COURTSHIP DISPLAYS AND MATING BEHAVIOUR OF THREE SPECIES OF CHLOROCYPHIDAE (ZYGOPTERA)

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The mating behaviour of *Platycypha fitzsimonsi*, *Chlorocypha consueta* and *Rhinocypha unimaculata* is described and compared with that of *P. caligata* (described elsewhere). Generally, as in *P. caligata*, males of the first two (and possibly the third) species are territorial around oviposition sites, attract females to these and court them there. Unlike *P. caligata*, *P. fitzsimonsi* males use only the blue tip of the abdomen in female attraction and vibrate the expanded and cream-coloured tibiae differently in courtship. Differential recognition of these two different displays by females of the two species apparently allows their sympatric coexistence. Unlike the *Platycypha* species, *C. consueta* males only use their unexpanded white tibiae in the courtship display, i.e. not also in territorial interactions, which also involves display of the pink-red abdomen dorsum. *R. unimaculata* again uses its unexpanded white tibiae and femora in courtship but also displays iridescent green bands on its hind wing in a fashion similar to some *Calopteryx* courtship displays. Expectations of complex and varied courtship displays in most chlorocyphids appear justified.

INTRODUCTION

Together with the Calopterygidae, in which the courtship displays of many species have been described (cf. HEYMER, 1973; WAAGE, 1973), the Chlorocyphidae is often considered to be a major family with many species exhibiting courtship displays prior to the attainment of tandem and copulation (e.g. CORBET, 1962). These have however to my knowledge only been briefly described for *Platycypha caligata* (Selys) (e.g. CARPENTER, 1928; PINHEY, 1951; CONSIGLIO, 1974) and *Chlorocypha glauca* (Selys) (NEVILLE, 1960). I have elsewhere reported a detailed study of the mating behaviour of *Platycypha caligata* (ROBERTSON, 1982). Here I report subsequent observations on *Platycypha fitzsimonsi* (Pinhey) and *Chloro-cypha consueta* (Karsch), and describe the courtship display of *Rhinocypha unimaculata* Selys from a film made by Dr J.M. van Brink. The behaviour of these species is compared with that of *P. caligata*.

MATERIAL AND METHODS

P. fitzsimonsi was observed on the Umzimkulwana River in Oribi Gorge (Natal, S.A.; 30°42'S, 30°16'E), where it occurs sympatrically with *P. caligata*, on 28-30 March 1978 and 28-31 December 1978; and at a stream near the Royal Natal National Park (R.N.N.P.) (Natal, S.A.; 28°39'S, 29°02'E), where it occurs alone, on 20, 21 January 1981. At Oribi Gorge females were individually marked with unique codes of dots of "Humbrol" enamel paint on the thorax and abdomen. At the R.N.N.P. the meso- and metatibiae of males were painted white anteriorly.

C. consueta was observed on the Nyamataka River near the Vumba Mountains in Zimbabwe (19° 12°S, 32° 46'E) on 9, 12 December 1980.

Dr J.M. van Brink observed and filmed *R. unimaculata* on the Godawari Rivulet near the Royal Botanical Gardens in the Katmandu Valley, Nepal on 27 May 1973.

RESULTS

PLATYCYPHA FITZSIMONSI (PINHEY)

This species is similar to *P. caligata* in morphology and colouration, except that the males'tibiae are not as expanded, the tibial fronts are cream-coloured rather than bright white, and the abdomen dorsum is bicoloured with segments 1-4 red, 5 and 6 black, and 7-10 blue.

At both Oribi Gorge and R.N.N.P. the males defended territories around potential oviposition sites (sedge stems and driftwood at Oribi Gorge and driftwood at R.N.N.P.). Territorial interactions were not always as complex as in *P. caligata* (they often only involved chases), but all the behaviours described for *P. caligata* were observed at some stage, and males inspected oviposition sites by "treading" on them.

In the sympatric situation at Oribi Gorge the males of the two species were completely interspecifically territorial and defended similar oviposition sites. Indeed males were repeatedly observed to take over the territory of a nonconspecific and subsequently to use the same oviposition site. Interspecific territorial interactions did not appear as well structured as intraspecific interactions and usually simply involved vigorous chases with continuous display of the tibial fronts.

The mating behaviour of P. fitzsimonsi is generally similar to that of P. caligata. Males intercepted passing females and attracted them to their oviposition sites by displaying the dorsum of their abdomens. This differed from P. caligata in that only the last four segments, i.e. the blue part of the abdomen, were displayed by bending these down separately as a unit and

waggling them from side to side. Once the female had landed on the site and was examining it by making oviposition movements on it, the male courted in a similar fashion to *P. caligata* males by displaying the cream fronts of the tibiae. This courtship display differed from that of *P. caligata* in that it was less vivid because of the less expanded and cream-coloured tibiae, and also in that the tibiae were not vibrated separately but held together and swung vigorously from side to side. Receptive females flew up, allowed the male to copulate, and were then returned to the oviposition site in tandem by the male. Copulation duration was not measured but seemed similar to that of *P. caligata*, i.e. about 60 seconds. Twenty-two succesful and sixteen unsuccessful such interactions were observed at Oribi Gorge. All other interactions and courtships, i.e. not involving interception and attraction of the female and her examination of the site, were unsuccessful.

In the sympatric situation at Oribi Gorge males reacted to, intercepted, and attempted to attract any passing female. Their coexistence must therefore depend on differential mate recognition by the females of the two species. A brief attempt was made to establish whether this involved the differences in the males' attraction and courtship displays noted above. A major difficulty was that the cryptically coloured females of the two species were also indistinguishable to me. So females were caught in copula, marked, and subsequently considered to be of the species of the male with which they were caught. Observations of subsequent interactions by such females yielded the following results. Six P. fitzsimonsi females were subsequently successfully attracted by P. fitzsimonsi males and none by P. caligata males. All six mated. Four P. caligata females were attracted by P. caligata males (and one mated) and one by a P. fitzsimonsi male. Also, two unmarked females were observed being attracted by males of both species in succession. It appears that females respond preferentially but not exclusively to the attraction displays of conspecific males. The three interspecific attractions observed led to the female decamping when the male started courting. Although hybrid males were specifically searched for, none were found. Assuming such hybrids would be viable, their absence, and the above observations, suggest that interspecific attractions do not lead to copulation, probably because the courtship displays are different.

The importance of this difference in courtship displays was partially examined in another brief experiment conducted with the allopatric population at R.N.N.P. Some males' meso- and metathoracic tibiae were painted bright white to simulate those of *P. caligata* males (the prothoracic tibiae were too difficult to paint). Of 17 successful attractions of females by these males, 13 led to copulation. Clearly this change did not prevent females from recognising these males as conspecific. Perhaps the crucial difference between the two courtship displays is the difference in patterns of tibial vibration.

CHLOROCYPHA CONSUETA (KARSCH)

The males of this species have unexpanded tibiae which are white anteriorly, and the abdomen dorsum is uniform pink-red. Otherwise they are morphologically similar to the *Platycypha* species and the females are again very similar. The stream on which they were observed was similar to those where the *Platycypha* species are found in South Africa, i.e. swift-flowing and rocky with little emergent vegetation, and driftwood or treeroots for oviposition sites.

The behaviour of this species was generally similar to that of the *Platycypha* species but differed in the displays. The males were territorial around the oviposition sites which they examined as usual. However, the territorial interactions were completely unstructured, involved no tibial displays, and simply consisted of chases and jittery side-by-side and circular flights. Occasionally one male would fly in front of the other with his abdomen lowered, thus displaying the pink-red dorsum.

Males intercepted passing females and attracted them by displaying the entire pink-red abdomen as in *P. caligata*. The females examined the sites as usual while the males courted. Again the courtship display was different. The male displayed the white fronts of his tibiae by holding them together, without vibration or swinging, below the thorax. This created a small patch of white colour which was far less vivid than the *Platycypha* displays. At the same time the male arched his abdomen above his head in a dramatic display of the pink-red dorsum. As in the *Platycypha* species successful courtships led to copulation away from the oviposition site, after which the male returned the female to oviposit. Five measured copulations had durations of 101 ± 33 seconds. Of 18 such interactions observed, six led to mating. All other interactions away from oviposition sites were unsuccessful.

RHINOCYPHA UNIMACULATA SELYS

The males of this species have unexpanded tibiae, but the fronts of both the tibiae and femora are white. The abdomen dorsum is black but the distal two thirds of the hind wings are darkly pigmented. Approximately half-way along the hind wings there is a transverse hyaline band or window in this pigmented section, which reflects a brilliant green irisdescence. Again the females are cryptically brown-coloured.

The following is a description of a single courtship sequence filmed by Dr J.M. van Brink. The female was making oviposition movements on a piece of driftwood at the water surface and wing-spreading while the male courted her. The hovering male described an arc around and facing her while continuously displaying the white fronts of his legs in a similar fashion to C.

consueta, i.e. held stationary together, creating a clear white patch below the head. He repeatedly held the hind wings stationary, forward and downward for brief periods during the courtship while continuing to hover with the fore wings. This created a brilliant flashing display of the green bands on the hind wings. The pair apparently copulated away from the site and the male returned the female to oviposit on it.

DISCUSSION

The three species reported on here are members of three major genera of the family Chlorocyphidae. That they all exhibit male courtship displays supports expectations that most, if not all, chlorocyphids will be found to have courtship displays. For example, all the African species of *Chlorocypha* and especially *Platycypha* have coloured abdomens and most have at least some colour on the tibiae (PINHEY, 1966). Territoriality around potential oviposition sites may also be a characteristic of the family. This would fit my earlier speculation that there is a causal link between such territoriality and the evolution of courtship displays in odonates (ROBERTSON, 1982). Certainly the present observations do not conflict with this idea.

Two further points of speculation raised in the above paper may be considered. Firstly, mate recognition in these species consists of an initial visual recognition of the female by the male. This is followed by female recognition of the males' attraction and courtship displays. Differences in female colouration and male recognition of females is unlikely to be sufficient to facilitate species coexistence. Such sympatric coexistence in chlorocyphid species probably depends entirely on differences in male attraction and/or courtship displays, and female specificity in recognition of these, as appears to be the case for *P. fitzsimonsi* and *P. caligata* described here. Chlorocyphid male anal appendages are not used in taxonomy because they vary little between species, so specific female recognition of these (cf. ROBERTSON & PATERSON, 1982), if present, is probably also not important in sympatric coexistence.

Secondly, the finding that *C. consueta* males only use their coloured tibiae in the courtship display suggests that this colouration evolved in this context. On the other hand, that the *Platycypha* species only use the red posterior surfaces of their tibiae in territorial interactions demonstrates that at least this colouration evolved in that context. Thus tibial expansion and colouration in chlorocyphids may have evolved in either context. Clearly the diferent courtship displays of *C. consueta* and *R. unimaculata* evolved independently of territorial contexts and the discovery of still other courtship displays may be expected. The display of only the tip of the abdomen as a separately articulated unit has been observed here in *P. fitzsimonsi* and also in *Chloro*- cypha glauca (NEVILLE, 1960; R.M. Gambles, pers. comm.). It is probably used by all species with bicoloured abdomens as an attraction display, and perhaps, as a courtship display (NEVILLE, 1960).

It should be noted that I view the mating behaviour of these species in terms of the Recognition concept of species (PATERSON, 1980; 1981) and not in terms of isolating mechanisms or sexual selection. Thus the terms "attraction" and "courtship" are simply used as convenient descriptions of displays directed at and recognised by the females.

Finally, the display of the hind wing in *R. unimaculata* is similar to the various courtship displays described for some *Calopteryx* species (e.g. WAAGE, 1973). This is probably a convergence and suggests that many other species in other zygopteran families with coloured or iridescent wings may also have courtship displays involving these.

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