

DRAGONFLIES OF THE CAMPUS AT MADURAI KAMARAJ UNIVERSITY, TAMIL NADU, INDIA**P.L. MILLER**

Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS, United Kingdom

Abstract – 26 spp. were observed on the campus during Sept. 1987 - Feb. 1988, and Aug.-Sept. 1990. Of these, proof of breeding on the campus was obtained for 16 spp. and there was strong circumstantial evidence of breeding in at least a further 2 spp. 5 bred only in permanent habitats and 7 only in temporary habitats, the remainder probably doing so in both types. 16 spp. were sexually active at the largest habitat, a seasonal lake. 5 further spp., although commonly present, showed no sexual activity at campus sites.

Introduction

While there have been many reports on the odonate faunas of various parts of northern India and adjacent countries (e.g. BHARGAVA, 1989; BISWAS et al., 1990; KUMAR, 1972, 1985; RAM et al., 1983; PAJNI & TEWARI, 1988; MAHATO, 1989), only a few deal with the southern part of the sub-continent (LARSEN, 1987; MATHAVAN & MILLER, 1989; THOMAS & GLADSTONE, 1989) and none seems previously to have considered the dragonflies of the Madurai district. A brief report is presented here of the species of Odonata observed as adults at various habitats on the campus of Madurai Kamaraj University in 1987 and 1990.

Locality and habitats

The campus of Madurai Kamaraj University is situated 14 km W of Madurai ($9^{\circ} 55' N$, $78^{\circ} 07' E$) and about 40 km E of the Cardamom Hills, part of the Western Ghats. The campus is backed along its northern border by a long granitic ridge about 100 m high which rises out of the flat plain – itself about 100 m above sea level. The ridge separates the campus from the Vaigai River which contains some water all the year round. Rain falls mainly during the NE monsoon (September-November), the mean annual fall being 30 cm. The mean mid-day temperature in December is $30^{\circ}C$ and in June $40^{\circ}C$. Many rice paddy fields lie close to the campus.

The campus was founded in 1972 and it ex-

tends for about 1 km E-W, covering an area of about 300 ha. Many trees were planted at its inception and there is an extensive and well wooded Botanical Garden. At this latitude the difference between the longest and shortest days is 1.56 h.

Permanent aquatic habitats on the campus include a number of ornamental ponds from 1 to 10 m in diameter, mostly containing fish and with submerged vegetation, and experimental ponds used for the culture of fish and other animals. There are also three deep rectangular tanks, about 5 m square, cut out of the rock, which act as dry-season reservoirs. Their water surface is usually from 4 to 7 m below ground level and thus receives little direct sunlight. Some smaller pools situated close to bore holes are semi-permanent and are used by water buffaloes and goats. Nearby in the village there is a large and permanent but highly eutrophic reservoir.

Temporary habitats include several small streams, seepages, ponds and pools, and a larger pond, ca. 80×50 m, in the Botanical Garden, here called the 'lake'. It is surrounded by bushes and small trees, mainly *Syzygium cumini* (L.), *Casuarina* sp. and various leguminous species, and further small bushes grow in the lake bed. In 1987 the lake became filled with water during September and had dried out completely by 19th Jan. 1988. In 1990, small pools formed in it during September, but none lasted for more than 5 days. Observations were made from 7th Oct. 1987 to 2nd Feb. 1988, and from 6th Aug. to 21st Sept. 1990. Identifications were carried out using FRASER (1933-1936), and with the kind assistance of S. J. B. Rookes of the Natural History Museum, London.

Observations

Table I shows the estimated numbers of each species observed together with evidence of breeding. Behavioural notes are given here for some species and comparisons are made with KUMAR's (1972, 1985) results from Dehra Dun.

Leistes elatus – Although adults were seen

Table I — The occurrence and estimated abundance of Odonata on the campus of Madurai Kamaraj University — (Six categories of abundance were established during each visit to a habitat: 0=0, — A=1, — B=2-5, — C=5-10, — D=10-50, — E=>50; — *: species seen to be reproductively active and ovipositing at a campus site; — **: species for which proof of breeding was obtained [observation of larvae, exuviae or tenerals]; — p = permanent; — t = temporary).

Species	Abundance		Evidence of reproductive activity	Site of activity (p=permanent) (t=temporary)
	1987-89 Oct.-Feb.	1990 Aug.-Sept.		
LESTIDAE				
<i>Lestes elatus</i> Hag.	E	0	*	t
COENAGRIONIDAE				
<i>Ceriagrion coromandelianum</i> (Fabr.)	D	E	**	p
<i>Ischnura a. aurora</i> Br.	C	B		
GOMPHIDAE				
<i>Ictinogomphus rapax</i> (Ramb.)	B	A	**	p (t?)
<i>Paragomphus lineatus</i> (Sel.)	B	A		
AESHNIDAE				
<i>Anax guttatus</i> (Burm.)	C	A	**	t
<i>Gynacantha dravida</i> Lieft.	B	0		
<i>Hemianax ephippiger</i> (Burm.)	C	0	**	t
LIBELLULIDAE				
<i>Brachythemis contaminata</i> (Fabr.)	D	C	**	t (p)
<i>Bradinopyga geminata</i> (Ramb.)	E	E	**	p
<i>Crocothemis s. servilia</i> (Dru.)	D	C	*	p, t
<i>Diplacodes trivialis</i> (Ramb.)	E	B	**	t
<i>Indothemis carnatica</i> (Fabr.)	C	0	**	t
<i>Orthetrum chrysis</i> (Sel.)	A	A		
<i>O. pruinosum neglectum</i> (Ramb.)	A	0		
<i>O. s. sabina</i> (Dru.)	E	D	**	p, t
<i>O. taeniolatum</i> (Schneider)	B	0	**	t (p?)
<i>Pantala flavescens</i> (Fabr.)	E	E		
<i>Potamarcha congener</i> (Ramb.)	E	D	**	t
<i>Rhyothemis v. variegata</i> (L.)	A	A		
<i>Tholymis tillarga</i> (Fabr.)	E	B	**	t
<i>Tramea basilaris burmeisteri</i> Kirby	D	0	**	p, t
<i>T. l. limbata</i> (Desj.)	C	B	*	p, t
<i>Triithemis aurora</i> (Burm.)	D	D	**	p
<i>T. pallidinervis</i> (Kirby)	C	0		
<i>Zyxomma petiolatum</i> (Ramb.)	D	C	**	p

earlier, oviposition by tandem pairs was not observed before the beginning of November and it continued throughout December. Oviposition took place into twigs or grass stems 10-20 cm above the water of the lake. This suggests the occurrence of a long egg diapause until the next monsoon season.

Ceriagrion coromandelianum — Very abundant at two well-shaded, permanent ponds in the Botanical Garden which contained abundant submerged vegetation, mainly *Nymphaea* spp. Reproductive activity was observed in all the observation months, pairs ovipositing in tandem into waterlily petioles. It was noted by KUMAR

(1972) as a pond and stream breeder and its reproductive behaviour has been discussed by SRI-VASTAVA & SURI BABU (1985) and SURI BABU & SRIVASTAVA (1990) who observed four generations per year in Madhya Pradesh.

Ischnura aurora — Intermittently present in all months but never abundant and not apparently sexually active at campus sites. It was much commoner at the Vaigai river. In New Zealand, *I. aurora* is known for possessing monogamous females which accept mating while teneral (ROWE, 1978, 1987), behaviour which has also been observed in the Periyar National Park, Kerala (MATHAVAN & MILLER, 1989).

Ictinogomphus rapax — Present in small numbers from August, but no adult was seen after early December. Exuviae were noted in August in the deep tanks. It is a widespread species which exploits a wide variety of habitats from large lakes to small but permanent pools. Copulation is brief and aerial, and males may guard ovipositing females without contact.

Anax guttatus — Adults were seen in September after the first heavy rains and they were abundant from October until observations ceased on 2nd Feb. They were reproductively active at the lake throughout October and November, but after Dec. 3rd, no further reproductive activity was seen although the species remained common in the vicinity of the lake. Sexually active males searched for females at the lake throughout the day. Females appeared at all times of the day but were often most abundant after sunset when many were seen to oviposit alone into the stems of small saplings above and below water level. Males behaved aggressively towards tandem pairs sometimes knocking them into the water or forming a triple tandem with them. After copulation males guarded ovipositing females usually with, but sometimes without, contact. — Many adults emerged from the lake in December, and in mid-January, as the lake dried out, mature larvae were extensively preyed upon by pied kingfishers. During January many sexually inactive individuals remained in the vicinity of the lake, perching high in trees and showing a marked phase of crepuscular feeding activity.

Gynacantha dravida — This species was found only at lights at night in October and November. It is not known where it breeds at Madurai.

Hemianax ephippiger — Numerous individuals were seen to be reproductively active at the lake during October, the last being observed on 1st Nov. Tenerals appeared in late November and further sexual activity was seen intermittently at the lake from 7th Dec. until the end of the month. Although well known for its migratory behaviour, no evidence of a migration was obtained.

Brachythemis contaminata — Fairly common at the eutrophic village tank but never more than sporadically present on the campus, with a few individuals usually appearing at the lake and at the permanent bore-hole pools (cf. MATHAVAN, 1985).

Bradinopyga geminata — Commonly seen perching on roads, rocks and walls in many parts of the campus in all the observation months, this species bred in the deep tanks and permanent artificial ponds. In November up to four males were frequently present at a circular concrete pond, 15 m in diameter, perching round the margin. It was never seen to perch on plants and did not appear near any temporary habitat. At Dehra Dun, KUMAR (1972) describes it as breeding specifically in cemented permanent tanks and as being on the wing from February to September.

Crocothemis servilia — Males were frequently observed at most of the permanent ponds and sometimes also at the lake in all the observation months. Tenerals appeared near the lake in late November. In Dehra Dun it is a multivoltine species breeding in temporary and permanent habitats (KUMAR 1972, 1985).

Diplacodes trivialis — This was the most abundant libellulid on the campus from October and it was also present in smaller numbers in August and September. It was commonly seen perching away from water very low on vegetation or on the ground, sometimes on the hillside. Evidence was obtained for breeding in the lake and semi-permanent bore-hole pools.

Indothemis carnatica — Sexually active individuals were seen at the lake from October and they were most abundant in early-mid December, disappearing towards the end of the month. Males were not territorial and after copulation, tandem pairs flew round the lake many times, releasing batches of sticky eggs close to vegetation at 3-5 min⁻¹. Many larvae were found in the lake in December and January.

Orthetrum sabina — Present in all the observation months and becoming most abundant in November and December. It was frequently found away from water on the granite ridge and it bred in both temporary and permanent habitats, but mainly in the former. Oviposition was frequently observed at the lake from October to January, continuing until just a few days before all water had evaporated. A male at the water remained temporarily localised close to potential oviposition sites. Immediately after copulation he released the female, which remained perched, and then he flew in a semi-circle round her while dipping down towards the water, as though indicating an oviposition site. He then perched beside her, only to repeat the manoeuvre two or three more times until she started to oviposit. At Dehra Dun this species breeds in ponds and streams and adults appear in April-May and July-October (KUMAR, 1972; cf. MATHAVAN, 1985).

O. taeniolatum — Exuviae of this species were found on a wall above a small permanently running gutter. Adults were seen to be sexually active in November near the gutter and also at some smaller temporary ponds. At Dehra Dun it breeds in streams and adults are active from May to September (KUMAR, 1972).

Pantala flavescens — Gravid females containing sperm were found in all the observation months. Their numbers were very high in October and November, but surprisingly, no territorial activity was observed and no evidence of breeding was found on the campus. The species probably bred in paddy fields nearby and aerial copulations were occasionally observed occurring at up to 10 m above the ground among feeding swarms.

Potamarcha congener — Abundant from October to the beginning of February, with much sexual activity until early December at the lake. Ovipositing females flicked their eggs towards the bank, and such eggs have been shown to remain viable for atleast 80 days if kept moist in air (MILLER, 1991). In August and September only a few individuals were seen with one or two males behaving territorially at a small permanent pool near the bore hole. More began to do so in the lake bed where small pools formed during September. At this time gravid females with full sperm loads were found but no copulation or oviposition was noted. — Gregarious roosting was observed during December and January with

groups of up to 100 individuals assembling on the same branches each night (JOSEPH & LAHIRI, 1989; MILLER, 1989). Similar behaviour, but involving maximally only 7 individuals in a group, was seen early in August. At Dehra Dun this species breeds in ponds and is on the wing from June to September (KUMAR, 1972).

Rhyothemis variegata — Males appeared intermittently at the lake during October and November, interacting and apparently defending territories. However, only one female was observed and that was in September. No evidence of breeding on the campus was obtained. — This species feeds in the characteristic *Rhyothemis* manner by hovering and fluttering on its very broad wings in the vicinity of bushes and trees.

Tholymis tillarga — Very abundant from October to January at the lake and also occasionally at some of the permanent ponds. Sexually active males patrolled continuously without perching from about 16.00 h (exceptionally from 14.00 h) till after sunset, and oviposition took place onto floating pieces of vegetation. As soon as small pools formed at the beginning of the monsoon in September, a few sexually active individuals were observed and oviposition occurred even although the pools dried out again within a few days. Elsewhere this species is known to breed in permanent and temporary habitats (KUMAR, 1972; MATHAVAN & MILLER, 1989).

Tramea basilaris — Numerous individuals bred in the lake and emerged during December and early January. Sexually active males patrolled over temporary and permanent waters, and after copulation a male flew in tandem with a female, vigorously chasing away single males and sometimes circling the lake for up to 25 minutes while ovipositing. As in other members of the genus, the female was periodically released to dip down and release an egg batch after which she was immediately reclasped. At Dehra Dun this species is a pondbreeder, adults being seen from July to September (KUMAR, 1972).

T. limbata — This species bred in permanent and temporary habitats and was seen in all observation months. Mature males patrolled over the water, sometimes making dipping movements as though soliciting females to oviposit. Several tandem pairs sometimes appeared simultaneously, and oviposition took place either with periodic disengagement and reclasping of the female, as

in *T. basilaris*, or at one place with the male hovering above and the female dipping down and permanently disengaged.

Trithemis aurora — Present in all the observation months, this species bred in several of the permanent ponds, and males were sometimes also seen perching at the lake. In contrast it is reported as a stream breeder at Dehra Dun, adults being active there between September and December (KUMAR, 1972).

Zyxomma petiolatum — This species bred only in permanent habitats including some ornamental ponds and deep tanks, and it was present in all the observation months. Its reproductive behaviour resembled that of *Tholymis tillarga* in the manner of oviposition and in the timing of reproductive activity, but not in the sites utilised for oviposition. Males patrolled continuously over the water surface in crepuscular periods, interacting aggressively with intruders. — KUMAR (1972, 1985) describes this species as replacing *Bradinopyga geminata* in pools which become stagnant (eutrophic) but at Madurai both were found to breed in the deep tanks and in some of the ornamental ponds.

Conclusions

The campus odonate fauna of 26 species included no unusual or rare species. The list probably contains all the species (18) regularly breeding at sites on the campus during the observation months, but it is incomplete in that a few other species, including a cordulegastrid and an aeshnid, visited the campus briefly but were not identified. Eighteen of the species are abundant and widespread throughout India and have been reported from many sites in the north including Dehra Dun (KUMAR, 1972). Likewise 18 of them have been reported from the Periyar National Park in Kerala (MATHAVAN & MILLER, 1989).

Seven species, namely *Lestes elatus*, *Anax guttatus*, *Hemianax ephippiger*, *Diplacodes trivialis*, *Indothemis carnatica*, *Potamarcha congener* and *Tholymis tillarga*, were seen to breed only in temporary habitats on the campus. A further species, *Pantala flavescens*, bred at such sites off the campus. Five species, *Ceriagrion coromandelianum*, *Ictinogomphus rapax*, *Bradinopyga geminata*, *Trithemis aurora* and *Zyxomma petiolatum* were seen to breed only at permanent cam-

pus sites. The remaining six species probably bred in both types and such species are likely to be seen as adults throughout the year. However habitat permanence is not necessarily the only relevant criterion in habitat choice since the temporary lake was much larger than any other habitat on the campus and I have observed *Anax guttatus* and *Tholymis tillarga* breeding in large permanent lakes elsewhere. *T. tillarga* was seen to oviposit at small pools as soon as they had been formed at the start of the monsoon, whereas other species were more cautious.

Species which breed only in temporary habitats may be able to survive prolonged dry seasons in one of several ways. They may lay drought-resistant eggs, have drought-resistant larvae which become buried in mud, migrate as adults to other regions, or remain in the area as adults in reproductive diapause. Examples of each of these methods are known from species in other parts of the tropics, but there is little information concerning this problem for Indian species. The distribution of several of the species which depend on permanent aquatic habitats and may have relatively short life cycles has probably been much extended by the construction of numerous man-made dams, tanks and reservoirs during the last few thousand years in southern India. Since these store water during prolonged dry seasons their formation may have considerably enhanced the distribution of certain species in such areas, some of which may in turn have become adapted to identify and exploit such habitats.

Acknowledgements — I am grateful to the Royal Society, the Indian National Science Academy, the Trustees of the Aneurin Bevan Foundation and the Indian Council for Cultural Relations which made my visits possible. I am deeply grateful to Professor T.J. PANDIAN and Dr S. MATHAVAN for hospitality at Madurai.

References — BHARGAVA, R.N., 1989, *Ind. Odonatol.* 2: 45-46; — BISWAS, V., M.A. BAS-HAR & A. BEGUM, 1990, *Ind. Odonatol.* 3: 65-66; — FRASER, F.C., 1933-1936, *Fauna of British India including Ceylon and Burma*, Vols 1-3, Taylor & Francis, London; — JOSEPH, K.J. & A.R. LAHIRI, 1989, *Adv. Odonatol.* 4: 45-52; — KUMAR, A., 1972, *Odonatologica* 1: 199-207; — 1985, *Proc. 1st Ind. Symp. Odonatol.*,

- Madurai, pp. 73-90; — LARSEN, T.B., 1987, *Notul. odonatol.* 2: 154; — MAHATO, M. 1989, *Ind. Odonatol.* 1: 15-20; — MATHAVAN, S., 1985, *Proc. 1st Ind. Symp. Odonatol., Madurai*, pp. 93-106; — MATHAVAN, S. & P.L. MILLER, 1989, *Soc. int. odonatol. rapid Comm. (Suppl.)* 10: 1-10; — MILLER, P.L., 1989, *Odonatologica* 18: 179-194; — 1991, *Physiol. Ent.* 17: 68-72; — PAJNI, H.R. & P.K. TEWARI, 1988, *Ind. Odonatol.* 1: 139-141; — RAM, R., V.D. SRIVASTAVA & M. PRASAD, 1983, *Notul. odonatol.* 2: 15-16; — ROWE, R., 1978, *Odonatologica* 9: 285-292; — 1987, *The dragonflies of New Zealand*. Auckland Univ. Press, Auckland; — SRIVASTAVA, B.K., & B. SURI BABU, 1985, *Proc. 1st Ind. Symp. Odonatol., Madurai* pp. 209-216; — SURI BABU, B. & B.K. SRIVASTAVA, 1990, *Ind. Odonatol.* 3: 33-43; — THOMAS, M. & M. GLADSTONE, 1989, *Ind. Odonatol.* 2: 49-50.

Received August 31, 1992