OVERWINTERING DRAGONFLIES IN AN AFRICAN SAVANNA (ANISOPTERA: GOMPHIDAE, LIBELLULIDAE)

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To better understand overwintering capability of dragonflies in the African savanna, observed individuals were placed into predetermined age categories at sites along the Mogalakwena river, Limpopo province, South Africa, during mid-winter. Age categories were determined by degree of wing wear each individual had sustained. The Dragonfly Biotic Index (DBI) was used to categorize spp. into rare, widespread generalists versus rare, narrow-range specialists. All the recorded spp. were common, widespread generalists, occupying microhabitats created by the winter dry season decrease in water level and flow rate, and able to survive seasonal habitat changes. Seven of the 8 spp. were libellulids, and 1 gomphid. Their ability to thermoregulate by selecting appropriate perch sites, in addition to their high habitat tolerance, plays an important role allowing them to survive as adults throughout winter. It is confirmed that the libellulids observed here were highly habitat tolerant, common and widespread spp. whose success comes about at least partly from their ability to overwinter and be ready to take advantage of the first rains.

INTRODUCTION

Thermoregulation is an essential survival mechanism for many insects. They have to regulate their body temperatures between certain ranges, independently of the ambient temperature, to sustain essential activities and reproductive fitness (CORBET, 1999). Thermoregulation can be achieved in two ways: ecothermically and endothermically, by either involving changes in metabolic heat production and/or heat exchange with the environment (CORBET, 1999). Thermoregulation allows insects to occur in a variety of environments, filling many microhabitats.

However, a challenge for insects is to be able to survive the cold winter. Many insects do this by being in an immature state or going into diapause, while some thermoregulate as adults, using physical and/ or behavioural adaptations. Examples include winter moths such as *Eupsilia* and *Lithophane* species which use an extensive 'fur' coat covering their thorax for heat retention (VERDU et al., 2004). As dragonflies do not have thoracic 'fur', they use other mechanisms for increasing body temperature. Shivering or 'vesper warming' (a technique described for butterflies) and perching to warm up their flight muscles are two activities which dragonflies employ to increase body temperature before flight or before finding cover for the night (CLENCH, 1966; CORBET, 1999). Endothermic warming is assumed to be the most derived condition in dragonflies and is mostly among larger species (MARDEN et al., 1996).

Little information is available on which dragonfly species overwinter in the African savanna, where summers are generally hot and wet and winters dry and cold. We studied here the phenology of dragonflies in the savanna of South Africa and ascertained their ages to determine which species were surviving through as adults and whether there may also be any eclosion to adulthood during the winter. The age and composition of the overwintering species were studied to create a platform from which further studies can evolve.

SITES AND METHODS

STUDY AREA – A 3.54 km stretch of the Mogalakwena river in the northern Soutpansberg region of the Limpopo province, was the study area (22°43'S, 28°46'E). The river flows throughout most of the year. During winter, the river decreases substantially in size, and forms many pools and slow flowing streams which connect the pools.

STUDY SITES – Six study sites of 50 × 25 m were chosen for their accessibility, safety (from crocodiles) and most importantly, occurrence of dragonflies (Fig. 1). Sampling was between 19 June and 7 July 2008. Within each study site, there were both large bodies of water and smaller pools, scattered with rocks and sand banks, in natural savanna.

SAMPLING METHODS – Dragonfly species were observed and sampled between 11:00 h and 15:00 h on windless, sunny days. Recording lasted for 1.5 h at each sample site. Voucher specimens were retained as for age referencing. Two observation methods were used to determine species and age of each individual. Individuals were identified and aged using close focus binoculars and a guide (SAMWAYS, 2008). Photographs were also taken to confirm age of individuals. Individuals were aged according to wing wear, viz. 1: whole, perfect wing margins indicated young individuals, 2: individuals with 1-5 mm of wing wear were classified as middle aged (see Fig. 2), and 3: those with more than 5 mm of wing wear were classified as old (Fig. 3). Each species was also allocated a Dragonfly Biotic Index (DBI) value, which is a composite measure of geographical distribution, Red List status and sensitivity to changing environmental conditions (SAMWAYS, 2008; SIMAIKA & SAMWAYS, 2008). The DBI ranges from 0 to 9, with a low value (0-3) indicating a geographically-widespread, non-threatened, habitat-tolerant species.

RESULTS

In total, 142 individuals in eight species were sampled (Tab. I). All were anisopterans, and only one species was not in the Libellulidae. All had a low Dragonfly Biotic Index (DBI), ranging between 0 and 3, indicating widespread generalists. The most abundant species was *Orthetrum chrysostigma,* making up 28% of all individuals observed. *O. chrysostigma* has a DBI of 2 (Tab. I). Average age of observed individuals of this species, based on wing damage, was category 2. *Ictinogomphus ferox* and *Trithemis annulata* were the least abundant species and only two individuals of each species were observed. For each of these an average age of category of 1.5 was determined. *I. ferox* has a DBI of 2 and *T. annulata* 1. The species with the highest DBI was *Crocothemis sanguinolenta,* with a DBI of 3 and average age category of 1.5 (Tab. I). This species was not at all sites. *T. arteriosa* and *C. erythraea* had the oldest average age, 2.3 and 2 respectively. Both species have a DBI of 0 (Tab. I). *T. furva* and *T. kirbyi* both have a DBI of 0 and average age category of 1.6 and 1.8 respectively.

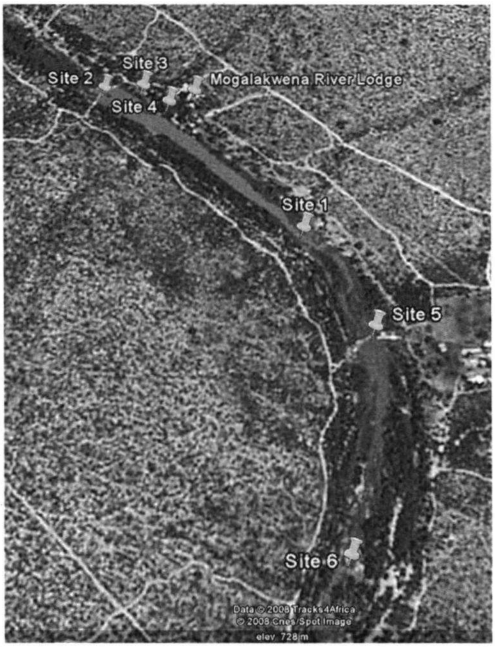

Fig. 1. The study area showing the Mogalakwena river and the matrix of dry savanna.

Overall, average age of individuals ranged from 1.5 to 2.3. Four species (*I. ferox, O. chrysostigma, C. sanguinolenta* and *T. annulata*) had an average age of 1.5. These species also had DBI values above 0 (2, 2, 3, and 1 respectively) (Tab. I).

Virtually all individuals were males, but both female and male individuals of *O. chrysostigma, C. erythraea* and *T. kirbyi* were at certain sites, and engaged in courtship. *T. kirbyi, T. furva, O. chrysostigma* and *C. erythraea* males were highly territorial among themselves and with each other.

DISCUSSION

For an adult dragonfly to maintain vital activities, it must maintain body temperature within a specific range, independent of ambient air temperature (CORBET, 1999; MAY, 1978). MAY (1976) found that the minimum temperature a dragonfly must maintain to sustain flight in a laboratory experiment was 21.3 ± 1.6°C. In order to achieve this temperature, independent of the ambient temperature, drag-

Figs 2-3. Examples of dragonfly individuals of different age: (2) a middle-aged *Orthetrum chrysostigma* male (age category 2), with some wear in the anal area of the hindwing; – (3) an old *Trithemis arteriosa* male (age category 3), with extensive wing wear along the margins of both the fore- and hindwings.

onflies must thermoregulate (MAY, 1976). Previous studies have shown that adult dragonflies can be divided into two general groups, perchers (which regulate their body ectothermically) and fliers (which regulate endothermically) (CORBET, 1999).

Table I
Abundance, average age and DBI of species observed

Species	No. individuals observed	Average age	DBI
Ictinogomphus ferox	2	1.5	2
Orthetrum chrysostigma	35	1.5	2
Crocothemis erythraea	22	2.0	0
Crocothemis sanguinolenta	20	1.5	3
Trithemis annulata	2	1.5	1
Trithemis arteriosa	17	2.3	0
Trithemis furva	24	1.6	0
Trithemis kirbyi	20	1.8	0

Out of the eight species here, only one, the gomphid *I. ferox*, was not in the Libellulidae. In general, individuals in the Libellulidae do not endothermically generate heat by shivering. In addition, they cannot increase the rate of heat loss by increasing blood circulation through the abdomen, because of the high energy cost which is incurred by small-bodied dragonflies when they attempt to regulate their body temperature endothermically (HEINRICH & CASEY, 1978; McGEOCH & SAMWAYS, 1991).

Individuals here mostly basked on the ground, rocks, dam walls, or other perches, and made short trips between perching sites, and longer, territorial and foraging flights, returning to perch to ectothermically raise or lower body temperatures.

By being able to utilise the sunny winter days (although the nights are cold), it is possible for certain Libellulidae species to occur in this savanna region all year round. Winter in these savanna areas is characterized by dry atmospheric conditions, very little rain, dropping water levels, and change in rapid-flowing river conditions into a slow stream, pools and in places even a dry river bed, with a concurrent decrease in insect abundance and species diversity (SUH & SAMWAYS, 2000).

However, by overwintering as adults, species are able to complete at least two generations in one year. This allows them to have univoltine or multivoltine life cycles (CORBET, 1999). As the savanna here is a sub-tropical, regulated ecosystem, the dragonflies are likely to have an A.2.1.2. or A.2.2 life cycle (CORBET, 1999), where the species spend dry winter months as pre-reproductive adults or as eggs.

Most of the individuals sampled were young, suggesting that they were not survivors from the summer months, but rather emerged during late autumn or early winter. This could be as a result of multivoltinism or an A.2.1.2 life cycle, where the adults only emerge in the dry season. *T. kirbyi* and *O. chrysostigma* males were very territorial and mated. This appears to predispose them to be reproductively mature and ready for the first rains and flowing river conditions (CORBET, 1999).

All the species observed were common generalists with low DBI values. As habitat generalists, they were able to survive the winter by utilising microhabitats created by changes in flow of the river and decreased areas of shade. This agrees with SUHLING et al.'s (2006) findings in Namibia, that harsh conditions favour generalist species.

Species diversity of dragonflies differs from one location to the next and is especially different as habitat composition changes during different times of the year (MOORE, 2001; STEWART & SAMWAYS, 1998). The results here suggest that several libellulids are remarkably resilient to changing environmental conditions, with their winter survival as adults associated with their ability also to be abundant and widespread. The study confirms the category of these savanna species also being truly common, widespread generalists.

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