OBSERVATIONS OF THE REPRODUCTIVE BIOLOGY OF THE INDIAN CHAMELEON, *CHAMAELEO ZEYLANICUS* (LAURENTI)[1]

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The Indian chameleon, *Chamaeleo zeylanicus* was studied in Orissa, in captivity and in the wild. Captive specimens were housed in enclosures with ample vegetation, and maintained on an insect diet. Smallest female with functional ova was 375 mm in length. Mating occurred during the last week of August, and egg laying in October. The shape and size of the nest depended on the suitability of the ground. On soft fine sand the nest was an oblique hole, 22 cm in depth, 9 cm in diameter at the mouth. The eggs were 15-22.5 mm x 9-12 mm x 1.0-2.0 gm. There was indication of increase in size and weight of the eggs during incubation. Hatching occurred after eight months in June when small insects were available in large numbers. In three of the four cases reported, the female died within 1-42 days after egg laying. Females move less and are more territorial. Females are intolerant of close approach of other chameleons of either sex except of suitor males during a period of a few days when they are ready to mate. Mating is preceded by display by female and 'chase and escape' behaviour between the male and the female. Display by female and male (against other males) included assumption of deep green body colouration with dark spots and blotches, lateral flattening of the body, and hissing with open mouth.

INTRODUCTION

The Indian chameleon, *Chamaeleo zeylanicus*, an oviparous species, is distributed from Punjab in the north to Sri Lanka in the south (Boulenger 1890, Parshad 1914, Smith 1935, Deraniyagala 1953). Knowledge of the species' reproductive biology was based on Trench (1912). Then considered to be *Chamaeleon calcaratus*, Trench (1912) studied the behaviour of a male and female in captivity. Both individuals were obtained from 'Jubbulpore, C. P.' (= Jabalpur, Madhya Pradesh). Deraniyagala (1953) has provided preliminary data on the habits, reproduction and dimensions of male and female individuals. Biswas and Acharjyo (1977), while giving a general account on the ecology and biology of some reptiles occurring in and around the Nandankanan Biological Park, Orissa gave the species' distribution in Orissa, clutch sizes and egg measurements.

The solitary habit, procryptic behaviour and appearance make *C. zeylanicus* difficult to study in the wild, and it is difficult to keep for long periods in captivity without elaborate arrangements. Observations made on aspects of the reproductive biology in captivity and in the wild are presented in this paper.

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Materials and Methods

Two of us (LAKS and HRB) observed the species at and around the Gharial Research and Conservation Unit, Tikerpada (GRACU) within the Satkoshia Gorge Sanctuary situated in 84°47′E longitude and 20°35′N latitude, and LNA observed it at the Nandankanan Wildlife Sanctuary, in 86.25°E longitude and 20.25°N latitude. All the observations were made between 1975 and 1980.

Chameleons reared in captivity at GRACU were kept in enclosures used for rearing crocodilians. One enclosure was 23.7 x 4.9 x 2.6 m and another 12 x 12 x 2.5 m with ample vegetation cover inside. The chameleons reared at NBP were in an enclosure measuring 4 x 3 x 2.5 m. All specimens were maintained on an insect diet, and were measured and sexed when received. The base of the tail is somewhat swollen in males due to the hemepenes, which can be extruded by applying gentle pressure from back to the front.

Captive observations are based on four females — three at GRACU (CF1, CF3 and CF4) and one at NBP (CF2), and three males (CM1, CM2 and CM3) at GRACU. Observations in the wild are based on one male (WM1) and two females (WF1 and WF2) at Tikerpada.

Courtship observations were made from WM1, WF1, CF1, CM1 and CM3. Data on nesting are recorded from CF1, CF2, CF4 and WF2, and on the clutch size and female-size from WF2, CF3 and CF4. Egg biometrics and information on changes of these during incubation were obtained from clutches obtained from WF2, CF2 and CF3. Eggs were incubated in sand, kept moist at approx. 7% water by weight. No attempt was made to record the nest temperatures although the ambient temperature in a standard Stevenson Screen fluctuated between 4.5°C and 46.0°C, since the duration of incubation included winter and summer seasons. Observations on hatchlings were made possible from the nest laid by CF4 the precise location of which was not known until actual hatching took place.

Courtship and Mating

Courtship behavious was observed during the second week of August. During this period CM1 became markedly territorial towards the other males, CM2 and CM3, displaying a deep green colour with black blotches and spots and hissing loudly with laterally flattened body as has been described for *C. gracilis* by Bustard (1967). Frequently CM1 was also seen chasing the other males trying, and actually biting these, particularly on the flanks as reported for *C. gracilis* (Bustard 1967).

Initially the female was not receptive to any of the males and it moved away with vigorous rocking movements or displayed hissing with open mouth and laterally flattened body. This 'chase and escape' behaviour between the territory-holding male and CF1 persisted for a week except during heavy showers and at night when these chameleons used to perch asleep on the same plant at a distance of at least 15 cm.

Courting records from the wild included observation of the 'chase and escape' behaviour between WM1 and WF1 over two days. On the morning of the third day, at 0600 hours these had moved and could not be traced.

Mating was observed in captivity only once in the morning at 1000 hours. It lasted about three minutes. CM1 was partly over the back of CF1, holding it with all four limbs. CM1 had also bent down its hind quarters down below CF1. Both appeared motionless. After mating CF1 confined itself to a large *Butea*

superba and after a week it became territorial and displayed at CM1 and the other males, which kept away from the *Butea*.

During the period CM1 and CF1 were courting they did not eat but later they fed voraciously. The female, however, showed low appetite after about a month, and completely stopped feeding 55 days after mating.

NESTING

LNA observed CF2 on 3.10.75 at about 16.30 hours when it was unsuccessfully trying to dig a nest hole inside the enclosure. After several unsuccessful diggings, by 07.15 hours on 5.10.75 it had already laid the eggs and was covering the nest. Five eggs were still partly visible. The female was deep green and facing away from the nest with its tail held in the air. Two different types of limb actions were observed during covering the nest. In one, both fore limbs, acting alternately, dragged the soil close to the hind limbs, which, also acting alternately, pushed the soil back over the eggs. In the other type of limb action, the limbs of only one side acted at a time — the fore limb brought the soil near the hind limb of its side which in turn shifted it over the nest. During covering of the nest the female often rested for short periods and changed to the limbs of the other side. On a few occasions it also attempted to collect soil from stony areas on either side of the nest. When the female was covering the nest it reacted to any disturbance with puffed body and hissing with open mouth, the display directed towards the source of disturbance.

At about 11.30 hours covering of the nest was complete. Thereafter the female appeared tired and inactive and remained within 2 m of the nest. At about 14.00 hours on 6.10.75, the day after egg laying, it was found dead near the nest. On autopsy no more eggs were obtained from the body. On excavation of the nest, 34 eggs were collected. The nest was almost saucer shaped, 17 cm diameter and 5 cm in depth.

CF1 was observed while nesting in captivity on 20.10.75. About a week before this the female was restlessly moving in the enclosure. Suspecting that it was ready to lay eggs, a 25 cm thick sand-bed was provided but CF1 constructed its nest 4 m away from this. The details of nest construction were not recorded. However, after laying the eggs and covering the nest it too appeared exhausted and refused to eat. It was found dead on 2.11.75, 13 days after egg laying.

At about 2200 hours on 14.10.77 a group of fishermen of the Tikerpada village had located WF2 on the sand of a nearby stream. They kept the chameleon under a bucket and brought it to GRACU on the next morning. It had moist sand smeared all over the limbs and head. On questioning, the fishermen informed that "it had dug a hole in an attempt to escape out of the bucket cover". On an examination at the spot the hole was found to be obliquely dug, 10 cm deep and 7 cm diameter at the mouth. On digging it further 32 eggs were recovered within 15-20 cm depth from the surface. About 20 m away on the bank there was a 'pit', 12 cm deep and 9 cm diameter at the mouth. Further away from this another equal-size pit was located among the bushes. Both these pits were dug oblique to the ground and presented a superficial resemblance to the actual uncovered nest with the eggs. However, these were not fresh and it could not be ascertained if these were dug by WF2.

Eggs collected from the nest by WF2 were kept under incubation in an enclosure in two divided batches. The female, also kept in the

same enclosure, refused to accept any food and died after 42 days, on 25.11.77.

The nest of CF4, which was discovered after the young hatched, was dug in sand and was 22 cm deep and 10.5-11.0 cm in diameter at the bottom. Like other females which had nested, CF4 also died in captivity. Since the exact date of egg-laying was not known, the date of the death cannot be related to nesting.

The Eggs

At an early stage of development the ova are pinkish in colour. At postmortem on 4.6.77 a female, outside the present study sample, contained over fifty developing ova, all pinkish in colour and 1-3 mm in diameter. The female measured 375 mm in total length, 175 mm in snout-vent length and 105 gm in weight.

Gravid females had yellowish-red patches on the lower half of the body and thus were readily recognised. Such females also had a skinny appearance with extended abdomens where eggs could be felt when the abdomen was gently palpated. CF3, a freshly killed female received at GRACU on 3.10.75, measured 200 mm for SV (snout-vent) and weighed 153.5 gm. The tail was missing as it had been removed for medicinal use. The oviducts contained 40 eggs, weighing in total 43.0 gm (mean 1.075 gm). A sample of ten eggs measured as below: 5 eggs were 19 x 12 mm, 2 eggs 19.5 x 12 mm, 1 egg each 20 x 12 mm, 21 x 11 mm and 22.5 x 11 mm. The eggs were fully formed with white shell, clearly on the point of deposition.

The eggs from the clutch laid by CF2 were 1.0-1.1 gm in weight, 15-18 mm in length and 9-11 mm in breadth. The female was not measured.

Of the 32 eggs collected from the clutch of WF2 31 were normal — 18.15-20.0 mm in length, 10.5-11.5 mm in breadth and 1.25-2.0 gm in weight, and one was smaller than the rest — 16.0 mm x 9.0 mm x 1.0 gm.

CF4, measuring 170 mm in SV, 380 mm in total length and weighing 115 gm had laid a clutch of 34 eggs. (Table 1).

Incubation and Development

Eggs of none of the clutches obtained from CF1, CF2, CF3 and WF2 hatched. However, measurements and weights of eggs from the clutches of CF2, CF3 and WF2 showed slight increase in size and weight during incubation (Table 2). The study could not be pursued since the eggs spoiled due to rotting or ant-invasion.

Table 1

Size of three female *Chamaeleo zeylanicus* and their clutch size

Female Chameleon	Date measured	Total body length (mm)	Snout-vent length (mm)	Body-weight (gm)	Clutch size (no.)
CF3	3.10.75	—	200	153.5 (with eggs)	40
CF4	18.9.77	380	170	115 (with eggs)	34
WF2	14.10.77	365	170	72 (no eggs)	32

TABLE 2

CHANGE IN THE EGG SIZE AND WEIGHT OF EGGS OF *C. zeylanicus* ARTIFICIAL INCUBATION

Chameleon no.	Stage of incubation (weeks)	No. of eggs measured	Egg length (mm)	Egg breadth (mm)	Egg weight (gm)
CF3	0	10	19.0–22.5	11.0–12.0	1.075 av.
	2	10	19.0	12.0	2.0
CF2	0	10	15.0–18.0	9.0–11.0	1.0–1.1
	4	10	17.0–19.0	11.0–12.0	1.3–1.5
	11	3	19.0–21.0	12.0–13.0	2.0–2.3
WF2	0	31	18.25–20.0	10.5–11.5	1.2–2.0
	5	12	21.5–22.75	12.2–13.2	1.5–2.0
	9	7	22.2–24.0	13.0–14.0	2.5–3.0

HATCHING

Between 21.6.78 and 23.6.78 nine living and two dead chameleon hatchlings were found close to the nest of CF4. Upon examination of the nest the following information was recorded. At the surface the nest had two small openings, through which the hatchlings had escaped. The openings were approx. 1.5 cm in diameter and 2.0 cm apart. Hatching had taken place in the early morning of 21.6.78 because inspite of a 29 mm rain during the previous night the holes were not blocked with sand.

The nest contained a total of 34 eggs of which white and empty shells numbered 15 (hatching of 44.1%), black empty shells indicating early fungal attack in 7 eggs (20.5%), eggs with early embryonic mortality 5 (14.7%) and with late embryonic mortality 7 (20.5%). Dead late-stage embryos were found in the egg with limbs folded and directed forward and tail coming forward almost to the neck and twisted round it from its left. The tongue was slightly protruded in all dead embryos.

THE HATCHLING

When discovered, the hatchlings were green in colour, showing slow rocking movements like the adults. Defensive behaviour was also like the adult — laterally flattened body, assumption of black blotches over the green coloration and hissing with low noise from open mouth. The hatchlings were different from the adults in not possessing the casque although the head at this presumptive area was slightly convex. Four live hatchlings measured 70.0-72.5 mm (total length), 33.0-34.5 mm (SV), and seven hatchlings weighed 6.5 gm (mean 0.92 gm).

DISCUSSION

Bustard (1965, 1966a) provided the details of colour, body shape and behaviour in *C. hohnelii* and *C. bitaeniatus* to distinguish the sexes. There is, however, no noticeable sexual dichromatism in *C. zeylanicus*, except that gravid females exhibit yellowish-red blotches

on the lower half of the abdomen. Trench (1912) has also mentioned of a change in the colour of his female chameleon during the period following mating. But Deraniyagala (1953) has not mentioned any such colour difference in the sexes although he has noted that males are larger than the females.

The gravid female colouration advertises the condition of the female and is a direct parallel to the dominant and non-dominant colour patterns shown by *C. hohnelii* (Bustard 1965). Presumably it has a similar function of preventing unnecessary interaction/conflict situations by preventing males making unnecessary mating attempts which could be rebuffed.

As described for *C. hohnelii, C. bitaeniatus* and *C. gracilis* (Bustard 1965, 1966a, 1967), in *C. zeylanicus* too, colour display plays an important role in social behaviour.

Female *C. zeylanicus,* like most *Chamaeleo* species, are intolerant of close approach of other chameleons of either sex except for suitor males during a period of a few days when they are ready to mate. Actual mating is preceded by a prolonged 'chase and escape' behaviour which is explicable in an analogy to other vertebrates (Manning 1972) where because of the solitary nature, the first response of a potential mate to the other's approach may show elements of attack and escape Since coloration has not been observed to be a sex-advertising sign in *C. zeylanicus* at this stage of the life, the immediate response of a territory-holding female to a male is of that towards an intruder. This response results in display. Later, following a male's continued attempt at contact, the response is escape. Perhaps some chemical communication comes into play at a still later stage to effect mating.

Bustard (1965) mentions for *C. hohnelii* that the tendency for males to wander may be important in increasing the probability of their locating mates, since they are solitary animals. Similar to the above observation, for *C. zeylanicus* too, we believe that the males wander more than the females because during this study and from our unpublished records we noticed many more males than females — an observation also recorded by Biswas and Acharjyo (1977).

Male displays are directed only to other males competing or thought to be competing to court a female. Such male displays include close approach, pausing to inflate and hiss, and attacks on the flanks. These male displays have also been recorded by Bustard (1965) in *C. hohnelii.*

Females on the other hand move less. The post-mating male avoidance behaviour of the female is highly pronounced. Trench (1912), who had also noticed this, stated: after mating the female "showed rage if the male came near her, rocking her body to and fro and gaping at him with faint hissings. He on the other hand would fly in ludicrous terror falling head long from his perch if she came near, as though paralysed."

Position taken during mating — male holding the female with all four limbs — is similar to the description given earlier by Trench (1912) for this species (*C. zeylanicus*) and by Schreiber (1912) for *C. chameleon,* Bustard (1963) for *Microsaura pumila* and Bustard (1966a) for *C. bitaeniatus.*

Fully formed eggs were seen in autopsy of females during the middle of September but egg laying began only between the 1st and 3rd weeks of October. Actual laying of eggs occurred after two days of digging — an observation also recorded by Trench, who, however, mentioned egg-laying in November. The difference in this may be due to the difference in latitude. (Trench made his observation at Jabalpur, Madhya Pradesh at approx. 23°N

and 80°E.) Deraniyagala (1953) have mentioned of a female captured at Marichchukate in November, 1933 that contained 22 eggs.

Deraniyagala (1953) have noted that the gestation period is one month for *C. zeylanicus*. In the present study the gap between mating and egg laying is from six to eight weeks.

In the present study four females have been noted as dying after egg laying. CF2 died after the day of nesting, CF1 after 13 days, WF2 (caught from the wild) after 42 days, and for CF4 the gap period is not known.

The shape and size of the nests depended on the nature of the ground in which these were dug. When the ground was of soft, fine, sand the nest was an oblique hole up to 22 cm deep and 9 cm diameter at the mouth, but when the ground was hard the nest was wider (17 cm) and shallower (5 cm). About two days of unsuccessful digging may precede actual completion of nest digging and egg laying.

Egg sizes provided for the species by Trench (1912) are 13 x 7 mm, by Smith (1935) 19 x 12 mm, by Deraniyagala (1953) 18-19 x 12-12.5 mm, and by Biswas and Acharjyo (1977) 16-19 x 10-12 mm. In the present study the measurements recorded were 15.0-22.5 x 9-12 mm x 1.0-2.0 gm. From Table 2 it is noted that during incubation the eggs tend to increase in size and weight as is observed in agamid eggs (Bustard 1966b). Since the chameleonidae are considered to be a descendant from agamid stock, certain behavioural similarities as pointed out by Bustard (1965) are expected.

The incubation period was eight months, which is apparently timed so that the hatchlings emerge when there is abundant small insect food at the onset of the monsoon in June.

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THE INDIAN CHAMELEON, *CHAMAELEON ZEYLANICUS* (LAURENTI) IN SATKOSHIA GORGE SANCTUARY, ORISSA: NOTES ON AVAILABILITY, GROWTH AND BIOMETRICS[1]

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(With three text-figures)

Between September 1975 and August 1980, 113 chameleons were obtained from local people (accidental captures) within a 5-km radius of Tikerpada in Satkoshia Gorge Sanctuary. Marking by toe-clipping is believed to have shortened the life span when 96 chameleons were returned back to the wild. Based on capture record that indicated a gradual decline in the juvenile and adult population it is believed that the adults are distributed in the study area in a very low density may be 1-2 animals per sq. km. Low density of distribution supports an observed sex ratio of 1 female: 2.46 male; since males wander more, are less territorial and a larger number of males offers a selective advantage in producing offsprings sired by a better male. Availability of chameleons depended on food- availability. More number of animals were obtained after each seasonal rain in monsoon, winter and summer. Procryptic behaviour in young ones were more pronounced. The rate of growth in the wild is estimated to be about 11 mm (average SV) per month during the first year. The 33 mm (SV) long hatchlings approach adult-hood at about 155 mm at the end of the first year. The average maximum size was about 180 mm and animals above 200 mm and beyond second year were rare. For SV lengths of 100, 150 and 200 mm respectively the TBL were 216, 324 and 432 mm, HC were 32, 46 and 60 mm, and W 16, 53 and 125 g. The hatchlings weighed 0.9 g. Variations from a straight-line relationship between SV and HC are suggested as variations in the size of the casque on the head. The casque is used in female to assist in nest-digging and suspected to be an organ of advertisement for courting males.

INTRODUCTION

The present paper reports preliminary observations made on variable availability, growth rate, biometrical relationships and the probable life-span of the Indian chameleon, *Chamaeleon zeylanicus*. The information recorded for the present paper were made possible during my stay in the Satkoshia Gorge Sanctuary, Orissa in connection with the Crocodilian Conservation Programme. It is believed to form a valuable adjunct to another paper (Singh *et al.* 1984) that reported on observations on the reproductive biology of the species as observed in the wild and captivity, also in Orissa. Hitherto the knowledge on *C. zeylanicus* have remained limited to range-distribution notes by Boulenger (1890), Parshad (1914), Smith (1935) and Deraniyagala (1953), and

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preliminary observations on the reproductive biology by Trench (1912), Biswas and Acharjyo (1977) and Whitaker (1978). A recent compilation on the species (Daniel 1983) had evidently relied mostly on the author's (Daniel, J. C.) own experience and Trench (1912) and Whitaker (1978).

Materials and Methods

The observations were recorded between September 1975 and August 1980 at Tikerpada in the Satkoshia Gorge Sanctuary located in Central Orissa (84°47'E/20°35'N). Materials for the study were obtained from two sources — from nature and from young ones hatched in captivity from eggs laid at the Gharial Research and Conservation Unit (GRACU), Tikerpada. During the period of five years 113 individuals from nature were mostly (accidentally) caught by local people and sold to me at a nominal rate of Rs. 2 to 3 per animal. All animals were procured from an area spread over a radius of 5 km on the northern side of River Mahanadi — a hilly tract of moist deciduous forest, hills ranging upto 700 m in height. The chameleons were caught during the day, except a lone nesting female, from public or private roads and rarely from the inside forest, and no special effort was made to conduct a systematic capture operation.

Out of 113 wild chameleons received at GRACU 96 were returned back to the wild soon after marking by toe-clipping. Normally all wild chameleons had reached GRACU on the day of capture. The following information on each chameleon were recorded against the date of its arrival at GRACU: total body length (TBL), Snout-Vent length (SV) and the body weight (W). In some instances the tails were missing from the live animal — a result of the belief regarding its use in talismans curing infantile convulsion (Singh 1979). For 76 individuals the lengths of head and casque (HC) were also recorded, and at a later stage during the study sexes were recorded for 45 animals.

The information recorded for wild chameleons were used to determine the variation in their availability during different years and months, and for different size classes. The wild growth rates were studied indirectly from the sizes available in a calendar month taking due consideration of the phenomenon of variable growth rate in the same brood (Singh 1978) as seen in other reptiles. The relationships between TBL-SV, SV-HC and SV-W were determined from the biometrical data. These studies later were supported with information on captive-hatched chameleons.

The study years were considered from September through August (Fig. 1a, c) and month-wise availability were considered with the hatching-month June (Singh *et al.* 1984) (Fig. 1 b).

For analysing the number of chameleons available according to their sizes (SV), the animals were grouped under eleven groups, each group considering 15 mm of SV. The first group was 45-59 mm SV and the last 195-209 mm.

SV lengths of chameleons were plotted against their date (fortnight) of arrival in Fig. 2. This was used to determine the growth rate in the wild.

Relationship of TBL, HC and W with SV were determined by plotting the points against SV on a graph sheet (Fig. 3 a and b). By visual estimation mean lines representing the relationships were plotted on the graph. From the latter mean TBL, HC and W were determined for standard SV values.

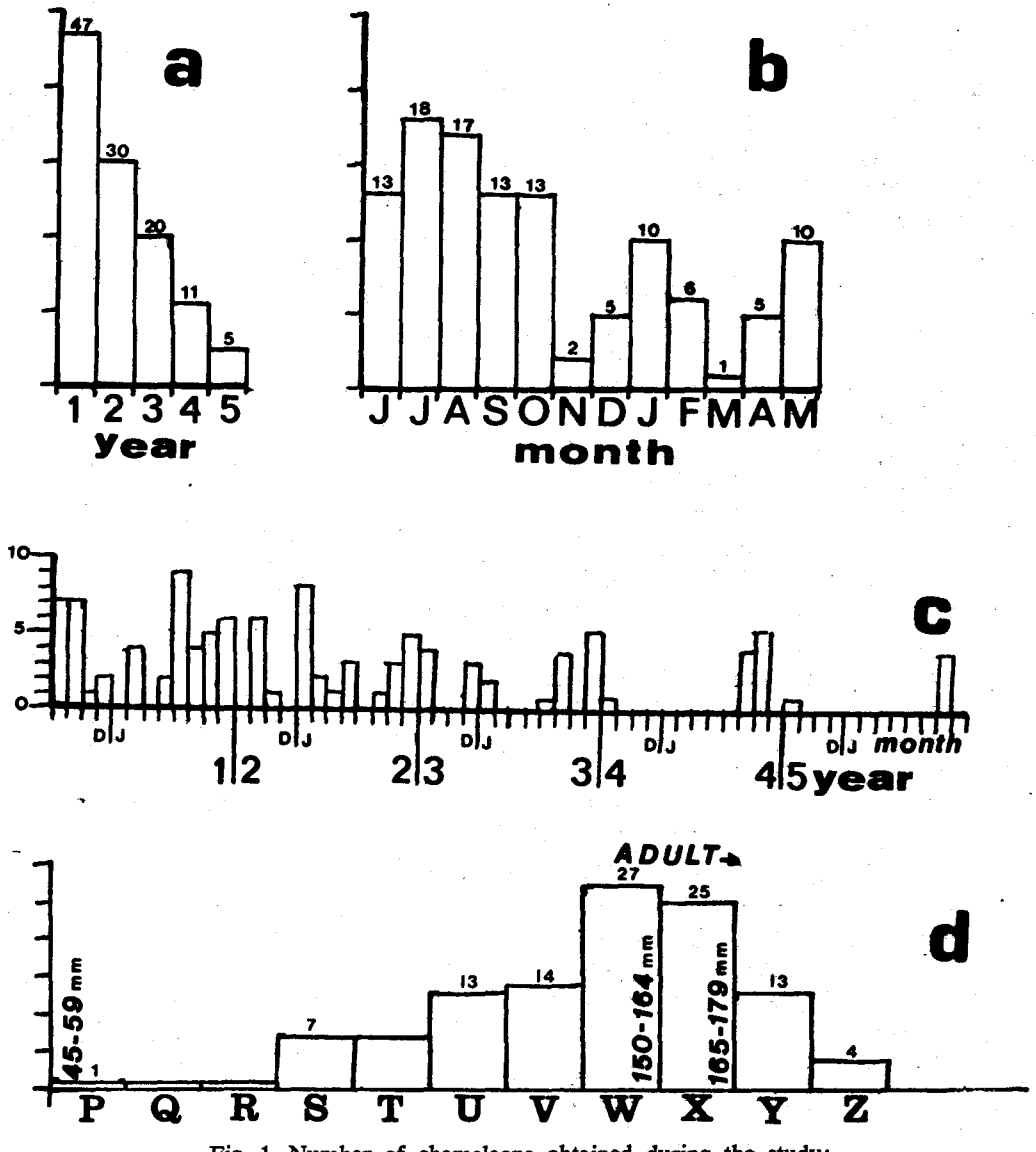

Fig. 1. Number of chameleons obtained during the study:

a. per year (September through August) for the 5-year study period (1 through 5).
b. per month (cumulative data for 5 years) from June (J), the month of egg-hatching,
c. per individual month throughout the 5-year period — D, December; J, January; 1 through 5, years of study as in Fig. 1 a,
d. per 15 mm (SV) size groups (P through Z).

RESULTS

1. **Availability :**

The number of chameleons caught during the first year (September 1975-August 1976) was 47. The number decreased to 30, 20, 11 and 5 during the second through the fifth year (Fig. 1a).

The highest number of chameleons were available during May (1st year), January (2nd year), August (3rd year) and July (4th and 5th years). The next high number of chameleons were obtained during September (1st year, 3rd year and 5th year), October (1st and 2nd year), and June (3rd and 4th year). During the 1st year no chameleon was obtained, during January and March. In the 2nd year there was no collection during September, December and May, and collections during the 3rd year were only in September, December, January, May, June and August. During the 4th year collections were in September, June and July, and during the 5th year collections were in September and July (Fig. 1 c).

As shown in (Fig. 1 b), the highest number of chameleons were obtained during July and August, 15.9% and 15.0% of the total. These numbers were followed during the months of June, September and October, each recording 11.5% of the availability. The lowest numbers were obtained during February (5.3%) and November (1.7%).

Out of 45 cases where sexes were definitely known and recorded, 32 were males and 13 females. The likelihood was that some females were confused with immatures and were not assigned to any sex group.

With the increase in size-groups there was a gradual increase in the number of chameleons that were available up to 150-164 mm SV. This was followed by a gradual decrease in the number for the three groups that followed the highest-represented group (Fig. 1 d).

Out of the total 96 releases after marking, only one chameleon was recaught within six days. There were no other recapture records.

2. **Growth :**

On plotting the points for studying the growth rate in the wild (Fig. 2) S-line indicated the extent of fast-growth recorded for the first year, and T-line the zone for slow-growing 2nd-year chameleons. No other space was clearly demarcated to demonstrate the continuation of growth through a 3rd year or beyond. The zone between P and Q (150-160 mm SV) appeared to be the transitional sizes for averagely growing chameleons from the 1st year to the 2nd year.

Four chameleon hatchlings were measured soon after hatching in captivity: these were 71.7 mm (TBL), 33.5 mm (SV), 11 mm (HC), and 0.9 g (W). After 18 days the measurements were: 86.5 mm (TBL), 40.5 mm (SV), 12.5 mm (HC) and 1.2 g (W), and after a month and a half these were 104 mm (TBL), 50.5 mm (SV), 15 mm (HC) and 2.7 g (W).

For SV lengths 50 mm, 100 mm, 150 mm and 200 mm the TBL were respectively 108, 216, 324 and 432 mm, and HC were 18, 32, 46 and 60 mm (Fig. 3 a). Body weights were 16, 53 and 125 g for SV lengths 100, 150 and 200 mm respectively (Fig. 3 b).

DISCUSSION

1. **Availability :**

Since recapture of marked and released animals have been only 1 out of 96, it is suspected that the method of toe-clipping is not suitable with this species (*C. zeylanicuc*). It is

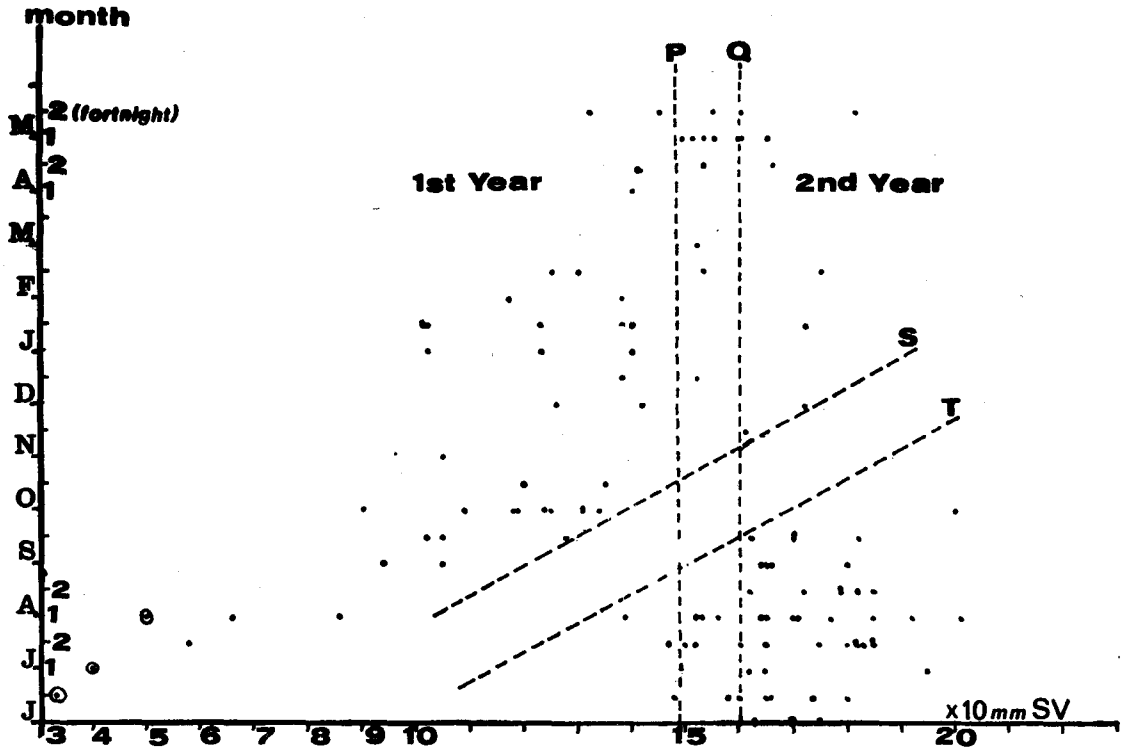

Fig. 2. Indirect record of growth of *C. zeylanicus* in the wild in Satkoshia Gorge Sanctuary. PQ, zone of transition between 1st year and 2nd year after hatching; S, limit of fast-growing 1st year forms; T, limit of slow-growing (in the present case) 2nd-year form. Each point corresponds to the size (SV) against date of arrival of a chameleon.

not possible to provide the exact nature of the effect of toe-clipping but there is indication that the marking method might have caused the death of younger chameleons and further cut-short the life of adults who in any case were in their second year of life (see below). Honegger (1979), discussing of the marking techniques for amphibians and reptiles, have also stated of the probable limitations in toe-clipping amphibians. The gradual decrease in the number of captures of chameleons from 47 in the 1st year to 5 in the 5th year (Fig. 1a), number of adults (Table 1) from 27 to 5 and juveniles from 20 to nil are indicative of a distributional density of the species in the wild. If it is assumed that none of the 'released' chameleons returned back to the population, the captures in the subsequent years are from the survivors and that there is no 'influx' of individuals from the adjacent areas, then *C. zeylanicus* is extremely solitary (Singh *et al.* 1984), and the density may be 1-2 adults per sq. km.

Low density of distribution also support the significance of a greater proportion of males in the population. In the recorded in-

TABLE 1

Chamaeleo zeylanicus IN SATKOSHIA GORGE SANCTUARY, TIKERPADA: AVAILABILITY OF DIFFERENT SIZE GROUPS (SV MM) THROUGH DIFFERENT YEARS. EACH STUDY YEAR BEGINS WITH SEPTEMBER AND ENDS WITH AUGUST. OBSERVATIONS WERE RECORDED BETWEEN 1975 AND 1980.

Size group	Years of Study					Total
	1	2	3	4	5	nos.
Juveniles:						
45-59	1	–	–	–	–	1
60-74	–	–	1	–	–	1
75-89	–	–	1	–	–	1
90-104	3	4	–	–	–	7
105-119	2	3	1	1	–	7
120-134	8	5	–	–	–	13
135-149	6	2	5	1	–	14
Sub-total	20	14	8	2	–	44
Adults:						
150-164	17	5	1	3	1	27
165-179	9	4	6	4	2	25
180-194	–	6	4	1	2	13
195-209	1	1	1	1	–	4
Sub-total	27	16	12	9	5	69
Total	47	30	20	11	5	113

stances for the present study, the female: male ratio was 1:2.46. Since males are less territorial and wander more than the females (Bustard 1965, 1966, Singh *et al.* 1984) more number of males favours a greater chance of their 'meeting' a female during the breeding season. When more than one male is available for courting the female, there is always a selective advantage to produce offspring sired by a better male.

Irrespective of the fall in yearly captures, the number of chameleons were the maximum during or after the rains in monsoon, winter and summer. The least number were collected during the driest months. Availability, depending on ground-level activity, appeared dependent on food-availability. Singh *et al.* (1984) have also mentioned that the hatching process is timed to food-availability with the beginning of monsoon.

Procryptic behaviour of chameleons have always made it difficult to study it in the wild. This behaviour may be more evident in the juveniles. With the approach of adult-hood their movements and appearances become greater, and because of their larger size these are easily detected. The above explains the reason for the gradual increase in number of chameleons that were available up to the size group 150-164 mm SV (Fig. 1 d). The size groups 150-164 mm and 164-179 mm are almost equally represented in the capture record — 23.8% and 22.1% respectively. The two size groups following these are also adults in their breeding-size but apparently such sizes are attended to less often (see below).

2. **Growth:**

The growth rates were extremely fast, for the hatchlings in the beginning. Four captive hatchlings measuring 33 mm (SV) had grown to 40 mm in 18 days and 50 mm (n=2) in 1.5 months, indicating growth of about 11 mm during the first month. At the end of the first year the average size of *C. zeylanicus* is estimated to be about 155 mm (SV) (Fig. 2) indicating a mean growth rate of 11.1 mm a month over the 33 mm size of the hatchlings. The estimated wild growth rate of 11.1 mm a month during the first year includes, obviously, a slower rate of growth during the winter when temperature and food supply are low. Therefore, the normal wild growth for early hatchlings may be much higher than 11.0 or 11.1 mm as stated above. In the present study the growh of captive hatchlings during the

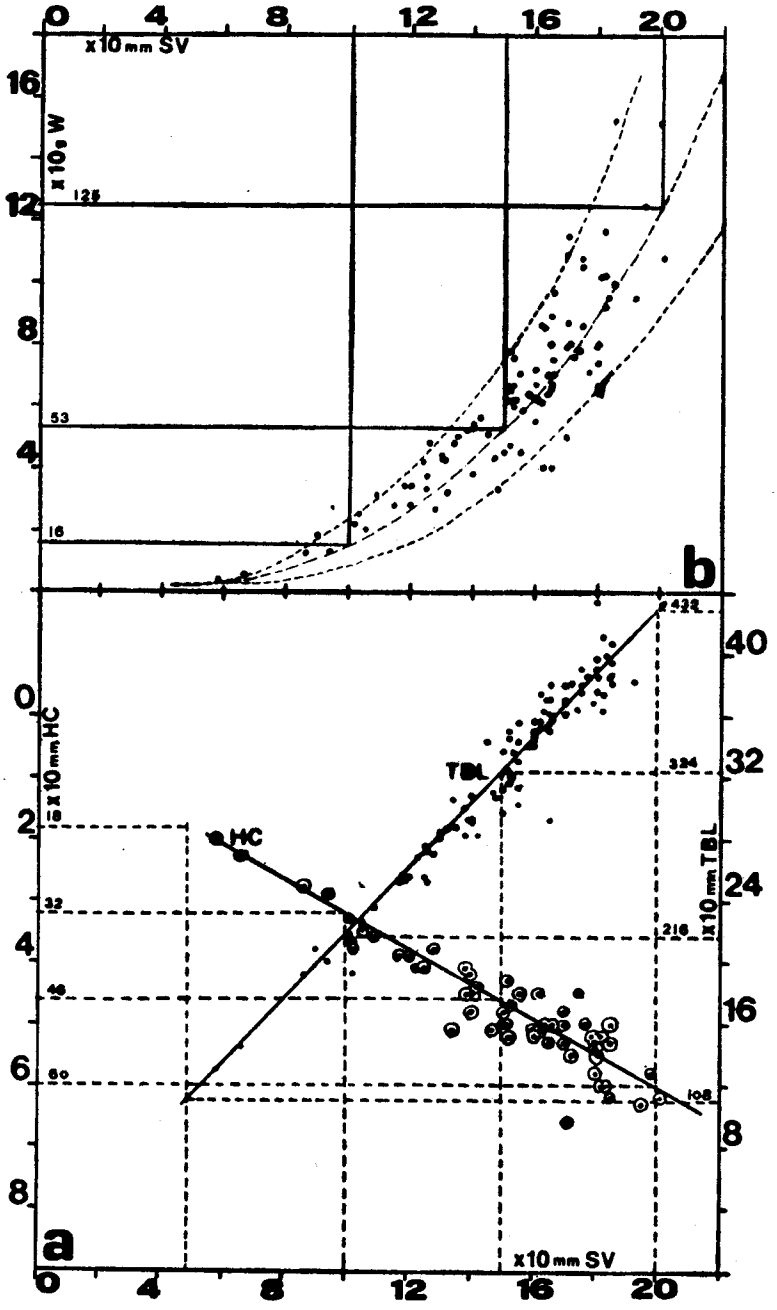

Fig. 3 a. Relationship between SV-TBL and SV-HC (see text).
b. Relationship between SV and W (see text).

first 1.5 months might have been low due to a restriction in food choice. Mentioning about *C. hohnelii*, Bustard (1965) has also recorded a fast rate of growth for the species — a specimen 48 mm long (SV) reached 53 mm in 18 days. The hatchlings are 44.0-49.7 mm in TBL and above 20 mm in SV.

The largest male and female *C. zeylanicus* recorded during the study were 201 and 195 mm (SV) respectively. The average maximum size may be about 180 mm and sizes up to and above 200 mm are perhaps not common, as seen in Fig. 1 d. The predominance of the group 150-164 mm SV is perhaps because of the commencement of the breeding activity (Fig. 1d). This size range (150-160 mm) is also the transition from the first to the second year after hatching (June).

Singh *et al.* (1984) mentioned that the female chameleons die within 1-42 days after egg laying. This may be a natural phenomenon too. From observations made in the present study (Fig. 2), there is no indication of growth beyond the second year. The life span of *C. zeylanicus* may be rarely entered into the third year. Shifter (1975) has also mentioned for chameleons in general that they grow quickly and many species "reach sexual maturity before the end of their first year. No one knows how old chameleons become in the wild, in terrariums they very rarely live longer than four or five years." Shifter's account, which is almost silent regarding the Indian chameleon, was perhaps mostly based on information on species of the African countries.

The TBL-SV-TL relationship is that of a straight line. The growth in body weight (W) (Fig. 3) with respect to SV does not follow a straight line and instead is proportionately high with the advancing body size.

Singh (1978) mentioned for the gharial (*Gavialis gangeticus*) that morphological features that do not have a functional significance at the time of hatching show a suppressed growth during in-the-shell stage of development. The same phenomenon is expected to being shown by the casque in *C. zeylanicus.* The casque is not developed in hatchlings (Singh *et al.* 1984) and as seen in the present study the smallest chameleon that had possessed a casque on the head measured 58 mm (SV) at about two months old. The function of the casque as a digging organ for nesting female chameleon has been mentioned in Singh *et al.* (1984). Its presence in males is perhaps related to the male's extent of dominancy and use as an 'advertisement' during the breeding season. Morphological coloration seems to play a major role in chameleon displays during the breeding season (Bustard 1965, 1967). The proportion of head (skull) to SV is almost the same from young to the adult stage of the chameleon. The variations in SV-HC relationship (Fig. 3a) appear to be more due to the size of the casque.

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