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PRELIMINARY STUDY ON THE BREEDING PATTERN OF THE EGYPTIAN TORTOISE, *TESTUDO KLEINMANNI*, IN ISRAEL

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ABSTRACT

Egyptian tortoises were collected in the field and X-rayed at 2-4 week intervals during two breeding seasons. Females laid 2-3 clutches per year, each consisting of 1-3 large eggs. The internesting period was estimated to be 20-30 days. The nest was a shallow pit at a base of a bush. The breeding biology of *Testudo kleinmanni* is similar to that of other small highly specialised tortoises.

INTRODUCTION

The Egyptian tortoise, *Testudo kleinmanni*, is a small terrestrial tortoise which inhabits sandy areas and dunes throughout northeastern Libya (Schleich, 1989), northern Egypt, Sinai and eastwards to the northern Negev in Israel (Flower, 1933; Iverson, 1986; Mendelssohn, 1982). The Egyptian tortoise is an endangered species threatened by habitat destruction (Mendelssohn, 1982) and commercial collecting (Buskirk, 1985).

The limited information on its breeding biology has originated from captive individuals in Egypt and Israel. Data on wild populations are not available. Lortet (1887) observed mating during March-April and nesting during May. Flower's (1933) observations on a large number of individuals in Giza Zoo indicated that peaks in copulation frequency occurred in September-October while eggs were laid mainly in June. Egg length and width ranged from 29-30mm and 22-23mm, respectively. Sixty-nine individuals hatched in Giza Zoo, 53 per cent in October, 24 per cent in November, 9 per cent both in September and February and 5 per cent in January (Flower, 1933). These young were totally yellow in colour and their carapace length, width and height was 33mm, 28mm and 18mm, respectively. In Israel, captive tortoises mated during October-November and February-April, while eggs were laid between April and July. Hatching started in August and ended in October, except for a single case in December. The incubation period, at constant 30°C, was 97-119 days (Mendelssohn, 1982). Half of these clutches (n = 12) consisted of one egg, two clutches consisted of two eggs, three other clutches of three eggs and one of four eggs (Mendelssohn, 1982).

This paper describes preliminary observations on the breeding pattern of a wild population of the Egyptian tortoise in Israel.

METHODS

Study site — The study was carried out at Holot Agur, about 15km north of Beer-Milka (34° 24′ E, 31°C 00′ N), in the northwestern Negev desert. The area is characterised by east-west trending sand ridges separated by deep valleys. Mean annual air temperature is 20°C (Israel Meteorological Service, unpubl. data), with mean maximum 30°C in the hottest month (July) and mean minimum 12°C in the coldest month (January). Subzero temperatures are rare. Large fluctuations in air temperature (10-15°C) are common during the day. Most precipitation (100-200mm) occurs between October and March. Vegetation cover averages 20-30 per cent and consists primarily of *Artemisia monosperma* plant association (Waisel, Pollak and Cohen, 1982).

Field methods — Adult females were randomly collected, mainly by following fresh tracks on the sand, and X-rayed (Gibbons and Green, 1979; Turner, Medica and Lyons, 1984) using a portable X-ray generator (Softex K-2; 3mA; 50kV; individuals were placed 50cm away from the generator and were exposed for 10 seconds). Four females were fitted with radio-transmitters (15-17g) that were glued with dental acrylic to the posterior carapace (Geffen and Mendelssohn, 1988, 1989). These females were X-rayed every 2-4 weeks during their daily inactivity period (evening, Geffen and Mendelssohn, 1989), between January and July, and were returned to the location of collection a few hours later.

In May 1984 two females, that were previously X-rayed and were known to carry eggs, were each placed in a small enclosure (1m²) for 2-3 weeks. Each enclosure was built around a large bush with a complex system of rodent burrows. The females were released after the eggs were laid. The aim of this procedure was to enable us to locate nests and monitor the incubation period in the wild. We used only two females, largely because very few females were located daily.

Every 2-4 weeks daily air (50cm above ground) and surface (1 and 5cm deep) temperatures were taken, using a digital thermometer (Wescor TH-65, accurate to ±0.1°C), from a bush base near each nest. At each visit, temperature measurements were taken at equal intervals four times daily. In addition, sand samples were collected twice a day (at 0500 and 1400) from the

			1983					1984					
	SCL	Age	15.4	29.4	6.5	20.5	24.6	18.2	16.3	13.4	4.5	18.5	8.6
#1	111.3	9							0				
#2	113.6	8	0							0			
#3	116.5	9			2	2	0						
#4	106.4	6		2	2	2	1			0		0	
#5	113.4	7						0	2	1	3	3	0
#6	113.0	9	2					0		1	2	2	0
#7	112.6	6							1	2	2	0	0
#8	120.7	8										2	
#9	114.3	7										1	2
#10	107.3	7						0					
$\overline{X}$	112.9	7.6	1.0	2.0	2.0	2.0	0.5	0	1.0	0.8	2.3	1.3	0.5

TABLE 1: Number of eggs, determined by X-ray, in nine Egyptian tortoise females during two breeding seasons. Dates of X-raying are presented for each year, with the mean number of eggs per tortoise for each date shown at the bottom line. SCL = Straight Carapace Length (mm). Age represented as number of growth rings counted on carapace plates.

	Intercept	Slope	r^2	*F*	*P*	d.f.
Clutch size	−2.50	0.04	0.05	0.59	>0.4	1.13
Egg width	8.92	0.14	0.20	5.60	<0.05	1.23
Widest egg per clutch	1.75	0.21	0.37	7.01	<0.05	1.13

TABLE 2: Linear relationships of reproductive variables to body size (straight carapace length) in *Testudo kleinmanni*.

surface (1 and 5cm deep) and stored in sealed containers. The sand samples were later weighed, dried in a oven (100°C) and in a desiccator. Water content in the sand was calculated as the difference in weight of samples before and after drying.

Data analysis — Clutch size and measurements of eggs were calculated from X-ray negatives. Correction for egg positions in the tortoise body (≈ 2cm above the X-ray film) were made by reducing measurements by 2 per cent. Linear regression and one way ANOVA were used in the statistical analysis.

RESULTS

During this study we observed only two mating pairs, both during March. On one occasion a male was observed to attempt copulating 28 times within one hour. This behaviour consisted of series of knocks on the posterior part of the female's carapace, causing the female to stop, followed by the male climbing on the female's back, pushing his tail beneath hers and simultaneously uttering a series of high pitched, rasping calls (described by Flower, 1933 and Loveridge and Williams, 1957).

Table 1 summarises the number of eggs observed in nine females during two nesting seasons. During no other period of the year did females carry eggs. Eggs were first observed in the oviduct during March-April and last observed during the end of June. Most clutches (8) consisted of two eggs (total number of clutches = 14), five consisted of one egg and one consisted of three eggs (mean ± SD = 1.71 ± 0.61).

Two nests were found in July (6.7.84), one in each enclosure. The nests, that contained two and three eggs, were located in a shady spot at a base of a bush, facing south. The eggs in each nest were laid in a shallow pit (3-4cm deep) and covered with sand. The sand around the eggs was clumped as if it was previously wetted. Mean (±SD) length and width of the eggs was 31.6mm ±1.1 and 21.4mm ±0.5, respectively. The eggs were not moved from their original position when measurements were taken. Sand temperature at a depth of 5cm ranged between 24.3-38.2°C in July, 23.5-35.3°C in August and 23.9-34.5°C in September. Sand water content at the surface during the summer ranged between 0.13-0.30 per cent and at depth of 5cm between 0.16-0.27 per cent.

In one nest two young hatched after 70-90 days. On 14.9.84 we observed one individual hatching, the other hatched one or two days later. Hatchling body length was 25.7 and 30mm and their weight was 3-4g. No hatching occurred in the other nest, but an egg from this nest contained a live embryo (10mm) and a large yolk sac 10 months after the eggs were laid.

Egg width and number were measured from X-ray negatives. Mean egg width was 24.3mm ±1.1, and varied significantly between females (F=4.6, d.f. =6.23, P<0.01). Egg width significantly correlated with body size (Table 2).

DISCUSSION

The period of mating appeared to be limited to the spring (March). Although copulations were reported to occur in captivity during autumn (September-October, Flower, 1933; Mendelssohn, 1982), there were no indications that they occur in autumn in the wild. Furthermore, Geffen and Mendelssohn (1989) reported that captive individuals showed a different annual activity cycle due to availability of food round the year. This phenomenon might have implications on the breeding behaviour of tortoises in captivity. Copulation attempts during autumn were observed in the wild in *Gopherus polyphemus* but females were not receptive during that time (Landers, Garner and McRae, 1980).

Sperm storage is a well documented phenomenon with terrestrial tortoises (Moll, 1979). Fitting four females with transmitters prevented them from copulating due to the location and size of the transmitter, however they produced 2-3 egg clutches annually. Sperm storage appears to be an especially important mechanism in species with relatively low density populations (e.g. Egyptian tortoise, 27 individuals per km^2; Geffen, 1985), ensuring reproduction when males are not encountered.

Ovulation of similar sized ova in the ovaries occurs simultaneously (Moll, 1979), so presence of different numbers of eggs in a female's oviduct at different times within one season is indicative of several different clutches. Differences in shell thickness are easily observed by X-ray, where thin shelled eggs indicate the formation of a new clutch. We concluded from Table 1 that:

1) The nesting period lasted from March to the end of June.

2) Within the nesting period each female produces 4-6 eggs in two-three cycles.

3) The internesting period is estimated to be between 20 and 30 days.

Egg size in nature was similar to that measured in captivity by Flower (1933). Congdon and Gibbons (1983, 1985) studied the relationships between reproductive characters and body size in a variety of turtle species, and concluded that among species clutch size increases with body size. In many species, egg width increases with body size (Congdon and Gibbons, 1985; Hailey and Loumbourdis, 1988) probably reflecting the width of the pelvic canal. Hailey and Loumbourdis (1988) argued that small individuals can overcome this constraint by modifying egg shape, thus smaller individuals are expected to carry more elongated eggs. This could not be investigated here as egg length can not be accurately measured from X-ray photographs. It appears that production of multiple clutches per year is a common phenomenon in the *Testudo* species and it may reflect the morphological constraint of packing shelled eggs within the body (Swingland and Stubbs, 1985; Andreu and Villamor, 1986; Hailey and Loumbourdis, 1988).

The nest construction, as well as the indication for urination during oviposition are typical for terrestrial tortoises (Ehrenfeld, 1979). Urination in the nest may camouflage the eggs' smell, thus decreasing detection by potential predators (Patterson, 1981). Urination may also increase the humidity in the nest, thus decreasing water loss by evaporation from the eggs. Incubation time in the wild was lower than in captivity (Mendelssohn, 1982) but this may be due to the difference in temperature regime during incubation. Fluctuations in nest temperature and low rates of humidity have also been observed in *Testudo hermanni* (Cheylan, 1981). Data from Giza Zoo showed that hatching takes place mainly during autumn and early winter. In this period food (annual plants) is likely to be most abundant and potential predators are either hibernating (desert monitor, *Varanus griseus*) or elsewhere (birds of prey, Geffen and Mendelssohn, 1988, 1989), thus hatching during autumn and early winter may increase survival of the young. The extended and unsynchronised hatching period reflects the annual nesting cycles, but it also provides a mechanism to ensure that at least some of the young will emerge when conditions are more favourable, especially in years with low rain fall. The case of the egg, that after 10 months had not yet hatched, but contained a live embryo, may indicate that under the same ambient conditions changes in incubation time can occur. Such, probably mutative, changes may have selective survival value if hatching occurs in winter, when food is most abundant, instead of during early autumn.

The Egyptian tortoise breeding strategy can be categorised as type II (Moll, 1979), characterised by a small number of relatively large-size eggs, a prolonged nesting period and solitary nesting site that does not require specific location or structure. Tortoises that are included in this category are highly specialised small species like *Homopus*, *Kinixys* and *Malacochersus*. The small body size limits the number of eggs in each clutch because egg size cannot be reduced beyond a certain point and still contain the necessary amount of water and energy reserves needed for the embryo to develop and survive the incubation period. Evolution led these species to develop fewer but larger eggs yielding fewer offspring but increasing their survival. Small numbers of eggs and the lack of need for a specific nesting location decreases egg predation in these species (Moll, 1979).

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REFERENCES

Andreu, A. C. and M. D. Villamor (1986). Reproduction of *Testudo graeca graeca* in Donana, S.W. Spain. 589-592. In: Studies in Herpetology. Rocek, Z. (ed.). Charles University, Prague.

Buskirk, J. R. (1985). The endangered Egyptian tortoise, *Testudo kleinmanni*: status in Egypt and Israel. In: Proceedings of the Ninth International Herpetological Symposium on captive propagation and husbandry. 35-51. McKeown, S., Caporaso, F. and K. H. Peterson (eds.). Thurmont: Zoological Consortium Inc.

Cheylan, M. (1981). Biologie et ecologie de la tortue d'Hermann *Testudo hermanni*, Gmelin, 1789. Contribution de l'espece a la connaissance des climats quaternaires de la France. *Mem. Trav. E. P. H. E. Ins. Montpellier* **13**.

Congdon, J. D. and J. W. Gibbons (1983). Relationships of reproductive characteristics to body size in *Pseudemys scripte*. Herpetologica **39(2)**, 147-151.

Congdon, J. D. and J. W. Gibbons (1985). Egg components reproductive characteristics of turtles: relationships to body size. Herpetologica **41(2)**, 194-205.

Ehrenfeld, D. W. (1979). Behaviour associated with nesting. In: Turtles perspectives and research, 417-434. Harless, M. and H. Morlock (eds.). Willey-Interscience.

Flower, S. S. (1933). Note on the recent reptiles and amphibians of Egypt. *Proc. Zool. Soc. Lond.* 745-749.

Geffen, E. (1985). On the biology of the Egyptian tortoise (*Testudo kleinmanni*) in Holot Agur, Israel. M.Sc. thesis, Tel Aviv Univ. (in Hebrew with English summary).

Geffen, E. and H. Mendelssohn (1988). Home range use and seasonal movements in the Egyptian tortoise (*Testudo kleinmanni*) in the northwestern Negev, Israel. Herpetologica **44(5)**, 354-359.

Geffen, E. and H. Mendelssohn (1989). Activity patterns and thermoregulatory behaviour of the Egyptian tortoise *Testudo kleinmanni* in Israel. *J. Herpetol.* **23(4)**, 404-409.

Gibbons, J. W. and J. L. Green (1979). X-ray photography: a technique to determine reproductive patterns of fresh-water turtles. Herpetologica **35**, 86-89.

Hailey, A. and N. S. Loumbourdis (1988). Egg size and shape, clutch dynamics, and reproductive effort in European tortoises. *Can. J. Zool.* **66(8)**, 1527-1536.

Iverson, J. B. (1986). A check list with distribution maps of the turtles of the world. Indiana: Paust Printing.

Landers, L. J., J. A. Garner and W. A. McRae (1980). Reproduction of the Gopher tortoise (*Gopherus polyphemus*), in southwestern Georgia. Herpetologica **36**, 353-361.

Lortet, L. (1987). Observations sur les tortues et paludines du bassin de la Méditérranée. *Archiv. Mus. Natur. Lyon.* **4**, 1-26.

Loveridge, A. and E. E. Williams (1957). Revision on the African tortoises and turtles of the suborder Cryptodira. *Bull. Mus. Comp. Zool.* **115**, 276-283.

Mendelssohn, H. (1982). Egyptian tortoise. In: The IUCN Amphihibia-Reptilia red data book, **1**, 133-136. Groombridge, B. (ed.), Switzerland, Gland: IUCN.

Moll, E. O. (1979). Reproductive cycles and adaptations. In: Turtles perspectives and research, 305-331. Harless, M. and H. Morlock (eds.), Willey-Interscience.

Patterson, R. (1971). The role of urination in egg predator defense in the desert tortoise (*Gopherus agassizii*). Herpetologica **27**, 197-199.

Schleich, H. H. (1989). Merkwalsausbildungen an Land-schildkröten in Nordost-Libyen. Herpetozoa **1**, 97-108.

Swingland, I. R. and D. Stubbs (1985). The ecology of the Mediterranean tortoise (*Testudo hermanni*): reproduction. *J. Zool.* **205**, 595-610.

Turner, F. B., P. A. Medica and C. L. Lyons (1984). Reproduction and survival of the desert tortoise (*Scaptochyles agassizii*) in Ivanpah valley, California. *Copeia* **4**, 811-820.

Waisel, Y., G. Pollak and Y. Cohen (1982). The ecology of vegetation of Israel. Tel Aviv Univ. Tel Aviv: Sifriat Poalim L.T.D. Publ. House (in Hebrew).

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SHORT NOTE: VISUAL STIMULI AND SPONTANEOUS LOCOMOTOR PATTERNS OF COMMON LIZARDS, *LACERTA VIVIPARA*

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ABSTRACT

The movement pattern of adult male *Lacerta vivipara* travelling spontaneously along a wooden-walled channel was similar to the previously measured pattern of animals moving across an open space, comprising an alternation of short (~1 s) bursts of locomotion with even shorter (~0.1 s) pauses. Changing the structure and appearance of the walls of the channel altered the locomotor pattern. Grass turf separated from the lizards by glass had the greatest effect, causing a decrease in mean burst speed and an increase in mean pause duration. This persisted for 25 trials, suggesting that the response to the visual stimulus presented by turf was investigatory and not merely due to its novelty, whereas the smaller effect seen when the walls were of white card waned with time and so may have been primarily a response to change.