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AN UNUSUAL MALE AGGREGATION IN THE ODONATA: AN AERIAL MATING SWARM IN *PROTONEURA CARA* CALVERT AND NOTES ON OTHER MEXICAN PROTONEURIDAE (ZYGOPTERA)

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On several occasions aggregations were seen hovering high among trees beside streams in Mexico. Intermittent arrival of conspecific ♀♀ at some aggregations and their departure, sometimes in tandem, and the apparent absence of foraging within aggregations supports the inference that such aggregations are mating swarms. It remains to be discovered whether trees over which swarms form are potential oviposition sites for this sp., or are places in which both ♂♂ and ♀♀ overnight. Flying aggregations of ♂♂ in other spp. of Protoneuridae are described and discussed.

INTRODUCTION

In most species of Odonata the preferred place for the sexes to meet and mate, the 'primary rendezvous' sensu CORBET (1999), is at or very close to the oviposition site, which is typically at water. In some species mating can occur in more than one place or opportunistically, and not necessarily at water. Adults of some Anisoptera congregate in flight to prey on swarming insects. This behaviour must not be confused with the process of swarming itself, and so has been termed "swarm feeding" or more appropiately "swarm foraging" (CORBET, 1999: 360). In some species, such a foraging site can serve also as a rendezvous, as in the eocrepuscular *Neurocordulia xanthosoma* (Wllmsn) (WILLIAMS, 1976) and *Boyeria irene* (Fonsc.) (MILLER & MILLER, 1985). In the libellulid fliers, *Miathyria marcella* (Sel.) and *Tauriphila azteca* Calv., both active at mid-day, copulating pairs were detected occasionally within the foraging aggregation (GONZÁLEZ-SORIANO, 1997). However, flying aggregations apparently formed primarily or exclusively

for mating, have not been reported for any species of Odonata.

Here I describe a case of an aerial mating aggregation in the protoneurid zygopteran *Protoneura cara* Calv., and report observations on aerial aggregations in other species of Mexican protoneurids.

OBSERVATIONS ON *PROTONEURA CARA*

Protoneura cara is slightly sexually dimorphic. Males have a dark metallic thorax and an abdomen patterned with red-orange stripes, whereas females are similarly coloured but paler. Sexually mature females are easily distinguished from males in the field by the abdomen, in which segments 5-10 are widened because of the eggs inside.

In tropical areas of Mexico, adult *P. cara* are commonly seen flying along streams and rivers, either as solitary males or tandem pairs. In most localities, males patrol the water surface, apparently searching for ovipositing females. Males shift from one perch site to another without seeming to defend a particular area. Such behaviour has been termed 'cruising' and is employed by several other non-territorial Zygoptera, including species of *Enallagma* and *Ischnura* (BICK, 1972) and *Neoerythromma*.

Although in some places population density of *P. cara* is high, copulation has very seldom been witnessed. It perhaps occurs several meters from the water, probably high in the surrounding vegetation. However, I observed a copulating pair perched on grasses at the edge of a spring-fed pond near the city of Colima (Los Almeales) (19°14´N, 103°43´W) on 29 July 1996.

Oviposition occurs in tandem, and tandem pairs fly along streams and rivers searching for oviposition sites which consist of a variety of substrates, including submerged grasses, living roots and floating objects such as small pieces of wood. During tandem oviposition, the male remains erect, beating his wings.

In the Chamela preserve (19°30´N, 105°00´W), state of Jalisco, on 25 and 26 August and 22 October 1995, I observed (and video-recorded) a small aggregation of *P. cara* flying above the bank of a small temporary stream. The group consisted of approximately 6-8 males hovering in a mosquito-like fashion (i. e. remaining in a stationary flight in which males keep station) 4-5 m above ground level, 2-3 m from the stream edge. The aggregation occurred in a forest gap surrounded by small trees no more than 10 m high. All hovering individuals faced the same direction, apparently against the wind, and brief chases occurred within the group. No foraging activity was observed within the aggregation. On 22 October, after filming the male aggregation for a few minutes, I saw a flying *P. cara* female (easily recognised as a female by its wider abdomen) enter the male aggregation. After a few seconds, she departed unaccompanied, disappearing from my sight among the foliage of a neighbouring tree, without having been grasped for any male of the aggregation.

Aggregation behaviour by males was observed a second time in the region of

Huautla state of Morelos. On 11 July 1996 I discovered a small group of 4-5 males of *P. cara* hovering in the manner described above, near a bank of the Quilamula river (18°27´N, 99°02´W). However, in this particular area which I had visited monthly during a one-year period, most males employed the cruising behaviour described above. At this place I also observed a rather unusual behaviour in which males visited small trees and bushes growing along the water´s edge and repeatedly darted into the foliage, behaviour that is also probably directed toward the acquisition of receptive (ovipositing?) females because no foraging activity (e.g. gleaning prey from foliage) was seen during this activity.

The best observations and recordings of aggregation behaviour by *P. cara* were made on 3 March and 3 September 1997 in the area of San Buenaventura, state of Jalisco (19°47´N, 104°03´W), again during monthly visits. Here I observed a large aggregation (10-15 males) of *P. cara* above the bank of a permanent river in an open area surrounded by 4-5 trees (mostly *Salix* sp.) approximately 10 m high. At this site I was able to observe tandem formation within the aggregation, although I was not able to identify the site where copulation occurred. I returned briefly to the same site on two other occasions in 1997 and found the aggregation to be there whenever weather conditions appeared favourable.

On 19 September 1998 I returned to the same locality and saw a tandem formed within the aggregation. The next day a group of about five individuals formed at ca 10:00 h local time, (ca 2 hours before solar noon) and 15 min later the aggregation had increased to about 15 individuals. However, at 11:15 h, a sudden fall of rain caused the aggregation to disperse.

OBSERVATIONS ON OTHER MEXICAN PROTONEURIDAE

The following notes derive from field observations I made in several localities in Mexico.

In Los Tuxtlas area, state of Veracruz (18°35´N, 95°06´W), I observed in 1988 a group of unidentified zygopterans flying high (ca 7-8 m above ground level) in a swarm-like fashion far from water, near the top of a *Cecropia obtusifolia* Bertol. tree. Although I was not able to identify the species because of distance, I concluded, from the adults' overall morphology, that the aggregation consisted of Protoneuridae.

In August 1997, in the same area, another small group of 3-4 males of *Protoneura aurantiaca* (Lieft.) was seen hovering 3-4 m above ground level near the edge of a small stream.

In contrast to the behaviour described above for certain *Protoneura* species, in which males formed aggregations in open sites, I discovered approximately at 14:30 h Local Time (ca 2.30 hrs after solar noon) an aggregation of *Neoneura amelia* Calv. males at a shady place near the Rio Coy, in the state of San Luis Potosi (21°43´N, 98°58´W), on 31 August 1999. The group consisted of 6-8 males hovering at ca 2-3 m above ground level below the top of an unidentified tree around 40 m from

the river's edge. Some chases were observed among members of the group, and individual males combined periods of hovering flight with restless intervals, during which a male perched on the tip of a branch.

DISCUSSION

The Protoneuridae comprise a large zygopteran family, distributed throughout the Tropics, and the behaviour of component species is little known.

LIEFTINCK (1953) was apparently the first to point out the apparent dependence of protoneurids on trees. DAIGLE (1990) reported males of *Protoneura dunklei* Daigle perching ca 3-4 m high on the tips of leaves and branches of shrubs in sunny glades in La Vega Province, Dominican Republic. On 27 July 1990, at Misol-ha, Chiapas state, (17°23'N, 92°01'W) I discovered a large aggregation of males of *P. cupida* Calv. flying around bushes over small islets below a waterfall. Although no oviposition was detected at Misol-ha, one female of this species was seen ovipositing alone in non-aquatic vegetation growing at the edge of a small shaded stream in the Los Tuxtlas area. This observation reinforce the possibility that females of this species uses non-aquatic plants to oviposit at least in some part of their distributional range.

The affinity of protoneurids for trees and other types of vegetation, is perhaps functionally related to their oviposition behaviour, as manifest by *Selysioneura cornelia* Lieft. (LIEFTINCK, 1953) and *P. cupida* (González-Soriano unpublished), and/or by the tendency of both sexes to roost at night amongst foliage. The oviposition behaviour may also help to explain why males (e.g. in *P. cara* and *P. cupida*) appear to search around trees and bushes and perhaps why males aggregate high in forest gaps. However, more observations on the movements of receptive and ovipositing females are needed in order to understand the reproductive behaviour of this and other species of Protoneuridae.

The aggregation behaviour of *P. cara* is remarkable because it represents the first case of an aerial mating assemblage reported for any species of Odonata. In none of the instances reported here was the aggregation and hovering of males seen to be combined with foraging, as often occurs in Anisoptera (CORBET, 1999). In our observations of *P. cara*, the only apparent function of male aggregation was the acquisition of a mate. It is therefore appropriate to call these aggregations 'swarms' in the sense that this term is applied to mating assemblages of many Diptera (DOWNES, 1969), especially if, as seems to be the case, the protoneurid males are assembling over a visually perceived 'marker.'

More information is needed before this mate-finding tactic can be assigned with confidence to any of the categories of odonate mating systems so far proposed (WAAGE, 1984; CONRAD & PRITCHARD, 1992; FINCKE et al., 1997; CORBET, 1999). It will be necessary to decide, for example, whether the swarming of males over trees is functionally related to the role of trees as oviposition sites or if they

only use them as roosting sites. Pending further information, it may be appropriate to assign the protoneurid mode of mate finding to mating system 3 ("Hinterland rendezvous") proposed by CORBET (1999: 553). A remarkable feature of the behaviour of these male protoneurids is their ability to keep station while hovering, an activity that is energetically costly. It would be informative to determine how long each male remains in a swarm. Hovering by Zygoptera while foraging has been observed in *Chlorocnemis flavipennis* Sel., each adult hovering for about 10 min and 1 m from its nearest neighbour (LEMPERT, 1988), and in pseudostigmatids when preparing to pluck a spider from a web (e.g. FINCKE, 1992).

Finally, it is interesting to note that males of *P. cara* apparently employ at least three strategies for obtaining mates. The commonest one observed in this species throughout its range is to patrol above the water surface, a mode prevalent in other non-territorial zygopterans (BICK, 1972); less common modes are the swarming described above, in which males assemble in aerial aggregations, apparently waiting for receptive females, and searching amongst shore-side vegetation. The second (swarming) strategy was often seen in some places (e.g. the Jalisco sites), but was rare in others (e.g. the Morelos sites). The third (searching) strategy was observed only in the Morelos population and is uncommon in Zygoptera. However, the large male aggregations of *P. cupida* observed in Misol-ha suggests that the searching strategy is probably used by other species of protoneurids as well.

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