Hermann's tortoise body temperatures and the thermal environment; a field study using null models

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We are currently studying the thermal ecology of Hermann's tortoise (*Testudo hermanni boettgeri* MOJSISOVICS 1889) in Danilovgrad municipality, Montenegro. Previous studies have shown that this species is heliothermic shuttling between hot and cool areas of the environment to regulate body temperature. However tests for evidence that *T. hermanni* was actually regulating body temperature has previously only been shown in a laboratory heat gradient. Our study attempts to test for evidence of thermoregulation in *T. hermanni* in its natural environment using two approaches. Firstly, estimates of the distribution of possible body temperatures available for the tortoises were made by placing water filled copper cylinders, as null models, in various areas in their habitat; in sunny areas where the highest temperatures were expected, in shaded and partially shaded areas where lower temperatures were expected. These thermal data were compared with the body temperatures of the real tortoises during daily activity (N=133). Secondly in a thermoregulatory efficiency test we compared both tortoise body temperatures in the field, corresponding temperatures of the null models in the field and compared these to the set point range of body temperatures of *T. hermanni* found in the laboratory heat gradient. The heat gradient represents a `cost free thermal environment` where the tortoises were not dependent on weather, food availability or presence of predators. The degree of differences between the body temperatures of tortoises and non-thermoregulating null models will indicate the degree of thermoregulatory efficiency. Our preliminary results, based on pooled male and female tortoises body temperatures indicate *T. hermanni* was around 70% effective as a thermoregulator during a combination of sunny, cloudy and partial weather conditions.

Methodology

Null models are copper cylinders filled with water, and they represent operative temperatures. Five cylinders are used and placed at the following microhabitat types:

1. One cylinder in an open habitat - directly exposed to the sunshine
2. Two cylinders in various degrees of half shade
3. Two cylinders in full shade.

Cylinders were moved occasionally one to two meters in different directions at same type of microhabitat to ensure that they remained in the appropriate habitat – for example half shade.

Monitoring of activity and behaviour was carried out during the day, which give an insight into the time budget for different weather conditions using spot sampling.

Data that are collected are:

-Temperatures of water in the cyilinders (Tm) at a predetermined time

-Type of microhabitat individual was found

-Behaviour of the tortoise (basking, active, in shade etc)

-Time of measurement

-Weather conditions

-Cloacal temperatures (Tb) of individuals.

-Basic morphometric measures.

Cylinder filled with water (Null model) with thermometer

Hermann`s tortoise measurement

At field

Formula used for analysis of thermoregulatory efficiency:

$$E = 1 - (P)Tm = Tset/(P)\ Tb = Tset$$

Which is a modified version proposed by Hertz et al (1993) and Van Damme et al (1989). This is where the index of thermorgulatory efficiency *E* is calculated from Tb, the body temperatures of tortoise in the field, Tm model temperatures in the field and Tset the body temperatures selected by the tortoises in a laboratory heat gradient.

Our preliminary results have confirmed T. hermanni controls body temperature by shuttling between different areas of the environment. This involves selecting appropriate areas in the environment to elevate (basking) or reducing (shade seeking) body temperature. During sunny weather 51.2% of body temperatures were within the set point range, defined as the physiological optimum range, indicating a high level of body temperature control even using a crude pooled data set, which makes no allowance for sex or size. Our data for cloudy and/or variable weather conditions are fewer and hence the results are very much tentative. What data we have has indicated that only 23.5% of tortoises were within the set point range because of a smaller range of available operative temperatures in different microhabitats.

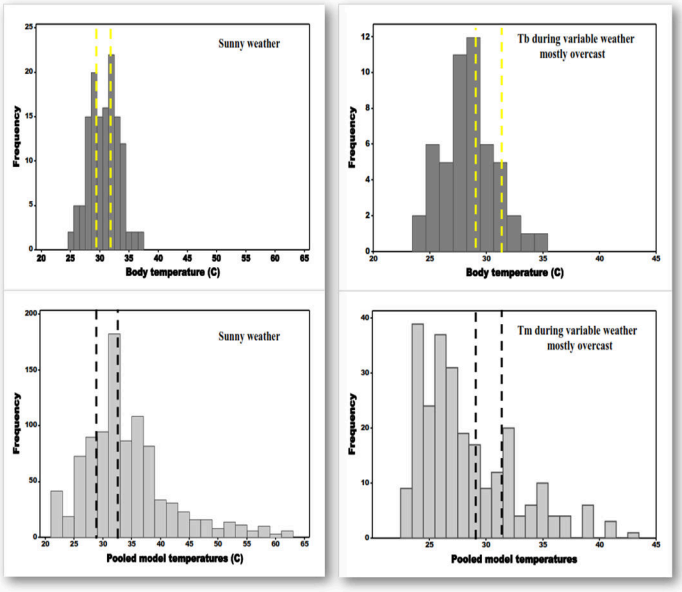

Figure 1. Disrtibution of Tb and Tm in *Testudo hermanni* population at Danilovgrad, showing a frequency of pooled males and females in set point range (dashed lines) proposed by Cherchi (1956;1960) and a frequency of Tm in mentioned set point range during a sunny weather and during a variable weather (with most overcast periods). This graphs show how much turtles are effective in a termoregulation.

Our study will now progress to examining differences in the thermal ecology of males and females and search for the effects of size on thermal ecology especially during cooler weather or seasons. Unfortunately juvenile tortoises are difficult to detect but if possible we will be looking at any possible differences in their thermal ecology given that previous studies have suggested they live in different microhabitat from adults.

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XXI European Congress of Herpetology
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ABSTRACT ACCEPTANCE NOTIFICATION

Dear Ms Vujović,

We are pleased to inform you that your abstract entitled "Hermann's tortoise body temperatures and the thermal environment; a field study using null models" passed the peer review process and has been accepted for poster presentation at XXI European Congress of Herpetology which will take place from 5th to 9th September 2022 in Belgrade, Serbia.

Abstracts will be included in Conference Book of Abstracts with the ISBN.

More information about registration and fees find at https://www.seh-congress-belgrade2022.com/registration-and-fees. If you need any help with visa, travel, and accommodation, please contacts the official congress agency "Impala Travel Belgrade" (http://impalaconferences.com/seh.php). If you are necessary to obtain a travel visa, you may use this letter as a recommendation.

Thank you for taking interest in the XXI European Congress of Herpetology. See you soon in Belgrade!

Sincerely,

Dr Jelka Crnobrnja-Isailović
Chair of the Local Organizing Committee