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Thermal Behaviour of the Malagasy Spider Tortoise *Pyxis arachnoides arachnoides* (Bell, 1827)

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Abstract. Five adult specimens of the Malagasy Spider Tortoise (Pyxis arachnoides arachnoides) collected in southern Madagascar have been housed at Acquario di Genova since April 1997. The 2.3 square metres wide terrarium in which they are hosted has been filled with limestone sand and placed close to a north facing window. UV and infrared bulbs have been positioned to allow temperature and light gradient along the longest terrarium side. During the first two years, the tortoises have adapted themselves to be active from April to October and to hibernate during the remaining part of the year. During the last two years a web-cam connected to a PC was used 24/24h in order to collect data on reproductive biology and activity patterns. Thermal preferences were investigated mainly by means of an infrared thermometer which avoided interference with tortoise behaviour. The two sexes showed significantly different thermal preferences and habitat use. Correlations between thermal behaviour and biological cycle are discussed.

Introduction

Pyxis arachnoides is a small tortoise restricted to coastal sandy soils of SW Madagascar. In the past this taxon has been considered as vulnerable by IUCN (Groombridge 1982), but in 2002 it has been moved to the "endangered" category because of several threats: habitat loss, over-collecting, human consumption, etc. Recently this species has been included in the Appendix I list of Cites.

In 1997 the Acquario di Genova established a cooperation with the Department of Animal Biology of the University of Antananarivo and the population of the subspecies *Pyxis a. arachnoides* has been investigated *in situ* (Jesu & Schimmenti 1995). On that occasion a few adult specimens were collected and transferred to Genova to establish a colony *ex situ* with the purpose of contributing to the knowledge of reproductive and thermal biology of this taxon.

Materials and methods

The five individuals (two males and three females) have been housed in a PVC open terrarium measuring 1.8 x 1.3 x 0.5 m^3, placed in front of a wide window facing the north.

The terrarium, which has been filled with fine carbonatic sand, hosts some beach plants (*Rhoeo* sp.) which shade about one third of the entire surface; this has been divided into twelve quadrants (Fig. 1) grouped into four sectors based on average temperature (Tab. 1). The photoperiod is naturally provided from outside, while the UV irradiation is guaranteed by an additional Osram Ultravitalux 300W lamp placed about one meter from the sand surface. A suitable daily temperature range is provided by means of two ceramic 150 W bulbs hanging about 15 cm from the sand surface within quadrant A1. All temperature data whether on substrate or tortoises have been gathered using an infrared thermometer Raytek MX4PTDG. During the thermal biology study period – extending from June to October 2004 - carapace temperature has been monitored every five minutes from 9.00 a.m. to 8.00 p.m. four days a week. It has been taken note of the behaviour observed in the moment in which each single temperature data has been collected. Data has been processed by the statistic program Minitab12.21.

Results

Figure 2 and 3 show the occurrence of females and males in five different times of the day within the four sectors in which the terrarium has been divided. It is evident that males prefer cooler areas of the terrarium during the night and most of the morning, moving to the basking area mainly in the second half of the day. Females, on the contrary, spend the night randomly and move to the basking area much earlier than males. This behaviour obviously conditions the body temperature of the tortoises during the day: as the analysis of variance clearly shows (table 2), the two sexes show significant different temperatures from 10.00 am to 1.00 pm, females being warmer than males. From the early afternoon, male temperatures tend to female ones because of their occurrence in the same areas (see again fig. 2 and 3).

For each category of behaviour identified, the two sexes (females vs. males) have shown significantly different average temperatures in two cases: feeding (27.13 vs.

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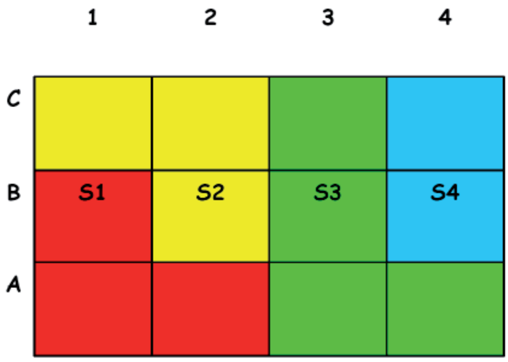

Figure 1. Terrarium area division.

Sector	Quadrant	Temperature average
S1	A1,A2,B1	31
S2	B2,C1,C2	28
S3	A3,A4,B3,B4	25.5
S4	B4,C4	24

Table 1. Temperature average in all sectors.

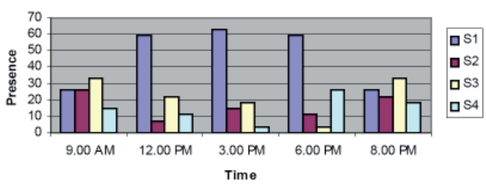

Figure 2. Female spatial distribution during the day.

Time	Male mean average	P	DF	Female mean average
9.00	24.84	0.143	1	25.19
10.00	25.32	0.001	1	26.85
11.00	26.74	0.001	1	28.55
12.00	27.58	0.000	1	29.50
13.00	29.92	0.032	1	31.76
14.00	30.70	0.066	1	32.19
15.00	32.38	0.277	1	33.33
16.00	32.19	0.382	1	33.15
17.00	31.00	0.469	1	31.58
18.00	30.73	0.441	1	31.34

Table 2. Comparison between male and female average body temperature (DF = degree of freedom).

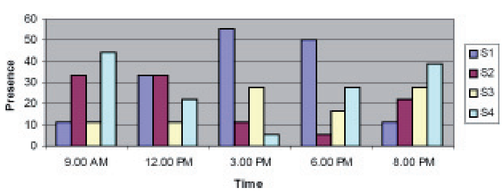

Figure 3. Male spatial distribution during the day.

27.95; p=0.004) and moving (28.74 vs. 30.22; p=0.000). Fig. 4 and 5 show the distribution of records respectively for feeding and moving within the ten temperature ranges recorded.

Discussion

The results show evidence for significant differences between males and females in terms of thermal behaviour and the activity rhythms. They can be summarized as follows:

(1) Females are used to start their daily activity long before males and with lower body temperatures, so they begin to eat and bask earlier. This behaviour can be explained assuming that females need a much higher energy income, compared to males, because of their different reproductive role. Such a difference is remarkable because although females have larger body volumes than males this is not enough to prevail in temperature conservation overnight but during the day it allows them to move less than males.

(2) Once gradually having reached their preferential body temperature (around 31-32°C), the females tend to maintain it rather steadily; on the contrary, males, once moved to the basking area, need less time to reach their preferential body temperature, but they need to move continuously from one sector to the other in order to adjust it. This is evidently due to their scarce thermal *inertia*, i.e. the higher heat dispersion of a small body, compared with a bigger one.

(3) These remarkable behaviour differences allow a correlation between thermal behaviour and reproductive activity. In particular, the early start of foraging activity characterizing the females can be correlated with the high energy cost for egg production; the same applies to their capability of keeping a rather constant high body temperature and related metabolism, which are presumably fundamental during ovulation. On the other side, the frequent movements of the males to keep their preferential temperature are also likely to favour their search for adult females.

(4) Concerning spatial distribution, males utilize constantly a specific area which at night is the cooler and vegetated one. Females, on the contrary, spend most of the nights in the areas used for basking, foraging and drinking. The present study cannot establish whether this behaviour is related to the restrictions of a terrarium or can also be observed in nature.

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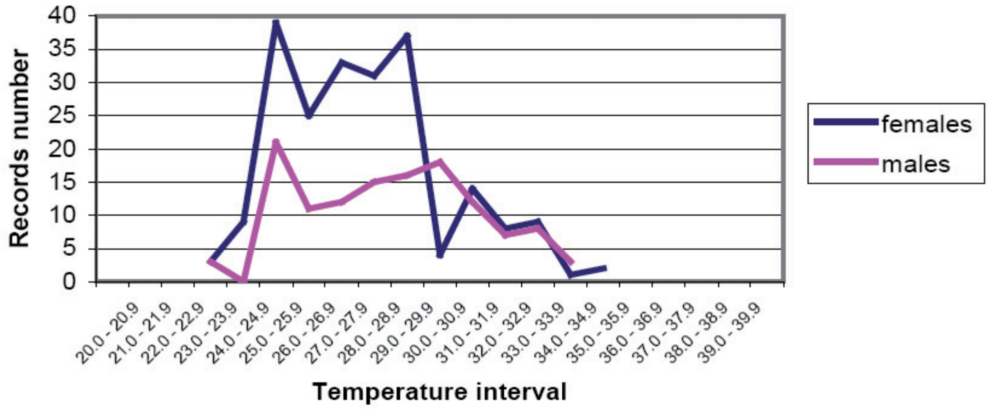

Figure 4. Distribution of feeding behaviour records according to body temperature intervals.

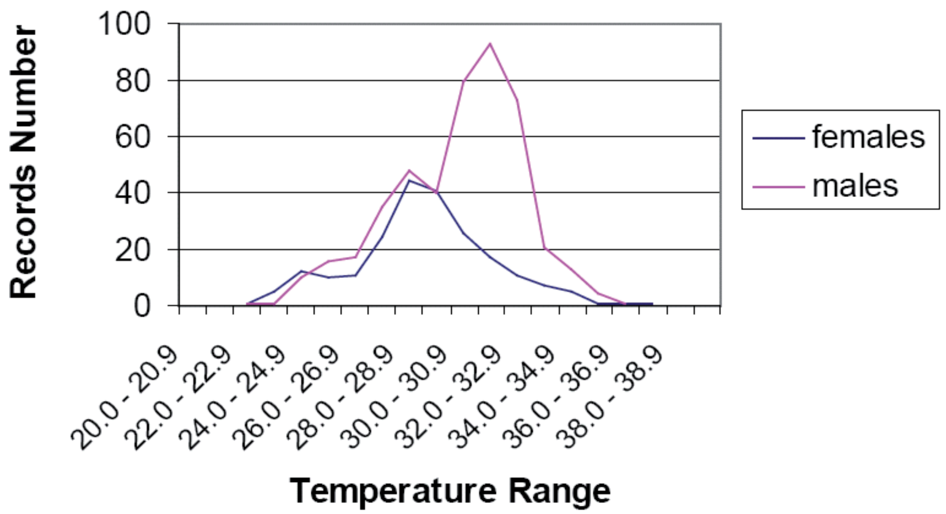

Figure 5. Distribution of walking behaviour records according to body temperature intervals.