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SHORT COMMUNICATIONS

REPRODUCTIVE BEHAVIOUR OF *DIASTATOPS OBSCURA* (FABRICIUS) IN A RIVERINE ENVIRONMENT (ANISOPTERA: LIBELLULIDAE)

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The reproductive behaviour of this neotropical dragonfly is described in a riverine environment in NE Brazil. In areas used for reproduction, the ♂♂ behave like territorial perchers in order to defend the territories that will be used by ♀♀ during their oviposition. The preferences of the ♂♂ in reproductive territorial selection and the variation of their reproductive strategies are analyzed from an adaptationist point of view.

INTRODUCTION

The genus *Diastastops* Rambur is composed of eight species of neotropical distribution (PAULSON, 1998), characterized by large dark wings and small to medium size. It belongs, with *Perithemis, Zenithoptera* and *Palpopleura,* to the subfamily Palpopleurinae.

D. obscura is one of the smallest species of the genus. It presents some sexual dichromatism, in the wings and in the abdomen. Its larvae live as much in lotic environments (CARVALHO & NESSIMIAN, 1998) of moderate flow, as in lentic environments, in clean water with a well developed community of aquatic macrophytes.

Studies of neotropical libellulid reproductive behaviour have only just started (e.g. MAY, 1977; NOVELO-GUTIÉRREZ & GONZÁLEZ-SORIANO, 1984; HARVEY & HUBBARD, 1987; CONVEY, 1989; MICHIELS & DHONDT, 1990; DE MARCO et al., 2002.). Among neotropical palpopleurines, reproduc-

tion has been studied only in *Perithemis mooma* Kirby (WILDERMUTH, 1991, 1992) and *Diastatops intensa* (Montg.) (WILDERMUTH, 1994).

The objective of this work is to describe the *D. obscura* reproductive behaviour in a lotic environment, and to compare the most significant aspects with those described for *D. intensa* in lentic waters.

LOCALITY, MATERIAL AND METHODS

The research took place at three points in the middle stretch of the Pitimbu River, Rio Grande do Norte State, Brazil. It is a permanent watercourse of small dimensions (mean width in the stretch 8 m; mean depth in the stretch 90 cm), clean water and abundant aquatic vegetation (*Eichhornia crassipes, Nymphoides indica, Polygonum* sp., *Nymphaea* sp., *Pistia stratiotes, Spirodela* sp.) and semi-aquatic vegetation (*Monotrichardia* sp.) accompanying many Cyperaceae and Juncaceae). Adjacent to the river are inundatory herbaceous vegetation, pastures and small fragments of Atlantic coast rain-forest.

Observations were made by eye or with the aid of binoculars (Nikon Travelite IV 10 × 21). They were accomplished in three stages: 4 days in September 2002, 15 days between April and May 2003 and 5 days in July 2003, in a total 65 hours of observation in a natural environment. While the first stage used the *ad libitum* method (MARTIN & BATESON, 1993), in the two following we preferred to use continuous focal observation (MARTIN & BATESON, 1993) giving special attention to females and couples, with duration undetermined because of the beginning and ending of male-female interactions. A total of 102 males and 6 females of this species were measured and had their wings marked with numeric codes made with permanent pens to make monitoring of individuals possible.

MALE TERRITORIAL BEHAVIOUR

During the months of greatest activity (March-June), *D. obscura* males occupied the river after 07:15 h on sunny days; this time could be one hour later dur-

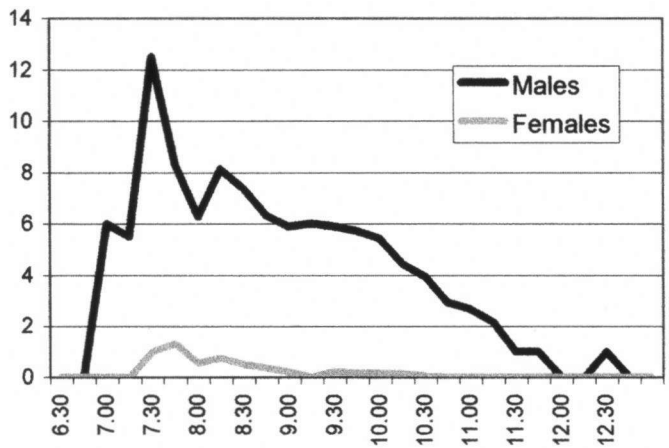

Fig. 1. Distribution and frequency of *D. obscura* males and females in reproductive areas: males arrive earlier and in a greater number than females, and they stay longer in the rendezvous.

ing the months in which imagos were scarcer. After then, the density of males increased quickly (Fig. 1) and, because of this, they started intense territorial activity trying to win and defend territories, mainly along the edge of the river. In a period of approximately two hours, all kinds of escalated conflicts between males occurred: horizontal pursuits, vertical chases, expulsions, changes in territorial ownership and fights with beating of wings. The greater the density of males in the area, the greater the frequency of fights and persecutions. During this time, three different male strategies could be observed in this area: river-bank territorial strategy; river-centre territorial strategy; and satellite behaviour, localized around the territories, where they tried to catch incoming females. After this highly energetic stage, a calmer phase succeeded in which the territories were defined and both the density of individuals and the agonistic interaction between males decreased. After approximately 11:00 h, the male density in the reproductive area decreased significantly until a few minutes after 12:00 h when no male was keeping territory. When rain appeared, they left the river earlier and this usually happened during the rainy season (March-July). In the afternoons, only sporadic solitary males could be seen at the river. On rainy days no males appeared at the rendezvous.

In the subsequent days, males that won and defended a territory the day before, showed a clear tendency to territorial fidelity.

MALE-FEMALE INTERACTION: SEXUAL BEHAVIOUR

The arrival of the females at the river was quite irregular: on 39% of the days their presence was not recorded in the studied stretch and on other days observations of their presence were concentrated in a few minutes (Fig. 2). The females

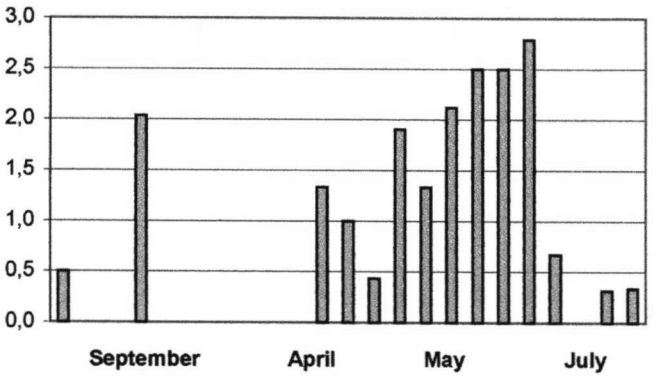

Fig. 2. Distribution of *D. obscura* females per hour of observation: much variation among months.

usually started arriving after 07:45 h. In the first hour, 55.7% of the total observed females arrived, and after 2½ hours this percentage had increased to 90.2%. After 10:30 h no female was recorded in the reproductive territories (Fig.1).

The females approached the rendezvous flying from the nearby arboreal-bush vegetation, or through the high grass when larger vegetation was far from the riverbank; this resembles what was described for *D. intensa* in a lentic environment (WILDERMUTH, 1994). Before flying over the river, the females made small, characteristic flights of a few centimetres, semi-hidden in the riverside vegetation. These flights are similar to the ones observed in males during hunting activity, characterized by a slow lowering of the four wings followed by a quick raising of the wings.

Once a female crossed over the riverbank and entered the field of vision of any territorial male, he flew after the female and tried to catch her in the air. In a tandem flight the male carried his partner to his territory. They perched on a leaf or an aquatic macrophyte twig and there copulation took place. At other times, copulation started during the tandem flight. The copulation is brief, its duration is between 3 and 7 seconds (mean = 5.23; s = 1.58; n = 25). After copulation, the female stayed on the perch, resting. The male became really agitated around the female for some seconds, then he perched close to his partner. If some other male approached, the guarding male would pursue it aggressively to repulse it, and come back quickly to his female. If not disturbed, the males waited for their female to start oviposition and guarded it while it was within their field of vision. In 18.8% of the observed copulations, the post-copulation rest was not followed by oviposition, but by the female's escape.

OVIPOSITION AND POST-COPULATORY MATE GUARDING

Oviposition occurred in one or, more frequently, two or three bouts, each lasting between a half and two minutes, interrupted by rest intervals. The guarding male repeated the same cadence of 'flight-alight' shown by the female, always really close to the female, except when it had to repel a competitor. The ovipositing female touched semi-decomposed floating or slightly submerged (up to 2 cm) vegetal structures with the tip of her abdomen. In some cases, oviposition occurred in more exposed areas, where the predominant vegetation was developed at a horizontal level; however, in other cases, the females sought shelter between the leaves of *Eichhornia* and other taller aquatic plants, where they oviposited stealthily. In these situations, the guarding males that were flying away from the plants often lost visual contact with their partners, and came back to their territories, where they made a nervous patrol flight before perching on one of their habitual perches.

Once oviposition ended or was disturbed by another male, the female left the river in a straight, fast and ascending characteristic flight, and sought shelter in

the neighbouring forest. When the density of territorial and satellite males was high, a female might copulate again; nevertheless, the general rule was that females clearly avoid the approach of a non-partner male. Males were observed abandoning the guarding of a female to copulate with another which had just arrived, and subsequently trying, at least partially, to guard both ovipositing females. There was evidence of male willingness to copulate repeatedly (a maximum of 5 copulations with different females in 37 min was recorded).

In 10.4% of observed ovipositions, the females approached the river flying fast and high, stopping in a central area of the river and ovipositing immediately without copulation or guarding. Even females that had probably copulated with males in another area tried to avoid males approaching to re-copulate.

DISCUSSION

D. obscura presents a territorial behaviour with some aspects similar to those found in many other libellulids. The males behave as perchers (HEINRICH & CASEY, 1978) in reproductive areas. They approach the river earlier than females and a phase of continuous agonistic interactions starts, trying to establish and defend territories, then a calmer phase occurs, when displays and visual communication between them become predominant.

The males establish their hierarchies and dominance of oviposition areas and the females arrive later in the reproductive area and spend less time there than males. When the females are ready to copulate, they fly down to the river and are intercepted by males still in the air; the males take them to their territories to copulate and oviposit. Apparently the females can choose where they appear in the river; however they do not seem to choose a partner for copulation. Usually, the first male to see a female and pursue it is the one with which she will copulate. Thus, the territories by the riverbank with a wider visibility must be the favourites for dominant males, and most copulations occur there (73.2% of the observed copulations). Weaker males must confine themselves to territories separate from the riverbank, where they have fewer options to catch a receptive female. In this way, the female will be fertilized by a dominant male whenever it approaches slowly and allows itself to be caught by the first male that sees it, because the male has to be strong enough to keep a riverside territory. This explains the strong competition among males to obtain a territory next to the river bank.

The copulation is short, as in the other palpopleurines (*D. intensa,* WILDERMUTH, 1994; *P. mooma,* WILDERMUTH, 1991) and some other libellulids (*Erythrodiplax connata,* DEL CARMEN-PADILLA & GONZÁLEZ-SORIANO, 1980; *Orthemis ferruginea,* NOVELO-GUTIÉRREZ & GONZÁLEZ-SORIANO, 1984). The female presents a post-copulatory rest, behaviour also described for other members of this family (MILLER & MILLER, 1989); oviposition may follow that rest (79.1% of observations). Oviposition can be accom-

plished in exposed places, such as on horizontally-growing aquatic vegetation (in that case the female is often guarded by the male which has just inseminated it), or in semi-hidden places, under vertical structures of taller macrophytes. As the male does not enter the dense vegetation it leaves the guarding of the female when it loses visual contact with her and comes back to patrol its territory. In any case, unlike what was described for *D. intensa* (WILDERMUTH, 1994), a second copulation is infrequent in *D. obscura* females. They avoid interaction with other males after being inseminated and, if males persist, the females often stop oviposition and leave the reproductive area. This behaviour can explain the sporadic appearance of non-receptive females ovipositing alone among the floating macrophytes in the centre of the river, far away from the great density of territorial males next to the riverbank.

The males possess a great ability to copulate; they can do it continuously. This is the advantage of non-contact guarding, already cited by other authors (ALCOCK, 1979, 1992; McMILLAN, 1991; CORBET, 1999), to the males of the species that present this behaviour, because they can copulate with a new female while they guard another female and defend their territories. Besides, the risk of losing inseminated females to other males is relatively low because the females often avoid a second copulation, so this behaviour justifies the absence of contact guarding in this species.

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