Thermoregulation in *Homopus signatus*

Project proposal for a field study 2012–2014

Victor Loehr
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Homopus Research Foundation
Kwikstaartpad 1
3403 ZH IJsselstein
Netherlands
loehr@homopus.org

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Introduction

From 2000 to 2004, an elaborate field study in a population of speckled padlopers, *H. signatus*, provided insight in the taxon's ecology (Hofmeyr *et al.* 2005; Loehr 2002a,b, 2004, 2006, 2008, 2010; Loehr *et al.* 2004, 2006a,b, 2007a,b, 2009, 2011, 2012). These data are particularly relevant because *H. signatus* is listed in the IUCN Red List of Threatened Species (Branch 1996), with a proposed status Vulnerable (Turtle Taxonomy Working Group 2011). The field study that took place from 2000 to 2004 demonstrated that *H. signatus* suffers from droughts, which may locally increase in frequency and intensity as a result of climate change in the next decades (Hoffman *et al.* 2009; MacKellar *et al.* 2007; Rutherford *et al.* 1999).

Most papers have focussed on relationships between rainfall, body condition, body size, and egg size. However, a recent analysis (Loehr 2012) identified a further mechanism that might adversely affect *H. signatus*: relatively low environmental temperatures in winter and spring, when food is available in the Namaqualand winter rainfall region, appear to require considerable basking time for the species to elevate body temperatures to levels that can support activity and metabolism. This basking time is not available for other activities, yet there are several factors that might facilitate *H. signatus* spend a significant amount of its time budget basking. Annual food plants are abundant and readily available in spring (Cowling *et al.* 1999; Loehr 2002a). Furthermore, tortoise population density may be high, requiring little time for mate-finding, and predation pressure on tortoises that are exposed during basking is low (Loehr 2010). Anthropogenic impacts, including climate change, may alter these factors and consequently behavioural time budgets and body temperatures. In turn, such changes may have important fitness consequences (Huey & Berrigan 2001; Martin & Huey 2008).

Loehr (2012) formulated two study objectives that need attention to establish the vulnerability of *H. signatus* to changes in behavioural time budgets and body temperatures:

1. *Operative temperatures*
   We do not know the operative temperatures (i.e., the array of potentially obtainable body temperatures) for *H. signatus* in its habitat. These data are required to answer the question if low environmental and operative temperatures are challenging *H. signatus* at times when food is available.

2. *Individual time budgets*
   We do not know how much time, at the individual level, *H. signatus* spends basking, and engaging in other activities. These data are required to test how operative temperatures translate to individual time budgets.

While this proposed field study focuses on *H. signatus* and its conservation status, little data is available on environmental and body temperatures, and relating behaviours, in other tortoises from arid winter rainfall regions (e.g., Geffen & Mendelssohn 1989). Therefore, this study will increase our understanding of arid winter rainfall tortoises in general.

Research aim and questions

The primary aim of the proposed study is to gather and publish information that demonstrates if low environmental temperatures are challenging *H. signatus* at times when food is available, and how operative temperatures relate to individual time budgets. By measuring operative temperatures for differently sized tortoises, it can also be established if the small body size of *H. signatus* is beneficial. The following questions will be addressed:

Operative temperatures

1. What are the annual operative temperatures for average-sized *H. signatus*?
2. What are the annual operative temperatures for *H. signatus* half the average size?
3. What are the annual operative temperatures for *H. signatus* twice the maximum size?

4. What is the relationship between operative temperatures and annual body temperatures?

Individual time budgets

1. What are the individual time budgets for males in late winter and spring?
2. What are the individual time budgets for females in late winter and spring?
3. What is the relationship between season and time budgets?
4. What is the relationship between weather conditions and time budgets?

Materials and Methods

Study area

The study area used for the 2000-2004 fieldwork will be revisited for the proposed study. This area measures 3.7 ha and has a dense tortoise population. Observations in 2012-2014 may be used for population dynamic comparisons. The area is located near Springbok (Northern Cape Province), and consists of a slope that faces southeast.

In August-September 2012, differently sized painted copper or aluminium models with temperature loggers (thermochron iButtons) will be placed in the field at open sites, under shrubs, and in rock crevices (Table 1), to record operational temperatures. Steel pegs and metal wire will secure the positions of all models.

Table 1. Use of models and iButtons in the field.

Model size	Microhabitat	Replicates
0.5 * average size	Open	2
0.5 * average size	Shrub	2
0.5 * average size	Crevice	2
1 * average size	Open	2
1 * average size	Shrub	2
1 * average size	Crevice	2
2 * average size	Open	2
2 * average size	Shrub	2
2 * average size	Crevice	2
Live male tortoises	-	10
Live female tortoises	-	10

Fieldwork episodes and personnel

Fieldwork is scheduled for August-October 2012 (8 weeks), September-October 2013 (3 weeks), and September-October 2014 (3 weeks). In 2012, four persons will work in the field during 3 weeks, and two persons will continue to work another 5 weeks. The study area will be methodologically inspected for tortoises daily from 08:00-18:00 hrs, until 10 males and 10 females fit for telemetry and/or iButtons (e.g., with sufficient body mass) will have been found. These tortoises will each be equipped with a transmitter and/or an iButton (covered with plastidip to avoid failure). After release, the telemetered tortoises will be tracked and followed frequently to determine individual time budgets (see also Keswick *et al.* 2006).

In 2013, fieldwork will be conducted by three persons, and will consist of tracking telemetered tortoises to download temperature loggers and replace transmitters. Furthermore, non-transmittered tortoises with iButtons will be located for download. In 2014, four persons will track telemetered and locate non-transmittered tortoises, and download and remove temperature loggers and transmitters. All field equipment will be removed at the end of the 2014 fieldwork.

Data collecting

The data collecting format for each encountered tortoise will be similar to that used in 2000-2004 to facilitate comparisons of data. Nevertheless, fewer data will be collected, to ensure that the monitoring of the telemetered individuals may start as early as possible (2012), and all non-transmittered tortoises will be recaptured (2013 and 2014). When a tortoise is encountered, the following records will be taken:

- Date and time

- GPS locality
- Body mass of the tortoise
- Tortoise ID (if marked in 2000-2004)
- Shell dimensions (straight carapace length; maximum shell width, at xth marginal; shell width at the 6th to 7th marginal; maximum shell height, at xth vertebral; shell height at the 4th to 5th vertebral; straight plastron length; size of the anal gap)
- Group (male; female; juvenile)
- Activity (basking; walking; hiding; feeding; combat; mating)

Before releasing newly captured tortoises, they will be notched (Cagle 1939) and digitally photographed (plastron and carapace) for future identification.

Temporary removal of tortoises

In some cases, it will be essential to remove tortoises temporarily (< 48 hrs) from their habitat:

- Equipping with radiotransmitters (August-October 2012)
- Equipping with thermochron iButtons (August-October 2012)
- Replacing radiotransmitters (September-October 2013)

Permits and Dissemination of Results

This proposed study would run from August 2012 until October 2014, including three fieldwork episodes. A permit is required for capturing, handling and marking a maximum of 100 tortoises in August-October 2012, September-October 2013 and September-October 2014, 20 of which will be temporarily removed from the field to attach transmitters and iButtons in 2012 and 2013.

The side project (see "Side project: *H. signatus* near Pofadder") requires a permit as well. In August-September 2012, a maximum of 20 *H. signatus* will be captured and handled (not marked) near Pofadder. For these tortoises, blood, faecal and urine samples will be collected, and deposited at the University of the Western Cape.

Gathered data will be processed in two batches. Individual time budget data will be processed after October 2012. The operative temperature data will be processed after October 2014. Two manuscripts will be submitted for publication in international, peer-reviewed journals. The publishing process may take several years from October 2012. In the end of 2012, 2013, and 2014, the Northern Cape Department of Environment and Nature Conservation will be sent a progress report.

Budget

Budget for this study is available from the Homopus Research Foundation. The required capacity (including management) will be provided by volunteers. All costs are listed in Table 2, and are totals for the entire project (2012-2014, including the side project in this proposal).

Table 2. Required budget and sources.

Item	**Costs (€ / R[1])**	**Source of funding**
International travel expenses	10,000 / 103,080	Volunteers
National travel expenses	1,200 / 13,272	Volunteers
Housing	3,100 / 31,961	Volunteers
Radiotransmitters (10 pieces)	2,500 / 25,775	Homopus Research Foundation
Rebattering existing transmitters (10 pieces)	1,500 / 15,461	Homopus Research Foundation
iButtons (1922L-F5, 40 pieces)	2,500 / 25,775	Homopus Research Foundation
Operative temperature models	250 / 2,577	Homopus Research Foundation
Various field materials	500 / 5,154	Homopus Research Foundation
Unexpected - 10% of budget	2,155 / 22,218	Homopus Research Foundation
Total	**23,705 / 244,399**	

[1] Exchange rate 13 January 2012

Volunteers

The previous work on *H. signatus* (and *H. boulengeri* and *H. femoralis*) has benefited from volunteer assistance in the field. Most volunteers were private tortoise keepers or zoo staff from overseas. There are both positive and negative aspects that need consideration. Positively, volunteers provide expert capacity (i.e., they are familiar with the biology of tortoises and often have field experience), allowing to locate reasonable numbers of tortoises in a short time, at virtually no costs. In addition, they may provide additional funding. Several volunteers who have participated in *H. signatus* fieldwork continued to contribute financially later. The most important benefit of working with volunteers probably is increased tortoise conservation awareness. Without exception, volunteers had a much better understanding of factors that threaten the survival of tortoises in the wild after their participation. Back home, this awareness transfers to other tortoise keepers, via lectures and informal contacts. Illegal trade in poached tortoises is a continuing threat, and increasing awareness may be an effective way to help prevent it. Either because tortoise keepers no longer find it acceptable to purchase (potentially) illegal specimens, or because there is social pressure illegitimating purchasing such tortoises.

Negatively, volunteer participation implies the risk that tortoise localities become public knowledge, increasing the risk of poaching. This may particularly threaten the Pofadder locality (see "Side project: *H. signatus* near Pofadder"). To reduce this risk, all volunteers are explicitly asked not to share localities, or photographs that contain landmarks that may direct others to the sites. In ten years of research on *Homopus*, there has been no evidence of localities shared. Considering positive and negative aspects, the advantages appear to outweigh the disadvantages.

Collaborators

In this study, several organisations will collaborate:

University of the Western Cape (prof. MD Hofmeyr)

Throughout the project, plans and results will be communicated and discussed with the Chelonian Biodiversity and Conservation programme of the University of the Western Cape to ensure that the project will complement the programme's efforts. Furthermore, this project will collect blood, faecal and urine samples for deposition at the university for tortoise health analysis.

Northern Cape Department of Environment and Nature Conservation (Mr. J Koen and Ms. E Swart)

The Northern Cape Department of Environment and Nature Conservation is the competent authority for wildlife in the Northern Cape Province. Since the study area is located in the Northern Cape, Northern Cape Province will advise and consider the permit applications for this project.

Side project: *H. signatus* near Pofadder

In September 2006, one solitary *H. signatus* was found outside of the taxon's known range, near Pofadder (Branch *et al.* 2007). Morphology and genetics suggest that the individual differs from typical *H. signatus* (Branch *et al.* 2007; MD Hofmeyr, personal communication). Since only one specimen is known, it is important to establish if a sizeable population is present. In August-September 2012, the Pofadder locality will be visited three times (circa 8:00-18:00 hrs) to locate additional specimens. Each specimen found will be measured similar to *H. signatus* near Springbok, and blood, faecal and urine samples will be collected for analysis in a separate project at the University of the Western Cape.

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