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THE BURROWS OF *VARANUS BENGALENSIS* : CHARACTERISTICS AND USE

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(With 1 Text-figure)

The only varanid species for which adequate information is available on burrow characteristics and use is *Varanus komodoensis* (Auffenberg, 1981A). That other species use burrows is well documented (Green and King, 1978, for *V. gouldii* ; Pianka, 1968, for *V. eremius* ; Corkhill, 1928, for *V. griseus* ; and others). During 1979 I was afforded an opportunity to study the burrows of *Varanus bengalensis* in several areas of northern India. I am also including a few data that I obtained during 1974 in Sri Lanka on burrows of the same species. The only statements previously made regarding burrows in this species were by Mahendra (1931), who reported on the resting posture of an individual in its burrow. D'Abreau (1933) and Smith (1932) simply stated that this species digs burrows. Deraniyagala (1957) described the construction of a nest by a female of this species.

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METHODS

Two major burrow types were investigated—those excavated in high sandy bunds surrounding agricultural plots on terraces above the Yamuna

River, approximately 6.8 km NE Agra, and those in the large termitaria of *Heterotermes* sp., 2.5 km S Sikandra and 12 km N. Agra, both in Uttar Pradesh State, India. Additional notes on similar termitaria in Yala National Park, Sri Lanka, are included, as are data on nest chambers and burrows in Keoladeo Ghana Sanctuary, Rajasthan, India. In all cases burrows were carefully excavated in the field, with measurements of all hole diameters, length, and distances from the surface made with a fiberglass retracting centimeter scale. The few temperatures given were obtained with an armoured field thermometer marked in the Celsius scale and accurate to 0.3°. Where appropriate, a few data are added from a group of captive *Varanus bengalensis* maintained by me in Florida, U. S. A. (see Auffenberg, 1981B, for description of captive facility).

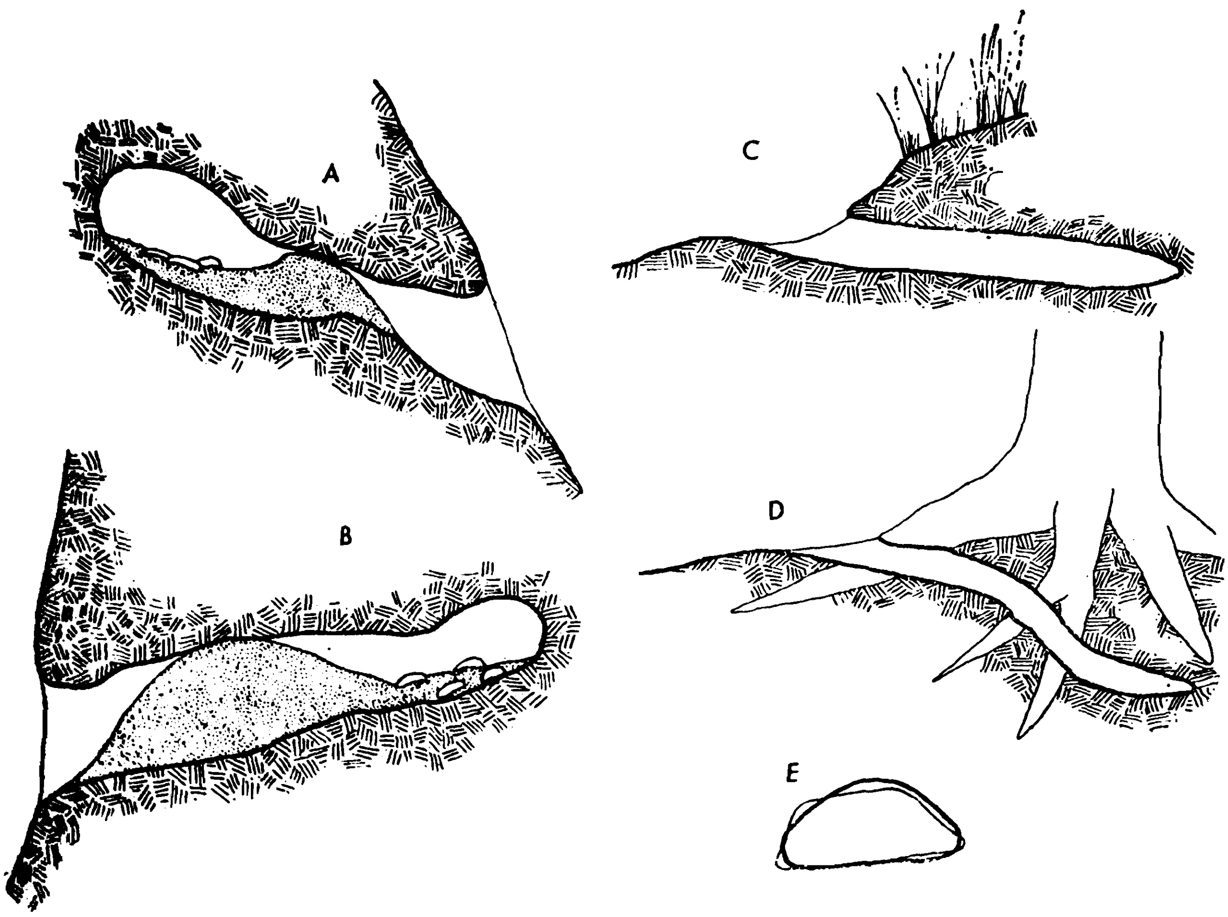
Results

Burrows in Earth.—While individuals of *Varanus bengalensis* are capable of digging their own burrows and frequently do so, most are enlargements of pre-existing rodent burrows or natural cavities. During certain seasons hollow tree limbs and trunks are commonly utilized. When burrows are excavated entirely by the monitor lizards, they are most often dug into earthen mounds, slopes of vertical faces, and also under exposed roots and large stones (Text-fig. 1C, D) ; and the burrow cross sections are usually transversely oval, with the roof more convex than the floor (Text-fig. 1E), at least near the mouth. Farther inside the burrow lumen usually becomes more cylindrical. It is also generally widest at its mouth, usually maintaining a generally even taper to more or less accommodate the head and body of the lizard ; rarely slightly enlarged terminally.

Excavation of at least the burrow mouth area takes place at almost every entry into it, the individual using its front feet alternately to throw earth from particularly the burrow floor. At an old, frequently used hole such "cleaning excavation" is begun as much as 20 cm in front of the mouth and is continued for an almost equal distance inside as the monitor slowly enters the burrow. It is for this reason that there is rarely an earthen mound in front of the burrow, and why the mouth is frequently wider than the remainder of the hole.

The main part of the passage is relatively free of much loose earth, but not at the terminal end, where it is not uncommon to find 1-2 cm of accumulated soil. Among captive adults maintained in large semi-natural enclosures, I have noticed that individuals scratch at the terminus at almost every entry, but make relatively little effort to throw the loose earth towards the opening. Both the narrow lumen and the loose soil at the terminus may be important in a defensive context, as explained below.

In general, the diameter of the burrows excavated are approximately the same as the vertical diameter of the body and 10-37% ($\overline{X}$=29%) wider than the greatest transverse diameter of the widest part of the belly (data from 16 captives and the holes constructed by them). However, individuals often use one another's burrows, so that hole diameter is not a reliable indicator of the size of the resident monitor, for the lizard may be much smaller than suggested.



Text-fig. 1. A and B, *Varanus bengalensis* nests in vertical banks at Keoladeo Bird Sanctuary, Bharatpur. C, typical longitudinal section of *V. bengalensis* home burrow in sandy soil without obstructions. D, typical longitudinal section of *V. bengalensis* home burrow in soil with subsurface obstructions. E, cross sections of two *V. bengalensis* home burrow mouths in sandy soils near Agra.

Except for those burrows encountering stones or roots, most are rather straight, especially in the soft earth of the Yamuna River bunds. None of the burrows is forked, though the smaller burrows of other animals frequently connect with them.

Though rural folk are often of the opinion that the burrow is very extensive (up to 15 m, I was told), excavation of 53 of them show that in at least those habitats studied, none is very long. The mean length of all the burrows is 1.02 m, and there is no significant difference between the burrow lengths in different habitat types (Table 1). Mean depth is 0.61 m, with a significant different (t test, $P < 0.05$) between the bund burrow depth and the other types, primarily due to the fact that the bund holes are excavated into a more or less vertical face. The difference is also partly due to variation in excavation techniques in the habitats considered.

TABLE 1. *Varanus bengalensis* burrow parameters.

Locality	N	$\bar{X}$ length (in cm)	$\bar{X}$ depth (in cm)	$\bar{X}$ angle (in %)
Yamuna Bunds	28	110	121	15
Keoladeo				
Among tree roots	20	82	93	47
On open, level	5	97	51	28

Only a few burrows occur on level ground (10.6% of the present sample, though biased because they were more easily seen than those under tree roots). Table 1 shows that there is a great difference in burrow declination angle, with bund burrows least inclined, burrows on level ground more so, and those among roots most inclined. The difference between the pairs tested is significant at the 0.05% level in all cases (t tests for bund-roots $P < 0.01$, for roots-level $P = 0.05$, and bund-level $P < 0.05$).

In the Yamuna bund and Bharatpur root sites the holes showed a significantly contagious distribution on the basis that the variance of the distance between the burrows exceeded the means (Southwood, 1966). However, burrows on level land are randomly distributed. Burrows in earth are significantly more common per hundred meter transects in treeless areas than areas with trees. Thus in the Yamuna River area the mean number of burrows increased from more heavily forested sites near the Dayal Bagh Road to the virtually treeless terraces above the river ($\bar{X}$ distances between burrows Dayal Bagh=93.1 m, s^2 = 19,681.7 m, sd±104.9 m, O. R.=0.9-346.3 m, transect length=5404 m, N holes=40 ; Yamuna bund area=29.7 m, s^2 =891.5 m, sd±29.3 m, 0. R.=0.6-95.4 m, transect length 970 m, N holes=44). Further discussion of hole density, etc., as it relates to monitors per ha, is provided in a manuscript (in preparation) by the author.

Burrows in Termitaria.—Sixteen burrows located in the earthen termitaria of *Heterotermes* sp. were excavated, all near Sikandra. In each case the burrow was relatively short and diameters much more variable along the burrow length than in burrows excavated in earth (Table 2). Burrow declination angle was about 45°, with the lumen more or less contained within the area originally excavated and modified by the termites.

TABLE 2. *Varanus bengalensis* burrow dimensions (in cm) in *Heterotermes termitaria*

Burrow depth	Burrow length	Declination Angle
87-140, $\bar{X}$ =110	78-121, $\bar{X}$=92	39-47°, $\bar{X}$=45.3°

All burrows were located in abandoned termitaria, in which erosion by particularly monsoon rains had apparently weakened and in many cases even breached the carton envelope. The monitors apparently enlarge any surface break, as well as slightly widening the extensive system of large tunnel-like chambers below the surface. The excavations are apparently often made during the monsoon (July-August) for evidence of passage into or out of the openings when the soil was soft and muddy is often still present in the subsequently hardened clay (October-November). However, the crumbly dry soil at the mouths of other burrows suggests that some are made during the dry season as well.

The multiplicity of monitor burrow sizes in single termitaria suggests that several monitors use each complex, at least on a temporary basis. This is confirmed by the local snake charmers, who informed me they often saw two monitors run into the same termitarium at the same time. However, my excavations proved that these burrows were rarely interconnected by the activity of the monitors under the surface. Mammals, snakes, and other lizards also use the termitaria as refuges, but apparently the original large openings are made mainly by the monitors. During our excavations I found one *Naja naja* and one *Oligodon arnensis* in termitaria occupied by a monitor lizard, though in both instances these snakes were located in the interconnected side chambers originally made by the termites. Of the 46 termitaria examined, at least 73% had been used by one or more *Varanus bengalensis* on the basis of various signs (hole shape, scratches, tail drags, etc.).

The termitaria vary in height from 10 to 90 cm, and termite activity may extend as far as 2 m below the surface. However, most larger termite chambers rarely extend below 1 m deep. In a sample of 18 measured termitaria the circumference of the entire structure varied from 30 to 405 cm. The number of openings used by the monitors

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in each of these termitaria varied from 1 to 16 ($\bar{X}$=6.6 openings) and opening size (N=46) varied from 2 to 25 cm ($\bar{X}$=67.1 cm, sd±3.1 cm). Intertermitarium distance was 3.9-36.2 cm ($\bar{X}$=16.5 m, sd±10.9 m), showing great variability (s^2 =11.5 m). In spite of this, bolting monitors seem to know the location of most, if not all old termitaria nearby, for even if forced to change course through interception by our party, the monitors veered and headed straight for another, though not necessarily the closest termitarium.

Burrow Use.—Mahendra (1931) has shown that in at least one instance, a *Varanus bengalensis* was in its hole bent into a U, with its head and tail facing the opening. Observations of the Florida captives show that this is the position most frequently taken when they are resting and in an unfrightened state during either the day or night. The same position has been noted in resting *Varanus komodoensis* in the wild (Auffenberg, 1981A). However, all individuals of *V. bengalensis* uncovered during the present study had run into the burrows for refuge, and the positions they assumed must be construed to have been taken in a defensive context. All were found in the same position and at the burrow terminus. The body, tightly jammed into the narrow lumen at this point, was oriented to the rear of the burrow, with the head bent back toward the opening at a sharp angle. The tail was curled laterally so that its base was pressed against one wall of the lumen and then passed to the other side, from where it extended toward the head, sometimes parallel to the body and sometimes undulating over the body from one burrow wall to the opposite one. The loose soil at this part of the burrow tended to cover most of the hind legs and tail. When touched, the lateral part of the tail was often quickly and forcefully pushed against my fingers so that the coarse, heavily keeled scales in this area were clearly felt. The movement can only be considered a defensive act, meant to discourage a potential predator. A captive spiny-tailed monitor (*V. acanthurus*) in its burrow once even drew blood by the same action as I jammed my finger in its burrow. Cogger (1967) stated that this species "holds its tail in front of its body for protection" when in rocky crevices. The spiny-tailed agamid lizard, *Uromastix hardwickii*, uses a similar tactic to defend its burrow (Smith, 1935).

Both termitaria and ordinary burrows are ordinarily used at night and during most of the day in the cooler months (October-February). During my visit in October-December I found that the monitors usually left the burrows of either type every morning, particularly after a cold spell, though they rarely wandered far from them. Observations during the entire day made from an appropriately placed blind at the Yamuna

River terrace area showed that during this time of year they do not necessarily return to the same hole on subsequent nights. One monitor used two different holes on two consecutive nights, and the second individual used three different holes in three nights. However, local snake charmers insist that during the cold months of January and February the monitors leave their burrows for only a few hours each day and return to the same one each night, sunning themselves most of the time in nearby appropriate spots. The daily pattern of an adult male and female *V. bengalensis* observed every day for five days at Bharatpur showed this pattern, with basking normally occurring within 5 m of their burrows. The male tended to wander over a greater distance during the day ($\bar{X}$ total daily distance traveled = 27.3 m) than the female ($\bar{X}$ total = 12.7 m). Though the differences were not statistically significant, the data are consistent with earlier studies showing that male *V. bengalensis* are generally more active than the females at all times of the year (Auffenberg, 1979).

Several holes I excavated in the Yamuna River terraces contained two monitors, though there were many unoccupied holes (only 10.7% of 28 burrows excavated at the Yamuna site contained one or more monitors). While there is undoubtedly a strong tendency for dispersion, data from movement of temporary escapees in Florida show a remarkable tendency for one individual to climb and use as an overnight shelter certain trees which had been used by others previously, in spite of the fact that hundreds of other apparently identical nearby trees remain unvisited (author's unpubl. data). Hatchling *Varanus komodoensis* are thought to remain together, moving through an area in a loose group (Auffenberg, 1981A). Hatchling of *V. bengalensis* probably do the same, for I caught 12 juveniles, undoubtedly all from the same clutch, in two large adjacent trees in Pahang Malaysia. A group of 8 juveniles were seen in three adjacent trees in Yala National Park, Sri Lanka ; in spite of the fact that hatching in this area had been completed at least three months previously. Thus, at least the very young individuals of *Varanus bengalensis* seem to exhibit a tendency to cluster, and the contagious distribution of burrows at the Yumuna River site suggests that the same tendency may occur in the adults as well.

Nests.—Local snake charmers near Agra, India, told me they found eggs in the termitaria in June and July and that they have seen hatchlings in July and August. They also said that the eggs are placed in a partly filled burrow in termite-abandoned termitaria. The latter is corroborated in one nest I discovered in Sri Lanka (28 July 1974). Ten fairly recently laid eggs were found in a termitarium 1m in diameter and 0.7 m in height. Evidently several monitors had broken through the outer carton and into the large internal chambers. One chamber, with a transverse diameter of 8 cm, was blocked with an earthen plug 13 cm long near the carton opening. The eggs were loosely piled at the unfilled end of the chamber, occupying approximately the terminal 12 cm. It was clear that the female had sealed the tunnel with earth removed from the surrounding walls. This situation is thus unlike that described by Cowles (1930) for some nests of *Varanus niloticus* in Africa, where the chamber opening was in an active termitarium and was said to have been closed by activity of the termites.

In the Sri Lanka nest the easiest route for the escaping hatchlings would have been through the plug, which was composed of loosely packed earth. I doubt that the hatchlings would have found it possible to dig through the tough carton walls of the termitarium, which were from 1 to 2 cm thick in this case. They might, however, have been able to find one of the several openings to the outside without doing any digging by following the labyrinthine chambers of the termitarium to any one of these openings.

In the absence of termitaria, *V. bengalensis* lays its eggs in a burrow in the soil excavated by the female. During November, 1979, three such nests were found in the southern end of the Keoladeo Ghana Sanctuary. Two were located on opposite sides of a nearly vertical narrow bank in an abandoned borrow pit (Text-fig. 1A, B). The eggs (4 and 8 shells in each and already hatched several months previously) were deposited in chambers 10 cm in transverse diameter, slightly less vertically, and 30 and 63 cm in length respectively. One had evidently been a rodent burrow originally, with a diameter of 5-7 cm. Though it continued toward the surface, it was blocked by a natural earth plug. Both nest burrows slanted upward at an angle of about 15°. The eggs were placed near the end of the enlarged part of the chambers, and the entrances for 20 and 31 cm respectively were filled with soil loosened from the roof and walls of the chamber. Some soil covered most of of the eggs. Escape in both cases had evidently occurred at the top of the loose earthen plug, where it touched the ceiling of the chamber.

The third nest chamber was found in one of a cluster of 14 apparently aborted chambers excavated by monitors (scratch marks from their claws were still easily apparent) in a vertical exposure of earth above and on either side of the mouth of an unoccupied striped hyaena den. All 14 chambers were very close together, most separated by about 20-30 cm and pockmarking a wall about 1.5 m high and 2.3 m wide. The depths of the excavations varied from 15 to 80 cm ($\overline{X}=51$ cm), and eight of these were slightly inclined upward toward the end, while the remaining six were more or less level. Two had apparently been excavated by enlarging some sort of pre-existing small burrow (cliff swallows ?), but the others showed no evidence of this. Their transverse diameters fall into three size categories (10 cm=3, 7. 5-8 cm=3, 6.0-6.5 cm=8), suggesting three different females may have been responsible for the excavations. Their appearance (deterioration) suggested they had been excavated over a long period of time, and many of those in the smaller diameter class had the rim of their mouths overgrown with a species of moss that lightly covered much of the face, suggesting that these were probably the oldest. Thus I conclude that three separate females, during at least two different seasons, excavated this face with a series of nest chambers, some of which may have been aborted. However, the loose filling in the floor of one of these contained bits of egg shell of the same thickness and surface structure as those in the nests in the bank, so that at least one of these openings was at one time used as a burrow in which eggs were deposited.

In the case of both the bank and hyaena den face situations it seems significant that the nest chambers are in groups. I described similar clusters of *Varanus komodoensis* burrows from both Komodo and Flores, Indonesia (Auffenberg, 1981A). Because examination of several of them revealed no eggshell fragments, I concluded that these clusters of *V. komodoensis* burrows were not associated with reproduction. My recent discoveries regarding the apparent clustering of nests of *Varanus bengalensis* suggest that my interpretation of the *V. komodoensis* clusters may be incorrect ; that is, they may be nest clusters. Lending further credence to the latter interpretation is that most of the *V. komodoensis* burrow clusters are on steep hillsides, and, as in the case of the *V. bengalensis* clusters on nearly vertical faces, many are some distance above the base of the exposure. All of the *V. komodoensis* burrows slanted slightly downward. However, the upward slant of the chambers in *V. bengalensis* nest holes on vertical faces is probably due to the position necessarily assumed by the digging female. In any event, the location of nest burrows on steep slopes or vertical faces in either species is probably related to reducing predation. This behaviour, if I have interpreted it correctly, is to my knowledge the first instance of this particular type of antipredator tactic (nests in steep or vertical exposures) in reptiles, though Deraniyagala (1957) described still another nest chamber for *Varanus bengalensis*, in which the female laid its eggs in a flask-shaped chamber at the bottom of a large, shallow body pit. Thus at least this monitor species may lay its eggs in such diverse excavations as abandoned termite nests, flask-shaped holes on level ground, or burrows excavated into steeply sloping, or even vertical, earthen cliffs. This variation is rather surprising, since most reptiles are apparently quite species-specific in regard to nest construction. This variation is even more significant when such variation occurs in populations of the same species separated by relatively short distances (ca 100 km), albeit in different ecological settings. Such variation shows that my earlier conclusions regarding the unusually high level of behavioural plasticitv in this family (Auffenberg, 1981A) is additionally justified. Further observations and data regarding the nesting behaviour of *Varanus bengalensis* are welcomed from biologists living within the range of the species.

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