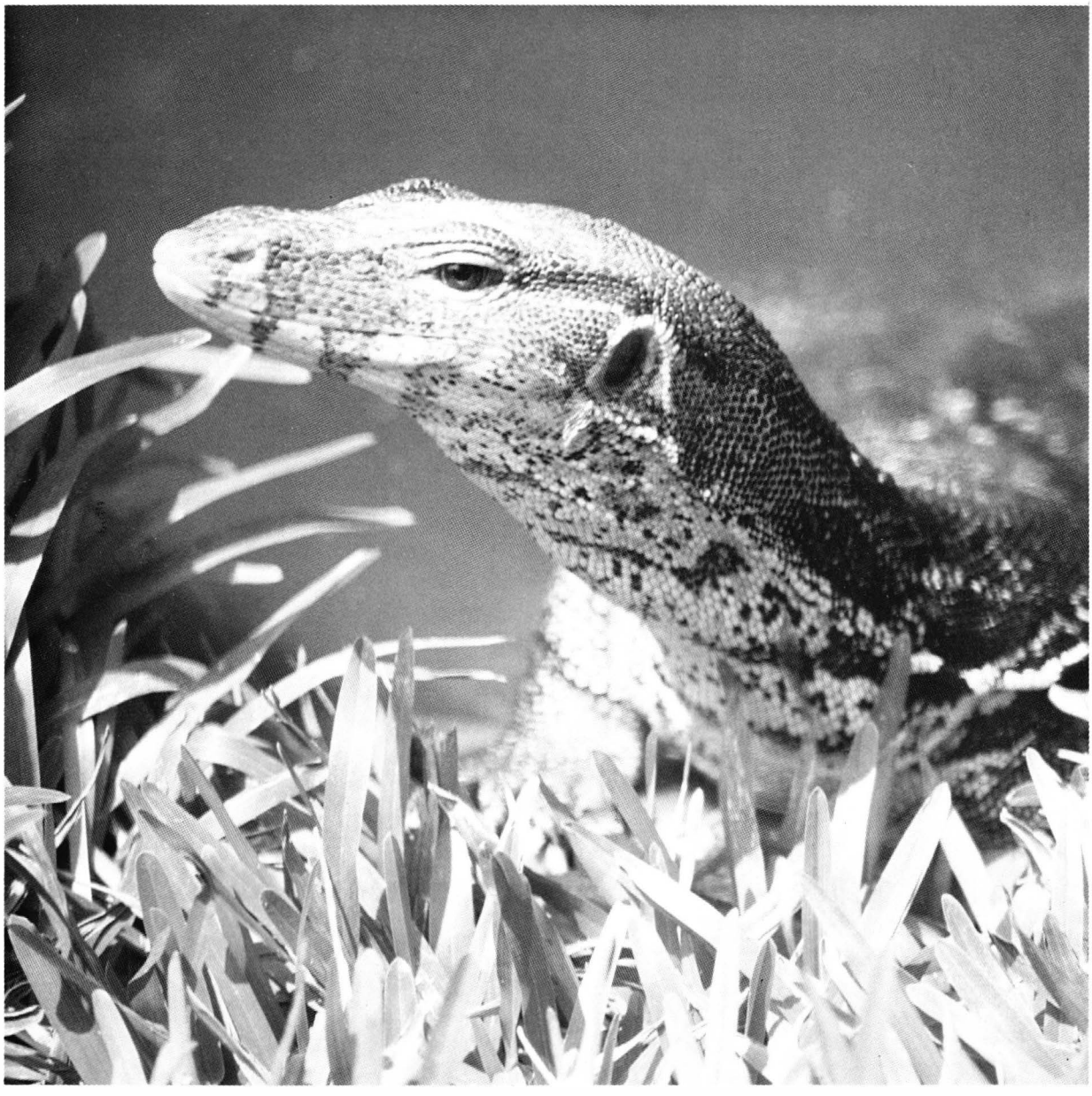
Volume 5, Number 1

January 1995
ISSN 0268-0130

THE HERPETOLOGICAL JOURNAL



Published by
THE BRITISH HERPETOLOGICAL SOCIETY

Indexed in
Current Contents

HERPETOLOGICAL JOURNAL, Vol. 5, pp. 189-194 (1995)

SEXUAL MATURATION IN *VARANUS SALVATOR* (LAURENTI, 1768),WITH NOTES ON GROWTH AND REPRODUCTIVE EFFORT

HARRY V. ANDREWS

Centre for Herpetology, Madras Crocodile Bank, Post Bag 4, Mamallapuram, Tamil Nadu 603104, India

In captivity, *Varanus salvator* attains sexual maturity when they are just over one metre in total length and 50 cm snout-vent length. Maturity can be attained at the end of two years. Males and females tend to grow throughout the breeding season. Egg-laying seasons are closely synchronized with those in the wild. No significant difference was noticed in clutch and egg sizes of younger females when compared to those of older and larger females.

INTRODUCTION

Little is known about the age at which the water monitor lizard *(Varanus salvator)* attains sexual maturity. Determining the age of wild-caught animals is difficult. Most captive specimens are wild-caught and lack sufficient life history data. Vogel (1979) estimated the age at maturity to be three to four years in the case of females and four to five years in the case of males. Authors have assumed age at maturity to be three years (Andrews & Gaulke, 1990; Daltry, 1991). Some smaller species like *V. bengalensis* mature at the end of the second year or beginning of the third year (Auffenberg, 1983, 1988).

For *V. salvator*, size at maturity has been noted previously. Vogel (1979) reported 1.4 m total length for females, 1.7 m for males in the wild and 1.2 m as the minimum size of a female breeding at the Zurich Zoo (Honegger, in Vogel, 1979). A wild-caught pair consisting of a 1.4 m female and a 1.5 m male, both of unknown age, bred in captivity at the Ahmedabad Zoo (David, 1970). Jasmi *et al.* (1986) designated wild-caught animals over 1.6 m in total length as adults, and a smaller size class of 1.3-1.6 m as sub-adults. Luxmoore & Groombridge (1990) report that size at maturity may vary between populations and could be dependent on the maximum adult size attained. Hairston & Burchfield (1992) reported two females of unknown age and total length 1.5 m and 1.6 m that bred at the Gladys Porter Zoo, and 1.6 m and 1.8 m total length for breeding males. However, it is not mentioned if these females had previously nested. In *V. olivaceus*, males and females appear to mature when just over a metre in size (Auffenberg, 1988). Of the 37 wild-caught males sampled by him, sperm was detected in the seminiferous tubules of animals with total length of 1.2 m and snout-vent length over 0.45 m.

The results of a captive breeding programme at the Madras Crocodile Bank indicate that *V. salvator* in captivity reach sexual maturity when males and females are just over a metre in total length, and 50 cm snout-vent length at the end of the second year. In this paper, I present observations and measurement data of two groups of captives that have been monitored from the time of hatching. In the discussion, I relate these findings to conservation and management programmes based on captive populations of *V. salvator*.

MATERIAL AND METHODS

The study animals consisted of captive-bred *V. salvator* maintained at the Madras Crocodile Bank (see Andrews & Gaulke, 1990; Daltry, 1991). All animals were individually marked by tail-notching and housed in a small enclosure. Initially, as hatchlings, the animals were measured (total body length, TBL; snout to vent length, SVL) and weighed every month for the first year, and subsequently at intervals of two or three months. The first group (Group 1) comprising four males and 11 females, were all captive-bred at the Madras Crocodile Bank in 1988 and 1989. Incubation and growth records of this group in the first year have been reported by Andrews & Gaulke (1990). On April 14, 1990 animals of this group were measured, weighed and moved to a large breeding enclosure (Enclosure 1), which housed a large-size wild-caught male from the initial breeding group. These animals were measured and weighed again on July 6, 1990 (Daltry, 1991). Several females from this group laid eggs in 1990. In October 1990, the large wild-caught male was transferred to a separate enclosure. The second group (Group 2), offspring of animals belonging to Group 1, comprising six males and two females, were hatched in captivity in 1991. This second group of animals were

maintained in a separate enclosure. One of these females nested in this enclosure in 1993.

RESULTS

1990 NESTING - 1991 HATCHING

Egg incubation extends for seven to nine months in this species; an increase in incubation temperature reduces the incubation period (Andrews & Gaulke, 1990). Two clutches laid by two females of Group 1 in 1990 went undetected until the following year. On March 31, 1991, three hatchlings were noticed in the enclosure, and on April 16 eight more hatchlings were observed emerging from a burrow. All 11 hatchlings were transferred to a hatchling pen. Excavation of the burrow revealed 11 hatched egg shells with longitudinal cracks all around and an opening at one end.

The second clutch hatched on April 22, 1991. Eight hatchlings were observed emerging from a burrow at 0730 hrs and were immediately removed. On closer examination, the hatchlings revealed the presence of an egg tooth, fresh umbilical scars and a few of them had extended umbilical cords. On excavating the burrow, eight freshly hatched egg shells and one whole egg was found which had completely dried out. Considering the extended incubation period, these two clutches were probably laid in July or August 1990.

1991 NESTING - 1992 HATCHING

During the 1991 breeding season, mating among the two- and three-year olds was noticed in April and May. Between May 31 and July 15, four females were observed nesting. Eggs were removed, measured, weighed and candled to determine fertility rate, and fertile eggs were incubated. Each female was measured and weighed immediately after she had nested. On July 15, 1991, all the animals of Group 1 were measured, weighed and transferred to a new, larger breeding enclosure (Enclosure 2).

On March 4, 1992, 25 hatchlings were recovered from Enclosure 1 and seven hatchlings were recovered from Enclosure 2. The recovery of these 32 hatchlings indicate that two females had nested in Enclosure 1 before being transferred to Enclosure 2 and another female of the same group (Group 1) had nested in Enclosure 2 immediately after the transfer.

SEXUAL MATURITY IN FEMALES

In 1990, the exact sizes of the two-year old females that nested could not be determined, because the animals could not be identified. However, measurements and weights of all the animals taken at the onset of the breeding season (April, 1990), and during the egg-laying season (July, 1990), show that sizes of the two year old females during the egg-laying season (n = 6) ranged from 108 cm to 125 cm (mean 113.8 cm) TBL; 45 to 49 (mean 46.5 cm) SVL and 1.3 to 2.5 kg (mean 1.87 kg) weight. The two-year old females that nested for the first time in 1991 and 1993 were 114.5 cm TL and 47 cm SVL, and 123.5 cm TL and 48 cm SVL (Table 1). Egg-laying by the two females in 1990 and the results of 1991 and 1993 breeding season show that female *V. salvator* reach sexual maturity at the end of two years.

Continual growth monitoring helped ascertain age and size at maturity. Measurements taken in April and July 1990 (a 76 day interval) show that females continue to grow even during the breeding season (Table 2).

SEXUAL MATURITY IN MALES

Although mating activity was observed among members of Group 1, it was not possible to determine whether the two-year old males fertilised the females of this group in 1990, due to the presence of the old, wild-caught male from the intial breeding stock. This was later determined when one of the females of Group 2

TABLE 1. Reproductive effort and size of two and three year old *Varanus salvator* females taken immediately after nesting. (TBL = total body length; SVL = snout-vent length).

Female code	Year hatched	TBL (cm)	SVL (cm)	Wt. (g) after laying	Date laid	Clutch size	Egg wt. (g) range	Clutch wt. (g)	Clutch wt. % body wt.
10	1989	114.5	47.0	1700	31.5.91	11	64.15-58.4	678.4	39.90
07	1988	124.0	50.5	2325	9.6.91	12	64.7-52.9	689.5	29.65
04	1988	132.5	54.5	2320	10.6.91	14	62.65-47.10	768.6	33.12
02	1988	133.0	53.3	2520	15.7.91	9	65.9-59.9	563.2	22.34
11	1991	123.5	48.0	2350	21.6.93	8	78.8-60.8	520.3	22.14

TABLE 2. Growth and size of female *Varanus salvator* recorded in April and July 1990 in the second year, and July 1991 in the third year.

Female code	Year hatched	TBL (cm)			SVL (cm)			Weight (kg)		
		(1990)		(1991)	(1990)		(1991)	(1990)		(1991)
		14/4	6/7	15/7	14/4	6/7	15/7	14/4	6/7	15/7
01	1989	84.0	95.5	116.0	33.3	38.4	47.5	0.76	1.18	2.10
02	1988	111.0	125.0	133.0	45.0	48.0	55.3	1.32	1.80	2.52
03	1988	75.7	94.0	124.0	30.5	37.0	50.0	0.57	1.98	2.52
04	1988	109.0	120.0	133.0	45.0	45.0	54.0	1.42	2.32	2.30
05	1989	85.3	99.0	120.0	32.8	39.0	49.0	0.71	1.00	2.72
07	1988	104.7	108.0	124.0	43.7	45.0	50.5	1.42	1.30	2.52
08	1988	106.5	112.0	130.0	41.5	45.0	53.0	1.37	1.70	3.12
09	1988	102.0	112.0	131.0	40.0	47.0	53.0	1.20	1.62	2.33
10	1989	106.5	116.0	123.0	42.8	49.0	50.0	1.77	2.50	3.72
12	1989	97.9	104.0	126.0	40.2	42.0	52.0	1.00	1.30	2.62
17	1989	69.2	80.4	94.2	27.4	31.0	40.0	0.41	0.60	1.52

TABLE 3. Growth and size of male *Varanus salvator* recorded in April and July 1990 in the second year, and July 1991 in the third year.

Male code	Year hatched	TBL (cm)			SVL (cm)			Weight (kg)		
		(1990)		(1991)	(1990)		(1991)	(1990)		(1991)
		14/4	6/7	15/7	14/4	6/7	15/7	14/4	6/7	15/7
06	1988	115.0	135.0	149	46.4	53.5	63.0	2.12	3.22	5.17
07	1988	104.0	115.0	130	42.7	48.0	56.0	1.77	2.25	3.67
11	1989	84.0	95.5	119	33.3	38.4	47.5	0.76	1.18	2.62
13	1989	77.6	92.2	116	31.0	36.0	45.0	0.56	0.9	2.26

(hatched in 1991) nested in June 1993 in a different enclosure, which housed both males and females of the same age group. The sizes of the males from this group (n = 6) were TBL = 111 to 133.6 cm, SVL = 46 to 55.5 cm, weight = 1.5 to 3.35 kg. Table 3 shows size and growth at one, two and three years of age. Thus the results of the 1993 breeding season demonstrate that both males and females can attain sexual maturity at two years of age.

Reproductive Effort

Clutch weight (n = 5) ranged from 520.3 to 768.6 g, comprising 22.3 to 39.9% of the body weight of the females after nesting (Table 1). Clutch sizes of the smaller two year old females (n = 5) ranged from eight to 14 when compared to older and larger females of the initial breeding stock (n = 6), which ranged from seven to 17 (Andrews & Gaulke, 1990). Egg sizes (n = 54) of the two year old females from five clutches ranged from 67.8 to 89.1 mm in length (average 79.4 cm) and weight ranged from 52.9 to 78.8 g (average 59.6 g).

Egg sizes from the older and larger wild-caught females of the initial breeding stock; (n = 76) from six clutches ranged from 67.2 to 82.6 mm and averaged 73.11 mm; egg weights ranged from 33 to 82 gm, average 63 gm. There was no significant difference in egg size and weight of young females nesting for the first time when compared to that of older and larger females.

Since 1987, the timing of the egg-laying season at the Madras Crocodile Bank has varied. The initial breeding stock that was acquired from north-east India laid eggs in May and again during August of 1987. In their second year of breeding here, in 1988, eggs were laid in September and October, respectively.

Offspring from the initial breeding group laid at the end of May and the other females laid in June and July. In 1992 females laid in July, and in 1993 two females nested in June.

DISCUSSION

The above observations and results clearly demonstrate that male and female *V. salvator* are sexually mature when they are just over a metre in total length and 50 cm in snout-vent length, at the end of their second year.

In the first three years of growth there was no marked difference in size between females, and males (n = 4) grew 5.0 - 7.1 cm (mean 5.63 ± SE 0.50) in 76 days, while females (n = 10) grew 1.3-7.0 cm (mean 4.42 ± SE 0.65), in the same period. Within the year (358 days), the same males (n = 4) grew 8.0 - 9.5 cm (mean 8.90 ± SE 0.32), while the same females (n = 10) grew 1.0-13.0 cm (mean 7.99 ± SE 0.93). Comparisons of growth rates between the sexes show no significant differences (Mann-Whitney U-test; U = 3, P> 0.05, in both cases).

Enhanced feeding regimes under captive conditions may result in early sexual maturity, in which case sexual maturity will be dependent on growth, rather than age. This feature has been demonstrated for various species of crocodilians (Andrews, *unpubl. obs.*). Bustard & Singh (1981) reported that captive *Crocodylus palustris* under optimum husbandry conditions exhibit rapid growth, thereby leading to early onset of sexual maturity. They also demonstrate that breeding can be hastened and sexual maturity is dependent on growth, rather than age. Nichols & Chabbeck (1980) reported that enhanced feeding leads to faster growth rates, resulting in early breeding in alligators. Joanen & McNease (1975) have also reported that sexual maturity is dependent on size rather than age for alligators. However, this aspect is still to be tested in *V. salvator* when comparative information from the wild becomes available.

The oviposition cycle in *V. salvator* has been discussed by several authors. At the Nandankanan Biological Park, Orissa, eastern India, eggs were laid in July for two years in captivity by a female (Biswas & Acharjyo, 1977) and by another in June in the same Park (Acharjyo & Mohapatra, 1980). Khan (1969) reported that different wild individuals in the Malay peninsula are reproductively active throughout the year, with a peak from September to October. Erdelen (1991) thought that it is likely that *V. salvator* in south Sumatra reproduce continuously throughout the year, with egg-laying peaking at the same time as in the Malay peninsula, as reported by Khan (1969). Gaulke (1992) found considerable variation in the breeding season between wild populations found in the various islands of the Philippine archipelago. For example, nesting in May was observed in one island and in November in another. Hairston & Burchfield (1992) reported marked oviposition cycle differences in two breeding females in captivity. These females laid eggs in December, April, July, August and September. Authors have also reported multiple clutches by the females in a single year, a phenomenon reported by Andrews & Gaulke (1990).

At the Madras Crocodile Bank, where the rainy season starts in June, the 1991, 1992 and 1993 egg-laying seasons closely synchronize with that reported by Smith (1935), namely, eggs being laid in June at the onset of the rainy season in Thailand. A female in captivity was also reported to have laid 14 eggs in June (Whitaker, 1978). June has also been reported as the egg-laying season coinciding with the south-west monsoon season in north-east India, Bangladesh and Andaman and Nicobar Islands (Whitaker & Khan, 1982). Biswas & Kar (1981) also reported that in north-east India, egg-laying in the wild occurred in June. Keatzer (1973) also reported egg-laying in July. Similar findings of eggs being laid from May through July in the north-eastern India population (R. Ghosh, *pers. comm.*) are known.

V. salvator has the largest distributional range of all the varanids (Gaulke, 1991). It is also the most exploited species for skin and meat throughout its range. (Das, 1989; Luxmoore & Groombridge, 1990). Habitat destruction also poses a major threat for the species' survival (Andrews & Gaulke, 1990; Erdelen, 1991).

Previous observations in captivity have demonstrated that the species can be bred in captivity with a high degree of success (Andrews & Gaulke, 1990). Considering the growth rate of the species, hatchling survival rate and their ability to breed in two years under captive conditions, the species can easily be made a resource for skin and meat. In countries of tropical Asia, captive-breeding for farming can be taken up under eco-development programmes for the benefit of local people, thereby reducing the pressure on wild populations.

Captive-breeding can also serve as a conservation tool, and for maintaining gene pools. Besides farming, offspring raised to the appropriate size can be restocked in habitats where populations have been decimated. Thus, besides facilitating a better understanding of the biology of *V. salvator*, captive breeding can greatly aid in the management and conservation of the species.

ACKNOWLEDGEMENTS

My special thanks to R. Whitaker, I. Das and M. Gaulke for reviewing an earlier draft of this manuscript and providing useful comments. J. W. Lang is acknowledged for his critical review and valuable comments. The study is part of an extensive research programme funded by grants from the Smithsonian Institution and National Science Foundation, U.S.A. The Trustees of the Centre for Herpetology, Madras Crocodile Bank are gratefully acknowledged for their support of this study. Lastly, special thanks is due to my wife Romaine, for her encouragement and help in editing and typing this manuscript.

REFERENCES

Acharjyo, L. N. & Mohapatra, S. (1980). Eggs of the water monitor (*Varanus salvator*) laid in captivity. *Indian Forester* **106,** 230.

Andrews, H. V. & Gaulke, M. (1990). Observations on the reproductive biology and growth of the water monitor (*Varanus salvator*) at the Madras Crocodile Bank. *Hamadryad* **15**, 1-5.

Auffenberg, W. (1983). Courtship behaviour in *Varanus bengalensis*: (Varanidae). In *Advances in Herpetology and Evolutionary Biology: Essays in Honor of Ernst E. Williams*, 535-551. A. G. J. Rhodin and K. Miyata (eds.) Cambridge Mus. Comp. Zool. Harvard Univ.

Auffenberg, W. (1988). Gray's monitor lizard. University Presses of Florida, Gainesville. 419 pp.

Biswas, S. & Acharjyo, L. N. (1977). Notes on ecology and biology of some reptiles occurring in and around Nandankanan Biological Park, Orissa. *Rec. Zool. Survey of India* **73**, 95-109.

Biswas, S. & Kar, S. (1981). Some observations on nesting habits and biology of *Varanus salvator* (Laurenti) of Bhitar Kanika Sanctuary, Orissa. *J. Bombay nat. Hist. Soc.* **98**, 303-308.

Bustard, H. R. & Singh, L. A. K. (1981). Age at onset of sexual maturity in male Indian mugger (*Crocodylus palustris*, Lesson) reared under ideal husbandry conditions in captivity. *J. Bombay nat. Hist. Soc.* **78**, 607-610.

Daltry, J. (1991). The social hierarchy of the water monitor *Varanus salvator*. *Hamadryad* **16**, 10-20.

Das, I. (1989). Indian monitor lizards: A review of human utilisation patterns. *Hamadryad* **14**, 16-19.

David, R. (1970). Breeding in the mugger crocodile and water monitor *Crocodylus palustris* and *Varanus salvator* at Ahmedabad Zoo. *Int. Zoo Yb.* **10**, 116-117.

Erdelen, W. (1991). Conservation and population ecology of the monitor lizard: the water monitor *Varanus salvator* (Laurenti, 1768) in south Sumatra. *Mertensiella* Supplement zu Salamandra. Advances in Monitor Research. Wolfgang Böhme and Hans-Georg Horn (Eds). **2**, 120-135.

Gaulke, M. (1991). Systematic relationship of the Philippine water monitors as compared with *Varanus s. salvator* with a discussion of dispersal routes. *Mertensiella* Supplement zu Salamandra. Advances in Monitor Research. Wolfgang Böhme and Hans-Georg Horn (Eds.). **2**, 154-167.

Gaulke, M. (1992). Taxonomy and biology of Philippine water monitors (*Varanus salvator*). *Philippine J. Sci.* **12**, 345-381.

Hairston, C. & Burchfield, P. M. (1992). The reproduction and husbandry of the water monitor *Varanus salvator* at the Gladys Porter Zoo, Brownsville. *Int. Zoo Yb.* **31**, 124-130.

Jasmi, A., Jamaluddin, H. & Abdullah, W. M. W. (1986). Preliminary study on the growth rate and movement of water monitor lizard (*Varanus salvator*) at Sungai Tembeling, Taman Negara. *J. Wildl. Parks* **5**, 63-77.

Joanen, T. & McNease, L. (1975). Note on reproductive biology and captive propagation of the American alligator. *Proc. 29th Annual Meeting Southeast Assoc. Game and Fish Comm.* **29**, 407-415.

Khan, M. (1969). A preliminary study of the water monitor *Varanus salvator*. *Malayan Nat. J.* **22**, 64-68.

Kratzer, H. (1973). Beobachtungen Überdie Zeitigungsdauer eines Eigeleges von *Varanus salvator* (Sauria: Varanidae). *Salamandra* **9**, 27-33.

Luxmoore, R. & Groombridge, B. (1990). *Asian monitor lizards: A review of distribution, status, exploitation and trade in four selected species.* Convention on International Trade in Endangered Species of Wild Fauna and Flora, Lausanne. 195 pp.

Nichols, J. D. & Chabreck, R. H. (1980). On the variability of alligator sex ratios. *Amer. Nat.*. **116**, 125-137.

Smith, M. A. (1935). *The fauna of British India, including Ceylon and Burma. Reptilia and Amphibia. Vol. II: Sauria.* Taylor and Francis, London. 440 pp.

Vogel, P. (1979). *Zur biologie des Bindewarans (Varanus salvator) in Westjavanischen naturschutzgebiet Ujung Kulon.* Ph.D. dissertation, University of Basel. 139 pp.

Whitworth, J. (1971). Notes on the growth and mating of American alligator (*Alligator mississippiensis*). *Int. Zoo Yb.* **11**, 144.

Whitaker, Z. (1978). *Varanus salvator* breeding at Madras Snake Park. *Hamadryad* **3**, 4.

Whitaker, R. & Khan, M. A. R. (1982). Key to the Indian varanid lizards. *Hamadryad* **7**, 9-10.

Accepted: 9.7.94