STUDIES OF RATS AND RAT TRAPS OF KERALA

BY

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THESIS

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1979

DECLARATION

I hereby declare that this thesis entitled "Studies of rats and rat traps of Kerala" is a bonafide record of research work done by me during the course of research work and the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
10-7-1979.

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CERTIFICATE

Certified that this thesis entitled "Studies of rats and rat traps of Kerala" is a record of research work done independently by Sri.C.M.George under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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CERTIFICATE

We the undersigned members of the Advisory Committee of Sri.C.M.George, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology agree that the thesis entitled "Studies of rats and rat traps of Kerala" may be submitted by Sri.C.M.George in partial fulfilment of the requirements for the degree.

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INTRODUCTION

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Rodents have come to play a very decisive role in the food and health problems of man the world over. The heavy damage incurred by them to the crops in India is gaining serious concern and the very high population of rats is poignantly realized both in urban and in rural areas. The losses caused by rats are not confined to field crops, substantial quantitative and qualitative losses are inflicted to stored grains also. The many dreaded diseases they spread among human beings and live-stock also warrant an immediate focussing of attention on this matter of national importance.

Increasingly aware of this fact, multifarious efforts are in progress to tackle the problem on a national level. A clear understanding of the problem with respect to systematics and ecology is vital in any rodent control campaign. Rat infestation depends on various factors, of which, the rat species, its accessibility to the property, the environmental conditions available for shelter and feed etc. are a few of the most important.

The ravages due to rat menace is no less in Kerala. The State is blessed with rich flora and fauna providing a cosy habitat for a number of rodent species. Information

on the bio-ecology and distribution of rats in the State is quite meagre. An exhaustive study of the distribution, bio-ecology and fossorial habits of the species is an essential pre-requisite to successful rat control campaign. The present studies have been taken up with the objective of gathering some information on the distribution and habits of rats occurring in the State.

In an integrated strategy of rat population management the use of suitable mechanical traps is of considerable importance. A detailed study about the uses and limitations of indigenous traps would be helpful for the identification of the promising ones that can be recommended for adoption on a large scale. Studies on indigenous traps in use in the State have also been taken up to meet the above desideratum.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A. Traps

Pits have been used to catch rodents (Fisher, 1895). The best success with pits has been with the aid of steep-sided trenches, the bottom of which have metal or glazed earthen ware containers to hold animals as they fall in (Kinoshita and Shibota, 1954). Philip Goose (1921) reported 'Nilgiri trap' being used by the tribal class, 'Inular' of Nilgiri, to catch hares and jungle fowl. Here glues are used for trapping, in which a sticky substance entangles the animal. Bird lime is extensively used to catch small rodents (Bourke, 1925).

Pot trap consists of a round earthen pot 8" diameter and 6½" height with a cupshaped lid and seven wooden pegs, each of one foot length. The pot is balanced in an inverted position at a height of 3" from the ground level over a tripod of three pegs, one of which is slightly raised. The lid is firmly fixed to the ground, supported by the remaining four pegs all around. The bait is placed on the lid and inside the pot. The rat after eating the bait on the lid tries to eat the bait inside the pot which

on being disturbed, falls on the lid and traps the rat (Ali, 1958).

Abraham (1959) gave description of an indigenous trap (The Thanjavur bamboo trap) used in rice fields and cocoonut grooves of Thanjavur area of Tamil Nadu State. Ghosh (1960) recorded the utility of bamboo hammer-trap in controlling rice field rats in Burma.

The different types of traps used in India include box trap, break back trap, snap or guillotine trap, well trap, pit trap, pot trap, barrel trap, wonder trap, cage trap, bamboo arrow trap and the post trap. (Reddy, 1965, Deoras, 1964; Mehta 1961 and Rai 1972). According to Deoras (1964) wonder traps developed by the Haffkine Institute have been quite popular in India.

Pottery traps are used in Iran, Afghanistan and Pakistan (De Cardi, 1967). Other traps include the metal live-catch-wonder trap developed by the Haffkins Institute, Bombay, small wooden live catch trap in Rangoon, metal break back traps and wiremesh single catch live traps in Hongkong (Sawford 1970; Drummond, 1974).

Majumder (1968) gave brief descriptions of different

types of rat traps used in India and stated that the snap trap was found to be the relatively better and more popular. The traps are generally effective to kill bait shy rats in circumstances where the use of poison baits will be hazardous and trapping is useful to clear small infestations or to prevent re-invasion following control compaigns (Davis, 1970). The efficiency of bamboo noose trap in controlling R. bengalensis is described by Pisharody and Thampan (1976). The effectiveness of two rat traps, bamboo snap back-cum noose trap and plank trap was tested in a cocconut plantation by Chandy Kurian et al.(1977). Pingale et al. (1967) suggested effective methods of putting up rat traps under field conditions. For trapping field rodents, runway traps are to be set in the natural pathways made by the animals. As far as possible, large and complicated traps are not to be used. Traps which are open at both sides are relatively better than single entrance traps. Token amounts of bait materials should alone be sprinkled at the entrance of the trap and the bulk of bait exposed on the treadle or trigger plate. The traps should be set firmly on the ground so that these are held in the same position even when the

animals attempt to enter them. Cleaning up the area around the entrances of traps will be useful in attracting the rats.

According to Storer (1958) human odour from handling traps will not keep rats and mice away from the traps. Fitzwater (1966) reported that the odour of other rats tends to draw more rats into the traps.

B. Biology, Binomics and habits of rats

In India the rats (Family - Muridae) are represented by two sub families i.e., Murinae comprising of the genera, Apodemus, Bandicota, Chiropodomys, Daonoyms, Golunda, Niliardir, Mus, Nesokia, Rattus, Vandeleuria and Gerbillinae comprising of Gerbillus and Tatera. Deoras (1964) listed out 92 species of rats as occurring in Nepal, Bhutan, Sikkim and different states of the Indian Union. Krishnakumari (1968) and Yashoda (1968) classified the Indian rats and mice into domestic rats and field rats and the important species are as follows:-

1. Domestic rats.

(a) Rattus rattus Linnaeus

(b) Mus musculus Linnaeus

(c) Bandicota indica Bechstein

(d) Rattus norvegicus Berkenhout

2. Field rats

(a) Tatera indica Waterhouse

(b) Millardia gleadowi Murray

(c) Millardia meltada Gray

(d) Bandicota bengalensis Gray

1. The Indian Gerbil or Antelope-Rat

Tatera indica cuvieri

Of the four sub species of T. indica viz., (1) T.i. indica (2) T.i. ceylonica (3) T.i. hardwickei and (4) T.i. cuvieri. T.i. cuvieri is widely distributed in South India (Allerman, 1961). According to Krishna Ayyar (1931) T.i. cuvieri had their permanent residence in bushes, prickly pear and such suitable places. T. indica was usually found in cultivated lands under bushes hedges and in open plains (Krishna Kumari, 1968; Yashoda, 1968).

The burrows of T.i. cuvieri had more or less a

straight run and the depth might vary from 0.5 to 2 feet. The burrows might have more than one entrance. Those burrows were often made in a day and were not extensive as those of Gunomys (Krishna Ayyar, 1931). Pingale et al. (1967) observed the burrows of this species to be very much elongated with winding passages, a number of emergency escapes and a breeding or living chamber in the centre. Yashoda (1968) reported that the rats dug burrows in open plains and in rocky regions around cultivated fields. The indication of inhabitance of the burrow system could be made out by the presence of beaten pathways from one opening to the other and left over cut bits of leaves and slender branches across the pathways. Each burrow system had two to four openings and there would be a main entrance running for some distance which then branched off into two or three tunnels.

Srinivasachar (1972) located the burrows of T. indica along the bunds of cultivated lands. It constructed extensive burrows with numerous openings and a large central chamber, 6 to 12 inches long with beds of grasses.

The burrows of T. indica was found in sandy areas and one to five adults generally occupied a single burrow.

These gerbils made the deepest burrow (100.5 cm) and the radius of the burrow ranged from 4.8 cm to 7.7 cm (Sundara Bai, 1972). Bindra and Prem Sagar (1975) found that the burrows of T. indica were some what complicated having one to ten surface openings. In some burrows one or two surface openings were blocked with small quantity of soil and were temporarily out of use. Such openings were readily used by the rats in case of emergency.

Barnett and Iswar Prakash (1975) noted that the burrows of T. indica were of simple pattern with three to ten openings, a central chamber and a few emergency escapes. More than one individual lived in a single burrow system.

Yashoda (1968) observed the nests of T. indica in concealed tunnels. They build the nest with hay and leaves collected from the nearby places. Eight to twelve young ones were found in the burrow. According to Srinivasachar (1972) the central chamber in the burrow system was provided with beds of grasses. Sundara Bai (1972) reported that one to five adults usually occupied a single burrow.

Prem Sagar and Bindra (1970) reported that in *T. indica* the peak breeding seasons were March to May and August to mid October. In each of these breeding seasons *T. indica* reproduced one to three times. Barnett and Iswar Prakash (1975) stated that the litter size in *T. indica* ranged from two to nine.

According to Krishna Ayyar (1931), this species was destructive to paddy, especially stored paddy, outside buildings in Aduthurai (Tanjore). They also destroyed cocoanut seedlings in some parts of Malabar by burrowing underneath and feeding on the tender portions of the shoot inside.

The food of *T. indica* consisted mainly of grains, roots, leaves, grasses and insects. These rats suitably shifted their food habits to different items in different seasons to utilise the materials available in different seasons (Yashoda, 1968). Srinivasachar (1972) reported that *T. indica* fed mostly on roots, grasses, seeds and grains. They particularly preferred the 'harayali' grass (*Cynadon dactylon*), Jowar and bajra. According to Sundara Rai (1972) these rats feed on grains, roots,

leaves, insects, sugarcane etc. Mann (1973) while studying the population level of different species of rats and mice in different crops found that T. indica preferred the methi crop during rabi and brinjal during kharif. Rajasekharan et al. (1975) recorded that T.i. cuvieri caused damage to the wheat crop in Andhra Pradesh. Sood and Ubi (1975) could capture T. indica from groundnut, maize, wheat and sugarcane fields.

2. Norway rat, Brown rat, Barn rat or Sewer rat
Rattus norvegicus (Berkenhout)

Blanford (1888-1891) included this species in his work on Indian mammals but Wroughtoni (1919) did not consider it as native to India. According to Ellerman (1961) this species is commensal and is distributed throughout the greater part of the world. It is certainly not indigenous in India, though now found in all large towns and villages, along the banks of navigable rivers and on high roads.

According to Barnett and Iswar Prakash (1975) R. norvegicus are distributed in tropical countries mainly in ports, where it is apparently an introduction from Europe.

According to them very little is known about the habits of R. norvegicus in tropical countries. In temperate regions, this species was found in farm lands as well as cities. It inhabited buildings, yards, hedges, fields and ricks.

Pingale et al. (1967) stated that R. norvegicus preferred to use the same runway always and ran close to walls and between sacks of food rather than across open spaces and exhibit pronounced new object reaction. Majumder (1968) reported that R.norvegicus was a burrowing type which could climb and swim and this species exhibited new object reaction. It was often found in ports and large port cities. Cotton (1963) found that these rats stayed within 75 - 100 feet of their burrows unless to travel further for food. The norway rats fed at any time of the day but were most active during the first hour after dusk.

Joshee (1961) found that R. norvegicus burrowed to a depth of 18.24 inches. Deoras et al. (1966) noted R. norvegicus burrowed to a depth of 18.24 inches. Deoras et al. (1966) noted R. norvegicus to be swifter than

B. bengalensis in burrowing.

Pingale et al. (1967) described that the nest of rats in sewer system were located mostly in the soil around them. Large or medium sized sewers were runways and meeting places of individuals that fed on suspended kitchen waste at regular hours. The nest was in small side drain and was inaccessible for control from the canals.

3. Lesser Bandicoot/Indian Mole rat.
Bandicota bengalensis bengalensis (Gray)

Srinivasachar (1972) indicated that these were found in greater parts of Penninsular India almost from base of Himalayas to Cape Comorin. The south Indian variety was smaller, usually paler in colour.

It is distributed in whole of India, but not so far authentically reported from desert of Rajasthan (Barnett and Iswar Prakash, 1975).

Krishnakumari (1968) and Yashoda (1968) stated that they inhabited the border and bunds of cultivated plains, gardens and pasture lands. Burrows would be found in such places wherein they got surplus quantity

and type of food they required. B.b. bengalensis preferred to dig burrows in fine and moist soil. Hence most of the burrows were found all along the borders of paddy and sugarcane fields (Yashoda, 1968).

According to Ramakrishnan (1968), burrows of this rat were confined to rice field bunds during cropping season and were found in the field also in the fallow period. Barnett and Iswar Prakash (1975) reported that these rats were exceptionally versatile, wide spread and common species, present in irrigated fields, villages and towns. Krishna Ayyar (1931) reported that the burrows of B. bengalensis were long, extensive and some what complicated. They extended to 20 or 30 feet or even more. They had sometimes four or five openings or exits. The runs seldom go beyond a depth of two feet below ground and are rarely more than three or four inches in diameter. The presence of a burrow was always indicated by the heap of fresh earth thrown by the side of the bund. Generally the main entrance was kept obscured from this heap of earth. There were sometimes three or four branches (even half a dozen) some of which might ended in blind alleys. Generally only one rat, rarely two were found to inhabit one burrow.

Joshee (1961) observed that B. bengalensis burrowed to a depth of 18.24 inches. Deoras (1962) had recorded the depth of a B. bengalensis burrow to be 29 inches and that one burrow ramified upto more than 100 feet. Groundnut, paddy and local grains were recovered during October from the cells in the burrow. The faecal pellets were found not in the nests but in the adjoining cells.

The burrow of B. bengalensis were largest and tortuous compared to those of M. malabda., T. indica and M. booduga and it had 1 - 2 openings, 1 - 3 bed chambers and 1 - 3 food chambers and usually there was only one adult per burrow (Anon. 1965).

The inhabited burrows could be identified by the presence of gritty excavated earth near the openings. There would be one main tunnel running in zig - zag manner throughout the area with openings closed with fresh head of mud. Burrows extended over a wide area, sometimes even few yards taking many turns, ending in a circular living chamber. Small circular chambers were excavated along the zig - zag path or to one side of it. Many times these circular chambers would be dug

one above the other resembling the gallery (Yashoda, 1968). She also reported 3 - 5 openings while according to Prem-Sagar and Bindra (1973) there were 2 - 12 surface openings. Sundara Bai (1972) recorded that the depth of burrow ranged from 30.5 cm to 122 cm with the average of 74 cm. In the nesting chamber, the female lived with the litters. Ragi, paddy etc. were hoarded during the harvesting season. Soil was fine and the moisture content of the burrow was very high.

According to Prem Sagar and Bindra (1973) burrowing pattern of B. bengalensis was very complex and interesting. The males and females live in separate burrows. At a short distance from the main surface opening of the burrow, the tunnel branched off into two to five lanes, about fifty per cent of which sometimes terminated in blind alleys or food chambers and the rest were sometimes found to be artificially closed. In the centre at the maximum depth of the burrow there was a large circular or semicircular area which was found to be utilised by the rats as a bed/brood chamber. This chamber could be reached by the rats only after going through zig - zag alleys. The brood chamber contained

wheat straw and grasses. Besides, the burrow contained a couple of food chambers in which were found wheat ears arranged systematically one over the other. In the burrows containing the male bandicot, the bed chamber did not contain any nesting material. However, it also contained a couple of food chambers similar to those in the burrows of the female bandicot rat.

Rajasekharan and Edwin Dharmaraju (1975) observed that the average length of burrows of B.bengalensis was 3.87 m in alluvial soils while it was 5.37 m and 5.28 m in clay loams and heavy black clays respectively. In paddy fields the average length of the burrow was 5.76 m. The average diameter and number of openings per burrow were 7.45 cm and 4 respectively. Maximum number of bed chambers in a burrow were two with the size ranging from 7.5 × 10.0 cm to 30.0 x 45.5 cm.

Deoras (1966) could collect 14.005 kg of food from thirty burrows of B. bengalensis. Pisharody and Thampan (1976) reported that B. b. bengalensis operated in complete darkness and could detect food from underneath the soil and reach the food exactly at the right

spot by burrowing across underneath the soil surface following the intensity of smell. If some one opens the outside opening of the burrow, the rat would return within minutes to close the opening with soil.

Pingale et al.(1967) reported that B.bengalensis breeds during September - October and January - March coinciding with the fag end of short leaf blade stage of crop of paddy, the litter size being 5 to 13.

Yashoda (1968) reported that in the burrow system of B.bengalensis only two to three nests of leaves and hay were commonly found. Prem Sagar and Bindra (1973) noted that progenies were produced throughout the year except during January, February and September. March and August were the months of peak breeding. An individual female produced 1 - 5 litters during August - December and 2 - 4 litters during March - July.

Towards harvest time the burrow entrances of B.bengalensis were found to be unplugged and the galleries free of loose soil as described by Wagle (1927). The feeding habits of B. bengalensis were described by Chakraborty (1975). When there was abundance of food,

it consumed only part of the grain. Adult rats fed in the open space as well as under the cover but the young ones consumed mainly the grains stored inside the burrow system. The rats bent down mature paddy plants bearing near-mature panicles and cut the earheads by standing erect on their hind limbs. In addition to the grains, leaves and stems of paddy, grasses, colocasia and molluscs also formed a part of their field diet.

4. The Bandicoot-Rat/Large Bandicoot-Rat.
   Bandicota indica indica (Bechstein)

According to Ellerman (1961) this species is distributed over Rajputana southwards through the Indian Peninsula to Ceylon and in Nepal, Burma, Yannan, Formosa, Indo-China, Siam, Java and Sumatra.

B.indica lived around human dwellings and in close association with man (Barnett and Iswar Prakash, 1975).

The burrows of B.i. indica were dug in the back-yard and they entered the house through the lanes. It preferred to live in light humid surroundings. Nests were made by soft materials, rags, cotton and hay collected

from nearby surroundings (Yashoda, 1963).

Srinivasachar (1968) reported that it fed mostly on field crops vegetables and grasses.

5. The brown spiny mouse
Mus platythrix (Bennett)

This species is distributed in Penninsular India. Kerala to Sind, Kathiawar, Cutch, Kumaon, Punjab, Mt. Poppa District of Burma (Ellerman, 1961).

M. platythrix is found all over India except in Bengal. Generally they made burrows in the red gravelly soil on side of a bank (Srinivasachar, 1972).

This species are burrowing type and small pebbles are found near the mouth of the burrows (Krishnakumari, 1963 and Srinivasachar, 1972).

6. The Common Indian Field Mouse
Mus booduga booduga

This species is only known from India. It occurs commonly in the Peninsula northwards to cutch and adjacent districts, Punjab, Kumaon, possibly in the Bhutan Duars and in the Mt. Pappa district of Burma (Ellerman, 1961).

M.booduga is found in fields, compounds, gardens and may even enter into the house (Krishnakumari, 1968 and Srinivasachar, 1972).

According to Ramakrishnan (1972) the burrows of this species were found in the paddy fields and were the smallest as compared to other species. One or two adults were found in each burrow. The length of the burrow ranged from 50 - 116 cm, while the diameter of the galleries was only 2 - 3 cm. The number of bed chamber was only one, the size being 7 x 6 x 8 cm. There were no well defined food chambers in the burrows of this rodent. They had litters in the months of September, October and February and the number of young ones per litter ranged from 3 to 9. They were found feeding on paddy grains in the mature crop as well as the seeds sown in the nursery.

Considering the population level of different species of rats and mice in different crops, found that M.booduga preferred radish, sarson and egyptian clover during rabi season and groundnut during kharif season (Mann, 1973).

7.The Fawn-Coloured Mouse
Mus cervicolor (Hodgson)

This species is similar to M.booduga and is distributed in Ceylon, Peninsular India in part, north upto South Rajputana, Nepal, Assam, Burma, Linkiu Islands, Indo-china and Siam. It was found inhabiting plains, fields and forests (Ellerman, 1961).

According to Barnett and Iswar Prakash (1975) M.booduga is fossorial and nocturnal. The burrows were not long and were simple. Very little information is available on food preferences or on damage caused to food crops or other vegetation.

8.The House Mouse
Mus musculus (Linnaeus)

This species have a world wide distribution owing to accidental human introduction to America, Australia, Tropical Africa etc. (Ellerman, 1961).

M. musculus lives indoors and outdoors, gardens, fields near villages and towns (Krishnakumari, 1968; Srinivasachar, 1972 and Barnett and Iswar Prakash, 1975).

According to Barnett and Iswar Prakash (1975) M. musculus is nocturnal and fossorial. It feeds on a great variety of foods not only those destined for man but also for insects. It does much damage to sacks and other textiles, including clothes and papers.

M.musculus breed three to four times in an year. Four to eight young ones are born at each birth. Usual life span of M.musculus is 15 to 18 months but may live upto 6 years (Yashoda, 1968).

Barnett and Iswar Prakash (1975) observed that in favourable conditions of food supply and temperature house mouse reproduced throughout the year. Southwick (1966) observed that the mean litter size of M.musculus varied from 3.9 to 6.4 and annual productivity from 29.1 to 57.2 young ones per female.

9. House Rat

Rattus rattus wroughtoni (Hinton) and R. r. rufescens (Gray)

Rattus rattus has a world wide distribution owing to accidental human introduction (Ellerman, 1961).

This is the commonset Indian rodent. The Indian specimens have been worked out in very great detail by Hinton (1918).

R. rattus live inside the buildings. It can climb very high, hence penetrate into roof flats and upper floors of the buildings. Bamboo thatched roofs provide a very good permanent shelter. Although R.rattus is not a good burrower, it can burrow under forced circumstances and such burrows will be dug in the surface soil in a very irregular manner (Yashoda, 1968).

Damage to coconuts is mostly caused by various sub species of R.rattus. Damage usually consists of a single hole in the husk of the immature fruit, occurring between the fourth and eighth month of development, which is before significant endosperm is laid down. A damaged nut detaches from the inflorescence two to six days after attack (Smith, 1967 and Smith, 1969).

According to Mann (1975) Rodents exhibit preference for different crops. R.rattus preferred onion, cauliflower and radish. Barnett and IswarPrakash (1975) observed that R.rattus bred throughout the year, but

with seasonal fluctuations. The cannibalistic habits of the house rat R.ratius was reported by Ghosh (1960).

10. The Indian Long Tailed Tree Mouse
Vandaleuria oleracea (Bennett)

This species is distributed in Ceylon, Peninsula of India northwards to Kumaon, thence eastwards to Nepal, Assam, Burma, Indo-China and Siam.

V. oleracea are found in most part of India inhabiting trees and shrubs. Generally they make a nest of grasses and leaves on the branches of trees (Krishnakumari, 1968 and Srinivasachar, 1972).

11. Indian Bush Rat
Golunda elliotti (Gray)

This species is distributed in the Indian Peninsula and Ceylon (Ellerman, 1961).

According to Krishnakumari (1968), G.elliotti were usually found in the forest areas, but they were also found in cultivated lands. They lived under bushes in nests. Srinivasachar (1968) mentioned it as diurnal in habit and were reported to live in forests in thick bushes.

According to Srinivasachar (1972) these rats were destructive to coffee plants, feeding on the buds and flowers. Mann (1973) considering the population level of different species of rats and mice in different crops found that G.elliotti preferred lucerne in the rabi season and fodder (mixture of pearl millet, sorghum, cowpea and cluster bean), napier-bajra hybrid and sugarcane in the kharif season.

12. The Soft-Furred Field-Rat
Millardia meltada meltada (Gray)

This species is distributed over Ceylon, the Peninsula of India, Cutch, Kathiawar, Sind, Nepal, Terai and Punjab (Ellerman, 1961).

The rats are found mostly in cultivated fields in pairs or small groups of five or six animals (Srinivasachar, 1968). According to Krishnakumari (1972), M.meltada lives in cultivated fields, forests and rocks prevalent in black cotton soil.

Barnett and Iswar Prakash (1975) reported their presence in irrigated fields, in bunds, in clear patches and in hedges and grass-lands.

Blandford (1888-1891) mentioned that large numbers of M.meltada died when the field cracks in which they lived were filled with rain water. According to Yashoda (1968) and Sundara Bai (1972), the openings of the burrows were surrounded by small stones, pebbles, broken earthen pots, collected from the vicinity. Two to three openings were common for the burrow system and there was a main tunnel with two to three branches.

Ramakrishnan (1972) reported that the food chambers were usually not present in the burrows of this rat. The length of the burrow ranged from 62 to 304 cm. The number of exits was usually two or even one. Only one bed chamber of dimensions varying from 5 x 5 x 5 cm to 12 x 1.. x 10 cm was found in the burrow system.

According to Barnett and Iswar Prakash (1975) M.meltada lived in simple burrows which opened out, often under bushes. Bindra and Prem Sagar (1975) noted one to four surface openings.

Yashoda (1968) reported that M. meltada fed on

grains and roots. Srivastava (1968) found that the average daily consumption of food by M.meltada was 34.5, 30.5 and 3.87 g of wheat, maize and gram respectively.

According to Ramakrishnan (1972) B. bengalensis, M. booduga and M.meltada were the three species of rats which damaged the rice crop. In the transplanted crop, the rat damage started from the time of planting and continued upto harvest. The tillers were cut to the water level and drawn pell mell one over the other to form a platform for the rats to sit and eat the inner soft portions of stem or the boot. Damage by M.meltada was usually observed in patches away from the field bunds.

Rajasekharan and Edvin Dharmaraju (1975) reported that B. bengalensis, M. meltada and R.r. rufescens were the rat species causing damage in rice fields. These rats cut the rice plants at a height of 10 cm to 22 cm from the surface of water, the cut end showing a slanting edge. Percentage of tillers damaged ranged from 9.56 to 60.8 per cent during the monsoon crop and 0.44 to 30.90 per cent in the second crop.

Mann (1973) studied food preference of different

species of rats and mice in different crops and found that M.meltada preferred cauliflower and onion during rabi and cowpea, fodder (mixture of pearl millet, cowpea, cluster bean and sorghum), ground nut, pearl millet and sorghum during the kharif season.

In M.meltada breeding continues throughout the year, the peak breeding periods being March to May and August to October. In each breeding period, M. meltada reproduced one to four times and a female produced a maximum of three litters during March to May and four litters during July to September. The number of young per litter varied from one to eight. The gestation period was 20 days or even shorter (Bindra and Prem Sagar, 1968).

According to Guraya and Gupta (1975), the litter size of M.meltada in natural habitat and captivity varied from 3 to 1[illegible]. But Blandford (1888-91) recorded 6 to 8 young ones per litter in M.meltada.

Cannibalism by lactating mothers of M.meltada was common in captivity and according to Guraya and

Gupta (1975) the cannibalistic nature might be due to nutritional deficiencies.

13. Rattus ranjiniae

A new species of field rat described by Agrawal and Ghosal (1969). This specimen was collected by Miss. P.V. Ranjini and is now deposited in the National Zoological Collection, Zoological Survey of India, Calcutta. The collector reported that this new field rat jumped and escaped into nearby water when attempts were made to catch it.

14. Malabar Spiny Mouse
Platacanthomys lasiurus

This species is reported to live in hollowed cavities in trees. They are said to destroy pepper, jackfruit, and cardamom in hill tracts of Travancore, Anamalais etc. They are also reported to heard up grain and roots like B. bengalensis. P.lasiurus is said occasionally to get into toddy pots. They are said to be easily smoked out of the hollow dead branches which form their chief abode (Krishna Ayyar, 1931).

According to Srinivasachar (1972) P. lasiurus was found in Malabar coast, Anamalai and Travancore hills. Generally they live on large trees in which cavities are present and they used leaves for making nests. They are said to be destructive to pepper and jack fruits.

MATERIALS AND METHODS

MATERIALS AND METHODS

In order to study the distribution of different species of rats in the State, a detailed survey was conducted in different parts during September 1978 to February 1979. For the survey work, the State was divided into eight agro-climatic zones (Map: Table -1).

In each zone, four representative areas were selected for conducting the survey work.

The distribution in each agro-climatic zone was studied by setting up wooden traps (45 cm x 20 cm) and the 'Moncompu' traps (Fig.1) in which fresh tapioca tuber bits were used as the bait material. For the house mouse Mus musculus, poison baiting was carried out for the survey work. For poison baiting, cut bits of ripe plantain were used as the carrier. Zinc phosphide at 2.5 per cent on W/W basis was introduced into the plantain bits through a cylindrical hole scooped out on any one side and the opening was plugged with the scooped out bit.

In order to gather detailed information on the special features of the burrow pattern of different species of rats occurring in diverse conditions and to study their relative

Map of Kerala showing localities selected for survey work

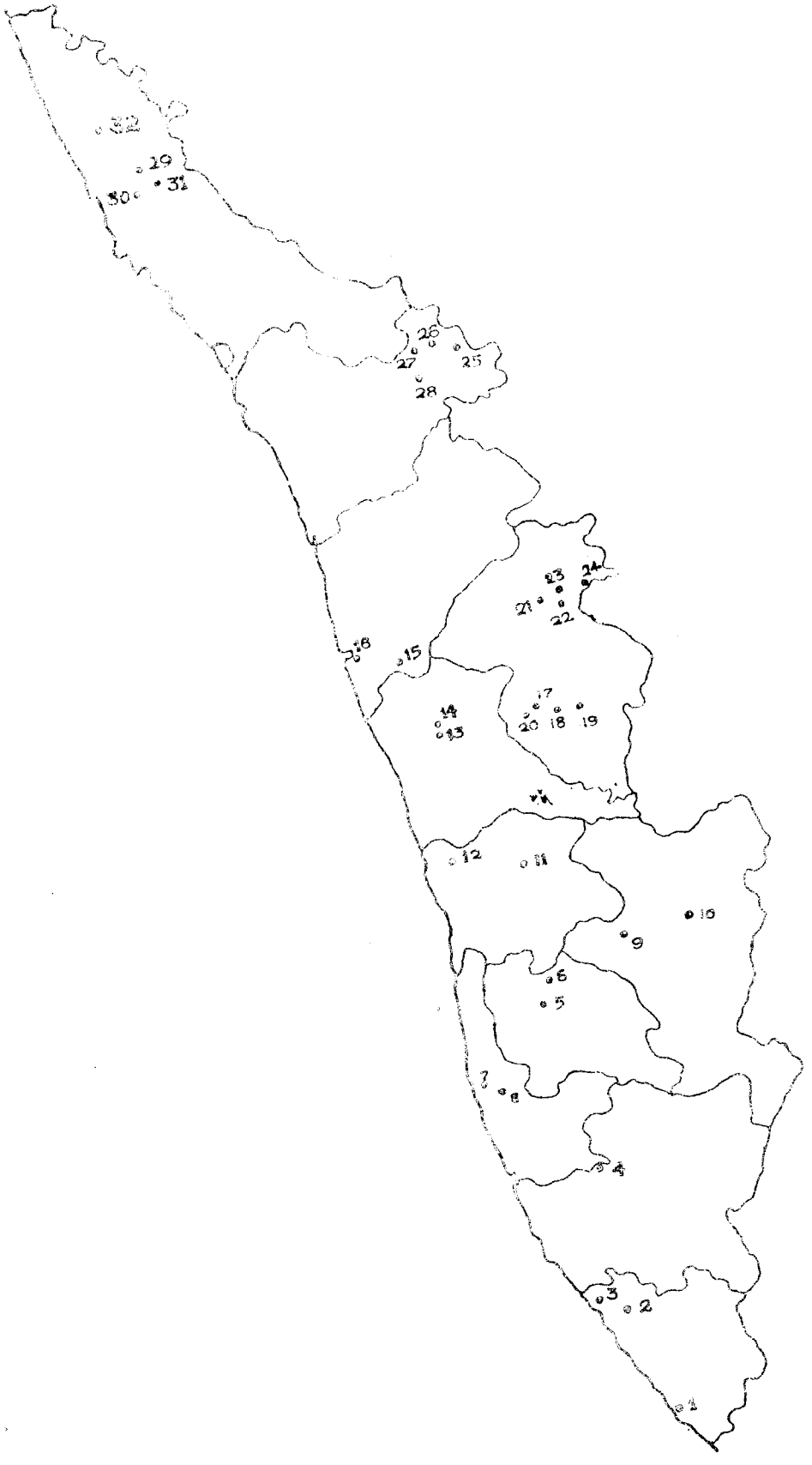


Table - 1

Details of Agro-climatic zones selected for survey work

Sl.No. of Zone	Zones	Localities selected for survey work	Remarks
1.	Trivandrum and Quilon Districts	Vellayani Aattingal Varkala Adoor	
2.	Kottayam and Alleppey Districts	Ettumanur Kurianadu Monoompu Kidangara	
3.	Idukki and Ernakulam Districts	Muthalakodam Moolamuttom Perumbavoor N.Parur	
4.	Trichur and Malappuram Districts	Vellanikkara Pattikkadu Thavanur Ponnani	
5.	Palghat District	Melarkode Nenmara Thiruvazhiyadu Vadakuncheri	
6.	Attappady in Palghat District	Thavalam Chundukulam Koolikadavu Aanakatty	
7.	Wynad in Calicut District	Kuppamudi Battery Meenangadi Kalpatta	
8.	Cannanore District	Thirumeni Cherupu ha Aravanchal Vellirikundu	

abundance, the burrow openings were first located. The adults and the offsprings in each live burrow were collected by employing different methods outlined as follows:-

1. Tatera indica cuvieri

The emergency escapes which are concealed about 2 to 3 cm below ground level, were first located by random probing with a crowbar in a specific direction along the burrow following the soil crest location. Around the emergency escapes, the soil easily crumbled down and such areas were immediately sealed off by compaction after putting rubbles. Additional emergency escapes were marked out by careful observation of the escaping rats consequent on "smoking" carried out as described hereafter.

2. Bandicota bengalensis bengalensis

The burrow system of B. bengalensis bengalensis being quite extensive, a different method was employed for capturing them. To locate the actual region of occurrence of the rat and their brood, the burrow system was opened up at three to four spots in the entire burrow network. The actual segment of the burrow containing the rat was then identified on the basis of plugging of such segment consequent on exposition.

3. Bandicota indica indica

Live burrows of B. indica indica were located in the garden lands around the paddy and tapioca fields and also in areas put under colocasia, yams, dioscorea etc. The identification of the live burrows of B. indica indica was confirmed on the basis of the following features:

a) Presence of well defined runways extending from the burrow openings to the cropped fields.

b) The main entrance of the burrow system remaining clean and tidy revealing the presence of footprints.

c) Absence of spider-webbing around the burrow openings.

d) Presence of a minimum of two openings, one serving as the main entrance and the other serving as an exit for loose soil from the burrow network.

4. Rattus norvegicus

The burrows of this species were mostly located along the rice field bunds and the rats were captured from their burrows by 'smoking'. R. norvegicus was also caught in the 'Monocompu' trap.

5. Mus platythrix

Mice of the species M. platythrix were captured from garden lands and denuded areas having sparse vegetation. These were mostly found in gravelly soil. The burrow openings were easily identified by the presence of a circular ridge formed by small pebbles and by internal plugging of the burrow system with similar pebbles. The rats were collected from the burrows by opening up with a crowbar.

6. Mus saxicola

These were captured using the techniques employed for M. platythrix.

7. Mus booduga booduga

The burrow systems of M. booduga booduga were found in garden lands and along field bunds. The rats were recovered from the burrows by opening them with the help of a crowbar, taking care that the animals did not get out through the emergency escapes.

8. Mus cervicolor

These were captured using the techniques employed for M. booduga booduga.

9. Mus musculus

The burrow networks of M. musculus were located below the plinth level in dwelling houses and other buildings. These mice were ensnared by employing poison baiting with 2.5 per cent zinc phosphide on W/W basis using ripe plantain carriers.

10. Rattus rattus wroughtoni

These were collected from coconut crowns. From the crowns the animals were caught by abruptly pressing the nests, thereby killing the rats contained inside the nests. These rats were also found in houses and paddy fields where they could be collected by setting up the 'Moncompu' traps.

11. Rattus rattus rufescens

These rats were collected from houses using traps such as wooden box type, scissor type (metallic) etc., while from paddy fields capturing was accomplished by setting up the Moncompu traps.

12. Vandeleuria oleracea

These types of rats were got from arecanut crowns by first locating the nests and by dislodging the animals

by shaking the nests violently. They were also collected from grass strips around millet crops.

13. Golunda elliotti

G. elliotti adults were collected from semi-forest areas and from jowar and ragi fields. These were also collected from thick grass lands. For this, their runways were first located by the presence of cut grasses along the passages. The areas close to their nests were then beaten around with a long stick. The rats which escaped from the nests as a result of disturbance always moved through the well-defined runways and these were captured mechanically.

14. Millardia meltada meltada

These specimens were collected by setting the Monocomou traps in the paddy fields.

Technique of smoking for rat capture

In order to kill the rats inhabiting the burrows, smoking was carried out as follows.

Initially all the burrow entrances other than the principal one was closed by putting rubbles and by compacting the locations around the openings. Smoke was puffed into the

burrow system through the principal opening through burning sheaves of dry coconut leaflet bits. The portion of the sheaf projecting out of the burrow was burnt while the other end was introduced through burrow entrance. The burning extremity was fanned vigorously to ensure continuous inflow of smoke stream through the other end and thereby to saturate the entire burrow network and to induce suffocation. The sheaf was never allowed to burn out faster with naked flame.

While smoking burrows of B.indica indica, fanning was withheld for a few minutes at periodic intervals and the pattern of outcoming smoke streams was closely observed to confirm whether rats were actually present within the burrows. The presence of rats was ascertained by gentle inward and outward movement of smoke at intervals of a few seconds. Smoking was discontinued in burrows which did not reveal this positive sign.

Studies on burrow patterns

For studying the burrow patterns of fossorial rats, the entire network was carefully exposed by gently working with a crowbar or suitable spade. After exposure of the burrow network the internal dimensions of the burrow system in relation to the location of the brood chamber/chambers

and the food chamber/chambers were recorded. The depth of the different segments of the burrow systems was also measured and recorded.

Food habits of rats

The nature of the damage inflicted by the different species of rats was ascertained by looking for the damage symptoms in cropped areas along the horizontal profile of the burrow systems. The remnants of food particles recovered from the burrow systems were collected and identified to serve as an index of the normal food habits of the species concerned. Damage to standing field crops was confirmed by setting up traps in infested pockets and capturing the species concerned.

Study of indigenous rat traps

An extensive collection of the different indigenous rat traps used in different parts of the State was made and their utility for capturing different species of rats was ascertained in the different zones covered by the survey.

RESULTS

RESULTS

Studies on rat traps

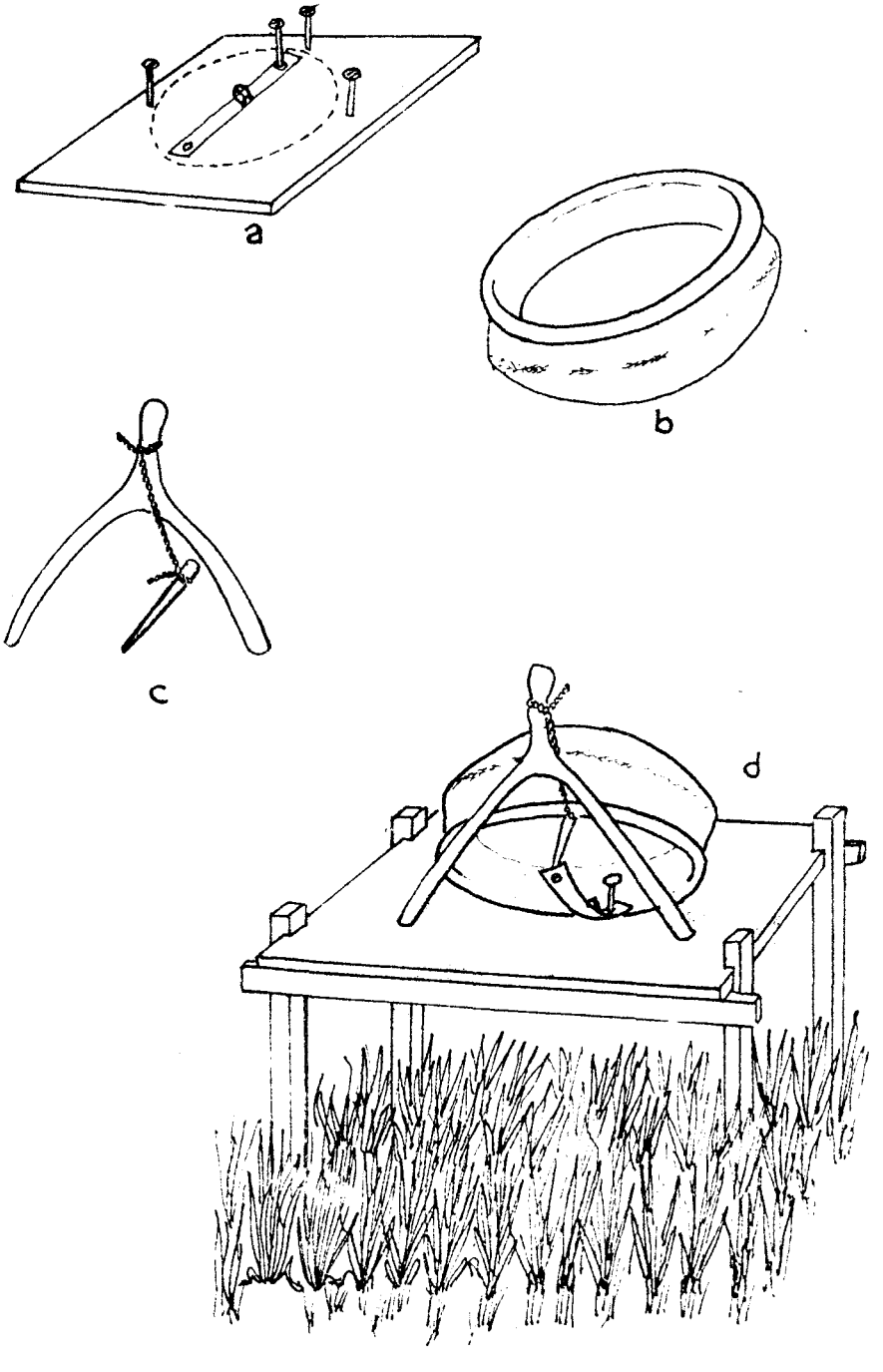
The indigenous and improved rat traps which are being used in different parts of the State have been collected and their utility and limitations evaluated. The following were the traps studied.

1. Monoompu trap

A highly effective and relatively cheap mechanical trap for capturing the rice field rats has been developed at the Rice Research Station, Monoompu by the author.

The trap (Fig.1) consists of a base plank, 50 cm x 40 cm x 2.5 cm, on which is held an inverted pot of 27 to 30 cm diameter. The pot is lifted on one side and held in that position by means of a wooden needle 5 cm long (Fig.1-c) suspended on the stem of a Y-shaped twig support (Fig.1-c) using a country twine. On the needle the twine is tied at 0.5 cm away from the thicker end so that the free tip of the needle is inserted to a terminal circular slot on a metallic strip 28 cm long x 2.5 cm broad (Fig.1-d), the other end of which is nailed to the plank. The bait is tied on the metallic strip (Fig.1-a) near the nailed portion

FIG: 1. MANCOMPU TRAP



prior to lifting and setting of the pot on the Y - support. On the base plank three nails (Fig.1-a) are driven along the outer rim of the pot to ensure that the pots are not displaced after it falls from the support.

The trap is to be set up in rice fields after placing the base plank above the canopy level on a specially erected scaffolding of wooden poles (Fig.1-d).

The rats attracted by the baits climb over to the base plank and try to snatch off the bait tied on to the metallic strip. Slight disturbance of the strip dislocates the wooden needle from the strip slot and causes the pot to fall down abruptly over the rat. The pot and the plank are tightly held and removed in that position and immersed in water after inversion for killing the trapped rat.

This trap can also be effectively used for catching house rat, brown spiny mouse and the gerbil rat. When used in dry lands the wooden plank on which the pot is set can be placed on the ground itself.

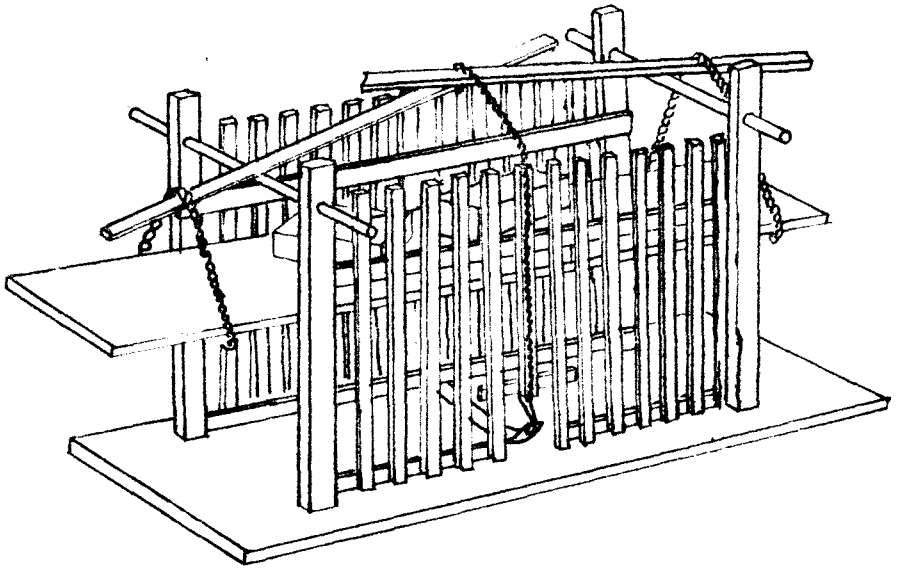
This trap was evaluated at the Rice Research Station, Monocmpu and was found very effective in controlling the rice field rat Rattus norvegicus.

2. 'Adichil' trap

This trap was collected from Thodupuzha, Idukki district. This is being used to trap all the species occurring in dry land conditions particularly Bandicota indica indica.

It consists of a basal wooden plank of size 75 x 30 x 2.5 cm (Fig.2). Another wooden plank of size 35 x 17 x 2.5 cm is provided in the trap to fit loosely over the first plank. Wooden rods of length 55 cm long and girth 2 cm are vertically driven on the wooden plank at intervals of 2 cm along the sides of the basal plank in such a way that the inner plank is held loose. The wooden rods have a length of 55 cm. These wooden bars are held together tightly by a cross bar fixed along the upper margins. Four larger wooden pieces each of size 70 x 3.5 x 2cm are provided on the corners of the basal plank. A flat metallic strip of size 17 x 2 cm is fixed across the centre of the basal plank as shown in Fig.2. One end of the strip is fixed loosely on the plank while the other free extremity is provided with a minute hole. There are two wooden poles of 55 cm long meant for holding the inner plank which is lifted while setting the trap. On one of these poles a twine 60 cm long is provided and a wooden needle 7 cm in length is fixed on the free end.

FIG: 2. 'ADICHIL' TRAP



The trap is set as follows. The bait is first tied to the metallic strip at the centre of the basal plank. Then the upper plank is lifted by means of suitably sized coir rope loops and the lifted plank is held in that position by arranging the two wooden poles close together and by passing the extremities through the two loops. The system is set in that condition by drawing the twine over the wooden poles and taking the twine vertically downwards and pivoting the needle on to the hole in the metallic strip ensuring that the other end of the needle rests on the wooden strip fixed across the lateral bar system. Weights of about 15 to 20 kg is placed on the upper plank. The trap is to be placed where rodents are regularly found. When the rat touches the bait the needle on the metallic bar is abruptly dislocated and the upper plank suddenly falls down on the back of the rat crushing it dead.

The utility of this trap was studied at Muthalakodam and Melarkode. This was found effective in killing B. indica indica, M. booduga booduga and T. indica cuvieri.

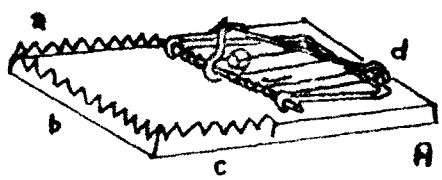
The disadvantage of this trap is that it is not available in the market as such. This has to be fabricated on the basis of prototypes standardised for the particular purpose. Further the shifting of the trap from place to place is somewhat difficult.

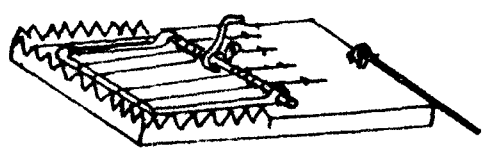
3.'Adivil' trap

This trap is commonly used throughout Kerala. This is mainly used to capture large bandicoot rat, the gerbil rat and the house rat.

The trap essentially consists of a wooden plank of size 35 x 20 x 1.5 cm on which the trap mechanism is mounted (Fig.3). A strong galvanised iron (G.I.) rod 20 cm long is fixed across on the plank at a distance of about 15 cm from one end by driving hooks over both the extremities. Another G.I.rod is folded at right angles at two points to get a 'C' - shaped piece of dimensions 13 x 13 x 13 cm on the base and across the arms. The tip of the arms are hooked and the wire frame work is pivoted on the metallic rod fixed across the plank as described earlier. Four sets of spring systems, each with two arms one hooked on to the 'C' - shaped rod and the other resting on the plank horizontally, are also inserted into the cross rod in between the pivoted points of the 'C' - arms. The 'C' - fixture can be drawn towards the opposite direction only by applying considerable pressure due to spring system. Along the margin (a, b, c) saw-toothed metallic plate is fixed as shown in Fig.3. On the other side of the plank(e),

FIG:3 ADIVIL TRAP





B

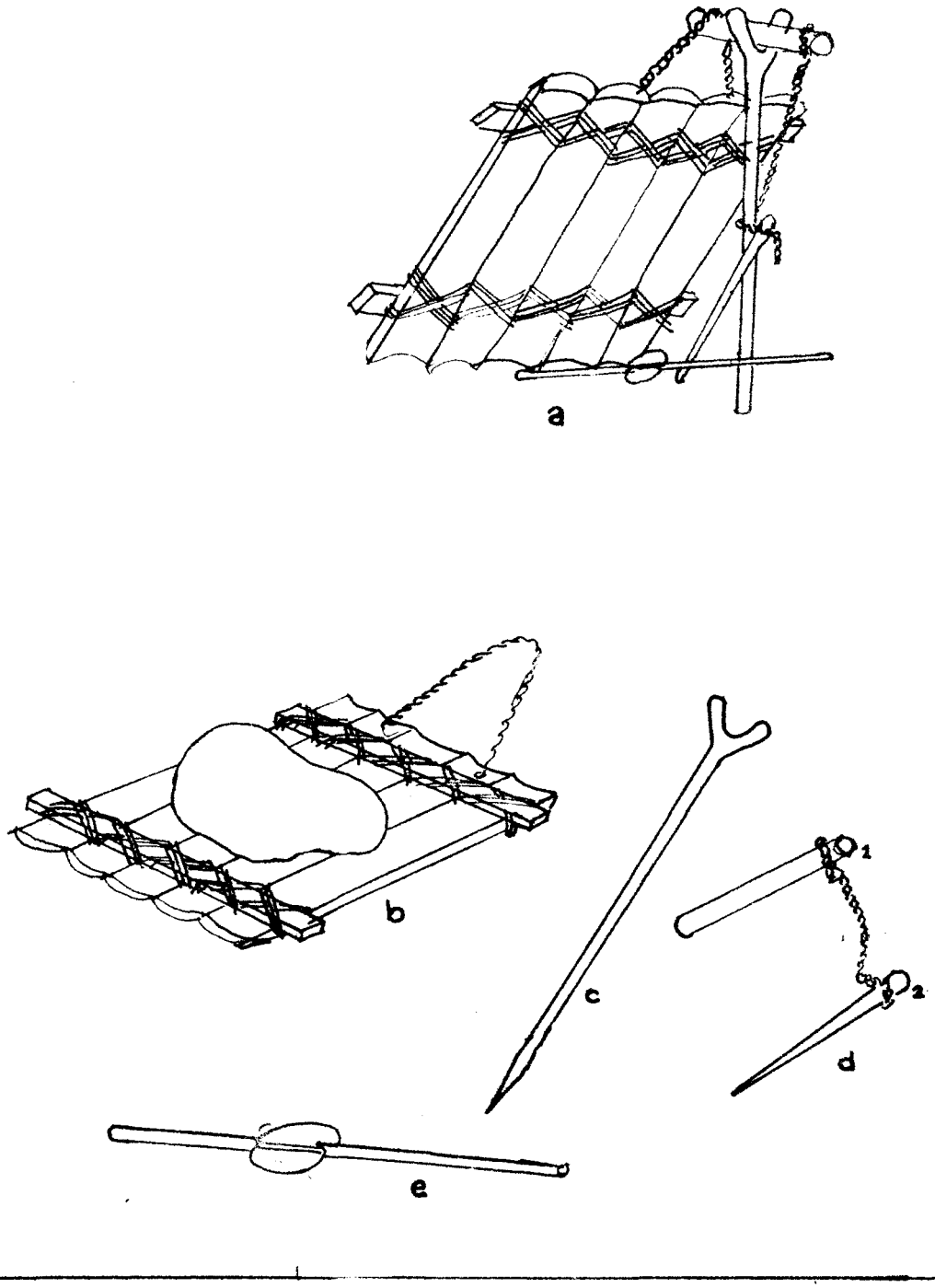
along its border a G.I.wire of 18 cm length is loosely fixed on a hook. In the centre of the cross rod, a slender wire is loosely held. This wire piece has a short arm with hooked apex and a long arm which is bent at right angles. The 'C'- shaped fixture is drawn backwards by applying pressure and is held in that position by mounting the long rod over the frame work such that the tip of the rod is hooked loosely to the metallic bit. Bait is tied on to this metallic piece so that when rats try to snatch off the bait, the rod is abruptly released from the hook. This causes immediate striking of the 'C'- frame against the opposite side of the plank with great force squeezing the rat in between the frame and the plank.

A. Kumarakom trap

This trap (Fig.4) was collected from Kumarakom. The main utility of this trap is to capture R. rattus and R. norvegicus.

The trap essentially consists of coconut fronds cut to pieces, each 60 cm long and the pieces are held by means of two transverse bamboo poles to get a total width of about 60 cm. A wooden pole of about 60 cm in length which is forked at one end and pointed at the other is driven vertically to the ground at the pointed end.

FIG. 4. KUMARAKOM TRAP



To one end of a small cylindrical wooden rod of about 15 cm length and 2 cm girth, a wooden needle 15 m long is tied by means of a coir rope of about 20 cm in length. The free end of the wooden rod is inserted into a coir rope handle loop on one side of the frond plate which is kept raised from ground level. The raised frond plate is held in that position by pivoting the centre of the cylindrical rod on to the fork of the vertical pole and balancing the needle on to an elongate pole of suitable length to serve as a trigger rod for balancing the trap in the elevated position. The coir rope holding the needle is partially wound around the vertical rod so that an angle of 45° is subtended by the needle and the vertical pole. One end of the trigger rod is pushed under the frond plate and the other end is just allowed to cross the vertical pole. Through the centre of the trigger rod, a circularly cut dry leaf bit is passed through an incission to serve as a temporary platform for the bait. The frond platform is loaded with heavy weight of about 20 kg to ensure that the trapped rats are crushed to death. Bait materials such as unhusked paddy are placed on the circular leaf platform inserted through the horizontal twig. When rats come and try to snatch off the bait, the delicate balance of the trap is upset and the frond

platform immediately collapses killing the rat instantaneously.

This trap was evaluated at Kurianadu in Kottayam district and was found useful in catching B. indica indica, T. indica cuvieri and R. norvegicus.

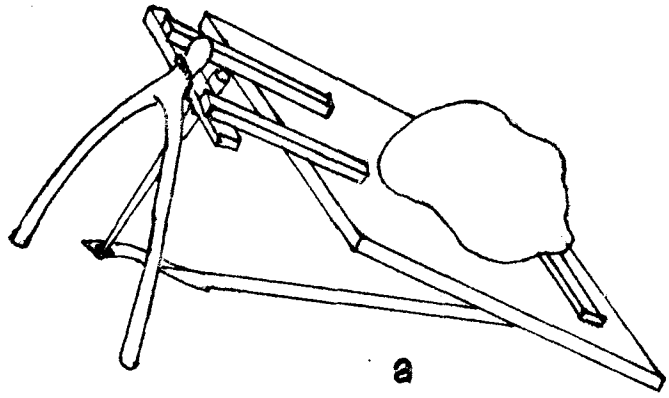
The trap is very cheap and can be made using materials available locally. The setting of this trap is found to be relatively more difficult than other indigenous traps. The platform requires periodical replacement since the frond platform will be spoiled due to alternate wetting and drying under out-door conditions.

5. Improvised Kumarakom trap

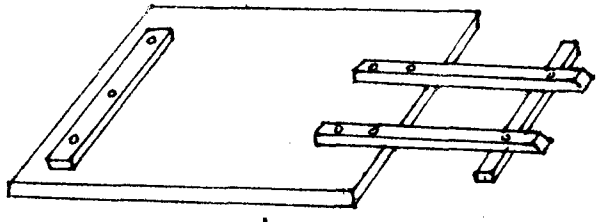
This trap is just a modification of the Kumarakom trap (Fig.5). It was fabricated at the College of Horticulture, Vellanikkara after improving the original design to correct the draw backs.

This trap consists of wooden plank 2.5 cm in thickness and 60 x 55 cm in size. Towards one end of the plank a handle-like wooden fitting is nailed, 10 cm apart. An inverted Y - shaped twig of arm length 35 cm and stem length 5 cm is taken. A twine is tied on the stem of the inverted Y - piece and to the other end of the twine a

FIG: 5. IMPROVISED KUMARAKOM TRAP



a



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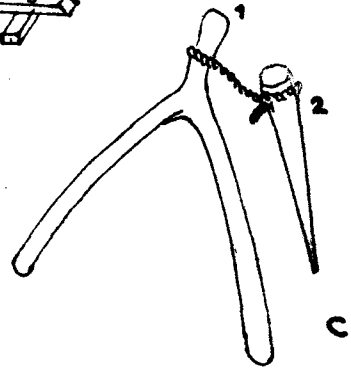


c

d

needle of 25 cm length is attached. A flat metallic bar of about 75 cm in length and 1.5 cm in width is attached to one end of the wooden plank and on the other end of the bar, a small round hole is provided. Bait will be tied on the metallic bar 10 cm away from the point of its attachment with the wooden plank.

To operate this trap, the forked twig is first placed erect. The wooden plank is lifted at one end and the handle is placed on the thick end of the needle. The tip of the needle is then gently slipped into the hole in the metallic bar such that the elevated plank is delicately mounted and held in that position. Heavy weight of about 20 to 25 kg is placed on the top of the plank platform. When the rats try to snatch off the bait, the delicate balance is instantaneously upset and the loaded plank immediately drops crushing down the rats.

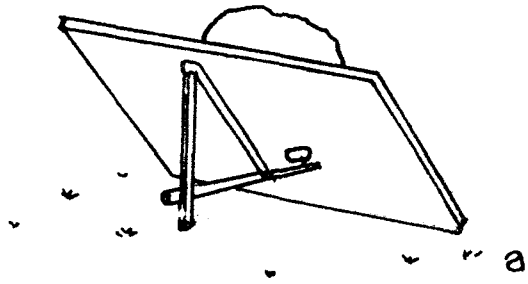
The efficiency of this trap was evaluated at Vellanikkara in Trichur district. It was found effective in controlling all types of field rats except those prevalent in wet land conditions. This trap needs no replacement of parts since the materials used in the construction are more durable. The operation of this trap is quite simple as compared to the original Kumarakom trap.

6. Calicut trap

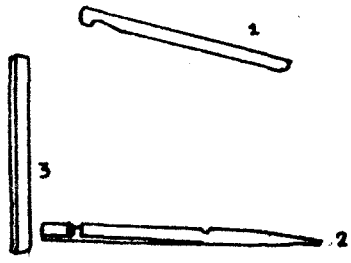
This trap (Fig.6) was collected from Karimpanapalam near the Calicut city. The main utility of this trap is to capture the large bandicoot rat, B. indica indica and R. rattus.

A flat bamboo pole 35 cm long and 2 cm wide is placed vertically on the ground. Another flat bamboo piece (1) 35 cm long with a slit on one end is placed on the vertical pole in such a way that the slit of the latter fits into top of the former. There will be a third flat piece (2) of 45 cm in length having a side cut on one end and a slit on the upper surface of the other end to serve as a catch for the base of the pole forming the hypotenuse line of the triangle formed by all the three poles. A wooden plank of size 60 x 50 cm is held slopping from the vertical pole to serve as a roof over the collapsible triangular frame work. The plank is loaded with stones to ensure its falling down abruptly on the collapse of the frame work. The side cut of the piece (2) is hooked into the lower portion of the vertical pole (3) at a height of 8 cm above the ground level. Baits such as cocconut meat or tapioca tuber bits are tied on to the horizontal pole. As the rats nibble on the bait, the

FIG: 6 CALICUT TRAP.



a



b

delicate balance is upset and the plank abruptly falls down and kills them by the impact.

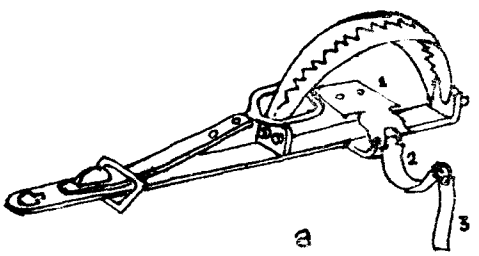
The utility of this trap was evaluated at the Vellanikkara main campus of the Kerala Agricultural University and was found effective in trapping B. indica indica, T. indica cuvieri, M. booduga booduga and R.rattus. But this trap is not good for catching rice field rats.

7. Saw-toothed scissor-type trap

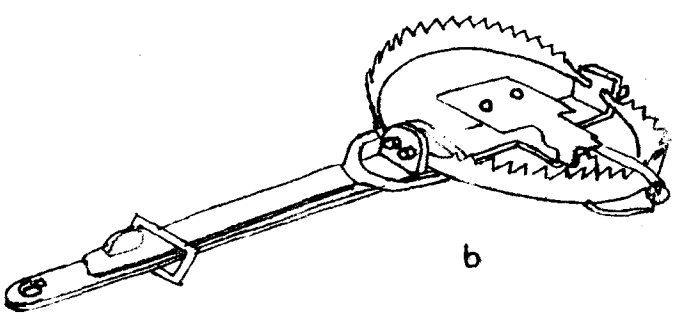
This trap is used throughout Kerala and is readily available in most of hardwares dealer's shops. The main purpose of this trap is to catch B. indica indica, B. bengalensis bengalensis, T. indica cuvieri, R. rattus wroughtoni, R. rattus rufescens and G. elliotti.

In this type there are two hemispherical flat metal pieces, each with internal rows of sharp teeth. The two pieces are separately pivoted to a metal bar toward one end (Fig.7). The sides of the hemispherical piece which are pivoted to the near-centre of the basal bar is taken through a D - shaped metallic strip. The D - strip is connected to another elongate bar which is drawn backwards and fixed by means of a flat projecting rivet. A metallic hook is provided to prevent the trap

FIG: 7 SAW TOOTHED SCISSOR TRAP.



a



b

from closing accidentally while setting. Along the centre of the basal piece which serves as the radius, a trigger plate of size 6 cm x 6 cm is loosely articulated to a projecting lateral piece arising from the basal plate. Semilunar metallic blade is also pivoted to the above lateral piece as a transverse fixture in a direction opposite to the trigger plate. To the semilunar plate is also attached a loose rectangular tonnage which is meant to be set under a minute projection of the handle of the trigger plate.

In order to set the trap, bait materials such as cocoonut meat, tapioca tuber bits etc. are tied to the trigger plate through the two holes provided on it. By exerting force the metallic piece connected to the basal bar is pressed down. Then the saw toothed crescentic pieces are wide opened like a book along the pivot and held in that position. In the open position, arm of the crescentic piece rests in the semilunar fixture. The tongue then taken over the toothed crescentic plate and delicately balanced on to the projecting piece, located at the handle of the trigger plate.

When the rat tries to snatch off the bait from the trigger plate the tongue steps over and the two blades

strike together with violent force and the rat is squeezed in between the rows of sharp teeth on the blades.

The efficiency of this trap was evaluated in the College of Horticulture, Vellanikkara and this was found effective in trapping all the field and commensal rodents except B. bengalensis bengalensis. These rats can also be trapped by opening up their burrow systems in certain segments and keeping the traps set as already described, in the opened portion. The opened segment has to be covered over by twigs, foliage and earth more or less to restore the original condition.

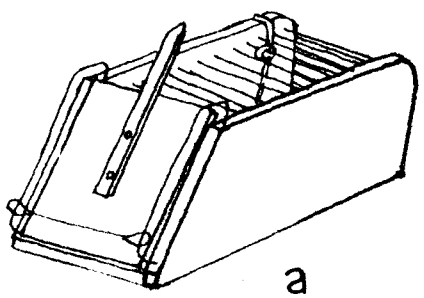
8. Wooden box-type trap (single door)

This trap is quite popular all over Kerala for capturing B. indica indica, R. rattus and R. norvegicus.

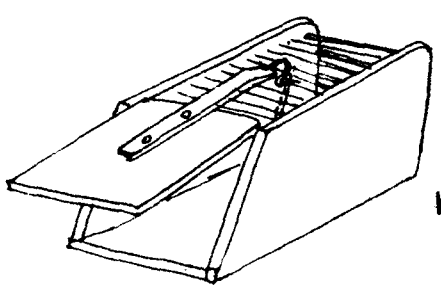
It is a trap with box like construction. Wooden planks are provided at the bottom and on the two sides (Fig.8). At the open end of the trap a spring motivated door is mounted in a slanting manner. On the upper side and on the rear, iron rods are fixed across 2 cm apart. On top of the box near the central portion an iron rod with hooks on either ends is loosely hooked to the iron bar by another hook.

FIG: 8 WOODEN BOX-TYPE TRAP

SINGLE DOOR



a



b

In order to set the trap, appetising baits such as dried fish, tapioca or cocconut meat are skewered to the bit of a wire of which the other end is fixed to the central rod of the door. When the unsuspecting rat walks inside and touches the bait, down comes the door with a bang imprisoning the rat. The trapped rats can be killed by immersing the trap in water or by pressing them with iron rods. To keep the shut down door retained in that position, a simple lock arrangement is provided. This consists of two wire rods which are driven on the frontage of the two lateral planks in such a way that the rod projects over the lateral frontages. Through these two lateral frame works another transverse wire rod with hooks on either extremity is allowed to slide down faster as the door closes. Thus when the door is shut, the transverse wire rod also falls down and this operates as an effective lock.

The utility of this trap was tested at the Vellanikkara Campus of the Kerala Agricultural University and in near-by paddy fields: It was found efficient in trapping R. rattus, B. indica indica and R. norvegicus from paddy field bunds and T. indica cuvieri.

This trap is effective only for a few successive days. A break of two weeks is found necessary after a few

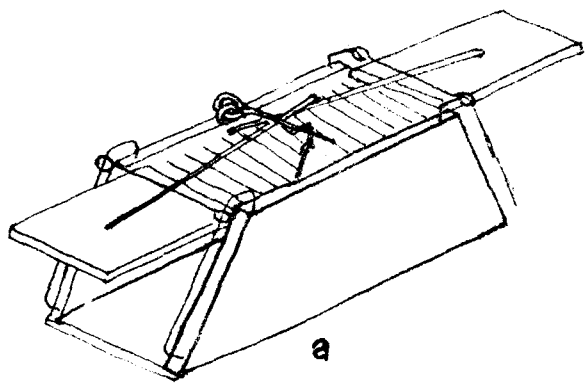
days of continuous trapping. Mice such as M. musculus and M. booduga were also captured in this trap but these small animals escaped through the iron rod frame work.

9. Wooden box-type trap (Double door)

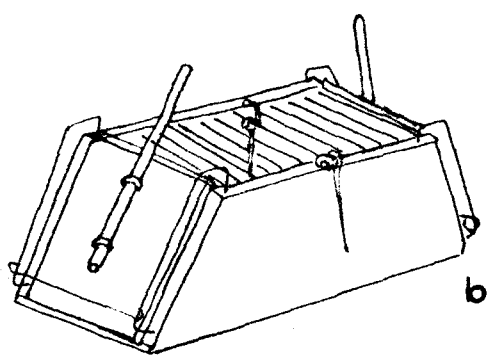
This trap was collected from parts of Trichur district. It is being used to trap B. indica indica and T. indica cuvieri. This trap, though more efficient than the single door type is not quite popular among the cultivators.

The trap (Fig.9) is provided with two doors, one on either side. On the upper portion of one of the lateral planks a metallic hook is fitted. To this hook an iron rod is loosely attached by a basal hook. All other fittings are same as that of the single door trap. After tying the bait inside the box on the hook of the iron rod the doors are opened simultaneously and the loosely fixed iron rod on the lateral plank is placed over it and held in that position by just inserting on the outer hook of the iron rod to which bait is tied. When rats try to feed on the bait, the rod which is just touching the hook is displaced and the two doors are simultaneously closed and rat is thus trapped.

FIG: 9 WOODEN BOX TYPE TRAP- DOUBLE DOOR



a



b

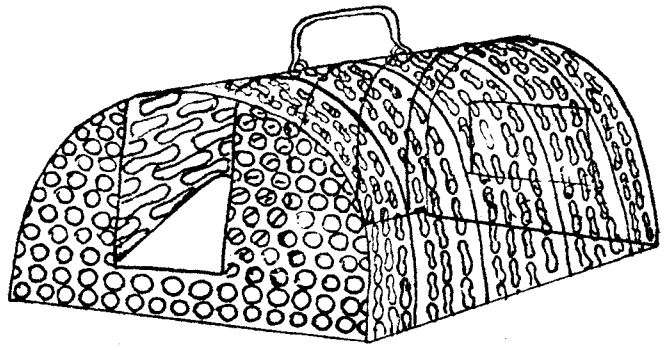
The utility of this trap was tested at Vellanikkara. It was found that the trap is useful in capturing all types of rats. Since the trap is opened at both ends, the rats will readily enter into the trap and so it is more effective than the single door type.

10. Metallic box-like trap

This is a very simple trap (Fig.10) available all over Kerala as a ready made trap. This can be used to trap all types of commensal and field rats other than B. indica indica.

A spring motivated trigger plate is mounted on the entrance of a rectangular box-like contrivance with a runway in the centre for the entry of rats. The bait material is to be put inside the box. For the rats to enter the runway it has to reach the trigger plate and as soon as it steps on the plate the door is opened and the rat is entrapped. The trigger plate then comes back to the normal position. The stage is now set for another victim to walk in. The return of the plate to the original position does not make any sound and the trapped rat never becomes suspicious and keeps on feeding without any inhibition. This attracts other rats also to the same trap. Agitated movement of rats inside the trap will

FIG:10.SINGLE DOOR METALLIC TRAP



normally repel others which come around the trap attracted by the bait material. At the rear of this trap there is a metallic plate which slides into grooves. The bait is introduced into the trap through this lifted metallic plate.

The utility of this trap was tested at the College of Horticulture and this was found beneficial in capturing all types of field and commensal rats.

The easiness of operation of this trap is its prime merit. This type is quite useful for trapping mice which often escape from other traps.

One of the drawbacks of this trap is that after some days of continuous use the spring may become loose and thus the metallic plate may not revert to its normal closed position. The spring has to be changed frequently. After 2 or 3 days of continuous use, the rats may develop trap-shyness and try to avoid the trap. This trap can be used only occasionally once in two to four weeks to gain maximum catch.

11. Pot and plantain leaf trap (Type A)

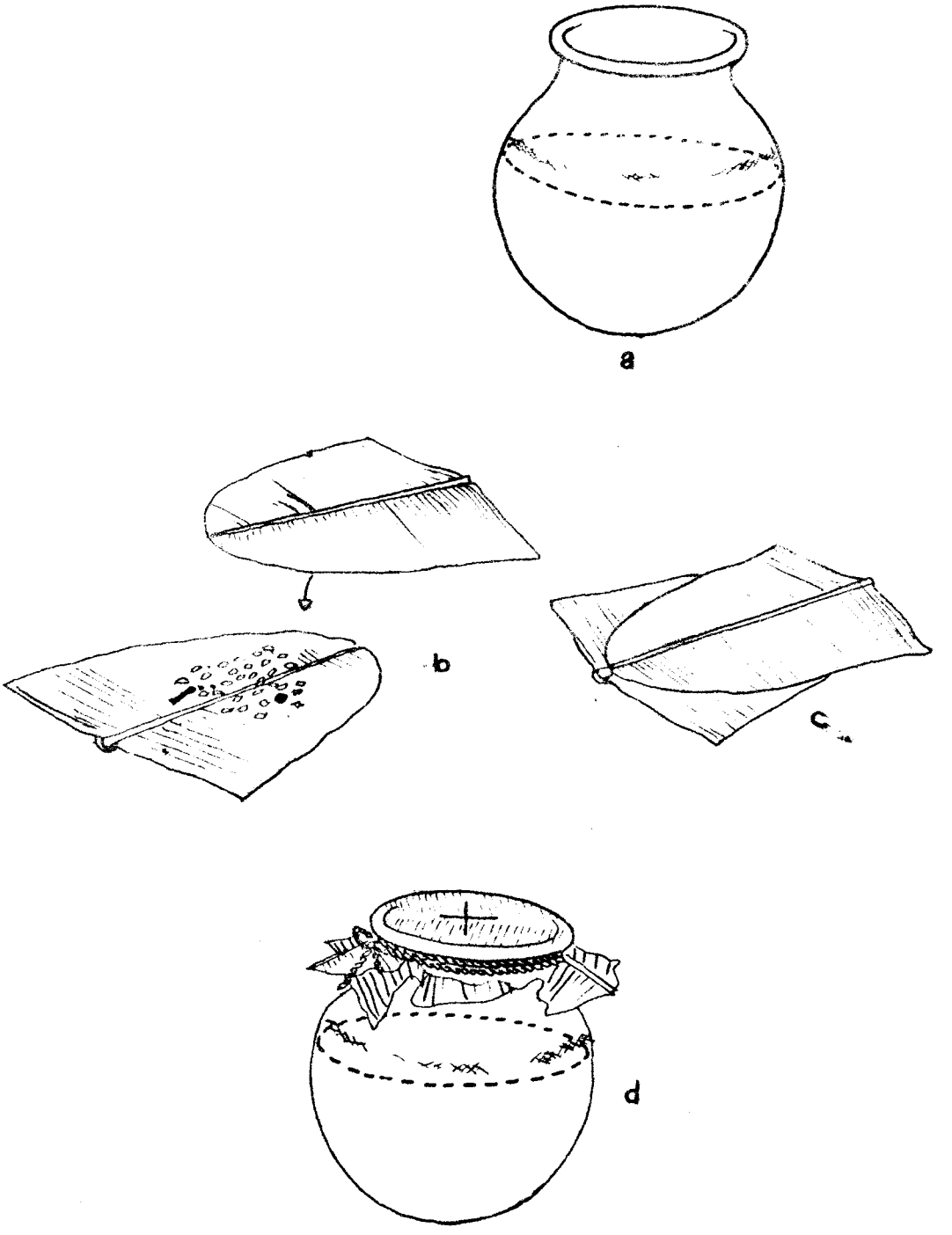
This simple trap was collected from parts of Kothamangalam, Ernakulam District. This is being used to

capture the rice field rats which are a serious menace during the post-booting stage.

Essentially, it consists of a mud pot of twenty litre capacity (Fig.11) which is half-filled with water. The mouth of the pot which is having a diameter of about 20 cm is covered over by two plantain leaf apex-bits of suitable size which are held in position by tying with banana fibre. The raw leaf bits are gently heated in naked flame to impart flaccidity so that the leaves are tied flush over the pot-mouth. Fried and coarsely powdered unhusked paddy is sandwiched as a thin layer in between the two flaccid plantain leaves, prior to covering the pot mouth. A cross-shaped incision of size 8 x 8 cm is made in the centre of the double-leaf cover with a sharp blade. The trap which is now ready for use is set in paddy fields in pockets of infestation. The rice field rats identified by the Zoological Survey of India, Calcutta as R.norvegicus which are attracted by the aroma of freshly fried paddy grains are trapped in water contained in the pot as they climb over to the double leaf layer, since the cross-shaped incisions immediately open up widely due to the weight of the rat.

This type of trap was evaluated under rice field conditions in Kuttanadu and Muthalakodam. In all these

FIG: 2. POT AND PLANTAIN LEAF TRAP A

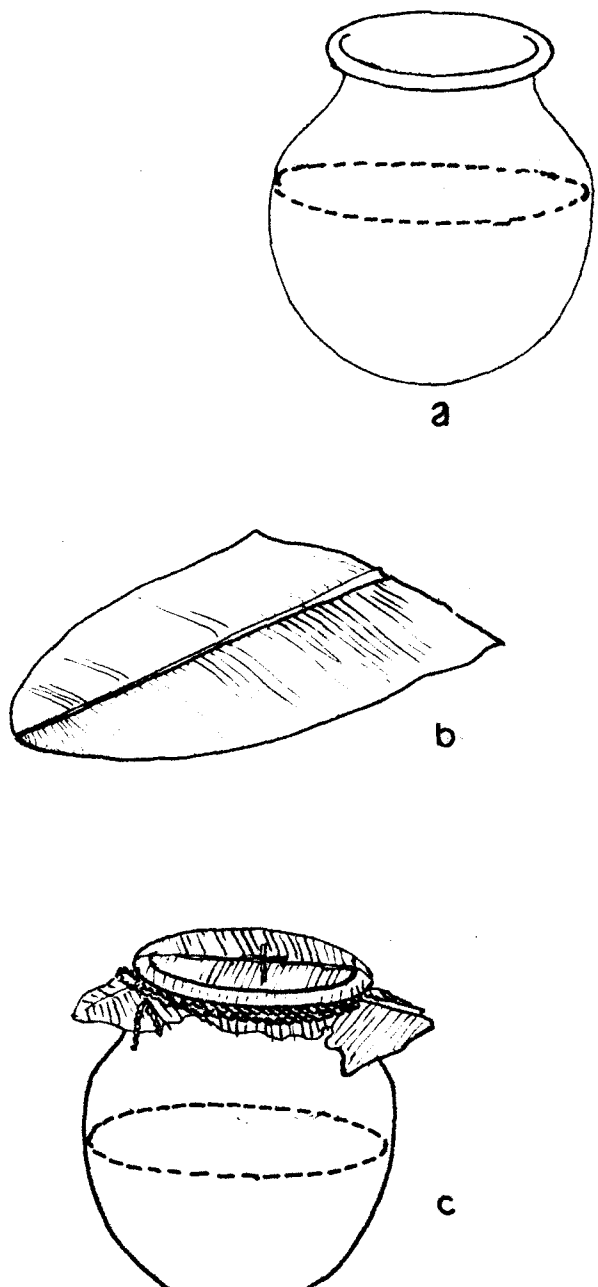


localities the rice field rats could be collected at the rate of one to two per trap per day and in all these cases it was observed that the leaf cover regained the original condition even after trapping rats. Rats could be trapped even on rainy days. In some cases the captured rats were dead or moribund. Rarely, the rats were caught live and in such cases they were killed by covering the mouth with a wooden plank of suitable size and by fully filling the pot with water through the rim taking care to see that the rats did not escape. The live rats were also killed by submerging the pots in water after covering it with wooden plank.

12. Pot and plantain leaf trap (Type B)

This trap (Fig.12) was collected from Vellirikundu in the Cannanore district. The main purpose of this trap is to capture the rice field rats and the bush rats G. elliotti occurring in 'Modan' (dry land crop) paddy. Essentially this is similar to the trap of Type A. Instead of double layer plantain leaf cover for the pot mouth, only single apex bit is used for covering the pot. Fried and coarsely ground unhusked paddy is scattered over the leaf cover which is provided with a cross-shaped cutting as in Type A. The pot is filled to half the capacity with

FIG. 12. POT AND PLANTAIN LEAF TRAP - B



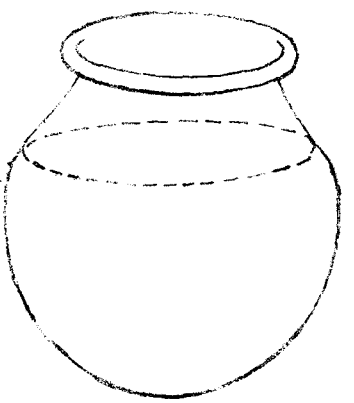
a sticky fluid prepared by incorporating a gummy substance in water. The rat, which is attracted by the aroma of the fried paddy, climbs over the leaf cover and is trapped inside the gummy fluid immediately since the cross-shaped incision gives way. The trap was evaluated at Thirumeni of Cannanore district and was found useful in catching R. norvegicus and G. ellioti. The only disadvantage of this trap is that it cannot be used on rainy days since the bait will easily get spoiled.

13. Camouflaged pot trap

This was collected from Kanjirappilly area of the Kottayam district.

A wide mouthed earthen pot is filled three-fourth with water (Fig.13). Molasses and ripe-crushed plantain fruits are incorporated into the water so that the aroma emanates from the vessel. Sawdust or rice bran is thickly scattered on the fluid surface so that the presence of the fluid is effectively camouflaged. One or two rubbles are kept near the pot to facilitate easy access for the rats to the pots. Rats which are attracted to the pots due to the aroma of molasses and ripe plantain, jump into the pot which present deceptive solid cover and are actually trapped in the fluid. Due to the presence of

FIG. 13. CAMOUFLAGED POT TRAP



banana and molasses the water inside the pot will be somewhat pasty and so the rat cannot escape from the trap.

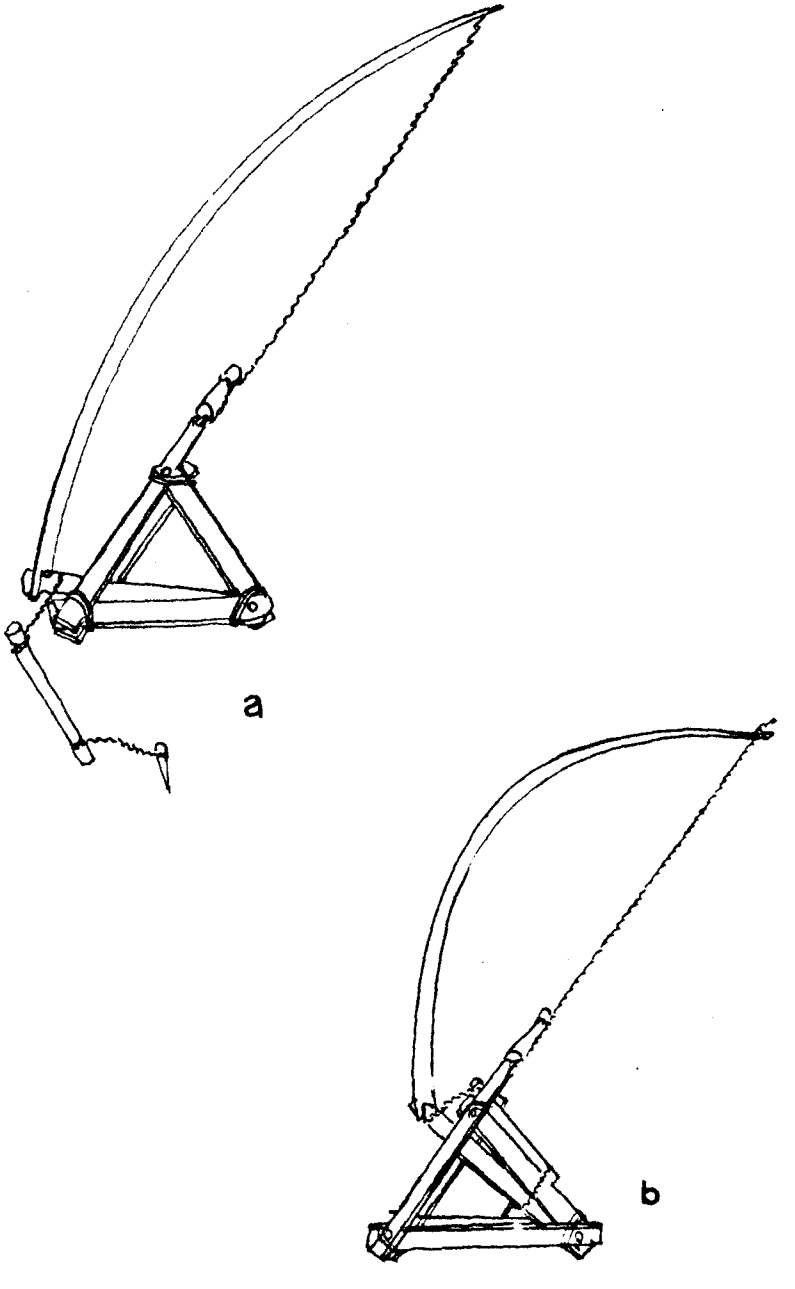
The trap was found to be effective to capture almost all types of rats. Only one rat was trapped per day per trap. It was found that every time when a rat falls, the saw dust cover is very much disturbed which render the trap ineffective for subsequent captures.

14. Kathara trap of Attappady

This trap (Fig.14) was collected from Chundukulam area of the Attappady tract. This is being used by the tribals to trap B. indica indica, T. indica cuvieri, G. elliotti and mongoose.

It consists of five flat bamboo pieces each 1.5 cm. wide, arranged in a triangular frame work. Of the five pieces, two each are placed on the base and on one of the sides. The remaining piece placed on the other side is relatively longer and projects upwards. The distal end of it is provided with a cut at the apex to which the bow string is tied up. On the free end of the basal movable piece close to the pivoting of the bow tip a string is tied (as shown in the figure) and a wooden rod of 13 cm. length is tied to the string. A slender

FIG:14. KATHARA TRAP OF ATTAPADI.



wooden needle is tied on the tip of this rod.

In setting the trap, the bow is elevated (Fig.14 B) by lifting the basal movable piece and drawing the twine on the upper angle of the triangle and thus keeping the rod with the free end along the side. The needle is then delicately held by means of a cocoanut leaflet midrib of suitable length which is held across the base of the triangle.

The trap is placed in runways with the base of the triangle touching the ground and is held in that position by tying the bow on a twig. Preferred food materials such as puffed rice, tapioca bits or paddy are put on either side of the triangular passage. When rats come around the trap they first feed on food placed in any one side and then try to reach the otherside through the triangular passage. The midrib of the cocoanut leaflet is then disturbed and consequently the needle gets dislodged. Suddenly the bow gets straightened up and due to this force, the movable bar is released and it strikes on the back of the rat with violent force killing the rat instantaneously.

The utility of this trap was tested in Attappady and was found quite effective in capturing B. indica indica

T. indica cuvieri and G. elliotti. It is a very cheap trap for use in rural areas.

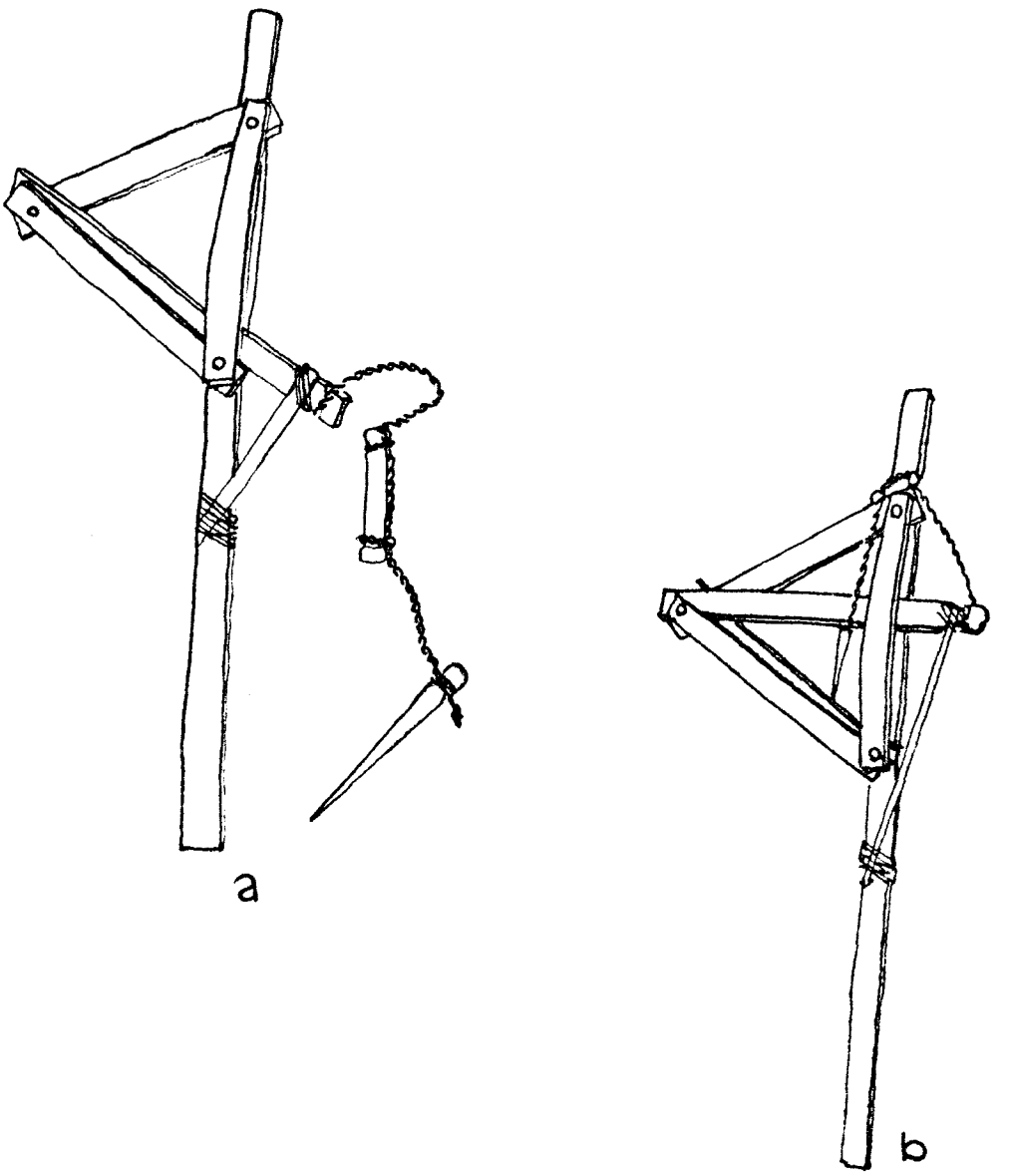
The trap will be effective only when it is set along specific runways as an obstacle for the movement of rats along such pathways.

15. Modified 'kathara' trap

This trap was collected from the Thathamangalam area of the Palghat district. The trap is basically similar to the 'kathara' used in Attappadi. The bow provided in 'kathara' trap is dispensed with and instead a strong rubber strip is tied to the movable lower bar (Fig.15) and the elongate bamboo pole projects downwards from the base of the triangular frame to a distance of about 30 cm. For setting the trap the movable bar is lifted and the wooden rod is passed over the angular joint near the extremity of the vertical pole and the thick end of the needle is gently hooked on to the lifted basal piece while the pointed end is delicately balanced on a coconut leaflet midrib which is inserted close to the base of the triangle.

The provision of the rubber band instead of the bow arrangement renders the movement of the basal piece,

FIG:15.MODIFIED KATHARA TRAP



restricted to the extent of elastic limits of the rubber strip. Therefore the movable bar is lifted only upto half the maximum limit and the length of the twine holding the wooden piece and the needle is increased to suit the lifted position of the horizontal bar. For setting the trap the elongated bamboo pole is driven into the ground so that the base of the triangle is close to the soil surface. This trap is also to be placed along specific runways.

The utility of this trap was tested in Vellanikkara and this was found useful in capturing B. indica indica only, which moves about in definite runways.

This modified 'kathara' trap is simple to construct. The striking force of the movable piece in the modified trap is relatively weaker. Further, it is observed that the rubber strip loses its elasticity after frequent use and the strip has to be replaced. Due to the elongate piece which is driven into the soil, the setting of the trap is found to be tedious.

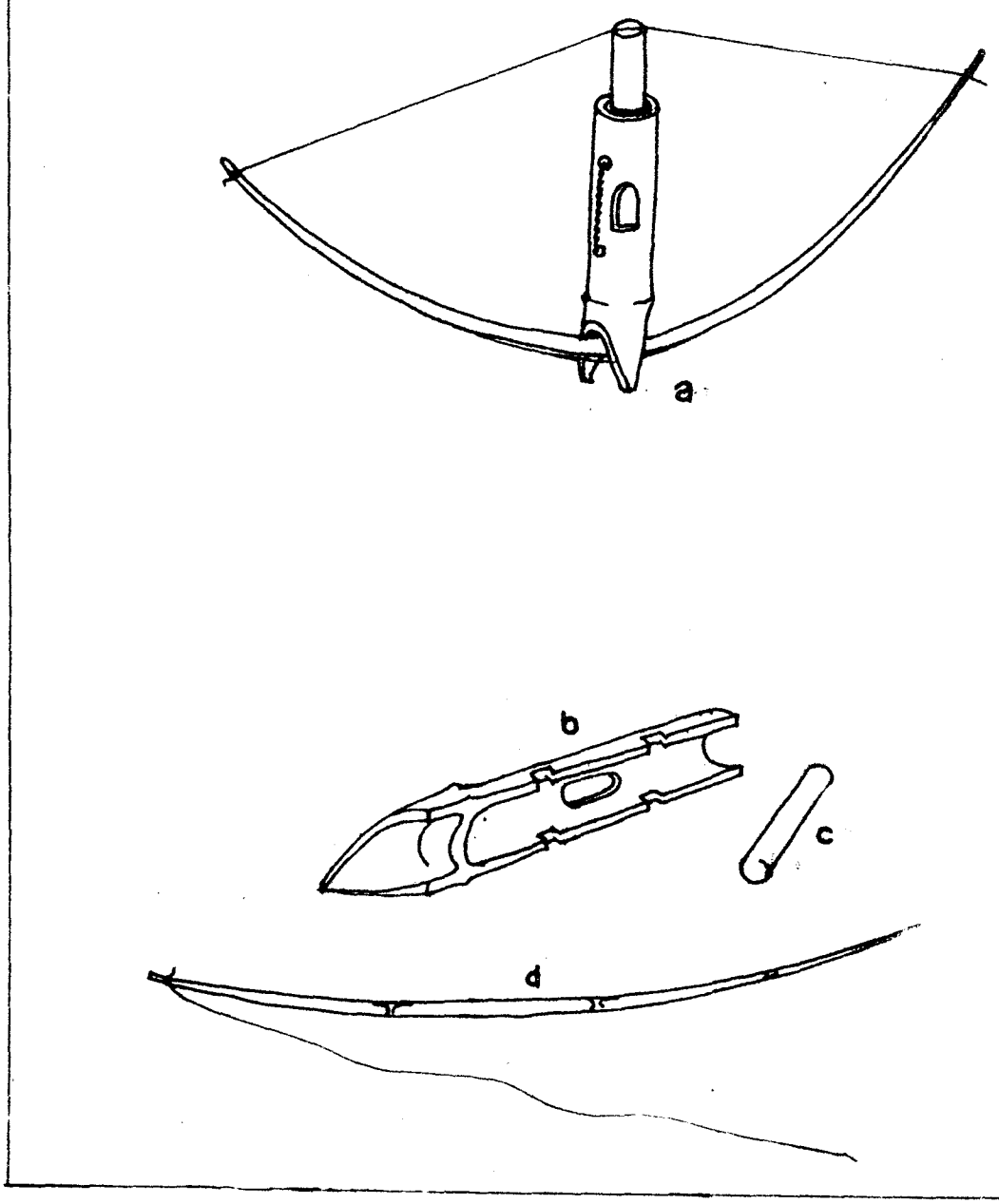
16. Bamboo bow trap

The trap was collected from Ollur and Cranganore areas of the Trichur district and Karimpanapalam in the Kozhikode district and is being commonly used to capture

house rats *R. rattus* and the rats inhabiting coconut crowns.

The bamboo bow trap (Fig.16 a to c) consists of a mature bamboo pole of 30 cm length and 6 cm girth. One end of the pole is kept open and in the other the internodal partitioning wall is retained. The closed end of bamboo piece has an inverted V - shaped projection to serve as a 'hold' for the bow, one meter long. The bow is made of split arecanut stem. Near the centre of the bamboo pole four holes are provided, two on the upper plane and the other two on the lower plane along the horizontal planes, the distance between the two planes being 10 cm. In between these four holes an elongated hemispherical opening (radius about 5 cm) is made on the trap body. A banana cord is inserted through the four holes and the free ends tied up. On the upper cord line a cylindrical wooden block of 25 cm length and 3 cm girth is allowed to rest firmly due to the tension created by the wire rope of the bow which is drawn up and mounted on the upper face of the wooden block in a narrow furrow. Baiting material such as tapioca tubers or cocoanut meat are to be placed on the internodal partitioning wall of the trap stem just below the lower banana cord obstacle. The rats

FIG: 16. BOW TRAP



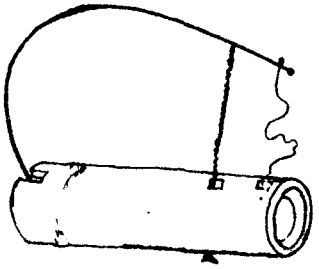
which are attracted by the bait try to enter through the hemispherical opening and chew off the cord that blocks its passage to reach the bait. As soon as the cord is broken, the cylindrical wooden block strikes deep into the trap-stem and hits the rat with force instantly killing it.

17. Bamboo noose trap

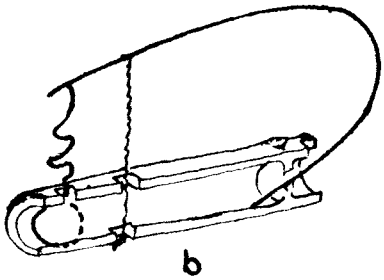
This was collected from Vellanikkara and other parts of the Trichur district. The bamboo noose trap is mainly being used for capturing B. bengalensis bengalensis and consists of a dry hollow bamboo pole of 30 cm length and 56 cm girth in which one internodal partitioning is retained. Near the partitioning wall an umbrella-rib of 45 cm length is driven vertically (Fig.17). On the other extremity (open side) two openings are made on a vertical plane at 5 cm and away from the open end; through these two holes a banana fibre cord is passed. One end of the thread which is thus drawn out is tied over to a wooden piece 1.5 cm long to serve as a 'hold' for the cord. The free end of this is then tied to the umbrella rib at a point 10 cm away from the apex.

One end of an extra thin wire-rope is noosed and the free end is taken out through a hole driven close to the

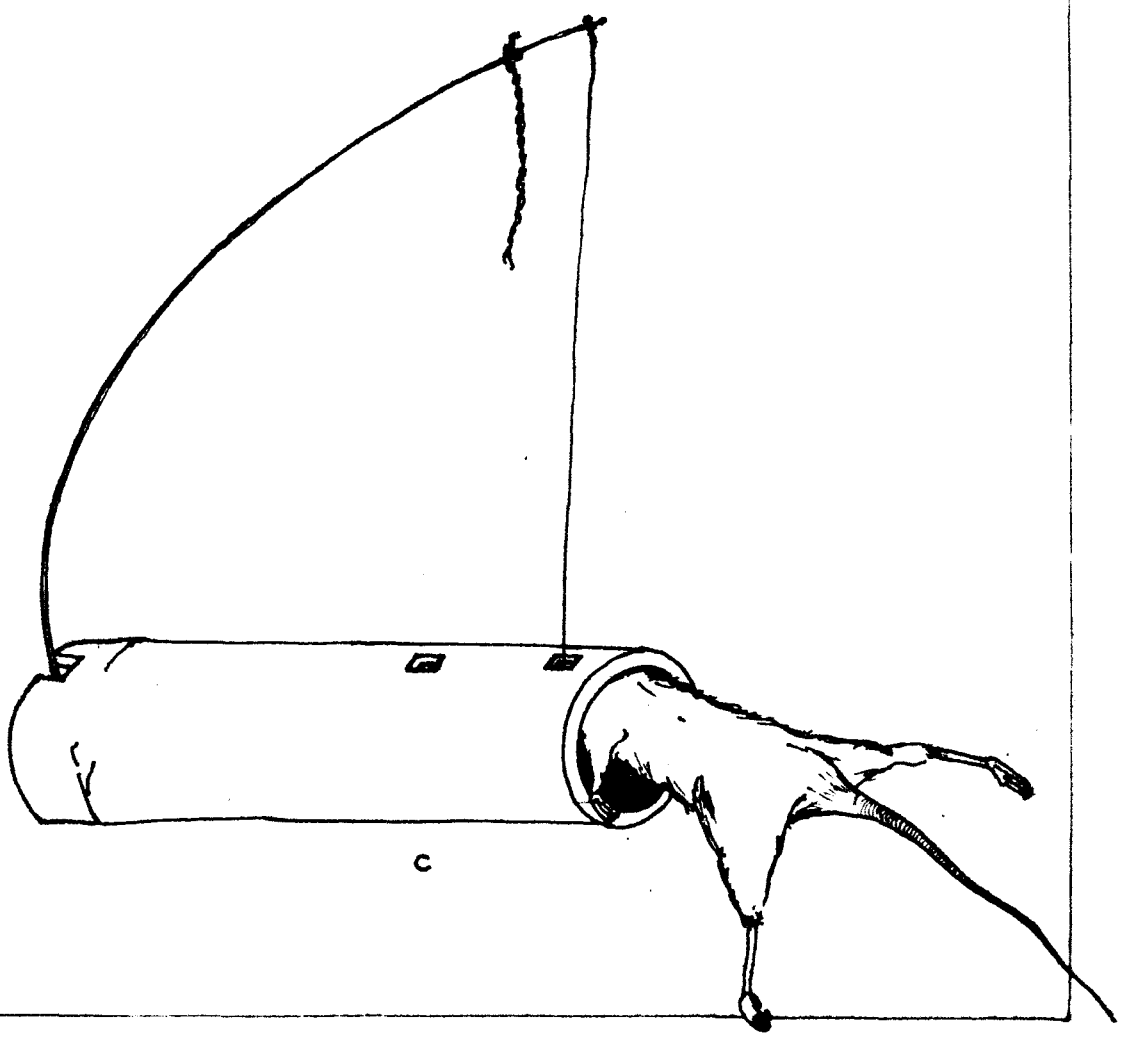
FIG:17. BAMBOO NOOSE TRAP



a



b



c

open extremity of the bamboo trap and tied on the apex of the umbrella rib such that the noose fits close inside the inner rim of the open extremity of the bamboo pole. The length of the wire-rope is such that it sags loosely when the umbrella-rib is held arched under tension created by the banana cord tied as explained above. Just before setting the trap, the banana cord is drawn through a large chunk of onion tuber to ensure retension of the characteristic odour which is reported to be a good attractant to the rats.

The utility of this trap was evaluated at the main campus of the Kerala Agricultural University at Vellanikkara. In open tapioca fields, the traps were not effective. But when the open end of the trap was introduced into the burrow mouths of B. bengalensis bengalensis, the traps were found to be quite effective in trapping these rats both during day and night. The survey revealed that this trap is also being used in parts of Kottayam, Idukki, Ernakulam and Cannanore Districts for capturing B.bengalensis bengalensis. This being quite active inside the burrow system is annoyed by slight interference anywhere in the burrow network and as soon as the trap is introduced, the rat enters the bamboo piece through the noose and chews

off the banana cord which blocks their onward passage. On tearing off the banana cord, the umbrella-rib straightens out abruptly and with it the thin wire rope is also pulled up all of a sudden. The noose tightens totally around the neck or belly of the rat. Since B. bengalensis bengalensis occurring in garden land seldom move out of their burrow system, none of the other types of traps is found effective in trapping them.

This trap was found to be ineffective against other types of rats.

Studies on burrow patterns

1. Tatera indica cuvieri

Altogether nine burrow systems were studied and the details are as follows.

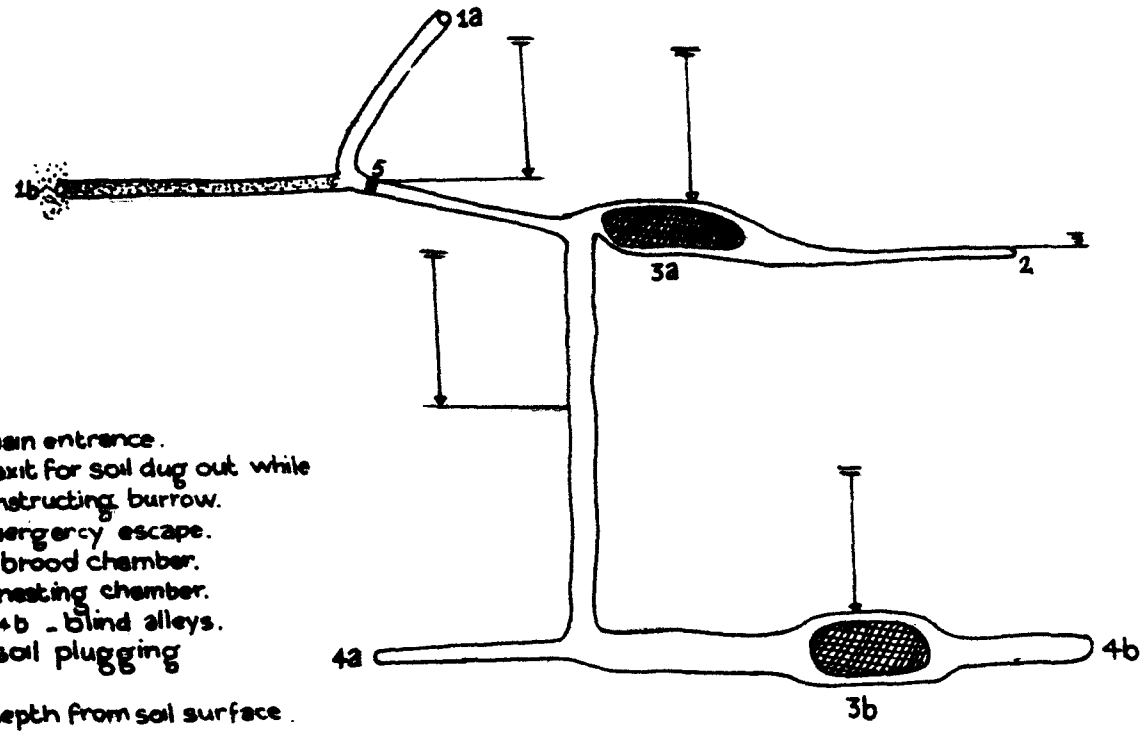
1.1 Burrow system 1 (Fig.18)

This burrow was located in laterite soil under teak plantations at Muthalakodam in the zone 'Idukki and Ernakulam' districts. The period of excavation was September 1979. Soil dug out from the burrow was thrown out through the opening (1b) and the opening was plugged with soil after completion of the burrow system. Main

Fig.13. 33.1

Burrow system of Eutrera indica cunieri

FIG. 18. BS.1.



1a. main entrance.
1b. exit for soil dug out while constructing burrow.
2. emergency escape.
3a. brood chamber.
3b. nesting chamber.
4a & 4b. blind alleys.
5. soil plugging

depth from soil surface.

1 metre.

entrance (1a) was very clean, 5 cm in diameter with path ways in all directions and it was plugged with soil 60 cm inside the opening. The burrow system was 'H' shaped with the brood chamber (3a) and the nesting chamber (3b) located on either arms of the 'H'. From the burrow a mother rat, an adult male and 3 young ones were located at almost identical depth and were connected by a burrow of 130 cm long. Brood chamber ended in an emergency escape (2) of 3 cm diameter, whereas the nesting chamber ended in a blind alley. The brood chamber was 50 cm long with diameter of 17 cm at its widest part. Measurements of nesting chamber: length 45 cm and width 21 cm. The nesting material comprised of dried teak leaves. The burrow system was ramified to a length and width of 3.4 m each.

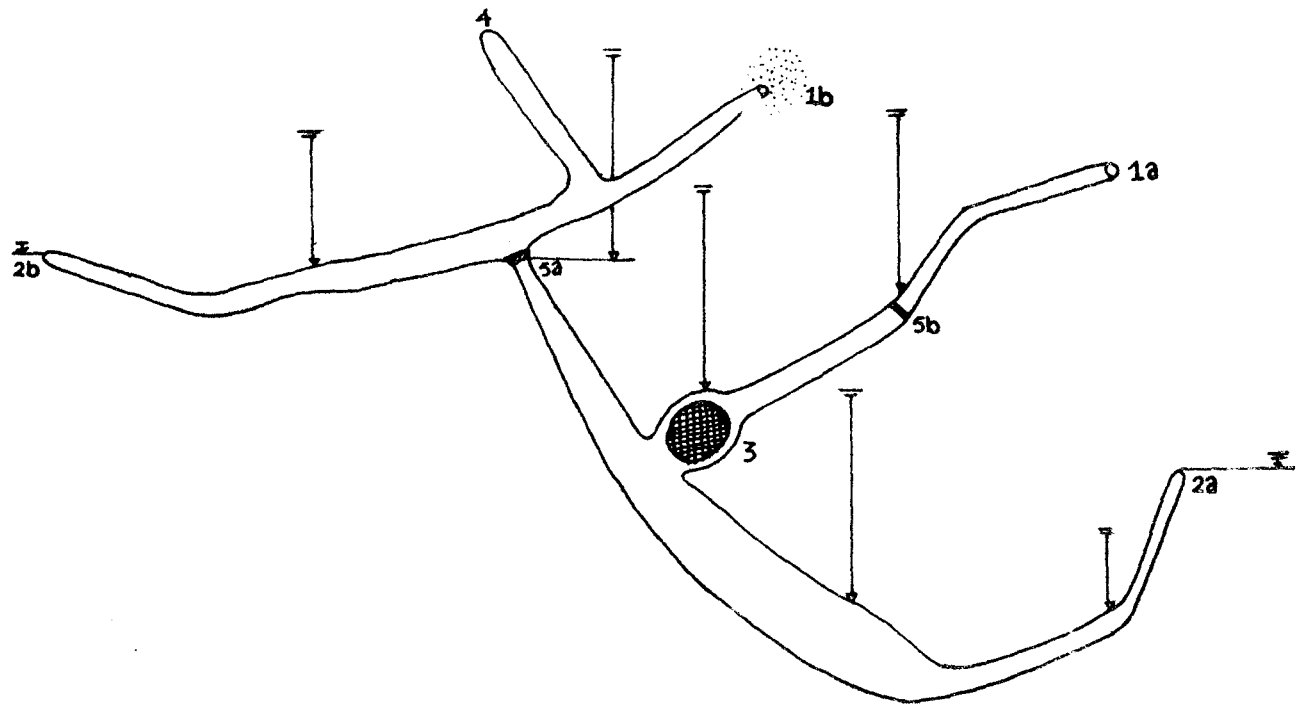
1.2 Burrow system 2 (Fig.19)

The burrow was exposed during September 1978 in a teak plantation at Muthalakodam. The exit hole (1b) for soil was open with a plugging 87 cm inside. The plugging was at the junction where the burrow deviated to the nesting chamber. The burrow starting from 1b terminated in an emergency escape (2b) and before the soil plugging it branched to form a blind alley (4). The nesting chamber (3) which was almost round in shape was directly

Fig. 1. p. 2

Micro system of Tafeln Indice cantieri

FIG. 19. BS. 2.



1 metre.

1a. main entrance.
1b. exit for soil dug out while constructing burrow.
2a & 2b. emergency escapes.
3 . nesting chamber.
4 . blind alley
5a & 5b. soil plugging

depth from the soil surface.

connected to the main entrance (1a). The main entrance also had a plugging with soil (5b) at a distance of 95 cm from the entrance. A central chamber having a maximum width of 23 cm and length 101 mm was found in the burrow system which ended in an emergency escape (2a). The nesting chamber was at a depth of 65 cm. The emergency escape abruptly ended 2 cm below the soil surface. The burrow system was ramified to a length of 3.6 m and width 2.4 m. The total length of the burrow system was 7.91 m and it had a depth ranging from 26 to 70 cm. The nesting material comprised of dried grass. One male and one female rat were present in the burrow system. There were definite pathways interconnecting the entrances and proceeding to the nearby areas.

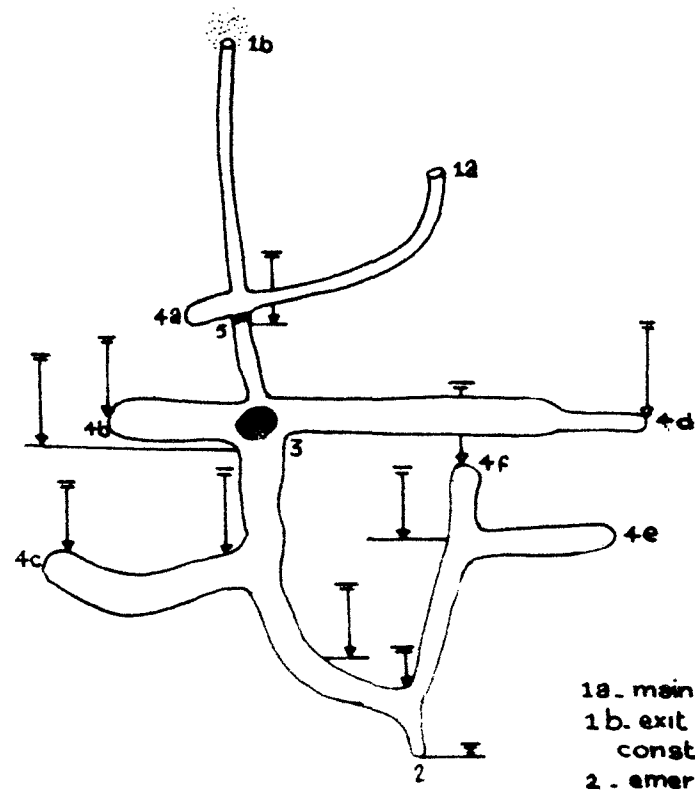
1.3 Burrow system 3 (Fig.20)

The burrow was located in laterite soil at Melarkode in the zone 'Palghat' district during November 1978. The exit hole (1b) was concealed by heap of soil and the burrow starting from this opening was filled with soil to a length of 90 cm. The main entrance (1a) was located near the soil exit hole and was plugged inside (5) at the union of the two burrows. The burrow system had a depth range of 13 to 29 cm and diameter 4 to 12 cm.

Fig.20. R3.3

Burrow system of *Tatera indica cuvieri*

FIG. 20. BS.3.



1 metre

1a. main entrance.
1b. exit for soil dug out while constructing burrow.
2. emergency escape
3. nesting chamber.
4a to 4f. blind alleys
5. soil plugging

depth from the soil surface.

The nesting chamber (3) was located at the junction of four burrows at a depth of 27 cm. There was only one emergency escape (2). The burrow system was ramified to a length of 2.4 m and width 1.9 m. The nesting material comprised of dried leaves of Terminalia paniculata. Collected one male and one female rat from the burrow system.

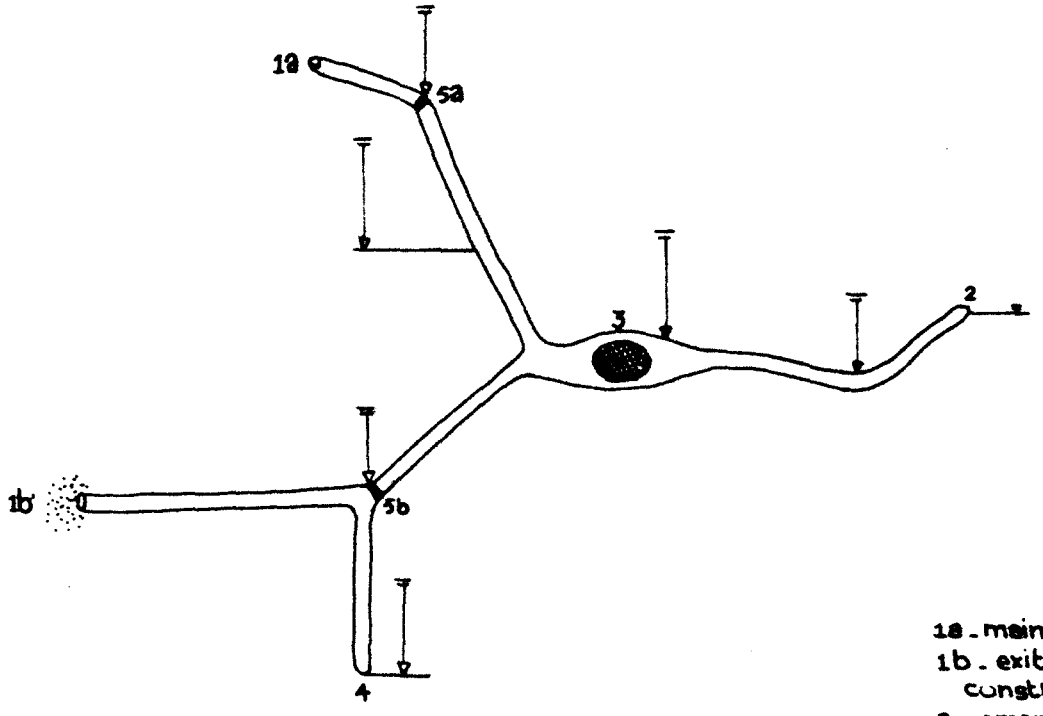
1.4 Burrow system 4 (Fig.21)

The burrow was located in Melarkode at the back yard of a house in laterite soil. The period of excavation was november 1978. The crops around the area were cocconut, banana, mango etc. The exit for soil (1b) was 5 cm in diameter and was plugged 90 cm inside. The burrow system had a blind alley (4) starting from the point of soil plugging - 5 b. The main entrance (1a) was very clean with runways in all directions, plugged 35 cm inside. The burrows starting from the entrances 1a and 1b united at the brood chamber (3). The brood chamber was 46 cm long with a maximum width of 20 cm and was located 34 cm deep. The burrow continuing from the brood chamber ended in an emergency escape (2). The burrow system was ramified to a length of 2.9 m and width of 2 m. The entire burrow system was very clean and devoid of any faecal matter and stored foods. The burrow system had in general a 'Y' shaped

Fig.21. pg.4

Bureau system of **Tatas** Indian Civil

FIG. 21. BS. 4.



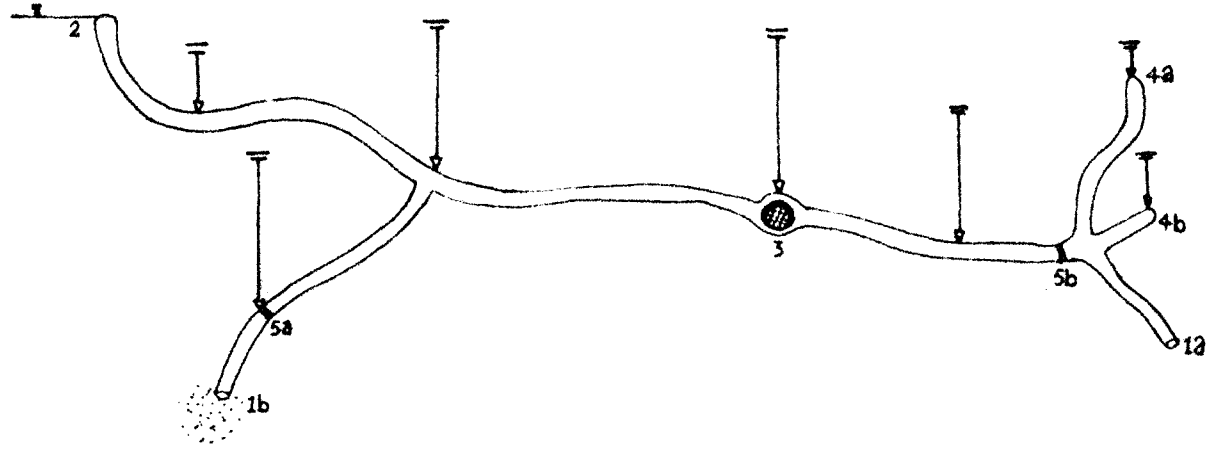
1a - main entrance.
1b - exit for soil dug out while constructing burrow.
2 - emergency escape.
3 - brood chamber.
4 - blind alleys
5a & 5b - soil pluggings
depth from the soil surface.

appearence. The total length of the burrow system was 4.94 m. One female and four young ones were present in the burrow.

1.5 Burrow system 5 (Fig.22)

This burrow was located in a rubber estate at Vellanikkara inthe zone 'Trichur and Malappuram' districts. The period of excavation was December 1978. The soil was laterite. The burrow system was ramified to a length of of 5.4 m and width 2 m. The burrow system was 'Y' shaped with the brood chamber situated at its centre. The brood chamber was somewhat round in shape. The nesting materials wasa dried rubber leaves. One mother and four young ones were collected from the burrow system. The exit for soil dug out (1b) while constructing the burrow and main entrance (1a) were seen located on either extremities of the burrow system and both these openings were plugged inside. Both the soil pluggings (5a and 5b) contained a lot of rat hairs. The depth of the burrow system ranged between 15 to 80 cm and the brood chamber was located at the maximum depth (80 cm). There was no distinct central chamber to the burrow system. The emergency escape (2) did not open to the exterior and was at a depth of 2 cm. The total length of the burrow system was 9.56 m. Though there was no eaten rubber nuts seen inside the burrow, in

FIG. 22. BS. 5.



1 metre

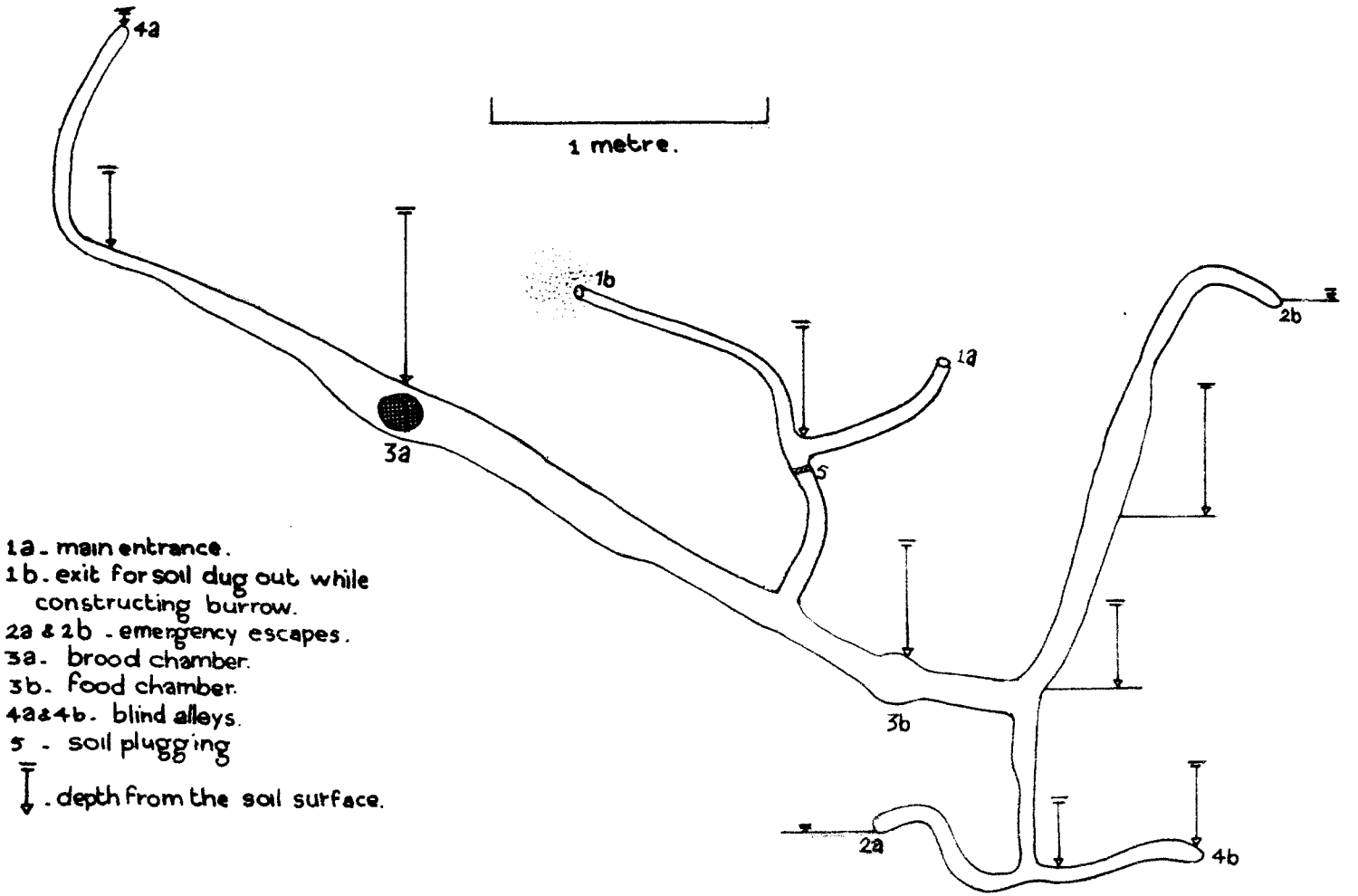
1a. main entrance.
1b. exit for soil dug out while constructing burrow.
2. emergency escape.
3. brood chamber.
4a & 4b. blind alleys.
5a & 5b. soil plugging
depth from the soil surface

certain adjacent small burrows of the same species of rat, in which no rats were found, there were remnants of rubber kernels and broken shells in the burrow. Here also the entire soil, removed from the burrow while constructing it, was thrown out through a particular opening (1b). There was a road close to the burrow and rats were seen moving about in the road during night time.

1.6 Burrow system 6 (Fig.23)

This burrow was located at Vellanikkara in a pulse field. The soil was laterite. The burrow system had a main entrance (1a) and an exit (1b) for removal of soil. In addition to this, there were two emergency escapes (2a and 2b) and two blind alleys (4a and 4b). The burrow system which had no specific shape was ramified to a length of 4.4 m and width 3.1 m. For the openings 1a and 1b there was a common plugging (5). These two openings were located almost at the centre of the burrow system. The depth of the burrow network ranged from 5 cm to 63 cm and the brood chamber was at the point of maximum depth. The nesting material comprised mostly of dried cowpea shoots. The brood chamber (3a) had a width of 17 cm and the food chamber (3b) was round with a diameter of 10 cm. There was an elongate main chamber having a length of 3.8 m with a width ranging from 11 to 20 cm and this main

FIG. 23. BS. 6.



1a - main entrance.
1b - exit for soil dug out while constructing burrow.
2a & 2b - emergency escapes.
3a - brood chamber.
3b - food chamber.
4a & 4b - blind alleys.
5 - soil plugging
I - depth from the soil surface.

chamber comprised of a brood chamber and the food chamber put together. From the burrow, a mother rat and six young ones were captured. There were definite pathways from the burrow entrances. The exit hole was quite clean and tidy than the main entrance, perhaps due to the frequent use of this opening (1b) for entrance and exit. As shown in Fig.23 one end of the main chamber ended in a blind alley (4a) about 5 cm deep. While exposing the burrow the rat was found burrowing at this end to make an escape. The other end of the main chamber branched into two and one of the branches terminated in an emergency escape (2b) concealed under ground 2 cm deep. The other branch forked further into two giving the shape of an anchor. One of these branches ended in an emergency escape (2a) while the other led to a blind alley.

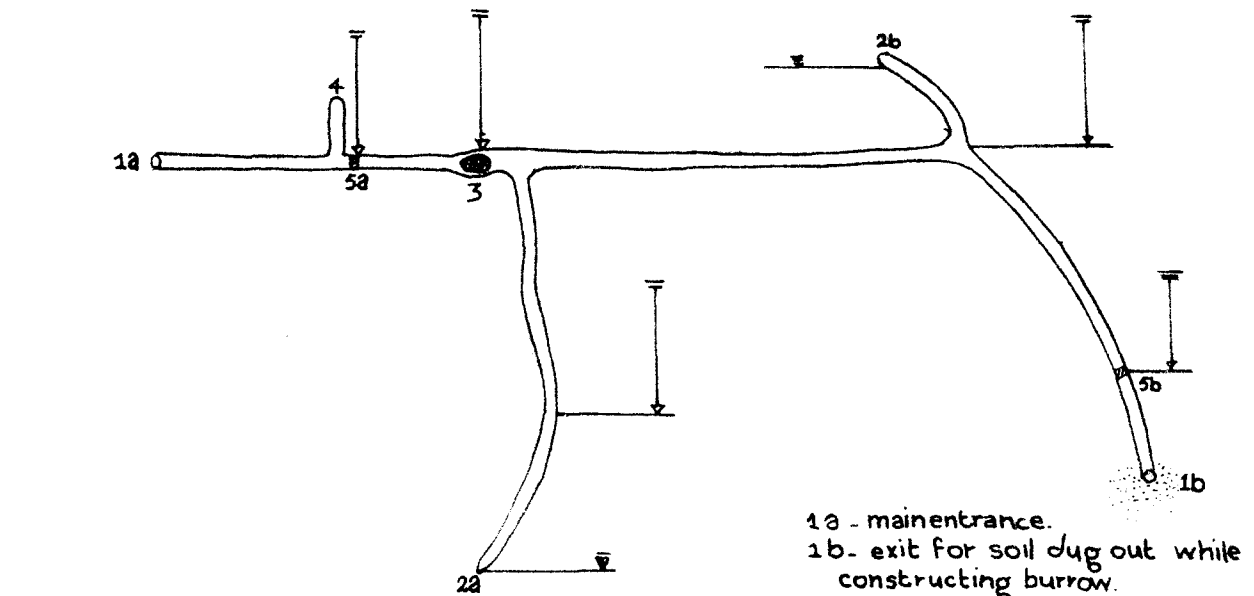
1.7 Burrow system 7 (Fig.24)

This burrow system was located at Nariparamba, in the zone 'Palghat' district in sandy soil during December 1978 in a fallow land. The burrow pattern was very simple. It had a total length of 5.52 m. The exit for soil (1b) was seen opened up with a heap of soil around. It was plugged 37 cm inside. The main burrow extended from this opening to the main entrance (1a). Both these openings were on both ends of the main burrow. The main

Fig.21. F8.7

Burrow system of <u>Tatera indica cuvieri</u>

FIG. 24. BS. 7.



1 metre.

1a - main entrance.
1b - exit for soil dug out while constructing burrow.
2a & 2b - emergency escapes
3 - brood chamber.
4 - blind alley
5a & 5b - soil pluggings

depth from the soil surface.

burrow had two branches on either side and these branches led to the emergency escapes (2a and 2b). One of these branches (length 132 cm) deviated from the vicinity of the brood chamber while the other branch had a length of only 43 cm (2b). Both emergency escapes were below the soil surface and were located at a depth of 2 cm. There were runways of rats leading from the burrow entrances and these led to the surrounding areas. The main entrance was clean and tidy and was plugged inside at a distance of 60 cm from the exterior. Close to the plugging, there was a blind alley, 20 cm long. The nesting chamber with dried grass as bedding material was relatively small with a width of only 8 cm. As usual, the maximum depth of the burrow system was along the brood chamber. The depth of the burrow system was between 30 and 45 cm and there was no central chamber. While opening the burrow system, one of the rats escaped through the emergency escape (2a) and this led to another burrow of the same species located about 25 m away. This rat was subsequently caught easily since this burrow (retreat burrow) was very small in size. The burrow system was ramified to a length of 3.2 m and width 1.7 m. One mother and five young ones were collected from the burrow.

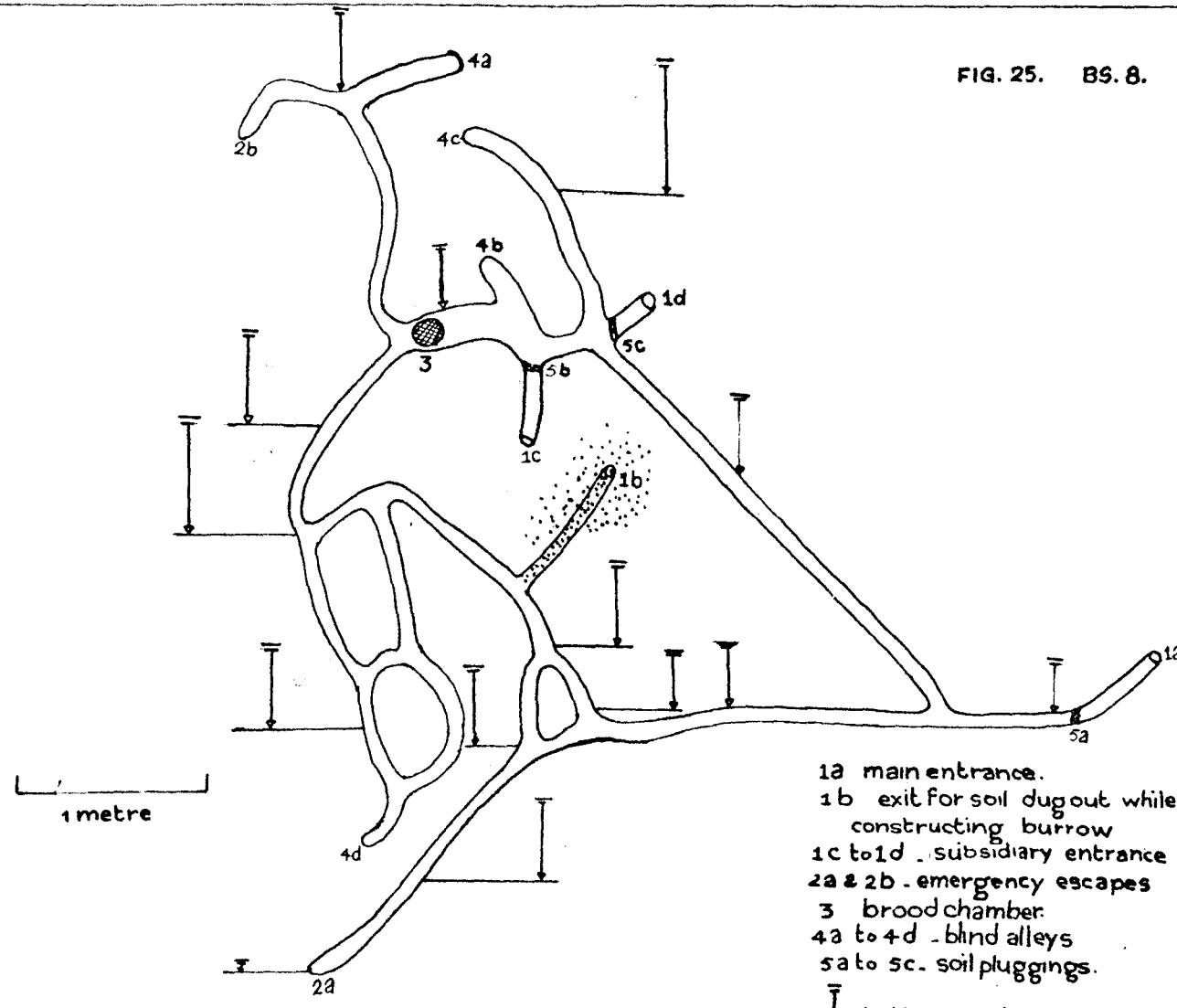
1.8 Burrow system 8 (Fig.25)

This burrow was located at Aravanchal in the zone 'Cannanore' district. The soil was gravelly and the field was small and surrounded by denuded rocky grass-lands on three sides and a road on the side. The period of excavation was January 1979 and the soil was very hard and dry upto a depth of about 30 cm to 40 cm. Unlike the burrows of T. indica cuvieri described earlier this system was very extensive with a total length of 20.3 m. The width of the burrow system ranged from 7 cm to 20 cm and it had a maximum depth of 69 cm. There were two emergency escapes (2a and 2b). The burrow system was ramified to a length and width of 4.95 m each. The exit for soil (1b) was surrounded by burrow on all sides. The soil exit burrow was filled with soil to a length of 81 cm, after which it bifurcated. The main entrance (1a) was plugged 50 cm inside. In general, the width of the burrow system was 7 cm and there was no distinct central chamber though an area near the brood chamber with a width of 19 to 20 cm and length of about one metre could be considered as a central chamber. Close to this chamber there were two openings (1d and 1c) which were also plugged inside. Shed coats were always present amidst the soil pluggings. A total of four blind alleys (4a to 4d) were present in the burrow system. Most of the area of the

Fig.27. T. C

Bureau général des Travaux Publics Casier

FIG. 25. BS. 8.


4a
2b
4c
4b
1d
5c
3
5b
1c
1b
1a
5a
4d
2a
1 metre
1a main entrance.
1b exit for soil dug out while constructing burrow
1c to 1d . subsidiary entrance
2a & 2b . emergency escapes
3 brood chamber.
4a to 4d . blind alleys
5a to 5c . soil pluggings.
depth from the soil surface.

burrow system was located at a depth of 30 cm to 50 cm. The brood chamber (3) was located at a depth of 31 cm and was provided with nest of dried grass. Close to the central chamber, a blind alley, 144 cm long and 10 cm wide was found going deep and this was having a maximum depth of 69 cm. From the burrow,a male, one mother rat and four young ones were captured. One of the young ones was badly wounded perhaps by the parent rat, enraged due to suffocation from smoke.

The specialities of this burrow was the inter-connecting nature of the burrow network and the extra-ordinary length of the burrow system.

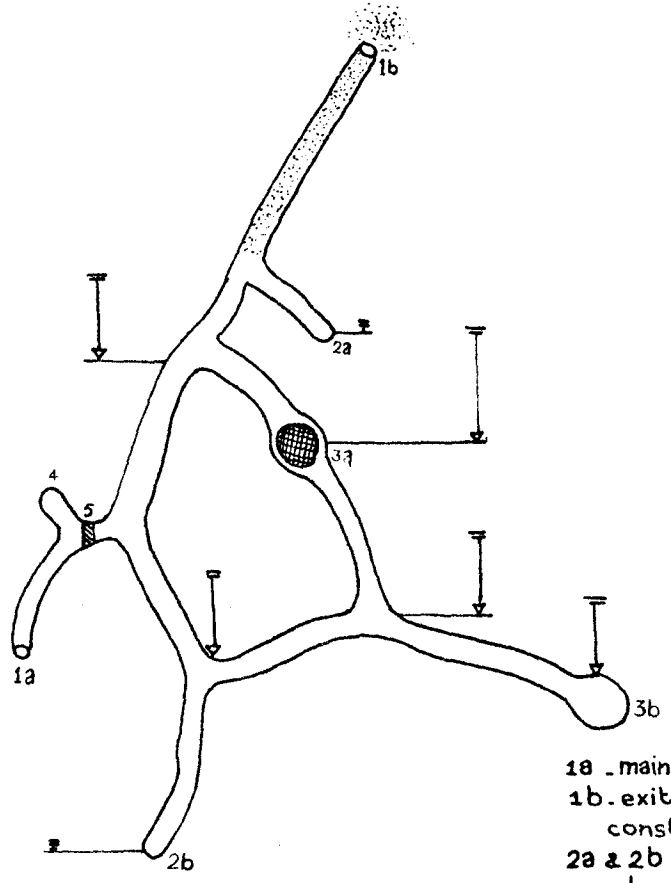
1.9 Burrow system 9 (Fig.26)

This burrow was located at Kurianadu in the zone 'Kottayam and Alleppey' districts. The period of survey was during January 1979. The soil was laterite and the area was a neglected cocoanut garden. There was not much of grass growth, but a few Eupatorium odoratum plants were found growing around. The total length of the burrow system was 6.21 m and the width of the burrow ranged from 6 cm to 18 cm. The exit for soil (1b) was found closed and soil was filled in this burrow to a length of 85 cm. The main entrance (1a) was plugged 45 cm within (5). Just close to the plugging, there was a blind alley, 13 cm long. The brood

Fig.26. Bs.C

Burrow system of Tatera indica cuvieri

FIG. 26. BS.9.



1 metre

1a - main entrance.
1b - exit for soil dug out while constructing burrow.
2a & 2b - emergency escapes.
3a - brood chamber.
3b - chamber for excretion.
4 - blind alley
5 - soil plugging
$\overline{\downarrow}$ - depth from the soil surface

chamber (3a) was somewhat round in shape and was having a diameter of 18 cm. The nesting materials comprised of bits of cocoonut roots, dried grass and dried stem of Eupatorium odoratum. There was only one immature female rat in the burrow. A separate chamber (3b) filled with faecal pellets was present. The major portion of the burrow system was having a depth ranging from 20 cm to 30 cm. There were two emergency escapes (2a and 2b). There was also a main entrance for the burrow system. The runways of rats leading from the entrance were quite clean. The burrow system was ramified to a length of 2.7 m and a width of 2 m.

2. Rattus norvegicus

Studied only one burrow system. The details of it are given below.

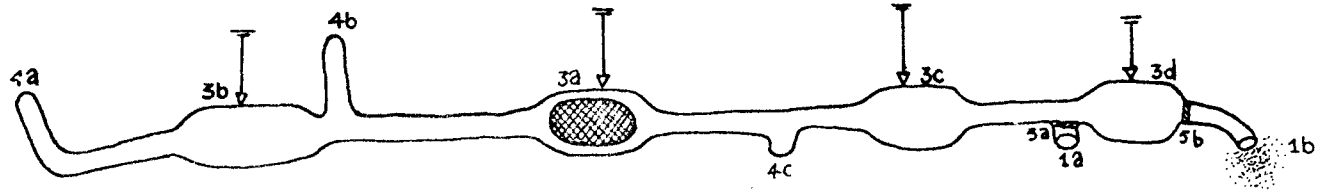
2.1 Burrow system 10 (Fig.27)

This was located at Muthalakodam in the zone 'Idukki and Ernakulam' districts along a paddy field bund. The burrow was exposed one day after harvesting the crop in September 1978. The soil there was clayey. The burrow system had a total length of 6.431 m and width ranged from 11 cm to 30 cm. The maximum depth of the burrow system was 40 cm and depth ranged between 30 cm and 40 cm. The burrow system had a main burrow starting from 1b, the soil exit

Fig. 1.10

Bruce Baker on Writing Notations

FIG. 27. BS. 10.



1 metre

1a. main entrance.
1b. exit for soil dug out while constructing burrow.
3a. brood chamber.
3b to 3d . extra chambers.
4a to 4c blind alleys.
5a & 5b. soil plugging

depth from the soil surface.

hole and ended in a blind alley (4a). There were a total of four chambers of identical dimensions of 40 cm each, of which the chamber - 3a was the brood chamber and the rest of the chambers were of unknown use. Food materials were not stored in the burrow system except an earhead of paddy and two snails. There were one mother rat and twelve young ones in the burrow system. The major portions of the burrow system including the main entrance (1a) was submerged in water and the rat entered the burrow through water. The nesting material used was hay.

3. Bandicota bengalensis bengalensis

Altogether fourteen burrow systems were excavated. The details are as shown below.

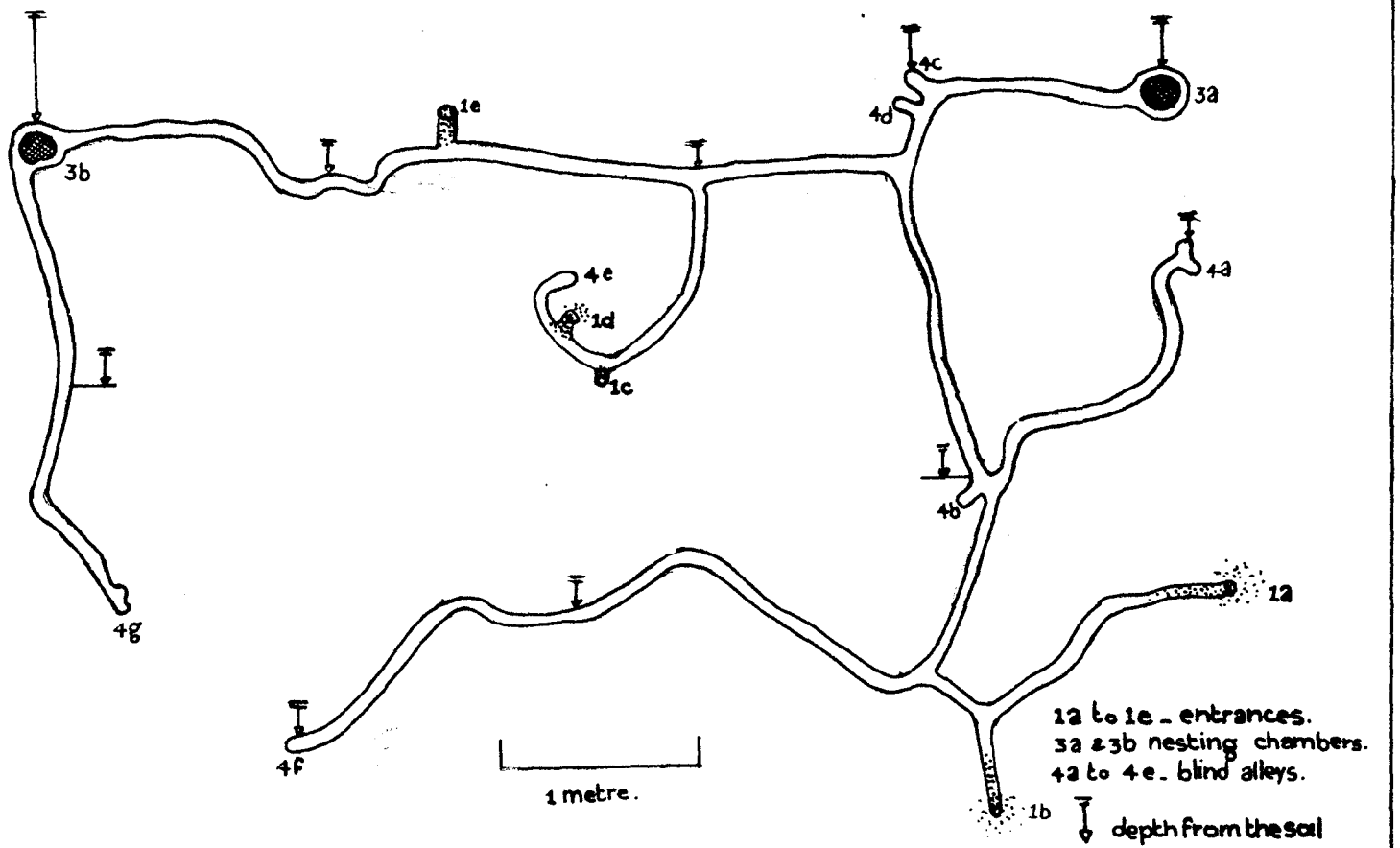
3.1 Burrow system 11 (Fig.28)

The burrow system was located in laterite soil at Muthalakodam, Idukki district, in a tapioca field and was excavated during October 1978. The total length of the burrow system was 19.84 m and the width of the burrow ranged from 5 cm to 21 cm. Altogether there were five openings (1a to 1e). At each opening, there were heaps of soil and the burrow entrances were concealed with soil. There were two nesting chambers (3a and 3b) which were

Fig.26. No.11

Burrow system of *Bandicota bengalensis bengalensis*

FIG. 28. BG. 11

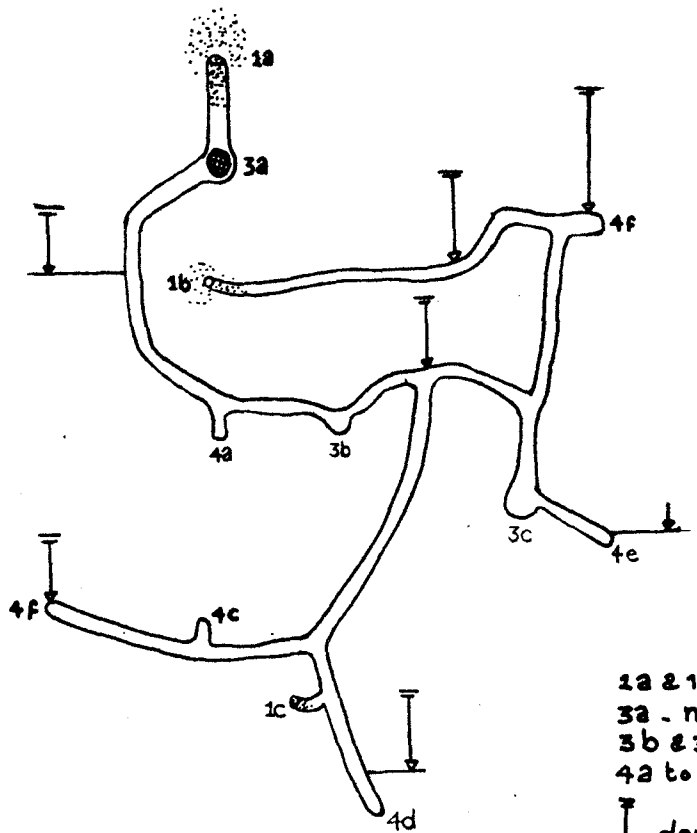

1e
4c
3a
4d
3b
4e
1d
1c
4a
4b
4g
1a
4f
1 metre.
1b
1a to 1e - entrances.
3a & 3b nesting chambers.
4a to 4e - blind alleys.
depth from the soil surface

almost round in shape. The burrow network was ramified to a length of 6.21 m and 2.4 m width. The nesting chambers were at a depth of 45 cm and 23 cm. The nesting material comprised of tapioca leaves and petioles. For the rest of the burrows, the depth ranged from 15 cm to 20 cm. There was no definite shape for the burrow network. There was only one rat in the burrow system. One of the nests appeared defunct.

3.2 Burrow system 12 (Fig.29)

The burrow was located at Muthalakodam in laterite soil in a tapioca field and was exposed during the month of September 1978. The soil was relatively loose and wet. The total length of the burrow system was 9.9 m and the width ranged from 5 cm to 15 cm. The burrow system was ramified to a length of 3.1 m and width 2.3 m. Out of the three openings (1a to 1c) only two (1a and 1b) were having heaps of soil, concealing the entrances. The third burrow opening (1c) was devoid of soil heap. It was plugged inside about 4 cm beneath the soil surface. The nesting chamber had a width of 15 cm and was located at a depth of 35 cm. There were two semicircular chambers (3b and 3c) of unknown use. The burrow system was located under a standing crop of tapioca and tubers were eaten off from within the burrow. Major portions of the burrow system was at a depth of 25 cm

FIG. 29 BS.12.



1a & 1b & 1c - entrances.
3a - nesting chamber.
3b & 3c - extra chambers
4a to 4f - blind alleys.

depth from the soil surface.

1 metre

below the soil surface. There was only one female rat in the entire burrow network.

3.3 Burrow system 13 (Fig.30)

This burrow was located in a paddy field bund in Melarkode, Palghat district. The burrow was exposed two days after harvesting. The soil was clayey. The burrow system had a total length of 6.431 m. The width of the burrow ranged from 5 cm to 10 cm. The burrow had a maximum depth of 29 cm. There were two entrances (1a and 1b) and these were concealed by heaps of soil. The entrance burrows united to form a common burrow or main burrow which was plugged inside (5). A number of short blind alleys started from the main burrow. The nest was semicircular in shape and the width of the nesting chamber was 10 cm. The maximum depth (29 cm) of the burrow was in the nesting chamber. The depth of the other parts of the burrow system ranged from 15 cm to 22 cm. There was no food chamber or any stored food in the burrow system.

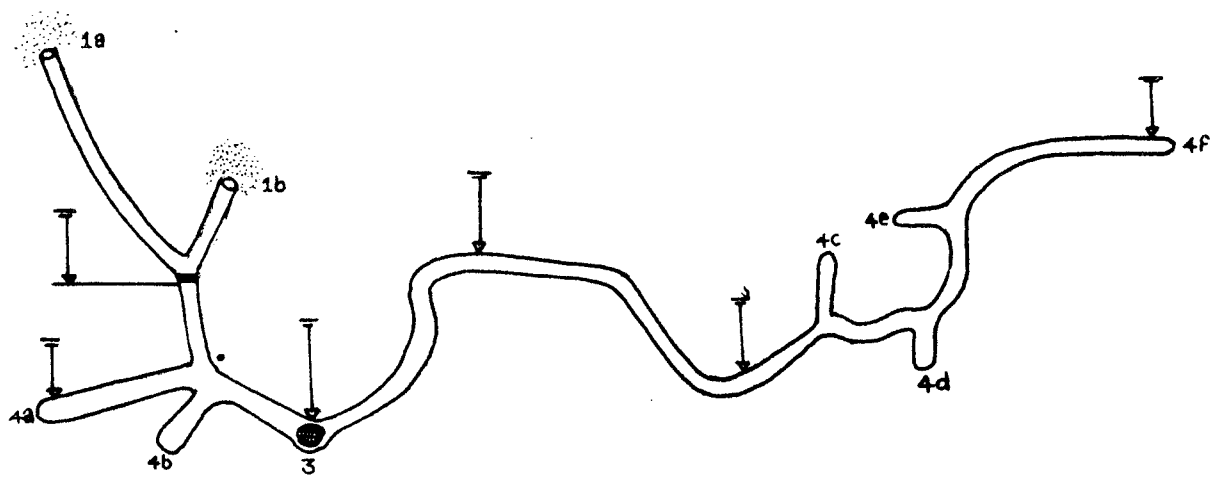
3.4 Burrow system 14 (Fig.31)

This burrow was located at Melarkode along a paddy field bund. The paddy crop was sufficiently ripe for harvest. The burrow system had a total length of 2.55 m

Fig. 30. 49.13

Burrow system of Bembicotta peregrinella peregrinella

FIG. 30. BS. 13.



1 metre

1a, 1b } Entrances

3. nesting chamber

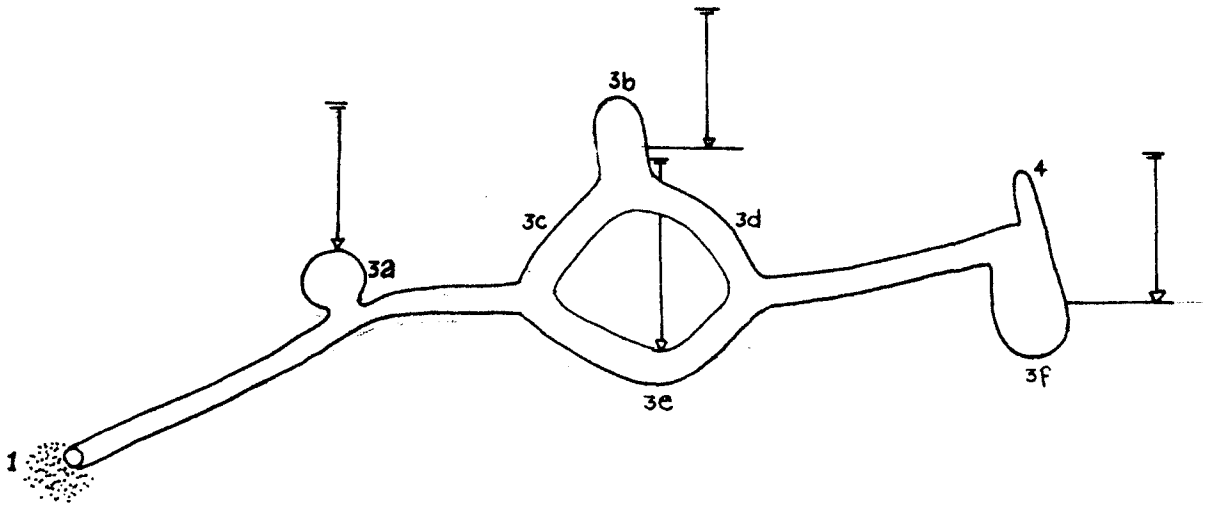
4a to 4f } blind alleys

depth from the soil surface.

Fig. 34. p. 14

Burton system of Bendigo Consolidated Gold Mines

FIG. 31. BS. 14.



1 metre.

1 - entrance.
3a to 3f - food chambers.
4 - blind alley

depth from the soil surface.

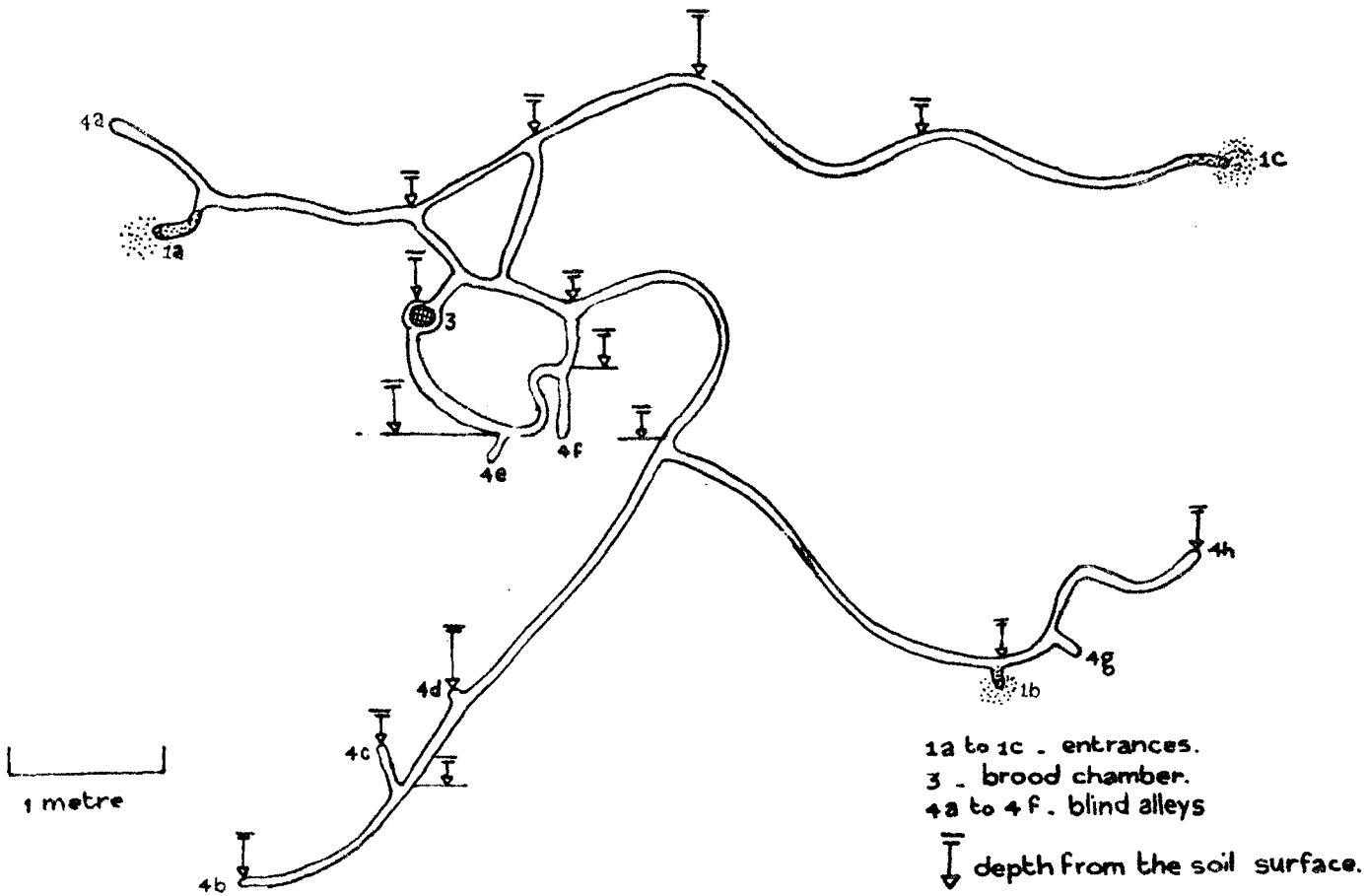
with a width ranging from 4 cm to 11 cm. No rat was found inside the burrow. The entrance was concealed by a heap of soil. The entire burrow system was partly filled with neatly arranged paddy ear heads with very little space for the rat to move about. There was only one entrance (1) for the burrow system. A portion of the burrow (3e) was full of paddy earheads with no space for the rat to move about. The total weight of the paddy earhead stored in the burrow was 425 g. In contrast to the previous burrow the main burrow was found lacking and there was no nesting chamber. The burrow system had a maximum depth of 23 cm. There were definite pathways starting from the burrow entrance and proceeding to the paddy crop.

3.5 Burrow system 15 (Fig.32)

This burrow was located at Melarkode, Palghat district in a tapioca field. The soil was loose and sandy. The burrow system was extensive without any definite pattern. The total length of the burrow network was 25.08 m with a width ranging from 4 cm to 12 cm. Altogether, there were three burrow entrances (1a to 1c) which were concealed by heaps of soil. The burrow network was ramified to a length of 7.2 m and 5.2 m width. Brood chamber was

Fig. 32. Pl. 1.

FIG. 32. BS. 15.


4a
1a
1c
3
4e
4f
4h
4g
1b
4d
4c
4b
1 metre
1a to 1c . entrances.
3 . brood chamber.
4a to 4f . blind alleys
depth from the soil surface.

semicircular in shape having 12 cm diameter. The nesting materials were dried leaves and petioles of tapioca. The burrows were located under standing tapioca. Tapioca tubers projecting into the burrows were damaged by rats. The maximum depth of the burrow system was 37 cm and the depth of the brood chamber was only 27 cm. In the major portions of the burrow system, the depth from the soil surface ranged from 12 cm to 25 cm. A main burrow for the system was lacking. A total number of 3 females, 2 males and 6 young ones were captured from the burrow. The mother rat was not present in the burrow.

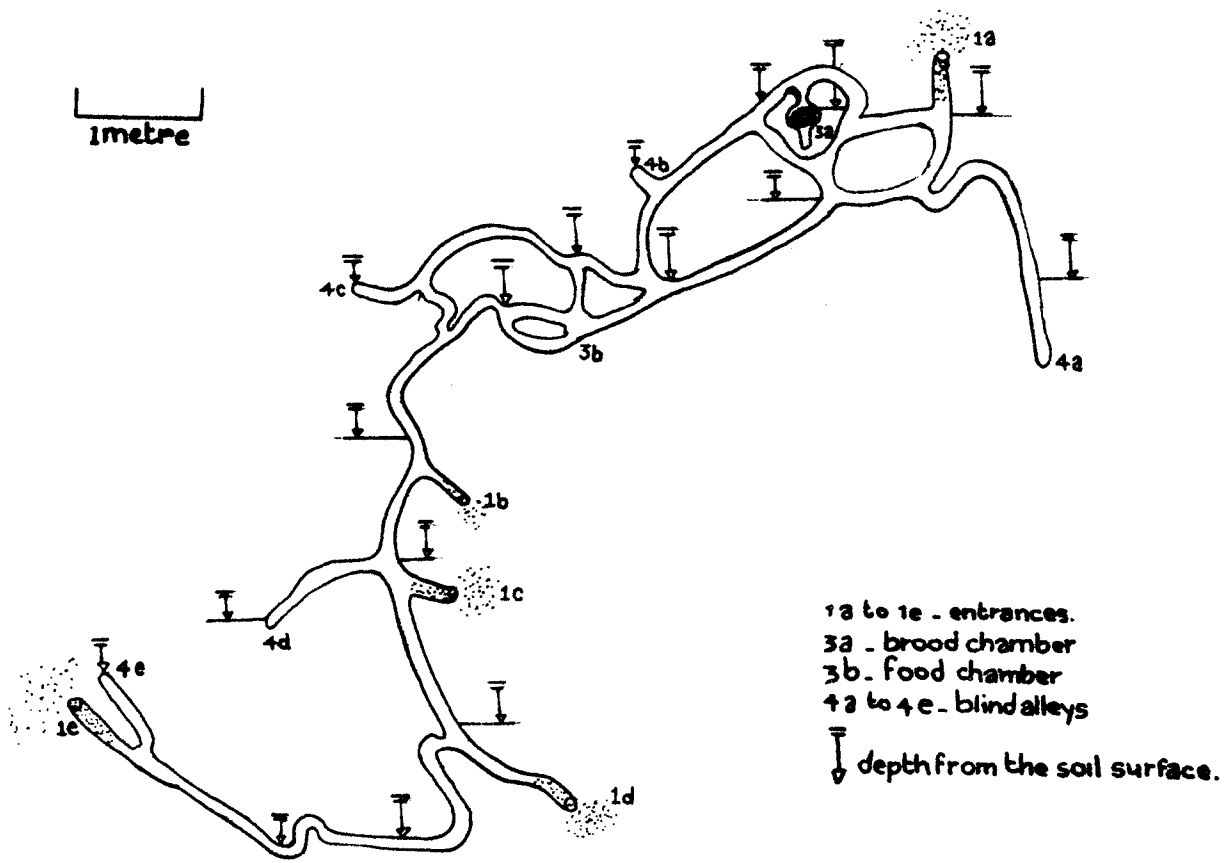
3.6 Burrow system 16 (Fig.33)

This burrow was located at Vellanikkara, Trichur district, in a tapioca field. The soil was laterite. The total length of the burrow system was 29.19 m. The burrow system was interconnected. The width of the burrow ranged from 7 cm to 10 cm and the burrow network had a maximum depth of 50 cm. The burrow system was ramified to a length of 7.9 m and 6.25 m width. There were 5 entrances (1a to 1e) and all of them were concealed by heaps of soil. The burrows leading from the openings were filled with soil to varying lengths and to a maximum of 60 cm. The brood chamber (3a) was 10 cm wide and at the maximum depth of 50 cm and was surrounded by burrows on all sides. There was a

Narrow system of Bandicoot Peramelemia peramelomia

Fig.33. B3.16

FIG. 33. BS. 16.


1metre
1a
3a
4b
4c
3b
4a
1b
1c
4d
4e
1e
1d
1a to 1e - entrances.
3a - brood chamber
3b - food chamber
4a to 4e - blind alleys
depth from the soil surface.

food chamber (3b) in which few tapioca tubers were seen stored. Tapioca tuber-bits were also seen in the brood chamber. All the tapioca tubers projecting into the burrow were partially eaten by the rats. Major portions of the burrow system were at a depth range of 20 cm to 35 cm. The nesting material found in the brood chamber comprised of tapioca leaves. One mother rat and two young were captured from the burrow system. Though the burrow system was extensive, there were only five blind alleys and the burrow network had no definite shape.

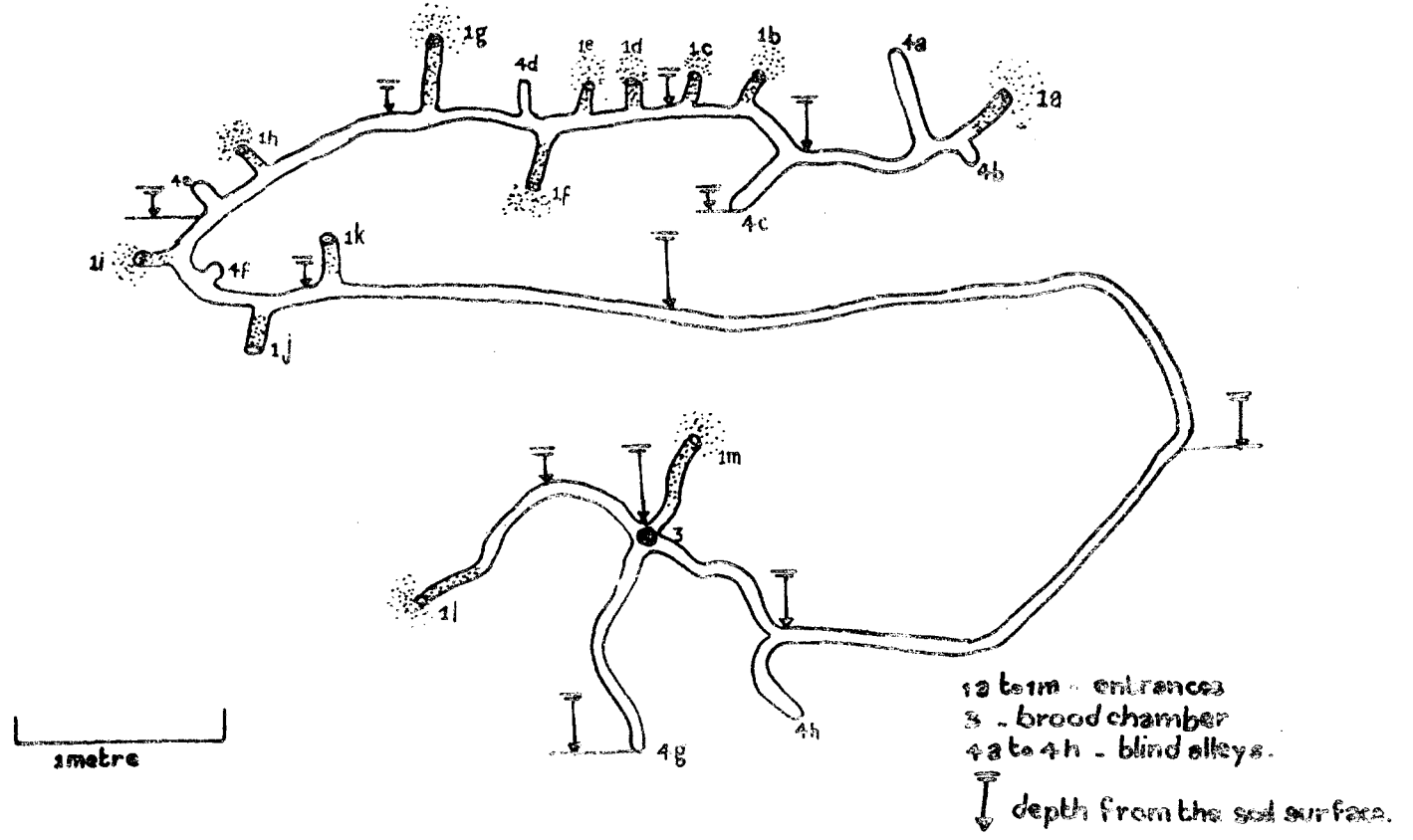
3.7 Burrow system 17 (Fig.34)

This was located in a rubber plantation at Vellanikkara in laterite soil. The period of excavation was October 1978. Altogether there were thirteen openings and all were concealed by heaps of soil. Rat runways were absent from the burrow entrances. The total length of the burrow system was 19.63 m with a maximum depth of 33 cm and a width of 6 cm to 12 cm. The entrances were filled with soil to varying lengths ranging from 15 to 40 cm. The burrow system was ramified to a length of 5.1 m and 3.6 m width. The brood chamber was located at the junction of four burrows, two of which led to openings and one led to a blind alley and the fourth one was the main burrow. The brood chamber (3a) was at the maximum depth (33 cm).

Fig. No. 32.17

Burton system of tandoor dehydrated beetroots

FIG. 34. BS. 17.


1g
4d
1e
1d
1c
1b
4a
1a
1h
4e
1f
4b
4c
1i
1k
4f
1j
1m
3
1l
4g
4h
1 metre
1a to 1m - entrances
3 - brood chamber
4a to 4h - blind alleys.
depth from the soil surface.

The nesting material was of dried rubber leaves. The burrow system had a main burrow running in a more or less zig zag way 10 cm to 33 cm below the soil surface with a number of secondary burrows which terminated either in openings or in blind alleys. There was no food chamber. Food was not stored in the burrow . One mother rat and four young ones were captured from the burrow.

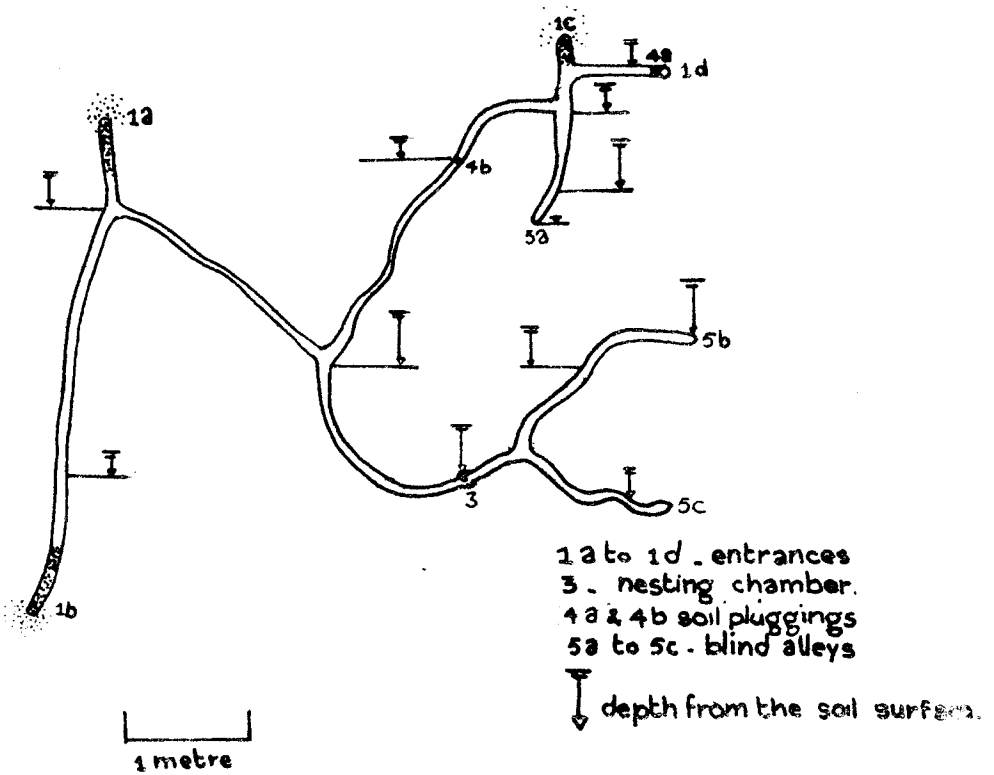
3.8 Burrow system 18 (Fig.35)

This was located at Kuppamudi, Wynad, in the zone 'Calicut' district in a tapioca field. The soil was laterite. Total length of the burrow system was 17.16 m. The width of the burrow ranged from 5 cm to 11 cm with a maximum depth of 40 cm. There were altogether four burrow entrances (1a to 1d) and all except 1d were concealed by heaps of soil. The opening 1d was plugged from within (4a). There were two rats - one male and one female and the burrow network was partitioned by a second plugging (4b), for occupation by these two rats. The male rat had no nesting chamber and it occupied only a small sector of the burrow system. The burrow system was ramified to a length of 5.3 m and to a width of 4.75 m. The nesting chamber was at the maximum depth of 40 cm. The depth of major portions of the burrow network ranged from 20 cm to 25 cm.

Fig. 35. pg.18

Arrow system of **Bandicota** **bengalensis** **bengalensis**

FIG. 35. BS. 18.


1c
4a
1d
1a
4b
5a
5b
3
5c
1b
1 metre
1 a to 1 d . entrances
3 . nesting chamber.
4 a & 4 b soil pluggings
5 a to 5 c . blind alleys
depth from the soil surface.

3.9 Burrow system 19 (Fig.36)

The burrows were located at Thirumeni, in the zone 'Cannanore' district in the premises of a house and exposed for study during January 1979. It was located in between two rocks and was surrounded by solid rocks on all sides. The total length of the burrow system was 130 cm and the maximum width was 15 cm. The depth could not be measured because of the rocks. No soil heap was noticed in front of the burrow opening. The only one opening of the burrow was plugged 72 cm away from the mouth. There was a nest inside the burrow 36 cm from the soil plug. The nesting material included dried leaves of rubber, empty pulse pods, tapioca rind, leaves of Ailanthus malabarica and dried coconut leaflets. There was only one female rat in the burrow.

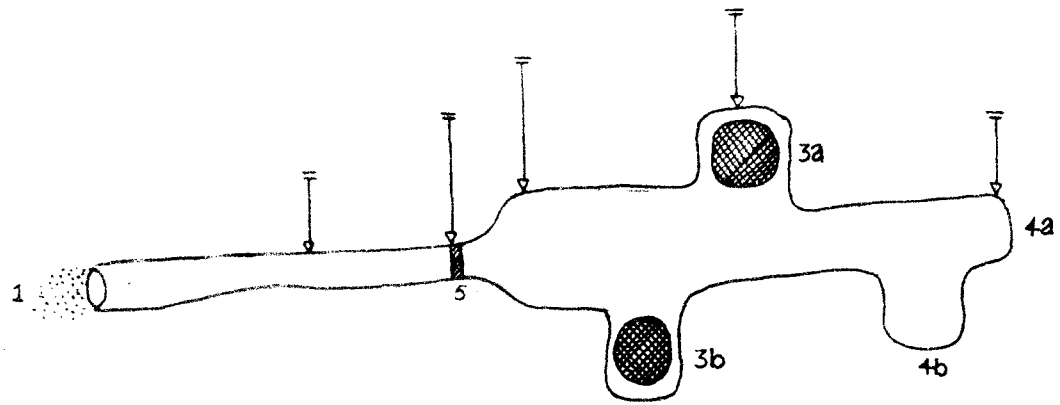
3.10 Burrow system 20 (Fig.37)

This was located at Thirumeni on the border of a tapioca field. The soil was laterite and the total length of the burrow system was 3.18 m. The width ranged from 15 cm to 30 cm and the maximum depth was 43 cm. Only one entrance to the burrow system (1). It was close to a heap of rubbles and was plugged at a point 106 cm inside (5). Starting from the plugging the width of the burrow suddenly increased to about 20 cm to 30 cm. There were two nesting

Fig. 36. pg.19

Burrow system of Bandicota bengalensis bengalensis

FIG. 37. BS. 20.



1 metre.

1 - entrance
3a & 3b - nesting chambers.
4a & 4b - blind alleys.
5 - soil plugging
depth from the soil surface.

chambers (3a and 3b). One of the nests was an old one and was not being used by the rat. The nesting material comprised of dried jack leaves. The maximum depth of the burrow system was at the point of plugging and the brood chambers were at a depth of 30 cm and 32 cm. The burrow system was spread to a length of 3 m and width 95 cm. The burrow entrance was open and not concealed by heap of soil. One mother rat and two middle aged young ones were captured from the burrow system.

3.11 Burrow system 21 (Fig.38)

This burrow was located at Thirumeni in a cocconut garden, during the month of January, 1979. The soil type was laterite. The total length of the burrow system was 3.85 m and width ranged from 5 cm to 8 cm. Maximum depth was 32 cm. Altogether there were four burrow entrances (1a to 1d). The nesting chamber was found at a depth of 14 cm. Nesting material included dried tapioca leaves and petioles. A small burrow, 15 cm long, was directly connected to the nesting chamber which ended in an opening (1d) and was completely filled with soil. Another burrow from the nesting chamber was divided into two and both ended in openings (1b and 1c) and the entire length from

Fig. 38. Dr. C.

Narrow system of Bandicota bengalensis bengalensis

the nesting chamber was filled with soil. The third burrow from the brood chamber was hollow and it was the one for the rat to move about. This burrow branched twice to form blind alleys and finally opened to the soil surface where the burrow was filled with soil for a length of 26 cm. All the burrow entrances were concealed by heaps of soil. The burrow system was scattered to a length of 2.1 m and width 1.1 m. There was only a single male rat in the burrow system.

3.12 Burrow system 22 (Fig.39)

The burrow was located at Cherupuzha,'Cannanore' district in a tapioca plot. The period of study was January 1979. Soil type - laterite. The total length of the burrow system was 59.11 m and had a maximum width and depth of 20 cm and 90 cm respectively. The burrow system was very extensive with only two openings (1a and 1b). The openings were concealed by heaps of soil. The burrow system was interconnected. A total number of 21 blind alleys were present (4a to 4u). The soil was very hard and dry due to severe summer and the nesting chamber was located at a depth of 59 cm, where the humidity was high. Two blind alleys (4i and 4j) starting from the brood chamber had a maximum depth of 85 cm and 90 cm respectively. The depth of the

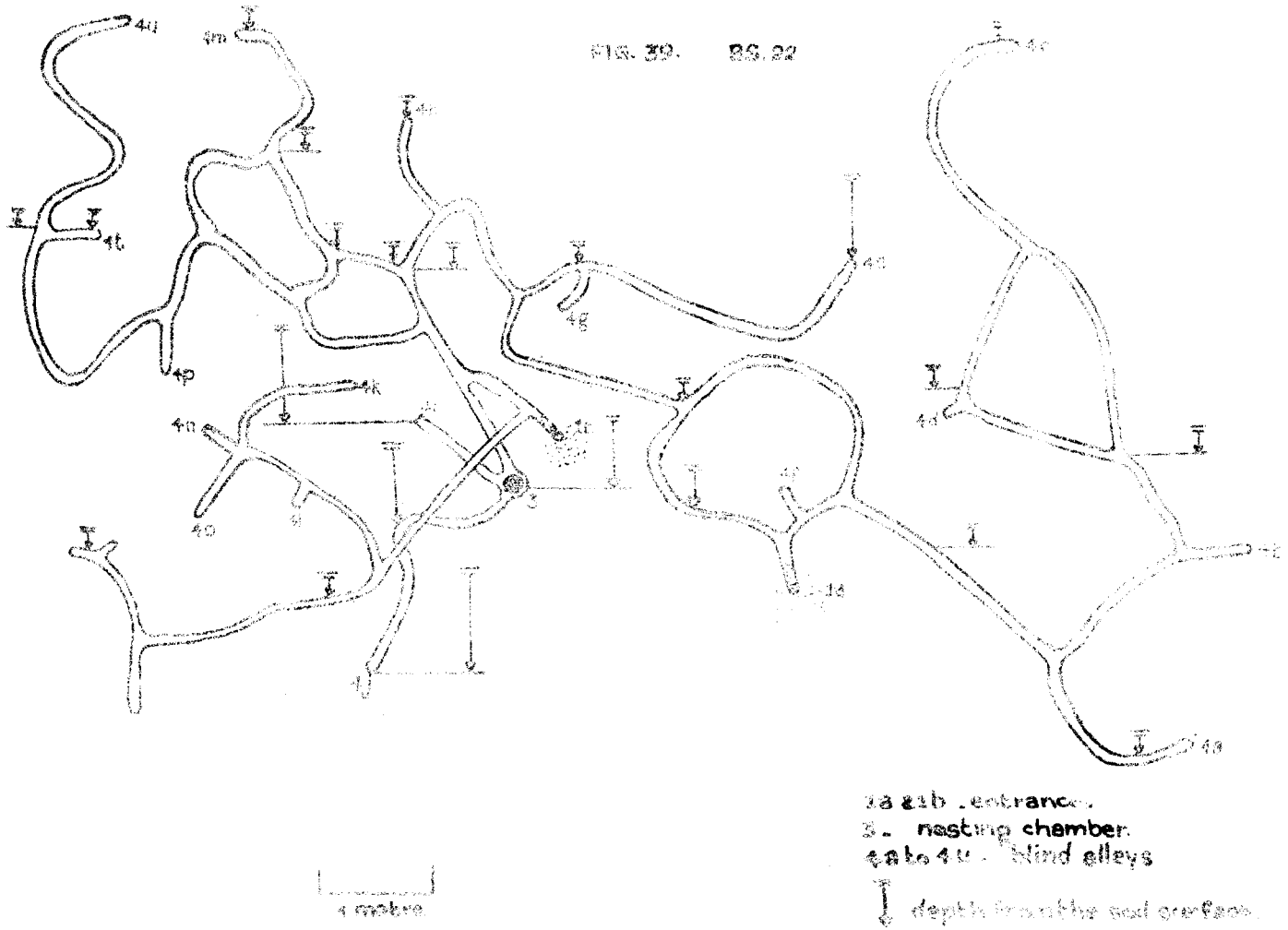


FIG. 39. BG. 22
1a & 1b . entrance.
3 . nesting chamber.
4a to 4u . blind alleys
depth from the soil surface
1 metre

major portions of the burrow network was in a range of 10 cm to 20 cm. The burrow system went deep to get a humid and cooler atmosphere. Tapioca tubers projecting to the burrows were seen eaten as in the previous cases. The burrow system was ramified to a length of 10.85 m and width 6.7 m. The nesting chamber was round in shape having a diameter of 20 cm. Nesting material included dried tapioca leaves and petioles and bits of dried banana leaves. Only one adult male was found in the burrow.

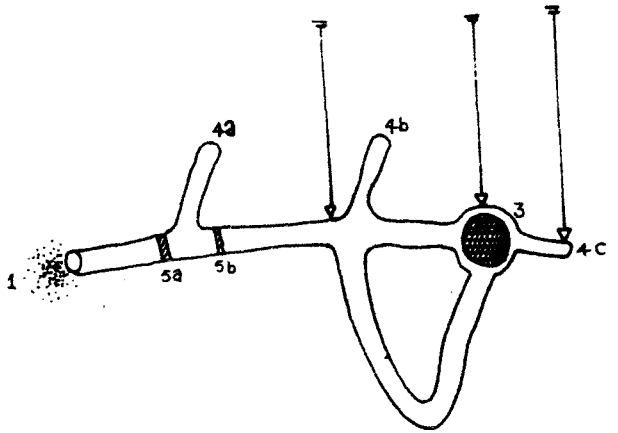
3.13 Burrow system 23 (Fig.40)

The burrow was located at Moncompu in the zone 'Kottayam and Alleppy' districts, on the outer bund of a paddy field. The period of study was January 1979. The bund was separated from the paddy field by a canal 20 m wide and in order to reach the field the rat had to swim through the water. The soil was clayey loam. Total length of the burrow system was 3.22 m and width ranged from 7 cm to 20 cm and depth 25 cm to 75 cm. There was only one opening to the burrow system. The burrow opening was very clean, showing foot prints of the rat and was plugged 35 cm inside and the plugging was visible from outside (5a). There was a second plugging (5b) at 20 cm away from the first plugging. In between the two soil

Fig. No. 32. 23

Curve shows of Pennsylvania Bituminous Coal

FIG. 40. BS. 23.



1. entrance.
3. brood chamber.
4a to 4c - blind alleys.
5a & 5b. soil plugging
depth from the soil surface.

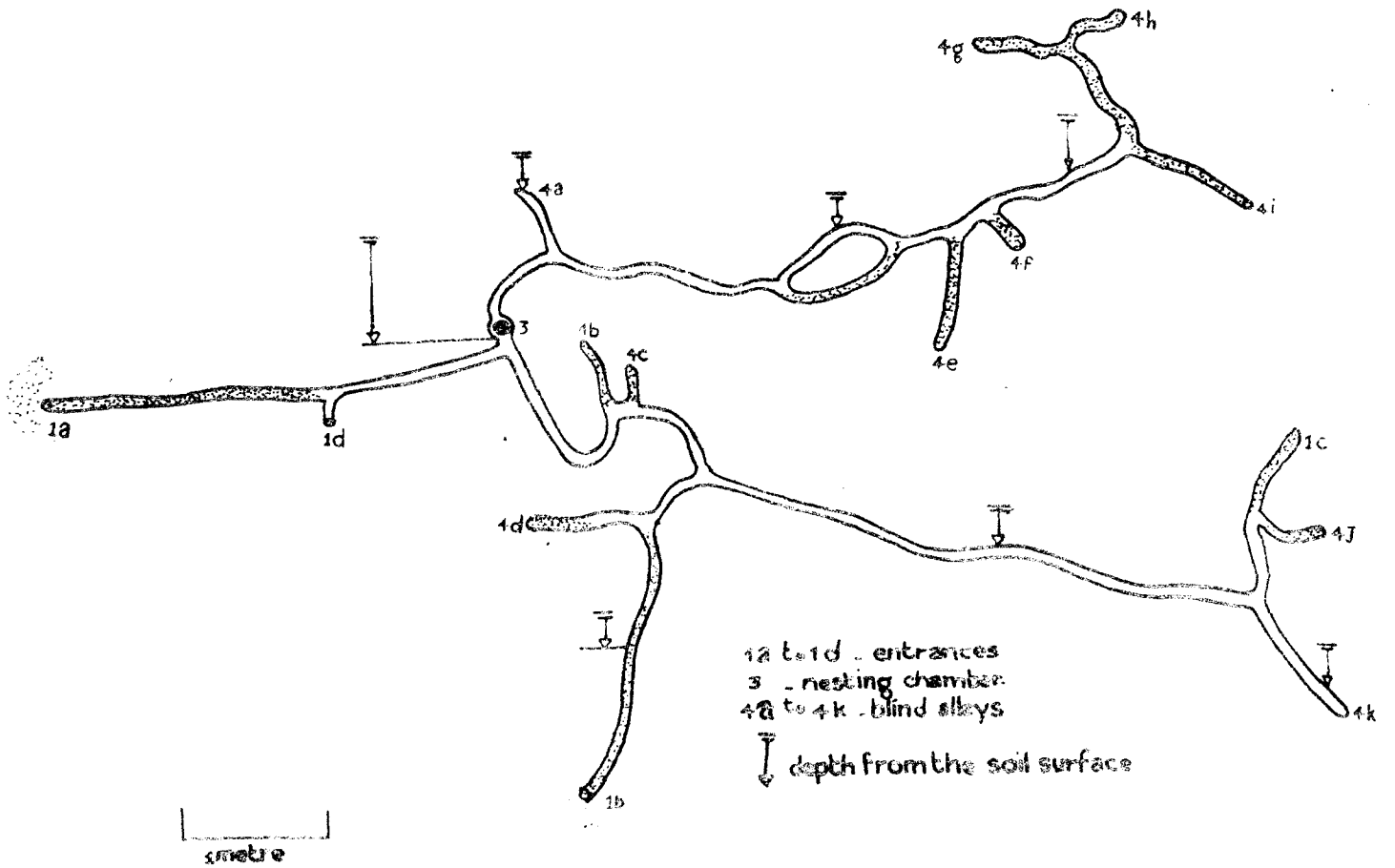
1 metre

pluggings there was a blind alley (5a). The burrow system was interconnected and the interconnecting burrow started from the brood chamber (3) and ended at the base of the blind alley - 4b. The brood chamber (3) was round in shape with a diameter of 20 cm and was placed at a depth of 60 cm. The nesting material comprised of dried grasses. There was a main burrow for the burrow network, starting from the entrance (1a) and ending in a blind alley (4c). There were 3 young rats together with a female, but the mother rat was not found in the burrow. The burrow system had a 'P' shape in general.

3.14 Burrow system 24 (Fig.41)

This was located at Kurianadu in the zone 'Kottayam' district in a tapioca field during February 1979. The soil type was laterite. Total length of the burrow system was 26.91 m and the maximum width was 11 cm. There were four entrances (1a to 1d) to the burrow system out of which two (1a and 1b) were not used by the rat and was filled with soil to a length of two metres each. The burrow opening (1d) was seen opened with neither heap of soil in front, nor soil plugging inside. This entrance is believed to be used for bringing nesting materials to the brood chamber. The rat present in the burrow was an aged pregnant female.

FIG. 41. BS. 24.


4h
4g
4a
4i
4f
4e
3
1b
4c
1a
1d
1c
4d
4J
4k
1b
1a to 1d . entrances
3 . nesting chamber
4a to 4k . blind alleys
depth from the soil surface
1 metre

Out of the 11 blind alleys (4a to 4k) present in the burrow system, 9 were completely filled with soil and out of use. The period of excavation was during summer and hence the soil was very hard. The round shaped brood chamber (3) was at the maximum depth of 69 cm where the humidity was high. Nesting material comprised of dried tapioca leaves and petioles. Major portions of the burrow system were at a depth of 12 cm to 30 cm. The burrow system was ramified to a width of 5.4 m and a length of 9 m. The rat was pregnant and its womb contained three young ones.

4.Bandicota indica indica

Altogether seven burrow systems were studied and the descriptions are as shown below.

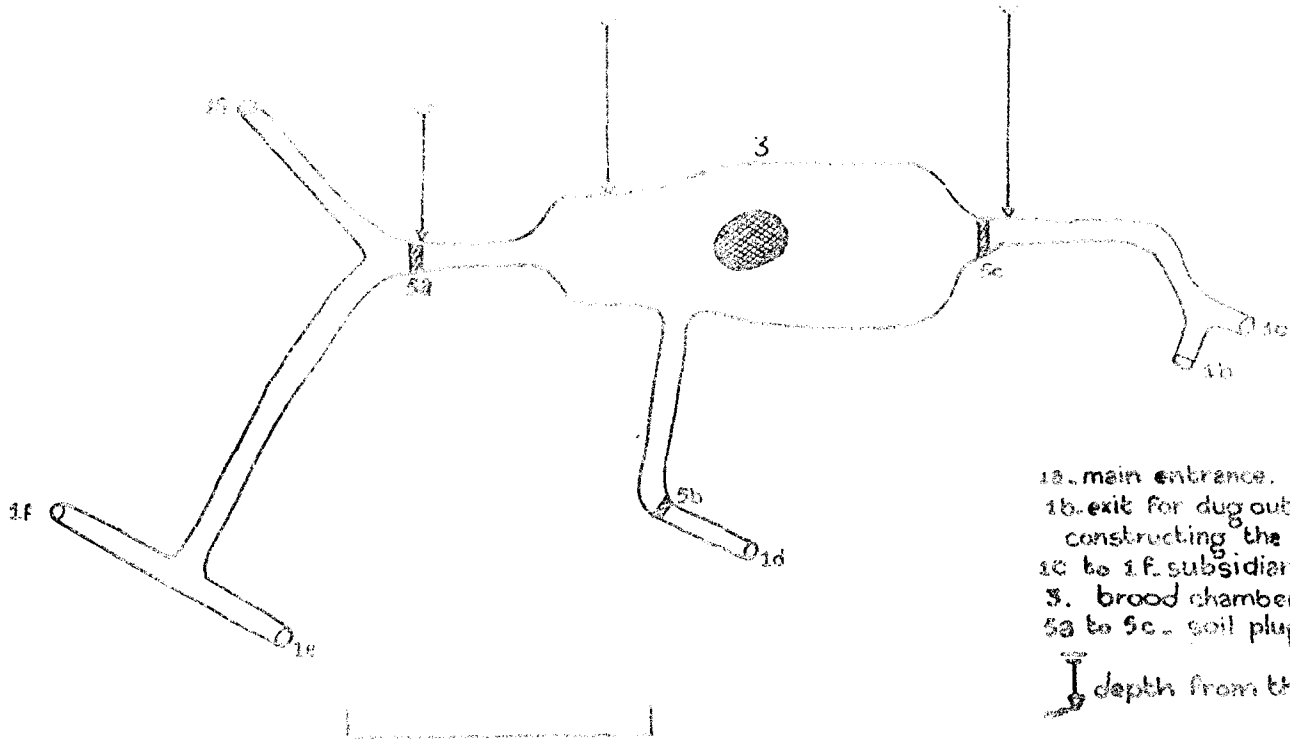
4.1 Burrow system 25 (Fig.42)

The burrow was located at Muthalakodam in the zone 'Idukki and Ernakulam' districts during September, 1978. Tapioca, colocasia and pineapple were grown nearby in laterite soil. The burrow system had a total length of 6.72 m and a depth ranging from 43 to 70 cm. The diameter of the burrow system was in between 5 cm to 50 cm. A total of six burrow entrances (1a to 1f) were noted. The burrow was located near an earthen embankment and the openings

Burrow system of *Bunaloots indios indios*

Fig. 42. B6.25

Fig 12. (S. 95)



1a. main entrance.
1b. exit for dug out while constructing the burrow.
1c to 1f. subsidiary entrance.
3. brood chamber.
5a to 5c. soil plugging
I depth from the soil surface.

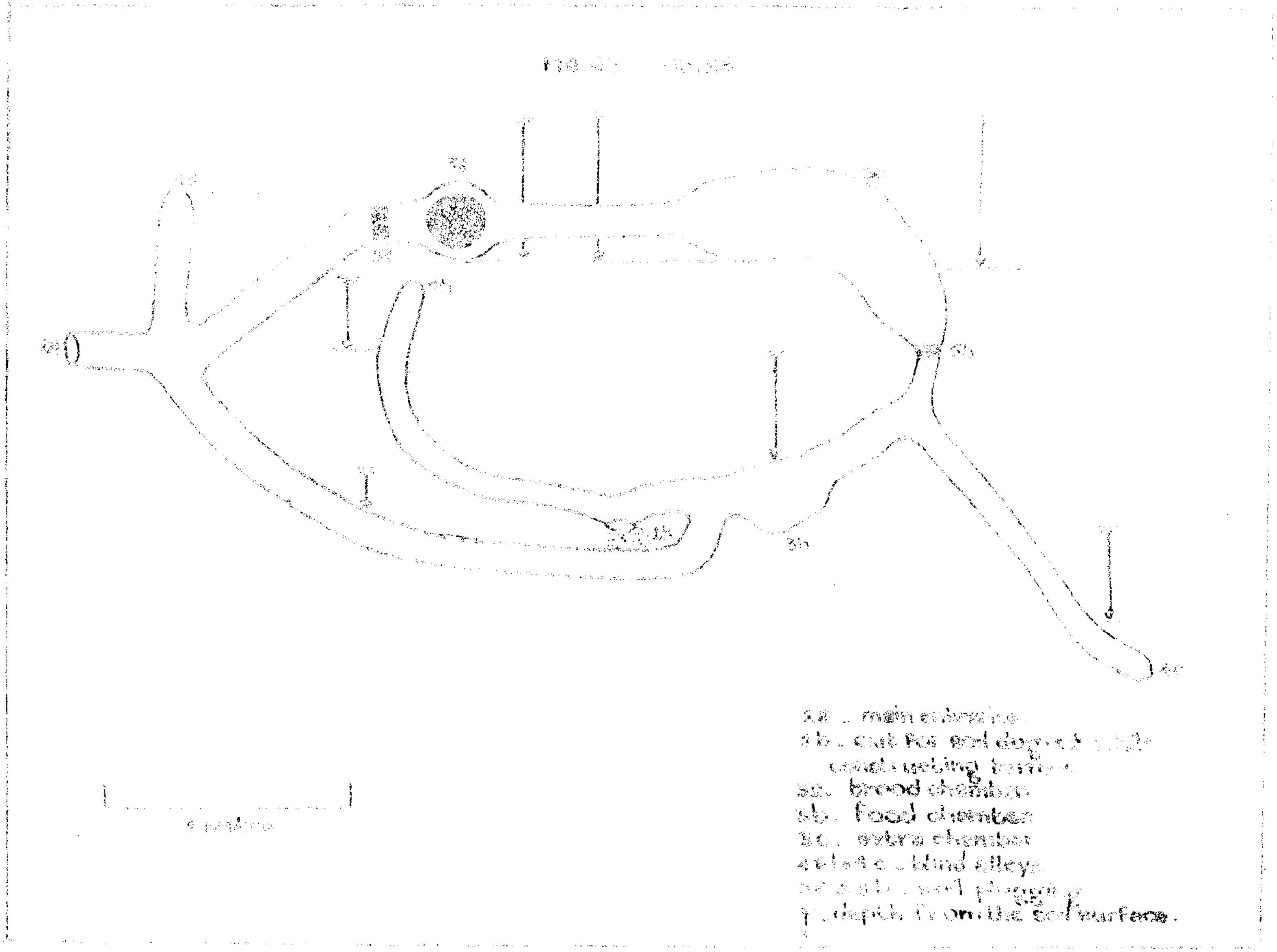
1e, 1d, 1b and 1c were on the embankment. The dugout soil was expelled through a single opening (1b). The main entrance (1a) was concealed under a few pineapple plants. The openings 1b and 1c unite to form a main burrow which was plugged 100 cm inside. Beyond the soil plugging (5c), the main burrow suddenly became large to form a chamber of 140 cm long and with a maximum of 50 cm width. This was the brood chamber (3) with the nest in the centre. The nesting material comprised of dried jack leaves. From one side of the brood chamber a burrow led to an opening (1d) at the earthen enbankment which was also plugged inside (5b). Beyond the brood chamber, the central chamber became narrow and opened to the exterior by three openings (1a, 1e and 1f). The main entrance 1a was very clean with runways in all directions. One mother rat and five young ones were collected from the burrow system.

4.2 Burrow system 26 (Fig.43)

The burrow was located at Muthalakodam on the border of a tapioca field during September 1978. The soil was laterite. Total length of the burrow system was 7.91 m and width ranged from 10 cm to 33 cm and depth

Fig. 45. No. 50

Narrow system of **Bangalore** Indian Indies


main entrance
brood chamber
food chamber
extra chamber
blind alleys
depth from the soil surface.

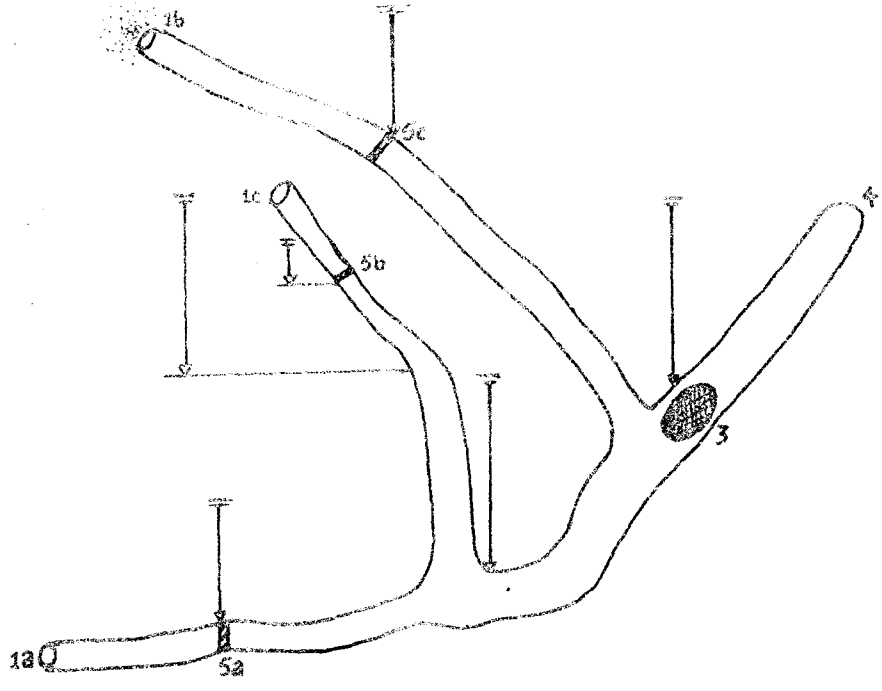
17 cm to 57 cm. The burrow was located near an earthen embankment and the openings 1a and 1b were on the enbankment. But the brood chamber and the connected burrows were under ground level. The soil exit hole (1b) was plugged 1.38 m inside. From this opening the burrow diverged into two, one ended in a blind alley (4b) and the other led to the food chamber (3b) and other chambers (3c and 3a). The main entrance (1a) and the opening 1b were interconnected by a burrow running along the earthen embankment. At the beginning of this burrow, near the soil exit hole (1b) was the food chamber (3b), which was 25 cm wide and in which stored tapioca tubers were found. A blind alley of 1.45 m long leading from near the soil plugging 5b was present. Just after the soil plugging (5b) the burrow enlarged to form a chamber (3c) of 1.72 m long and 21 cm to 33 cm wide. This chamber was connected to the brood chamber by a burrow - length 66 cm and width 16 cm. The brood chamber, round in shape with a diameter of 33 cm was provided with a nest at the centre, made of dried jack leaves. The burrow leading from the main entrance was directly connected to the brood chamber and was plugged (5a) 20 cm away from the brood chamber. The burrow system

was ramified to a length of 4.35 m and width 2.1 m. There were distinct runways from the burrow entrances to the nearby crop fields. One mother and four young ones were present in the burrow system.

4.3 Burrow system 27 (Fig.44)

The Burrow was located at Vellanikkara in the zone 'Trichur and Malappuram' districts, in a rubber plantation. The soil was laterite. The burrow system had a total length of 10.43 m, width 12 cm to 27 cm and depth 60 cm to 90 cm. The entire burrow system was under a large heap of loose soil left aside during the construction of a pond. Altogether there were three openings for the burrow network. The exit hole for soil (1b) was plugged inside 1.9 m. The main burrow started from the main entrance (1a) and ended as a blind alley (4). It branched twice, one led to the soil exit hole (1b) and the other to the opening 1c. These two branches were running almost parallel to each other. The nest was located 80 cm deep in the centre of a large chamber of 2.5 m long and 20 cm to 27 cm wide. The nesting material comprised of dried rubber leaves. Only one female rat was present in the burrow.

FIG. 44. 33. 27.



1 metre

1a. main entrance.
1b. exit for soil dug out while constructing the burrow.
1c subsidiary entrance
3 nesting chamber
4 blind alley
5a to 5c soil pluggings.
depth from the soil surface.

4.4 Burrow system 28 (Fig.45)

This burrow was located at Vellanikkara in laterite soil during December 1978 on a large bund. Crops nearby were tapioca, banana, colocasia and jack. The burrow system had a total length of 13.22 m, width 11 cm to 40 cm and depth 25 cm to 100 cm. There were a total of four openings in the burrow system. A common plugging (5) for the main entrance (1a) and soil exit hole (1b) was present. The main burrow of the system extended from the main entrance and ended in the subsidiary entrance 1c. The three adult females present in the burrow had separate nests in the chambers 3a, 3b and 3c. The chamber 3a was large having a length of 3.1 m and 12 to 30 cm wide while the other two chambers were comparatively small. Nesting chamber 3b was almost round in shape with a diameter of 30 cm, whereas the chamber 3c was 60 cm long and 30 cm to 40 cm wide. Between the soil pluggings 5a and 5b, the depth ranged from 80 cm to 100 cm. Nesting materials included dried jack and banana leaves.

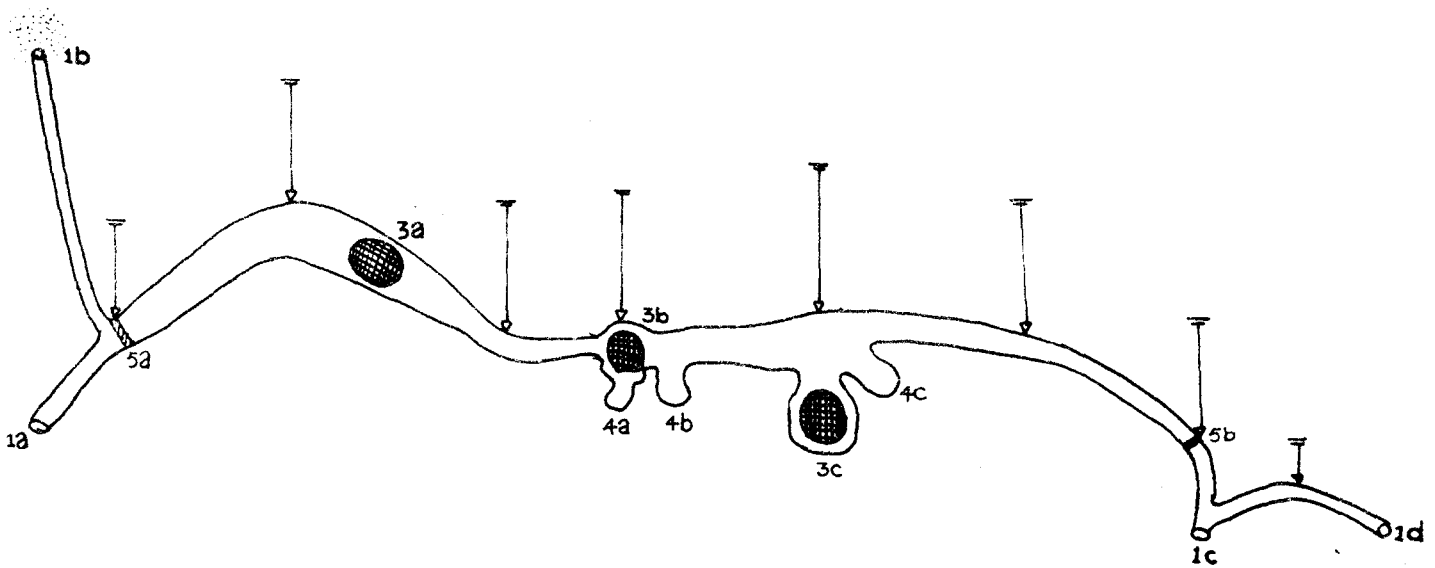
4.5 Burrow system 29 (Fig.46)

This was located at Kuppamudi, Wynad in the zone Calicut district, in laterite soil, at the backyard of a

Fig. 45. No. 28

Burrow system of *Bandicota indica indica*

FIG. 45. BS. 28.



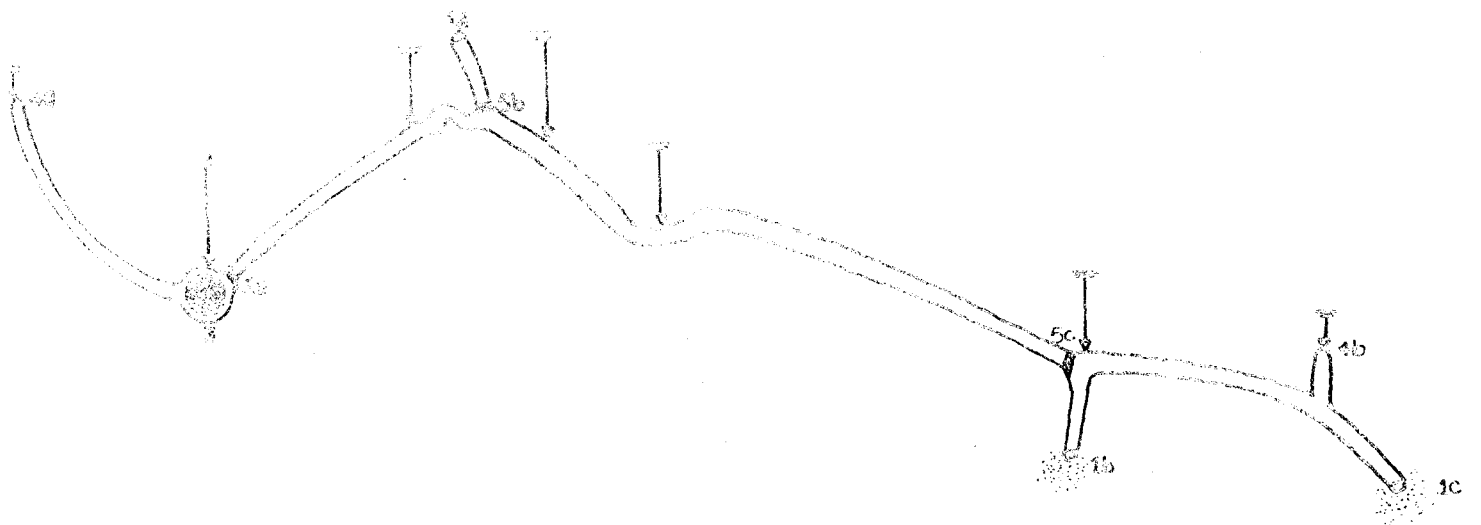
1 metre.

1a. main entrance.
1b - exit for soil dugout while constructing burrow
1c & 1d - subsidiary entrances.
3a to 3c - nesting chambers
4a to 4c - blind alleys
5a & 5b - soil pluggings

depth From the soil surface

Fig. 46. P. 29

Nervous system of Dermacentor <u>indicus</u> <u>indica</u>



1 metre.

1a. main entrance.
1b & 1c exit for soil dug out, while constructing burrow.
2. nesting chamber
4a & 4b - blind alleys.
5a to 5c - soil plugging

depth from the soil surface.

convent, where tapioca, colocasia and yam were cultivated. The burrow system had a total length of 12.47 m and width 10 cm to 32 cm. The main burrow extended from the soil exit hole 1c to the blind alley 4a. The dug out soil was thrown out through the openings 1b and 1c. Both these exit holes had a common plugging at 5c. The main burrow branched into two at 4.53 m away from this plugging, one leading to the main entrance (1a) and the other leading to the nesting chamber (3). The main entrance was also plugged inside (5b). The nesting chamber was circular in shape with a diameter of 32 cm. A blind alley(4a) branched off from the nesting chamber (3). Just before the nesting chamber the burrow was closed with nesting materials (5a). The nesting materials included dried leaves of jack, dioscoria, amorphophalus, coffee, grass and also few cardboard bits. The nest in the nesting chamber was found scattered. The depth of the burrow at the place of nesting chamber was 65 cm and the maximum depth of the burrow system was 75 cm. The main entrance (1a) was located at the base of a standing colocasia and few tubers of it were seen damaged by the rat. A partly eaten dried jack seed was found inside the burrow. Only one female rat was present in the burrow system.

4.6 Burrow system 30 (Fig.47)

It was located at Kuppamudi in laterite soil in the frontyard of a house during December 1978. Total length of the burrow system was 8.57 m with a diameter of 9 cm to 32 cm and depth 27 cm to 58 cm The only one opening (1a) of the burrow system was located at the side of an earthen embankment. The main burrow extended from the blind alley 4a to 4d. The entrance was plugged inside as usual. The depth of the burrow at the site of the blind alley (4a) was only 7 cm. The burrow system was spread to a length of 3.9 m and width 1.6 m. The shape of the brood chamber was round, placed at a maximum depth of 55 cm. The nesting materials comprised of dried banana leaves and leaf sheath, coffee leaves, bits of plastic paper and a few tapioca rinds. The mother rat and four young ones were present in the burrow system.

4.7 Burrow system 31 (Fig.48)

The burrow was located during January 1979 at Cherupuzha in the zone Cannanore district in laterite soil. The total length of the burrow system was 12.54 m with a diameter of 8 cm to 25 cm and depth 30 cm to 95 cm. The soil exit hole (1b) was located on a small earthen

Fig. 47. Pg. 50

Larva eyespot of Bandicota indica indica

FIG. 47. BS. 30.

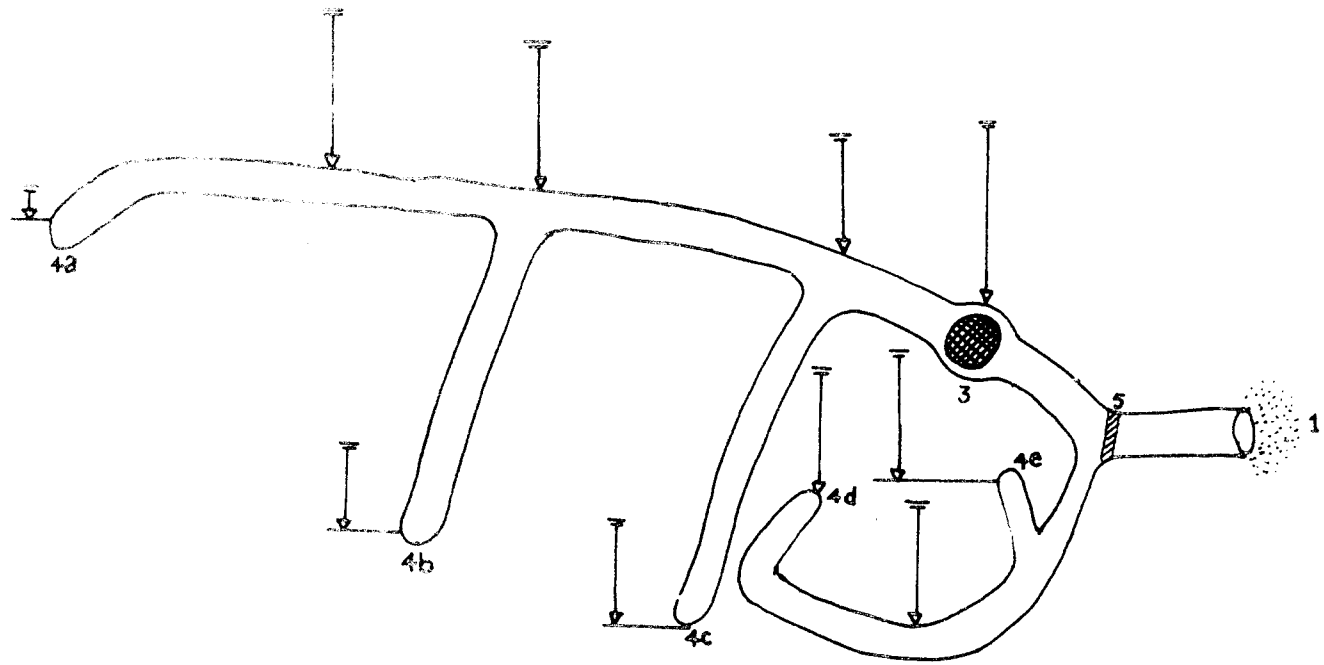
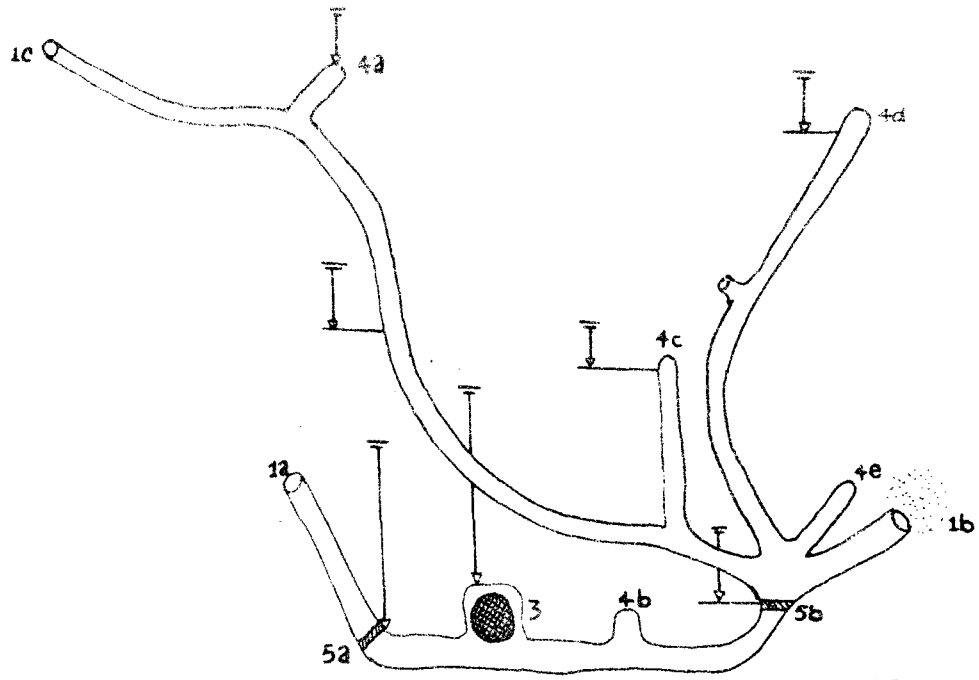

4a
4b
4c
4d
4e
3
5
1
1 metre
1. entrance
3. brood chamber
4a to 4e. blind alleys
5. soil plugging
depth from the soil surface.

Fig.43. Dr.M

Micro system of Semitone Index Index



1 metre

1a. main entrance
1b - exit for soil dug out while constructing burrow.
1c & 1d - subsidiary entrances.
3 - brood chamber
4a to 4e - blind alleys
5a & 5b - soil plugging

depth from the soil surface.

embankment and was plugged 50 cm inside (5b). One main burrow for the burrow system extended from the main entrance (1a) to the exit hole 1b. The main entrance was also plugged, one metre inside (5a). The rat was confined to the region between the two soil pluggings and the rest of the burrow system was left unoccupied. The brood chamber was some what square shaped having a maximum width of 25 cm and was placed at a depth of 95 cm. Beyond the soil plugging 5b, the main burrow branched into four, two of which ended in blind alleys (4d, 4e) and the others in subsidiary openings (1c and 1b). The length of the burrow system inside two soil pluggings, in which the rat was present was only 2.35 m whereas the length of the burrow outside the pluggings was 10.19 m. The depth of the burrow in between the soil pluggings 5a and 5b was 45 cm to 95 cm and for the rest of the burrow system the depth varied between 20 cm to 30 cm. The burrow system was ramified to a length of 4.1 m and width 3 m. One mother rat and three young ones were present in the burrow. The brood chamber was devoid of any nest and only a bit of plastic sheet was present inside the brood chamber.

5. Mus platythrix

Altogether five burrows were studied. The details are given below.

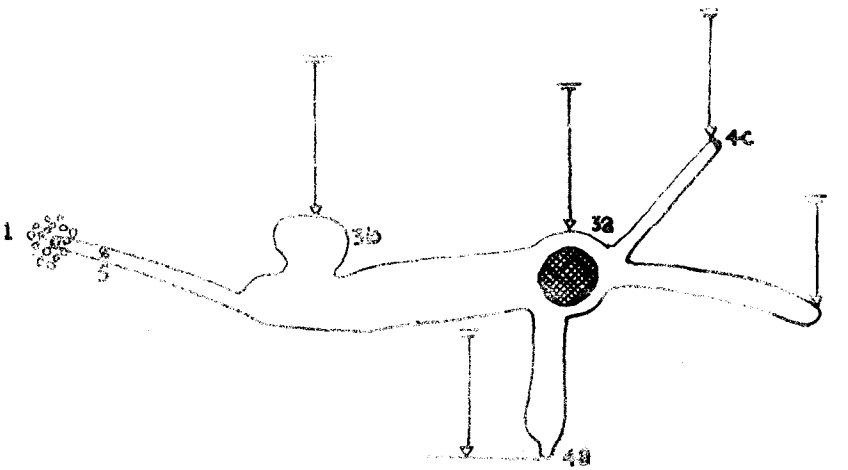
5.1 Burrow system 32 (Fig.49)

The burrow was located in a tapioca field at Thiruvazhiyadu at Palghat district in laterite soil during October 1978. Total length of the burrow system was 1.67 m.with a diameter of 2 cm to 14 cm and depth 16 cm to 25 cm. The only one opening (1) to the burrow system was encircled by pebbles. The opening was sealed 8 cm inside with pebbles (5). The diameter of the entrance burrow was 2 cm at the beginning and it suddenly enlarged 31 cm inside to form a central chamber which constituted the brood chamber (3a) and a semicircular extra chamber (3b), the purpose of which is not known. The blind alleys 4a to 4c directly branched off from the brood chamber. The brood chamber having a diameter of 14 cm was at a depth of 23 cm. Few pebbles were found scattered inside the burrow. The dug out soil was not heaped near the burrow entrance. One mother and three young ones were collected from the burrow system. The nest was made up of

Fig. 49. pg. 32

Burrow system of Mus pinetorum

FIG. 49 PL. 32.



1 entrance.
3a brood chamber.
3b extra chamber.
4a to 4c blind alleys.
5 pebble plugging.
depth from the soil surface.

1 metre

dried tapioca leaves.

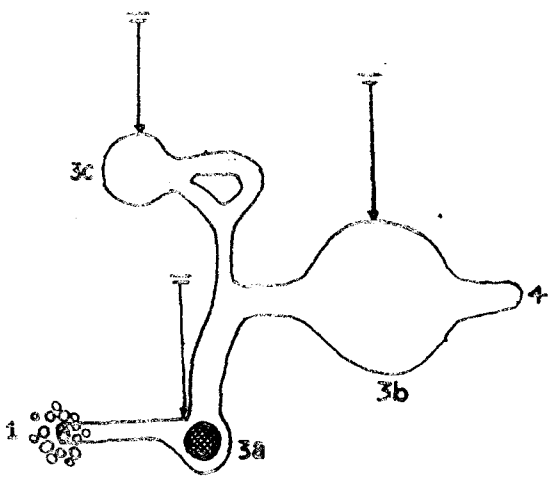
5.2 Burrow system 33 (Fig.50)

It was located during October 1978 at Melarkode, Palghat district, under teak plantation in laterite soil. The burrow system had a total length of 1.35 m, diameter ranging from 3 to 33 cm and depth 18 to 23 cm. The only entrance (1) to the burrow system was closed by pebbles at the entrance, which was encircled by pebbles. The burrow system consists of three distinct chamber (3a to 3c) of which 3a was the nesting chamber and the other two chambers were of unknown use. The nest was made up of dried rosewood leaves. The nesting chamber had a diameter of 10 cm and was at a depth of 23 cm. One male and one female mouse was present in the burrow. The soil removed while constructing the burrow was not heaped near the burrow entrance.

5.3 Burrow system 34 (Fig.51)

It was located at Vellanikkara, Trichur district in gravelly soil during October 1978. The burrow system had a total length of 102 cm, diameter 4 to 6 cm and depth 20 to 40 cm. It had two entrances (1a and 1b) and both of

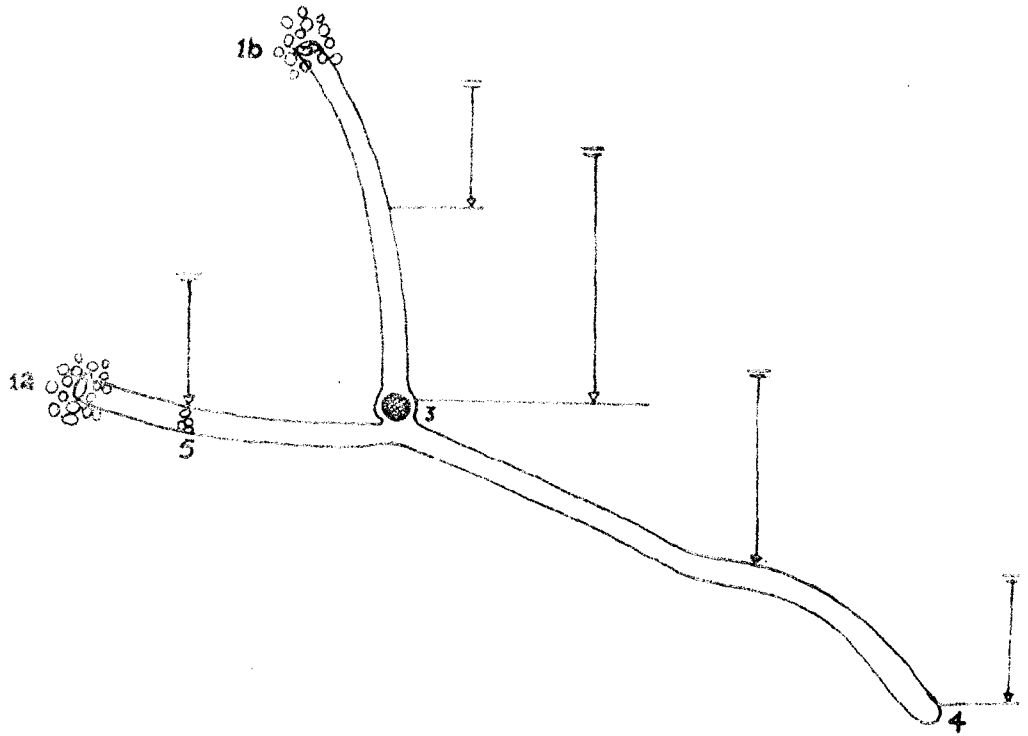
FIG. 50. BS. 33.



1. entrance.
3a - nesting chamber
3b & 3c - extra chambers
4 - blind alley
depth from the soil surface.

1 metre

FIG. 51. BS. 34.



1 metre

1a. main entrance
1b. subsidiary entrance.
3. brood chamber.
4. blind alley
5. pebble plugging
. depth from the soil surface.

these were encircled by a ridge of pebbles. The main entrance (1a) was clean and open with runways in all directions and plugged 17 cm inside with pebbles (5). The entrance-1b was concealed by pebbles arranged in a circular manner. The burrow system had a 'Y' shape and the burrow starting from the entrances formed the forks of the 'Y'. At the base of the burrow, starting from the entrance-1b was the round shaped brood chamber (3) with diameter of 6 cm. The tail of the 'Y' had a length of 50 cm which ended in a blind alley (4). The brood chamber was at the maximum depth (40 cm) of the burrow system. The nesting materials included dried leaves and stems of cowpea and dried leaves of rubber. Only one adult male was present in the burrow. The dug out soil was not heaped near the entrances. The burrow system was spread to a length of 140 cm and width 110 cm.

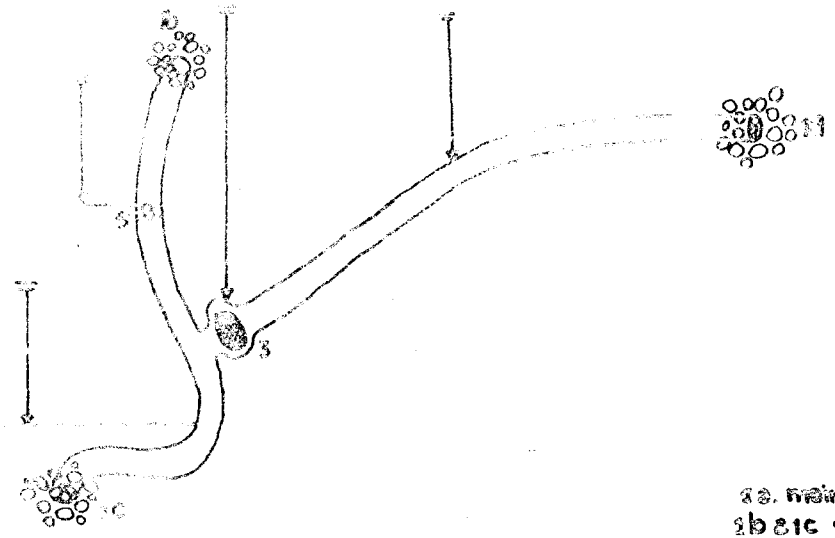
5.4 Burrow system 35 (Fig. 52)

This was located in a cowpea plot at Vellanikkara, in gravelly soil during October 1978. Total length of the burrow system was 2.04 m, diameter 8 cm and depth 20 to 48 cm. The burrow system was very simple and somewhat 'Y' shaped in appearance. There were three entrances (1a,

Fig. 32. [illegible]

[illegible] to motor [illegible]

FIG. 52. BB. 55.



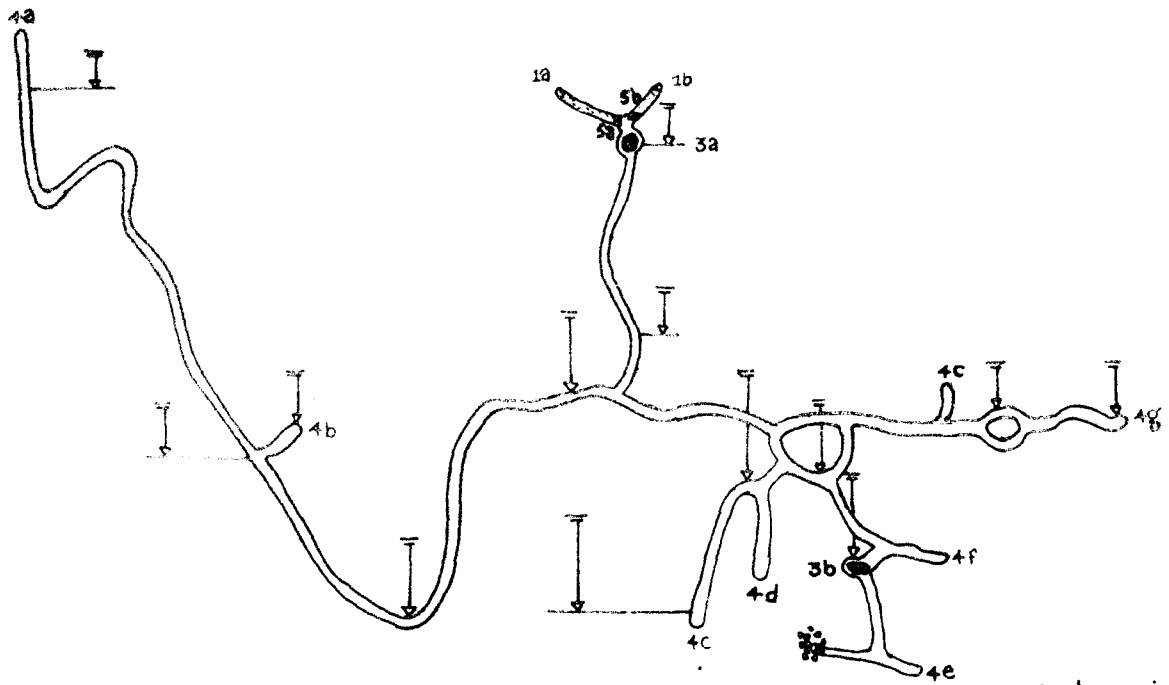
1a. main entrance.
1b & 1c subsidiary entrances.
2. nesting chamber.
3. pebble plugging
↕ depth from the soil surface.

1b and 1c), encircled by ridges of pebbles. The ridge was larger in size at the entrance 1a. The openings 1a and 1c were plugged with pebbles at the ground level and entrance 1b was plugged 22cm inside with pebbles. The nesting chamber (3) was at a depth of 48 cm and somewhat circular in shape with a diameter of 8 cm. The dugout soil while constructing the burrow was not seen heaped near any of the three entrances. The nesting material was made up of dried cowpea stems. One mother, eight young ones and an adult male was present in the burrow system. The burrow system was ramified to a length of 110 cm and width 70 cm.

5.5 Burrow system 36 (Fig.53)

This was located in a cotton field at Thavalam, Attappady during February 1979. The soil was laterite the Burrow system had a total length of 20.4 m, diameter 3 to 10 cm and depth 20 to 57 cm. The period of excavation was during extreme summer and the soil was hard like rock. In contrast to the previous burrows there were two main entrances (1a and 1b) for the burrow system with runways on all directions. These main entrances were devoid of any pebbles. Just before the union of the

FIG. 53. BS. 36.



1 metre.

1a & 1b main entrances.
1c subsidiary entrance
3a & 3b. nesting chambers.
4a to 4f. blind alleys.
5a & 5b. pebble plugging

depth from the soil surface.

burrows leading from the main entrances they were plugged inside (5a and 5b) by a few pebbles. The circular shaped nesting chamber (3b) was located immediately after these pluggings. In this chamber, an old, worn out nest made up of dry leaves of cotton was noted. The width of burrows upto the nesting chamber (3b) was 3 cm and the rest of the burrows had a diameter of 6 cm except the brood chamber where it was having 10 cm diameter. The nesting chamber (3a) was at a depth of 24 cm. The burrow system was interconnected. There were altogether three entrances and the subsidiary entrance 1c was closed with pebbles as well as encircled by pebbles. The brood chamber was at 54 cm deep and the maximum depth of the burrow system was 57 cm. The nesting material inside the brood chamber was dried leaves of rosewood. The burrow system was ramified to a length of 7.2 m and width 4.2 m. There were two adult males, one mother and three young ones in the burrow system.

6. Mus saxicola

Only one burrow system was located. The details are as shown below.

6.1 Burrow system 37 (Fig.54)

It was located at Vellanikkara in laterite soil during October 1978. The burrow system was very short without any branches and ended in a blind alley (4). Only one entrance (1) and it was plugged with pebbles at the ground surface. Pebbles were also seen encircling the entrance. The burrow had 3 to 11 cm diameter and 30 to 40 cm depth. The brood chamber was at a maximum depth of 40 cm and it had a diameter of 11 cm. The nest was made up of dried cowpea stems. One mother and seven young ones were present in the burrow.

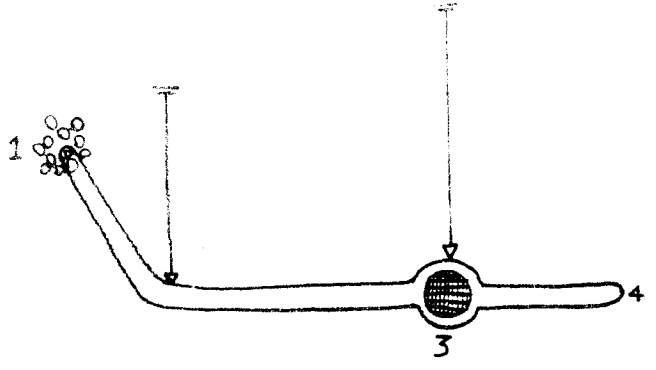
7. Mus booduga booduga

Altogether four burrow systems were studied and the details are given below.

7.1 Burrow system 38 (Fig.55)

This burrow was located at Vellanikkara in laterite soil during October 1978 on the side of an earthen embankment. Total length of the burrow system was 1.14 m with a diameter ranging from 2 to 11 cm and depth 10 to 36 cm. It was a simple and short burrow with only one opening (1).

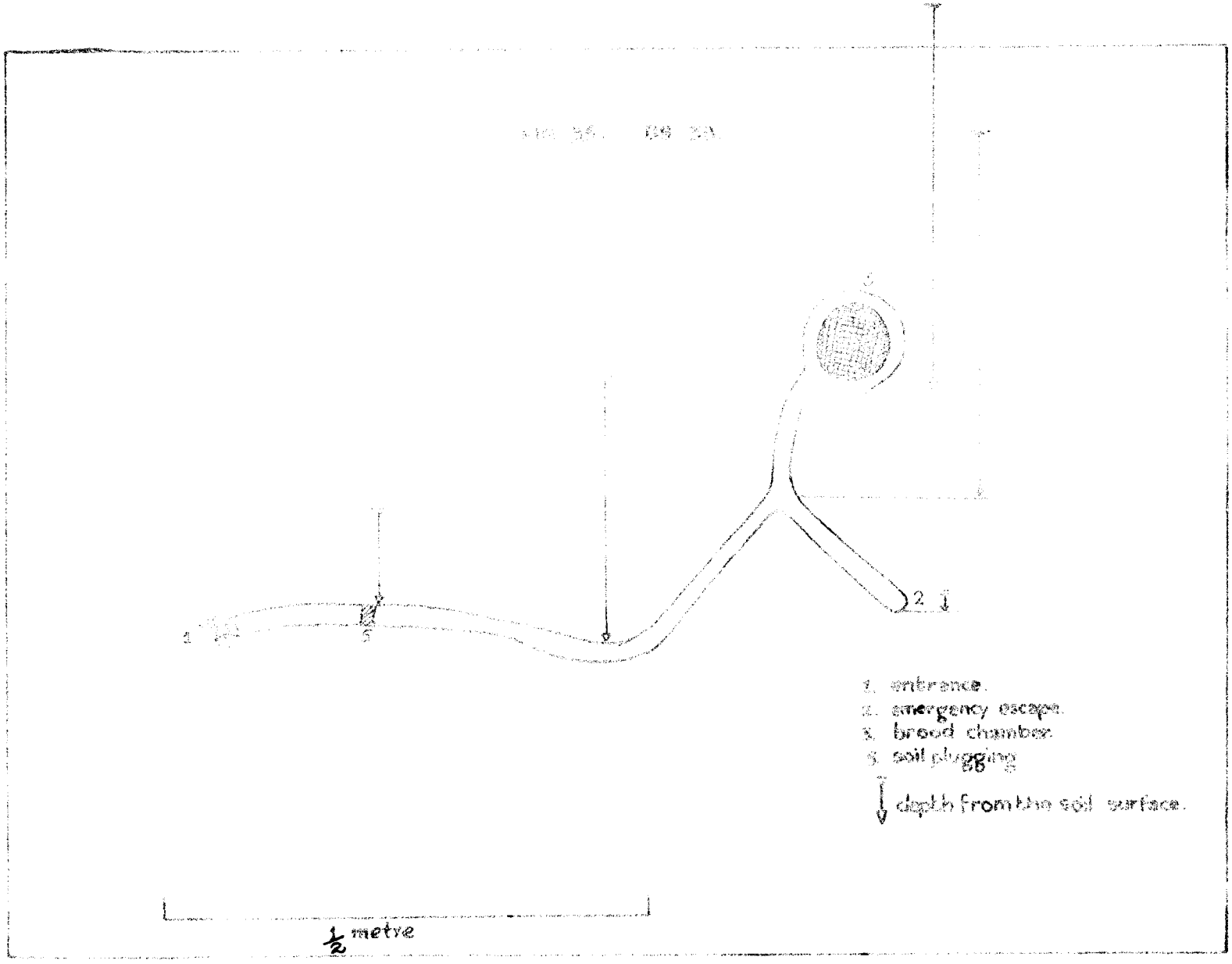
FIG. 54. BS. 57.



1 . entrance.
3 . brood chamber.
4 . blind alley

depth from the soil surface.

1 metre


1. entrance.
2. emergency escape.
3. brood chamber.
4. soil plugging.
depth from the soil surface.
½ metre

The entrance was plugged 16 cm inside. The burrow branched into two 58 cm away from the soil plugging (5). One branch ended in an emergency escape (2) while the other terminated in a blind alley with the brood chamber (3) at its end. The brood chamber was round in shape, diameter 11 cm, and was placed at a depth of 36 cm. The emergency escape was not opened to the exterior. The burrows excluding the brood chamber had a diameter of 2 cm. One mother and seven young ones were present in the burrow system. The nesting material comprised of dried rubber leaves.

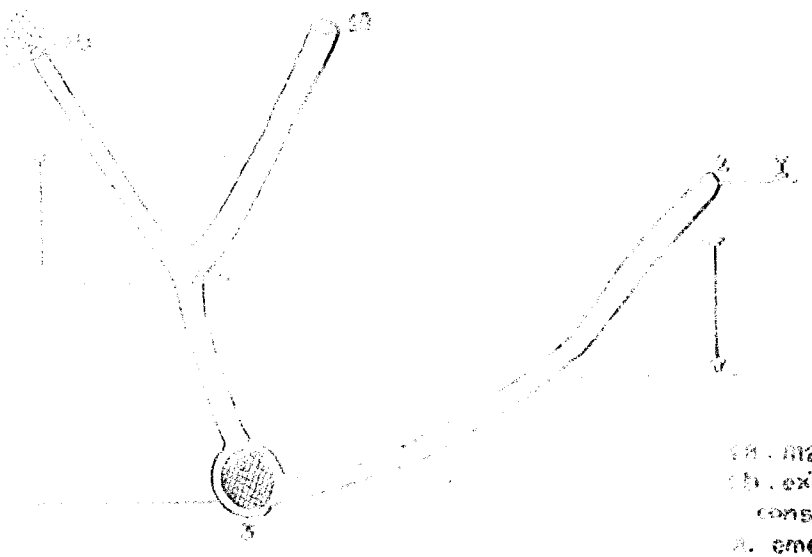
7.2 Burrow system 39 (Fig.56).

It was located at Vellanikkara in laterite soil during October 1978 on the side of an earthen embankment. The burrow system had a total length of 102 cm, diameter 2 to 6 cm and depth 10 to 20 cm. The burrow starting from the main entrance (1a) and the one from the soil exit hole (1b) were of equal length and they united to form a main burrows. A soil plugging (5) at the union of these two burrows was noted. The round nesting chamber (3) of 6 cm diameter was located 14 cm away from the soil plugging. It was at a maximum depth of 20 cm. The

Fig. 36.

Burrow system of the pocket gopher

FIG. 38. FIG. 39.



a. main entrance
b. exit for soil dug out while constructing the burrow
c. emergency escape
d. nesting chamber
e. soil plugging
depth from the soil surface.

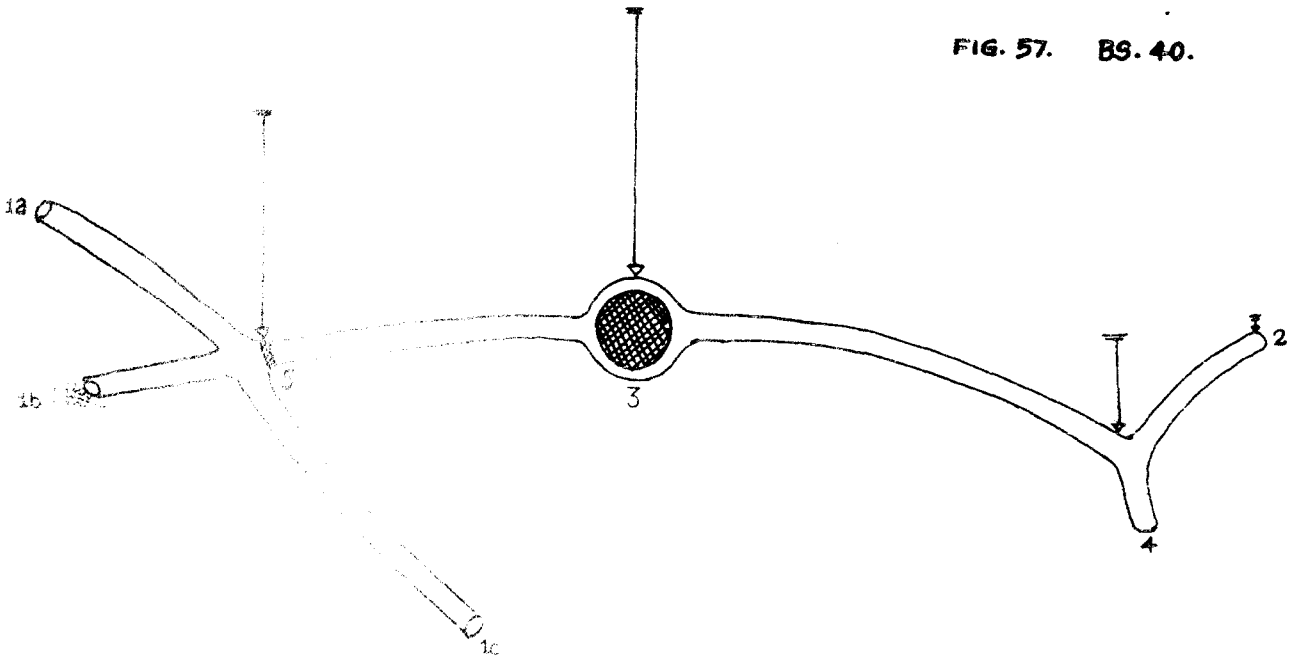
1/2 actual size

nesting material used was dried rubber leaves. The burrow leading from the nesting chamber ended in an emergency escape (2) near the soil surface. In general the burrows had 2 cm diameter. Including the emergency escape there were three openings for the burrow system which was ramified to a length of 55 cm and width 40 cm. Only one adult male was present in the burrow.

7.3 Burrow system 40 (Fig.57)

This was located at Vellanikkara in laterite soil during October 1978 on the side of an earthen embankment. The total length of the burrow system was 1.3 m, diameter 2 to 8 cm, and depth 5 to 22 cm. There were a main entrance (1a), exit hole (1b) for removal of soil from the burrow and a subsidiary entrance (1c) for the burrow system, in addition to the emergency escape (2). The burrows starting from the three entrances 1a, 1b and 1c united to form a main burrow with a common plugging (5). The round nesting chamber (3) of about 8 cm diameter was at the centre of the main burrow. The nesting material was dried banana leaves. The emergency escape (2) was not opened to the exterior. One adult male and two females

FIG. 57. BS. 40.



1a. main entrance
1b. exit for soil dug out while constructing the burrow.
1c. subsidiary entrance.
2. emergency escape.
3. nesting chamber.
4. blind alley.
5. soil plugging.

Depth from the soil surface.

½ metre

were present in the burrow. The maximum depth of the burrow system was at the point of brood chamber.

7.4 Burrow system 41 (Fig.58)

This was located at Kuppamudi in Wynad, Calicut district during December 1978 in a paddy field bund. The total length of the burrow system was 2.19 m, diameter 2 to 12 cm and depth 25 to 31 cm. The round brood chamber was having 12 cm diameter and located at the deepest part of the burrow system. There was a main entrance (1) and two emergency escapes (2a and 2b) for the burrow system. The emergency escapes were not opened to the exterior. The burrows leading from the main entrance and the emergency escapes united together near the brood chamber. Paddy straw was used for making nest. One adult female was present in the burrow.

Fig. [illegible]

Narrow section of the [illegible] [illegible]

1 . entrance
2 . emergency escape
3 . nesting chamber
4 . soil plugging

depth from the soil surface

DISCUSSION

DISCUSSION

In order to study the distribution of different species of rats and their burrow patterns in the State, a detailed survey was conducted in different parts during September 1978 to February 1979. For the survey work, the State was divided into eight agro-climatic zones. An extensive collection of the different indigenous rat traps used in different parts of the State was made and their utility for capturing different species of rats was ascertained. The various aspects studied during the survey work are discussed below.

1. Tatera indica cuvieri

This species was found in all the zones except Wynad and Parts of Idukki districts. It is found that places of higher elevations are not occupied by these rats.

Of the four subspecies of T. indica only T. indica cuvieri is so far found present in Kerala. This finding is in accordance with the observations made by Ellerman (1961) that the South Indian species of T. indica belong to T. indica cuvieri.

Burrows of T. indica cuvieri were found under diverse conditions such as in fields cropped with pulses, ginger, rubber, backyards of houses, thick grass growth around cotton fields teak plantations and barren waste lands. Krishnakumari (1968) and Yasoda (1968) mentioned its presence in cultivated areas and in open fields. It is now found that these rats live in a wide range of other habitats too. Their burrows were found located inside the crop fields, though Srinivasamurthy (1972) reported that their burrows were located along the bunds of cultivated lands.

Pingale et al. (1967) reported that the burrows of T. indica were elongated consisting of winding passages, a number of emergency escapes and a breeding or living chamber in the centre. However, during the present study, certain burrows were found quite simple in construction (BS. 4,5 and 7) while in certain other cases (BS. 1 and 3) there was only one emergency escape each. Another marked deviation was that the brood chamber/living chamber was not always centrally located (BS. 1,3,4,6,7 and 8). Thus the present studies indicate that the burrows of T. indica cuvieri may be simple, or elongated with winding passages having one or more emergency escapes and with or without a central chamber. The burrow width of T. indica ranged

from 4 cm to 25 cm. Sundara Bai (1972) reported that the diameter ranged between 9.6 cm and 19.4 cm. According to Yashoda (1968) live burrow systems of F. indica can be traced out by the presence of beaten pathways from one opening to the other and left-over cut bits of leaves and slender branches across the pathways. The present study clearly shows that the presence of a soil plugging in the burrow exhibiting the above mentioned character is more dependable and fool proof. Such a finding is reported for the first time.

All the burrows studied had one or two entrances without heaps of soil and an exit hole for throwing out the soil at the time of construction of the burrows. In addition to this there was invariably one or more emergency escapes. Thus there were a minimum of three openings including the emergency escape. This finding is in accordance with the report of Barnett and Iswar Prakash (1975). However Yashoda (1968) reported 2 to 4 openings and Bindra and Prem Sagar (1975) reported 1 to 10 surface openings.

It has been further noted that in all the cases the soil dug out while constructing the burrow was thrown

out through a particular opening and this phenomenon is not seen reported earlier.

According to Bindra and Prem Sagar (1975), certain surface openings of F. indica burrow systems are blocked with a small quantity of soil and are used only in emergency for escape. But according to the present study such blocked surface openings were not at all observed. The burrow leading to the emergency escapes stops abruptly 1 cm to 3 cm below the soil surface thereby leaving a crust of soil undisturbed for subsequent usage as emergency escapes by rapid pushing off of the crust.

Yashoda (1968) has reported that the nests were located in the concealed chamber. But this was not true in the burrow systems 1,2,3,5 and 7. According to Yashoda (1968) F. indica build nests with hay and leaves collected from the nearby places Srinivasachar (1972) found nests of grasses in the nesting chamber. During the present investigation different types of nests were found such as nests made up of (i) dried tea leaves (ii) dried grasses (iii) dried leaves of Terminalia paniculata (iv) dried rubber leaves (v) dried cowpea shoots and (vi) bits of coconut roots + dried grass + dried stem of

eupatorium. So it is inferred that the nesting materials will depend on the nature of the vegetation of the surroundings.

Only one to three adults were caught from a single burrow as against one to five adults collected by Sundara Bai (1972). The litter size varied from 3 to 6 but Yasnoda (1968) recorded 8 to 12 and Barnett and Iswar Prakash (1975) reported 2 to 9.

Usually T. indica cuvieri is seen wandering in open plains especially along roads during night hours. So it seems that these rats have a tendency to wander in open grounds. Burrows of T. indica were found in areas where there were no crops or human dwellings and with only wild grass growth. In these places the rats may be depending on insects, grasses and similar things for its food.

Yasnoda (1968) and Sundara Bai (1972) reported these rats to feed on grains, roots, leaves etc. But according to Srinivasachar (1972), in addition to the above items they feed on jowar and bajra. The present study revealed that in Kerala T. indica cuvieri damages tapioca, pulses, paddy, jowar and cotton. It also causes

damage to ginger crop by burrowing the bed and exposing the rhizomes.

2. Rattus norvegicus

According to Ellerman (1961), Pingale et al.(1967) and Barnett and Iswar Prakash (1975), R. norvegicus was reported to be commensal, seen mainly in ports, large towns, villages, along the banks of navigable rivers and on high roads. During the studies these rats were collected from interior places of Thodupuzha (Idukki district) and Melarkode (Palghat district) far away from ports and towns. They are also not necessarily commensal in habit and are found to be a severe threat to the paddy growers in Kuttanadu and Idukki areas. They damage paddy during the period between the tillering and booting stage, the maximum attack being during the latter stage. Anyhow, these rats never attack paddy after the earhead emergence. These are new reports on R. norvegicus in India.

The burrows of R. norvegicus were located on paddy field bunds. The litter size collected from a burrow was 12. The burrow system studied was (BS.10) partly submerged in water. Food materials were not stored in the burrow system except an earhead of paddy and two snails.

3. Bandicota bengalensis bengalensis

The present study revealed that in Kerala burrows of B. bengalensis were seen in garden lands where tapioca, colocasia, yam etc. were cultivated and in rubber plantations, cocconut gardens, orchards and thick forests. Burrows were also located along paddy field bunds. This finding was in variance with the observation of Ramakrisnnan (1968) that B. bengalensis was confined to rice fields and was in accordance with the observations of Krishnakumari (1968) and Yashoda (1968) that this species was found to inhabit the border and bunds of cultivated plains, gardens and pasture lands.

The burrows of B. bengalensis were located in all types of soils, both dry and moist, though Yashoda (1968) reported that B. bengalensis prefered to dig burrows in fine and moist soil. Krishna Ayyar (1931) found that the burrows of B. bengalensis were long, extensive and some what complicated and they extended upto 20 to 30 feet or even more. During the present studies certain burrows were found quite simple and short (BS. 14,19,20,21 and 23) and the rest of the burrows were long and extensive. The maximum length obtained for a burrow was 59.11 m as against 30 m observed by Deoras (1962).

The number of openings for the burrow system varied from 1 to 13 as against 4 to 5 openings, recorded by Krishna Ayyar (1931). According to him the burrows seldom went down beyond a depth of 60 cm. Deoras (1962) recorded a depth of 72.5 cm. But under the present investigation a maximum depth of 90 cm was recorded (BS.22).

Only one rat or rarely two were found to inhabit a burrow as reported by Krishna Ayyar (1931). Anonymous (1965) observed only one adult rat per burrow. The present study revealed that in general there was only one adult rat in a burrow, but in one case (BS. 15) three females, two males and six young ones were captured. Although there were five adults in the burrow network, only one nest was present inside.

Prem Sagar and Bindra (1973) noted that the brood chamber/bed chamber was located at the centre and at the maximum depth of the burrows. In the present investigation the brood chamber was found at the centre of the system, only in BS. 15 and BS. 23. In burrow systems 11,13,16,17, 18,23 and 24 the brood chamber/nesting chamber was placed at the maximum depth, whereas in other cases the brood chamber/nesting chamber was not found at the maximum depth of the burrow system.

Prem Sagar and Bindra (1973) recorded that in the burrows inhabited by males, the bed chamber will not be provided with nest but in burrow systems 21 and 22 in which male rats were present, contained nests.

Wagle (1927), Deoras (1966) and Chakraborty (1975) observed B. bengalensis hoarding food in their burrows, and there were definite food chambers in the burrow system for storing food materials. But during the present investigations, out of the fourteen burrows of B.bengalensis studied, three (BS. 13,14 and 23) were on paddy field bunds and only the burrow system - 13 contained stored paddy. Here the grains were stored throughout the length of the burrow network with only a little space for the rat to move about. In a State like Kerala, with ever green vegetations, the rats are assured an abundant supply of food throughout the year and hence may not be necessary for them to store food inside their burrows. The burrow system - 18 contained an adult male and a female rat and were found in isolated compartments of the burrow system. According to Prem Sagar and Bindra (1973), the males and females of B. bengalensis generally occupied separate chambers.

A main tunnel for the burrow system, as observed by Yashoda (1968) was not always found in Kerala except in a

few cases where the burrow was located on a field bund. In other circumstances, the burrow systems followed no special pattern.

The findings of the present investigation agree with that of Pisharody and Thampan (1976) that B. bengalensis bengalensis operate in complete darkness and can detect food from underneath the soil and can reach the food exactly at the right spot by burrowing across underneath the soil surface and if someone opens the burrow at any point, the rat would return immediately to close the opening with soil.

The young ones of B. bengalensis were found in burrows during October, January and February and this is in accordance with the findings of Pingale et al. (1967) that breeding occurred during September-October and January-March and in variance with the findings of Prem Sagar and Bindra (1973) that the progenies were produced throughout the year except January, February and September.

In general the burrows of B. bengalensis were seen in diverse conditions. It was seen in both wet and dry conditions. In dry lands there was no definite pattern for the burrow system and a main tunnel was also lacking. In Kerala B. bengalensis are more predominent in garden

lands than in wetlands. In certain localities such as Kuttanadu and Idukki districts its presence in paddy fields is very rare. Among the various burrows examined on field bunds, only very few contained hoarded paddy.

4. Bandicota indica indica

B. indica indica is distributed all over Kerala. These rats were collected from different parts of the State. According to Barnett and Iswar Prakash (1975) and Yashoda (1968) B. indica is commensal and is found to live around human dwellings and in close association with man. During the present study B. indica indica specimens were collected from areas under tuber crops such as tapioca, colocasia, yam etc., and from the borders of rubber plantations, paddy fields and the backyard of houses. In areas such as Idukki, Kottayam, Cannanore, Trivandrum and Ernakulam districts, these rats were mainly found in the fields and their burrows were located away from houses. But in places like Ponnani, Nariparamba etc. in Malappuram district, the rat burrows were nearer to houses under their basements.

Srinivasachar (1968) reported that B. indica fed mostly on field crops, vegetables and grasses. Under Kerala conditions these rats depended mainly on tuber crops and paddy.

The following important observations on *B. indica* were obtained during the present study.

B. indica indica under Kerala conditions behaved mostly as a field rat and is a serious pest of tuber crops. There was a minimum of two openings for the burrow system. The soil thrown out while digging the burrow was through a single opening and large heaps of soil were found in front of this opening. In addition to this opening there was a main entrance which was always very clean, devoid of spider webs. There were runways starting from these entrances to the nearby cropped fields. The exit for disposal of soil was found located at higher elevations such as on the sides of earthen bunds. The burrow openings of these rats were larger than those of the related species. Width of the burrow system ranged from 8 cm to 50 cm. The maximum depth of the burrow system was 130 cm. Nesting chamber/brood chamber of the *B. indica indica* was comparatively longer than that of other species. No food materials were seen stored in their burrows.

Usually one adult rat was present in a burrow system. But in burrow system 28, located on a large earthen bund, were found three adult females, each having separate nesting chambers. The materials used for making nests included dried leaves of jack, rubber, dioscoria,

yam, coffee and banana. Grass, cardboard bits and tapioca rinds were also used for making nests.

The burrow of B. indica indica were seen always plugged from inside. During smoking operations, these plugs are removed by these rats, resulting in their own death. But in one case the rat after opening the plug made another plug near the nesting chamber with materials used for nesting. This shows that these rats may erect a second plugging in the burrow system during emergency.

Young ones were found in September, December and January. Litter size varied from three to five. The total length of the burrow systems was within a range of 6.72 m to 13.22 m.

5. Mus platythrix

M. platythrix was collected from Idukki, Ernakulam, Trichur, Malappuram and Cannanore districts. They were not present in Wynad area of Calicut district.

The burrows of M. platythrix were common in the gravelly areas of Vellanikkara, Trichur. This observation agrees with the findings of Srinivasachar (1972). Small ebbles were found arranged around the mouth of the burrows. Similar observations were made by Krishnakumari (1968) and Srinivasachar (1968).

Under the present study, burrows were located in diverse conditions. Burrow system - 32 in a tapioca field and burrow system - 33 was located under teak plantations in laterite soil. Burrow system - 34 and 35 were found in cowpea plots. Burrow system - 36 was located in cotton fields. In all cases except burrow system - 36 the openings were encircled by pebbles and had a pebble plugging inside. In certain cases, the pebble plugging was at the soil surface whereas in certain others the plugging was a few centimetres inside the burrow. The size of the pebble ridges around the openings may vary for the different openings of the same burrow system. The runways of rats commencing from the burrow entrances were more distinct at one of the openings of every burrow system and this opening was considered to be the main entrance. The number of openings varied for different burrows and ranged between one and three. Varying number of chambers were found in the burrow system. In some cases two to three chambers were found (35.32 and 33). Nest was found only in a single chamber. The purpose served by the extra chamber/chambers in the burrow system is not clear at present.

In general, burrows of M. platythrix were simple in construction. The maximum length of burrows except

BS.36 was 1.67 m. But burrow system 36 was very extensive with winding passages and it had an unusual total length of 20.4 m. For this burrow system there were two main entrances and both these entrances were not encircled by pebbles, eventhough pebble - plugging was seen inside as usual. There was a third entrance for the burrow system encircled by pebbles. In this system there were two nests out of which one was defunct and deserted.

Young ones were found during October and February and the litter size varied from 3 to 8. More than one adult was found inside a single burrow. The nesting chamber/brood chamber was provided with beds of dried tapioca leaves, dried rosewood leaves, dried leaves and stems of cowpea or dried leaves of cotton, and it seems that the nesting materials vary according to the vegetation around.

Another interesting feature was that there were no signs of soil thrown out while constructing the burrow network whereas in the burrow of all other fossorial rats found in Kerala, the soil thrown out was seen at anyone of the burrow openings. So it is assumed that M.platythrix is not a fossorial rat and they live in discarded burrows of other species such as M. booduga and B. bengalensis.

All the burrow systems of M. platythrix were having a diameter of 2 cm in general except burrow system 36 where the diameter of the burrow system was 6 cm. So the burrow system 36 might be a deserted burrow of B.bengalensis and all other burrows which were having a diameter of 2 cm.might be the discarded burrows of M. booduga. This also explains the reason for the extensive network of burrow system - 36.

6. Mus saxicola

The burrow of M. saxicola was located in laterite soil in a pulse field. It was very similar to that of M. platythrix. The rats were also similar to M. platythrix.

7. Mus booduga booduga

Burrows of M. booduga booduga were located in all areas selected for the survey work. Krishnakumari (1968) and Srinivasachar (1972) found M. booduga in fields, gardens and even in houses. The present findings also agree with the earlier observations. Burrows of M.booduga were located in paddy fields and in garden lands where tapioca, rubber, vegetables etc. were cultivated. However, Ramakrishnan (1972) reported that the burrows of this species were found in paddy fields only. He also recorded that the burrows contained more than one adult with one bed

chamber and with no food chambers. Similar observations were obtained during the present study also. As in T. indica cuvieri described earlier, burrow system of M. booduga had also invariably one or more emergency escapes.

8. Mus cervicolor

Specimens of M. cervicolor were collected from a paddy field-bund and the burrow was similar to that of M. booduga booduga. The species resembled M. booduga booduga in appearance also.

9. Mus musculus

Burrows of M. musculus could be located only in houses as against the observation made by Krishnakumari (1968), Srinivasachar (1972) and Barnett and Iswar Prakash (1975) that these were found indoors, outdoors, gardens, fields near villages and towns. As the burrows were located inside houses, the burrow pattern could not be studied.

10. Rattus rattus

R. rattus rufescens and R. rattus wroughtoni are the two subspecies present in Kerala. R. rattus rufescens was ensnared in Moncompu trap from houses and also from a waterlogged paddy field having 20 cm of standing water.

The observation indicated that R. rattus rufescens was a good swimmer and that the rat was capable of damaging wetland paddy also.

R. rattus wroughtoni was collected from houses, coconut crowns, paddy fields, and nests made in tree cavities and pepper vines. Damage to coconut in Kerala was found to be caused mainly by the sub species R. rattus wroughtoni.

Under conditions of stress, R. rattus was reported to make burrows of irregular type (Yashoda, 1963). But during the present study no burrows of R. rattus could be located. Certain rats of the species while being chased, jumped from coconut trees and pepper vines and escaped into certain burrows of irregular type and whether these burrows actually belong to R. rattus is not yet confirmed.

11. Vandeleuria oleracea

In confirmation with the observations by Krishnakumari (1968) and Srinivasachar (1972), V. oleracea were found to inhabit trees and shrubs. Specimens were collected from arecanut crowns and from nests in grass around cotton and jowar fields. Pregnant rats were collected in January and February and their womb contained 3 to 4 young ones.

V. oleracea damages the arecanut palm by cutting the inflorescence for making its nests. Dry leaves of arecanut were also used along with the inflorescence for nesting.

12. Golunda elliotti

These rats are seen all over Kerala. Krishnakumari (1968) observed these rats in forests and in cultivated areas, living under bushes in nests. The present study revealed their presence in nests under thick grass growth in forests and around crop fields. They were noted damaging dryland paddy by cutting the culms.

13. Millardia meltada meltada

This species was collected from a paddy field in Wynad, Calicut district. Its nature of damage, burrow patterns etc. could not be studied.

14. Rattus ranginiae

This is a new species of rat collected from Trivandrum by Dr.(Miss) P.V.Ranjini and described by Agrawal and Ghosal (1969). No rats of this kind could be collected during the present investigations.

15. *Platacanthomys lasiurus*

This species is reported to live in cavities of trees. A number of specimens collected from Travancore area are preserved in the museum of Zoological Survey of India, Calcutta. These are medium sized rats with long spiny hairs all over the body and tail. Though no rats of this type could be collected during the present study, the traditional rat catchers of the 'Nayadi' tribe confirmed its presence in cashew plantations damaging cashew nut.

SUMMARY

SUMMARY

In order to study the distribution of different species of rats in the State, a detailed survey was conducted in different parts from September 1978 to February 1979. For the survey work, the State was divided into eight agro-climatic zones and from each zone four representative areas were selected for conducting the survey work.

To gather detailed information on the special features of the burrow pattern of different species of rats occurring in diverse conditions and to study their relative abundance, the burrow openings were first located. The adults and the offsprings in each live burrow were collected through different methods. The findings of the present investigation are summarised below:

Fifteen species of rats were found present in Kerala. The informations gathered about the various species are briefly stated below.

1. Tatera indica cuvieri.

Of the four subspecies of T.indica found in India,

only T.indica cuvieri had been found present in Kerala. This was distributed all over Kerala, but the population was meagre in higher elevations.

The burrow system of T.indica cuvieri followed no definite pattern and it may or may not be extensive. The emergency escapes were concealed underneath. A minimum of three openings were there for the burrow systems. Food materials were not seen stored in the burrow system. More than one adult were present in a burrow. T. indica exhibited a tendency to wander in open plains and tarred roads.

2. Rattus norvegicus

In Kerala R.norvegicus always behaved as a field rat. It was found to be a swimmer and was confined to paddy fields and banks of ponds. It had turned a severe problem to rice cultivation in Kuttanadu area of Alleppey district. Maximum attack to the crop was incurred at the booting stage.

3. Bandicota bengalensis bengalensis

This species is more predominant in garden lands

than in wet lands. Though B.bengalensis had been reported to be a hoarding type by almost all the previous workers, the present study revealed that they never hoard food materials inside their burrows in garden lands. Even in paddy fields, only a few rats were noted storing food inside burrows.

The burrow entrances of B.bengalensis were always concealed by heaps of soil. There was no specific pattern for their burrows, which were usually very extensive and might even extend to 60 m in length.

4. Bandicota indica indica.

B.indica appeared mostly as field rat under Kerala conditions and was met with in diverse conditions such as areas cropped under tapioca, colocasia, yams, rubber, backyards of houses etc., inflicting severe damage to the cultivation. A minimum of two openings were present in their burrow systems.

5. Mus platythrix.

The burrow patterns of M.platythrix were found very simple. The burrow openings were surrounded by

pebbles in addition to a pebble plugging few centimetres inside the entrance. In rare cases, the burrows were found to be unusually extensive. The burrowed out soil was not found at any of the entrances. Hence M.platythrix was assumed not to be a fossorial rat and it occupied deserted burrows of other species.

6. Mus saxicola.

This species was similar in appearance to M.platythrix and its burrows were also having entrances encircled by pebbles.

7. Mus booduga booduga.

This species was found in paddy field bunds and garden lands. Their burrows were of simple pattern, with one or two emergency escapes which were not opened to the exterior. More than one adult occupied a single burrow.

8. Mus cervicolor.

It lived in burrows similar to those of M.booduga booduga and their burrows were usually located on paddy field bunds.

9. Mus musculus.

A commensal rodent usually found burrowing inside houses. Their burrows were not seen in the fields.

10. Rattus rattus

Two sub species of R.rattus were found in Kerala.

a) R. rattus rufescens.

This subspecies was collected from houses and paddy fields and could damage paddy even in wet lands where there was standing water in the field. The catches showed that it was rarer in Kerala compared to R.rattus wroughtoni.

b) R. rattus wroughtoni.

A rat attacking cocconut. Specimens were collected from houses, cocconut crowns, and paddy fields. In cocconut trees, nests of R.rattus wroughtoni were seen on the crowns. The nesting materials included dried leaves of cocconut, bamboo etc. R.rattus wroughtoni were seen damaging paddy in Kerala.

11. Vandeleuria oleracea.

A mouse commonly seen in nests made on trees or under thick grass growth. V.oleracea causes damage to arecanuts by cutting the inflorescence for making its nest. This species was collected both from trees and from thick grass growths.

12. Golunda elliotti.

A wild rat usually seen in forest areas and thick grass growth surrounding cropped fields. This species is of minor importance. In certain areas G.elliotti was seen damaging dryland paddy.

13. Millardia meltada meltada.

This species was met with only in Wynad areas. No burrows could be located and the details of its damage to paddy crops in Kerala are yet to be studied.

14. Rattus ranjiniae.

This is a new species of rat found in Trivandrum inhabiting wet land areas. The biology and binomics of this rat are yet to be studied.

15. Platacanthomys lasiurus

It is a spiny rat present in tree cavities. This species was found to destroy cashewnuts in Idukki district.

Study on indigenous rat traps.

An extensive collection of the different indigenous rat traps used in different parts of the State was made and their utility for capturing different species of rats was ascertained in the different zones covered by the survey.

A total number of seventeen traps were collected as listed below:

1. 'Moncompu' trap.
2. 'Adichil' trap.
3. Adivil trap.
4. Kumarakom trap.
5. Improvised Kumarakom trap.
6. Calicut trap.
7. Saw-toothed scissor trap
8. Wooden box-type trap (single door).
9. Wooden box-type trap (double door)
10. Single door metallic trap.

11. Pot and plantain leaf trap (Type-A).
12. Pot and plantain leaf trap (Type-B).
13. Camouflaged pot trap.
14. Kathara trap of Attappady.
15. Modified Kathara trap.
16. Bamboo bow trap.
17. Bamboo noose trap.

Among these traps the Monoompu trap was found to be the most effective in controlling rice field rats. The improvised Kumarakom trap is found useful in controlling field rats in garden lands. The bamboo-noose trap is specially suited to capture the mole rats found attacking tuber crops and the bamboo bow trap is effectively used in controlling rats infesting coconut trees.

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STUDIES OF RATS AND RAT TRAPS OF KERALA

BY

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ABSTRACT OF A THESIS

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ABSTRACT

In order to study the distribution of different species of rats in the State a detailed survey was conducted in different parts during the period from September 1978 to February 1979. Burrows of the various species were excavated to get detailed information on the special features of the burrow patterns. The findings of the present investigations are summarised below.

It was found that 15 species of rats occur in Kerala.

1. Tatera indica cuvieri

Of the four subspecies of Tatera indica, only T. indica cuvieri was present in Kerala. This species was distributed all over Kerala except in higher elevations like Wynad. The burrow system followed no specific patterns with a minimum of three openings. The emergency escapes were concealed underneath. The burrowed out soil was expelled through a particular opening. More than one adult lived in a burrow system.

2. Rattus norvegicus

This was a serious pest of paddy in Idukki district and Kuttanad and was mostly a field rat in Kerala.

3. Bandicota bengalensis bengalensis

This species was more predominant in garden lands. Burrows were found extensive. Burrow entrances were concealed by heaps of soil. Food was found stored in the burrow system only in a few cases. Male and female rats lived in separate chambers/burrows.

4. Bandicota indica indica

A field rat causing great damage to tuber crops. The burrow openings were larger in size than those of other species. The exit for removal of soil was always located on a higher point. Definite runways starting from the entrances were seen.

5. Mus platythrix

The burrow openings of this mouse were encircled by pebbles. It lived in discarded burrows of other species of rats and not a fossorial type.

6. Mus saxicola

Similar to M.platythrix in every aspect.

7. Mus booduga booduga

It lived in small burrows in paddy fields and garden lands. The burrow system was always seen provided with one or more emergency escapes.

8. Mus cervicolor

Found similar to M. booduga booduga in appearance, habits and habitats.

9. Mus musculus

Found in houses and shops.

10. Rattus rattus

Two subspecies were found in Kerala viz., R.rattus rufescens and R.r.wroughtoni and the latter was found attacking coconuts.

11. Vandeleuria oleracea

Found inhabiting trees and under grass growth around crop fields.

12. Golunda elliotti

Found in forest and in thick grass growth around crop fields.

13. Millardia meltada meltada

Seen in paddy fields in Wynad, Calicut district.

14. Rattus ranjiniae

A new species of rat found in Trivandrum District.

15. Platacanthomys lasiurus

A spiny rat damaging cashewnut in Idukki district.

Study on indigenous rat traps.

A total number of 17 indigenous rat traps were collected from various parts of Kerala. Among the various traps, Moncompu traps, for capturing rice field rats, bamboo-noose trap for trapping mole rat from live burrows, and the bamboo bow-trap for capturing rats infesting coconut crowns were found most useful.