NESTING BEHAVIOUR AND CLUTCH AND EGG SIZE OF THE HINGEBACK TORTOISE *KINIXYS SPEKII*

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INTRODUCTION

Nesting of wild tortoises is rarely observed, unless females converge to nest in particular areas (Swingland and Stubbs, 1985). We report the nesting behaviour of an individual *Kinixys spekii* which was being followed by thread-trailing. (This species has only recently been elevated from a subspecies of *K. belliana* (Broadley, 1993). Iverson, Balgooyen, Byrd and Lyddan (1993) have summarised information on clutch and egg sizes in tortoises. The only published data for *Kinixys* was for *'K. belliana'* estimated from Loveridge and Williams (1957). We therefore include information on the clutch and egg sizes of *K. spekii* maintained in a large outdoor enclosure in Harare.

METHODS AND RESULTS

Fieldwork was at the Sengwa Wildlife Research Area, described by Hailey and Coulson (1995). A female *K. spekii* (No. 500) of midline plastron length 148mm was fitted with a thread-trailing device on 31 December 1992 (Plate 1). She was trailed continuously until 14 February 1993, and located from two to five times each day during this period. The home range of female 500 was to the west of a footpath between the Institute office and the staff compound (Fig. 1). The female was first captured near the pools below the rocky outcrop, and ranged over an area of about 5.5 ha over the next six weeks. The mean daily movement distance of this tortoise was 236m. Most of the area south of the stream was mature mopane *(Colophospermum mopane)* woodland, with trees >10m tall, and had little ground vegetation and apparently low food availability. The female spent most time in mixed woodland near the compound fence or around the stream. The habitat north of the stream and west of the rocky outcrop was bushed grassland.

Plate 1. The late Ian Coulson with female 500 when she had returned to her home range after nesting. Note the thread-trailing bottle

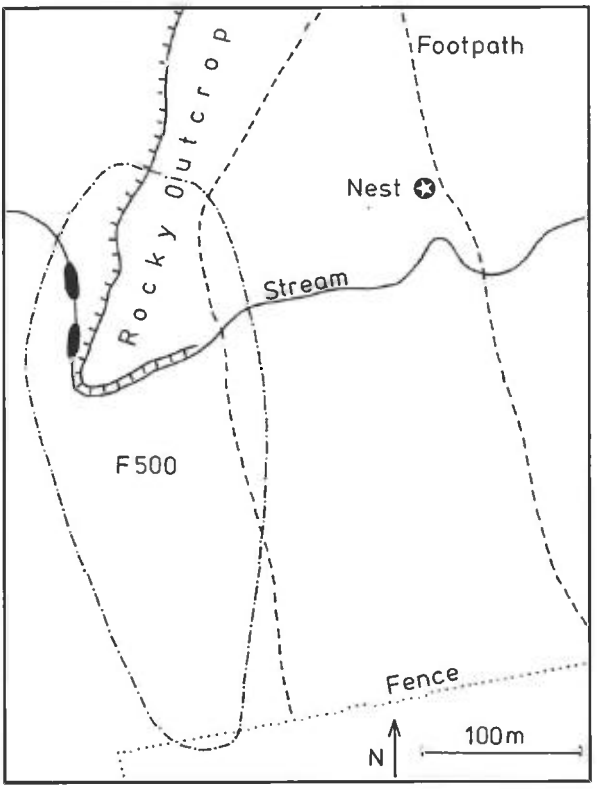

Fig 1. Position of the nesting area (star) in relation to the normal home range of female 500 (dot-dash line). The stream was usually dry, apart from the pools (shaded), but was flowing during February 1993. Dashed lines show the two footpaths between the Sengwa Wildlife Research Institute office and the staff compound, the fences of which are shown as the dotted line

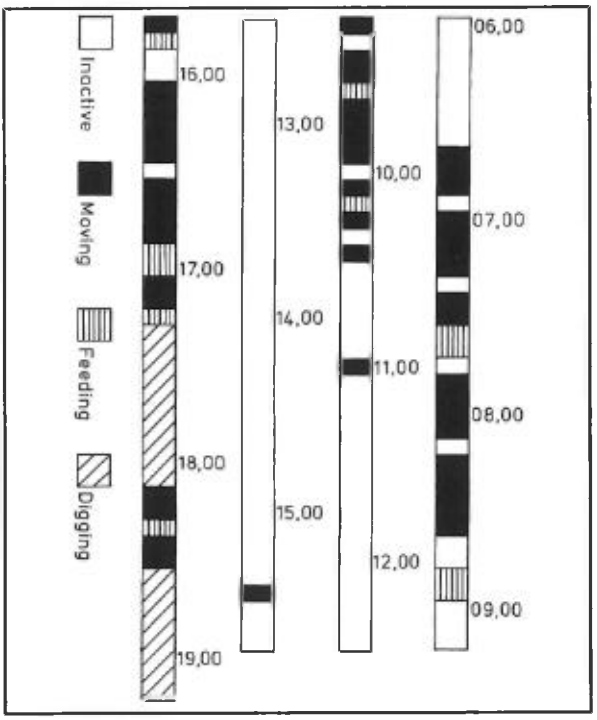

Fig 2. Activities of female 500 recorded at 5 minute intervals on 6 February 1993

Female 500 moved out of her previous home range on 5 February 1993, moving east along the stream, which she crossed three times. She moved a total of 405m on this day, the longest movement she had made since 13 January. The tortoise was observed continuously on 6 February, using binoculars, and her activity noted at 5 minute intervals. She was active in an area of bushes and small trees, 5m tall, about 130m east of her previous home range. This area had an incomplete canopy, and ground cover of grass about 30cm tall. The tortoise was active from 6.40 to 10.25h, with brief periods of inactivity and of feeding (Fig. 2), eating fungi, fallen fruits of the tree *Erythroxylum zambesiacum*, forbs, and a small dung beetle.

The tortoise remained in tall grass under a tree from 10.30 to 15.40, with only small changes of position of less than 1m. She stopped under a small *Combretum apiculatum* tree at 16.00h, and moved in small circles under this tree until 16.20h. In retrospect, this circling movement was probably investigation of the area as a nest site. Female 500 then moved to a small mopane tree, and scraped the litter of dead leaves from a small area under this tree. The tortoise dug a nest from 17.20 to 18.05h, using the hind legs, then moved 10m in a round trip back to the same tree. She then moved in circles covering about two square metres from 18.25 to 18.30h, and then dug another nest about 1.5m from the first. She was still digging this nest when the observer left at dusk (19.10h). The positions of these nests (1 and 2) are shown in Fig. 3. The female was active in the same general area on the following day (7 February). Her activities when located were: 7.38h active in thin grass; 11.05h active under *E. zambesiascum* tree; 12.22h inactive under same tree; 17.16h digging under *Mundulea sericea* tree (nest 4).

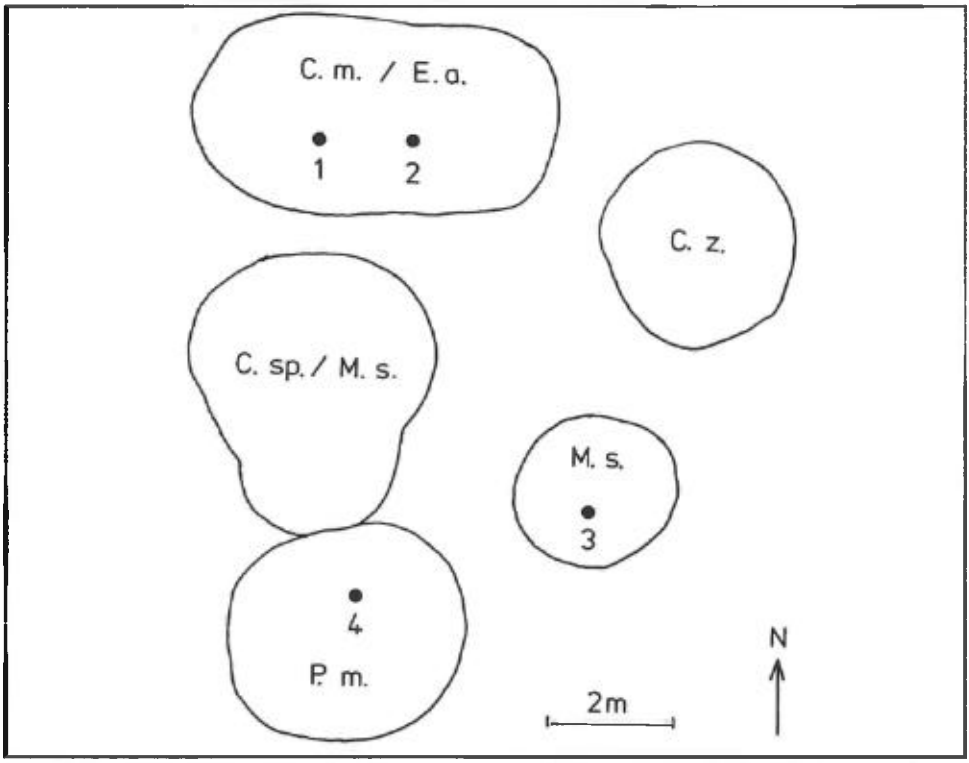

Fig 3. Location of abandoned (1-3) and successful (4) nests in relation to tree canopies. Tree species are: *Colophospermum mopane* (C.m.); *Erythrophleum africanum* (E.A.); *Combretum zeyheri* (C.z.); unidentified *Combretum* (C.sp.); *Mundulea sericea* (M.S.); *Pseudolachnostylis maprouneifolia* (P.m.).

Nests 1 to 3 were not used and left uncovered by the tortoise, but nest 4 was filled in when examined at 7.15h on 8 February. The nest was of similar stunted sock shape to those of other tortoises (Swingland and Coe, 1978). The hole was 4.5cm in diameter, widening to a chamber of 8cm diameter. The total depth was 10cm, with the egg chamber being 4cm in height. The chamber contained three eggs, and the hole was sealed with a compacted plug of soil 4.5cm deep (Plate 2).

Plate 2. Eggs and opened nest of *K. spekii*

The tortoise moved back to her original home range on 8 February, crossing the western path to the compound shortly before 17.00h. She moved a total of 578m on this day, compared to an average of 281m on the two previous (nesting) days. The movements from the home range to the nesting site on 5 February, and back to the home range on 8 February, were thus substantially longer than the usual daily movement distance of the tortoise. Nesting itself did not have a major effect on daily movement distance, or on feeding. There were 14 records of feeding on 6 February (some were between the 5 minute observations and are not shown on Fig. 2), compared to 16 on 23 January and 9 on 12 February, days when this female was also observed continuously. Female 500 was trailed until 7.06h on 14 February, and remained within the usual home range area. There were no further signs of nesting activity, such as thread trailed in circles over a small area.

Nesting activity was similar to that of the Mediterranean tortoise *Testudo hermanni* in being outside the normal home range and in taking place in the evening (Swingland and Stubbs, 1985). The major difference was that *K. spekii* nests were dug under the tree canopies (Fig. 3), whereas *T. hermanni* nests were in open areas, to which females migrated from woodland. Two advantages of nesting in the evening have been suggested for tortoises. First, to enable the female to assess the thermal characteristics of the nest site (Swingland and Stubbs, 1985), which will determine the sex of the hatchlings.

Second, to avoid overheating (Meek, 1988). *Kinixys spekii* nesting under tree canopies would not be under thermal stress at any time of day, and so the former seems to be a more general explanation of evening nesting in tortoises.

The positioning of nests in the shade presumably reflects the higher temperatures in the tropics. To test this, the temperature within the nest was monitored between 6.00 and 18.00h on 9 February 1993, using a YSI telethermometer with a soil probe inserted to a depth of 8cm (i.e. in the centre of the egg chamber). Another soil probe was placed at 8cm depth in the soil in an area of open grass nearby, and shade air temperature was also recorded. Nest temperature increased from 23.5 to only 27ºC, while the soil temperature at the exposed location rose to 36ºC (Fig. 4b). Shade air temperature reached a maximum of 30ºC; this is a typical value for the season (Fig. 4a), so the nest temperatures on 9 February were representative of the start of the incubation period. The nest was relocated in March 1994, and contained fragments of eggshell; it could not be determined whether the egg had hatched or been destroyed.

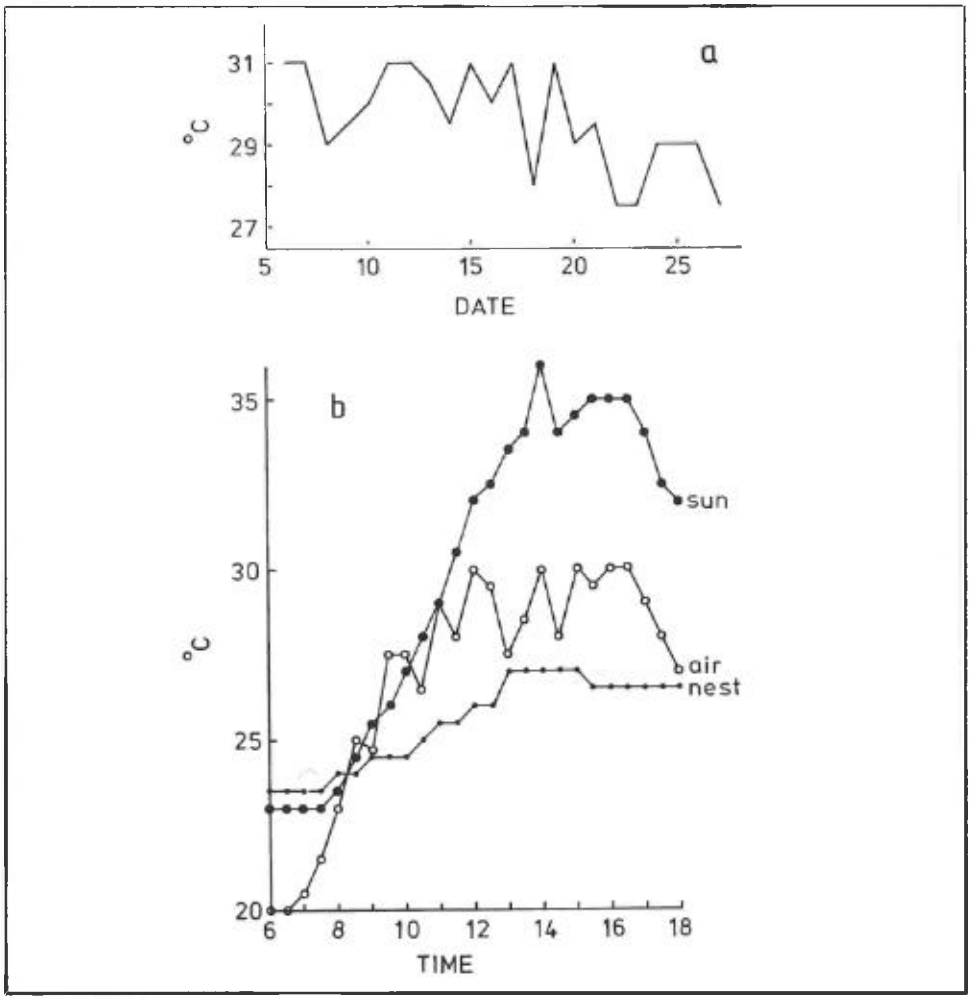

Fig. 4. a) Maximum shade air temperatures during February 1993. b) Temperatures recorded on 9 February 1993 at 8cm depth within the nest (•), at the same depth in unshaded grassland (●), and shade air temperature (o).

Female 500 weighed 885g after egglaying (at 17.47h on 8 February), allowing for the weight of the trailing box. The three eggs had mean dimensions of 40.7mm x 32.2mm and mass of 24.8g. Other data on clutch and egg size in *K. spekii* were obtained from tortoises kept in a 100 m² outdoor enclosure, with grass and trees, at the University of Zimbabwe. The tortoises were from several unknown locations, but probably from the highveld around Harare (18ºS). Fourteen female *K. spekii* were examined by x-ray (100 mAs, and 48-52 kV depending on body size) on 31 January and 6 December 1994, seven of them on both occasions. Seven individuals had eggs, with clutch size ranging from 2 to 5. Mean clutch size was 3.75 eggs (S.D.=1.0), including the female from Sengwa. Boycott and Bourquin (1988) give a clutch size range of 2-6 for *K. spekii* and 2-7 (exceptionally 10) for *K. belliana*, but do not give means or sample sizes. They indicate that both species may lay more than one clutch per year.

The eight females had mean midline plastron length of 161mm; this measure was used, rather than carapace length, as the carapace of this species is moveable. Most of these females were returned to the outdoor enclosure and the eggs were not obtained. Body mass excluding eggs has been calculated by subtracting clutch mass, estimated as clutch size x mean egg mass; mean body mass was 942g. There was a fairly strong correlation between clutch size and body size (Fig 5; r^2=42.5%). The correlation coefficient is greater than that found in *Testudo* (five populations studied by Hailey & Loumbourdis, 1987), although not significant because of the small sample size (P=0.079).

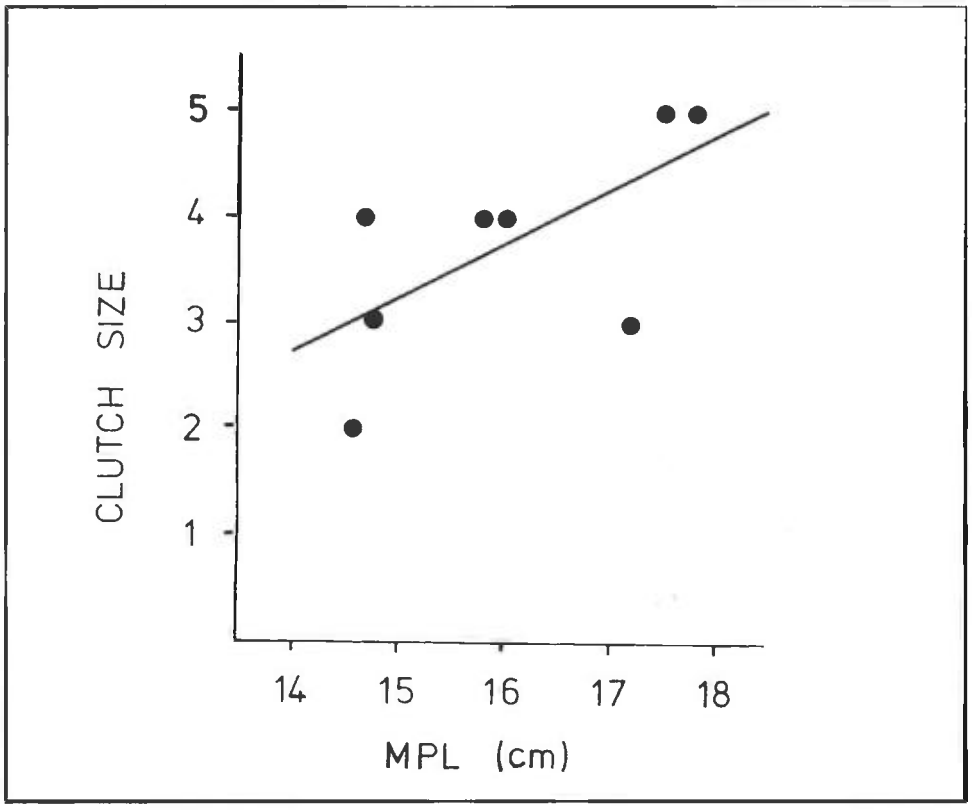

Fig. 5. The relation between clutch size (number of eggs, N) and body size (midline plastron length, MPL, in cm). The equation of the regression fit is: N = 0.52 MPL - 4.5.

Eggs were obtained from one female using oxytocin (Hailey and Loumbourdis, 1987). Twenty-one other eggs were laid by females kept in pens during feeding studies. Some of these eggs could not be assigned to particular individuals, but the timing suggested that they were laid by eight different females. Mean egg dimensions for the ten individuals (including the field and oxytocin-induced egglaying) are shown in Table 1. Mean egg size was towards the lower part of the range reported for *K. spekii* by Boycott and Bourquin (1988), which was 38-47x30-34mm and 20-31g. It is also of interest to compare these data with those for a temperate tortoise of similar body size; *T. hermanni* from Alyki and Litochoron (40ºN) in Greece (Hailey and Loumbourdis, 1987).

The eggs of *K. spekii* were of similar shape to those of *T. hermanni* (in which length/width=1.34), but larger; *T. hermanni* eggs were on average 37.3 x 27.9 mm and mass 16.9g. Relative egg size (mean egg/body mass) was about 40% greater in *K. spekii*, 2.44% (=23.0/942), compared to 1.68% in *T. hermanii*. This confirms the observation of Ewert (1979) that tropical chelonians produce larger eggs. The data for *'K. belliana'* (which may include *K. spekii)* from 80ºS continue this trend, with egg mass of 36.1g and relative egg mass of 3.00% (calculated from Iverson *et al.* 1993). The two populations of *Kinixys* also support the observation that clutch size decreases with latitude; *'K. belliana'* clutches averaged only 2.3 eggs. However, *K. spekii* clutches are of similar size to those of *T. hermanni* (mean 3.9 eggs). This suggests that larger egg size in the tropical *K. spekii* reflects greater reproductive investment than in the temperate *T. hermanni*, rather than a trade-off between egg size and clutch size.

Table 1.
Size and shape of eggs of *Kinixys spekii*. Means and S.D.s. were calculated from means for different females (N=10), but the minimum and maximum are for individual eggs. Shape = length/mean width.

	Mean	S.D.	Minimum	Maximum
Length (mm)	40.8	3.1	33.2	46.4
Mean width (mm)	30.7	1.2	28.3	34.2
Shape	1.33	0.12	1.10	1.52
Mass (g)	23.0	2.1	19.5	28.3

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REFERENCES

Boycott, R.C. & Bourquin, O. (1988). *The South African tortoise book.* Johannesburg: Southern Book Publishers.

Broadley, D.G. (1993). A review of the Southern African species of *Kinixys* Bell (Reptilia: Testudinidae). *Annals of the Transvaal Museum* **36** 41-52.

Ewart, M.A. (1979). The embryo and its egg: development and natural history. In *Turtles: perspectives and research,* 333-413. Harless, M. & Morlock, H. (eds). New York: Wiley.

Hailey, A. & Coulson, I.M. (1995). Habitat association of the tortoises *Geochelone paradalis* and *Kinixys spekii* in the Sengwa Wildlife Research Area, Zimbabwe. *Herpetological Journal* **5,** 305-309.

Hailey, A. & Loumbourdis, N.S. (1987). Egg size and shape, clutch dynamics, and reproductive effort in European tortoises. *Canadian Journal of Zoology* **66,** 1527-1536.

Iverson, J.B., Balgooyen, C.P., Byrd, K.K. & Lyddan, K.K. (1993). Latitudinal variation in egg and clutch size in turtles. *Canadian Journal of Zoology* **71,** 2448-2461.

Loveridge, A. & Williams, E.E. (1957). Revision of the African tortoises and turtles of the suborder Cryptodira. *Bulletin of the Museum of Comparative Zoology, Harvard* (115), 163-557.

Meek, R. (1988). Thermal loads experienced by a nesting female *Testudo hermanni. Amphibian-Reptilia* **9,** 311-312.

Swingland, I.R. & Co, M. (1978). The natural regulation of giant tortoise populations on Aldabra Atoll. Reproduction. Reproduction. *Journal of Zoology, London* **186,** 285-309.

Swingland, I.R. & Stubbs, D. (1985). The ecology of a Mediterranean tortoise *(Testudo hermanni):* Reproduction. *Journal of Zoology, London (A)* **205,** 595-610.