

Speckled dwarf tortoise
Chersobius signatus



Studbook Management Plan

Version 9, September 2018

Victor Loehr

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)
8 (draft)	August 2018	Updated after elevation of conservation status taxon, and name change of taxon and organisation
9 (final)	September 2018	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 Dwarf Tortoise Conservation.

CONTENTS

1. INTRODUCTION	4
2. DISTRIBUTION	4
3. HABITAT	4
4. PROTECTED STATUS	4
5. CONSERVATION STATUS	5
6. STATUS IN CAPTIVITY	5
7. STUDBOOK COORDINATION AND CONTINUITY	5
8. PARTNERS AND STAKEHOLDERS	6
9. SUITABILITY OF FACILITIES PARTICIPATING	6
10. ULTIMATE GOAL FOR THE CAPTIVE POPULATION	6
11. GENETIC AND DEMOGRAPHIC GOALS	7
11.1. <i>POPULATION SIZE</i>	7
11.2. <i>NUMBER OF FOUNDERS AND GENERATION TIME</i>	7
12. SEX RATIO	8
13. SOURCES FOR SPECIMENS INCLUDED IN THIS PLAN	8
14. GENETIC ISSUES THAT NEED TO BE RESOLVED	9
15. MANAGING THE STUDBOOK	9
15.1. <i>DISPERSAL OF OFFSPRING</i>	9
15.2. <i>SURPLUS</i>	9
15.3. <i>INDIVIDUAL IDENTIFICATION</i>	9
16. REQUIREMENTS TO SUCCEED IN ESTABLISHING A LONG-TERM CAPTIVE COLONY	9
17. ACKNOWLEDGEMENTS	10
18. REFERENCES	10
APPENDIX 1: OVERVIEW OF FOUNDER, F1 AND F2 COMBINATIONS OF CURRENT AND FUTURE BLOODLINES (ONLY LIVE OFFSPRING SHOWN)	12

1. INTRODUCTION

In 1995, four *Chersobius* (then *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 Dwarf Tortoise Conservation \(previously Homopus Research Foundation\)](#)). 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 7 that was prepared in April 2016. A preliminary draft was prepared in August 2018. The reason for the current update is (1) the changed IUCN conservation status of the taxon, (2) the name change of the taxon from *Homopus signatus* to *Chersobius signatus*, and (3) the name change of the Homopus Research Foundation to Dwarf Tortoise Conservation.

2. DISTRIBUTION

Chersobius signatus is restricted to north-western South Africa (Branch 1998). It occurs in two provinces, the Northern Cape and the Western Cape. All recordings of *Chersobius* in Namibia have proven to be *C.* (previously *Homopus*) *solus* (Branch 2007). Currently, *C. 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 *C. signatus* consists of rocky terrain in the Succulent Karoo and Fynbos biomes (Branch 1998; Boycott & Bourquin 2000). Consequently, its distribution is patchy. *Chersobius 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 *C. signatus* average 3,500 m², very small compared to home ranges of other tortoise species (Loehr 2015b).

4. PROTECTED STATUS

In its range provinces, *C. 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, *C. 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 *C. signatus*, the species continues to be occasionally offered commercially on the overseas markets.

International trade of *C. 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 *C. 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 conservation status of *C. signatus* in the IUCN Red List of Threatened Species is deteriorating. The species was originally placed in the category Lower Risk/Near Threatened, but this status was elevated to Vulnerable (Baard & Hofmeyr 2018). However, a new status Endangered is in preparation (M.D. Hofmeyr, V.J.T. Loehr & E.H.W. Baard, in press). This studbook management plan is based on status Endangered. The population size of *C. signatus* was estimated to have been reduced at least 30–40% over the past 25–50 years due to anthropogenic land transformation and other threats. When considering past and projected future changes due to land transformation, climate change, invasive predators and poaching, the decline in population size is projected to be in excess of 50%.

6. STATUS IN CAPTIVITY

The global species information system Species365/ZIMS (<https://zims.species360.org>) lists 7.2.3 (= number of males.females.juveniles) *C. signatus* at four public institutions (e.g., zoos). Three institutions are located in Europe and one in South Africa.

The studbook totals 48.27.17 live individuals; 3.2.0 at the three European Species365-institutions Amsterdam Zoo, Wrocław Zoo and Wuppertal Zoo, 0.1.0 at Plzen Zoo, and the remaining 45.24.17 at private facilities. All studbook locations are in Europe.

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

Chersobius signatus can successfully reproduce in captivity. Reproduction has succeeded at many locations (Loehr 1999b; Morgan 1993; Palmer 1994; Van Loon 2008; [annual reports Dwarf Tortoise Conservation](#)). A husbandry

protocol and publications are available at the [website of Dwarf Tortoise Conservation](#). 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 plays an important role in the supervision by the ESF.

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

Dr. Victor J.T. Loehr (strategic and tactic studbook management)
IJsselstein, Netherlands
loehr@dwarftortoises.org

Mr. Martijn Kooijman (operational studbook management)
Den Haag, Netherlands
studbookhomopus@gmail.com

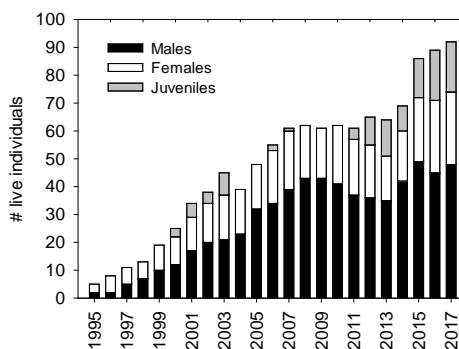


Figure 1. Numbers of live male, female and juvenile *C. signatus* in the studbook at the end of each year.

8. PARTNERS AND STAKEHOLDERS

The studbook is a collaborative effort of [Dwarf Tortoise Conservation](#) and the [European Studbook Foundation](#). Public facilities may participate in the studbook. Forty-two private facilities in Austria, Belgium, Czech, Cyprus, Germany, Ireland, Italy, Netherlands, Poland, Portugal, Sweden, Switzerland 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) *C. signatus* from the Northern Cape Province. Secondly, 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 *C. 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 *C. signatus* that might complement field studies (i.e., many scientific papers on *C. signatus* refer to captive results). Furthermore, participants often volunteer in scientific fieldwork conducted by Dwarf Tortoise Conservation 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. *Chersobius 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. *Chersobius 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 *C. 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 *C. signatus*. Such tortoises should not be subjected to display at public facilities. A protocol for the acclimation of wild-caught *C. signatus* to captive conditions is available. Parameters that will be used by the studbook coordinator to select suitable keepers for wild-caught *C. signatus* are experience of a keeper caring for wild-caught tortoises in general, period of time keeping (captive-bred) *C. 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 *C. signatus* is a heavily demanded species in captivity, by private and public facilities, the studbook encourages registration of each live *C. signatus* taken from the studbook's wild source population in the studbook. Registration of all wild-caught *C. 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

Dwarf Tortoise Conservation has signed a memorandum of understanding (2001) with 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 46). This will probably limit the size of the captive population to 300–350 individuals, unless some facilities would be prepared to permanently and responsibly 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 deteriorating conservation status of *C. 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 each generation. 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 (Table 1, Appendix 1), and the vast majority of all founders has reproduced. However, the genes of two founders were lost for the studbook, effectively leaving the studbook with 18 founders (29% of the anticipated total). Furthermore, most founders have not (yet) produced the anticipated 11 offspring. Founders that decrease prior to producing 11 (reproducing) offspring might require partial replacement to maintain genetic variation in the studbook. This will need to be assessed at a later time.

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.

Table 1. Status of founders and their offspring in the studbook. Red letters indicate that the genes of the founder were lost for the studbook. Note that each offspring originates from at least two founders.

Founder ID	Founder status ²	Founder reproduced	Number of live offspring	Offspring reproduced ³
WILD1 ¹	Not available	Yes	0	No
WILD2 ¹	Not available	Yes	2	No
1	Live (1995)	Yes	10	Yes (28 live)
2	Dead	Yes	5	Yes (10 live)
3	Dead	Yes	5	Yes (18 live)

Founder ID	Founder status ²	Founder reproduced	Number of live offspring	Offspring reproduced ³
35	Live (2001)	Yes	22	Yes (12 live)
36	Live (2001)	Yes	22	Yes (12 live)
37	Live (2001)	Yes	9	Yes (10 live)
38	Live (2001)	Yes	9	Yes (3 live)
60	Lost to follow-up	Yes	6	No
150	Live (2015)	No	0	-
151	Live (2015)	Yes	3	No
152	Live (2015)	Yes	2	No
153	Live (2015)	Yes	4	No
154	Live (2015)	No	0	-
155	Dead	No	0	-
156	Live (2015)	Yes	3	No
157	Live (2015)	Yes	2	No
158	Live (2015)	Yes	4	No
159	Dead	Yes	2	No

¹ Tortoise in the wild, producing offspring in the studbook through a gravidly imported female.

² Numbers are calendar years when founders were added to the studbook.

³ Numbers are numbers of individuals.

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 44 (22 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 44 recent wild-caught *C. 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. 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 *C. 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 Dwarf Tortoise Conservation](#)), and the sex ratio in offspring is now being controlled to balance the sex ratio of the population.

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 become unsuitable for *C. 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 *C. 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 *C. 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 *C. 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 Dwarf Tortoise Conservation contains a [procedure](#) that needs to be followed in case anyone is interested in receiving *C. 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 Dwarf Tortoise Conservation), 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 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 Dwarf Tortoise Conservation.

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 Dwarf Tortoise Conservation.

15.3. Individual identification

It is the responsibility of each studbook participant to individually recognise each tortoise. *Chersobius 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 *C. 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 *C. 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 <i>C. signatus</i> .	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 22.22.0 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. Continue supervision by the European Studbook Foundation.

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.

18. REFERENCES

- Baard, E.H.W. & Hofmeyr, M.D. 2018. *Chersobius signatus* (amended version of 2017 assessment). The IUCN Red List of Threatened Species 2018: e.T10241A129660689. Downloaded on 12 August 2018.
- Bertolero, A., Oro, D. & Besnard, A. 2007. Assessing the efficacy of reintroduction programmes by modelling adult survival: the example of Hermann's tortoise. *Animal Conservation* 10: 360-368.
- Boycott, R. 1986. A review of *Homopus signatus* with notes on related species. *Journal of the Herpetological Association of Africa* 32: 10–16.
- Boycott, R. & Bourquin, O. 2000. The southern African tortoise book: a guide to southern African tortoises, terrapins and turtles. Privately printed, Hilton, South Africa.
- Branch, B. 1998. Bill Branch's field guide to snakes and other reptiles of southern Africa. Third edition. Struik Publishers, Cape Town.
- 2007. A new species of tortoise of the genus *Homopus* (Chelonia: Testudinidae) from southern Namibia. *African Journal of Herpetology* 56: 1–21.
- Branch, W.R., Bauer, A.M., Jackman, T. & Marais, J. 2007. Geographical distribution, Testudinidae, *Homopus signatus*, Speckled padloper. *African Herp News* 43: 26–27.
- Daniels, S., Hofmeyr, M., Henen, B. & Baard, E. 2010. Systematics and phylogeography of a threatened tortoise, the speckled padloper. *Animal Conservation* 13: 237–246.
- Hambler, C. 1994. Giant tortoise *Geochelone gigantea* translocation to Curieuse Island (Seychelles): success or failure. *Biological Conservation* 69: 293–299.
- Hofmeyr, M.D., Loehr, V.J.T. & Baard, E.H.W. in press. *Chersobius signatus*. The IUCN Red List of Threatened Species 2018.
- Klerks, M. 2002. Adjusting the Namaqualand speckled padloper, *Homopus signatus signatus*, to captive conditions. *Turtle and Tortoise Newsletter* 6: 30–32.
- Loehr, V. 2004. First recorded second generation breeding with the Namaqualand speckled padloper, *Homopus signatus signatus*. *Radiata* 13: 11-12.
- Loehr, V.J.T. 1999a. Dietary requirements of captive hatchling Namaqualand speckled padlopers (*Homopus s. signatus*). *African Herp News* 28: 23–26.
- Loehr, V.J.T. 1999b. Husbandry, behavior, and captive breeding of the Namaqualand speckled padloper (*Homopus signatus signatus*). *Chelonian Conservation and Biology* 3: 468–473.
- Loehr, V.J.T. 2002a. Diet of the Namaqualand speckled padloper, *Homopus signatus signatus*, in early spring. *African Journal of Herpetology* 51: 47–55.
- Loehr, V.J.T. 2002b. Population characteristics and activity patterns of the Namaqualand speckled padloper (*Homopus signatus signatus*) in the early spring. *Journal of Herpetology* 36: 378–389.
- Loehr, V.J.T. 2006. Natural diet of the Namaqualand speckled padloper (*Homopus signatus signatus*). *Chelonian Conservation and Biology* 5: 149–152.

- Loehr, V.J.T. 2012. High body temperatures in an arid, winter-rainfall environment: thermal biology of the smallest tortoise. *Journal of Arid Environments* 82: 123–129.
- Loehr, V.J.T. 2015a. Twenty years of husbandry and breeding of the speckled tortoise (*Homopus signatus*) in a studbook: accomplishments and challenges for the future. *The Batagur* 5: 28–37.
- Loehr, V.J.T. 2015b. Small vernal home ranges in the Namaqualand speckled tortoise, *Homopus signatus*. *Journal of Herpetology* 49: 447–451.
- Loehr, V.J.T., Henen, B.T. & Hofmeyr, M.D. 2006. Shell characteristics and sexual dimorphism in the Namaqualand speckled padloper, *Homopus signatus signatus*. *African Journal of Herpetology* 55: 1–11.
- Morgan, D.R. 1993. Reptilia, Chelonii, Testudinidae, *Homopus signatus*, speckled padloper, reproduction. *Journal of the Herpetological Association of Africa* 42: 34.
- Palmer, M. 1994. The speckled tortoise, *Homopus signatus*, in captivity. *The Tortuga Gazette* 30: 1–5.
- Van Loon, F. 2008. Kweken met *Homopus signatus signatus*. *Terra* 44: 3–7.

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 (including deceased individuals that have produced surviving offspring)										
Bloodline:	A			B	C	D	E	F	G	
Founders:	1 x 2 [†]	1 x 3 [†]	WILD1 ^{NA} x 3 [†]	35 x 36	37 x 38	152 x 157	153 x 158	151 x 156	WILD2 ^{NA} x 159 [†]	Mult
#1	9	7	5 [†]	44	73	172	170	165	161	72
#2	10	11		96	79	183	176	175	162	
#3	13 [†]	14		106	91		177	182		
#4	42	25 [†]		107	99		178			
#5	43	41		121	100					
#6	51	74		128	111					
#7				128	113					
#8				131	123					
#9				132	142					
#10				137						
#11				138						
				139						
				145						
				146						
				147						
				148						
				149						
				166						
				167						
				168						
				169						
				174						

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

Premise: To maximise delay of inbreeding, bloodlines are combined as late as possible.
 = Offspring still to be produced to meet goals of studbook management plan.

(Partial) F1 and F2 (including deceased individuals that have produced surviving offspring)								
Bloodlines:	A x B	A x C	A x C	A x A	A x WILD	WILD x G	WILD x G	E x F
F1:	(1 x 3 [†]) x (35 x 36)	(1 x 2 [†]) x (37 x 38)	37 x (1 x 2 [†])	(1 x 2 [†]) [†] x (WILD1 x 3 [†])	(1 x 3 [†]) [†] x 60 ^{ff}	150 x (WILD2 ^{NA} x 159 [†])	154 x (WILD2 ^{NA} x 159 [†])	(153 x 158) x (151 x 156)
#1	71	164	112	53 [†]	82			
#2	77	171	114	66 [†]	86			
#3	94	181	115	75 [†]	87			
#4	110		117	76 [†]	88			
#5	118		124	Genes WILD1 lost	89			
#6	119		126	to population	92			
#7	120		136					
#8	125							
#9	144							
#10	146							
#11	163							
	179							

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

= Offspring still to be produced to meet goals of studbook management plan, where offspring should be homogeneously distributed among F1 parents.

(Partial) F2 and F3									
Bloodlines:	(A x WILD) x B	(WILD x G) x D							
F2:	((1 x 3)[†] x 60^{NA}) x (35 x 36)	(150 x (WILD^{NA} x 159[†])) x (152 x 157)							
#1									
#2									
#3									
#4									
#5									
#6									
#7									
#8									
#9									
#10									
#11									
#12									
#13									
† = dead									
N/A = Not available									
grey letters = planned									
	= Offspring still to be produced to meet goals of studbook management plan, where offspring should be homogeneously distributed among F2 parents.								