

SHORT COMMUNICATIONS

**PHENOLOGY AND OVIPOSITION BEHAVIOUR
OF *GYNACANTHA BIFIDA* RAMBUR IN BRAZIL
(ANISOPTERA: AESHNIDAE)**

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On 2 evenings in late Oct. 1999 several ♀♀ were observed laying eggs in almost dry mud and sand and under mosses, within a temporary pond system, surrounded by rain forest, nr Tiradentes, Minas Gerais, Brazil. The ponds are filled with water during the rainy season (Oct. – March) but dry up entirely by the end of the dry season (Aug. – Sept.). Data compiled from field records, odonatological collections and literature showed that in Brazil *G. bifida* stays on the wing throughout the year. Apparently, the sp. possesses a univoltine life cycle with 2 generations of larvae, one during the warmer rainy season and another in the early dry season (Oct./Nov. – Jan./Feb. and Feb./March – May/June, respectively). Mud attached to the terminal abdominal segments of ♀ specimens in odonatological collections was used as an evidence of an oviposition mode comparable to that observed in the field.

INTRODUCTION

Observations regarding the egg-laying behaviour of *Gynacantha* species from across the tropical and subtropical zones of the world, however scarce, show that females oviposit either in the mud or in vegetation associated with temporary ponds (cf. e.g. GAMBLES, 1960; FLETCHER, 1921; HAMADA & INOUE, 1985; WILLIAMSON, 1923). Since WILLIAMSON's (1923) observations in *G. mexicana* and *G. nervosa*, there have been only a few records on the egg-laying habitats and behaviour in the New World species (e.g. CARVALHO, 1987; CARVALHO & FERREIRA, 1989; CORBET, 1999; DUNKLE, 1976, 1989; KURI-BAYASHI, 1965; RAMIREZ, 1994; SANTOS, 1973, 1987; WILLIAMS, 1937).

CARVALHO & FERREIRA (1989) suggest that breeding habits of neotropical *Gynacantha* species indicate their preference for small marshes and temporary ombrophylous ponds or open places near forest cover. *G. membranalis* larvae, however, were also reported as occurring in tree holes in Panama, along with those of Pseudostigmatidae (FINCKE, 1984).

G. bifida is widespread in South America; it occurs in Brazil throughout the year and in the entire country, consequently, it is represented by the largest number of specimens in collections (CARVALHO, 1987). In spite of this, nothing is known on its oviposition behaviour. The species was observed ovipositing in October 1999 at the Serra de São José, Minas Gerais, Brazil. Those observations are discussed in detail below.

LOCALITY AND METHODS

Field observations were made at the Environmental Protection Area (Area de Proteção Ambiental – APA) São José, a State reserve, located ca 140 km S of Belo Horizonte, Minas Gerais, Brazil (21°5' S and 44°10' W). The APA São José has about 5000 ha and encompasses a diversified landscape along the São José mountain chain that includes, to the South, remnants of the atlantic rain forest; to the North, the cerrado (Brazilian savanna) and its gallery forests; and at its crest, altitudinal rocky fields. Altitudes vary between 800 and 1430m.

The mean annual rainfall amounts to ca 1435 mm. The dry season goes from April to September and peaks in July and August, when precipitation reaches only about 1,5% of the total. The wet season lasts from October until March, with over 51% of the total rainfall concentrated in December, January and February. The annual mean temperature is 19°C, with maximum and minimum mean values between 21-22°C (January - February) and 15-17°C (July - August), respectively. In the dry and colder season, night temperatures can occasionally drop to 12°C or below.

The area was visited more than 10 times over all seasons, from November 1996 through November 1999. Sweep net samples were taken at 35 collecting sites along the different types of moist habitats of the Serra and surroundings (including lentic, lotic, perennial and temporary ones). Whenever possible, evening catches were also made, averaging 2-3 occasions per field trip. Records on the abundance, life-stage and activity per species were treated as in SCHMIDT (1985), aiming the definition of a "Representative Spectrum of Odonata Species (RSO)", for use in biotope classification.

In order to identify for voltinism patterns in Brazil, 69 records of *G. bifida* were compiled. They include field data from the Serra de São José and surrounding municipalities, data from A.B.M. Machado's collection and records from the literature. When available, data include: collection date, age (depicted from wing condition: hyaline wings indicating a teneral, wings with coloration or signs of abrasion indicating a mature specimen), occurrence of late instar larvae and exuviae, and emergence of tenerals in the laboratory. The presence of mud on the terminal abdominal segments of female specimens was used as an indirect cue of the oviposition mode.

RECORDS OF ADULTS AND LARVAE

G. bifida is the most common of the four *Gynacantha* species at the Serra de São José area, followed by *G. adela* Martin and occasional records of *G. laticeps* Williamson and *G. nervosa* Rambur. Adult *G. bifida* were recorded in January, February, May, September and October, at different locations of the APA São José

and surroundings. These included gallery forest patches along clear acidic water mountain creeks, surrounded by pastures and remnants of cerrado (NW), along partly shaded trails in and around rain forest remnants, as well as at forest borders (SE and SW), in a house at the town of Tiradentes (SW), and around a small acidic water pool complex, surrounded by rain forest, at the foot of the quartzite cliffs (SW). Altitudes of the localities varied between 800 and 960m.

Aside of the oviposition records, most records were of males seen or captured flying in groups or alone, sometimes a few hundred meters away from the nearest water bodies. Most records were made between half an hour before sunset and darkness. On 13 May 1999, during the colder and drier season, *G. bifida* was seen flying as early as 17.40 h and at an evening temperature of about 18°C. On two occasions, a single male was captured in the early afternoon, while resting on a gallery forest tree after rainfall.

Late instar larvae were collected in January and February in two types of temporary pools. One of these was a small, shallow (ca 2-20 cm deep, when checked at the middle of the wet season) and fully shaded pool, located about 100 m inside a rain forest patch that bordered an urban wasteland in the town of Tiradentes. The substrate was muddy and covered with abundant leaf litter. The altitude is ca 900 m a.s.l.. Larvae collected on 12 February emerged in an aquarium on 1 March. The other habitat was a complex of four pools with acidic water, rocky and sandy substrate, surrounded by rain forest and located at the foot of the Serra (ca 960 m a.s.l.). At this time of the year the pools had water and several exuviae of *G. bifida* and *adela* were found. Most of the exuviae and some larvae ready for emergence were sitting ca 20 to 30 cm above the water surface, on large rocks. These rock pools also served as a reproductive site for *Aeshna cornigera planaltica*.

OVIPOSITION BEHAVIOUR

On 29 and 30 October 1999 we had the chance to watch *G. bifida*'s egg-laying behaviour. Several individuals started flying along a forest trail that winds up the southeastern slopes of the Serra, about 40 min before sunset. At about the same time, females started flying around the acidic water pool complex described above, at the end of the trail. The pools were completely dry, due to the advanced dry season. The substrate of the pools, then exposed, consisted of either white quartzite sand, mixed with stone blocks or a thin layer of mud, covered by newly grown grasses or mosses.

On both occasions, up to 10 or more females flew simultaneously around the pools, about half a meter to one meter above the ground, searching for oviposition sites. They would begin hovering ca 0,3 m above the borders and bottom of the ponds for a few seconds and then suddenly settle onto the substrate and start

laying eggs. This involved burying the abdomen tips for less than half to one minute; sometimes they vibrated their wings as well. Different kinds of substrate were chosen for laying the eggs, such as the almost dry sand, bare mud and piles of mosses. One female was seen crawling under a stick on the ground to reach the chosen ovipositing place. All specimens collected (9 females) showed broken abdominal appendages, contained ripe eggs and weighed 0.67 to 0.85 g (mean weight 0.75 (\pm 0.022 g)).

No males were seen or captured at the pools. Fifteen minutes after sunset they apparently stopped flying around, and further sightings were not possible due to full darkness. The air temperature in that period varied between 23°C and 25°C.

RECORDS FROM THE LITERATURE AND COLLECTIONS

A total of 69 records of adult and juvenile *G. bifida* were compiled for Brazil. These range from 1896 to 2000, and include 23 from the Serra de São José area and the surrounding municipalities, 42 from the A.B.M. Machado collection, and 4 from the literature (WILLIAMSON, 1923; SANTOS, 1970; RIS, 1913). The records cover the states of Paraná, Santa Catarina, Rio Grande do Sul, Rio de Janeiro, São Paulo, Minas Gerais and Goiás. Data on late instar larvae and adult emergence were obtained from Serra de São José and the literature (CARVALHO, 1987), and are summarized in Table I.

G. bifida stays on the wing throughout the year. Most records were made from November until March, corresponding to the rainy season in most of Brazil, while scant data are available for the dry season, from June to September.

Table I

Records of *G. bifida* compiled from field captures at the Serra de São José, MG; A.B.M. Machado collection and literature: 1 = Serra de São José and surroundings, specimen collected; - 1* = Serra de São José and surroundings, sighting; - 2 = A.B.M. Machado collection; - 3 = CARVALHO, 1987; - 4 = SANTOS, 1970; - 5 = WILLIAMSON, 1923; - 6 = RIS, 1913

Behaviour/Month	J	F	M	A	M	J	J	A	S	O	N	D
Mud / Oviposition			2							1;2	2	
Late instar larvae	1		3							3		
Emergence	1		1	3							3	
Juveniles	2;1	1	2				2		1			
Mature	2	2;1	2	2	2	2		2		2;1	2	
On the wing	5;2	2;1	4;2	2	2;1*	2	2	2	1	5;2;1	2	6
Number of records	9	16	16	3	4	1	1	1	1	11	5	1

Late instar larvae were reported for January (Serra de São José area), March and October (CARVALHO, 1987), and emergence was evidenced in January at the Serra de São José area, and in March, April and November under laboratory conditions (CARVALHO, 1987). Teneral were captured from January through

March and again in July and September (Serra de São José area and A.B.M. Machado collection).

Oviposition records were made in October for the Serra de São José area, and traces of mud were found on the terminal abdominal segments of 5 females (19% of the 26 mature females in the A.B.M. Machado collection), captured in March, October and November. No such traces were found in males. In 3 of the female specimens, a large amount of dried mud was present on the lateral parts of the tergum of abdominal segments 9-10 (one specimen with traces of mud also on the dorsal tergal parts), including the styles. Large amounts of mud were also present on the sternum of segments 8-9, including the base of the bifid dentigerous plate and on the ventral surfaces of the appendages. The remaining 2 specimens had a small amount of dried mud at the base of the bifid dentigerous plate, and one also had mud attached to the lateral part of tergite 9.

DISCUSSION

Like other American *Gynacantha* species, *G. bifida* is found to fly relatively far from water while hunting, sometimes in large groups (SORIA & MACHADO, 1982). Frequently it can be spotted near forest edges, around bush patches and green fences. Apparently, it prefers hunting along unimpeded shaded tracks, such as forest borders, shaded trails and small roads, green fences or creeks. This could also be the reason why *G. bifida* is often found in gardens and buildings, while in the pursuit of insect prey attracted by city lights (CARVALHO, 1987).

As to the phenology of *G. bifida*, the data confirm the statement by CARVALHO (1987) that the species occurs in Brazil throughout the year. Most records were made during the wet season, between November and March. Whether this concentration of records reflects actual annual abundance patterns or simply biased collecting efforts remains to be investigated.

CARVALHO (1987) reported that *G. bifida* breeds in small, open, temporary water bodies, in peripheral areas of rain forests, similar to the pools where we found larvae and exuviae and witnessed the oviposition at the Serra de São José. The records of adults in the valleys of two mountain creeks at the northern side of the Serra seem to support the use of temporary forest ponds as oviposition habitat, since the surroundings of these gallery forests, albeit covered by open farmland, have no temporary or permanent ponds. These records fit the observations by SANTOS (1973) for the Gynacanthini.

The oviposition behaviour in *G. bifida* is very similar to that in *G. mexicana* (WILLIAMSON, 1923) and *G. nervosa* (WILLIAMS, 1937; DUNKLE, 1976). Consistent with the observations of DUNKLE (1976), no *G. bifida* males were seen disturbing the females during oviposition. It is possible that males were mostly hunting along the forest trails at that time and trying to mate there, as was observed for *G. mexicana* in the Amazon.

In the Gynacanthini, the use of temporary pools as larval habitat involves burying eggs within muddy substrates of dry pond basins, possibly thus providing them with better insulation from high temperature and low humidity during the dry season, reducing the risk of desiccation, especially of the very young larvae. Specialized morphological features, such as the female's highly sclerotized ninth sternite and the two-pronged fork, are apparently used for scratching a hole in the mud or to anchor the end of the abdomen while the ovipositor is driven into the substrate (CORBET, 1999).

The finding of mud traces in the terminal abdominal segments (more constantly at the base of the bifid dentigerous plate) of 19% of the mature females and its complete absence in all males examined in the A.B.M. Machado collection corroborates the present observations on the actual oviposition of *G. bifida* in nature and what has been described for the oviposition of *G. mexicana* and *G. nervosa* by WILLIAMSON (1923). The fact that most mature females have no mud in their last abdominal segments does not mean that they have not yet laid eggs. It might simply indicate that the dried mud had already got loose from the abdomen or that the female oviposited in drier substrates or mosses, thus not leaving traces on her abdomen. The presence of mud, mainly on the ventral parts of the terminal abdominal segments, indicates that most females do not dip their abdomens completely into the mud. This is consistent with the observations and with the finding that even in those females with a large amount of mud on the last abdominal segment, mud was never found on the dorsal surfaces of the anal appendages.

Oviposition also took place on plant detritus layers under living moss piles at the edges of the ponds. Just as with the mud or moist sand, the substrate under moss piles would likely have a moderate microclimate and perhaps a higher moisture content.

We believe that *G. bifida* possesses a univoltine life cycle with two generations of larvae, one during the warmer rainy season and another in the early dry season (Oct./Nov. – Jan./Feb and Feb./March – May/June). This hypothesis implies non-diapause embryonal development, a larval life span of 3 to 4 months and a period of inactivity of prereproductive adults during the second half of the dry season (June – Oct.). Possibly, in densely forested places, where side pools of creeks and similar small water bodies won't dry up entirely, a third larval generation (much limited in number of individuals) may develop during the late dry season (May/June – Sept./Oct.). These behaviours fit *G. bifida*, according to the general classification of CORBET (1999; A.2.1.2. type, tab. 7.3), into the pattern of univoltine or partivoltine species that breed in temporary lentic waters in savannah with thicket or woodland.

By laying eggs over dry substrates, *G. bifida* acts as an early colonist of temporary lentic habitats at the beginning of the rainy season. Successful hatching and colonizing of the ponds would thus largely depend on the timing of subsequent periods of rain. However risky, this strategy could help minimize competi-

tion or predation risk, especially by other predatory benthic macroinvertebrates, including other Odonata (STERNBERG, 1994). Early colonizing of a temporary lentic habitat probably implies that the larvae of *G. bifida* require rather general conditions as to the breeding habitats (tolerance to low oxygen levels, high mineral nutrient levels and perhaps oscillations in diel temperature), in contrast with the sharp temporal niche specialization of the adults.

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