THORACIC TEMPERATURES IN FOUR LIBELLULID DRAGONFLIES (ANISOPTERA: LIBELLULIDAE)

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Abstract – The thoracic temperatures in *Orthetrum* cf. *caffrum* (Burm.), *Trithemis arteriosa* (Burm.), *T. dorsalis* (Ramb.) and *Palpopleura lucia* (Dru.) were measured in the field. All spp. belong to the percher type. Their thoracic temperatures were between 0.7 and 10.5°C above ambient temperature. The pale blue *O.* cf. *caffrum* had a higher body temperature than the dark blue *T. dorsalis*. The thorax temperature was positively correlated to abdomen length but not forewing length between species with a similar trend within *Trithemis dorsalis*.

Study site and methods

During a stay at the Pretoria University, we were able to visit a small stream on private farmland in the Boekenhoutskloof area (25°33'S 28°29'E), approx. 40 km northeast of Pretoria, Republic of South Africa.

On December 9, 1995, we carried out preliminary measurements of the body temperature of several dragonflies. Although these measurements were not continued (see below) and we finally obtained only a few data, we will nevertheless present this small sample as it may give a rough impression for later studies of thermoregulation in these abundant species. We furthermore intend to add a cautionary note on the use of the "grab and stab" method (STONE & WILLMER, 1989).

Between 11:30 h and 13:30 h local time, dragonflies were captured at the banks of the stream, usually at their perch sites. All but one were adult male. The only female was captured after she had completed oviposition. After netting, individuals were touched directly at their folded wings, taken out of the net and a fine thermocouple (Type K: NiCr, NiAl 0.2 mm) was inserted about 2 to 3 mm into the thorax, between the 2nd and 3rd pair of legs on one side of the thorax. After touching, the measurement was carried out within 5 s. Thereafter, the needle was wiped dry and the temperature was measured at the perch site. Additionally, the length of the right forewing and the abdomen, as well as the time between capture and measurement were taken.

Results and discussion

The thoracic temperature of dragonflies depends on several factors. It is differently regulated in fliers and perchers. Thermoregulatory ability is also age-dependent (MARDEN et al., 1996). In our investigation we captured only perching adult males. However, we did not measure the time the individual had spent on its perch or its preceding patrol flight duration. Thoracic temperature is usually positively correlated to ambient temperature (e.g. MAY, 1987; POLCYN, 1994). It was not correlated to solar radiation in one odonate study (MAY, 1987), whereas the opposite was true in grasshoppers (SAMIETZ & KÖHLER, 1998). We have measured all T_{th} presented here within two hours, an interval, where a change of solar radiation is unlikely in cloudless skies.

An optimal body temperature is especially advantageous at the time when most of the species mate. Then, males should always keep their body temperature at the level necessary for take-off to approach females or arriving males (MAY, 1991). All individuals in our study had a thoracic temperature (T_{th}) higher than the ambient temperature (T_a) (Fig. 1). Sample size, thoracic temperature and its difference to the ambient temperature, as well as body measurements for the male specimens are shown in Table I.

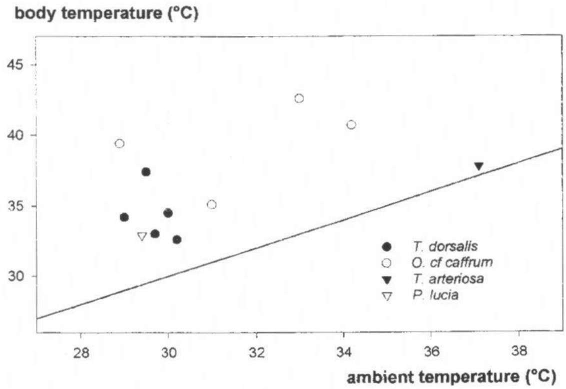

Fig. 1. The relationship between body and ambient temperature in four African species of libellulid dragonflies. The straight line indicates body temperature without thermoregulation.

For fliers, it is recommended that the time interval between capture and measurement should not exceed 10 s because of post-flight heating (STONE & WILLMER, 1989). For perchers, on the other hand, there is the danger of evaporative cooling and an interval of 5 s is recommended (STUTT & WILLMER, 1998). In our study it was impossible to stay within this limit. In *T. dorsalis* the time elapsed between capture and temperature measurement (range 9.8-30 s) was negatively but not significantly correlated to the difference between body and ambient temperature (Spearman rank, r_s=- 0.72, N=5, p=0.172). The same was true when all individuals were combined (r_s=- 0.38, N=11, p=0.25). We view these results with caution due to our small sample size and because of the contrast in results of different investigations (STONE & WILLMER, 1989). This, together with

Table I — Body temperature, elevation above ambient temperature and morphometric measurements of males of four species of libellulid dragonflies. N refers to sample size. Ambient temperatures were in the range of 29 to 37.1°C

Species	N	T_{th} (°C)	Tth-Ta (K)	Forewing length (mm)	Abdomen length (mm)
Orthetrum cf. *caffrum* (Burm.)	4	38.4 ± 2.4	4.1 - 10.5	32.9 ± 1.3	30.9 ± 1.5
Trithemis arteriosa (Burm.)	1	37.8	0.7	27.0	28.0
Trithemis dorsalis (Rambur)	6	34.5 ± 1.8	2.4 - 7.9	31.2 ± 1.0	26.1 ± 1.0
Palpopleura lucia (Drury)	1	32.4	3.5	21.2	15.7

the direct touching of the wings may have resulted in an underestimation of the thoracic temperature.

Even from our small sample size some interesting conclusions may be derived. Body temperature was positively correlated to the abdomen but not forewing length (Tab. I), also when individuals of all species are pooled and are corrected for the time between capture and measurement (partial correlation r_s=0.67, N=9, p=0.025). This was expected, because larger species in general require a higher temperature for flight (HEINRICH, 1993). The data is too scarce to show the positive correlation within one species, although the trend is similar in *T. dorsalis* (Spearman rank correlation, r_s= 0.71, N=6, p=0.11). The strong influence of abdomen size may also explain why the body temperature was higher in *O.* cf. *caffrum* than in *T. dorsalis* (Wilcoxon rank test, W=32.0, p=0.03), although the latter is much paler.

The highest thoracic temperature measured was that of an ovipositing *Orthetrum* female (42.6°C) which at the same time was the individual that had been flying probably for the longest time before capture, pointing out the potentially high cost of thermoregulation during oviposition.

After releasing the captured individuals, we were not able to follow them further. Some flew out of sight immediately, others escaped into the grassy vegetation. Three individuals (21%) appeared so badly damaged that a lethal injury almost certainly occurred. To our knowledge, a figure for the percentage of injured individuals has never been reported for any insect species. If a figure with 20% or greater mortality, as well as an unknown percentage of sublethal injuries occurs, there should be some ethical concern, especially in investigations using larger sample sizes.

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