Namaqualand speckled tortoise
Homopus signatus

Studbook Management Plan

Version 7, April 2016

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VERSION HISTORY

Version	Date	Changes
1 (draft)	May 2008	-
2 (draft)	May 2008	Comments from genetic advisory board European Studbook Foundation implemented
3 (draft)	May 2012	Comments from South African authorities and studbook participants implemented
4 (final)	May 2012	Final review comments participants implemented
5 (final)	April 2013	Comments from South African authorities' formal review implemented
6 (draft)	February 2016	Updated after adding new founders
7 (final)	April 2016	Minor changes (no comments from South African authorities and studbook participants received)

This plan will be reviewed and updated once every five years, and after each supplementation of new founders or change in the IUCN conservation status of the taxon. Progress will be reported annually, in the annual reports of the Homopus Research Foundation.

CONTENTS

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1. INTRODUCTION

In 1995, four *Homopus signatus* were captured in the wild to initiate a studbook. At that time, little was known about husbandry methods and captive reproduction for this taxon. Since 1995, husbandry protocols have been developed, captive-breeding has been prosperous, and additional wild-caught individuals have been added to the captive population (Loehr 2015a; annual reports Homopus Research Foundation). In 2011, the participants in the studbook decided that the captive population should be managed and developed in such a way that it will remain suitable for future reintroductions should the need arise. This aim was elaborated in a studbook management plan, to clarify the policies and methods of the studbook. The current studbook management plan updates version 5 that was prepared in April 2013. A preliminary draft was prepared in February 2016. The reason for the current update is the collection and addition to the studbook of 10 new founders in September 2015.

2. DISTRIBUTION

Homopus signatus is restricted to north-western South Africa (Namaqualand) (Branch 1998). It occurs in two provinces, the Northern Cape and the Western Cape. All recordings of *Homopus* in Namibia have proven to be *H. solus* (Branch 2007). Currently, *H. signatus* does not contain subspecies (Daniels *et al.* 2010), but there are two distinct morphs (Boycott, 1986) and some populations might represent different taxa (e.g., Branch *et al.* 2007).

3. HABITAT

The habitat of *H. signatus* consists of rocky terrain in the Succulent Karoo biome (Boycott & Bourquin 2000). Consequently, its distribution is patchy. *Homopus signatus* appears to favour intergrade areas between rocky hills with few annual plants, and level areas with abundant spring growth of annuals (Loehr 2002b). This might relate to their diet and preference for shallow, concealed rock crevices as retreats (Loehr 2002a,b, 2006). Individual home ranges of *H. signatus* average 3,500 m^2, very small compared to home ranges of other tortoise species (Loehr 2015b).

4. PROTECTED STATUS

In its range provinces, *H. signatus* is protected fauna that may not be hunted, collected, or handled without permits from the provincial authorities. In the Northern Cape, the species is Specially Protected according to the Northern Cape Nature Conservation Act (Act 9 of 2009) as implemented from January 2012. In the Western Cape, *H. signatus* is a Protected Wild Animal as listed in Schedule 2 of the Nature Conservation Ordinance No. 19 of 1974. This outdated Ordinance is currently being turned into the Western Cape Biodiversity Bill. Enforcement requires considerable capacity and budget due to the remoteness of some areas, making it difficult to patrol on a regular basis. Although law enforcers pay attention to poaching of *H. signatus*, the species continues to be occasionally offered commercially on the European market.

International trade of *H. signatus* is controlled through the Convention on Trade in Endangered Species (CITES). The species is listed in Appendix II, because it is not necessarily threatened with extinction, but utilisation may be incompatible with its survival. An export permit or re-export certificate (only if the specimen was imported in accordance with the convention) issued by the Management Authority of the country of export or re-export is required. An export permit may be issued only if the specimen was legally obtained and if the export will not be detrimental to the survival of the species. Furthermore, live *H. signatus* must be prepared and shipped in a way that minimises any risk of injury, damage to health or cruel treatment. Although CITES requires no import permit for species on Appendix II, it is a requirement in many national laws. Import permits in the European Union can only be issued after confirming the exporting country's non-detriment finding.

5. CONSERVATION STATUS

The IUCN Red List of Threatened Species lists *H. signatus* in the outdated category Lower Risk/near threatened (Branch 1996), translating to the current category Near Threatened (IUCN Red List Unit, pers. comm.). However, the Red List indicates that this evaluation is outdated, and a new status Vulnerable is in preparation (Turtle Taxonomy Working Group 2014). The species is particularly threatened by aridification as a result of climate change, which hampers growth, reproduction, and hatchling survival (Loehr *et al.* 2007, 2009, 2011). The conservation of *H. signatus* might require the formation of corridors of protected areas to higher altitude regions (e.g., SKEP 2008), and translocations of wild populations (Loehr 2008). Potential anthropogenic threats to thermoregulatory requirements of *H. signatus* in its winter rainfall habitat may exacerbate survival risks (Loehr *et al.* 2015). A wild population in a relatively pristine area that was followed between 2000 and 2015 showed a severe decline (V.J.T. Loehr, unpubl. data).

6. STATUS IN CAPTIVITY

The global International Species Information System (ISIS, http://www.isis.org) lists 4.1.2 (= number of males.females.juveniles) *H. signatus* at three public ISIS Species Holdings (e.g., zoos). Two institutions are located in the USA and one in the Netherlands.

The studbook totals 49.23.14 live individuals, 1.1.2 at Amsterdam Zoo, which is one of the ISIS-institutions above, the remaining 48.22.12 at private facilities. This includes the latest addition of 10 founders that were collected in the wild in September 2015. All studbook locations are in Europe.

Besides the animals listed here, several illegally exported *H. signatus* are present in Europe, and probably reproduce. Similarly, illegal individuals may be present elsewhere.

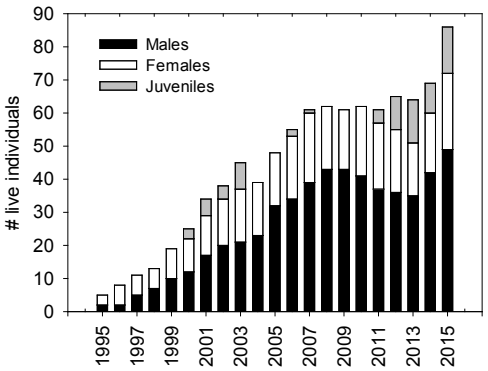

Figure 1. Numbers of live male, female and juvenile *H. signatus* in the studbook at the end of each year.

Homopus signatus can successfully reproduce in captivity. Reproduction has succeeded at many locations (Loehr 1999b; Morgan 1993; Palmer 1994; Van Loon 2008; annual reports Homopus Research Foundation). A husbandry protocol and publications are available at the website of the Homopus Research Foundation. Second-generation reproduction has also been reported (Loehr 2004). In the studbook, mortality is relatively low.

7. STUDBOOK COORDINATION AND CONTINUITY

To guarantee the continuity of the studbook, it is coordinated by two persons. Supervision of the European Studbook Foundation (ESF), a well-established private studbook organisation, gives access to a reservoir of experienced studbook coordinators. This studbook management plan will play an important role in the supervision by the ESF.

Currently, the studbook is coordinated by the following two persons:

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8. PARTNERS AND STAKEHOLDERS

The studbook is a collaborative effort of the Homopus Research Foundation and the European Studbook Foundation. Public facilities may participate in the studbook. Thirty-four private facilities in Austria, Belgium, Czech, Cyprus, France, Germany, Hungary, Italy, Netherlands, Poland, Portugal, Sweden and UK harbour the majority of the tortoises. Any facilities in Europe or elsewhere interested in participation in the studbook are considered potential partners.

The primary stakeholder for the studbook is the Northern Cape Department of Environment and Nature Conservation in South Africa. This authority is responsible for the conservation of the taxon, has provided the founder population to the studbook, and retains ownership of the studbook population as agreed in a memorandum of understanding in 2001 (e.g., making the captive population available for future reintroduction projects if necessary). Furthermore, the department is the competent authority for the issuance of permits to collect and export (CITES) *H. signatus* from the Northern Cape Province. Secondarily, CapeNature in the Western Cape Province is an important stakeholder, providing expert knowledge to the Northern Cape.

Further stakeholders are the land owners from where founder tortoises are collected. These may be private farmers, or municipalities. Which land owner this will concern will depend on land developments in the region, as founders are only collected on land that will likely become unsuitable as habitat for *H. signatus* (see Chapter 13).

A final stakeholder is the Chelonian Biodiversity and Conservation Programme of the University of the Western Cape (UWC) in South Africa. The studbook generates data on *H. signatus* that might complement field studies (i.e., many scientific papers on *H. signatus* refer to captive results). Furthermore, participants often volunteer in scientific fieldwork conducted by the Homopus Research Foundation in collaboration with UWC.

As agreed in the memorandum of understanding with the Northern Cape Province (2001), the studbook has a non-commercial basis. Therefore, commercial reptile dealers or breeders are not considered stakeholders.

9. SUITABILITY OF FACILITIES PARTICIPATING

Many of the current participants in the studbook are tortoise husbandry experts, with long-term breeding experience. Some of them also have field experience. *Homopus signatus* is the world's smallest tortoise species and does not require large enclosures. Their arid climate is easily mimicked in indoor enclosures in humid and arid regions alike, and some keepers in warmer regions experiment with outdoor keeping during summer. *Homopus signatus* requires a herbivorous diet that is easily catered for. The most important factors for successful husbandry are the provision of adequate moisture for juveniles (Loehr 1999a), and a stable environment with minimal disturbance and handling for all size classes. A husbandry protocol is available.

There appears to be a difference between husbandry of wild-caught and captive-bred *H. signatus*. Wild-caught individuals may require several years to fully adjust to captivity (Klerks 2002; Loehr 1999b), and are easily upset when moved to a new enclosure. Recently exported wild-caught individuals will be housed at expert tortoise keepers, or at keepers with experience keeping captive-bred *H. signatus*. Such tortoises should not be subjected to display at public facilities. A protocol for the acclimation of wild-caught *H. signatus* to captive conditions is available. Parameters that will be used by the studbook coordinator to select suitable keepers for wild-caught *H. signatus* are experience of a keeper caring for wild-caught tortoises in general, period of time keeping (captive-bred) *H. signatus*, mortality and reproduction rates, and commitment to participation in the studbook.

10. ULTIMATE GOAL FOR THE CAPTIVE POPULATION

The medium-term goal (0-50 years) of the studbook is to increase the genetic variation of the captive population by the addition of new founders (see detailed analysis in Chapter 11). Because *H. signatus* is a heavily demanded species in captivity, by private and public facilities, the studbook

encourages registration of each live *H. signatus* taken from the studbook's wild source population in the studbook. Registration of all wild-caught *H. signatus* will reduce the need to collect founders specifically for the studbook population and will therefore limit pressure on the wild population.

On the longer term (50-100 years), the captive population should become semi-autonomous, requiring very limited addition of wild-caught individuals. This would further relieve pressure on the species in the wild. Despite the lack of frequent wild-caught additions, the population should remain genetically healthy.

Ultimately, this captive population should be suitable and available for reintroduction purposes should the need arise in the distant future. In tortoises, reintroducing captive individuals to the wild may be a useful conservation tool, although many factors will need be addressed (Bertolero *et al.* 2007; Hambler 1994).

11. GENETIC AND DEMOGRAPHIC GOALS

11.1. Population size

The Homopus Research Foundation has signed a memorandum of understanding (2001) for the South African authorities that requires that all future offspring will be registered in the studbook. For the studbook to remain manageable (i.e., containing a restricted number of facilities and tortoises), the total number of studbook locations should not exceed 200 (currently 39). This will probably limit the size of the captive population to 300-350 individuals, unless some facilities would be prepared to permanently house a relatively large number.

Ideally, the captive population should be housed at public and private facilities. Public facilities often have little space restrictions, whereas private facilities generally have little financial and time restrictions. Furthermore, public facilities offer an opportunity to educate the general public on the conservation of tortoises.

11.2. Number of founders and generation time

Given the maximum manageable population size (300-350 individuals), the captive population would require 62 founders. In this composition, the first generation (F1) would theoretically preserve approximately 99.9995% of the genetic material of the founders and retain 62 bloodlines, as each founder couple could produce approximately 11 offspring (i.e., 31 couples times 11 offspring makes 341 individuals). This number of founders is lower than advised for tortoises (i.e., 100 founders; E. Gubbels and G. Hofstra, personal communication), but a larger number would result in larger genetic losses in the first generation due to smaller numbers of F1 offspring per founder couple. Moreover, the declining conservation status of *H. signatus* (see Chapter 5) warrants a conservative approach regarding the number of founders removed from the wild. Increasing the generation time as much as possible may, in part, counterbalance the relatively small number of founders. In other words, offspring (F1, F2, etc.) should not reproduce until after a reasonable number of years, to minimise genetic losses over many generations. Considering growth rates and mortality in the current captive population, reproduction should take place when captive-bred animals are approximately 10 years old.

The current number of founders in the studbook is 20 (see appendix 1), and all founders have reproduced (i.e., there are no live potential founders in the studbook). However, five founders have produced fewer than the anticipated 11 offspring and are unable to produce additional hatchlings, due to death or lost to follow-up, or because the founder is a tortoise in the wild. This issue will be addressed at a later time, but might lead to a requirement for several additional founders. It is unlikely that there are potential founders present in captivity, outside of the studbook population, because illegally exported individuals usually lack origins of capture and may originate from other regions than the studbook population.

Since the anticipated number of founders in the studbook is 62, the additional number of (captive-reproducing) founders required from the wild is at least 42 (21 couples). Ideally, these founders should be added to the population simultaneously, to ensure that offspring will fall within the same age group. However, the risks involved with the simultaneous husbandry of 42 recent wild-caught *H. signatus* is not acceptable. Therefore, founders should be added in smaller batches of 10 individuals (five couples). To ensure that the first batch will have produced at least 11 surviving offspring at the time that the last batch will have produced 11 offspring, founders will be allowed to reproduce unlimited offspring to

counterbalance possible mortality in the first generation.

During the time period that founders are being collected and added to the captive population, founder mortality will be carefully monitored. Founders that decease prior to reproduction should be replaced to maintain the genetic variation envisaged in this management plan. Prior to collecting a new batch, founder mortality rates will be reviewed, and the management plan revised if necessary.

All current founders originate from the same wild population. In order to maintain a genetically valuable captive population, all additional founders should originate from this same wild population.

12. SEX RATIO

Male and female *H. signatus* can usually be kept in couples year-round, so the studbook aims to form a population with equal numbers of males and females. On the long run, a slight bias towards females might be acceptable because multiple females may be housed together and would not increase the number of studbook locations. The actual studbook population is skewed towards males, as a result of male-biased breeding results through temperature-dependent sex determination. In the last years, an incubation protocol was developed to produce females (see annual reports of the Homopus Research Foundation), and the sex ratio in offspring may now be controlled.

13. SOURCES FOR SPECIMENS INCLUDED IN THIS PLAN

The tortoises required to develop a semi-autonomous captive population in the next decades will all originate from the wild. In part, these individuals may be collected specifically for the studbook, but the South African authorities are already consulting the studbook in case third parties submit permit applications. Such third parties may be suitable studbook participants.

It is important to note that the wild locality for the existing studbook tortoises is increasingly (1995-2015) disturbed and partly destroyed by anthropogenic activity. On the long term, this locality will probably become unsuitable for *H. signatus*, so removal of additional tortoises here has little additional impact. Some of the founders that were collected in 2015 were captured under waste materials at housing construction sites.

14. GENETIC ISSUES THAT NEED TO BE RESOLVED

There are no genetic issues that may have consequences for the studbook, because the studbook is based on founders from a single, known locality. However, recent genetic work on *H. signatus* originating outside the known distribution range may have impact on the taxonomy of the species (MD Hofmeyr, personal communication). This perspective emphasises the need to develop the studbook population based on founders with known origin.

15. MANAGING THE STUDBOOK

15.1. Dispersal of offspring

Currently, studbook locations that breed *H. signatus* usually recommend candidates for their offspring to the studbook coordinator. As long as transfers will benefit the studbook aims, recommendations are followed.

Secondly, the studbook coordinator maintains a waiting list of facilities that have requested *H. signatus*. If facilities are suitable (e.g., have sufficient knowledge, understand the goals and methods of the studbook), offspring may be transferred.

The website of the Homopus Research Foundation contains a procedure that needs to be followed in case anyone is interested in receiving *H. signatus* to participate in the studbook.

An important characteristic of this studbook is that virtually all tortoises remain the formal property of the South African authorities (managed by the Homopus Research Foundation), all tortoises and their offspring have to remain registered in the studbook, and no tortoises (regardless of ownership) may be

used for commercial purposes. Transfers are generally loans. These conditions follow directly from the memorandum of understanding with the South African authorities (2001). To ensure that all studbook participants will adhere to the conditions, they must sign a formal agreement with the Homopus Research Foundation.

15.2. Surplus

Since all future offspring needs to remain registered in the studbook, which is limited to 300-350 individuals, the studbook will not breed surplus tortoises. Each tortoise bred will have a role in forming the ultimate captive population. Therefore, it is of the utmost importance to determine which adult couple should breed how many offspring, and when. This will be a continuous process, and targets and results will be presented in the annual reports of the Homopus Research Foundation.

15.3. Individual identification

It is the responsibility of each studbook participant to individually recognise each tortoise. *Homopus signatus* has a colourful shell that may be used for identification over short periods, but juvenile shells may change colour pattern rapidly (i.e., within one year, Loehr *et al.* 2006). Alternative methods to temporarily mark captive tortoises are numbered queen bee tags epoxied to the shell, nail polish dots, or writing the studbook number on the shell with a permanent marker.

When transferring a tortoise, the keeper should ensure that the receiving party is able to identify each tortoise. Permanent methods of marking are not currently used in the studbook; the body size of *H. signatus* is too small to safely use PIT tags, and notching the marginal scutes will only be useful when strictly coordinated for the studbook population as a whole.

16. REQUIREMENTS TO SUCCEED IN ESTABLISHING A LONG-TERM CAPTIVE COLONY

The following table summarises requirements for the establishment of a long-term captive population of *H. signatus*, along with measures intended to help meet the requirements.

Requirement	**Supportive measures**
A large number of capable and dedicated studbook participants prepared to follow the methods in the studbook management plan, despite increasingly available illegally imported *H. signatus*.	Emphasise the unique selling point of the studbook: participation will not merely provide personal pleasure, but is an important contribution to the taxon's conservation.
Successful breeding (i.e., production of at least 11 offspring per founder couple).	Motivate studbook participants to share experiences, and intervene when participants remain unsuccessful.
Permission from the South African authorities to export 21.21.0 tortoises in badges of 5.5.0 in the next decades.	Involve the authorities in the development of the studbook management plan, and ensure appropriate annual reporting.
Permission from the European authorities, and possibly other continents, to import wild-caught tortoises.	Maintain an excellent track record, and work in a transparent manner.
Successor studbook coordinators in the next decades	Work with two coordinators to reduce work load and to facilitate personnel changes.

17. ACKNOWLEDGEMENTS

The Turtle Survival Alliance is thanked for making available the format for its Taxon Management Plans. The South African authorities and all studbook participants are thanked for their valuable comments on earlier versions of this plan.

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Appendix 1: Overview of founder, F1 and F2 combinations of current and future bloodlines (only live offspring shown)

All numbers are studbook numbers, and black cells indicate bloodlines that cannot produce additional offspring.

F0 and F1

Bloodline:	A			B	C	D	E	F	G	H		I	J	
Founders:	1 x 2†	1 x 3†	WILD$^{N/A}$ x 3†	35 x 36	37 x 38	152 x 157	153 x 158	151 x 156	150 x 155	154 x 159	WILD$^{N/A}$ x 159	WILD$^{N/A}$ x WILD$^{N/A}$	WILD$^{N/A}$ x WILD$^{N/A}$	Mult
#1	9	7	5†	44	73						161			72
#2	10	11		96	79						162			
#3	42	14		106	91									
#4	43	40		107	99									
#5	51	41		121	100									
#6		59		137	111									
#7		74		138	113									
#8				139	123									
#9				145	142									
#10				146										
#11				147										
#12				148										
#13				149										
#14				128										
#15				131										
#16				132										
#17				130										

† = dead
N/A = Not available
grey letters = planned

Premise: To maximise delay of inbreeding, bloodlines are combined as late as possible.

(Partial) F1 and F2

F1 couples that have produced F2 offspring:

A x A
A x B
A x C
A x WILD

These bloodlines will be reshuffled depending on actual offspring per bloodline

Bloodlines:	A x A (inbred)	A x A	A x B	A x C	A x C	A x WILD	D x F	E x H		G x I
F1:	(1 x 2†) x (1 x 3†)	(WILD$^{N/A}$ x 3†) x (1 x 2†)	(1 x 3†) x (35 x 36)	(1 x 2†) x (37 x 38)	37 x (1 x 2†)	(1 x 3†) x 60^{ltf}	(152 x 157) x (151 x 156)	(153 x 158) x (154 x 159)	1 x (WILD$^{N/A}$ x 159)	(150 x 155) x (WILD$^{N/A}$ x WILD$^{N/A}$)
#1	95$^{N/A}$	76	71		112	82				
#2			77	FIRST PRIORITY:	114	86				
#3			93	THIS COLUMN	115	87				
#4			94	SHOULD BE	117	88				
#5			109	FILLED WITH	119	89				
#6			110	F2 OFFSPRING!	124	92				
#7			118		126					
#8			120		133					
#9			122		135					
#10			125		136					
#11			143							
#12			144							
#13			160							

† = dead
N/A = Not available
grey letters = planned
ltf = Lost to follow -up

(Partial) F2 and F3

Bloodlines:	A x B
F2:	(35 x 36) x ((WILD$^{N/A}$ x 3†) x (1 x 2†))
#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	
#9	
#10	
#11	
#12	
#13	

† = dead
N/A = Not available
grey letters = planned