland County, Pennsylvania); and CM-CUA, Carnegie Museum-Catholic University of America Expedition to Eastern Mexico, 1966. We include in the list only those records in which either the time of day, or the sex of the active partner, or both, is recorded, and add the data of the observation. To save space, and because the precise locality is not of critical importance, we usually give only the state or country in which the observation was made.

PAPILIONIDAE

There are only Pronin's (1964) records of *Papilio machaon* Linnaeus (EUROPE, 1–2 P.M., \Im flying) and *Papilio multicaudatus* Kirby (CALI-FORNIA, 2–3 P.M.).

PIERIDAE

Records are particularly numerous in this family. Mating of pierids apparently takes place in the late morning to early afternoon (but note early morning record of *protodice*). The male is the active partner in nearly all records.

Pieris rapae (Linnaeus) PENNSYLVANIA (PNR), 6.V.1964, 11:35 A.M. and another 3:35 P.M. (HKC). Iowa, & flying (LDM). DC, & flying (Clark, 1932) EUROPE, & flying (Pronin, 1964) Pieris napi (Linnaeus) EUROPE, & flying (Pronin, 1964) Pieris virginiensis Edwards PENNSYLVANIA (PNR), 23.IV.1964, 1:20 P.M., & flying; and another 1:30 P.M., 3 flying (HKC). Pieris protodice Boisduval & Le Conte New Mexico, 21.VII.1963, 9:30 A.M. (HKC). Aporia crataegi (Linnaeus) EUROPE, 9 flying (Pronin, 1964) [record questionable] Appias d. drusilla (Cramer) TAMAULIPAS (MEXICO), 9.I.1966, 2:25 P.M., & flying (CM-CUA). Catasticta n. nimbice (Boisduval) HIDALGO (MEXICO), 13.I.1966, 12:30 P.M., & flying (CM-CUA).

Colias eurytheme Boisduval

Iowa, & flying (LDM). DC, & flying (Clark, 1932).

Colias hyale (Linnaeus)

EUROPE, & flying (Pronin, 1964).

Colias croceus Fourcroy

ENGLAND, August 1964, ca. 2:30 P.M. Disturbed on four occasions, the 3 flying each time (M. Clifton).

Eurema daira (Godart)

VERACRUZ (MEXICO), 16.I.1966, 2:40 P.M. (CM-CUA).

Eurema lisa Boisduval & Le Conte

VERACRUZ (MEXICO), 16.I.1966, 1:45 P.M., & flying (CM-CUA).

TAMAULIPAS (MEXICO), 26.I.1966, 12:55 P.M., & flying (CM-CUA). GEORGIA, 9.IX.1966: A mated pair was repeatedly disturbed. On the first two occasions the male flew; on the third, the female; on the fourth to sixth, the male. When the female took the lead the cover may have been so dense that the male could not fly (LDM).

FLORIDA, 22.III.1967, 10:55 A.M., & flying (LDM).

DANAIDAE

With the exception of Pronin's doubtful record, males are the active partner exclusively in danaids. The observations of Brower et al. (1965) are particularly significant, as they were part of an extended study of D. berenice courtship behavior and many pairs were observed.

Danaus plexippus (Linnaeus)

Iowa, VII, VIII, afternoon, several pairs, & flying (LDM).

CALIFORNIA, 9 flying (Pronin, 1964) [record questionable].

No LOCALITY, & always flying (Urguhart, 1960: 52).

Danaus gilippus strigosus (Bates)

ARIZONA, VIII.1958, afternoon, at least 2 pairs, & flying (LDM).

VERACRUZ (MEXICO), 16.I.1966, 3:30 P.M., & flying (CM-CUA).

Danaus gilippus berenice (Cramer)

FLORIDA, betw. 22.VII-11.VIII.1960 and betw. 2.VII-11.VIII.1961, betw. 2-5 P.M. (EST), many records, & always flying (Brower et al., 1965).

SATYRIDAE

Another well represented family. Females, without exception in the records, are the active partners, and matings take place from late morning to mid-afternoon, with a distinct predominance of records in early afternoon.

Cercyonis pegala maritima (Edwards)

MASSACHUSETTS, 27.VII.1964, 1:00 P.M. (HKC).

Cercyonis pegala (Fabricius), subspecies

PENNSYLVANIA, 23.VII.1961, 1:30 P.M., 9 flying (LDM).

Euptychia cymela (Cramer)

PENNSYLVANIA (PNR), 28.V.1964, 12:45 P.M., 9 flying; 5.VI.1964, 2:00 P.M.; and 3.VI.1965, 1:30 P.M., 9 flying (HKC).

Euptychia hermes (Fabricius) complex

VERACRUZ (MEXICO), 18.I.1966, 1:30 P.M., ♀ flying (CM-CUA).

Maniola jurtina (Linnaeus)

ENGLAND, 5.VII.1964, 1:30-3:00 P.M., 2 pairs, 9 flying (LDM). EUROPE, 9 flying (Pronin, 1964).

Melanargia galathea (Linnaeus), Erebia medusa Schiffermuller, Pararge aegeria (Linnaeus), Aphantopus hyperanthus (Linnaeus): all Europe, all & flying (Pronin, 1964).

Pierella l. luna (Fabricius)

Costa Rica, 18.VIII.1963, 11:00 A.M., 9 flying (LDM).

Pierella helvina incanescens Godman & Salvin

Costa Rica, 18.VIII.1963, 11:00 A.M., 9 flying (LDM).

Nymphalidae

There is much diversity in this family in the sex of the active partner. Females clearly predominate, but note the exceptions: *Speyeria nokomis* (sometimes) and *Anartia fatima* (but not *Anartia jatrophae*). Mating time may vary from group to group. The records suggest (hardly forcefully at this point) that *Phyciodes* and *Anartia* may mate in late morning, *Speyeria* in early afternoon, *Nymphalis* in mid afternoon and *Vanessa* in late afternoon.

Euptoieta claudia (Cramer)

NUEVO LEON (MEXICO), 2.VII.1966, 10:30 A.M., & flying (C. J. McCoy, Jr.). Speyeria cybele (Fabricius)

Iowa, 27.VIII.1956, \heartsuit flying (LDM).

Speyeria aphrodite (Fabricius)

PENNSYLVANIA (PNR), 8.VII.1965, 12:30 P.M., 9 flying (HKC).

Speyeria idalia (Drury)

DC, 9 flying (Clark, 1932).

Speyeria nokomis nokomis (Edwards)

COLORADO, 2.IX.1965, 2:30 P.M., $\hat{\sigma}$ flying (F. M. Brown). Mr. Brown has since observed a number of mated pairs of this species. On some occasions the male took the lead, on others, the female.

Argynnis paphia (Linnaeus)

EUROPE, VII, 9 flying (Pronin, 1964).

Phyciodes tharos (Drury)

DC, 9 flying (Clark, 1932).

PENNSYLVANIA (PNR), 25.V.1961, 12:00 noon (HKC).

NEW YORK, 3.VIII.1966, 1-2 P.M. (Sister M. Celestine).

Phyciodes phaon (Edwards)

TEXAS, 8.VII.1963, 10:00 A.M. (HKC).

Asterocampa leilia (Edwards)

TAMAULIPAS (MEXICO), 8.I.1966, 11:00 A.M., 9 flying (CM-CUA).

Anartia jatrophae luteipicta Fruhstorfer

TAMAULIPAS (MEXICO), 8.I.1966, 11:00 A.M., 9 flying (CM-CUA).

Anartia fatima (Fabricius)

COSTA RICA, 6.VIII.1963, 10:00–12:00 A.M., & flying (LDM).

Limenitis bredowii (Geyer)

CALIFORNIA, VIII, 2–3 P.M., 9 flying (Pronin, 1964)

Vanessa atalanta (Linnaeus)

Russia, V, 4:15 P.M. (Pronin, 1964).

Vanessa cardui (Linnaeus)

Russia, VII, 6:00 P.M. (Pronin, 1964).

Nymphalis antiopa (Linnaeus), N. polychloros (Linnaeus), N. io (Linnaeus), N. urticae (Linnaeus), Polygonia c-album (Linnaeus): all Russia, IV, 2–3 P.M. (Pronin, 1964).

Lycaenidae

All the reliable records indicate that the female is the active partner in this family. There are, however, several possible exceptions: those of Pronin (1964) which are uncertain; and several, not listed, observed by HKC with sex determination doubtful. Mating time is exceedingly varied, from mid-morning to early evening.

The possible restriction of mating in some species (*crysalus, acadica, augustinus iroides*) to the hours of early evening is noteworthy and so far known only in this family.

Hypaurotis crysalus (Edwards) COLORADO, 11.VIII.1962, 7 P.M. (Chambers, 1963). Satyrium acadica (Edwards) MICHIGAN, 22.VII.1951, 6-7 P.M., several pairs; and 24.VII.1951, 6-8 P.M., several pairs (HKC). CONNECTICUT, evening (teste C. L. Remington, Chambers, 1963). Chrysophanus titus (Fabricius) PENNSYLVANIA, 22.VII.1961, betw. 12:00-2:00 P.M., 9 flying (LDM). Callophrys (Incisalia) henrici (Crote & Robinson) NEW YORK, 7.IV.1906, 10:30 A.M. (Cook, 1907). Callophrys (Incisalia) augustinus iroides (Boisduval) CALIFORNIA (Contra Costa Co.), 24.V.1963, 5:30 P.M. (PDT); 26.V.1963, 5:20-7:45 P.M., 2 pairs (sunset); 30.V.1963, 5:15 P.M. "Although . . . individuals often perched on the tree during midday hours, none were seen mating earlier than 5:00 P.M. (4:00 P.M. P.S.T.)." (Powell, 1964). Lycaena phlaeas americana Harris PENNSYLVANIA (PNR), 16.IX.1965, 1:15 P.M. (HKC). Lycaeides melissa (Edwards) NEW MEXICO, 23.VII.1963, 2:00 P.M. (HKC). Plebeius argus (Linnaeus) and Polyommatus icarus (Rottemburg) EUROPE, VII, & flying (Pronin, 1964). Maculinea arion (Linnaeus) EUROPE, VIII, 9 flying (Pronin, 1964). Everes c. comyntas (Godart) PENNSYLVANIA, 14.VIII.1952, 6:30 P.M. (HKC). Everes comyntas texanus Chermock COSTA RICA, 11.VIII.1963, betw. 11:00 A.M.-1:00 P.M., 2 pairs, 9 flying (LDM). VERACRUZ (MEXICO), 16.I.1966, 3:05 P.M., ♀ flying (CM-CUA). Celastrina pseudargiolus (Boisduval & Le Conte) MICHIGAN, 29.IV.1951, betw. 11:30 A.M.-1:30 P.M. (HKC). HESPEBIIDAE

As far as records indicate, only the female is the active partner in hesperiids. There is a marked preponderance of records in mid to late afternoon.

Polythrix asine (Hewitson)

COSTA RICA, 3.VIII.1963, betw. 11-12 A.M., 9 flying (LDM).

Cogia calchas (Herrich-Schäffer)

COSTA RICA, 2.VIII.1963, 3:30 P.M., 9 flying (LDM).

Erynnis juvenalis (Fabricius) PENNSYLVANIA (PNR), 25.V.1961, 2:00 P.M. (HKC). PENNSYLVANIA, 10.V.1964, 1:20 P.M., 9 flying (LDM, HKC). MARYLAND, 11.V.1965, 4:00 P.M., 9 flying (HKC). Adopaea s. sulvestris (Poda) ENGLAND, 5.VII.1964, betw. 1:30-3:00 P.M., 9 flying, 2 pairs (LDM). Polites peckius (Kirby) PENNSYLVANIA (PNR), 3.VI.1965, 4:20 P.M., 9 flying; and 5.VIII.1965, 3:20 P.M., \mathcal{Q} flying (HKC). Euphyes conspicua conspicua (Edwards) DC, 9 flying (Clark, 1932). Hesperia columbia (Scudder) [CALIFORNIA], 2:15 P.M. (MacNeill, 1964:30). Hesperia juba (Scudder) WESTERN UNITED STATES, Q flying, 2 pairs (MacNeill, 1964:30). Hylephila phyleus (Drury) FLORIDA, IX.1962, ca. 4 P.M., 9 flying (J. N. L. Stibick).

DISCUSSION

Not surprisingly, more questions are raised than answered by the foregoing data. Even so, a few generalizations are possible and a few thoughts are suggested by the data.

1. Mating time of day. We give (fig. 1) frequency polygons of the observed flight times for each of the major families. They include even rough records, and are not corrected for Daylight Saving Time, so they are crude representations. We intend them to show only (a) that much variety exists; (b) that the Hesperiidae appear to mate somewhat later, on the average, than others; and (c) that the evening mating of some Lycaenidae is a significant departure from the norm.

The polygon of combined records (bottom figure) shows a marked peak between the hours of 1:00 and 3:00 P.M., the hottest part of the average day. This, together with the great variability in observed times of some species, suggests that clock, or solar, time may be of less significance in a particular mating than the ambient or antecedent weather. Despite the rarity of observations of mated pairs in the field, it is remarkable how many of the above records consist of two or more pairs seen on the same day, even the same hour. This may be additional indication that appropriate weather conditions are important.

Early evening mating in some lycaenids is well established; and late afternoon mating in some Hesperiidae also seems to be indicated. The significance of these facts we cannot even guess; nor can we explain the difference between such close relatives as *Callophrys (Incisalia)* henrici (morning mating) and *C. (I.)* augustinus iroides (evening mating).

2. Mating date. The calendar date on which mating occurs means little by itself; but taken in conjunction with the local flight period of



EXPLANATION OF FIGURE

Fig. 1. Frequency polygons of observed mating times in various families. P = Pieridae; S = Satyridae; N = Nymphalidae; L = Lycaenidae; H = Hesperiidae. "all" = sum of all these, plus the Papilionidae and Danaidae. Note: (1) thesomewhat later average mating time in Hesperiidae; (2) the bimodality of theLycaenidae, with a significant secondary peak in early evening; (3) the peak ofall observations falling between 1–3 P.M., the warmest part of the average day. the species it may be quite significant. In *Euptychia cymela*, the Powdermill records are all very early in the flight period: mating apparently occurs shortly after eclosion of the tardier sex. This appears to be true also in *Pieris rapae*, *P. virginiensis*, and *Phyciodes tharos*. On the other hand, in *Satyrium acadica*, *Chrysophanus titus*, and possibly *Hypaurotis crysalus* and *Cercyonis pegala*, the records indicate that mating occurs much later in the flight period, perhaps even towards its end. In *pegala* it may coincide approximately with the first eclosion of the very tardy females, but this is not true in the lycaenids.

3. Sex of the active partner. Some families seem to be quite consistent: Pieridae (males), Danaidae (males), Satyridae (females), Hesperiidae (females). The Lycaenidae also may be consistent (females), but data are too few to be sure. In the Nymphalidae, although females predominate, there are several inconsistencies. Brown's observations that in *Speyeria nokomis* either sex may take the lead may untimately be found true of many other nymphalids. The behavior of *Eurema lisa* (Pieridae) suggests that even in consistent families the normally passive partner may take the lead in some stress situations.

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PACIFIC SLOPE SECTION-1968 MEETING

The fifteenth annual meeting of the Pacific Slope Section of the Lepidopterists' Society will be held September 6–8, 1968, at the University of California, Berkeley. The program will include a field trip and open house at the museum Friday, September 6; presentation of papers Saturday and Sunday; and a banquet Saturday evening. Collections of the California Insect Survey and library facilities of the Department of Entomology will be available for study. Details of the program will be mailed to all Pacific slope members and to others who request them, in August.