However, Mahmoud *et al.* used only the data from Cloudsley-Thompson's Table 1 but this makes little difference between the equations giving

$$y = 10.05X^{0.39\pm0.02} \qquad (r = 0.99, n = 7) \qquad [2]$$

Mahmoud *et al.* analysed their data in units of cm and kg but this makes no difference to the value of b in the equations. Equation [1] is probably the more accurate description of the relationship since the measurement of the juvenile considerably extends the range.

As can be seen, these exponents are significantly different from the exponent of 0.91 calculated by Mahmoud and his co-workers for the Cloudsley-Thompson data; indeed they are in much better agreement with the 0.33 required for geometric similarity and exponent of 0.34 for four species of chelonians given in Meek (1982) which implies a retention of shape as growth proceeds. It would appear that Mahmoud *et al.* have committed errors in calculation, at least for Cloudsley-Thompson's measurements since as can be clearly seen in Fig. 1, an exponent of 0.36 is in good agreement with Cloudsley-Thompson's data. Equation [1] would therefore disagree with the conclusion of Mahmoud and his co-workers that 'the exponents for *T. sulcata* are higher than the exponents given for other tortoises'. An interesting point concerns the slope predicted by equation [1]. This would be in good agreement with the slope of Mahmouds *et al's.* data in their Fig. 1 (at least in comparison to the slope for group B) if the labelling on their Figure was reversed — that is, if the horizontal axis was labelled as body mass and the vertical axis as carapace length. A further error is the incorrect plotting of variables in Figs. 2a and 2b; since the variables on which the plots are based are logarithmic (Tables 1 and 2) the arithmetic plots in the Fig's cannot give linear relationships as drawn.

REFERENCES

Alexander, R. McNeill, Jayes, A. S., Maloiy, G. M. O. and Wathuta, E. M. (1979). Allometry of the limb bones of mammals from shrews (*Sorex*) to elephant (*Loxodonta*). *Journal of Zoology: London* **189**, 305-314.

Bailey, N. T. J. (1981). *Statistical methods in Biology London;* English Universities Press.

Cloudsley-Thompson, J. L. (1970). On the biology of the desert tortoise *Testudo sulcata* in Sudan. *Journal of Zoology; London* **160**, 17-33.

Iverson, J. B. (1984). Proportional skeletal mass in turtles. *Florida Scientist* **47**, 1-11.

Mahmoud, Z. N., El Naiem, D. A. and Hamad, D. M. (1986). Weight and measurement data on the grooved tortoise *Testudo sulcata* (Miller) in captivity. *Herpetological Journal* **1(3)**, 107-110.

Meek, R. (1982). Allometry in chelonians *British Journal of Herpetology* **6**, 198-199.

Sokal, R. R. and Rohlf, F. J. (1981). *Biometry* (2nd edn), San Francisco, Freeman.

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SHORT NOTE:

CAPTIVE REPRODUCTION OF KEMP'S RIDLEY *LEPIDOCHELYS KEMPI*

JAMES R. WOOD AND FERN E. WOOD

Cayman Turtle Farm (1983) Ltd., P.O. Box 645, Grand Cayman, BWI.

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ABSTRACT

Captive mating, nesting and hatching of the critically endangered Kemp's ridley sea turtle, *Lepidochelys kempi* has been achieved among a colony maintained at Cayman Turtle Farm in the Cayman Islands. The minimum age of sexual maturity was five years. Mating behaviour and nesting parameters are discussed in relationship to the captive green colony of the Farm.

INTRODUCTION

The single known aggregate nesting population of the endangered Kemp's ridley sea turtle has declined in recent years despite extensive protection and monitoring efforts by international organisations (Groombridge, 1982). Attempts to establish an additional population are ongoing on Padre Island off the Texas gulf coast (Klima and McVey, 1982). The mating, nesting and hatching in 1984 of Kemp's ridleys held in captivity provided increasing evidence that such a project could indeed prove successful (Wood and Wood, 1984). Cayman Turtle Farm (CTF) maintains a captive breeding population of green sea turtles, *Chelonia mydas*, (Wood and Wood, 1980) and has added to its facilities a small group of Kemp's ridleys for the purpose of establishing a captive breeding colony. The limited success of the 1984 season has been followed with nesting and hatching in 1986.

METHODS AND MATERIALS

In July 1980, CTF received 96 yearling and 67 hatchling Kemp's ridleys. The yearlings had been raised by the U.S. National Marine Fisheries Laboratory at Galveston, Texas. These turtles had been returned to the Mexican government and then, along with the 67 hatchlings from Rancho Nuevo, Mexico, transferred to Grand Cayman. Only a few of the hatchlings survived the transfer to Grand Cayman and approximately half of the yearlings survived the first year at CTF. The turtles received commercially available feeds and at the present time are maintained on a modified trout chow (Ralston Purina) (Wood and Wood, 1986).

The current breeding herd consists of 30 seven year olds, 3 six year olds and 4 four year olds (previously held by Key West Municipal Aquarium, Key West, Florida with permission of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service). The female to male ratio is 1.2:1. The turtles are held in a fenced section, 9 x 23m with an adjacent beach 9 x 11m, of CTF's breeding pond (Wood and Wood, 1980). The pond slopes from the beach to a depth of 2.8m. Water surface area per turtle is $6m^2$ and water turnover occurs every 2 hours.

During nesting, eggs were collected as laid and incubated in a temperature controlled hatchery in sand packed styrofoam boxes (Wood and Wood, 1979). Hatchery temperature was maintained at 28.0°C throughout incubation.

RESULTS AND DISCUSSION

Age and size data are summarised for the nesting turtles in Table 1. Thirty per cent of the females have begun nesting by the age of seven years at a size previously suggested for sexual maturity (Pritchard and Marquez, 1973). For the captive green turtle population at CTF, the average age of sexual maturity is 13 years (unpublished data). One of the ridleys has nested more than one season at an interval of 2 years. The Kemp's ridley population at Rancho Nuevo, Tamaulipas State, Mexico, exhibits a one or two year renesting cycle as opposed to other sea turtle species that typically nest every three years (Marquez *et al.*, 1982). The nesting cycle of CTF's captive green colony averages 1.6 years (Wood and Wood, 1980).

The mating results of 1984 reported previously (Wood and Wood, 1984) are summarised together with the results of the 1986 season in Table 1. Only two of the nesting females had observed mating activity, but in each season there was some observed mating between turtles whose tags could not be clearly identified. In 1984, 271 minutes occurred between unidentied turtles and in 1986, 76 minutes. In 1985, only limited mating activity was observed among the ridleys, totalling 427 minutes of observed mounting activity. Beach activity in 1985 was limited to crawls only for four females and one male.

Typically, the mating behaviour of the Kemp's ridley was characterised by a single male pursuing a female or, in several instances, pursuing another male. The aggressive male would circle the other turtle and actively approach the head. For the green turtle, the female continually circles and presents her head to the male as a refusal activity. The aggressive ridley male would continually bite the neck and shoulders of the non-aggressor. If not restricted by size, the male would then swing his body around into the mating position while biting. The mating position was the same as observed for the green sea turtle with the claws of the male's foreflipper secured over the anterior edge of the carapace and the male's rear flipper secured over the posterior edge of the carapace. Noticeably reduced in the mating behaviour of the ridleys were attendant males or females during the pursual and mating periods. Refusal activities by the female of closing the rear flippers, staying in shallow waters, and vertically positioning to prevent mating were not observed. The ridley population begins its limited observed activity

Turtle No.	Age (yr)	Weight (kg)	CCL (cm)	Mating (min)	Nesting Date	Nesting Time	Eggs Laid No.	Days to Hatch	Eggs No.	Eggs %
1324	7	23	56	0	02.V.86	1130	69	55	31	45
					18.V.86	1230	69	—	0	0
1335	7	24	56	0	10.V.86	0445	11	—	0	0
					18.V.86	0510	61	—	0	0
1336	5	24	53	0	10.VI.84	2325	7	—	0	0
	7	28	57	129	08.V.86	2000	103	—	0	0
1349	7	27	56	0	18.V.86	1330	75	54	26	35
1353	7	27	56	139	05.V.86	0215	68	54	18	26
					18.V.86	1545	79	—	0	0
1359	5	20	48	0	05.V.84	0005	62	62	3	5

TABLE 1: Breeding results for Kemp's ridley in captivity. Curved carapace length is abbreviated CCL; mating is defined as total observed mounting lasting five or more minutes.

earlier in the season than the greens, consequentially, some activity may go unobserved as a continual 24 hour watch is not begun on the breeding herd until the first of April.

Table 1 summarises nesting activity for the six nesting Kemp's ridleys. Clutch size for the captive ridleys, average 60 eggs, range 7-103, is considerably less than observed for wild populations, 105 eggs (Marquez *et al.*, 1982). Decreased egg production has been observed for neonates among the captive green population at CTF. Low hatchabilities in the ridleys also parallels observations made for the captive green population which has been primarily attributed to lack of mating (Wood and Wood, 1980). Of the non-hatching eggs, 54 per cent showed no signs of development, 28 per cent died early in development and 18 per cent died late in development.

The Kemp's ridley's, like the olive ridley's, nesting behaviour is characterised by aggregate nesting known as 'arribadas', in nesting areas where the number of nesting turtles is sufficient. Of particular interest is the nesting of three ridleys on 18 May, 1986 within a period of three hours. Two of these, were repeat nesters for the season, with internesting intervals of 16 and 13 days, suggesting a 'mini arribada', considering the captive population size. Of the 10 nesting emergences listed in Table 1, 4 occurred during daylight hours, including the three nesting emergences of the 'mini arribada'.

The Kemp's ridley exhibited unusual beach activity by occasionally coming onto the beach and covering themselves with sand and seemingly sleeping for extended periods, up to eight hours, both during the day and night. This behaviour was paralleled in the water where the turtles would burrow into the coarse sand bottom of the breeding pond to the extent that they would become almost invisible.

The short time period, as compared to other sea turtle species, for sexual maturity demonstrated for the Kemp's ridley and successful captive reproduction under conditions that can be met in other locations, offer avenues for recovery of this critically endangered species in addition to protection of wild populations.

REFERENCES

Groombridge, B. (1982). *The IUCN Amphibia-Reptilia Red Data Book, Part 1.* IUCN, Gland, Switzerland, 201-207.

Klima, E. F., and McVey, J. P. (1982). Potential and problems of headstarting Kemp's ridley turtle. In: Bjorndal, K. (Ed.). *Biology an Conservation of Sea Turtles*, 583pp. Smithsonian Institute Press, Washington, D.C., 481-487.

Marquez, M. R., O. A. Villanueva, and P. M. Sanchez (1982). The population of Kemp's ridley sea turtle in the Gulf of Mexico. In: Bjorndal, K. (Ed.). *Biology and Conservation of Sea Turtles*, 583pp. Smithsonian Institute Press, Washington, D.C., 159-164.

Pritchard, P. C. H. and Marquez, M. R. (1973). Kemp's ridley or Atlantic ridley, *Lepidochelys kempi, IUCN Monograph No. 2: Marine Turtle Series.* IUCN, Morges.

Wood, J. R., and F. E. Wood (1979). Artificial incubation of green sea turtle eggs (*Chelonia mydas*). *Proc. World Maricul. Soc.* **10,** 215-221.

Wood, J. R., and F. E. Wood (1980). Reproductive biology of captive green sea turtles *Chelonia mydas. Amer. Zool.* **20,** 499-505.

Wood, J. R., and F. E. Wood (1984). Captive breeding of the Kemp's ridley. *Marine Turtle Newsletter* **29,** 12.

Wood, J. R., and F. E. Wood (1986). Captive rearing and breeding Kemp's ridley sea turtle at Cayman Turtle Farm (1983) Ltd. In: Caillouet, C. W. and Landry, A. M. (Eds.). *Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management.* (Papers presented 1-4 October 1985, Galveston, Texas).