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BODY TEMPERATURES OF TWO SPECIES OF DESERT AMPHIBIANS, *RANA PEREZI* AND *BUFO MAURITANICUS*

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SUMMARY

Measurements were made in the field on the body temperatures of two species of anuran amphibians, *Rana perezi* and *Bufo mauritanicus*, in a desert region of southern Morocco. Both species were found to employ heliothermy to elevate their body temperatures above air and water temperature.

INTRODUCTION

Amphibians are ectothermic and rely on behavioural mechanisms to regulate their body temperature. Many species of anuran amphibians are heliothermic and through basking and conduction are able to raise their body temperature to levels that may be similar to those attained by certain species of reptilian heliotherms (for reviews see Brattstrom, 1963, 1979). However, the permeability of the amphibian integument and the excretion of nitrogenous wastes in the form of urea imposes severe water balance problems for these animals when they inhabit dry environments and thus in these regions heliothermy may be restricted to those species or populations that live in the vicinity of permanent water. This paper reports on observations on the body temperatures of two species of anuran amphibia: *Rana perezi* and *Bufo mauritanicus* which were found in a habitat consisting of a series of natural and man-made bodies of water in a desert region in Southern Morocco.

Brattstrom (1970) has drawn attention to the fact that body temperature data are conspicuously lacking for even the commonest amphibians from continents other than the Americas and there are indeed few such data available on species from the Mediterranean region. Under field conditions Busack (1978) found maximum body temperatures of 25°C in *Alytes obstetricans* and 16°C in *Salamandra salamandra* in Spain. These however fell below the body temperatures recorded for these species in a laboratory study by Strübing (1954).

METHODS, MATERIALS AND STUDY AREA

Field observations were carried out from late May through to mid-June 1980. Data on the temperature of both the animals and the environment were recorded with mercury bulb thermometers and a Whitley digital thermometer. The Whitley digital thermometer was battery operated and consisted of a silicon censor probe combined with LSI CMOS circuitry. This thermometer had a temperature range of −50 to +150°C with an error of ±0.5°C. The ambient air temperatures at the sites were recorded with the bulbs shaded; sand temperatures by inserting the bulbs approximately 8 mm into the sand. The water temperature was measured at depths of 10–15 cm. Body temperatures in both species were taken orally when the animals were out of water. To minimize the effects of heat transference, body temperatures were recorded as quickly as possible. A total of 55 body temperature readings on *R. perezi* and 40 on *B. mauritanicus* were taken. All *R. perezi* were caught with nets that had been constructed with adjustable handle lengths, which made it possible to capture animals at distances up to 3.5 m. All *B. mauritanicus* were caught by hand.

Rana perezi were studied at an irrigation channel running from southeast to northwest; *Bufo mauritanicus* at a small pond that lay 30 m from the channel. The area surrounding the site was mostly "reg" or stony desert which was typically barren with the only major plant life being patches of dense growth of succulents (*Euphorbia* sp.). The climate of the region is arid; the most extreme daily air temperatures occur during the months of August and September when maxima between 44–47°C may be experienced.

RESULTS

Rana perezi. Basking in *R. perezi* was observed at all times of day. Some of the frogs basked in open patches with no shade, but others were in partly shaded sites. All of the body temperature data recorded were under conditions of clear skies between 11:00–16:30 hr. During the time that data were gathered the relative humidity at distances of 3 m from the water averaged at 45% and never exceeded 48%. Sand temperatures ranged from 45°C to 55°C. Body temperatures for *R. perezi* in relation to air (T_A) and water (T_w) temperatures are shown in Fig. 1. A range of body temperatures from 24.5–32°C ($\bar{x}$ = 28.4°C, n = 55) were recorded. Generally they were found to be higher between 11:30–13:30 hr; after this time they showed a general decrease. As would be expected from the extremely high levels recorded, all frogs had body temperatures below that of sand temperatures, but all except one individual had body temperatures in excess

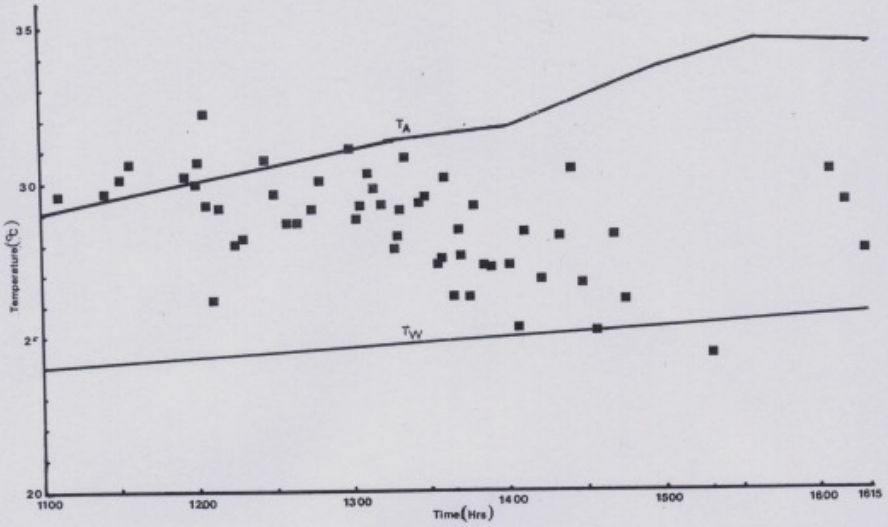

FIG. 1. Graph of body temperature against time of day for *Rana perezi* in relation to change in air temperature (T_A) and water temperature (T_w). Mean body temperature ± 1.96 SD $= 28.45 \pm 3.14$°C ($N = 55$).

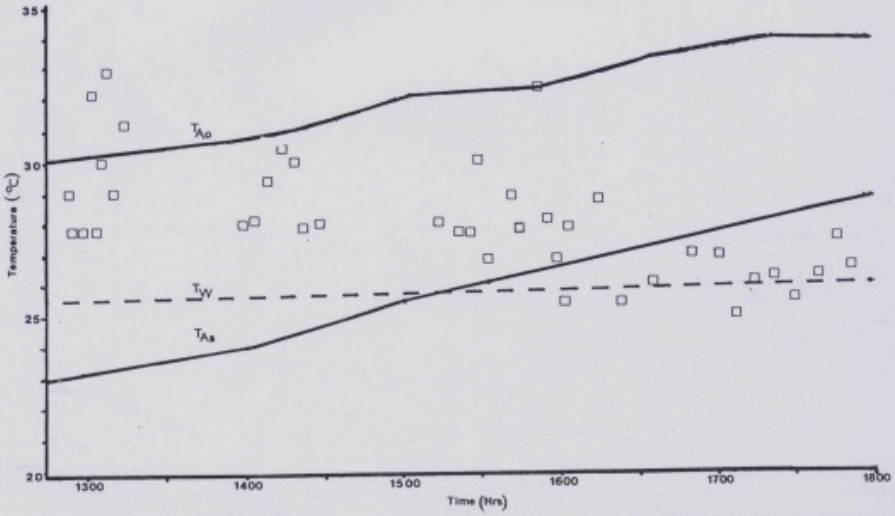

FIG. 2. Graph of body temperature against time of day for *Bufo mauritanicus* in relation to changes in air temperature in unshaded areas (T_{Ao}), air temperature in shaded areas (T_{As}) and water temperature in the pools (T_w). Mean body temperature ± 1.96 SD $= 28.15 \pm 3.79$°C ($N = 40$).

of water temperature (98.2%) with 16.3% of body temperatures exceeding air temperature. As the day progressed however the relationship between body temperature and air temperature altered. For example, no frog after 12:30 hrs was found to have a body temperature in excess of air temperature although one animal, at 12:55 hrs, had a body temperature equal to air temperature.

Bufo mauritanicus—Body temperatures in *B. mauritanicus* were recorded between 12:30 and 18:00 hr. In contrast to the area inhabited by *R. perezi*, this study site had abundant shaded areas in the form of

trees (*Eucalyptus sp.*) and crevices in the rocks, therefore a wider range of environmental parameters were recorded. The highest temperatures were those of the sand in the open areas which ranged from 45–55°C, but fluctuated around 30°C in the shade. The relative humidity in exposed sites was 45% but increased to 76% in the area surrounding the pool.

Basking on the sand in open unshaded areas was observed in only three *B. mauritanicus* and this was for only brief periods in each case. The data in Fig. 2 show the relationship between *B. mauritanicus* body temperatures and environmental temperatures. A range of body temperatures from 25–33°C ($\bar{x} = 28.1$, $n = 40$) were recorded. Generally they were higher between 12:30–15:30 hr after which the toads tended to retire to cooler sites. Ten percent of the toads had body temperatures higher than air temperatures in open areas while 60% had body temperatures in excess of air temperature in the shade. The majority (90%) had body temperatures equal to or higher than water temperature. The data recorded from 12:00 hr onwards show that after this time no animal had a body temperature in excess of air temperature in unshaded areas. The three animals found basking on the sand in the open area had body temperatures of 30, 32.3 and 33°C.

DISCUSSION

The observations on the behaviour and body temperatures of *R. perezi* and *B. mauritanicus* indicate that they regulate their body temperature by shuttling between sunlit and shaded areas or by retreating into water and are thus able to maintain body temperature to within a range of approximately 8°C. The ability to reduce body temperature may be increased as a result of the substantial amounts of evaporative cooling that take place as a result of the permeability of the amphibian integument (Mellanby, 1941, Cloudsley-Thompson, 1974). In a laboratory study of the water relations of *B. mauritanicus*, Cloudsley-Thompson (1974) measured the rate of evaporative water loss and compared it to evaporative losses in *B. regularis*. He found that at high air temperatures the losses were higher in *B. mauritanicus* but that this enabled *B. mauritanicus* to maintain lower body temperatures. The conclusions were that an ability to maintain low body temperatures may be more useful in dry environments than an ability to conserve body water since neither species demonstrated an ability to survive for long in a dry atmosphere. Evaporative cooling and a constant water supply is probably the major contributing factor in allowing these amphibians to remain abroad even during periods when because of high temperatures, most of the reptile species on the study area (*e.g. Eumeces*, *Sphenops* and *Tarentola*) retire underground or to shaded areas.

The maximum voluntary temperature of 32°C found for *R. perezi* and 33°C for *B. mauritanicus* compares with the maximum recorded for ranids of 34.7°C and bufonids of 33.7°C (Brattstrom, 1963), temperatures which fall just below the maximum recorded for amphibians of 34.8°C in *Acris crepitans* (Fitch, 1956, reviewed in Brattstrom, 1963). These observations on basking behaviour and body temperatures support the view of Brattstrom (1963) that heliothermy is possible in anurans while they are in association with permanent water. Clearly this effectively limits the problems of dehydration that they would encounter even while employing heliothermy in a region with high daily temperatures and low humidity levels.

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