

Speckled dwarf tortoise
Chersobius signatus



Studbook Management Plan

Version 11, January 2024

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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
	December 2011	Studbook meeting Isernhagen, Germany
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)
	September 2023	Studbook meeting Langenhagen, Germany
10 (draft)	December 2023	Updated after five years since last update
11 (final)	January 2024	Minor changes (no comments from 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.

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1. INTRODUCTION

In 1995, four *Chersobius signatus* (then *Homopus signatus 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 a small number of wild-caught individuals have been added to the captive population ([Loehr 2015a](#); [Loehr in press](#); [annual reports Dwarf Tortoise Conservation \(previously Homopus Research Foundation\)](#)). In 2011, the participants in the studbook, in consultation with the South African authorities, 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 (i.e., conservation breeding). This aim was incorporated in a Studbook Management Plan. The current Studbook Management Plan updates draft version 10, which updates version 9 that was prepared in September 2018. The reason for the current update is the 5-yearly schedule at which the Studbook Management Plan is being revised.

In preparation for this updated Studbook Management Plan, progress made by the studbook was evaluated and a discussion paper drafted ([Appendix 1](#)). The discussion paper was used to consult all studbook participants. In addition, it was discussed with 12 studbook participants from seven countries on 9–10 September 2023 in Langenhagen, Germany. Recommendations were formulated in a meeting report ([Appendix 2](#)). All recommendations have been implemented in the current version of the Studbook Management Plan, as following:

- [Chapter 9](#): Novice keepers of *C. signatus* are provided with an information package about husbandry and breeding of *C. signatus*, and all participants have the opportunity to enrol in a WhatsApp group.
- [Chapter 9](#): An update of the Dwarf Tortoise Conservation website, including the implementation of a forum for studbook participants, was included in the [action plan for 2024](#).
- [Chapter 10](#): The conservation breeding aim for the studbook was maintained.
- [Chapter 12](#): Additional founders will be collected and exported in smaller batches (i.e., maximum of three instead of five couples), to facilitate placement at expert keepers of *C. signatus*.

2. DISTRIBUTION

Chersobius signatus is restricted to northwestern South Africa ([Branch 1998](#)). It occurs in two provinces, the Northern Cape and the Western Cape. All records of *Chersobius* in Namibia have proven to be *Chersobius* (previously *Homopus*) *solus* ([Branch 2007](#)). *Chersobius signatus* populations show genetic differences, likely due to physical distances among populations ([Fritz et al. 2022](#)). Nevertheless, all populations are considered one monotypic species ([Daniels et al. 2010](#); [Fritz et al. 2022](#)). Morphological differences among populations ([Boycott, 1986](#)) have been attributed to adaptations to local rock types ([Daniels et al. 2010](#)).

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 growth of annuals in spring; [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 being replaced by the Western Cape Biodiversity Act (Act 6 of 2021), under which *C. signatus* will likely be listed as Protected Species in terms of section 49(2)(e). Enforcement requires considerable capacity and budget due to the remoteness of some areas, making it difficult to patrol on a regular basis. Nevertheless, the attention to poaching by law enforcers, judges and journalists successfully contributes to the very limited presence of the species on 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 in 1996, but this status was elevated to Vulnerable in 2013 (Baard & Hofmeyr 2017). In 2017, its status was elevated to Endangered (Hofmeyr et al. 2018). 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](#) lists 5.5.5 (= number of males.females.juveniles) *C. signatus* at five public institutions (e.g., zoos). All institutions are located in Europe and participate in this studbook.

The studbook totals 35.33.17 live individuals; 5.5.5 at the five European Species365-institutions Amsterdam Zoo, Heidelberg Zoo, Plzen Zoo, Wroclaw Zoo and Wuppertal Zoo, 1.0.0 at Crocodile Zoo Prague, and the remaining 29.28.12 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. Given the small number of illegal founders, their offspring is likely to have a high level of inbreeding.

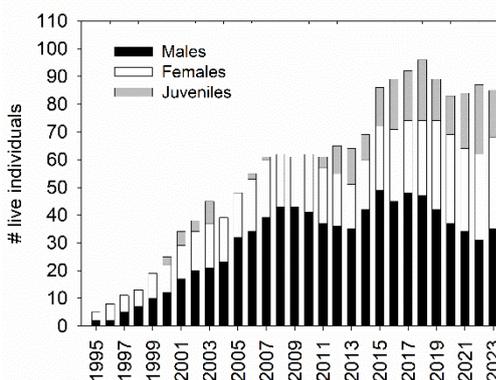


Figure 1. Numbers of live male, female and juvenile *C. signatus* in the studbook at the end of each year.

Chersobius signatus can successfully reproduce in captivity. Reproduction has succeeded at many locations (Loehr 1999b; Morgan 1993; Palmer 1994; Silva, 2021; Van Loon 2008; [annual reports Dwarf Tortoise Conservation](#)). A husbandry protocol and publications are available at the [website of Dwarf Tortoise Conservation](#). Second- and (partial) third-generation reproduction has also been reported (Loehr 2004; [annual reports Dwarf Tortoise Conservation](#); Table 1).

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. In addition, ESF provides cloud-based software for studbook management, guaranteeing access to the studbook registration in case both studbook coordinators would become unavailable. Dwarf Tortoise Conservation has also entered a formal agreement with the Dutch-Belgian Turtle and Tortoise Society, mandating the latter society to act as board of Dwarf Tortoise Conservation in case of unavailability of the Dwarf Tortoise Conservation board.

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

Dr. Victor J.T. Loehr (strategic and tactic studbook management)
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Mr. Martijn Kooijman (operational studbook management)
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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 ([Chapter 6](#)). Forty-two private facilities in Belgium, Czech, France, Germany, Italy, Netherlands, Poland, Portugal, Sweden and UK harbour the majority of the tortoises. Any knowledgeable facilities in Europe or elsewhere interested in participation in the studbook are considered potential partners.

The primary stakeholders for the studbook are CapeNature and the Northern Cape Department of Agriculture, Environment Affairs, Rural Development and Land Reform. These South African authorities are responsible for the conservation of the taxon. The latter 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.

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* ([Chapter 13](#)).

As agreed in the memorandum of understanding with the Northern Cape Province (2001), the studbook is strictly non-commercial. 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 subtropical arid climate is easily mimicked in indoor enclosures in temperate, warm, humid, and arid regions. *Chersobius signatus* requires a herbivorous diet consisting of readily available components. The most important factors for successful husbandry are well-structured enclosures, minimal disturbance and handling, appropriate annual temperature and photoperiodic cycle, and provision of adequate moisture for juveniles ([Loehr 1999a](#)). A [husbandry protocol](#) is available.

Nevertheless, the 1995–2022 median life expectancy of *C. signatus* in the studbook was a moderate 9.9 years (Loehr in press; Fig. 2), in part due to the absence of knowledge about captive husbandry and breeding of *C. signatus* in the early years of the studbook. The oldest live individual is more than 26 years old. Currently, novice keepers of *C. signatus* are pro-actively provided with information that helps them avoid known husbandry errors. In addition, all studbook participants have the opportunity to enrol in a WhatsApp group to improve information exchange among participants. The Dwarf Tortoise Conservation website will be expanded with an online forum for studbook participants in 2024.

Reproductive rates were lower than anticipated in previous versions of the Studbook Management Plan (Appendix 1). This was partly due to some participants assessing males and females as juveniles due to their small sizes, and subsequent solitary keeping of mature individuals. The information provided to novice keepers, the WhatsApp group, and online forum will help increase reproductive rates.

Wild-caught individuals may require several years to fully adjust to captivity (Klerks 2002; Loehr 1999b) and are easily distressed when moved to a new enclosure. Recently captured wild-caught individuals will be housed at expert tortoise keepers, or at keepers with extensive 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 coordinators 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.

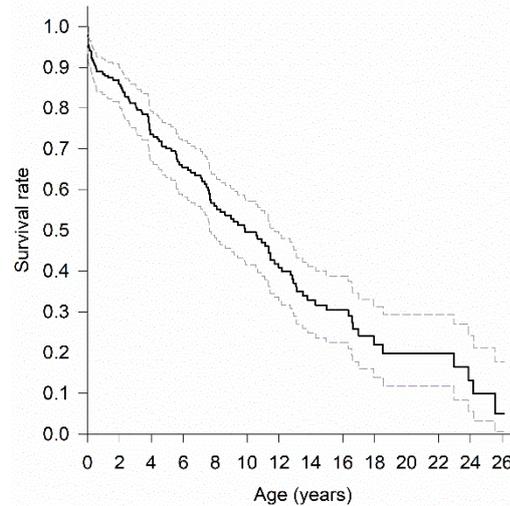


Figure 2. Survival curve with 95% confidence intervals of 217 *C. signatus* in the studbook between 1995 and 2022. Survival rates were similar between wild-caught and captive-bred individuals, and between males and females (Loehr in press).

10. ULTIMATE GOAL FOR THE CAPTIVE POPULATION

The medium-term goal of the studbook of the past 10 years will remain in place for the next 40 years: Increasing the genetic variation of the captive population by adding new founders, and consolidating the diversity in multiple captive-bred generations (see detailed analysis in Chapter 11). The studbook encourages registration of each live *C. signatus* taken from the studbook's wild source population (e.g., legally captured, rescued, or confiscated individuals) 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 (40–90 years from now), the captive population should become semi-autonomous, requiring very few additions of wild-caught individuals. This would further relieve pressure on the species in the wild. The broad genetic basis established in the first 50 years after developing the goal for the studbook will ensure that the semi-autonomous captive population will 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 to be addressed (Amavet et al. 2022; Bertolero et al. 2007; Hambler 1994; McGovern et al. 2020).

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 participants should not exceed 200 (currently 31). This will probably limit the size of the captive population to 300–375 individuals, unless some facilities would be prepared to permanently and responsibly house a relatively large number of tortoises.

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 dwarf tortoises.

11.2. Number of founders

Given the maximum manageable population size (300–375 individuals), the captive population would require at least 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 12 offspring (i.e., 31 couples times 12 offspring makes 372 individuals). This number of founders is lower than advised for tortoises (i.e., 100 founders according to the ESF genetics advisory board), 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* (Chapter 5) warrants a conservative approach regarding the number of founders removed from the wild. Increasing the generation time of subsequent generations (Paragraph 11.3) may reduce the rate of loss of genetic material, and counterbalance the relatively small number of founders.

The current number of founders in the studbook is 19, and the majority of all founders has reproduced. However, the genes of four founders were lost for the studbook, effectively leaving the studbook with 15 founders (24% of the anticipated total, Table 1).

11.3. Breeding strategy

Male and female *C. signatus* can usually be kept in couples year-round, so the studbook aims to form a population with similar numbers of males and females. An incubation protocol is available to reliably produce male and female offspring (annual reports of Dwarf Tortoise Conservation), and the current studbook population has a balanced sex ratio. Thus, each founder couple should produce 6.6 offspring (Paragraph 11.2), and each offspring couple in all subsequent generations should produce 1.1 replacement offspring. These are the offspring numbers that survive to maturity and reproduce, meaning that actual production should be larger. In particular, maximising generation time (Paragraph 11.2) implies increased losses of individuals prior to (delayed) reproduction. Considering life expectancy in the studbook population (Chapter 9), delaying reproduction to age 10 years (lower 95% confidence interval for survival rate = 0.43), as indicated in previous versions of the Studbook Management Plan, requires the production of 14.14 offspring from founder couples, and 4.4 (actually 3.3, but 4.4 simplifies develop a balanced sex ratio) offspring from offspring couples in subsequent generations.

Table 1. Production of offspring (numbers of males.females.juveniles) by founders and subsequent generations in 1995–2023, relatively to the Studbook Management Plan aims to produce 6.6 (surviving, reproducing) offspring per founder couple, and to produce 1.1 (surviving, reproducing) offspring from offspring couples in subsequent generations. Green numbers represent aims that were entirely reached, orange numbers represent aims that were not yet reached, and red numbers represent aims that will not be fully reached. Founders that died without reproducing (studbook numbers 4, 153 and 155) or without surviving offspring (studbook number 159), and two possibly inbred individuals (studbook numbers 72 and 215), have been excluded from the table.

Founder	F1 (aim: 6.6)	F2 (aim: 6 x 1.1)	F3 (aim: 6 x 1.1)
1 (dead)	6.6 (3.1 live) + 12.2.7 surplus (1.0.0 live)	6 x 1.1 (5 x 1.1 live) + 20.14.27 surplus (6.6.11 live)	0 x 1.1 + 3 x 0.0.2 + 2 x 0.0.1 (3 x 0.0.2 + 2 x 0.0.1 live) + 0.0.2 surplus (0.0.1 live)
2 (dead)	6.5 + 0.0.1 (0.1 live) + 0.0.2 surplus (0.0.0 live)	3 x 1.1 + 1 x 0.1.1 (2 x 1.1 + 0.1.1 live) + 7.6.4 surplus (2.1.2 live)	0 x 1.1 + 1 x 0.0.2 + 1 x 0.0.1 (0.0.3 live)

Founder	F1 (aim: 6.6)	F2 (aim: 6 x 1.1)	F3 (aim: 6 x 1.1)
3 (dead)	6.4 + 0.0.1 (3.0 live) + 7.0.3 surplus (0.0.0 live)	4 x 1.1 + 2 x 1.0 + 1 x 0.0.1 (3 x 1.1 + 1 x 1.0 + 1 x 0.0.1 live) + 12.10.21 surplus (3.4.7 live)	0 x 1.1 + 2 x 0.0.2 + 1 x 0.0.1 (0.0.4 live) + 0.0.3 surplus (0.0.2 live)
35 (live)	6.6 (6.6 live) + 9.7.2 surplus (1.1.0 live)	3 x 1.1 + 2 x 0.0.2 + 1 x 0.0.1 (3 x 1.1 + 1 x 0.0.2 + 3 x 0.0.1 live) + 6.8.17 surplus (2.4.7 live)	0 x 1.1 + 1 x 0.0.2 + 1 x 0.0.1 (0.0.3 live) + 0.0.3 surplus (0.0.2 live)
36 (dead)	6.6 (6.6 live) + 9.7.2 surplus (1.1.0 live)	3 x 1.1 + 2 x 0.0.2 + 2 x 0.0.1 (3 x 1.1 + 1 x 0.0.2 + 3 x 0.0.1 live) + 6.8.17 surplus (2.4.7 live)	0 x 1.1 + 1 x 0.0.2 + 1 x 0.0.1 (0.0.3 live) 0.0.3 surplus (0.0.2 live)
37 (live)	6.5 + 0.0.1 (6.3 live) + 11.0.0 surplus (2.0.0 live)	1 x 1.1 + 1 x 0.1.1 + 2 x 0.0.2 + 1 x 0.2.0 + 2 x 0.0.1 (all live except 0.2.0 is 0.1.0) + 0.1.6 surplus (0.0.3 live)	0 x 1.1
38 (dead)	6.2 + 0.0.1 (5.2 live) + 4.0.0 surplus (0.0.0 live)	1 x 1.1 + 1 x 0.1.1 + 1 x 0.0.2 + 1 x 0.2.0 + 1 x 0.0.1 (all live except 0.2.0 is 0.1.0) + 0.1.6 surplus (0.0.3 live)	0 x 1.1
60 ¹ (lost)	1.0 (1.0 live)	1 x 0.0.2 (1 x 0.0.1 live)	0 x 1.1
150 (live)	3.0 (2.0 live)	0 x 1.1	0 x 1.1
151 (dead)	3.1 + 0.0.1 (1.0 live)	0 x 1.1	0 x 1.1
152 (live)	0.2 + 0.0.1 (0.2.1 live)	0 x 1.1	0 x 1.1
153 (dead)	0.6 + 0.0.2 (0.5.0 live)	0 x 1.1 + 1 x 0.0.1 (1 x 0.0.1 live)	0 x 1.1
156 (live)	5.1 + 0.0.1 (3.0.0 live)	0 x 1.1	0 x 1.1
157 (live)	0.2 + 0.0.1 (0.2.1 live)	0 x 1.1	0 x 1.1
158 (dead)	0.6 + 0.0.2 (0.5.0 live)	0 x 1.1 + 1 x 0.0.1 (1 x 0.0.1 live)	0 x 1.1

¹ Founder not collected in the wild, but temporarily made available to the studbook. Hence, aims regarding offspring do not apply to this founder.

[Table 1](#) provides an overview of reproduction in the studbook population between 1995 and 2023, relatively to the aim to produce 6.6 (surviving, reproducing) offspring from founder couples, and 1.1 (surviving, reproducing) offspring from offspring couples in subsequent generations. For seven founders, the aims were not entirely reached, resulting in slightly lower genetic variation in the studbook population than anticipated. Towards the end of the time-frame for the medium-term studbook goal (~2060; [Chapter 10](#)), it should be assessed if the population will require additional founders.

Table 2. Breeding combinations of founders (left column), and the distribution of their genetic material over subsequent generations. All numbers are studbook numbers. Capital letters indicate breeding combinations of founders producing genetically related offspring. Grey characters indicate combinations not yet available in the studbook.

Founders	(Partial) F1	(Partial) F2
1 x 2 A	(1 x 2) x (37 x 38) A x C	((1 x 2) x 37) x (35 x 36) (A x 37) x B
1 x 3 A	(1 x 3) x (37 x 38) A x C	((1 x 3) x 60) x (35 x 36) (A x 60) x B
35 x 36 B	(1 x 2) x 37 A x 37	((1 x 2) x (37 x 38)) x 35 (A x C) x 35
37 x 38 C	(150 x 156) x (153 x 158) D x F	((1 x 3) x (35 x 36)) x (37 x 38) (A x B) x C
151 x 156 D	(151 x 156) x (153 x 158) D x F	((1 x 2) x (37 x 38)) x (35 x 36) (A x C) x B
150 x 156 D	... E x G	... (E x G) x (H x I)
152 x 157 E	... H x I	
153 x 158 F		((1 x 3) x (35 x 36)) x (153 x 158) (A x B) x F
... G	(1 x 3) x 60 ¹ A x 60 ¹	... (D x F) x (E x G)
... H	(1 x 3) x (35 x 36) A x B	
... I	(35 x 36) (153 x 158) B x F	

¹ Founder outside the studbook

To delay inbreeding, mixing of bloodlines is postponed for as long as possible ([Table 2](#)): Offspring from each specific founder couple is preferably combined with offspring from only one other specific founder couple (e.g., offspring from founder couple 1 x 3 is only combined with offspring from founder

couple 35 x 36). However, deviations from this procedure may occur when there is a risk of genetic material becoming extinct in the studbook population. For example, offspring from founder couple 1 x 3 was also combined with founder 60 that was in the studbook temporarily, and with offspring from founder couple 37 x 38 that had produced more offspring than could be combined with offspring from founder couple 1 x 2.

12. SOURCES FOR SPECIMENS INCLUDED IN THIS PLAN

The tortoises required to develop a semi-autonomous captive population in the next decades will originate from the wild. In part, these individuals may be collected specifically for the studbook, but rescued or confiscated individuals from South Africa or elsewhere would be valuable additions if they have known origins (i.e., originate from the same population as the founders in the studbook). Furthermore, third parties that might be granted collecting permits by the South African authorities could enrol in the studbook. It is important to note that the wild locality of the current founders in the studbook is increasingly disturbed and partly destroyed by anthropogenic activity. This locality will soon become unsuitable for *C. signatus*, so removal of additional tortoises here has little additional conservation impact. Founders collected in 2015 were captured under waste materials at housing construction sites (Figure 3).



Figure 3. Example of a founder *C. signatus* hiding under cardboard at a housing construction site in September 2015.

Ideally, all required 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 dozens recent wild-caught *C. signatus* is not acceptable. Therefore, founders should be added in smaller batches. In 2015, five couples were added simultaneously. Their survival appeared lower than survival of previously imported founders, although most deaths were unrelated to husbandry. Nevertheless, as a precautionary measure, future batches should not be larger than three couples. Smaller batches will facilitate placement at participants with extensive experience (see also Chapter 9). The survival of founders will be carefully monitored and evaluated prior to collecting a new batch.

13. GENETIC ISSUES THAT NEED TO BE RESOLVED

There are no genetic issues that may affect the studbook, because the studbook is based on founders from a single, known locality. Genetic studies have demonstrated that *C. signatus* is a monotypic species, that is genetically different among populations (Daniels *et al.* 2010; Fritz *et al.* 2022). Consequently, development of the studbook population will be based on founders from the original locality.

14. MANAGING THE STUDBOOK

14.1. Dispersal of offspring

Currently, studbook participants that breed *C. signatus* usually recommend candidates for their offspring to the studbook coordinators. As long as transfers will benefit the studbook aims, recommendations are followed. Secondly, the studbook coordinators maintain a waiting list of facilities that have requested *C. signatus*. If facilities are suitable (e.g., have sufficient knowledge, understand and support 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.

Important characteristics of this studbook are that 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. All transfers among studbook participants are loans. These conditions follow directly from the memorandum of understanding with the South African authorities (2001). To ensure compliance, all studbook participants must sign a formal agreement with Dwarf Tortoise Conservation.

14.2. Surplus

Since all future offspring needs to remain registered in the studbook, which is limited to 300–375 individuals, the studbook will not intentionally 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 are presented in the [annual reports and action plans](#) of Dwarf Tortoise Conservation.

14.3. 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.

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

[Table 3](#) summarises requirements for the establishment of a long-term captive population of *C. signatus*, along with measures intended to help meet the requirements.

Table 3. Requirements and supportive measures to obtain the aims in this studbook management plan.

Requirement	Supportive measures
A large number of capable and dedicated studbook participants prepared to follow the methods in this Studbook Management Plan, despite commercially available illegally imported <i>C. signatus</i> and their offspring.	Put emphasis on the fact that participation in the studbook will not merely provide personal pleasure, but is an important contribution to the taxon's conservation. Acknowledge the mutual dependence between participants and the management of the studbook.
Successful breeding (i.e., production of 28 offspring per founder couple, and 6 offspring per offspring couple).	Motivate and empower studbook participants to share experiences, and intervene when participants remain unsuccessful.
Permission from the South African authorities to collect and export additional founders in the next decades.	Involve the authorities in the development of the Studbook Management Plan, and ensure appropriate annual reporting. Practise full transparency and reliability in the reporting and communication.
Permission from the European authorities, and possibly other continents, to import wild-caught tortoises.	Practise full transparency and reliability.
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.

16. ACKNOWLEDGEMENTS

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Appendix 1: Discussion paper prepared in anticipation of Studbook Management Plan version 10

Future of the studbook on *Chersobius signatus*

Discussion paper

Dwarf Tortoise Conservation
Victor Loehr

30 July 2023

Introduction

The studbook population *Chersobius signatus* has developed from a small number of founders. Careful management to maximise genetic diversity has led to a population that is still demonstrably free of inbreeding after almost 30 years. This was accomplished by strictly combining pre-determined, genetically unrelated bloodlines to breed successive generations. Because the availability of such bloodlines is directly related to the number of founders in the population, we will soon run out of possibilities to form new genetically unrelated breeding couples.

Example of pre-determined combinations of genetically unrelated bloodlines

Offspring from founders 1×2 was combined with offspring from founders 37×38, and offspring from founders 1×3 was combined with offspring from founders 35×36. In the next generation, F2 offspring from (1×2)×(37×38) was combined with offspring from 35×36 to produce partial F3 offspring without inbreeding. Similarly, F2 offspring from (1×3)×(35×36) was combined with offspring from 37×38. See also Appendix 1 of the [studbook management plan](#).

The [studbook management plan](#) anticipates on gradually increasing the number of founders in the captive population, but the plan requires an update in 2023. The last addition of founders in 2015 was less successful than expected, so that we should evaluate our methods. Furthermore, the conservation status of *C. signatus* in the wild has deteriorated, demanding thorough consideration of any additional captures in the wild. As part of the upcoming studbook management plan update, it should be assessed if the current (conservation) aim of the studbook is still valid and realistic, or if we should downgrade the aim and accept degradation of the genetic quality of the captive population.

To succeed in achieving studbook aims, it is essential that participants understand and support them. Therefore, a meeting will be held on 9–10 September 2023 to discuss our strategy for the next 5–10 years. The current discussion paper was drafted in preparation for the meeting. It also enables participants who will be unable to attend (e.g., the zoos of Amsterdam, Plzen, Wroclaw and Wuppertal due to an EAZA meeting, and operational studbook coordinator Martijn Kooijman due to work obligations) to provide their input prior to the meeting.

Historical timeline of the studbook

1995: Import of 2.2 founders and start of the studbook
1996: First production of offspring (F1)
2001: Import of 2.2 founders
2002: First zoo participating in the studbook (Wuppertal Zoo)
2003: First production of second-generation offspring (F2)
2008: Studbook management plan drawn up
2013: Studbook management plan 5-yearly update
2015: Import of 5.5 founders
2016: Studbook management plan update after adding founders
2018: Studbook management plan update after *C. signatus* was assessed Endangered by the IUCN
2020: First production of third-generation offspring (F3)
2023: 86 live tortoises, 34 participants (5 zoos) in 11 countries

Permit requirements

The collecting permits issued to the Homopus Research Foundation (currently known as Dwarf Tortoise Conservation) contain strict conditions that help us acknowledge the view of the South African authorities on exploitation of wild tortoise populations (i.e., wild tortoise populations may not be used for commercial trade). The following conditions are particularly relevant:

Collecting permit issued by the Western Cape Province in 1995:

“Any hatchlings that have been bred in captivity must stay the property of the studbook and may not be used for commercial purposes.”

Collecting permit issued by the Northern Cape Province in 2001:

“Collected specimens may not be sold, traded, or used for any other commercial purposes.”

Memorandum of Understanding between the Homopus Research Foundation and the Northern Cape Province, signed in 2001:

“Subject to clauses 2 and 4 below, the Applicant may use the material and progeny or derivatives thereof (such as modified or unmodified extracts) for non-commercial purposes only.”

“Under this agreement, the Applicant may not commercialise the material or any progeny or derivatives thereof.”

“The Applicant may not transfer the material or any progeny or derivatives thereof to any third party [this includes studbook participants VL] without the prior informed consent in writing of the Director and then only under a written agreement containing terms no less restrictive than those contained in this agreement unless otherwise agreed in writing by the Director. The Applicant agrees to take every reasonable precaution to prevent the material coming into the possession of any unauthorised third party.”

Especially the last condition in the Memorandum of Understanding necessitates Dwarf Tortoise Conservation to enter formal agreements with studbook participants, transferring conditions to participants. Currently, every studbook participant in the studbook *C. signatus* (including zoos) has signed this agreement. The foundation has discussed with the South African authorities that it will act as an “operational manager”, so that it is not necessary to ask the authorities permission for each transfer.

Global trade of *C. signatus*

During the past 30 years, there has been virtually no legal commercial trade of *C. signatus* (Table 1). The last authorised commercial exports from South African were to the USA in 1993–1994. Within the EU, CITES authorities have legalised at least two confiscated *C. signatus* (one of which died soon thereafter), but it appears that their very limited offspring are all genetically related. Virtually all legal, captive *C. signatus* globally are owned by Dwarf Tortoise Conservation and managed by the studbook.

Table 1. All legal trade of live *Chersobius signatus* in the past 30 years. Green numbers indicate trade within the studbook. Red numbers indicate possible unauthorised trade (i.e., not reported by an importer or exporter).

Year	Importer	Exporter	Origin	Importer reported quantity	Exporter reported quantity	Purpose	Source
1993	JP	ZA		7	7	T	W
1993	US	ZA		18		T	U
1993	US	ZA			7	T	W
1994	US	ZA			13	T	
1995	NL	ZA		1		S	W
1998	US	AR			7	P	C
1999	US	ZA			4	B	W
2001	NL	ZA			4	S	W
2003	CZ	NL		2	2	Z	C
2007	GB	NA		1			I
2011	JP	ZA			15	T	C
2015	NL	ZA		10		B	W
2015	NL	ZA			10	N	W
2016	CH	IT	BE	1		B	C
2016	CH	IT	NL	1		B	C
2016	CH	IT			2	B	C
2017	CH	BE		1	1	T	F

Aim and methods in the current studbook management plan

The studbook management plan has been formulated in consultation with the South African authorities. The current plan (2018) aims to develop the captive population in such a way that it can serve as donor for reintroductions might the need arise in the (long-term) future (i.e., conservation breeding). To this end, the genetic diversity of the captive population is maximised by:

- acquisition of at least 31.31 founders (currently effective 9.10);

- delaying reproduction into subsequent generations of offspring (first reproduction at age 10 years in all generations);
- avoiding inbreeding.

In addition, the maximum size of the captive population was set at 300–350 individuals, to ensure that it will remain manageable and that no tortoises will become lost for the studbook. The maximum population size translates to a required production of approximately 6.6 F1 offspring per founder (i.e., surviving offspring that eventually reproduces into F2).

Results relatively to the aims in the studbook management plan

The [annual reports of Dwarf Tortoise Conservation](#) compare progress of the studbook on *C. signatus* with the aims in the studbook management plan. Overall, the following is relevant:

- Three deceased founders have no surviving offspring in the captive population (i.e., these bloodlines have gone extinct).
- None of the 5.5 founders imported in 2015 (currently 3.3 deceased) have yet produced the required 6.6 F1 offspring.
- Reproduction into F2 is skewed (i.e., not all F1 offspring have produced similar numbers of F2 offspring).
- Breeding quota per breeding couple have been implemented to avoid further skewness.
- Many studbook participants keep couples that should breed, but fail to produce the offspring needed. Studbook participants have been urged to follow the husbandry and incubation guidelines prepared by Dwarf Tortoise Conservation.

Summarising, the captive population has not reached maximum achievable genetic quality, despite the lack of inbreeding.

Example of skewed reproduction into F2

Founder 2 has produced 14 offspring (F1). Four of these have produced a total of 27 offspring (F2), whereas the remaining F1 offspring have not reproduced. According to the studbook management plan, 12 offspring (F1) should each have produced two offspring surviving and reproducing into F2.

Scenarios for the future

In light of the above, there are several scenarios how the studbook could proceed, each with its pros, cons, and requirements.

1. *Maintaining the studbook aim of conservation breeding*

In this scenario, the current aim and methods in the [studbook management plan](#) would remain in place.

Pros	Cons
Studbook continues to facilitate future conservation	Additional founders needed (preferably in 2024)
Coordinators/participants used to aim and methods	Survival of new founders should be improved
Aim is motivational for coordinators/ participants	Skewness in breeding F1...Fx needs to be solved
Requirements	
Volunteers to apply for permits, to finance, and to capture and export founders	
Permits issued by the South African authorities	
Plan to improve founder survival (e.g., importing smaller numbers of founders to successful locations)	
Plan to reduce skewness (e.g., transferring nonbreeding couples to successful locations)	

2. *Downgrading the studbook aim from conservation breeding to captive-conservation*

In this scenario, we would no longer pursue a conservation aim, but we would still optimise the genetic quality of the captive population (e.g., minimise inbreeding) to preserve it in captivity. The coordination of the studbook would mostly remain similar to the current situation (e.g., arranging combinations of certain bloodlines and setting breeding quota). Given the small number of founders, this aim might require a further increase of generation time (i.e., less breeding).

Pros	Cons
Few or no additional founders needed	No conservation benefit for wild population
No dependency on South African authorities	Skewness in breeding F1...Fx needs to be solved

Pros	Cons
	Further decrease of captive breeding
	Possibly too few founders for long-term success
Requirements	
Participants prepared to keep but not breed tortoises	
Plan to reduce skewness (e.g., transferring nonbreeding couples to successful locations)	

3. *Downgrading the studbook aim from conservation breeding to administrative*
 In this scenario, we would no longer manage the genetic quality of the captive population, but only its maximum size (e.g., 300–350 individuals, to avoid loss of tortoises from the studbook). Coordinators would merely register births, transfers and deaths, but not arrange certain combinations of bloodlines and breeding quota. All tortoises would still remain the property of Dwarf Tortoise Conservation, following permit conditions.

Pros	Cons
Simplified management of the population	No conservation benefit for wild population
Initially, removal of breeding quota	Rapid degradation of genetic quality (e.g. skewness)
Documentation of possible effects of inbreeding	Possible increase of genetic disorders
Requirements	
Coordinators willing to spend time on rather meaningless administration	

4. *Phasing out the studbook*
 In this scenario, we would give up the studbook entirely. Breeding would cease and the population would exist until the last tortoise will have died.

Pros	Cons
Simplified management of the population	No conservation benefit for wild population
Eventually, discharge of permit obligations	No captive data generated and published
	Efforts of the past 28 years in vain
Requirements	
Participants prepared to keep but not breed tortoises	
Coordinators willing to spend time on rather meaningless administration	

Concluding remarks

The current conservation aim of the studbook is linked to actual conservation in the wild. In 2018, the (conservation breeding) studbook was included in the [IUCN Red List](#) assessment. In 2020, the Endangered Wildlife Trust (South Africa) started surveys and habitat preservation work in which Dwarf Tortoise Conservation participates. And in 2023, CapeNature (South Africa) provided a support letter to Dwarf Tortoise Conservation acknowledging the work of the studbook, accepting the occasional need of wild-caught founders.

Appendix 2: Meeting report with recommendations for Studbook Management Plan version 10

Discussing the future of the studbook on *Chersobius signatus*

Report

Dwarf Tortoise Conservation
Victor Loehr

16 September 2023

Introduction

On 9–10 September 2023, 12 participants in the studbook on *Chersobius signatus* gathered in Langenhagen, Germany, to discuss the future of the studbook. The studbook management plan requires an update in 2023, and the discussion served to consider potential changes to the aims for the studbook, based on an evaluation of the results obtained so far.

The meeting date was selected after consultation with all studbook participants. On 30 July 2023, a discussion paper was drawn up and distributed among all studbook participants, and participants who were unable to attend the meeting were invited to send a response by e-mail. The Langenhagen meeting location was selected to equalise the travel distance for all participants. Eventually, participants originated from Belgium, Czech Republic, France, Germany, Netherlands, Poland, and Portugal. During the meeting, English was used as primary language.

Programme

The meeting programme included two evening lectures (Introduction to the dwarf tortoises, *C. signatus* in the wild, and a personal introduction of one of the participants and his husbandry of *C. signatus*) on 9 September, and the discussion and six additional lectures (Husbandry and breeding of *C. signatus* and other dwarf tortoises by four different participants, tick outbreak in an indoor population of *C. signatus*, and field studies, husbandry and breeding of *Chersobius boulengeri*) on 10 September.



Discussion

An evaluation of the studbook results shows that:

- there is no inbreeding in the studbook population despite 28 years of reproduction;
- average mortality is similar to mortality in the wild;
- mortality among the 5.5 founders imported in 2015 appears higher than mortality among previous imports of founders, albeit in part due to causes unrelated to captivity;
- several breeding couples are not reproducing as anticipated in the studbook management plan:
 - not all founders are producing 6.6 (surviving) F1 offspring;
 - not all F1 offspring produce a F2 generation;
- as many as nine breeding couples have matured and should have started reproduction in 2021–2023.

Consequently, founder genes are not uniformly distributed in the studbook population and the genes of several founders have gone extinct.

The meeting, and written responses on the discussion paper, made the following recommendations:

- Maintain the current conservation breeding aim for the studbook, given the deteriorating conservation status of the wild population, and solvable nature of the issues identified in the evaluation. This was a unanimous recommendation.
- If maintaining the conservation breeding aim would not be feasible (e.g., required permits), most participants preferred to downgrade the aim to a captive-conservation aim (i.e., managing the studbook to optimize genetic diversity without adding new founders).
- Reduce numbers of founders added to the captive population from 5.5 to 3.3 at a time, to enable all new founders to be acclimated and kept at participants who have been successful long-term. Relocate any possible long-term captive *C. signatus* already present at these locations.
- Lack of (sufficient) knowledge among some of the participants appears to be a central issue (e.g., participants are learning by doing, needlessly repeating mistakes that previous participants have already made). Implement the following to improve breeding results and (further) reduce mortality:
 - Prepare an information package for new studbook participants. This could include articles on husbandry and breeding of *C. signatus* that have been published in various languages, links to husbandry recommendations and annual reports with appendices that present information about husbandry and breeding, etc.
 - Facilitate horizontal information exchange among studbook participants; create a forum or app group that participants can use to discuss various issues related to husbandry and breeding. Preferably, this information should be retrievable using a search option at a later time.
 - Update the website of Dwarf Tortoise Conservation, and maintain it as the single portal for expert information about dwarf tortoises. It would be ideal if the forum or app group could be approached via this website.

These recommendations will be implemented in the update of the studbook management plan, and will be used to substantiate a permit application for additional founders.