Husbandry and reproduction of the African spurred tortoise, *Centrochelys sulcata* (Miller, 1779)

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Introduction

The African spurred tortoise (*Centrochelys sulcata*) is listed as vulnerable by the IUCN (2016). Populations of this species have decreased due to desertification, overgrazing, fragmentation of habitats and collection for the pet trade (Garrigues & Cadi 2011). This is the largest mainland species of tortoise in the world (Zwartepoorte 2002) and can attain carapace lengths of 85cm and weigh 105kg (Highfield 2006). It occurs mainly in northern Africa including the countries Egypt, Mali, Nigeria, Senegal and Sudan where it inhabits arid savannahs and acacia scrub lands (Highfield 1996).

Methods and materials

The two *C. sulcata* were captive bred and 26 years old during the breeding attempt. The female (1.1) weighed 34kg and the male (1.2) weighed 56kg. They were kept together in a fully insulated wooden enclosure measuring 3.5 x 2.5m (L x W) with a temperature and rain sensitive Velux window to allow for good ventilation and climate control. A large 2kw electrical heater with thermostat was placed on the wall to allow for a controlled ambient temperature. Two Arcadia UVB 160w bulbs were used for a combined basking and D3 synthesis with a 7.5-8 UVI. The UV Tool, designed by BIAZA Reptile & Amphibian Working Group, was used to help in the selection of appropriate UV lamps. Two Arcadia 10% T8 tubes were installed to the ceiling for extra light. Substrate was a mixture of soil and bark chippings at a maximum depth of 1.2m. Specimens also had access to a large outdoor paddock (Fig. 1) during the spring, summer and autumn to graze and bask in natural sunlight. A water bowl was always provided in their indoor quarters and outside during the summer months.

Indoor ambient day temperatures were between 28-35°C with the opportunity to bask at temperatures up to 45°C. Night temperatures were between 22-25°C. A photoperiod of 14hrs day/10hrs dark in the summer and 11hrs day/13hrs dark in the winter was implemented. During sunny weather with temperatures >10°C, specimens were allowed outside once

Fig. 1. The paddock and winter quarters of *Centrochelys sulcata* at Birmingham Wildlife Conservation Park.

their external shell temperature reached >30°C. The door was always left open to their indoor quarters so they could thermoregulate, whilst trees and bushes in the enclosure provided shade from the sun. Both specimens were often observed basking until carapace temperatures were at least 26-30°C. Once these temperatures were reached they would begin to graze the paddock.

During spring, summer and autumn, they had access to grazing in a large paddock with continued access to hay which was kept in their indoor quarters. Weeds were fed every two-three days including broadleaf/common plantain, clover, sow thistle and dandelion leaves and flowers. During the winter months, when access to the paddock was only allowed when external temperatures were >10°C, diet consisted of hay which was occasionally sprayed with water to entice feeding. Salad and vegetables were fed twice weekly and included chicory, endive lettuce, water cress, herbs including coriander and parsley mixed with Graze-On (Tortool 2009). Other vegetables including carrots and bell peppers were added occasionally to the diet, especially during training sessions. Food was served on a tray and dusted with Nutrobal (Vetark) multi-vitamin and mineral supplement.

During this breeding attempt, copulation was observed on 24th January 2015 and again on 27th January 2015. On 11th April 2015, the female was

Fig. 2. Female sulcata tortoise about to lay eggs in the nest chamber she has excavated.

observed digging on the side of a small grassy mound in the paddock. Over the next three days she was trying to dig in a couple of areas by the perimeter fence. On 15th April 2015, she was allowed access to the paddock at 09:00 and immediately continued to dig the hole she started on the 11th, and by 16:00 she had reversed into the hole. (Fig. 2). Contractions were obvious by her rhythmic movements in the egg laying chamber. At 19:00 she began to back-fill the nest with soil. Twenty-one eggs were collected and transferred to the incubator.

The eggs were divided into three tubs, individually numbered using a graphite pencil. Vermiculite mixed with water (volume ratio 3:1) was used as a substrate. Eggs were incubated at 30.5°C. Ten days into incubation, an electrical malfunction caused the eggs to drop in temperature to 15°C for >48hrs. Eggs were candled and weighed on 17th July 2015 to determine fertility. Eleven out of 21 eggs were fertile.

Results

On 30th July 2015, 106 days into incubation, cracks were observed on two of the eggs. Both of these hatched the following day (Fig. 3). A further five eggs had cracked on the 31st July 2015, three of which completely hatched by 4th August 2015. Two of the eggs that had cracked on the 31st had failed

Fig. 3. Sulcata egg in the process of hatching.

to hatch or make further progress by the 5th August, so a small window was cut into the egg using scissors and a sterilised sexing probe was used to gently touch the hatchling, but there was no movement and both had died. At closer inspection, both of these hatchlings had umbilicus and yolk sacs still attached and the shells were slightly deformed with poor fusion of the carapace scutes. On the 10th August 2015, four eggs remained and were cut open to reveal fully formed but dead tortoises. These were also deformed with irregular, domed shaped carapace and large yolk sacs still attached.

The hatchlings weighed between 30-36g. All five live hatchlings were kept in two containers on damp paper towel within the incubator until the yolk sacs had been absorbed (Fig. 4). The five hatchlings were raised in a communal enclosure measuring 60 x 45 x 45cm. A 160w Arcadia UVB basking bulb was used during the day for heat and UVB with a 7.5-8 UVI and a 150w infrared was also used during the day for extra heat but mainly

Fig. 4. New hatchling on a damp substrate to keep the yolk sac from drying out.

used during the night to maintain ambient temperatures. Photoperiod was the same as the adults' but basking temperatures were slightly lower and only reached a maximum of 35-38°C. Hatchlings were kept on damp kitchen towel and then moved onto bark chippings mixed with coco fibre when their umbilicus had dried up. Cardboard hide boxes were used and replaced frequently when soiled. Hatchlings were sprayed with water on a daily basis and the substrate helped retain humidity, which was kept at 60-70%. Substrate was 8-10cm deep to allow the hatchlings to dig if necessary. Hatchlings were fed a mixture of weeds including dandelions, sow thistle, clover, plantain, pulled grass mixed with Graze-On every 2-3 days dusted with Nutrobal (Vetark) vitamin and mineral supplements. Hay was always given ad lib and usually soaked or sprayed with water to entice feeding. A water bowl was added that was large enough for individuals to fully soak in.

Discussion

A high mortality rate was recorded during incubation. Of the 11 fertile eggs, only five hatched successfully. This was potentially due to an incubator malfunction that caused the temperature to fall to 15°C for >48hrs. Reptilian embryo development may cease during slight temperature fluctuations but temperatures outside the normal boundaries of incubation can cause deformities and increased mortality (Deeming 2004).

Over the past four to five years, clutches of eggs were laid two or three times a year. The female often struggled to find an appropriate nesting site

within the enclosure and oviposition resulted in crushed eggs. The female usually attempted to excavate a nest by the perimeter fence and failed due to the amount of tree roots. During the breeding attempt discussed in this paper, the female excavated a nest in a different area of the enclosure at the base of a grass mound with loose soil. The specimen was able to fully reverse into the nest and safely lay a clutch of eggs. The nest site was the deepest observed which allowed egg deposition with no crushed eggs. The crushing of eggs has been observed in other nest sites in the enclosure where the female fails to dig a hole deep enough. During the writing of this paper, the female returned to the same area to excavate a nest to lay another clutch of 21 eggs. This proves how important it is to provide a gravid *C. sulcata* with the correct nesting conditions and shows their ability to return to the same area to lay future clutches of eggs.

Copulation was usually observed during periods of low atmospheric pressure between March – September. During pre-copulation, shell butting from the male and biting at the limbs of the female has been observed in *C. sulcata* (Alderton 1988); however, none of these behaviours was observed in the specimens discussed in the paper.

Eggs were weighed multiple times during development and there was no correlation between egg weight and fertility. Indeed, some of the infertile eggs were heavier than the fertile eggs. The lightest fertile egg was 33g and the heaviest infertile egg was 40g, therefore candling the eggs is a far more reliable way of determining fertility. It is possible too much water was present in the 3:1 vermiculite/water incubation medium mix. This may have caused over-hydration of the eggs but further incubation experience and more published reproductive data on this species may allude to this in the future.

Shell butting and other antagonistic behaviours were not observed when keeping the hatchlings in a communal enclosure. This behaviour was prevented by having food present in the enclosure at all times (hay and Graze-On given ad lib) which was scattered all over the enclosure to allow all individuals to eat.

There were noticeable differences in the size of the hatchlings from five to eight months. At six months of age the smallest two tortoises weighed between 59-61g and the two heaviest tortoises weighed between 85-88g. Slight scute pyramiding was noticed in the heavier tortoises and no pyramiding in the smaller tortoises. A mixture of high levels of dietary protein and low humidity has been known to cause this (Wiesner & Iben 2003). Other factors that have been suggested as causes for this phenomenon are incorrect diet/over-feeding; lack of burrowing opportunities as aestivation is a natural behaviour; incorrect temperature and humidity; and lack of calcium and mineral supplementation (Stearns 1989). The hatchling tortoises at the Wildlife Park were kept at 60-70% RH and sprayed daily, having a deep

layer of substrate which acted as a humid medium. Pyramiding in the larger tortoises may have been exacerbated due to a higher intake of food rather than environmental parameters. Separating the larger and smaller tortoises from each other ensured a better control of their diet and basking sites were readily available and not taken up by larger and more dominant specimens.

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