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BURROW SYSTEM OF THE LARGE BANDICOOT RAT, *BANDICOTA INDICA* (BECHSTEIN) RODENTIA : MURIDAE IN WEST BENGAL

R. CHAKRABORTY and S. CHAKRABORTY

Zoological Survey of India, New Alipore, Calcutta—700 053.

INTRODUCTION

Like majority of murid rodents, *Bandicota Indica* spends much of its time in extensive burrow system dug by it. Damages to buildings and mud houses by its tunnelling in the walls and beneath the floors are well known (Hutton 1949, Prakash 1976). However, except for the works of Urs *et al.* (1969) at the villages near Mysore, Arjunwadkar and Gadgil (1974) at Poona, Tien and Cu (1965) in Vietnam and Marshall (1977) in Thailand, practically nothing is known about the pattern of its burrow systems, their diversity and microclimate. The present study involves the identification and excavation of its burrow systems in different habitats and data collecting of the microclimatic features of the same.

METHODOLOGY

Burrow systems at different habitats and at different times of the years 1981, 1982 and 1983 were excavated. Using a spade, the earth above the burrow was carefully removed and the course of the burrow was determined by introducing a long flexible rod. Number and diameter of burrow openings of each burrow system were noted. The measurements of the extension and depth were noted with a tape. Whenever nesting material were found, they were collected in a polythene bag and later analysed. Flora and fauna of the burrow systems were also collected, preserved and identified. To study the climatic condition of the burrow system, temperature and Relative Humidity near the burrow openings and at various depths were noted with the help of a Japanese made dial type hygrometer and a steelcased soil thermometer (Plate la).

STUDY AREA

The study was mainly conducted at Sagar Island (21.56° to 21.88° N and 88.08° to 88.16° E), the largest delta in the western sector of the Sundarbans. It is situated nearly 85 km. south of Calcutta. It is surrounded by large water bodies, namely the river Hugli in the northern and western sides and the river Mooriganga in the eastern side. The southern part of the Island faces the open area, the Bay of Bengal. Reclamation of the Sagar Island by deforestation was started early in nineteenth

century, but the southern part of the Island was covered with jungle till the first quarter of the present century. Gradual deforestation, cordoning of the island with high embankments and repeated monsoon wash the salinity of the soil and made the entire area cultivable. Several tanks were dug out which subsequently filled up with rain water to meet man's requirement.

Additional study was also made at Thakurpukur and Behala (South 24 Parganas District) regions of West Calcutta. Only few decades ago these regions were mostly under cultivation of paddy with much marshy areas. But in recent years most of the land have been reclaimed for construction of buildings, factories and roads. However, there are still a number of ponds, open drains and stretches of green land which are left over relics of the original topography of the area.

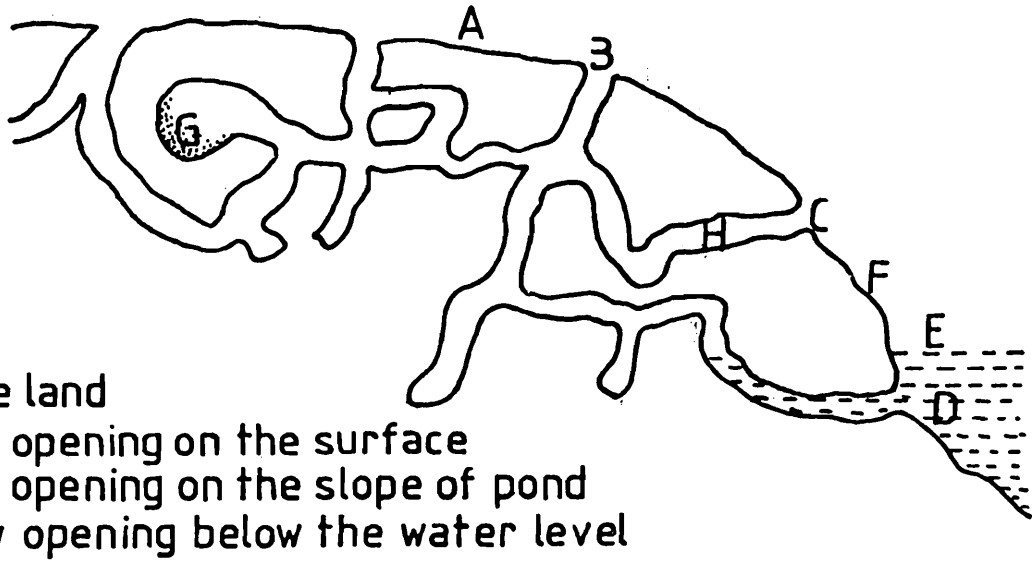
BURROW LOCATION AND INDENTIFICATION

Burrows of *B. indica* were observed in paddy fields, 'bumds', vegetable gardens, mud houses having a stock of food grains, along the ponds or other marshy areas as well as by the sides of open drains. Live burrow system can be recognised by the fresh wet globules of earth at the burrow openings and presence of foot prints, tail marks, soft faecal matter and sometimes fresh broken shells of crabs and molluscs (Plate Ib). Such burrows were observed throughout the year along the ponds, open drains or other water resources having some aquatic weeds, fish and molluscan population. In the paddy fields, live burrows were noticed only during late November to next May, and in the 'bunds' from June to December. Occurrence of live burrows along the boundary of vegetable gardens were observed only when there was standing vegetables in the garden, irrespective of season. Live burrows in or adjacent to the mud houses containing stored grains were only occasionally noticed, but in a fallow land with thick bush adjacent to a mud house, burrows were observed almost throughout the year. Month—wise occurrence of live burrows in different habitats of the Sagar Island and suburbs of Calcutta based on two years observations is summarised in table 1.

Burrow Pattern : Pattern and nature of burrow systems vary from habitat to habitat. The same has been described below :

Ponds and marshy areas : Along the ponds and marshy areas, as already stated, burrows are found throughout the year. Adjacent areas of twelve ponds each measuring 400 sq. m to 2500 sq. m of Sagar Island have been surveyed. Number of burrow systems varied from 3 to 17 and simple burrows 2 to 14 around each pond. However, are a of the pond has no relation with the number of burrow systems or simple burrows. Number is somewhat directly proportional to the thickness of the surrounding vegetation and richness of the molluscan population in the pond. Burrows are mostly located on the side having dense bush, bamboo thickets or trees like coconut, datepalm, *etc.* Sometimes burrows are located adjacent to the '*ghat*' (a cemented or wooden structure which facilitates the landing in the pond) used for cleaning the household utensils. A total of 24 burrow systems along the ponds were excavated for detail study. From the pattern, it appears that burrows were initially started on the sloping edge of the pond and then extension and ramification took place with the age of the occupant, and except the first opening others were made from inside the earth, forming tunnel. Each burrow system (Fig. la, Plate 2 a, b) had

a number of openings—one to three on the slope of the pond and zero to eleven on the adjacent surface land. Sometimes one of the openings on the slope might lie below the level of water. From the first opening above the level of water on the slope, a tunnel is traceable, which runs away from the pond for 30 to 64 cm. and then bifurcates. These two tunnels may run in the same or different directions, giving a number of branching tunnels mostly in linear fashion in all directions. Branches of one tunnel often communicate with that of other forming a net work below the tunnel often connunicate with that of other forming a net work below the ground. Some branches turned back towards the pond and opened on the slope or even below the level of water. Tunnels and its branches are tortuous and tortulous in nature. Most of the tunnels and their branches ended blindly below the surface with occasional enlargement, while others opened on the surface land adjacent to the pond. Entire burrow system is extended to at least two or more strata of the soil and depth varied from 30 cm. to 103 cm. Burrow openings on the surface land might be found even at about 3 meter away from the edge of the pond. However, it will not be out of point to mention about a particular burrow system observed at Santoshpur (South 24 Parganas) which extented from the slope of a pond to a mud house (containing stored grains at about 9 meters away from the pond), forming almost a straight tunnel at a depth of 40 to 60 cm. Mostly the extension of the burrow system and number of openings are some what directly proportional to the diameter of the original opening on the slope. The original opening on the slope is more or less elliptical in shape, 9 to 24 cm. in diameter and smooth in outline. Other openings are mostly roundish, 6-19 cm. in diameter with irregular or smooth outline. It appears that openings with irregular outlines are new ones. Diameter of the tunnel and its branches varies widely within the same burrow system ranging from 6-24 cm., expect at the point of enlargement where it is more. Boundary wall of the older tunnels and branches are very smooth but not so in the freshly constructed regions. Tunnels or branches are not sealed with soil except at the points where they accidentally opened on the tunnels of neighbouring burrow system. A detail statistics of the twenty four burrow systems dug out along the ponds are given in table 2.



A. Surface land
B. Burrow opening on the surface
C. Burrow opening on the slope of pond
D. Burrow opening below the water level
E. Water
F. Slope of pond
G. Brood chamber
H. Tunnel

Fig.1a. Pattern of a complete burrow system near pond.

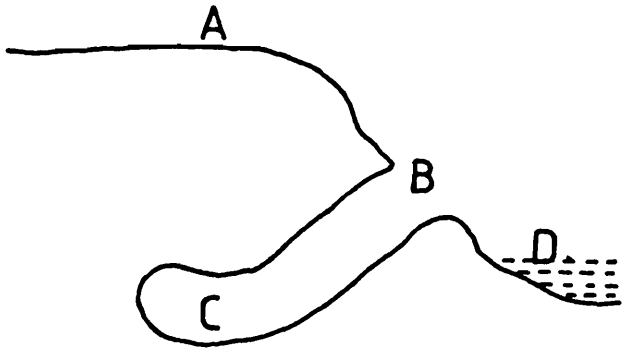
Table 1. Monthwise occurrence of five burrow systems of *Bandicota indica* in different habitats of Sagar island and sububs of Calcutta.

Habitat	January	February	March	April	May	June	July	August	September	October	November	December
1. Along the ponds or other marshy areas	+	+	+	+	+	+	+	+	+	+	+	+
2. Along the open drains	+	+	+	+	+	+	+	+	+	+	+	+
3. Paddy fields	+	+	+	+	+	–	–	–	–	–	+	+
4. *'Bunds'*	–	–	–	–	–	+	+	+	+	+	+	+
5. Vegetable garden	+	+	–	–	–	+	+	–	–	+	+	+
6. Mud houses and neighbouring land	+	+	+	+	+	+	+	+	–	–	+	–

All the burrow openings on the surface land as well as on the slope as observed remain permanently open. Globules of earth measuring 3 to 8 mm. in diameter are found particularly below the opening in the slope in case of fresh burrow system, but not in old ones. It appears that, after attaining a certain age, the animal stops the further extension of the burrow system. The presence of small whitish soft faecal pellets in the accumulated globules of earth indicates the existence of suckling youngs in the burrow system.

In seven out of 24 burrow systems, a brood chamber was found, which is nothing but a dilated blind end of a little upwardly directed tunnel, padded with some soft material like dry grasses, leaves and roots of aquatic weeds, *etc.* It is located at a depth of 40 to 90 cm. in somewhat central position of the burrow system. Shells of molluscs and crabs were often found inside the tunnel near the brood chamber.

In addition to the burrow system, some simple burrows were also found along the slope of ponds and marshy areas. The opening of which leads into a short, unbranched, curving tunnel extending into the same or two strata of the soil (Fig. Ib). Excavation of thirteen such burrows revealed that maximum length of the tunnel is about 72 cm. with diameter ranging from 6 to 14 cm. Animal was not found in any such burrows, but in six, floor of the tunnel was wet with fresh markings of foot and tail indicating that these were used by the animal for temporary shelter during the night. In five, broken shells were found inside the tunnel or just outside the opening. Thus, it appears that these burrows are also often used as feeding place.

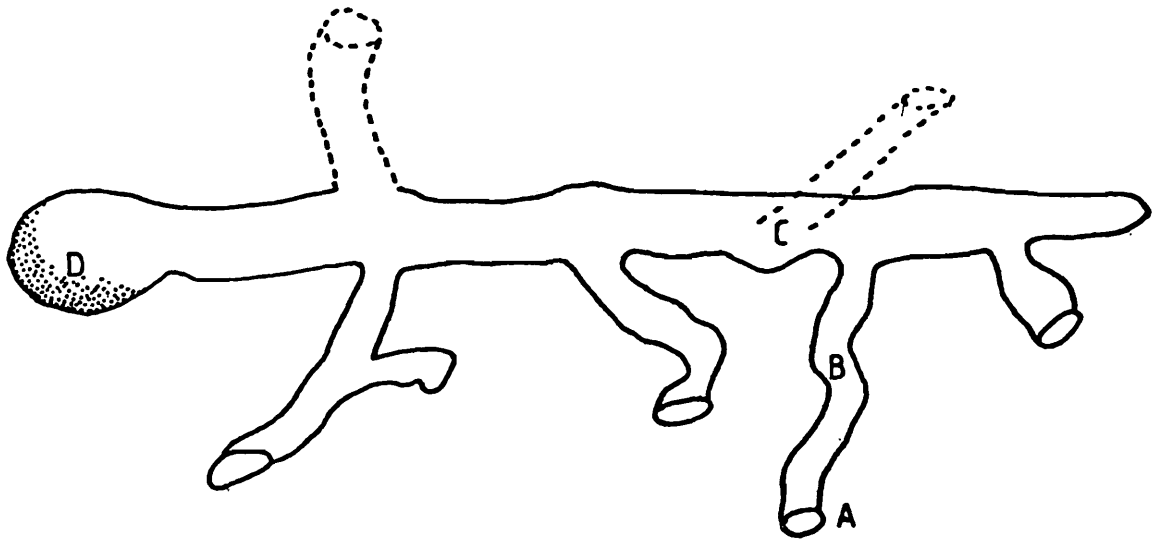


A. Surface land
B. Burrow opening
C Tunnel
D Water

Fig. 1b. Pattern of a simple burrow near pond

Bunds' : Live burrow systems were observed in the 'bunds' or highlands adjacent to the cultivated fields from April to December but the frequency was minimum. In about 9 km. of 'bunds' around paddy fields of four villages, *viz.*, Kachuberia, Kashtala, Phulbari and Sapkhali surveyed during the year 1981-82, only 14 live burrow systems could be found. Seven of them were excavated. A typical burrow system (Plate 3a, Fig. 2) consists of a series of openings on one side of the 'bund', some of which might remain under water during rainy season, a few on the upper surface and occasionally one or two on the other side of the 'bund' From each opening a small tunnel leads into the 'bund' to meet with a central tunnel lying at a depth of 30 to 60 cm. The central tunnel runs almost horizontal to the surface of the 'bund' and ends blindly on either sides. Number of burrow openings varied from

three to ten. Diameter of the burrow openings ranged from 4 to 13 cm. and the largest one always found on the side. Central tunnel is almost uniform in diameter but varies from one burrow system to other being 7 to 13 cm. Small tunnels are always narrower than the central. Maximum extension of the burrow system was found to be 232 cm. Burrow openings were clean, but when the fields became dry, globules of earth were often found on the ground below the openings.



A. Burrow opening
B. Tunnel
C. Central tunnel
D. Brood chamber

Fig 2. Pattern of a burrow system in the 'bund'

Out of seven burrow systems only in one (dug out in October) brood chamber was found, which was nothing but one end of the central tunnel padded with finely cut roots and leaves of paddy and some grasses. Statistical features of the seven dug out burrow systems are given in table 3.

Paddy fields : Live burrow systems in the paddy field were observed only from late November to early May of the next year depending on the time of ripening and harvesting of the paddy as well as the nature of land *i.e.* high or low. However, frequency of the occurrence of burrow system in the field was minimum and only 17 were observed during 1981-82 in 59 plots each having an average area of 860 sq. m. Burrows are initiated with the drying up of the field and maturing of the crop probably by the animals living in the adjacent 'bunds' or marshy areas. Altogether twelve burrow systems were excavated in different months. During November—December, burrow system is very simple consisting of one or two openings (Plate 3b). From each opening a tunnel runs obliquely downwards for 30 to 60 cm. In case of two tunnels, they communicate directly forming somewhat 'U' shaped structure or they are connected by a simple branch. Diameter of the same tunnel varies widely from 5 to 13 cm. Walls of the tunnels are very rough. Diameter of the burrow openings ranged from 5 to 13 cm. Heap of soft, wet globules of earth of about 4 to 12 mm in diameter are found outside, which partially coveres the burrow opening. A few scattered grains are found in the tunnel but without any sign of hoarding. From January onwards complicated burrow systems were observed, with increasing number of burrow openings, tunnels and their branches, which communicate with each other to form the usual network below the ground (Plate 4a, Fig. 3). Walls of

Table 2. Statistics of excavated twenty four live burrow systems of *Bandicota indica* along the ponds. Figures in parenthesis indicate the number of burrow systems.

No. of openings	Diameter of largest opening (cm.)	Maximum depth of the burrow system (cm.)	Maximum diameter of the tunnel (cm.)	Minimum diameter of the tunnel (cm.)	Maximum* extension of the burrow system (cm.)
1-3(4)	9-13(3)	30-55(5)	3-12(3)	6-8(9)	100-150(5)
4-7(15)	14-17(14)	56-76(14)	13-16(7)	9-11(10)	151-200(6)
8-10(3)	18-21(4)	76-95(3)	17-20(11)	12-14(5)	201-250(9)
11-13(2)	22-24(3)	95-103(2)	21-24(3)	—	251-302(4)

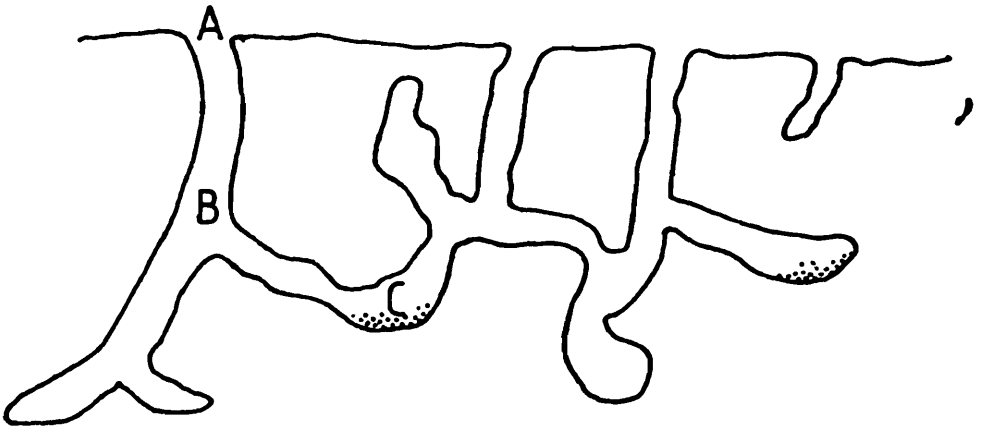
* Straight line distance between the two most distantly located burrow openings.

Table 3. Statistics of excavated seven live burrow systems of *Bandicota indica* on the '*bunds*'

Burrow number	No. of opening	Maximum diameter of the largest opening (cm.)n)	Maximum depth of of the burrow system (cm.)	Maximum diameter of the tunnel (cm.)	Maximum diameter of the burrow tunnel (cm.)	Maximum* extension of the burrow system (cm.)
1	3	8	30	9	7	98
2	5	8.5	49	12	10.5	113
3	4	10	78	11	9	145
4	8	13	114	12	10	180
5	9	13	98	13	11	165
6	8	12	111	13	11	232
7	10	9.5	106	12.5	10.5	170

* Straight line distance between the two most distantly located burrow openings.

the tunnel and their branches became smooth with occasional dilation particularly at the blind ends. A maximum of 6 burrow openings were observed, diameter of which ranged from 5 to 11 cm. Some of the openings were partially covered with globules of earth and rest were clean. Extension and depth of the burrow system did not exceed 198 cm. and 72 cm. respectively and extended in two to three strate of soil. In none of the excavated burrow system brood chamber was found. Ears of paddy, individual grains and also some straw were often noticed in the tunnel and dilated portion (plate 4b), but the total weight of all these material never exceeded 258 gm. Thus, it appears that the animal depends only partially on these hoarded grains during the period from February to May when little grains remain in the field.



A. Burrow opening
B. Tunnel
C. Hoarded grains

Fig.3 Pattern of a burrow system in the paddy field in March

Vegetable Garden : When there is a standing crop particularly sweet gourd, potato, pumpkin, *calocasia,* etc., live burrows or burrow systems are observed along the boundary of the vegetable garden. Usually most of the vegetable gardens of South 24 Parganas District have a boundary of thick bushes and the burrows are located inside the bushes (Plate 5a). Altogether 39 gardens of the Sagar Island, Behala and Thakurpukur were surveyed in which 16 live burrow systems distributed in 13 gardens have been observed at different times of the year. Being unable to get the permission from owners of the gardens, only two of them could be excavated. One of which consisted of a single burrow opening from which a tunnel of 48 cm. lead towards the garden without any branching. Tunnel wall was very smooth and its blind end was slightly dilated. Another burrow system had three openings within a small area of about 2600 sq. cm. inside the bush. From each opening, an obliquely directed tunnel went towards the garden at a depth of 30 to 40 cm. These tunnels were connected by simple branches. Two tunnels extended for 90 and 112 cm., and ended blindly with a little dilation, but the third one after extending for about 133 cm. below the ground, directed upwards and opened on the surface of the garden. The burrow system was almost restricted to one stratum of soil. Interestingly enough, burrow openings inside the bushes were free, but that on the garden was completely covered with loose soil. diameter of the tunnels varied from 6 to 13 cm. No brood chamber was found. There was no sign of hoarding but a few partly eaten potatoes were observed at different parts of the tunnel.

Mudhouses and adjacent land : Live burrow systems were found almost throught the year in or adjacent to the mudhouses having some stored grains. As many as 27 such burrow systems were observed at the Sagar Island of which 6 were excavated. However, due to practical difficulties proper excavation of the portion inside the house could not be done. Each burrow system had 3 to 19 openings, distributed inside as well as outside the house. These openings are connected by underground tunnels and their branches, depth of which went up to 65 cm. It is extended to three strata of the soil. Sometimes, tunnels go up through the wall of the mudhouse and open at a height of even 1.2 m. (Plate 5b). Extension inside the wall sometimes lead to the total collapse of the wall, as it is reported by the local people. Diameter of the burrow openings widely vary from 4 to 13 cm., and that ot the tunnels from 5 to 14 cm. Huge piles of the earth were found at the edge of the openings lying outside the house but not in those of inside. Some simple holes are also made at the base of the mud wall and used as ready passage for in and out. Though there was no definite storing chamber, but up to 500 gm. grains were found stored irregularly at different parts of the tunnels and their branches. In addition to the grains, other articles of daily household, *viz.*, soap, candle, spoon (steel), pieces of cloth etc., have been recovered from the burrow systems. Brood chamber which is a slightly upwardly directed dilated blind end of a tunnel, padded with variety of material like husk, cotton, jute, paper, etc., was found in three burrow systems.

Open drains : Along the sloping edge of the open drains at Behala and Thakurpukur a series of live burrow systems were observed throughout the year. Each burrow system (Plate 6) consisted of a number of openings on the slope of the drain almost in a linear fashion. From each opening a short tunnel of 30 to 40 cm. went slightly downwards and then upwards. These tunnels met with a central tunnel. Central tunnel ran almost parallel to the slope of the drain even up to 410 cm. Central tunnel gave rise one to four short, blind, upwardly directed branches opposite to the direction of slope. Diameter of the tunnels varied from 5 to 10 cm., and that of burrow openings from 4 to 7 cm. Accumulation of very fine globules of earth could be marked below each opening particularly during dry period of the year. Most of the dug-out burrow systems had a brood chamber, which was again nothing but a blind, upwardly directed branch, padded with fine dust of soil, pieces of paper, cloth, dry leaves and roots.

FLORAL COMPOSITION IN ASSOCIATION WITH THE BURROW SYSTEM

A number of plant species were found neighbouring the burrow system. The most of the burrow openings are not covered by the globules of earth, but often they are concealed by the growth of different plants. Different species of plants associated with the burrow systems in different habitats are listed in table 4. Variety and richness of the plant species are most pronounced near the ponds and marshy areas and minimum around vegetable gardens. Some of the plant species associated with the burrow system served as items of food of *B. indica,* which is advantageous for the youngs. In addition to the green plants number of fungi, *viz., Mucor, Aspergillus, Rhizopus* were also found in an around the burrow systems of all habitats.

Table 4. Floral composition in association with the burrow systems of *Bandicota indica* at different habitats.

	HABITATS			
	Ponds and marshy areas	Along the drains	Vegetable gardens	*'Bunds'* and paddy fields
	Imperata arundinacea	*Peperomia pillucida*	*Opuntia dillanii*	*Cynodon dactylon*
	Calocasia antiquorum	*Alternanthera sessilis*	*Calotropis* sp.	*Amaranthus gracilis*
	Alocasia indica	*Amaranthus viridis*	*Croton* sp.	*A. spinosus*
	Masilea quadrifoliata	*A. spinosus*	*Convolvulus* sp.	*Cammelina bengalensis*
	Ipomea sp.	*Chrosophora peicata*	*Jatropha gossypifolia*	*Andropogon scuarrosus*
F	*Sphenelea* sp.	*Oxalis corniculata*		
	Sesleania sp.	*Xanthium strumarium*		
L	*Trapa bispinosa*	*Croton* sp.		
	Vallieneria sp.	*Haliotropium indioum*		
O	*Atternanthera* sp.	*Eclipta prostrata*		
	Chrosophora plicata	*Glycosmis arborea*		
	Onalis corniculata	*Tagetes* sp.		
R	*Xanthium stromarium*	*Vernonia* sp		
	Glycosmis arborea	*Acalypha indica*		
A	*Sporonlus fertilis*			
	Lippia nodiflora			
	Tagetes sp.			
	Typha sp.			
	Cocos nucifera.			
	Borassus flabelliffer			
	Phoenix sylvestris			
	Cyperus kyllingia			

FAUNAL ASSOCIATION WITH THE BURROW SYSTEM

Faunal composition of six live burrow systems of five different habitats were studied. Protozoan and nematode species were studied by culture and seiving of the burrow soil respectively. As many as 36 species belonging to four different phyla were revealed. A burrow-wise detail analysis of the fauna is given in table 5. It appears that fauna of the burrow system located near a water source is comparatively richer than that of other habitats. Three species, *viz.*, *Colpoda cucullus, Pheretima posthuma* and *Cyphoderus* sp. are the most common species living in the burrow system and found in four out of six burrow samples studied. Though Arjunwadkar and Gadgil (1974) reported lizards as a commensal species in the burrows of *B. indica* at Poona, but no vertebrate commensal was found in the live burrow systems excavated during the present study. However, several amphibian and reptilian species use the deserted burrow systems at the Sagar Island as their shelter particularly during winter.

MICROCLIMATE

Soil : Soil of the Sagar Island may be classified into four categories, *viz., Matial, Baliara, Dhap.* Burrows were found in all the types, but more frequently in the *Baliara* and *Matial* type, Moisture-content of the soil lining the tunnels was very high in all the habitats. During the year 1981-82, it varied from 15 to 32 per cent at

the deepest position and 7 to 28 per cent at the upper region. Some whitish efflorescens of sodium chloride was found in the soils of the burrow systems of the Sagar Island, while soils from the burrows of Thakurpukur and Behala were often impregnated with 'Kanhar' and laterite debries.

Temperature : Temperature inside the burrow system at a depth between 70 and 100 cm. was measured by vertical drilling and inserting the thermometer there. For comparison, air temperature as well as temperature of the soil surface were also noted. Temperature was recorded at different hours of the day from 6.00 to 17.00 hrs. This study was conducted only during 1981-82.

Average hourly air temperature varied from 19.3° to 34.2° C during premonsoon, 24° C to 33.6° C during monsoon and 14.4° C to 28.6° C during post monsoon period. Peak in temperature was attained at about 14.00 hours during monsoon and premonsoon period while at about 15.00 hours during post monsoon (Table 6). Average hourly temperature inside the burrow at a depth of 70 to 100 cm. varied from 18.4° C to 28.3° C, 19.0° C to 26.8° C and 16.4° C to 26.6° C during premonsoon, monsoon and post-monsoon months respectively. Peak in temperature inside the burrow was attained about an hour later than that of outside in all the three seasons (Table 5). Average hourly soil surface temperature exhibited much variation during premonsoon and post-monsoon periods, but not so in the monsoon. During premonsoon and post-monsoon, average hourly soil surface temperature varied from 17° C to 35.2° C and 12.8° C to 28.5° C respectively, while it ranged from 20° C to 29° C during monsoon. Peak in the temperature of soil surface was usually attained a little before the peak of air temperature (Table 6).

Relative Humidity : Relative Humidity outside the burrow and at about 30 cm. inside the burrow system was noted at 8.30 hours and 17.30 hours. Relative Humidity inside and outside the burrow was maintained at a very high level throughout the year, particularly during premonsoon and monsoon (Table 7). Range of variation of Relative Humidity outside the burrow was practically negligible during premonsoon and monsoon, but about 8 per cent during post monsoon. Relative Humidity inside the burrow was always slightly more than that of outside and range of variation was further less, maximum being 3 per cent during post monsoon (Table 7).

ORGANISATION OF THE BURROW SYSTEMS

No particular organisation of the burrow system could be marked in the paddy fields, 'bunds' or vegetable gardens, but found scattered here and there. Near ponds and marsy areas, though scattered burow systems were found, but groups of two to five were also observed below some thick bush adjacent to the water. Similarly, series of two to four burrow systems with linear arrangement were found in some part of the open drain adjacent to a fallow land. Groups of two to three burrow systems were also observed in the fallow land adjacent to a mud house. From outside no line of demarcation among the burrow systems of a particular group couldbe found, the openings of one burrow system might lie within the extension of another. Distance of one group of burrow systems from another depends on the availability of next suitable site.

Table 5. Faunal association of six live burrow systems of *Bandicota indica* at five different habitats.

Fauna	Burrow No. Habitat	1 Marshy area	2 Marshy area	3 Paddy field	4 *'Bunds'*	5 Open drain	6 Vegetable garden	Frequency
Protozoa :								
Acanthamoeba palisalensis		+	+	–	–	–	+	3
A. glebae		+	+	–	–	–	–	2
A. culbertsoni		–	+	–	–	–	–	1
A. astronyxis		–	–	+	+	–	–	2
Colpoda cucullus		+	+	+	+	–	–	4
Hartmannela crumpae		–	–	–	–	+	–	1
Oxytricha fallax		–	+	–	–	+	–	2
Nemathelminthes :								
Eudorylaimus sp.		+	–	+	–	–	–	2
Thornenema sp.		+	–	–	–	+	–	2
Sicaguttur sp.		–	–	+	–	–	+	2
Aporcelaimellus sp.		–	+	–	–	–	–	1
Oxydirus sp.		–	–	–	+	–	–	1
Axonchium sp.		–	+	–	–	+	–	2
Annelida :								
Pheretima posthuma		+	–	+	–	+	+	4
Lampito mauritti		–	+	–	–	–	–	1

Insecta :							
Lepidocyrtus sp.	−	−	−	−	+	−	1
Isotomurus sp.	+	+	−	−	+	−	3
Cryptopygus sp.	−	−	−	+	−	−	1
Cyphoderus sp.	+	+	−	−	+	+	4
Grylotalpa sp.	−	−	+	+	−	−	2
Odontotermis sp.	−	+	−	+	−	−	2
Philoscia lodnensis	−	−	−	−	+	−	1
Solonopsia geminata	−	−	−	+	−	+	2
Monomorium latinoda	+	+	−	−	−	−	2
M. floricola	−	−	−	+	−	−	1
Camponotus compressus	−	−	−	−	+	−	1
Pronolopsis longicornis	+	−	−	−	−	−	1
Pheropsophus catorei	−	−	+	−	−	+	2
Abacetus guttaela	−	−	−	+	−	−	1
Onthrophagus sp.	+	+	−	−	−	+	3
Nonolepta nigobilineata	+	+	−	−	−	−	2
Arachnoidea :							
Lycosa sp.	−	+	−	−	+	−	2
Pisaurina sp. *ındi*	[illegible]	−	+	−	−	−	1
Pardośa mukundi	+	−	−	−	−	−	1
Myriapoda :							
Rhysida sp.	+	−	−	−	+	−	2

Table 6. Average hourly temperature of air, soil surface and at 70 to 100 cm. depths of the live burrow systems of *Bandicota indica* at Sagar Island during three different seasons of 1981-82.

Area	Temperature (°C) at different hours of the day											
	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
					Premonsoon							
Air	19.3	20	21.8	23	26.2	28.3	30.3	32.6	34.2	33	31.2	28.2
Soil surface	17	18.2	20.6	24.3	27	30.4	32.8	35.2	34.4	30.4	28.3	26.5
At 70-100 cm. depth	18.4	18.8	19.7	21.2	23.5	25.4	26.8	27.5	28.1	28.3	27.6	27
					Monsoon							
Air	24.7	24.7	24.8	25	24.8	25.6	27.2	29.2	33.6	31.6	31	29.1
Soil surface	20	22.1	22.87	23.7	24.4	26.1	29	28.6	27.4	27	26.4	26
At 70-100 cm. depth	19	19.1	20.5	21.7	22.6	23.1	23.9	24.4	25.7	26.8	26.6	26.2
					Post monsoon							
Air	14.4	14.6	16.9	10.2	19.3	21.1	23.4	26.1	28.6	28.3	26.2	20.1
Soil surface	12.8	12.9	13.4	15.7	19.3	22.9	26.1	28.5	28.3	27	23.2	20.1
At 70-100 cm. depth	16.4	16.6	17.5	18.1	18.4	19.3	20.3	21.4	22.9	24.6	24.4	23

Table 7. Average Relative Humidity of outside and at about 30 cm. inside the live burrow systems ot *Bandicota indica* at Sagar Island during different seasons of the year 1981-82.

Area	Relative Humidity	
	At 8-30 hrs.	At 17-30 hrs.
	Premonsoon	
Outside burrow	80.4%	81%
At about 30 cm. inside the burrow	82%	84%
	Monsoon	
Outside burrow	85.4%	84%
At about 30 cm. inside the burrow	85.8%	84.2%
	Post monsoon	
Outside burrow	74%	67%
At about 30 cm. inside the burrow	75%	72%

DISCUSSION

In some habitats, live burrow systems of *B. indica* are found only at certain period of the year, while in other habitats throughout the year. This indicates a sort of local migration of a part of population but not the entire. This migration is related partly to food, partly to shelter. With the maturing of the paddy ('Amon' variety) and drying up of the field, a part of population from the neighbouring 'bunds' and marsy areas migrate to the field and settle there. They remain in the field till there is crop or onset of monsoon. With the beginning of rain, ploughing activity starts resulting the destruction of burrow systems. Thus, the rats of the field migrate at that time to the neighbouring 'bunds' or other suitable sites. Similarly, vegetable gardens also attract some of the rats at different periods. Such local migration have also been reported in *Bandicota bengalensis* population of lower Bengal (Chakraborty 1977).

Study revealed that extension, depth, number of openings, *etc.*, of burrow system vary widely in different habitats as well as within the same habitat. Tien and Cu (1965) also found the similar variation at Vietnam. Such variations are mainly related to the nature of the soil and age of the animal.

Burrow system adjacent to the pond or marshy areas usually have an opening below the surface of water. Such opening facilitates entry as well as exit of the animal in secret during the time of emergency.

Brood chamber was found in some of the burrow systems and its occurrence was in no way related to the extension or location of the burrow system or seasons. Probably brood chambers was made only in the burrow which was occupied by an adult female. Location of the brood chamber in a somewhat upwardly directed tunnel is advantageous to protect the young ones against inundation during monsoon.

Sign of hoarding in the burrow systems was not much obvious. In fact, burrows were mostly constructed in the areas having some perennial source of food. Thus, hoarding was not required. Arjunwadkar and Gadgil (1974) also found that burrows of *B. indica* at Poona are not used for the storage of food grains. However, at Vietnam, dilated chambers of the burrow system are filled with stored grains like paddy, *etc.*, (Tien and Cu 1965). Similar geographical variation of habit is evident in *B. bengalensis,* which is famous for its hoarding habit (Jerdon 1874, Blanford 1891, Wagle 1927, Kamath 1961, Chakraborty 1977). However, George *et. al.* (1981) reported non hoarding habit of *B. bengalensis* population at Kerala and they attributed this habit to the easy accessibility to crops and other food material throughout the year. Thus, it appears that hoarding habit is not a species specific character, but an adaptation to a habitat having a period of food scarcity.

Moisturecontent of the burrow soil samples at Sagar Island was very high. This is in accordance with the somewhat amphibious habit of *B. indica.* Studies of Urs *et. al.* (1969) revealed that moisture content of burrow soils of different species of rodent is different. Barnett and Prakash (1975) found that some species of rodent live in dry soil others in wet soil. Thus, it may be concluded that moisture content of the soil has a definite role in the survival and distribution of different species of rodent specially of fossorial ones.

Mean temperature and Relative Humidity inside the burrows were slightly lower and higher respectively that those of outside. Moreover, range of variation was further less inside the burrow than outside. Thus, a microclimate is formed inside the burrow system. This microclimate protects the animal from the climatic extremities of outside during the period of rest.

From the above discussion it may be concluded that the large bandicoot rats use their burrow system for rest, protection, parturition, developing the young ones and to avail a most congenial microclimatic condition during the period of rest.

SUMMARY

Burrow systems of *B. indica* have been studied in different habitats. Live burrow system could be recognised by the presence of fresh globules of earth at the burrow openings, foot prints, tail marks, soft faecal matter and fresh broken shells of molluscs, crabs, *etc.* Most of the burrow systems have a number of openings leading in to branching tunnels. Brood chambers were found in many of the burrow systems. There was not much sign of hoarding in burrow system. Floral and faunal composition in association with the burrow systems were very rich. Range of variations of temperature and Relative Humidity inside the burrow were much less than outside. Burrows are mainly used for the shelter, protection and developing the youngs. Extensive tunnels are often responsible for the damage of mud houses and other structures.

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