ECOLOGY OF MURREE VOLE, *HYPERACRIUS WYNNEI* BLANDFORD, IN GALLIAT, HAZARA, PAKISTAN

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A thesis submitted to the University of Peshawar in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Zoology.

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Claim of originality and contribution to knowledge.

This is the first comprehensive study of the Murree vole, Hyperacrius wynnei, since its discovery in 1881, on morphological adaptations, distribution in Galliat, feeding habits, factors controlling its habitat, burrowing activities, reproduction, population structure and parasites. The pest status has been evaluated. The information will be helpful in the management of this species.

ABSTRACT

Ecology of the Murree vole, Hyperacrius wynnei, was studied in Galliat from 1985 to 1989. Being entirely fossorial the head is massive with short neck. Body is thick and cylindrical with short tail, small ears and small but strong fore-legs. Eyes are tiny with limitted vision. Variability in body weight, body length and tail length was more or less remained the same throughout the study period.

The Murree vole was well distributed in Galliat and was found from 1830-3050 m elevation, being quite abundant in the grass, cultivated and abandoned fields. Soil texture, depth of the top soil, grass, topography and presence of rocks influenced its spatial distribution. Distribution of the vole corresponded roughly with silver fir. It lived in colonies and excavated an extensive system of shallow galleries spreading over more than 400 m^2. The burrow system served for shelter, protection from enemies, as a means of obtaining food and as a place to rear young ones. The burrowing activities were related to rainfall.

The Murree vole is a generalist feeder; fragments of 22 species of herbs and one of shrub were identified from its stomach contents. During winter it mainly fed on the bark of the shrubs. Tall plants were preferred over small ones.

The Murree vole did not hibernate and bred throughout the year, the pregnancy rate being low (36.65%). Significantly high and low pregnancy rate was found in September-October and November-December samples of 1985 respectively. Litter size was small (1-4), usually 1-2, and during November-December, all the females had only one embryo. Prenatal mortality was very low (5.34%). There was no change in the mean testes length in different seasons.

In adults, sex ratios did not deviate from normal sex ratio (1:1). The juvenile showed imbalanced sex ratios skewed towards males, suggesting more mortality of young males during development. The major portion of the populations comprised of juveniles (28.4%). There was no significant seasonal difference in the mean body weight.

One species of nematode and one species of pentastomids were recorded. Fleas and mites were quite common in monsoon season. The only apparent serious predator was domestic cat.

The Murree vole is a pest of maize, potatoes and apple trees. About 4.0% of maize plants were damaged by the vole, while damage to potato crops was 6.8%. It fed on the bark of the apple tree and destroyed about 6.0% of the trees.

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CHAPTER-I

INTRODUCTION

Fossorial mammals evolved as early as Paleocene (Webb, 1977). However, impressive open country adaptations in rodents evolved only in the Miocene. In the Plio-pleistocene the climatic conditions were drier which resulted in a decrease in wood-lands and extension of grass lands, steppes and deserts. Desert conditions caused massive extinction of large ungulates and survival of small to medium-sized xeric species. New adaptive radiations of small fossorial rodents followed, including cricetids (voles, hamsters, and their relatives) in the Pliocene and spalacids (Mole rats) and ctenomyids (tucotucos) primarily in the Pliestocene (Webb, 1977).

Fossorial rodents are found on all the continents except Australia (Andersen, 1987). Hyperacrius wynnei (Family Cricidae; subfamily Microtinae) is a fossorial microtine, well adapted to live at high altitudes in Pakistan. It is larger as compared to other microtines and has limited distribution in the North West Himalayas.

Hyperacrius wynnei was first described by Blandford (1881), from cotypes obtained near Murree, as *Arvicola wynnei*. True (1894) named the second species of *Hyperacrius* as *Arvicola fertilis* from the specimens obtained from Pir-pingal Mountains of Kashmir. Miller (1896) proposed Hyperacrius as a subgenus of Microtus. He described two new species, Microtus (Hyperacrius) aichisoni, on the basis of a specimen (with crushed skull) from Gulmerg in the Pir-pingal mountains and Microtus (Hyperacrius) brachelix based on the specimens from Nagmarg, Kashmir in 1897 and 1899 respectively. Hinton (1926) studied the specimens of wynnei in the British Museum and raised the status of this subgenus to generic level. According to him, Hyperacrius differs from Microtus in cranial features. It was his opinion that Hyperacrius represents a highly specialized off shoot from the genus Alticola. Ellerman (1961) differentiated Hyperacrius from Alticola by the presence of a prominent orbital ridge, which is lacking in Alticola. Philips (1969) reviewed and further divided wynnei into sub-species. The small individuals from the west bank of Indus, he named H. wynnei wynnei and largest individuals from the eastern side were named H. wynnei traubi. He could not find any apparent qualitative morphological difference between the two sub-species, but two can be easily differentiated, on the basis of size and specially on some cranial dimensions. Roberts (1977) stated that Hyperacrius differs from Alticola on the basis of number of mammae. Hyperacrius has six mammae as compared to Aticola having eight. According to Hinton (1926) Hyperacrius represents a highly specialized offshoot from Alticola.

Ellerman (1961) endorsed Hinton's view and stated Hyperacrius was derivative of Alticola that had become highly specialized for fossorial life.

Hinton (1926) listed Murree as the type locality. Philips (1969) suggested that Murree itself is possiblly too low elevation to be the type locality. According to him cotype might had obtained higher in the Murree hills and suggested a restricted range between 1950m and 2500m, wherever suitable habitats exist. The university of Marryland expedition collected this species from Murree, Dungagali, Nathiagali, Thandiani, Shogran in Hazara district and Shangla and Yakhkundi in Swat (Traub and Evans,1967). However they were unable to trap this species from the upper Himalayan region. Roberts (1977) reported this species quite abundant in the Murree hills. He also stated that this species has not been reported outside Pakistan.

The apparently restricted and patchy distribution of Hyperacrius was discussed by Traub, et al (1967) on the basis of distribution of Rickettsia of scrub typhus, its associated vectors and endemic host mammals. According to them the Murree vole alongwith its ectoparasites had continuous distribution in coniferous forest in the late Pliocene. This continuous distribution was disturbed by the upheaval that formed the Himalayas and subsequently vast desert areas like Gilgit. They supposed that Hyperacrius is a relict species restricted to suitable habitats in the Himalayas. The isolated ecological Islands formed in the late Pliocene are found on the xeric northern slopes of the Western Himalayas. Philips (1969) pointed out that Hyperacrius would be found in many other places, when additional studies are made.

Hinton (1926) quoted from the field notes of H.H. Dun as follow "wynnei has mole like habits and is found in the grassy ground in the pine forests". Later on this information was repeated by many authors including Walker (1964) and Philips (1969). But according to Roberts (1977) this vole is exclusively, herbivorous and feed on a number of plants, under ground stems and roots. He also briefly reported the biology of the Murree vole. According to him the Murree vole excavates extensive system of shallow tunnels and due to its fossorial habits the seasonal temperature does not influence the animal. It is active throughout the year and does not hibernate. He stated that the Murree vole occupies the same ecological niche in the Himalayas as the snow vole Microtus nivalis in the Northern Europe. Females, most probably, produce two or three litters in summer and each litter comprises of two or three youngs (Roberts, 1977; Beg and Hussain, 1990).

Philips (1969) studied the Zoogeography and ecology of *Hyperacrius*. He agreed with the finding of Traub *et al*. (1967) and Traub and Evans (1967) that this vole is a relict species and it had continuous distribution before the formation of the Himalaya range. He further suggested that competition with other microtines also could account for further restricted range of *Hyperacrius*. He further stated that subspeciation in both *H. wynnei* and *H. fertilis* is related to their restriction to suitable habitat and some of the physical bariers. He also reported that two species of *Hyperacrius* do not only differ morphologically but also they have different ecological requirements. Taxonomic and zoogeographic distribution of fleas can be correlated with the systematics of these voles. Philips (1969) also observed a high proportion of subadults in the Murree vole.

Roberts (1977) pointed out that where this vole is found, it is quite plentiful but very little cultivation is done in these areas. According to him the Murree vole is not of any economic importance and do some damage to potatoes and also gnaw the bark of the apple trees. However Roberts in (1981), and also Beg and Hussain (1990) considered this species to be serious pest of apple trees. According to Roberts (1981), in Sirri (Mansehra District) a farmer lost his entire apple plantation due to this vole. Roberts (1981) and Khan (1990) suggested control measures for the protection of apple trees.

Traub *et al*. (1967) reported eleven species of mites from the Murree vole including four new species and recovered the *Rickettsia* of scrub typhus from the mites of both the species of *Hyperacrius*. Prior to their studies the *Rickettsia psupsugamushi* was unknown from the higher alpine elevation and coniferous forest of Pakistan. Trobiculid mites of genus *Leptotrombidium* are considered to be the vector of the *Reckettsia* of scrub typhus. Thirty three percent of the chiggers reported from the Murree vole were *Leptotrombidium tithwalenbe*. Traub and Evan (1967) reported three species of fleas including *Paleopsylla setezi*, *Xenodaeria telios* and *Stenishia* sp. from this vole.

The Murree vole has not been studied mainly for two reasons (1) limited accessibility to some of the areas where the vole is found, and (2) its fossorial habits. I n view of insufficient knowledge about the Murree vole (*Hyperacrius wynnei*), the present study was undertaken to provide information on the ecology of this vole pertaining to its management. The specific objectives of the present study may be outlined as follows:

1. To study morphological adaptations.
2. To examine variability in different body traits.

3. To study its distribution in the Galliat.
4. To examine its feeding and burrowing habits.
5. To determine the factors controlling its habitat.
6. To evaluate the breeding habits and population structure.
7. To study temporal changes in body weight.
8. To asses its pest status.
9. To investigate its parasites and predators.

CHAPTER-II

STUDY AREA

The investigations were conducted in Galliat area (Fig.I) lying between 33°-56' and 34°-21', 72°-55' and 73°-29' in Abbottabad district of Hazara Division, North West Frontier Province, Pakistan. Survey for pest studies was, however, extended upto Murree town. The area is mountainous having a main ridge running from north-west to south-east and steep slopes interspersed by deep nullahs.

A. CLIMATE

The cold season starts from early November and lasts upto the end of March with snowfall from end of December to middle of March. The winter rains extend upto April. From the end of May to middle of July the weather remains dry. The monsoon rains, usually, start in July and continue upto middle of September and thereafter the winter sets in.

The average data on rainfall, temperature and snowfall for 14 years i.e from 1971 to 1984 are given in Appendix-I. The annual rainfall is reasonably good and bulk of rainfall precipitates from July to September. The wettest year was 1978 with 1578.8 mm rainfall and 1972 was the driest year with 1024.34 mm of rainfall. The

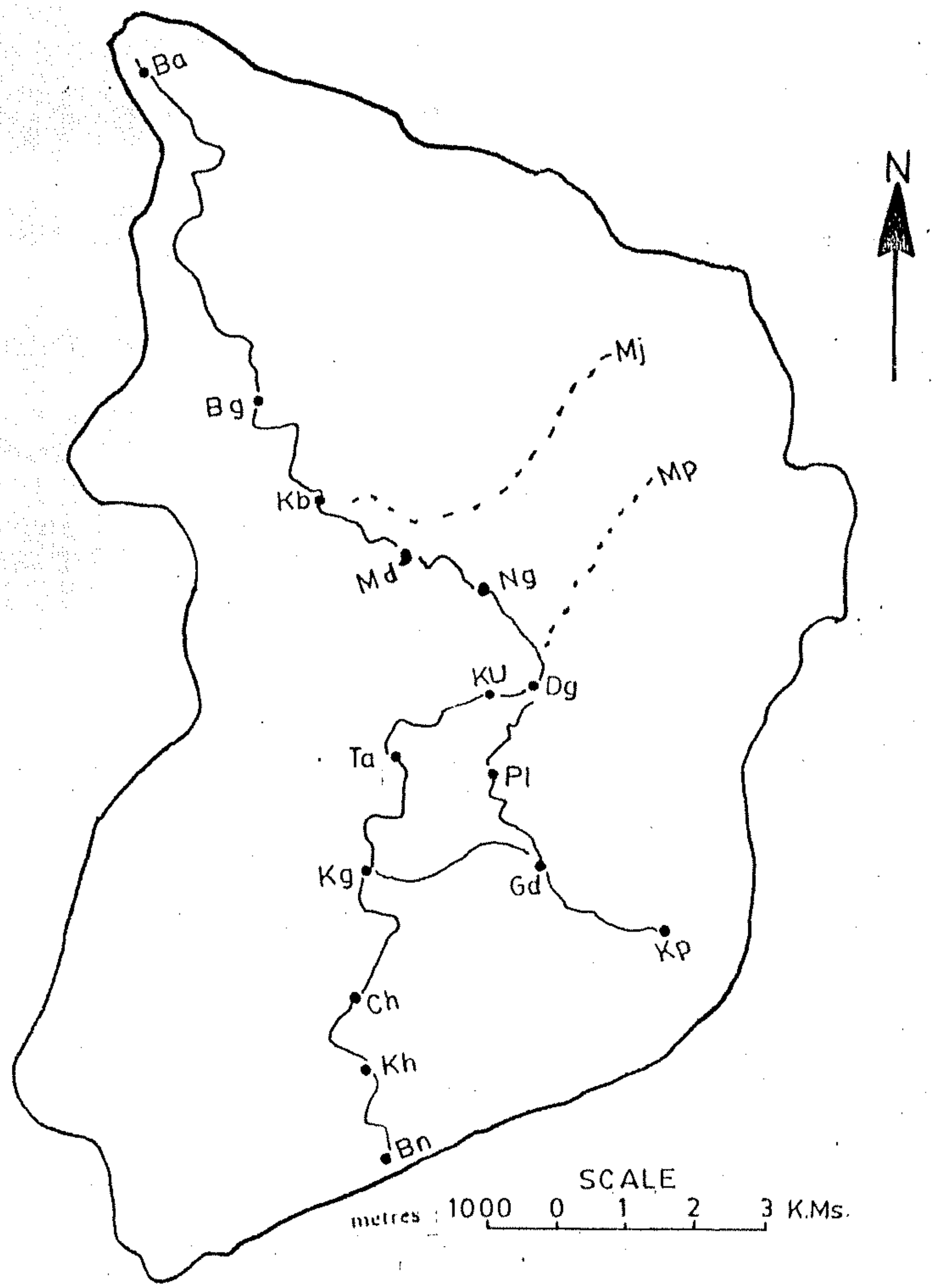

Fig 1. Map of the study area: Ba - Bangnotar; Bg- Baragali; Bn - Barian; Ch - Changlagali; Dg - Dungagali; Gd - Ghoradhaka; Kb - Kalabagh; Kg - Kozagali; Kh - Khairga Kp - Khanuspur; Ku - Kundla; Md - Mochidhara; Mj - Miranjani; Mp - Mukshpuri; Ng - Nathiagali; Pl - Pipel Ta - Tauheedabad.

temperature was minimum in January and maximum in June. The highest maximum temperature (25.8° C) was recorded during June, 1972. The lowest temperature (-0.8° C) was recorded during January 1975. The heaviest snowfall (707.6 mm) was recorded in 1976 and the lowest (230.34 mm) in 1971.

B. THE FOREST

The whole area may be labelled as forest. Though some slopes are devoid of thick vegetation. Forest is very variable in composition, quality and density. It varies with aspect, elevation, situation and intensity of grazing. Broadly speaking, it falls into following three main classes (based on predominant trees).

i. Silver fir forests.

ii. Kail forests.

iii. Chir forests.

i. Silver fir forests

Silver fir forests predominantly occur on the cool aspects of elevated peaks such as Kalabagh, Nathiagali, Dungagali, Ghoradhaka etc. The principal species is silver fir (*Abies pindrow*) mixed with some blue pine, (*Pinus excelsa*). Both silver fir and blue pine are mostly middle aged or young with some scattered old trees. In addition, barungi (*Quercus dilatata*), horse chesnut (*Asculus indica*), birdcherry (*Prunus cornuta*), maple (*Acer caesium*), yew (*Taxus baccata*), walnut (*Juglans regia*), are scattered in the overwood.

In the under growth, gutch (*Viburnum* spp.) grows profusely. It is mixed with simlu (*Barberis lycium*), wild rose (*Rosa coschata*) and (*Rubus* spp). The important climber is ivy (*Hedera halix*).

ii. Kail forests

Below the fir zone, kail (*Pinus excelsa*) predominates. Broad-leaved trees mentioned in the previous section occur scattered individually or in small patches in the overwood. The forest is mostly young or middle-aged but some poplar and oaks found at high altitude are old. Kail encroach upon the fir areas at high altitude and chir (*Pinus roxburghii*) at the lower elevation. It appears that after a few years it may invade the locality and push fir further above and chir below in the form of fringes.

The undergrowth is dense in depressions and thins out gradually as one moves upwards. It consists chiefly of *Berberris lycium* mixed with other species mentioned above.

iii. Chir forests

On the southern slopes and lower elevation below Baragali, chir (*Pinus roxburghii*) predominates. In protected places, it is associated with *Querus incana*. *Pyrus* pashia and Kangar (Pistacia integgrima) are also present. The under-growth is thin or absent. It consists chiefly of kakal (Myrsine africana) mixed with B. lycium and anar (Punica granatum).

C. GEOLOGY

Geological formation of the Galliat has been affected by the mountain building movements which gave rise to the Himalayas. Stratigraphically the pre-Eocene are conspicuously recognised. They consist of a series of lime-stone and slates, intruded by foliated biolite and granite in the north-eastern limits of the study area. Metamorphic series of phyllites schists and granites occur towards northern parts. Lime stones and quartzites of permocarvoniferous and cretaceous age form a part of formation passing through Thandiani Range. Grey and Purple sand stones with red and purple shales veined by calcite and rich deposits of soap are of common occurrence in Galliat, particularly in its western parts. The fossil records show that earlier beds in the mountain were deposited in somewhat brackish environments as compared with the later ones. Coarse and upgraded sand stones show that the sediments must have been brought down by rapidly flowing large masses of water and laid down in a wide depression of shallow water on a swampy area.

Soil formed by disintegration of shales and sandstones is leached free of lime to a varying depth. It is dark brown in colour, silty-clay or clayey in texture. It is generally shallow, dry, sterile on hot aspects and deep slopes but thick on the northern slopes and in protected situation, where it is richer due to the admixture. Soil on the whole has deteriorated considerably due to overfelling and denudation of forests.

D. ANIMALS

In addition to the Murree vole, the other mammals found in Galliat forest are Himalayan palm civet (*Paguma larvata*), Leopard cat (*Felis bengalensis*), Leopard (*Panthera pardus*), Red fox (*Vulpes vulpes*), Pine Marten (*Martes flavigula*), Asiatic jackal (*Canis aureus*), Himalayan black bear (*Selenoractos thibetanus*), Rhesus monkey (*Macaca mulatta*), common white-toothed shrew (*Crocidura russula*), Roof rat (*Rattus rattus*), Field mouse (*Apodemus sylvaticus*), House mouse (*Mus musculus*), Giant red flying squirrel (*Petaurista petaurista*), Small Kashmir squirrel (*Hylopetes fimbriatus*) and porcupine (*Hystrix indica*).

E. GROUND FLORA

The Galliat are very rich in ground flora. In spring and summer almost the whole ground is covered by the herbaceous plants. The most important species are given in Appendix-II.

CHAPTER-III

MATERIALS AND METHODS

The investigations were mainly carried out in Dungagali and Nathiagali and their surroundings. The occurrence of the Murree vole has been studied both in the villages and along the sides of the main road. Some observations were also made on some tracks in the forest. The study area was visited once a month from 1985 to 1989.

In the beginning, both snap and gopher traps were used to capture the vole. Snap traps were set in front of the burrow entrance, after removing the excavated soil. Different types of baits like vegetables, fresh fruits and dry fruits were used in snap traps but potato proved to be the best one. Being entirely fossorial, no vole was caught in traps placed a little far away from the burrow entrance. Gopher traps were set inside the burrows after widening the burrows, because the diameter of the burrows was smaller than the Gopher trap. The traps were visited in the morning and evening. As the efficiency of the two traps was the same, snap traps were used because they were easy to operate.

It is difficult, by snap trapping, to obtain data comparable for different habitats, years and seasons. Stickel (1946) pointed out that data obtained on small rodents by snap-trapping usually differ greatly from true density values. Kalela (1957) used trap lines in his investigation of Clethrionomys rufoconus. This method is good enough for studying the relative abundance of a species. According to Tast (1966) this method could not be used for those rodent species which occupy ecologically restricted habits and live in colonies.

To trap the vole alive, Sherman's traps were used but without any success. A special trap was designed for this purpose. The trap (Fig. 2A,B) comprised of a polyvenyle pipe (12 cm in length and 4 cm in diamter) and an ordinary paper clip, whose one side was removed, was fixed on one end of the pipe by a screw (Fig.2C,D). The other end was closed by a sliding door (Fig.2E). Just near the sliding door a hook (wire, two inches in length was bent at both the ends) was placed (Fig.2F). A nail 10cm in length was used to raise the front door and other end was placed under the hook. Lower end of the hook was used for the bait.

The voles were caught successfully in this trap. But the vole appeared very sensitive to the climatic conditions like temperature and rain. Most of the voles died due to very low temperature at night or high temperature during the day. Moreover setting the traps in the field was very laborious job and required quite a few people to place the traps in the field. So attempts to trap the vole alive were abandoned.

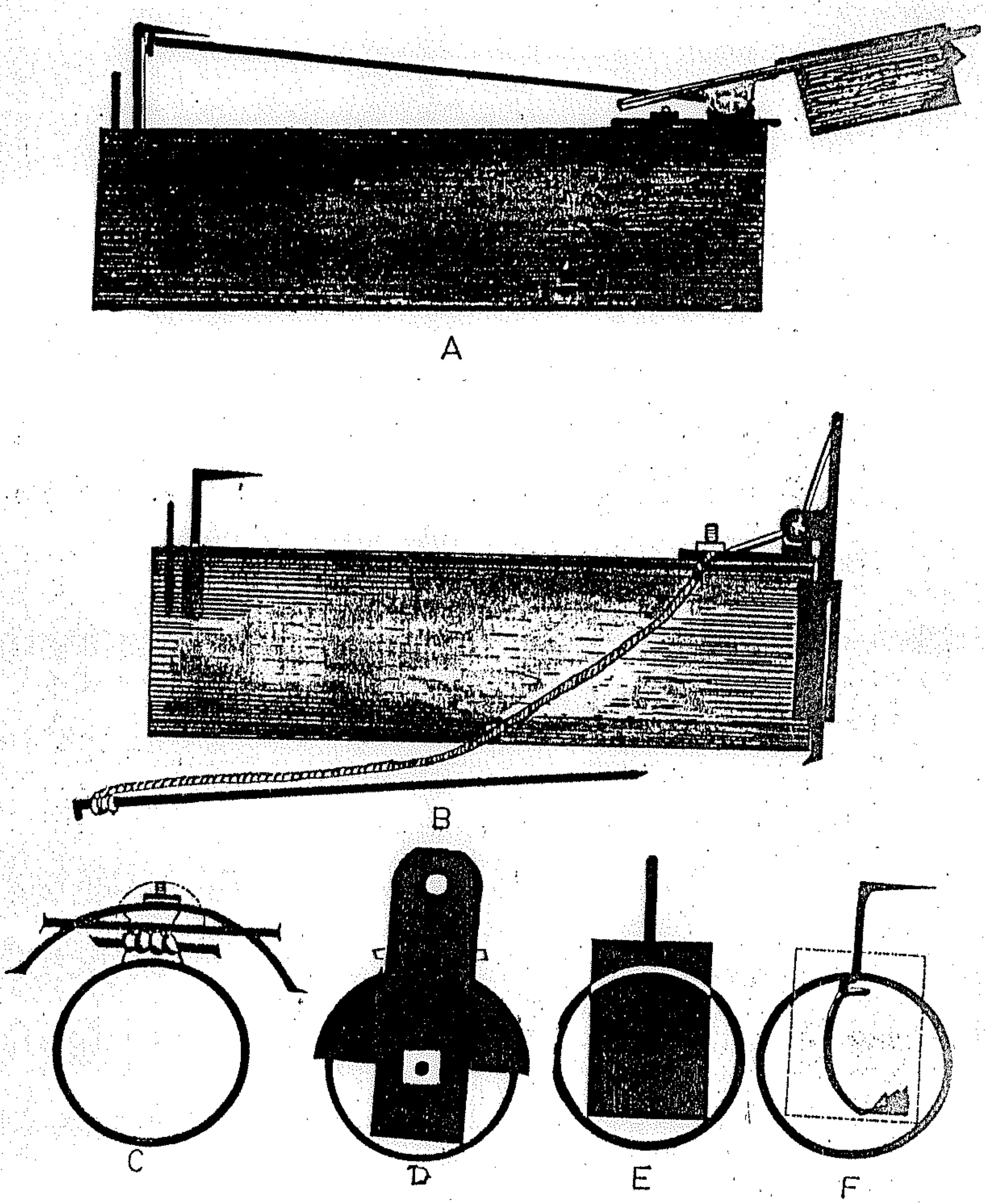

Fig 2. Trap: A - Trap in set position; B - Trap in sprung position; C and D - Front plan E - Posterior plan; F - Hook for bait and holding front door.

In the fossorial mammals the amount of soil excavated is related to the number of the animals (Davis and Winstead, 1980). Signs like burrows, tracks, faeces and dens have been used quite successfully for the measurement of the mammalian density (Davis and Winstead, 1980). The relative density of the Murree vole per unit area was estimated by counting the burrows with excavated soil in August, when the excavation activity was at its maximum.

The Murree vole collected by snap and gopher traps were brought to the laboratory in polythene bags and the information on date, location, weight, total length tail length, hind foot length and ear length from notch was recorded for each specimen (Appendix III). All the specimens were autopsied to determine reproductive status based on the following characteristics.

Female data

1. Lactation: lactating or not
2. Pubic symphysis: closed or open
3. Vaginal orifice: perforated or not
4. Placental scars: presence and their number
5. Embryos: presence and their number
6. Uterus condition: normal or enlarged

Male data

1. Testes: scrotal or abdominal
2. Average length of the testes.
3. Epididymal tubules: visible or not

Stomach contents were analyzed by the technique similar to those of Dusi (1949), Hansson (1970) and Williams (1962) with little modifications. Stomach was cut into two pieces and was transferred into a funnel having guaze of fine mesh. All the procedure from washing to staining of the stomach contents was done in the plastic funnel because it was easy to handle the materials and the narrow end of the funnel could be easily blocked with a wooden piece. The stomach contents were dried at room temperature and were macerated with 5%KOH and washed. The washed material was kept in sodium hydrochloride (NaHCl) for 24 hrs which served as bleaching agent. The bleaching agent then was removed by washing with cold water. The contents were stained and mounted in Berlese Media. The slides were dried on hot plate for several hours. Two slides were prepared from each stomach content. Reference slides were similarly prepared. Ten non-overlapping microscope (100X) spots were examined with a 10X10 ocular grid to divide each spot into 100 squares. The total number of squares in the combined 10 spots occupied by a given item, divided by the total squeres occupied by all the components, gave the relative percent volume of that dietry component.

The burrowing system was studied by excavating the tunnels. Five burrow systems were partly excavated but not a single system was entirely exposed. The burrow system proved to be extensive and after hours of digging and following about 433 meters of the tunnels, the efforts at excavating the whole system were abandoned as the burrow system was finally lost in the trees and the shrubs. During excavation a wood stick was inserted into each tunnel ahead of showel to facilitate tracing its course but still sometimes the track of the tunnel was lost.

To observe burrowing activity, eight plots of equal length (10X5m) were selected. All the excavated soil was removed and the volume of excavated soil was measured each month.

Strip count method was used to determine the relative abundance of the vole in different localities. The main bazar of each locality was taken a central point and by walking a distance of 500 m, the active burrows with their excavated soil were counted within 5 m area of both sides of the road.

Following variables were studied to evaluate microhabitat:

a. Plant density

b. Herbaceous percent cover

c. Soil

i. Soil texture

ii. Soil depth

iii. Soil organic matter

d. Topography

Line intercept method was used to measure the plant density. A measuring tape of 20 metres was laid out on a line transect. The line transect was subdivided into equal length of 1 metre for measuring the frequency of food plants and other plants. All those individuals whose tops or basal area either touched, underlied or overlied the intercept line were recorded for each species along the line. Relative density of the plant was measured by the formula:

$$\text{Relative density} = \frac{\text{Density of species}}{\text{Total density of all plant}} \times 100$$

The percent cover was measured by Nudds (1977) method with little modification. A density board measuring 1m in length with each 0.2m interval marked and numbered from 1-5 that corresponded to a range of quantities (e.g, 1 corresponded to a range 0-20%, 2 to a range of 20-40% -- etc). The board was fixed in the soil and reading was taken at a distance of 5m and figures obscured by the vegelation was noted.

Soil samples were taken from the locality, where the vole was found. These were mixed thoroughly and were dried in oven. Hundred grams of soil was taken in a glass beaker (250 ml). Saturated solution of sodium carbonate (25 ml) was added and stirred. The solution was allowed to slake for 16 hours and was then transferred to a cup of mechanical stirrer for 20 minutes. The dispersed soil was poured in 1 littre capacity sedimentation cylinder. The cylinder was filled upto 1-L mark with distilled water and hydrometer in it. The hydrometer was removed and contents of the cylinder were mixed by placing the dry palm of right hand over the mouth of cylinder. The hydrometer was carefully inserted into the suspension for 25 seconds and first reading was recorded 40 seconds after the start of sedimentation. After first reading the hydrometer was taken out and rinsed with distilled water. The same was followed after every observation. The second reading was taken after 120 minutes. Following formulae were used for the determination of percent by weight of various particle.

$$\text{Sand} = \frac{\text{40 second reading}}{\text{Oven dry weight of sample}} \times 100$$

$$\text{Clay} = \frac{\text{120 minutes reading}}{\text{Oven dry weight of sample}} \times 100$$

$$\text{Silt} = 100 - (\text{Sand \& Clay})$$

Organic matter in the soil was determined by ignition method. Twenty gm air dried soil was placed in crucible and the soil in the crucible was oven dried for 48 hrs. The sample was weighed. The crucible was placed in a muffle furnace at a temperature of 700° C for one hour. The crucible was removed from muffle furnace and placed in a dessicator and when it was cooled. Sample was re-weighed and total organic matter was determined as follows:

$$\% \text{ of organic matter} = \frac{\text{Decrease in sample weight}}{\text{oven dry sample weight}} \times 100$$

CHAPTER-IV

MORPHOLOGICAL ADAPTATIONS

The Murree vole has adapted for fossorial life in burrow systems. It has highly specialized morphologically and functionally for living an underground life. In the present account only those morphological features are highlighted which have adaptive value for fossorial life. Body form of the vole is rat-like with small tail, reduced eyes & blunt snout (Fig.3).The most remarkable morphological adaptations involved the major locomotory and burrowing structures such as head,neck, fore-limb and pectoral girdle. Body including limbs, tail and ears was covered with hairs. The hair coat protects the animal from the heat loss. External ears are not reduced but they are well embedded in the body fur. The average eye diameter and body length ratio was 0.03 (based on the calculation of 76 specimens). The young roamed about on the ground helplessly which indicated that vision was greatly reduced in the Murree vole.

In the Murree vole, the tail measured 27% of the body length (based on the measurements of 280 specimens). Due to small tail and short neck, heat is retained in the body which the vole requires for its survival in the cold climate of Galliat. The heat loss is further decreased by having hairs on the tail.

Fig 3. Hyperacrius wynnei: Murree Vole

Like other fossorial rodents the fore-limbs in the Murree vole were developed for digging purposes. They are short but with strong claws. The scapula does not differ in the general structure. However, the configuration of some bony processes differs from the other rodents.

The post scapular fossa (Fig.4-A), synonymous with the teres major fossa of Hill (1937), is absent in the Murree vole. Supraspinous fossa and infraspinous fossa are not flat but there are longitudnal depressions which give extra surface for the attachment of the muscles. The spine of the scapula is prominent and lips are thickened.

The acromion process is long and broad. It extends to the approximate region of the glenoid fossa. The coracoid process is stouter and prominent. The glenoid process is round.

The humerus, (Fig.4-B) is a cylindrical bone and head is more or less rounded. The deltoid tubercle is straight, triangular and is directed towards one third of the humeral shaft. The shaft of the radius is almost straight. The styloid process is present. The ulna (Fig.4-C,D) is attached to the radius. The olecranon process is prominent while coracoid process is well developed. Measurements of 85 specimens showed that the length of the fore-limb and hind-limb is almost equal.

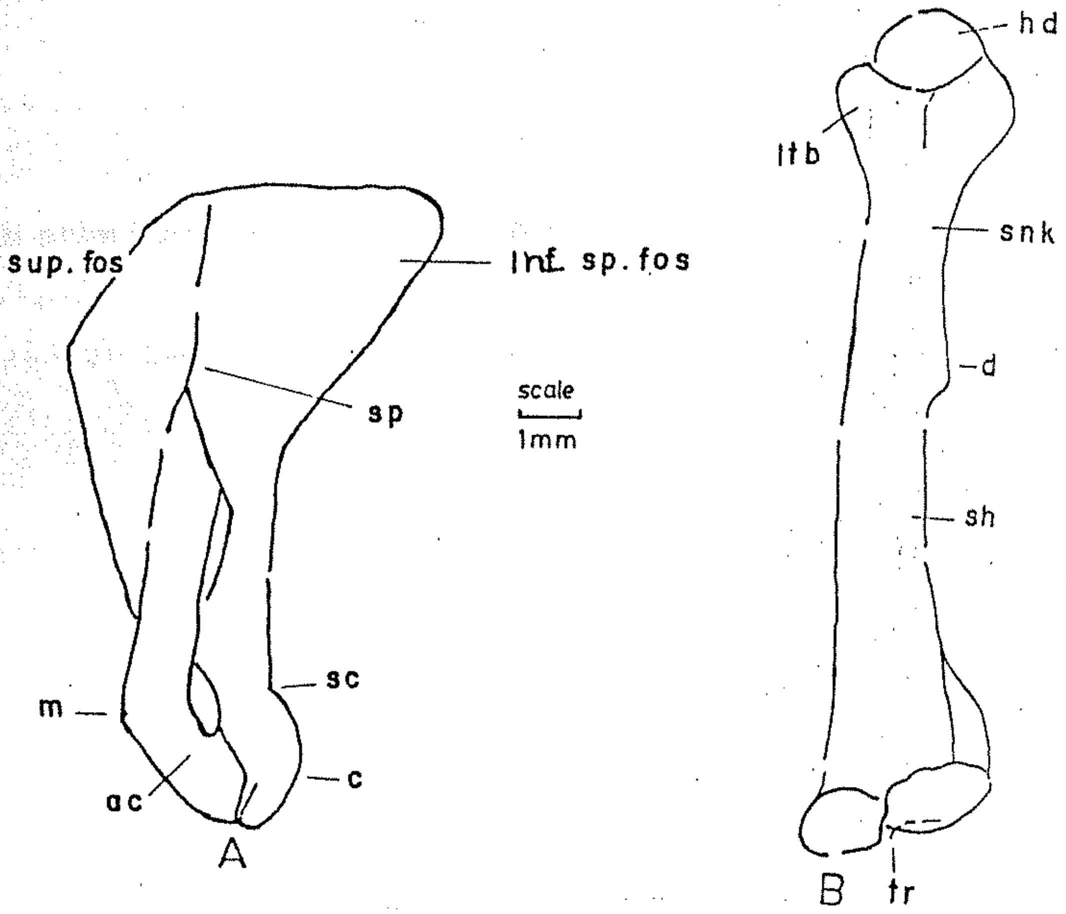

Fig 4. Fore-limb of H. wynnei. A - pectoral girdle: (ac) Acromion process; (c) Coracoid; (inf.sp.foss) Inrra superior fossa; (m) Metacromion; (sc) Scapularnotch; (sp) Spine; (sup fos) Supra spinous fossa. B - Humerus (d) Deltoid process; (hd) Head; (itb) Lesser tuberocity; (snk) Surgical neck; (sh) Shaft; (tr) Trochlea;

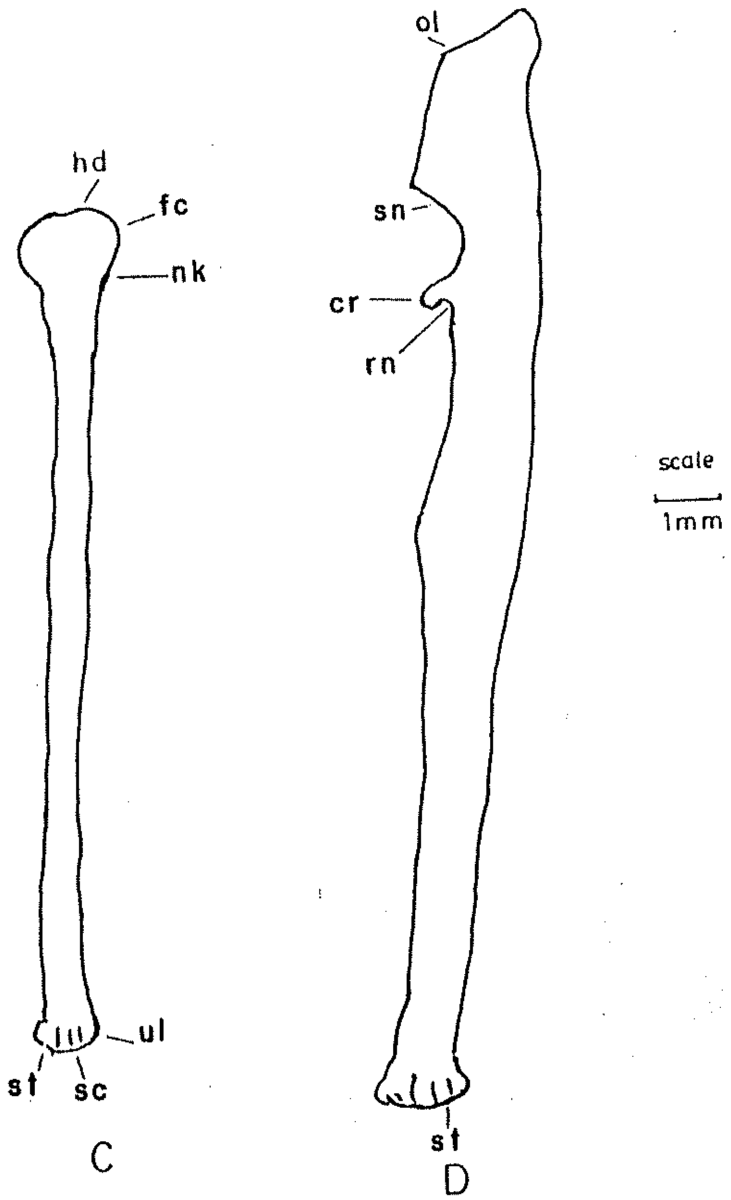

Fig 4. C-Radius: (fc) Articulatory surface for capitulum of humerus; (hd) Head; (nk) Neck; (c) Articular surface for scapholumer; (rn) Radial notch; (st) Styloid process; (ul) Facet for ulna. D-Ulna: (cr) cronoid process; (ol) Olecranen process; (rn) Radial notch; (sn) Semilunar notch; (st) Styloid process.

DISCUSSION

Fossorial rodents have a number of specialized morphological features including (1) reduction in relative size of the eye; (2) modification of foreleg or teeth, or both, to assist removing soil particles; (3) reduction in the size of external ear or pinna; (4) reduction in length of the tail; (5) shortening of the neck; (6) reduction of the undercoat especially in tropical forms (Nevo, 1979).

Eyes display all regressive stages in fossorial rodents from medium (Spalocopus) to small (Geomyidae, Bathyergidae), to completely covered by skin; partly degenerated (Tachyoryctes, Cei, 1946) to completely degenerated (Spalax,Cei,1946). Eye diameter/body length ratio varies from .009 to .003 in entirely fossorial manmal (Mcnab, 1966). Vision also decreases with the eye reduction. According to Jarvis (1973) photosensitivity exists in Tachyoryectes but not in bathyergids (Cei, 1946; Eloff, 1958). In the Murree vole the eye was reduced much but photosensitivity existed. On many occasions when the excavated soil was removed from the burrows entrance and as the light entered the burrow, the vole came to know with-in short time and tried to block the entrance by soil, suggesting the existence of photosensitivity. But vision was absent as in monsoon season voles were found roaming on the ground, and were unable to locate their burrows.

External ears are reduced in Tachyoryectes and Geomyidae and are completely absent in Spalax (Nevo, 1979). In the Murree vole the external ears are small as compared to body length and are well embedded in the hairs. Hearing was well developed and a slight disturbance on the ground caused the vole to retreat to its burrows.

Tail is absent in Spalax (Ognev, 1963) while in those fossorial rodents having tail, it varies from 11% in Ellobius (Allen, 1940) to 43% in Thomomys (Dalguest and Scheffer et al, 1944) of the total body length. The tail length in the Murree vole is 28% of the body length and is covered by hairs. Naked tail is found in Heterocephalus but it has long tail (67% of the body length) according to Hill et al. (1957).

Lehman (1963) studied the fore-limb architecture of some fossorial rodents and found the following modification of the forelimb architecture: 1. large teres major process; 2. large postocular fossa; 3. marked curved radial shaft; and 4. long acromion and olecranon process.

Of these modifications only elongation of acromion and olecranon are found in the Murree vole. The acromion process is more broad as compared to the fossorial rodents studied by Lehman (1963). Moreover the supra- and infra-spinous fossae have longitudnal depressions. These two structures give extra surface for the attachment of the muscles. In general, the fore-limb of the Murree vole resembles that of _Tachyoryectes_, _Brachyoromys_ and _Rattus_. According to Lehman (1963) the fore-limb architecture of fossorial rodents is designed to promote a more power flexing of the fore-limb against the resistance of the substrate. The fore-limb architecture of _Geomys_ is an exaggeration of the fore-limb architecture of _Liomys_, which in turn, is preadaptation to the fossorial habits. The architecture of _Ctenomys_ is similar to that of the _Geomys_. But _Tachyoryectus_, in general shows less morphological adaptation to fossorial life. The fore-limb of the Murree vole has not evolved much fossorial adaptations but the strong muscles and claws help the vole to dig soft soil. The loamy soil, the habitat of the vole, may be one of the reason for little modification of the fore-limb.

CHAPTER-V

VARIATIONS IN BODY WEIGHT AND BODY MEASUREMENTS

Phenotypic variation is the raw material for natural selection and population variability is an important adaptive property of a population. The study of variability of the phenotype is a necessary step in any kind of detailed study of a population. The body traits were measured for individuals more than 40 gm body weight, since less than 40 gm were considered immature. The coefficient of variability of the following body traits, was calculated by the standard formula:

$$C.V = \frac{\text{Standard deviation}}{\bar{X}} \times 100$$

The data were grouped by 2 - months periods for 1985 and 1986.

A. Body length (excluding tail) (cm).

B. Body weight (gm).

C. Tail length (cm).

D. Hind Foot length (cm).

A. BODY LENGTH

The coefficient variability of body length in the female voles varied from 4.00 - 7.36% in 1985 and 2.78 - 5.3% in 1986 (Tables 1,2). In March-April the variability

Table 1. Variability of body length of females in two months periods (1985)

Period	$\overline{X} \pm S\overline{X}$	Standard Deviation	C.V.	N
March - April	13.08 ± 0.3	0.6	4.00	23
May-June	11.4 ± 0.02	0.69	6.05	17
July-August	12.2 ± 0.17	0.74	6.10	20
September-October	11.63 ± 0.16	0.71	6.10	20
November-December	11.68 ± 0.23	0.81	7.36	14

Table 2. Variability of body length of females in two months periods (1986)

Period	$\overline{X} \pm S\overline{X}$	Standard Deviation	C.V.	N
March-April	12.2 ± 0.09	0.34	2.78	14
May-June	11.4 ± 0.10	0.36	3.42	14
July-August	11.5 ± 0.10	0.39	3.37	14
September-October	11.33 ± 0.14	0.60	5.3	18
November-December	11.13 ± 0.12	0.59	5.3	24

Table 3. Variability of body length of males in two months periods (1985)

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	13.8 ± 0.34	1.34	9.7	16
May-June	10.84 ± 0.23	0.98	8.6	19
July-August	11.4 ± 0.23	0.88	7.72	15
September-October	11.4 ± 0.21	0.71	6.27	12
November-December	11.3 ± 0.17	0.62	5.53	13

Table:4 Variability of body length of males in two months periods (1986).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	11.65 ± 0.14	0.49	3.25	12
May-June	11.56 ± 0.10	0.38	3.29	14
July-August	11.5 ± 0.10	0.39	3.37	14
September-October	11.33 ± 0.14	0.6	5.3	18
November-December	11.13 ± 0.12	0.59	5.29	24

was the lowest in both the years but it increased reaching its maximum in November and December. However, comparatively the average variability was higher in 1985 (5.91%) than 1986 (4.34%). For males the variability ranged from 5.52 - 9.7% in 1985 and 4.25 - 5.29% in 1986 (Tables 3,4). It is interesting to note that in 1985 variability showed a reverse trend i.e. it was maximum in March-April and decreased reaching its minimum value in November-December. The average variability of both the years was more in the males than females. On the whole the range of variability was 2.78 - 7.36% in females and 4.25 - 9.7% in the males.

B. BODY WEIGHT

Body weight variability showed great consistency and was more or less a homogenous trait. The variability of body weight was more than body length for females, the variability varied from 6.26 - 7.44% in 1985 and 6.10 - 10.69 in 1986 (Tables 5,6). The variability showed homogeneity in different periods of the two years, except for the September-October 1986 when there was pronounced increase in the variability (10.69%). However there was not much difference between the average variability of the two years. Among the males the variability ranged from 7.68 - 8.18% in 1985 and 6.3 - 7.35 in 1986 (Tables 7,8). Like

Table 5. Variability of body weight of females in two months periods (1985).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	50.17 ± 0.65	3.4	6.26	23
May-June	48.32 ± 0.81	3.34	6.91	17
July-August	49.41 ± 0.81	3.6	7.44	20
September-October	49.5 ± 0.68	3.03	6.38	20
November-December	47.75 ± 0.82	3.27	6.85	16

Table 6. Variability of body weight of females in two months periods (1986).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	50.51 ± 0.88	3.30	6.53	14
May-June	47.86 ± 0.78	2.92	6.1	14
July-August	47.8 ± 0.80	2.99	6.25	14
September-October	47.78 ± 1.11	5.11	10.69	19
November-December	46.04 ± 0.62	3.04	6.61	24

Table 7. Variability of body weight of males in two months periods (1986).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	47.09 ± 0.92	3.67	7.71	16
May-June	47.86 ± 0.88	3.82	7.98	19
July-August	45.5 ± 0.96	3.72	8.18	15
September-October	45.5 ± 1.03	3.50	7.8	12
November-December	46.35 ± 0.99	3.56	7.68	13

Table 8. Variability of body weight of males in two months periods (1986).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	49.46 ± 0.83	3.12	6.30	12
May-June	48.23 ± 0.90	3.37	6.98	14
July-August	47.77 ± 0.94	3.51	7.35	14
September-October	47.44 ± 0.78	3.41	7.18	19
November-December	47.75 ± 0.71	3.35	7.02	22

females the variability of weight in males did not show any heterongeneity.

C. TAIL LENGTH

The variability of the tail length appeared to be more than the body weight and body length. It ranged from 8.88 - 23.15% in 1985 (Table 9). In November-December it was higher than the rest of the period. In 1986 the variability of tail varied from 5.34 - 9.67%. November and December showed the highest variability (Table 10).

D. FOOT LENGTH

Foot length variability varied from 4.11 - 9.38% (Table 11) in 1985 and 4.10 - 10.95 in 1986 (Table 12). When the variability of the same period was compared, there was much difference in May-June and July-August. The average variability of 1985 (25.15%) was greater than 1986 (12.26%).

The average variability of the body weight, body length and tail length of the two years was more or less same.Except for the body weight of females, the variability of other traits was comparatively higher in 1985 than 1986. It is interesting to note that there might not be any difference but the trends towards increase or decrease of variability for some of the traits could be easily detected quite clearly. For example, body weight of male showed a trend towards increase in coefficient of variation in 1985 and decrease in 1986 from March-April to November-December.

Table 9. Variability of tail length in two months periods (1985).

Period	$\overline{X} \pm S\overline{X}$	Standard Deviation	C.V.	N
March-April	2.85 ± 0.04	0.30	10.64	39
May-June	3.50 ± 0.07	0.39	11.14	36
July-August	3.22 ± 0.05	0.29	11.69	35
September-October	3.23 ± 0.06	0.32	12.91	32
November-December	3.58 ± 0.14	0.74	20.67	27

Table 10. Variability of tail length in two months periods (1986).

Period	$\overline{X} \pm S\overline{X}$	Standard Deviation	C.V.	N
March-April	3.18 ± 0.03	0.17	5.34	26
May-June	3.25 ± 0.03	0.18	5.54	28
July-August	2.92 ± 0.04	0.21	7.19	28
September-October	3.44 ± 0.04	0.25	7.27	38
November-December	3.31 ± 0.05	0.32	9.67	48

Table 11 Variability of foot length in two months periods (1985).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	1.9 ± 0.01	0.08	4.19	39
May-June	1.89 ± 0.02	0.13	6.65	36
July-August	1.92 ± 0.03	0.18	9.38	35
September-October	2.04 ± 0.05	0.03	6.21	32
November-December	2.13 ± 0.02	0.09	4.23	27

Table 12 Variability of tail length in two months periods (1986).

Period	$\bar{X} \pm S\bar{X}$	Standard Deviation	C.V.	N
March-April	2.13 ± 0.02	0.09	4.10	26
May-June	2.1 ± 0.04	0.23	10.95	28
July-August	2.06 ± 0.03	0.15	7.28	28
September-October	1.87 ± 0.02	0.1	5.34	38
November-December	1.88 ± 0.01	0.08	4.71	46

In order to obtain a better picture of the comparative variability the coefficient of variation for each bi-monthly series has been arranged and compared in ascending order of variability (Table 13). The data showed that deposition of the same trait was closer in the sequence of variability in 1985 than in 1986. Trait 4 (tail length) in all the samples lies at the left and except July-August, when it occupies the 3rd position. Same is the case with trait 3 (Body weight) which, except July-August and September-October is on the right. But the difference between the values of coefficient are so insignificant that such an arrangement of coefficient of variation may be accidental. The coefficient of variations of different traits do not show a definite pattern. But it is clear that in most of the sample traits 1 (Body length) and 3 (Foot length) are presented on left side and traits 3 and 4 are on right side of the table.

DISCUSSION

It is generally accepted by the researchers that magnitude of variability is related to the intensity of natural selection. But a simple comparison of different points of view showed that the nature of this relation is understood quite differently. According to one point of view the variability, in favourble conditions increases

Table 13. A comparison of coefficient of variability in different body traits. The traits are arranged in ascending order (1 = body length; 2 = body weight; 3 = foot length; 4 = tail length.

Period	1985 Traits	1986 Traits
March-April	3124	1342
May-June	3124	1423
July-August	1243	1234
September-October	1324	1342
November-December	3214	3142

considerably and according to another view in unfavourable conditions the variability increases. According to Yoblokov (1974) natural selection under great pressure would not affect all the organs and traits to the same extent. Elimination of the final removal of the individuals, in other words of the whole ontogeny, will always have individual trait as focal point. During most intense selection, despite pressure on one trait or on a groups of traits the variability of the other trait may not even be affected in any way.

One major difficulty in attempting to make generalization from comparison of different populations like the Murree vole is the amount of genetical heterogeneity of samples. Simpson (1944) pointed out that one of the reasons for obtaining exceptionally low or high variability may be insufficient genetical homogeneity of the samples. In homogenous populations the variability may be the least.

The variability of body length in rodents has broader range from 0.5% in field vole (Microtus agrestis) to 12.9% in yellow-necked mice (Apodemus flavicollis) and 21.0% for the laboratory mice. However, in majority of the cases, the variability of body length ranges, in different species, from 3 or 4% - 6 or 8% approaching 5% on the average (Yablokov, 1974). The field data obtained for a number of samples in a species, show little scattering in values of coefficient of variation: 5.7 - 9.8% for _Apodemus sylvaticus_ (Adamczewska, 1959), 3.7 - 5.6% for _Peromyscus leucopus_ (Clark, 1940) and 3.1 - 5.2 for _P. maniculatus_ (Dice, 1938). The variability of body length of males and females of the Murree vole in all the samples of two years was more or less the same except for the males in 1985 when it ranged from 5.53 - 9.7%. In most of the other samples the variability ranged 3.7 - 7.36.

Body length variation showed a definite trend except in males during 1985. In both the years the less variability was noticed in March-April after which the variability increased. Males behaved differently in 1985 and maximum variability was noted in March-April. In 1985 the snow fall was very low and most of the snow melted in February, while 1986 received heavy snow and most of the area remained covered with snow till April. It indicated that activities of the Murree vole started much earlier in 1985. It was exposed to environmental hazards rather earlier (temperature was very low) resulting in high variability in March-April 1985. However, from March onwards as the environmental conditions became more favourable the variability also decreased. It was observed that males were more active than females, most of the food was gathered by the males in March-April and thus more variability was observed in males than in females in the beginning of the year but in the later half of the year the intensity of conditions was more or less the same. In 1986 the females behaved in the same manners as in 1985. Like 1985 more variability was observed in the male than females, indicating the fact that the males were more exposed to unfavourable environmental conditions.

Variability of weight is one of the most useful parameter in the analysis of data concerning population morphology. Due to the dependence of weight variability on seasonal factors, sex, growth and general condition of the animal, weight variability is an important index which should be given the foremost ecological and physiological significxance (Schwartz, 1962 and 1964). The range of variability of body weight in rodents is great from 24% in Legurus legurus to 22.7% in Mus musculus and as high as 28.2% in Rattus rattus. Even in the populations of the same species, studied under different environmental factors, there is much variation of the body weight. Castle (1938) reported low variability in Mus musculus i.e. 3.2-5.3% in one sample, whereas Dynowski (1963) recorded 15.9-30.9 variability in the same species. However those populations which are living under stable environment the body weight variability range is very narrow. In the Murree vole the variability of body weight ranged from 6.1-10.69% in two years and in majority of the samples the variability was between 6 - 8%.

Body weight, as mentioned earlier, is also related to season. Normally animals during peak season, when the food is maximum, gain weight and show lower variability (Yablokov, 1974). But there are not much variations in the body weight of males and females during the two years. Only September-October samples of males in 1986 showed a greater variability (10.0%). Which indicated that food conditions were more or less constant throughout the year except. September-October, 1986. This might be due to more exposure of the population to the environmental factors or lack of homogenous samples.

The values of variability for different body dimensions of rodents approach 5% on the average but the variability of tail length in all groups, as a rule is very high. The overall, range of variability is also high from 0.8% in A. sylvaticus upto 26.5% in one of the samples of field mice (Yablokov, 1974). On the average, it can be said that magnitude of variability of tail length ranges from 8 - 10%. Like other rodents the variability of tail length in the Murree vole was very high and showed scattering in the values of coefficient of variability. The tail length coefficient of variability ranged from 10.64 - 20.67% in 1985 and from 5.34 - 9.67% in 1986. In both the years for the first four periods there was not much variation, although the variability was much more in 1985 for these periods. However, for November and December the variability was higher than the rest of the periods, particularly in 1985 when the variability was 20.67.

Tail length variability showed that for the first four periods in 1985 and for all the period in 1986 the effect of environmental conditions on this trait might have excercised the same influence. Only in November-December the variability was 20.67% which might be accidental.

The variability of foot length in rodents is not more than the body length. On the whole the variability of foot length ranges from 1.5 - 3.1% in Peromystus maniculatus (Summer, 1920), 3.5 - 6.9% for Clathrionomys rutilus (Yoblokov, 1966) and 8.6 - 10.5% in Apodemes flavicallus (Ursin, 1956). In the Murree vole on the average the variability was more than the variability in the body length, which was rather complex behaviour of the index of variability. Ursin (1956) also obtained the same results for A. flavicollis. The foot length in the Murre vole, does not give a good picture of variability in relation to environmental factors, favourable or otherwise.

CHAPTER-VI

DISTRIBUTION

Genus _Hyperacrius_ comprises of two species: _wynnei_ having two sub-species (_wynnei_, _traubi_) and _fertilis_, with three sub-species (_fertilis_, _brachelix_ and _zygomaticus_). The genus has rather restricted distribution and is known from a small area (about 320 km east to west and 240 km north south) (Philips, 1969). _H. W. wynnei_ is found on the eastern side of the Indus river. Blanford (1881) first recorded this species from Murree and type locality has been listed as Murree (Hinton, 1926). According to Roberts (1977) it is quite abundant throughout the forest regions in the Murree Hills extending westward through the lower forested regions of Hazara District. In Hazara District it has been recorded from Dungagali (2400-2900 m), Nathiagali (2440 m), Thundiani (2530 m) and Shogran (2280 m). In Shogran it ascends to _Mt_. Mukra (3140 m) where its ranges overlaps with that of _H. fertilis_ (Philips, 1969).

H. w. traubi is found on the western side of the river Indus in the Swat Valley, where it has been collected from Changla (2225 m) and Yakhtangi (2070 m) by the University of Maryland Expedition (Roberts, 1977). It has not been reported out side Pakistan, neither it has extended its range northwards into dry alpine forest of Chitral or

Gilgit (Roberts, 1977; Traub *et al.*, 1967). Neithammer looked for this species in Afghanistan but failed to trap it (Neithammer, 1968).

In Galliat the distribution of *Hperacrius wynnei wynnei* appears to correspond roughly with that of mixed forest of silver fir (*Abies pindrow*) and the blue pine (*Pinus excelsa*). Baragali (2288 m) is the northern limit on the road side and has been found upto Barian (2196 m) (Fig.5). Beyond Barian its distribution is interrupted and no vole burrow was seen between Barian and Murree. It has more or less continuous distribution from Baragali to Barian, but it was found only at those locations where the silver fir was present. Relative density of the vole at different localities are given in Table 14 and distribution is shown in Fig.5.

In Baragali only two colonies were found near the bazzar on the road. But no vole was collected from the Peshawar University Summer Camp area. The camp area is at a higher elevation as compared to bazar, the top most soil (Horizon A) is completely eroded and clayey soil and rocks are exposed. In camp proper silver fir was totally absent but other food plants of the voles were present. On the same ridge of the hill the voles were trapped on the path going to Kalabagh where the forest was little disturbed and silver fir was present.

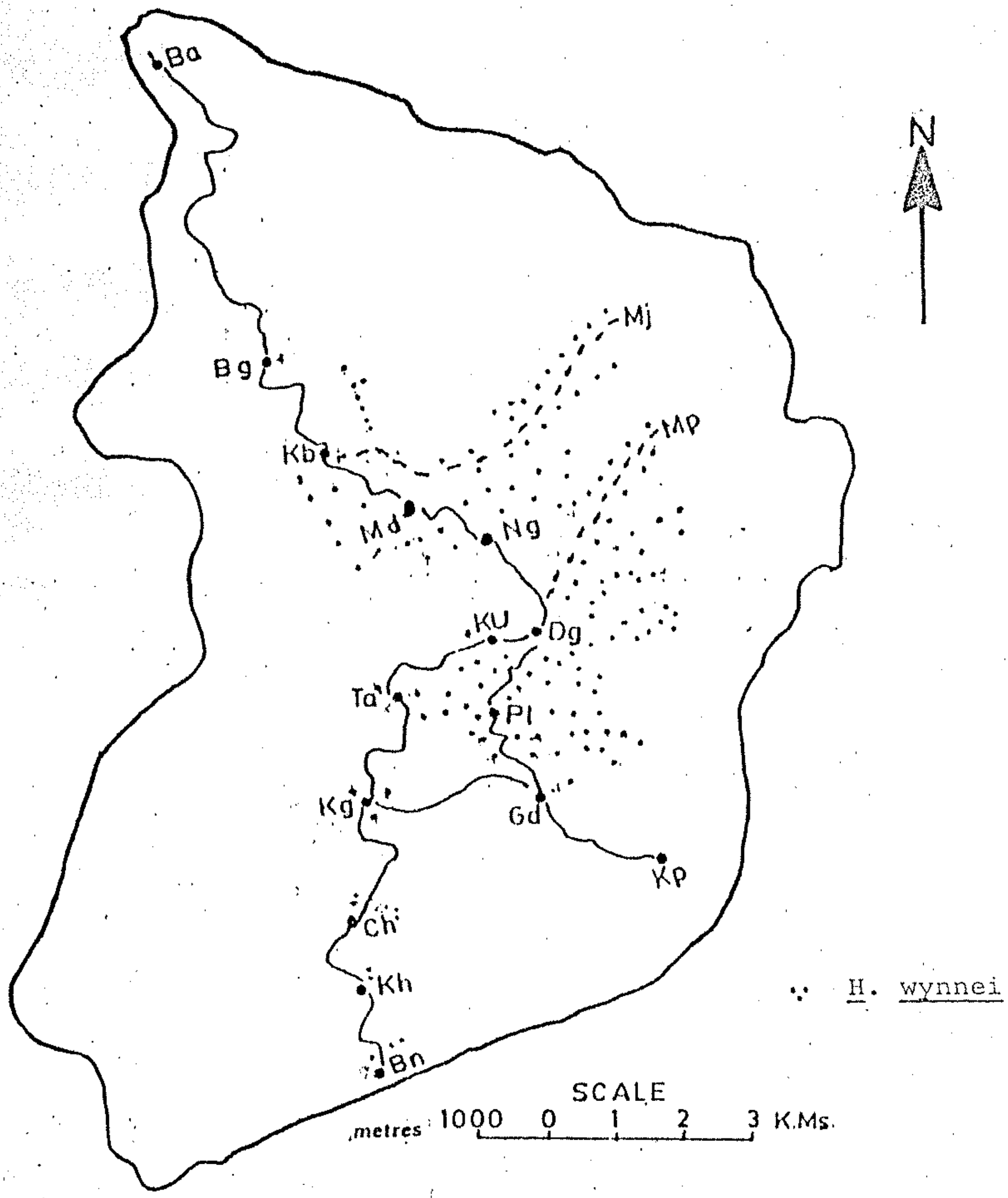

Fig 5. Distribution of H. wynnei in Galliat: Ba - Bangnotar; Bg - Baragali; Bn - Barian; Ch - Changlagali; Dg - Dungagali; Gd - Ghoradhaka; Kb - Kalabagh; Kg - Kozagali; Kh - Khairgali; Kp - Khanuspur; Ku - Kundla; Md - Mochidhara; Mj - Miranjani; Mp - Mukshpuri; Ng - Nathiag Pl - Pipeline; Ta - Tauheedabad.

Table 14. Relative density of *H. wynnei* at different localities in Galliat and Murree area.

No.	Locality	Elevation (metres)	No.of burrow openings/2500m^2
1.	Bangnotar	1800	0
2.	Baragali	2288	4
3.	Kalabagh	2410	30
4.	Miranjani	3290	21
5.	Nathiagali	2440	35
6.	Dungagali	2440	41
7.	Mukhshpuri	2928	33
8.	Pipe line	2365	20
9.	Ghoradhaka	2360	5
10.	Khanuspur	2300	0
11.	Tauheed Abad	2345	5
12.	Kozagali	2370	7
13.	Changlagali	2510	3
14.	Khairagali	2300	2
15.	Barian	2196	3
16.	Swargali	2100	0
17.	Kalimitti	1990	0
18.	Sunni Bank	2020	21
19.	Murree	2257	23
20.	Ghegagali	2100	0

The actual distribution starts from Kalabagh (2410 m) where it was collected on both sides of the road and was quite common in the lawns of the bungalows. Nathiagali (2440 m) and Dungagali (2440 m) are the ideal localities and vole were not only collected on both sides of the road but they were also trapped at Miranjani (3290 m), the highest point in Nathiagali and Mukshpuri (2928 m), the highest point in Dungagali (2440 m).

On the pipe line, a short path going to Khanuspur and Ghora Dhaka, the voles were found on the grass land. In Ghoradhaka it was collected only at the top of the hill, where the Chairlift ends. Soil conditions in Ghoradhakha and Khanuspur are same as those of Baragali. In the rest of Galliat this species was quite common in the forest nurseries (Tauheed Abad and Kozagali) in grassy land, forest and the cultivated fields near the road. However, on the lower side of the road the distribution was quite restricted and no specimen was trapped in the villages down the hill.

DISCUSSION

Blanford (1881) described _H. wynnei_ from the specimens collected near Murree which is also listed as type locality by Hinton (1926). However, Philips (1969) suggested that the ecotype of _wynnei_ lies higher in the Murree hills as Murree city is at low elevation. Actually

Murree city lies at an elevation of 2225 m and a number of workers have recorded this species from Murree (Roberts, 1977). During this survey the voles were not only collected from Murree city proper but also were found in the apple orchards on the Sunny Bank, which is still at a lower elevation than Murree. However this voles was not recorded from the other areas adjoining Murree town.

In the present study the lowest elevation at which this species was found was 2075 m (Sunny Bank) and the highest elevation was 3290 m (Miranjani, Nathiagali). It is in contrast to what has previously been stated by Philips (1969) & Roberts (1977).Philips (1969) stated that this species did not occur above 2500 m,whereas Roberts reported that this is found from about 1830-3050 m elevation.Eighteen hundred meter elevation is too low for this vole and none of these locali-ties, from which this species has been recorded, are below 1830 m. It certainly occurs above 3050 m (Miranjani).

Genus Hyperacrius has rather restricted, dis-continuous distribution & is known from a smaller areas (about 200 miles east to west and 150 miles north to south) but possibly has a wider distribution than indicated by the available literature (Philips, 1969). Traub et al.(1967) presented data on the distribution of Rickettsia tsutsugamushi, associated ectoparasites and endemic host mammals that could explain the small range and discontinuous distribution of Hyperacrius. They concluded that Shogran in Kaghan Valley & the Murree hills are ecologically similar and most of the fauna of the two places resemble.But Shogran, which receives more rainfall than the rest of the valley, is different from the other places in Kaghan and Gilgit.They suggested that in vast streches of desert of Gilgit, where there is plenty of available water, exist 'Ecological Islands'.They further suggested that many of the animals(rodents,insectivores,ticks, mites & fleas)inhabiting these reservations are relicts of a temperate era before the formation of deserts,when the entire region must have been covered by coniferous forest.Traub & Evans (1967) stated that in the late Pliocene there was a vast coniferous temperate belt, and animals including Hyperacrius or its precursor could had a continuous distribution in this coniferous forest,which might have widely disturbed by the upheaval that formed the Himalayas & subsequently vast desert areas such as Gilgit.According to Philips (1969) sub-speciations in both H. wynnei & H. fertilis is related primarily to two factors:(1) restriction to suitable habitat above 1830 m & (2)three deep river valleys(the Indus, Kashmir & Jhelum)& one broad valley(the vale of Kashmir)that are geographic barriers to the distribution of the species (Fig. 6).

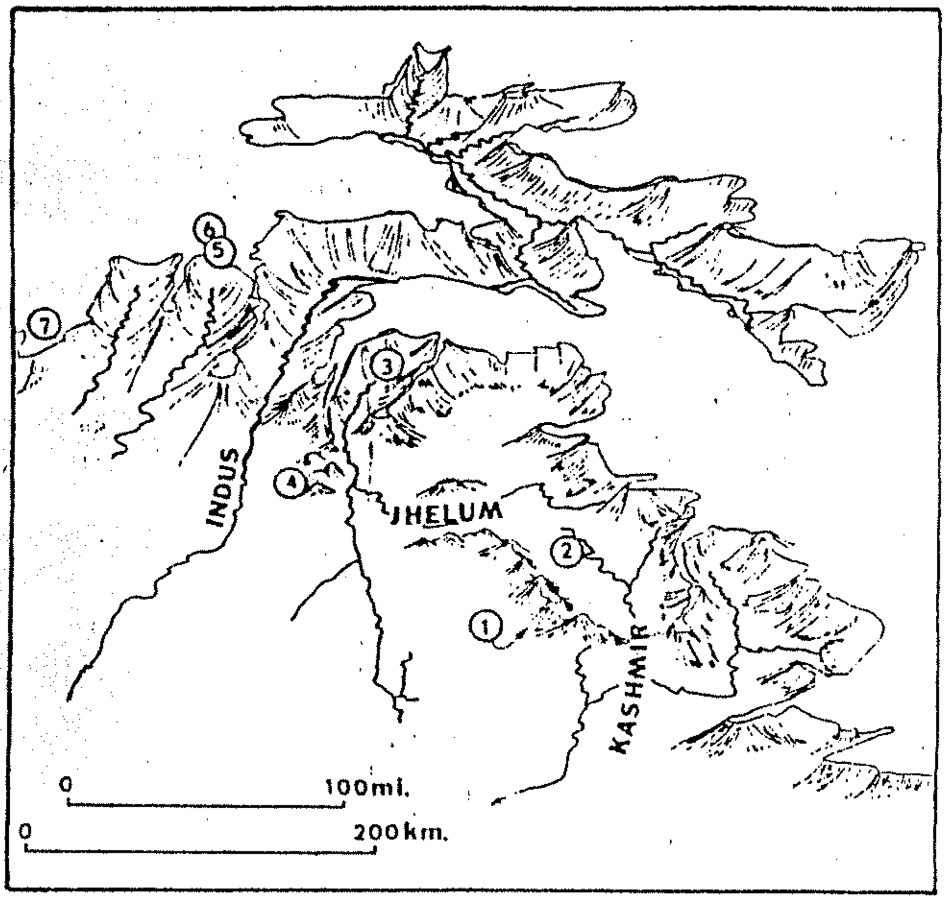

Fig 6. Diagramatic representation of zoogeography barriers of major importance to Hyperacrius. Number denote: Pir Panjal Mountains (1); Vale of Kashmir (2); Kaghan Valley (3); Murree Hills (4); Yakh Tangai and Shangla (5); Utror (6); Dir (7); Rivers are named. (Philips, 1969).

It is quite interesting that all the localities from where H. wynnei has been collected, are ecologically similar and have more or less similar fauna and flora. After the formation of the Himalayas and the ecological Islands, the distribution of this vole was further restricted by physical and climatological factors. For example the Galliat used to have vast and thick mixed forest of Abies pindrow and Pinus excelsa on both sides of the road. But on the lower side of the road due to intensive cultivation and destruction of the forest the top soil horizon has been completely washed out. Same is the case in Baragali,Ghoradhaka & Khanuspur,which were converted into the military cantonments after world war-I. As a result of the destruction of soil horizon A in these places the vole was eliminated and is now found only in those places, where A. pindrow, alongwith top loamy soil, is present.

CHAPTER-VII

FEEDING HABITS

The Murree vole digs multi-entrance burrows spreading over a large area. Due to its fossorial habit it was normally found feeding near the entrance and it was only during July, August and September, when the vegetation cover was maximum, that it was observed collecting plants beyond the burrows. The animal, cuts the plants a little above the ground level which are then held in the mouth and ultimately dragged into the burrows, where it was cut into small pieces. The vole was found active during day and night but most of the food was gathered only during the night while during July-September, the food was mostly collected during the day time.

The youngs had a limited sense of orientation. They fed just around the burrows entrance. A few females with advanced stage of prognancy were trapped, indicating that most probably the pregnant females were fed by other members of the family.

A number of plants (Table 15) like dahlia, tomatoes, Ariplex laciniata, Cordalis stevartii and Nepela errecta were observed being taken by the voles but were found absent from the stomach contents. On a number of occasions the pieces of leaves and stems were thrown out by the voles alongwith the soil.

The food of the Murree vole in the study area was entirely composed of vegetation. Insects were found in a few stomach contents but their presence in small amounts indicates that they were taken just by accident. Hairs of the voles were regularly found though in small amount throughout the year and most probably were ingested during grooming activities. However a few stomachs contained mostly hairs and striated muscles. Such voles might have fed on the dead vole. In a number of cases the viscera and major portion of the abdomen of the trapped animals were found missing. As the abdominal part of the trapped animals portion remained in the burrows, probably the missing portion was consumed by conspecific animals. Presence of striated muscles in a few voles substantiated the view that the Murree voles consumed the dead individuals.

The Murree vole feeds on a variety of plant species. Twenty three plant species were identified in the stomach contents (Table 16). A few plant species which were found in very small quantities are not included in the data and a few ornamental flowers were observed being taken by the vole into the burrows but were not found in the stomach. About 6.4% of the total volume of the vole food could not identified and there is every possibility that this portion may include some additional species of food plants. The monthly percent consumption of different food plants by

Table 15. List of the plant species observed to be carried into the burrows.

1*. Dhalia

2*. Tomato

3*. *Ariplex laciniata*

4. *Cynachuim leucroanthum*

5. *Leuchus lanla*

6. *Cannabis sativa*

7. *Scnicia chrysanthemoid*

8. *Rumex neplensis*

9. *Polygonum nepalensis*

10. *Scropularia polyantha*

11. *Bachopodium sylvalum*

12*. *Cordalis stevartii*

13*. *Nepela errecta*

* was not found in the stomach contents.

volume is given in the Table 16. Rumex napalensis was amongst the most favoured food plant, representing on the average, 31.0% of the total yearly diet (Table 16). Its importance was largely depended on its heavy utilization throughout the year (Fig.7). Several factors may determine the most pronounced and remarkable reliance upon this species by the Murree vole. One factor is the early growth of the plant. This was among the first few plants species which were available after the snow melted and remained green till November. The second factor was the distribution of this food plant. This plant apart from being quite common in the study area and also grew in clumps, forming a suitable habitat for the vole species. The vole dug many burrows in such clumps and without being exposed could push the plant parts inside these burrows.

The striking dependence upon R. nepalensis by the Murree vole may also be due to its size. It was the largest broad-leave herb in the study area. The plant consisted of numerous broad leaves on the ground with a long stem in the centre. From August onwards the main stem died out but ground leaves remained green. The consumption of the plant decreased during August and September (Fig.7) when a number of other plants were available in the area.

TABLE 15. Percent volume (V), percent frequency (F) of plant species utilized by E. wynnei during different months in Callias.
Figures in parenthesis show the number of stomachs examined.

Plant	March (25)		April (18)		May (8)		June (23)		July (20)		August (24)		Sept (21)		Oct (20)		Nov (18)		Total (201)	
	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F
1 Rumex nepalensis	33.0	73.0	44.2	72.2	40.4	50.0	35.3	65	37.3	65	35.1	41.6	15.3	42.84	35.5	50	28.3	56	31.0	46.3
2 Cynachium Leucoanthum	----	----	----	-----	-----	-----	1.3	4.34	2.1	20	4.5	16.6	2.3	23.8	-----	----	-----	-----	1.2	7.9
3 Urltrica dioeli	----	----	----	-----	15.4	25.0	8.6	43.4	15.1	45	19.1	33.3	19.3	19	11.5	20	15.5	22.4	13.7	21.5
4 Urltrica Ceea	----	----	----	-----	4.5	25	4.3	17.36	3.1	20	2.5	29.2	2.1	19	-----	----	3	11.2	2.3	13
5 Potato	----	----	----	-----	-----	-----	2.3	17.36	2.2	25	3.6	24.9	4.9	33.3	-----	----	-----	-----	2.2	12.4
6 Turnip	----	----	----	-----	-----	-----	1.1	4.34	1.5	10	-----	-----	-----	-----	-----	----	-----	-----	0.3	1.7
7 Fragaria nubicola	0.9	13	1.5	11.2	0.7	12.5	----	-----	0.7	5	-----	-----	-----	-----	-----	----	-----	-----	0.5	4.1
8 Stachys sericea	----	----	5.6	11.2	4.6	25	1	11.4	1.3	30	1.2	24.9	1.5	47.6	1.6	35	2.5	33.6	2.2	24.3
9 Leucus lanla	----	----	0.5	11.2	0.6	2.5	1.9	28.1	1.1	25	0.5	29	1.6	19.04	2.7	30	-----	-----	1	17.5
10 Cynoglossum lanceolum	14.3	60	7.4	56	6.4	50	5.6	39.1	2	40	3.5	33.3	3.5	33.3	3.5	30	3.5	22.4	4.3	58.8
11 Cannabis sativa	----	----	----	-----	-----	-----	----	-----	1.7	10	1.3	5.32	-----	-----	-----	----	-----	-----	0.3	3.4
12 Viola canescens	6.6	48	3.5	22.4	0.8	25	----	-----	-----	----	-----	-----	-----	-----	-----	----	3.5	11.2	1.2	1.3
13 Lanium album	----	----	----	-----	-----	-----	2.5	17.36	1.3	25.6	1.3	29.1	2.3	23.8	1.3	20	2.3	28	1.2	16.9
14 Chrysanthemum leucathemum	C.2	52	0.5	39.2	2.6	37.5	3.6	4.3	1.3	10	1.3	15.1	1.6	14.3	1.3	20	2.5	28	1.9	26
15 Brachyactis rosbusta	----	----	----	-----	-----	-----	----	-----	-----	----	-----	-----	3.5	19	6.6	40	2.6	28	1.4	9.6
16 Senecio chrysanthemoides	----	----	3.3	9.8	5.5	25	16.9	43.4	15.1	60	17.6	49.9	18.4	28.6	15.6	50	5.5	39.2	10.8	29.4
17 Onychum contiguum	----	----	----	-----	-----	-----	3.3	8.7	2.7	10	0.9	9.52	0.8	7.52	1.8	10	-----	-----	1.1	5.1
18 Scrophularia polyantha	----	----	----	-----	-----	-----	----	-----	2.2	2	1.3	25	2.8	23.8	3.7	25	1.5	28.6	1.3	10.7
19 Myractus wallichii	----	----	----	-----	-----	-----	----	-----	1.1	20	0.8	12.48	0.6	9.5	3.5	30	1.6	28	0.8	11.4
20 Viburnum grandiflorum	17.1	46	10.1	22.4	-----	-----	----	-----	-----	----	-----	-----	-----	-----	-----	----	12.3	56	4.4	11.3
21 Poa pratensis	20.1	94	18.8	84	8.8	60.1	6.5	86.4	2.1	90	3.1	83.2	4.1	80.4	6.5	80	4.6	67.2	8.2	89.3
22 Bachopodium sylvaticum	----	----	----	-----	-----	-----	4.2	13	2.5	30	8.1	33.3	3.1	23.8	1.5	25	1.6	4	1.9	15.8
23 Polygonum nepalense	----	----	----	-----	-----	-----	----	-----	-----	----	1.1	29	5.1	23.8	6.5	40	3	44.8	1.7	17.5
24 Un-identified plants	6.1	----	4.5	-----	10.7	-----	8	-----	3.7	----	2.1	-----	9.3	-----	6.9	----	7	-----	6.4	-----

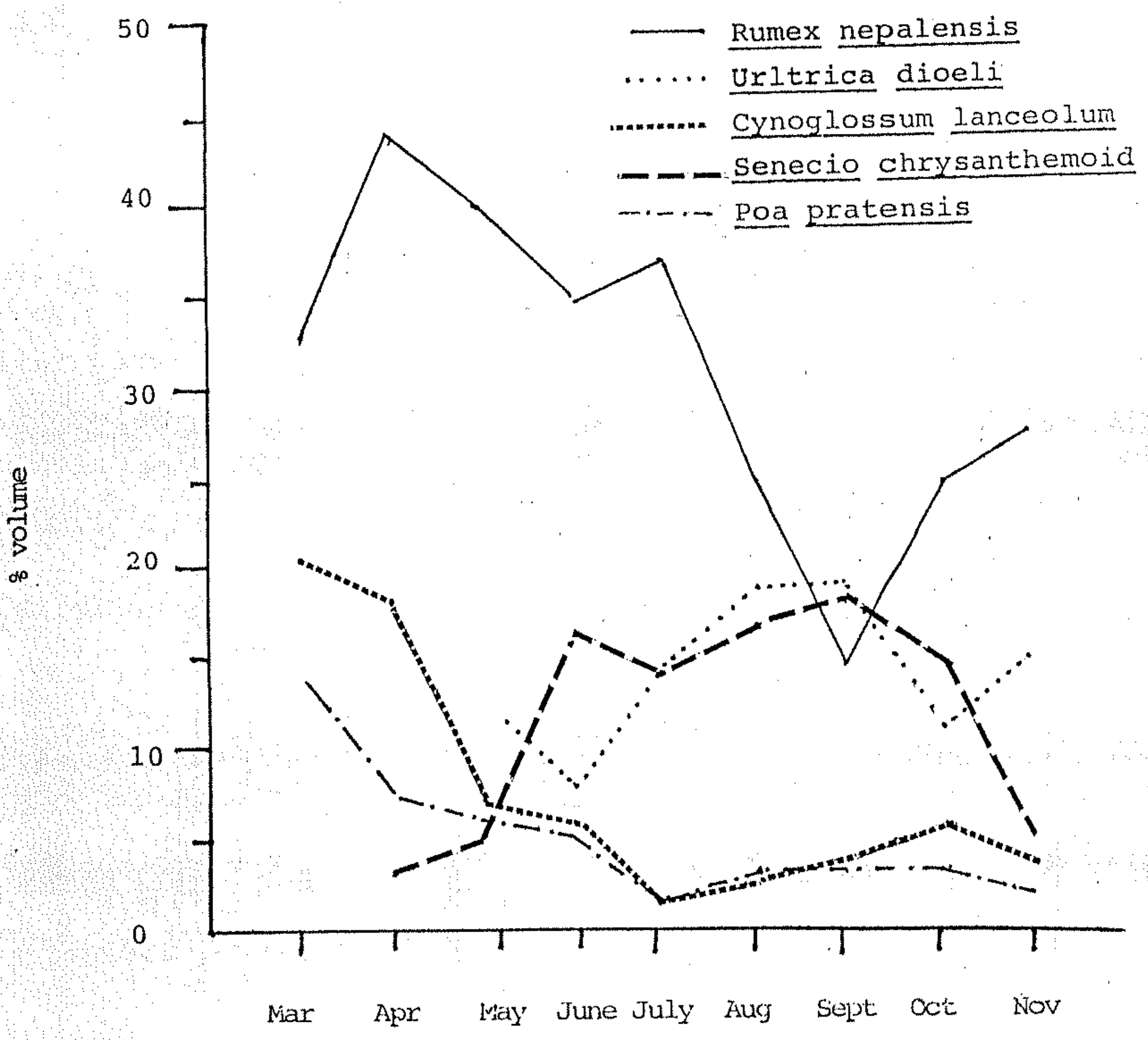

Fig 7. Comparison of percent volume of major food plant species, utilized in different months.

Two other important plant species were Urltrica dioeli and Senecio chrysanthemoides which were well distributed in the study area. U. dioeli also showed a clumped distribution. Both these species of plants collectively formed 24.5% of the total diet of the year (Table 16). These plants are of comparatively tall in size (more than 20 cm tall).

Small plants (less than 20 cm tall) were not less important, as they formed 16.8% of the annual diet. Among the small plants, Cynoglosum lanceolum was eaten consistently and accounted for 4.1% of the yearly diet (Fig.7). The plant was eaten from March to November and the amount varied with the time but was never a major food item, except in March when 14.3% of the total monthly diet consisted of this plant. This may be due to the fact that in March many plants were not available in the study area.

The only shrub found in the stomach was Viburnum grandiflorum and the vole fed on its bark. Its importance is quite evident (Table 16) in March and November when a few other food plants were available. Most probably it is the major food item when the ground is covered by snow. Roberts (1979) reported the feeding of the Murree vole on the bark of the apple. Stomach contents of a few voles trapped in winter showed that bark of the shrubs was their major food during winter.

Vegetables like potatoes and turnips consisted of 2.5% of the yearly diet. This low percentage may be due to low number of voles trapped in the vegetable fields.

Among other large plants Urltrica ceae was another important food plant. It showed a clumped distribution and in the diet of some voles trapped among the clumps it accounted for about 51.7% of the volume of the food.

Among the non-Angiosperm plants Onychum contiguum was the only species which was found in the stomach (Table 16). The plant had patchy distribution and was found in particular spots in the study area. In some stomachs this plant constituted about 40% of the total diet of the stomach.

Grasses formed 10.1% of the yearly diet (Table 16) and only two species of grass, Poa pratensis and Bechopodium sylvaticum were identified. P. pratensis was most important species of the grass and accounted for 8.2% of the yearly diet (Table 16). Its importance increased after melting of the snow in March when only a few other food plants were available (Fig.7). It was one of the major food plant during this period. Its frequency of occurrence was very high even in those months when other food plants were quite common. During this period the juvenile diet comprised of 50 percent of this grass, as it was quite common near the burrows. B. sylvaticum also shows patchy distribution. It was present in the stomach contents of only those voles, which were trapped in the area with plenty of this grass. In the study area a local farmer cultivated this grass at the edges of his fields for domestic animals.

DISCUSSION

Hinton (1926) quoted from the field notes of H.H. Dun that the Murree vole is mole like in habits. Later on many workers like Walker (1964) and Philips (1969) repeated this informtion. Roberts (1977) examined the stomach contents of a few voles and did not find any soil inhabiting invertebrates. He stated that these voles are exclusively herbivorous and also presumed that during summer, they feed largely on roots and under ground stems. The present study agrees with Roberts (1977) that the vole feeds entirely on plants but his presumption that during summer its food is largely based on roots and under ground stem is not correct. Except potatoes, no other under ground stem or root were observed in the stomach contents in any season. A few insects were found in some stomachs but these might have be ingested accidently. The only mole like habit which this vole had was the pushing of the excavated soil out through the burrows exits and this habit is also found in a number of other rodents.

The diet choice in small mammals is determined by presence of the competitors, relative abundance of food plants and its qualitative and handling characteristics (Flemming, 1979). Meserve (1976) stated that due to the presence of a large number of competitors in California Sage Scrub community, _Peromyscus maniculatus_ and _Reithrodontomys megalotus_ are generalized feeders. Due to their small size and subordinate position they cannot compete with other better adapted rodents. Husar (1979) documented a significant shift in the diet of the insectivorous bat (_Myotis evotis_) when it is sympatric with a morphologically similar bat (_M. auriculus_.).

At low food abundance, food generalists are favoured over food specialists, (Schoener, 1969; Schoener, 1971). This applies to many herbivores like _Ctenomys_, (Pearson, 1960), _Geomys_ (English, 1932; Vaughah, 1962; Vaughan, 1967) _Heterocephalus_ (Jarvis, 1978) _Taychoryctes_ (Jarvis and Sale, 1971) and _Cryptomys_ (Genely, 1965).

No other true burrowing rodent co-exists with the Murree vole in the Galliat area. Thus the latter is not subjected to a competition with any other species. The only other two species trapped from the burrows of this vole were _Apodemus sylvaticus_ and _Mus musculus_ but their numbers were too small to pose any threat to its food resources. Moreover, when their stomach contents were examined they contained only seeds and underground stems. Inspite of the fact that there are no competitors and food is quite abundant (except in winter) this vole is not a specific feeder and ingests a variety of plants. The reason is that this rodent is entirely fossorial and feeds on the plants available near its burrows. Even during August and September, when there is plenty of vegetative cover, the vole does not go far off from its burrows. So the accessibility of the food near the vicinity of the burrows has influenced the diet of the vole. The data showed that the vole preferred certain plants over other however, if these plants were not available then it may shift to others, plants. This also applies to other herbivorious fossorial rodents like Ctenomys (Pearson, 1960) Geomys (Hansen, et al., 1960; Miller, 1964; Wilks, 1963) Heterocephalus (Hill et al.,1957) and Cryptomys (Genelly, 1965).

Heteromyid rodents living in the desert have to avoid temperature and humidity extremes and potential predators. This is accomplished by being active above the ground for relatively a short period of time (Kenagy, 1973; Shah, 1934) and is assisted by the use of cheek pouches to minimize the number of trips required to collect food. Cheek pouches allow the heteromyid rodents to gather large quantity of food before returning to the relatively safer place (Reichman, 1975). The Murree vole has not devloped cheek pouches like these rodents. But the vole has to spend little time above the ground to avoid predators. Like Heteromyids, the dietry requirements of the Murree vole, however, are probably mediated by attempt to minimize the time spent above the ground foraging, thus avoiding predators. This is accomplished by being active above the ground for relatively short periods of time and is assisted by its preference for tall plants to minimize the number of trips required to collect the food. Frequency of trips to bring the same quantity of food, will be more for the small plants than tall plants.

In Heteromyids the food collecting and eating are two independent events. These rodents gather many seeds they encounter, as rapidly as possible, filling their pouches. They select the appropriate item in the burrow, which is a safer place. Feeding and collecting seem to be related phenomenon in the Murree vole as all the plants collected are consumed.

The fitness of the Murree vole is further maximized by an optimal foraging space. It had large home range, spreading over an area of about one acre and with the passage of time it keeps on expanding it. Fossorial rodents have further maximized their foraging efficiency by being active day and night (Vaughan and Hansen, 1961; Godfrey and Crowcroft, 1960). *Clethrionomys rutilus* has diurnal pattern during winter and autumn, and nocturnal pattern during spring and summer (YIonen, 1988). Like other fossorial rodents, the Murree vole was active day and night and had optimal foraging period. The cost of feeding was also shared and only few females with advance stage of pregnancy, were trapped, suggesting that these females were provided food by other members of the colony.

Most of the fossorial rodents, which do not hibernate, normally store food or utilize fats during winter. Fat bodies were not observed in the body and during exavation of tunnels no stored food was found. During snow period it was observed feeding on the bark of the apple trees (Roberts, 1977) and in the Galliat Veburnum grandiflorum bark was thrown out along with the soil. A few vole were trapped in winter and their stomach content showed that during winter major food of the vole was bark of the plants. Some Cletherionomys species also supplement their diet to considerable degree by the bark of the shrubs and trees in winter (Hanson, 1984). Microtus agrestis is the most serious debarker of trees in Europe (Myllymaki, 1979).

CHAPTER-VIII

HABITAT

As mentioned earlier the distribution of the Murree vole coincided with that of silver fir (*Abies pindrow*). In Galliat the vole was not recovered in those areas where *A. pindrow* was absent except on a single occasion when the vole was caught near Baragali Bazar where *A. pindrow* was absent. *A. pindrow* distribution starts from Baragali Gali (uppersides of the road) and ends at Barian. In between these two localities the vole was spotily distributed over much of the area.

Wherever this vole was found, no other burrowing rodents were found and it was entirely fossorial in its habits. Almost all of its activities were confined to its burrows. So wherever the burrows were found, the place was considered to be the habitat of the vole. The relative abundance was recorded by observing the number of active burrows. The active burrows were easily recognized by the excavated soil.

Data on the relative abundance of the Murree vole in four different habitats is presented in Table 17. Data indicate that the vole was present in the grassy lands, abandoned and cultivated fields. It was absent in the thick forests, however a few burrows were observed in the forests

Table: 17 Relative abundance (Number of active burrows/ 250 m^2) in different habitats.

Habitat	Relative abundance
Forest	0.9
Grass land	8.6
Abandoned cultivated fields	10.3
Cultivated field	11.3

along the grassy areas. These burrows were the extension of the burrow system of the voles living in the adjoining grass land. Not a single cultivated or non-cultivated field was found where this vole was absent. However, the vole was not present in some grassy areas as it also required some other suitable conditions. The cultivated and non-cultivated fields were the most preferred habitat of the Murree vole.

MICROHABITAT

To evaluate microhabitat the following variables were studied:

A. Plant density

B. Vegetative cover

C. Soil.

  i. Organic Matter

  ii. Soil Texture

  iii. Soil Depth

D. Topography

(A) PLANT DENSITY

Galliat is very rich in ground flora (Appendix-II). During summer all the ground is covered by the herbaceous plants. Food plants of the Murree vole were well distributed over the whole study area. Even these plants were quite common in those places where the vole was absent. The plant communities of two areas (where voles were present and where they were absent) were analyzed and community similarity coefficient was calculated, which showed not much difference between the flora of the two areas (93.35% of the plant species were common in both the communities). This indicated that the presence of food plants did not influence the habitat of the Murree vole. It is not surprising since the vole is a generalist in feeding habits. Any difference between the plant communities of the inhabited and non-inhabited area seemingly did not affect its distribution. However it had exploited some plants like Rumex, which had clumped distribution in the area, for its habitat. It was noted that wherever these plants was clustered, the burrows were found.

(B) VEGETATIVE COVER

The Murree vole has a permanent home range in the form of burrowing system, which may spread over an area of more than 450m² . Most of the activities were confined to its burrow. In March, November and December there was no vegetation and vegetative cover was almost zero. Normally when the vegetation cover was zero most of the food was gathered at night. During the day it fed on the grass just very close to its burrows, thus avoiding any threat of predators. Even in spring when the vegetative cover was maximum, a number of burrows were active in those areas where the cover was almost zero (Table 18). At Mukshpuri peak, a vole was observed collecting dry grass, perhaps for nesting, from an area where there was no vegetative cover. So the possibility that vegetative cover might regulate the habitat of the Murree vole is ruled out.

(C) SOIL

The distribution of the vole like other fossorial rodents is determined by the soil types. The soil of the area, where the Murree vole occurred was quite different from the area where this vole did not occur. Soil texture played an important role in the selection of the habitat by the Murree vole.

The analysis of the soil texture from different localities is presented in the Table 19. The soil in Galliat was composed of two distinct layers or horizons. Horizon A, which was quite distinct and was of black or dark colour, and horizon B was of light colour. Horizon A can be classified as a loam or silt loam, while Horizon B was clayey. The analysis of soil samples collected from different localities where the vole was found, showed that there is not much difference among soils of the localities as far as texture is concerned. The soil of Murree, which lies at a distance of 27 Km from Dungagali does not differ much from the rest of the localities in silt. The data (Table 19) indicate that the Murree vole seems to prefer a habitat where the silt percentage is about 40% or more.

Table 12 A comparison of relative abundance (No. of active burrows/250 m2) as a function of quality of five habitat characteristics

Depth of the soil Horizon A (cm)	No.of active Burrows	% of vegetative cover	No. of active burrows	Slope of the ground (degree)	No. of active Burrows	% of the Area covered by grass	No. of active Burrows	% of the Area covered by the stones	No. of Active Burrows
< 15	0	< 10	5.3	< 10	1.1	< 20	0	< 10	5.5
15-25	4.6	20-40	5.4	10-30	5.5	20-40	3.4	10-30	5.3
25-35	6.5	40-60	5.5	30-50	5.6	40-60	4.5	30-50	4.3
35-45	6.8	60-80	5.7	50-70	5.6	60-80	5.7	50-70	3.8
45-55	6.9	80-100	5.7	70-90	5.7	80-100	3.5	70-90	0

Table 19. Comparison of soil texture, sampled from five different localities.

Locality	Sand (%)	Silt (%)	Clay (%)	Organic matter (%)
1. Kalabagh	29.6	48.0	22.4	6.45
2. Nathiagali	35.8	55.8	8.4	6.28
3. Dungagali	44.0	47.6	8.4	7.31
4. Tauheedabad	43.6	50.0	6.4	6.97
5. Murree	51.8	39.8	8.4	6.93

There was a strong positive correlation ($r = .9$; $t = 8.0$; $df=4$; $P<0.05$) betweem depth of Horizon A and the Murree vole abundance (Table 18). Burrows were seldom found in soil having horizon. A less than 15 cm deep. The Murree vole is a poor digger and gravel and rocks also effected its distribution (Table 18). In the area where there was few rocks or stones the vole constructed the burrows all around the rocks instead of burrowing underneath them. Those area, where rocks occupied more than 70% of the total area, the vole was entirely absent. Relative abundance was correlated with presence of rocks ($r = .89$; $t = 14.8$; $df = 4$ $P<0.05$).

The Murree vole was not trapped from forest area but it was found quite abundant in the open land because soil in these areas was comparatively compact. Galliat receives heavy snow fall and in some year the snow fall exceeds 2.5 meters. In the case of construction of burrows in the loose soil there is a danger of damage to roof of the soil due to weight of the snow. At Mukshpuri peak, it was observed that the roof of the burrow was depressed but not fallen.

(D) TOPOGRAPHY

Topography also plays an important role in the selection of habitat (Table 18). Most of the burrows were observed on the edges of lawn or terrases or along the slopes of the hill. When snow melts or during rainy season

season steep slopes may provide better drainage. It was almost absent in level ground. The minimum slope it required was 10°. Above 10° slope the relative abundance was almost the same (Table 18).

Grass (Poa pratensis) also played an important role in selection of habitat. Many grass areas (including lawns in the residential areas) was occupied by this vole. Its abundance in the grass land was correlated with the percentage of area occupied by the grass ($r=.9$; $t=18.4$; $df=4$; $P<0.05$) (Table 18). The roots of the grass held of the soil and prevented any collapse of the roof and grass also provided nesting material. There were grass lands, where no vole was found. In these areas other conditions like soil texture, soil depth, slope etc. may not be favourable.

DISCUSSION

In choosing a habitat in which to live, fossorial rodents presumably are more responsive to certain habitat features than others. Various studies have shown that these features include soil type in Kangroo mice (Ghiselin, 1970), the diversity of branching patterns of density of logs in Permoyseus leucopsus (MCloskey, 1975), presence of low vegetative cover in Microtus pennsylvanicus (Grant, 1971), lack of vegetative cover in Dipodomys merriami (Rosenzweig, 1973), presence of specific kind of plant in the case of

Neotoma lepida (Brown *et al*., 1972) and the presence of specific food types in *Peromyscus maniculatus* (Drickamer, 1976).

In the present study it is clear that depth of the Horizon A and the texture of the soil were the most important factors in both the geographical and habitat distribution of the Murree vole. It is well accepted that the soil texture influences the distribution of burrowing mammals and many authors recorded gross characteristics of the soil where subterranean rodents have been trapped for a variety of purposes (e.g., Grinnel, 1922; Allered and Becks, 1963; Jorgenoun, 1963; Esinberg, 1963). It has been noted that soil type influences the distribution of pocket gophers (Kenerely, 1954; Howard and Child, 1959; Wilks, 1963; Miller, 1964). Hardy (1945), in the most extensive investigation of correlation of soil type with rodent distribution, reported very distinct association of fossorial mammals and soil type in South Western Utah (U.S.A). His data indicated that soil texture was related to the distribution of several species, apparently excluding some rodents from either fine or coarse soil. Ghiseline (1970) while discussing the edaphic control of Kangroo mice stated, that where *Microdipodops magacephalus* and *M. palladus* are sympatric, *M. megacephalus* is found in gravel soil, while *M. pallidus* is restricted to sandy soil.

Most of these authors concluded that the ease of digging must effect the liklihood of survival of population of fossorial animals in an area. Miller (1964) stated that if the ease of the digging was the only problem, one would expect that fossorial animals would use only their teeth and abandoned the use of their claws as Spalax and Heterocephalus have done. Ghiselin (1970) stated that habitat selection is an innate behaviour and is subject to same type of evolutionary adjustment as morphological or physiological trait. Choice of a habitat in which characteristics of an animal permit it to exist, must be advantageous and where its survival is favoured over less suitable places.

The high field porosity of sandy soil and low field porosity are more likely to be the factors determining gophers distribution (Mcnab, 1966). Consideration of the porosity of the soil is important, since all gas requirement of an animal living within the burrow must be met by diffusion through the soil. Penman (1940) has demonstrated that diffusion of gases or vapours through a soil is dependent upon the soil porosity.

The Murree vole like other fossorial rodents, might be facing the some problem of gas diffusion but unlike pocket gopher and majority of other fossorial animals, the problem of gas diffusion would be more severe for the Murree vole, who lives in colonies. The total rate of metabolism of a colony is likely to be much more than that of pocket gopher leading a solitary life. So the soil that has a low rate of gas diffusion may be rejected for habitation by the Murree vole.

Clayey soil has greater total porosity (no. of pores per unit area) than the loamy or silty loam but pores are much smaller requiring a greater force, because of retention of water due to capillary action (Mcnab, 1966).

Though the soil texture is the major factor in determining the habitat of the Murree vole, its existence in a habitat also depends on other factors like grass, slope and presence of rocks and roots of woody plant. The minimum slope requirement is 10°, which helps vole to solve the drainage problem. Grass (Poa pratensis) is not only a nesting material but it also holds the soil of the burrows roof from collapsing. Being poor digger it prefers to inhabit those areas which are free of rocks and woody material. This may be one of the reasons for its preference for the cultivated and grasslands, where roots and rocks are removed. One may conclude that the following are the minimum requirements for the Murree vole to exist in a particular habitat:

a. Loamy soil

b. more than 15 cm depth of soil Horizon A

c. 10° slope of the ground

d. more than 20% of the grass area

e. more than 30% of the area, free of rocks.

CHAPTER-IX

BURROW SYSTEM

The burrows serve the Murree vole for shelter, protection from enemies, as means for passage of food and as a place for rearing the young and to protect the animal from rigors of external environment. The social vole spends most of its life in the closed system of underground tunnels. The burrow system constitutes the vole home range. Being social, a system is occupied by a number of young , subadults and adults.

The Murree vole excavated an extensive net work of branching and anastomosing tunnels with attached nests and resting chambers. (Fig. 8). Unlike Gophers and some other fossorial rodents, which construct a close burrow system by plugging all the surface connections with earth when not actually being used, this vole formed an open system and only few burrows were plugged. Each system had several main tunnels which ran more or less parallel to the ground, relatively at shallow depths. About 90% of the system was observed just 20 cm below the ground in the soil (Table 20). The longer horizontal tunnels had laterals at frequent but irregular intervals. Many short laterals ascend to the surface, where they terminated in excavated mounds and other

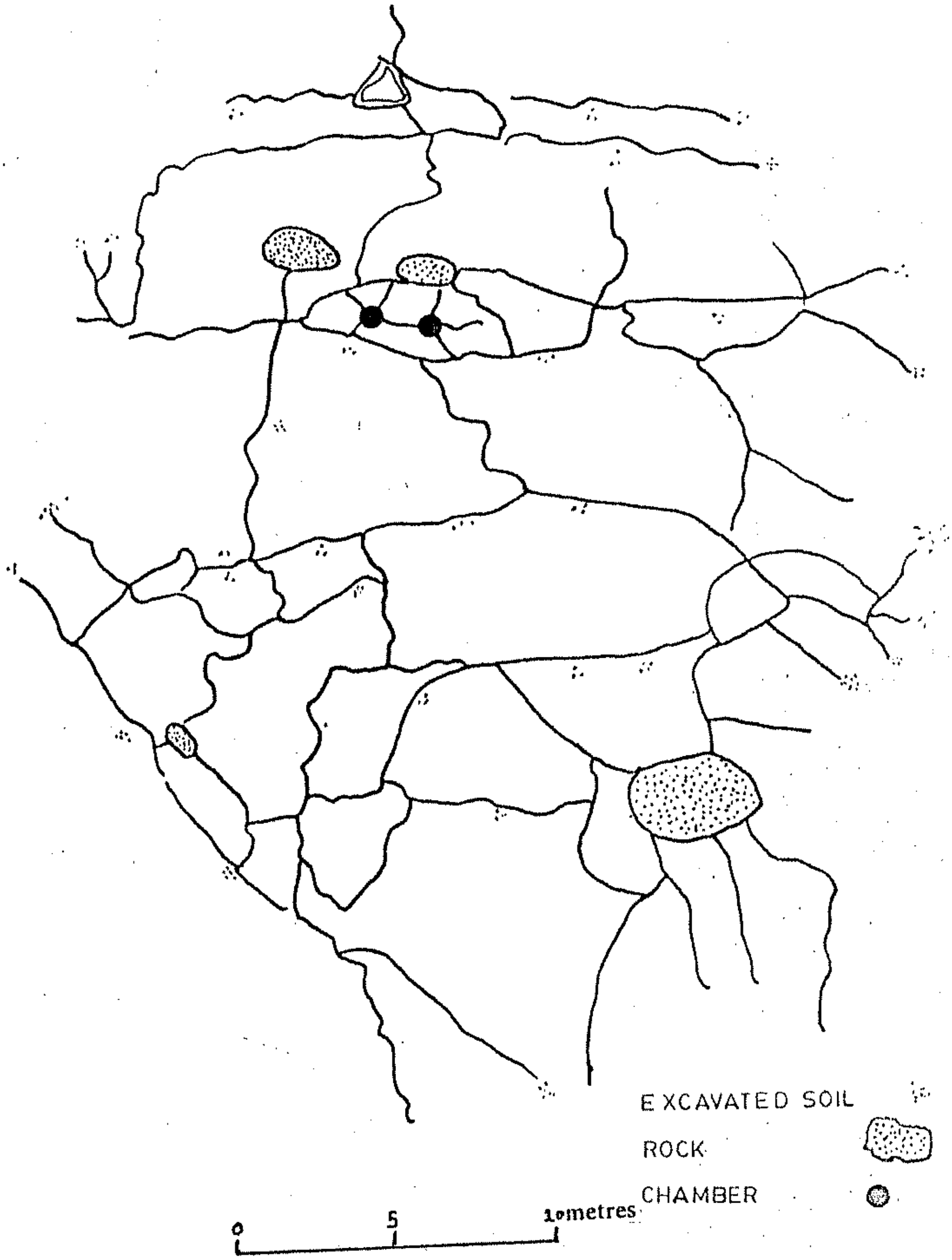

Fig 8. Plan of b[illegible]ving system of *H. wynnei*.

Table 20. Features of five burrowing systems excavated at Galliat.

Burrowing	Average depth soil horizon-A (cm)	Total length of excavated soil (m)	Length of burrows at 20 cm depth (%)	No.of burrows opening	No.of fresh burrows opening	Average Dia-meter of burrows (cm)	Dia-meter of nesting chamber (cm)	Average height of nesting chamber (cm)
1	2	3	4	5	6	7	8	9
A	24.8	43.3	93.3	75	23	6.3	14.5	19.3
B	22.3	30.5	89.4	61	17	6.1	13.3	15.5
C	28.5	21.3	91.5	56	15	6.4	-	-
D	22.9	11.2	87.3	45	13	5.9	-	-
E	30.1	8.0	95.5	39	11	6.4	-	-
Average	25.7	228.6	91.4	55.2	15.8	6.22	13.9	17.4

[illegible] conect the main laterals. Some of the tunnels were deep into the soil and their depth apparently depended on the thickness of the black soil. A few of them were observed at 35 cm. Slanting and vertical shafts connect the shallow tunnels with the deep tunnels. Tunnels were made in any and all direction for the purpose of finding food.

The nest chamber was in the middle of the system. Besides nest chamber one or two chambers were also made for feeding and resting. These chambers were dome-shaped and lied at the depth of 10-25 cm below the ground. More than half of the chamber was in the clayey soil. The chamber had three or four openings through which it was connected with the rest of the system. Nests were composed of pieces of dry grass, clothes, fibres and polythene bags left by the tourists. The faeces was not thrown out along with the excavated soil and was not found in the burrows. Defaecation areas were not found in or near the nest or in resting chamber. It seems probable that faecal pellets were dumped in the burrows system and not outside the burrows.

A vole was observed collecting nesting material at Mukhshpuri peak during monsoon season. The vole first brought the pieces of dry grass to the entrance of the hole, quite hidden in a depression. After collecting the material near the entrance, it was carried into the tunnel.

During winter the vole constructed two type of the galleries above at the interface of the ground and the snow cover. In one type after constructing the galleries on the ground, they were filled with the excavated soil. The other galleries, on the surface of the soil were constructed for foraging. Most probably, due to snow cover the ground surface does not get below freezing. According to Roberts (1977) <u>Hyperacrius wynnei</u> occupies an equivalent ecological niche in the Himalyas to the snow vole, <u>Microtus nivalus</u> in the northern Europe. When the snow melts these tunnels can be seen which are roofed over with a thin layer of matted chewed vegetation and soil particles. Roberts (1977) states that this prevents the snow arch from collapsing.

Most of the tunnels open on the slope of the hill or on the edges of the terraces where the vole easily push the excavated soil and it also solved the drainage problem.

The total annual rainfall of Nathiagali is about 250 cm and mostly occurs in July, August and September (Appendix-I). The burrowing activity recorded during 1987 is shown in the Table 21. The excavated soil was cleared on Ist May and observations were made on 15th of each month.

Little excavation was observed before July but there was a consistent increase during July to a peak in August. The peak was followed by a decrease in September.

Table 21. Burrowing activities of *H. wynnei* in different months. Figures show the amount of soil excavated (in cm^3).

Month	Plot I	Plot II	Plot III	Plot IV	Plot V	Average
May	2.2	2.4	2.5	2.4	2.3	2.36
June	2.1	2.6	2.7	2.5	2.8	2.54
July	11.5	19.5	18.4	17.3	18.5	17.04
August	16.5	18.8	16.3	19.6	18.5	17.94
September	14.5	13.3	14.8	15.2	12.3	14.02
October	8.9	5.4	9.3	8.8	10.6	8.6
November	2.3	2.2	3.1	1.5	3.4	2.4

When the vole activity was plotted against rainfall (Fig.9) it was noted that the burrowing activities correlated with the rainfall. The activities were maximum during monsoon seasons.

When the extent and complexity of the burrows system is considered it is obvious that the Murree vole must have excellent sense of orientation and direction to avoid getting lost and expending much energy in trying to find the way back to the nest. The sense of orientation was observed, when the parts of their burrow system were destroyed, new burrows adjacent to original site were constructed.

During monsoon season a few juveniles were observed wandering on the ground. The juveniles exhibited a limited sense of orientation; if they left the burrow it was quite difficult for to locate them.

During excavation of the burrows no vole was caught or seen but they were observed throwing soil from the burrows during pauses. On many occasions the tracks of the burrows were lost and located only the following morning by the newly excavated soil. On one occasion after finding the nest material, it was not disturbed but the next morning it was thrown out by the voles. Moreover if the excavated soil is disturbed or a trap is placed in front of the entrance, the vole within next few minutes will come to know about that and will throw soil on the entrance.

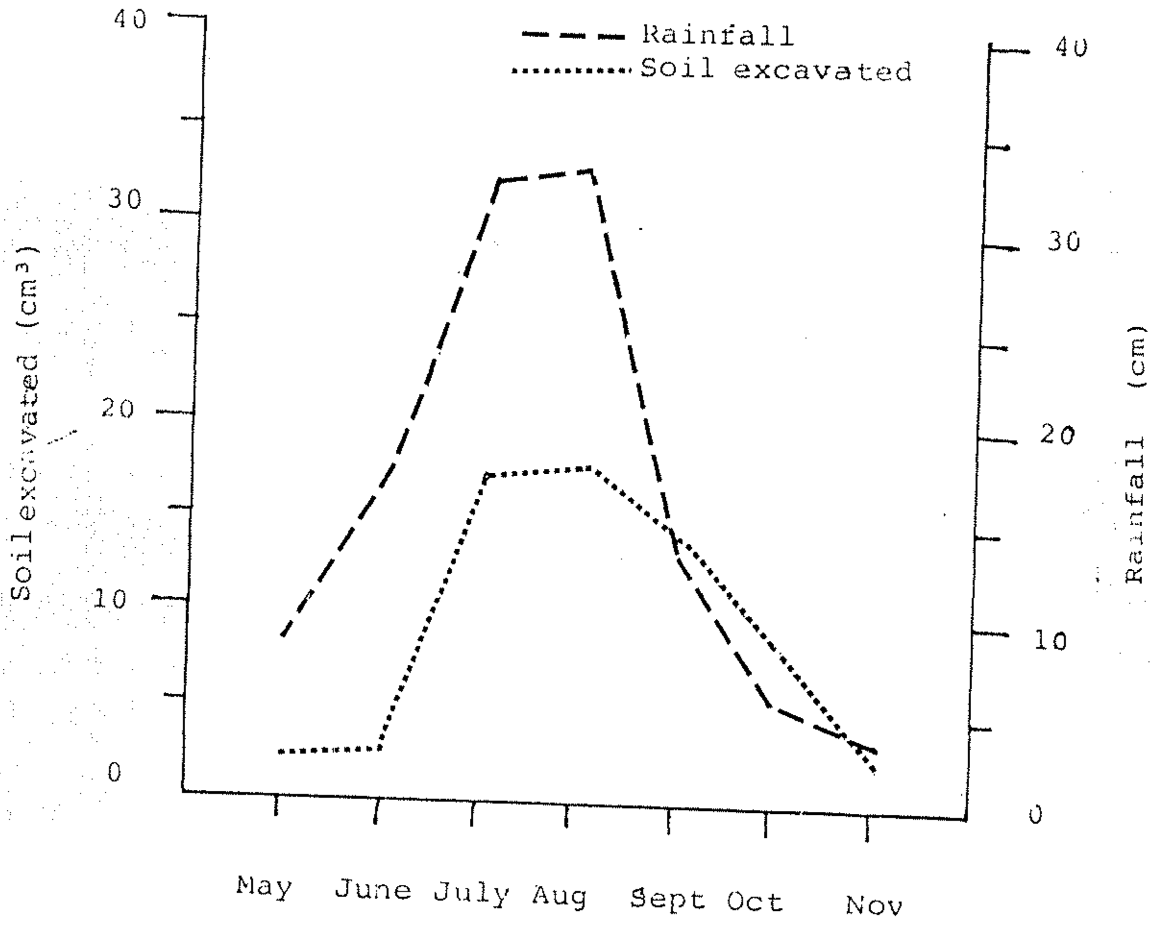

Fig 9. Relation of burrowing activities (Soilexcavated) of *H. wynnei* to rainfall in different months.

DISCUSSION

The Murree vole lives in an extensive and complex burrow system like most of the permanently fossorial rodents (African mole rats, Genely, 1965; Jarvis and Sales, 1971; pocket gophers, Miller, 1954; Howard and Child, 1959). The burrows in these animals serve for shelter, protection from enemies, as a passage ways for obtaining and storing food and as place for rearing the youngs (Andersen, 1987). As Ingles (1952) pointed out, the burrow system constitutes the home range or territory of the fossorial rodents. Once the home range is established by a fossorial rodents that has lived for one breeding season (in the case of pocket gophers), it tends to remain in that burrows for the rest of life except for minor boundary changes (Howard and Child, 1959). In case of the Murree vole like the other fossorial rodents, the burrow system is its permanent home. But unlike these animals the burrow system of the Murree vole is occupied by a number of individuals comprising adults, subadults and youngs. Pocket gophers, shortly after weaning, disperse over lands from the maternal burrows and each excavate its own tunnel system. Even, after breeding two sexes also separate and each sex has its own home range (Howard and Child, 1959; Nielson, 1986). The Murree vole on the contrary lives in colonies and all the member of a colony remains in the same system throughout their life. In this regard it resembles Heterocephalus (Jarvis and Sale, 1971) and Cryptomys (Pearson, 1960; Genely, 1965) and Spalacopus (Reig 1970), in which colony formation occurs. Heterocephalus also has evolved an adaptive heirarchic cast structure (Jarvis and Sale, 1971).

Burrow system of the Murree vole is an open system when compared with other fossorial rodents. Pocket gophers and Mole-rats seal a part or all the burrows to the surface. The earth is tightly packed into the tunnels and sealing makes the burrows predator proof.

In the Murree vole for the time being a few burrows are closed by the excavated soil, but once the excavated soil is washed by the rain the burrows remain open for the rest of the period.

All the fossorial rodents are aggressive and solitary in their burrows (Mcnab, 1966). Since small mammals do not indulge in songs and plumage display as birds do; this requirement may be met instead by fighting that occurs between individuals. Territorial system is only relaxed during breeding system and various combination of adult males, females, and young are found in the same burrow system. Territories are reestablished at the end of the breeding season (Miller, 1964). But no territorial system was observed in the Murree vole. No wounds or scars were noted on the body of the vole throughout this study.

One male vole was trapped in June 1985, in which a toe of hind feet was not present and in another female, half of the tail was missing. But this might be accidental. Absence of wounds and scars indicate that the Murree vole does not defend its home ranges.

The Murree vole lives in soft and porous soil, it has not developed its incisors like Spalax or member of family Rhizomidae, and Balthyergidae. The Murree vole digs the burrows by its fore-paws. The basic digging movements closely resemble those of Tachyorectes and Heliophobius. The soil is scratched by fore-paw and loosened soil is cleared also by the fore-feet. Soil is accumulated under the abdomen and then the hind-feet come forward, collect and kick the soil behind the animal.

By increasing the length of the burrows, the Murree vole increases the adequate diffussion of the gases. When the soil porosity is decreased during monsoon season the vole tends to burrow extensively. This behaviour may function to increase the available oxygen during low soil porosity due to high moisture.

More than 90% of the burrows are shallow and these superificial burrows contain a large volume of the air near the external atmosphere, which perhaps increases the rate of gas transfer, since the rate of gas transfer is inversely proportional to the depth of the burrows (Mcnab, 1966).

Ognev (1963) observed large number of Myosphalaz comming out of burrows, when the ground is covered by the snow. According to him Myospalaz crawls out to avoid suffocation because ice has a very low porosity. This may be true for the Murree vole, which may not come out in large numbers like Myospalaz, due to its extenssive burrow system but the runways which they build on the ground and below the snow, may help them to overcome suffocation problem.

Winter conditions may bring about more movements than occurring in the snow-free period of the year. Northern pocket gopher may use the snow pack to cross barriers in their habitats, such as streams, wet meadows or unfavourable soil types, to reach a new ground that previously did not harbour pocket gopher (Vaughan, 1963). According to Turner et al. (1973) melting of the snow pack required movements back to the subterranean system in pocket gopher, but not necessarily the same one occupied in the previous snow-free period of the year. But no such observations were made in the Murree vole. All the burrows constructed above the ground were observed in the areas where undergound burrows existed.

Normally fossorial rodents construct their burrows at a place, where the water drains quickly. Heliocephalus has much of its burrows on raised areas (Jarvis and Sale, 1971). During winter Thomomys talpoides population occupies slopes of 75° , although they may be apparently restricted to slopes of 65° or less in summer (Laycock, 1953). When the snow melts in mountain habitat, steep slopes may provide better drainage. Major portion of the burrows of the Murree vole is along the slopes of the hill or at the end of terraces, which may help them to overcome drainage problem not only in the winter, when the ground is covered by snow but also during the rainy season. Moreover on these slopes, snow is cleared a bit earlier as compared to level ground.

The Murree vole, like most of the fossorial rodents, collects food, and food plants are pushed into the burrows. They were found feeding on the ground during monsoon. Other fossorial rodents also store these plants in the burrow (Smith and Reichman, 1984). No such storage areas were found in the burrows. The sanitary areas were most probably overlooked but it is unlikely that special storage areas would have been missed. Hill et al. (1955) and Jarvis and Sale (1971) also failed to locate either of the areas in the burrows of Heterocephalus.

The length and complexity of the foraging burrows is determined by the availability of the food and energy requirement of the animals (Andersen, 1988). Tachyorectes eats a wide range of plants material, has a shorter burrow system. Females with greater food requirement during pregnancy, lactation and weaning of the young, have large burrow system than males. _Heterocephalus_ burrows are much larger and more complex because it lives in semi-desert habitat and is also a colonial in habits. The Murree vole resembles _Heterocephalus_ in the complexity of the burrow system. The vole though does not live in semi-desert, but conditions in winter are likely to resemble that of a

CHAPTER-X

REPRODUCTION

Studies on reproductive biology of the Murree vole were focussed on pregnancy rate, number of embryos, prenatal losses and changes in testes length.

A. PREGNANCY RATE

Pregnancy rate, the proportion of females pregnant at any given time, is an important component in polyestrous mammals. Small mammals are considered pregnant when the embryo becomes visible. Normally in voles the embryo becomes visible after 6th day of pregnancy (Hoffmann,1958). But the major problem in determining the pregnancy rate concerns with the denominator i.e. which females to include as potentially mature females. Leslee et al., (1952) were the first to point out this problem. Keller and Kreb (1970) have discussed this problem in detail. According to them one approach to this problem is to include all the females above certain minimum weight or length as mature and the other is to consider only the females with corpora lutea or corpora albicantia. The first approach ignores the possible changes in weight at sexual marturity; the second approach avoids this problem but becomes tautology by stating that only females of demonstrated reproductive capacity are mature.

In this study a females with a mass of 40 grams or more was considered potentially mature. Only one female below this weight was found pregnant. The females were divided into three classes. All the weights were corrected for embryos.

Class I	40 gm to 45 gm.
Class II	45 gm to 50 gm.
Class III	50 gm & above.

In testing the pregnancy rate due allowances were made for any variation in weight distribution by calculating the expected number of pregnant females, following the method described by Leslei <u>et al</u>. (1952).

A total of 241 females were examined, out of which 91 were pregnant. Their was no significant difference between the pregnancy rate of the two years, 37.39 percent females were pregnant in 1985 and 39.89 percent in 1986.

The Murree vole did not hibernate and was active throughout the year. The snow falls from November to March, when most of the land is covered by the snow. During winter (December to February) very few specimens were trapped. This winter sample also had pregnant females, which indicated that the voles also bred during winter. The winter breeding is further confirmed by the fact that the young voles were trapped in March.

In the absence of a breeding season and no difference between the pregnancy rate of the two years the data have been pooled into three seasons i.e. spring (from March to May), summer (from June to August) and Autumn (from September to November) and examined for difference in the pregnancy rate of three seasons using chi-square test for homogeneity. Tables 22 and 23 show the proportion of females pregnant in each season. No significant difference was observed among the three seasons in any of the two years (Fig.10) (1985:X^2=1.35; df=2; P>0.30. 1986: X^2=2.63; df = 2; P>0.05).

In order to examine seasonal effects more critically the data of each year were grouped into two months blocks (Tables 24 and 25) and examined for difference in the pregnancy rate with in and among the blocks. In 1985 no significant variation was observed (X^2 = 3.13; df = 4; P>0.20) but there was significant difference in 1986 (X^2 = 18.95; df = 4; P<0.05). When adjoining 2-months block of 1986 were compared (Fig.11) significant heterogeneity was observed between July-August and September-October samples (X^2 = 3.85 df = 1; P<0.05) and September-October and November December (X^2 = 14.89; df = 1; P<0.05). In 1986 the highest pregnancy was observed in September-October period, while November-December pregnancy rate was the lowest. When September-October sample was excluded from the data there

Table 22. Rate of pregnancy of H. wynnei for three seasons during 1985

Traping periods	Number of females	Number of pregnant females	Percentage pregnant females
Spring	45	14	31.11
Summer	27	15	55.5
Autumn	38	13	34.21
Total	110	42	38.18

Table 23. Rate of pregnancy of H. wynnei for different seasons during 1986.

Traping period	Number of females	Number of pregnant females	Percentage of pregnant females
Spring	31	9	29.03
Summer	38	15	39.47
Autumn	56	24	44.44
Total	125	48	38.4

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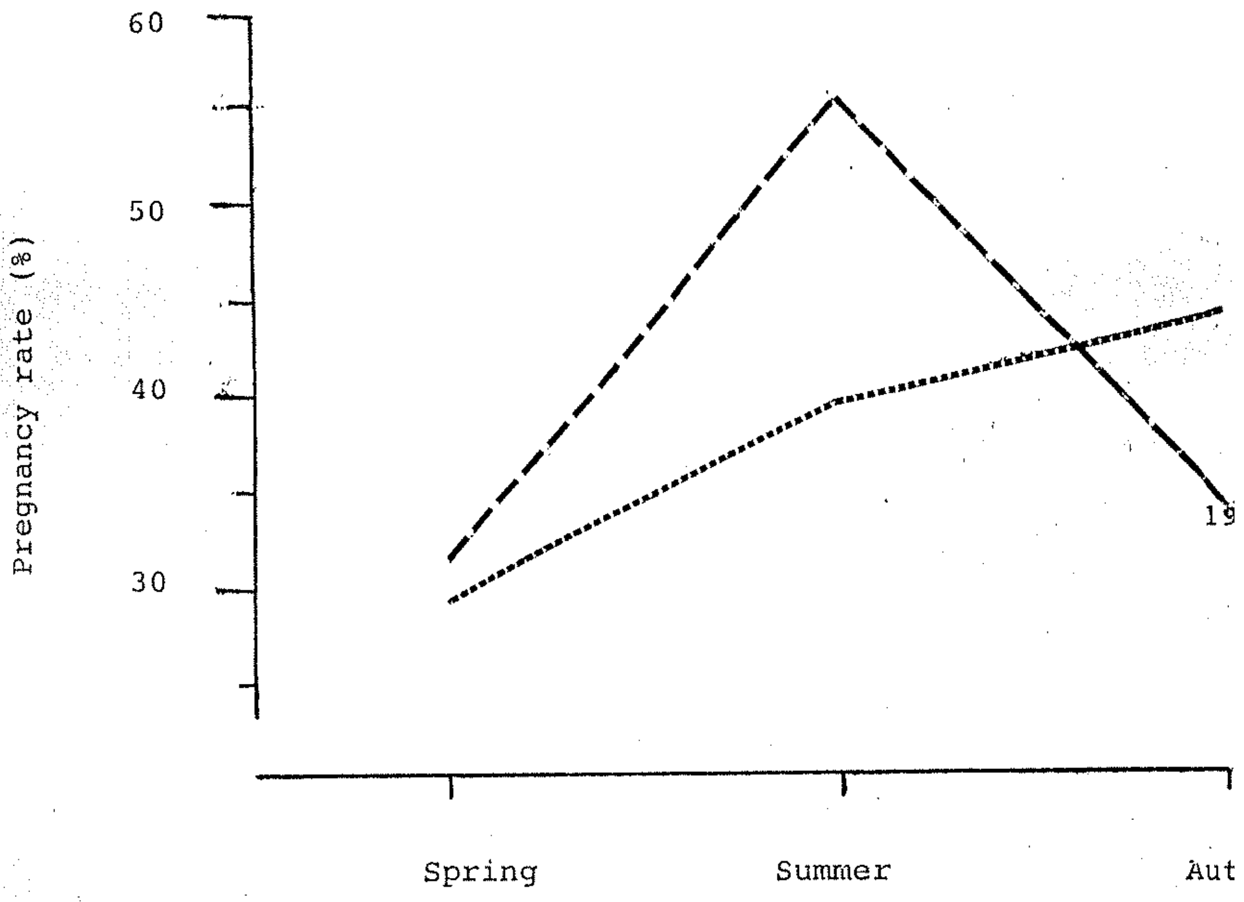

Fig. 10. Seasonal changes in pregnancy rate, of <u>H</u>. <u>wynnei</u> during 1985 and 1986. Data is classified into 3 months periods.

Table 24. Rate of pregnancy of _H. wynnei_, for two-months periods, during 1986

Traping period	Number of females	Number of pregnant females	Percentage of pregnant females
March-April	25	8	32.00
May-June	20	8	40.00
July-August	20	8	40.00
September-October	36	22	61.00
November-December	25	4	16.00
Total	126	50	39.68

Table 25. Rate of pregnancy of _H. wynnei_ for two-months periods during 1985.

Traping period	Number of females	Number of pregnant females	Percentage pregnant females
March-April	39	14	35.89
May-June	14	6	42.86
July-August	19	9	47.37
September-October	32	10	42.86
November-December	11	4	36.26
Total	115	43	37.39

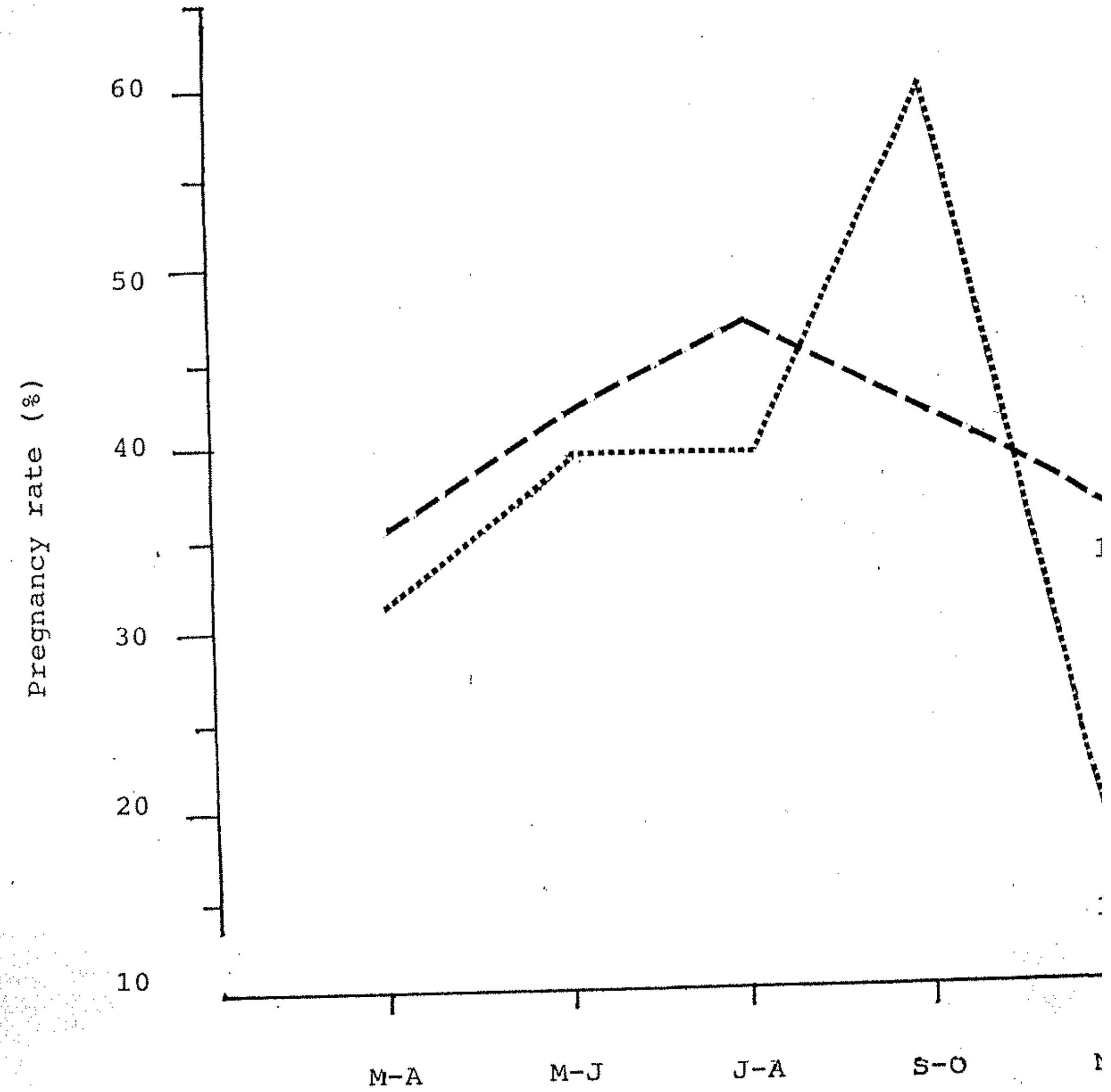

Fig 11. Seasonal changes in pregnancy of H. wynnei during 1985 and 1986. Data is classified into bimonthly periods.

was complete homogeneity among the remaining periods. Comparison made between the blocks of the same periods of the two years (Fig.11) showed significant heterogeneity only between September-October periods ($X2 = 7.79$; $df = P<0.05$) only.

Pregnancy rate in the weight class 3 was higher than the other two classes (Table 26). In class 3 in 1985 52% females were pregnant and 63% in 1986. In class 2,35% and 17% were found breeding in 1985 and 1986, respectively. In 1985 number of females pregnant in class 2 was lower than class I (Fig.12). However on the whole pregnancy rate of class 3 was higher than in class I or 2. In November-December period only the heavier females (Class 3) were found with embryos. During the same period in 1985 only one female was found pregnant in class II. All the females in class 3 had either placental scars or visible embryos in November-December period.

B. NUMBER OF EMBRYOS

Among the factors which can influence the number of embryos produced by a female are maternal body weight, previous reproductive experience and season. During two years of study a total of 91 pregnant females (having visible embryo) and 85 having placental scars were trapped.

Table 26. Rate of pregnancy in *H. wynnei* in different age classes. Sample size is given in parenthesis

Age classes	Percentage of pregnant females		
	1985	1986	Combined for two years
1	21.21	25.56	21.62
(40 gm to 45 gm)	(33)	(39)	(74)
2	35.00	17.1	25.33
(45 gm to 50 gm)	(40)	(35)	(75)
3	52.38	63.46	59.88
(50 gm and above)	(42)	(52)	(44)
Total	37.39 (115)	38.89 (126)	38.13 (241)

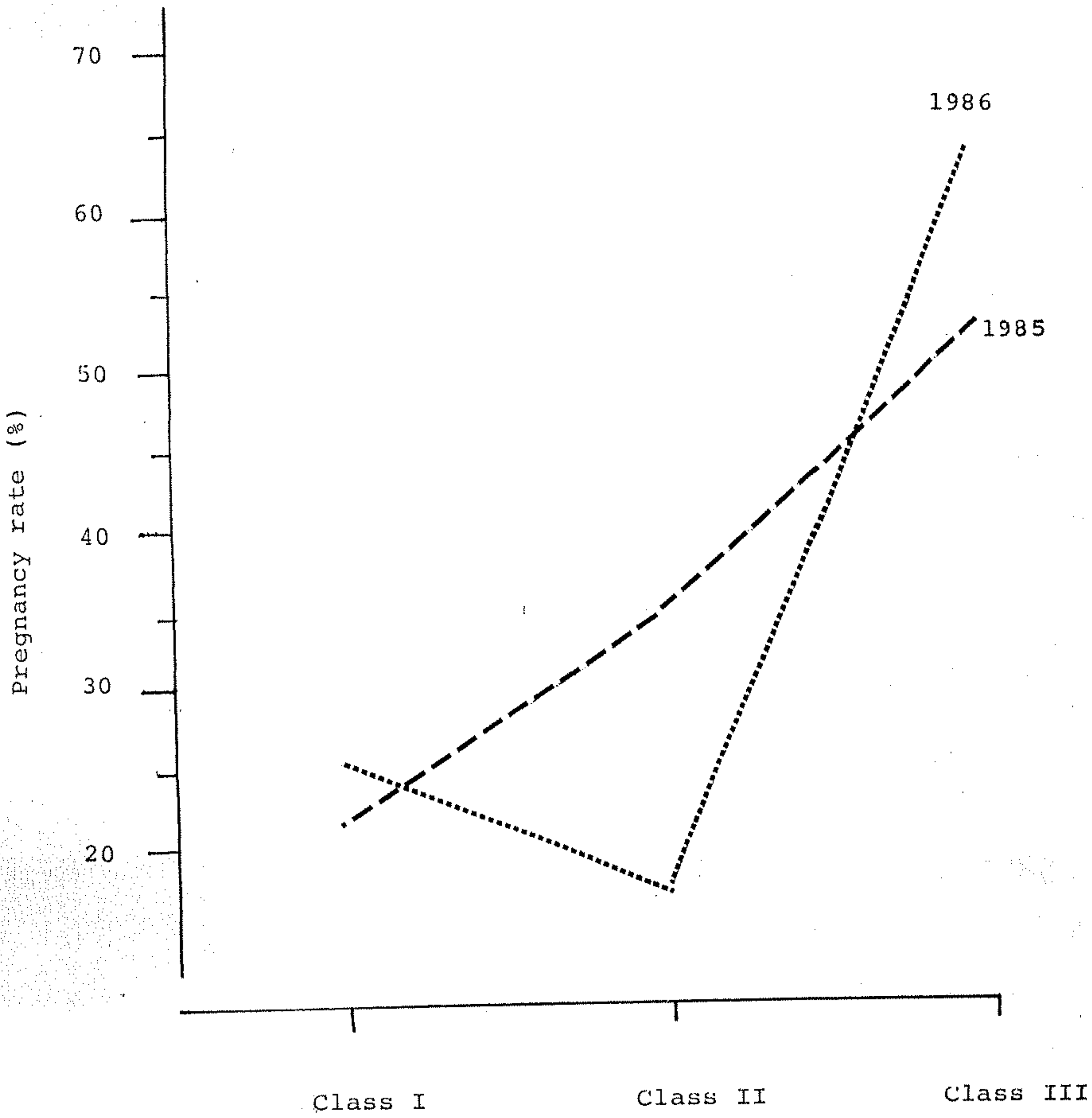

Fig 12. Seasonal changes in pregnancy rate of <u>H</u>. <u>wynnei</u> in different age classes during 1985 and 1986.

The embryo numbers varied from 1-4 per litter. Three and four embryos/litter were very rare and only 2 females having 3 embryos and two females having four embryos were caught. Two embryos per litter was quite common as compared to one embryo litter.

Number of embryos vary with the body size in majority of the rodents (Fitch, 1957; Kalela, 1957), while in some species there is no relationship between the body weight and number of embryo per female (Rose and Gaines, 1978). To analyze this relationship, correlation was calculated using the two years data which were pooled together. A significant correlation was found between embryo numbers and body weight ($r = .96$; $t = 26.03$; $df = 2$; $P<0.05$).

Those females having four or three embryos were not included in the data, as the three four embryos per litter were very rare.

To determine if there was any seasonal difference, the data pertaining to number of embryos per female were classified by three seasons (Tables 27 and 28) i.e. Spring (March to May), summer (June to August) and autumn (Septmeber to October) and were analysed by ANOVA. No significant difference was observed among the three seasons of 1985 ($F = .04$; $df = 2,35$; $P>0.1$) or 1986 ($F = 2.8$; $df = 2,33$; $P>0.1$). Same was the case when the corresponding seasons of the two years were compared (Fig.13).

In order to examine the seasonal effect more closely, the total females were divided into 2 months periods (Tables 29 and 30) and comparisons were made both within a year between the adjacent bimonthly periods and corresponding periods of the two years (Fig.14). There was no significant difference among the different corresponding periods of two years.

Comparison of adjacent bimonthly periods during 1985 (Fig.14) with respect to the mean of embryo numbers revealed significantly lower embryo counts in November-December compared with September-October ($F = 21.8$; $df = 1,12$, $P<0.05$) or March-April ($F = 11.1$; $df = 1,16$; $P<0.05$). A similar significant drop occurred in November-December sample of 1986: November-December averaged 1.00 embryo while the mean value for September-October sample was 1.77 ($F = 9.94$; $df = 1.24$; $P<0.05$) and it was further raised to 1.88 in March-April (Fig.14). The latter two values were significantly greater than the former. ($F = 9.94$; $df = 1,24$; $P<0.05$ and $F = 23.3$; $df = 1,10$; $P>0.05$). It is interesting to note that in both the years all the females during April had two embryos and in November-December had only one embryo per female.

Table 27. Mean litter size (= embryo counts) of _H._ _wynnei_ for three seasons (spring, summer and autumn) (1985).

Period	N	Mean litter size/season	Standard error
Spring	14	1.66	± 0.14
Summer	15	1.73	± 0.20
Autumn	13	1.62	± 0.13
Total	42	1.67	± 0.15

Table 28. Mean litter size (= embryo counts) of _H._ _wynnei_ for three seasons (spring, summer and autumn) (1986).

Period	N	Mean litter size/season	Standard error
Spring	9	1.89	± 0.13
Summer	15	1.46	± 0.12
Autumn	24	1.5	± 0.10
Total	48	1.56	± 0.11

Table 29. Mean litter size (= embryo counts) of H. wynnei for two months periods (1985).

Period	N	Mean litter size	Standard error
March-April	8	1.88	± 0.11
May-June	8	1.50	± 0.87
July-August	8	1.40	± 0.05
September-October	22	1.77	± 0.22
November-December	4	1.00	± 0.00

Table 30. Mean litter size (= embryo counts) of H.wynnei for two months periods (1986).

Period	N	Mean litter size	Standard error
March-April	14	1.60	± 0.14
May-June	6	1.50	± 0.28
July-August	9	1.8	± 0.13
September-October	10	1.8	± 0.13
November-December	4	1.0	± 0.00

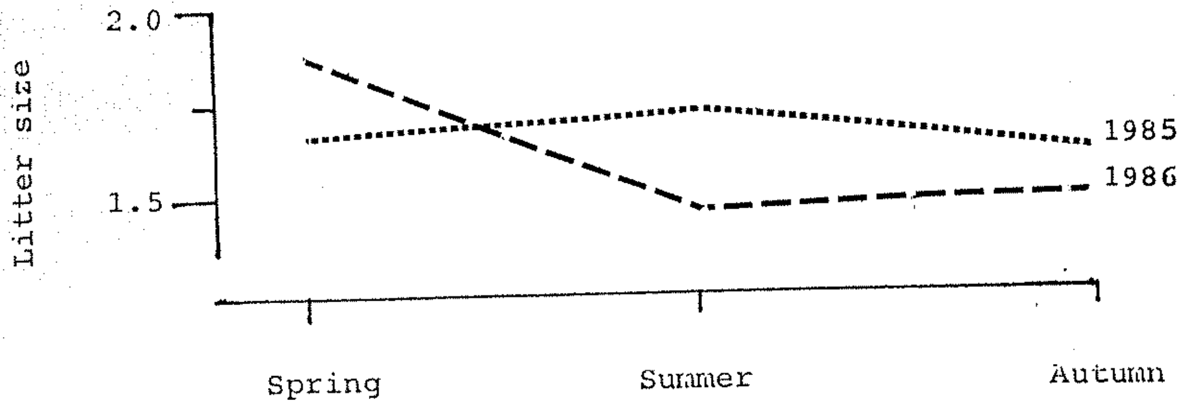

Fig 13. Seasonal changes in mean litter size of _H. wynnei_ during 1985 and 1986. Data is classified into three months periods.

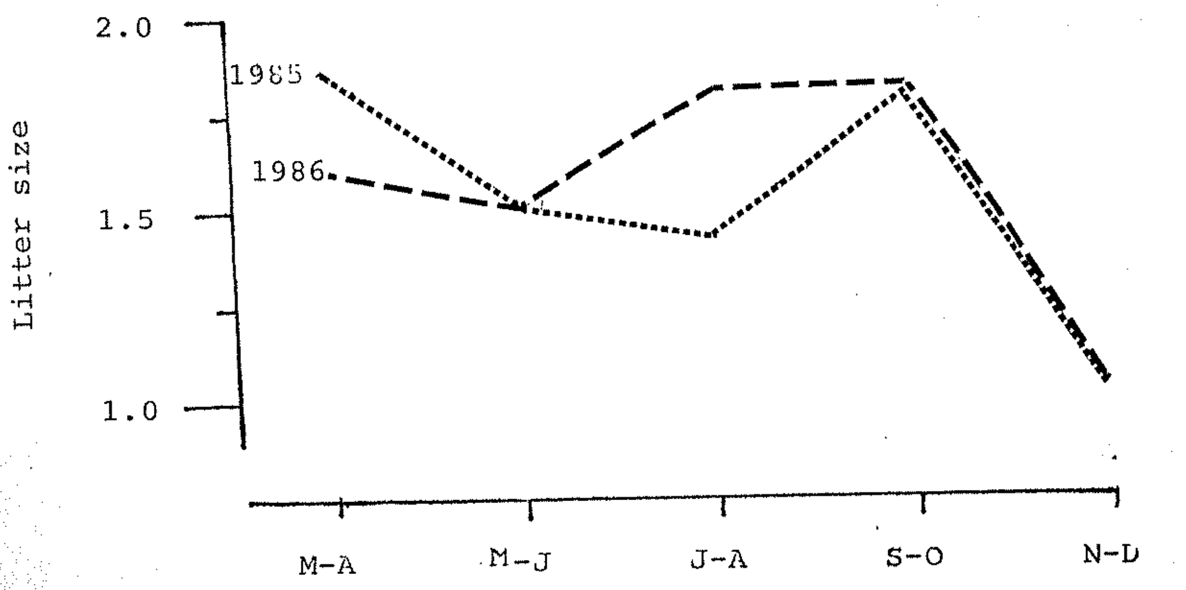

Fig 14. Seasonal changes in mean litter size of _H. wynne_ during 1986 and 1986. Data is classified into bimonthly periods.

C. PRENATAL MORTALITY

Reduction of realized litter size, given a constant ovulation rate, could result from the failure of a percentage of viable ova to be fertilized or from the intra-uterine death of one or more developing embryos. Losses of the first type termed, preimplanation mortality and of the second type are called postimplanation losses. Changes in the frequency of prenatal losses would affect the birth rate of rodents (Keller and Kreb, 1976). According to them these losses are associated with population density and their occurrence is more pronounced during the peak season. In this study prenatal mortality have been estimated for bimonthly periods of 1985 and 1986. The preimplantation and postimplantation losses were considered separately. Tables 31 and 32 summerize the data on prenatal mortality for the two years.

i. PREIMPLANTATION LOSSES

Preimplantation losses result from failure of an egg to pass down the oviduct, to be fertilized, to undergo normal cleavage, or to implant. Since corpus luteum forms at the site of the ovary where egg is liberated (Hamilton, 1949), the number of ova released can be approximated by counting corpora lutea. If the corpora count exceeds the implantation count, a preimplantation loss is suggested. In this study counts were made by gross examination of ovaries under binocular dissecting microscope.

The sample for preimplantation loss is too small to give a reliable indication regarding any seasonal effect (Tables 31 and 32). The total preimplantation losses were 5.4 and 7.0% for 1985 and 1986, respectively. No losses were revealed in July-August and September-October periods. The losses were maximum in November-December samples. Over 33% (33.3%) and 40% (42.9%) mortalities were observed during this period in 1985 and 1986 respectively.

ii. POSTIMPLANTATION LOSSES

Intra-uterine (postimplantation) losses result from the failure of an implanted embryo to survive to birth. Losses have been attributed to qualitatively inferior corpora lutea, social stress, maternal age and lethal genes (Batten and Berry, 1967). In this study the losses were determined from the count of amorphous embryos of greatly reduced size compared with other embryo in the same uterus. Any grossly smaller embryo is an indication of partial or complete postimplantation mortality.

Table 31. Prenatal losses in H. wynnei in 1985 for two months periods.

Sample	March April	May June	July Aug.	Sept. Oct.	Nov. Dec.	Total
Number of females (A)	14	6	9	10	4	43
Corpora lutea (B)	24	9	16	19	6	74
Total embryos (C)	23	9	16	18	4	70
Number of females showing losses (D)	1	0	0	1	2	4
Ova lost (B-C)	1	0	0	1	2	4
Percentage of females lossing ova (D/A)	7.1	0	0	10	50	9.9
Percentage of ova lost (B-C/B)	4.2	0	0	5.3	33.3	5.5
Resorbomg embryos (E)	0	0	1	0	2	3
Percentage of embryos lost (E/C)	0	0	6.25	0	50	4.2
Number of females with resorbing embryos (F)	0	0	1	0	2	3
Percentage of females with resorbing embryos (F/A).	0	0	11.1	0	50	6.9

Table 32. Prenatal losses in *H. wynnei* in 1986 for two months periods

Parameter	March April	May June	July Aug.	Sept. Oct.	Nov. Dec.	Total
Number of females (A)	8	8	8	22	4	43
Number of Corpora lutea (B)	16	12	11	40	7	74
Total embryos (C)	15	12	11	38	4	70
Number of females showing losses (D)	1	0	0	2	3	4
Ova lost (B-E)	1	0	0	2	3	4
Percentage of females lossing ova (D/A)	12.5	0	0	9.1	75	9.9
Percentage of ova	6.25	0	0	5.0	42.9	5.5
Resorbing embryos(E)	0	0	2	1	0	3
Percentage of embryos lost (E/C)	0	0	18.2	2.6	0	4.3
Number of females with resorbing embryos (F)	0	0	1	1	0	2
Percentage of females with resorbing embryos (F/A).	0	0	12.5	4.5	0	4.6

Although some small embryos may survive upto birth, but after birth they cannot compete with other ofsprings and may die. According to Rose and Gains (1978) this method is conservative because some losses will occur before the embryo is large enough to be visible and midterm losses may go un-noticed when implantation sites are obliterated after enlargement of two adjacent placenta. But still this method gives good estimate of losses.

Tables 31 and 32 show the postimplantation losses in 1985 and 1986 respectively. Only 4 females were having small embryos and one female was found in which the two embryos were absorbed and the whole uterus was black. Like preimplantation mortality, the data for postimplantation losses was too small to make any reliable inferences about the seasonal effect. In 1985 the mortality was 4.2% and in 1986 it was 3.8% (Tables 31 and 32). The average mortality over the two years was 3.85%.

D. CHANGE IN TESTES LENGTH

The position of testes and degree of pigmentation of scrotum are considered to be good criteria of measurement of reproductive competency of males in mammals. Batzli and Pitelka (1971) give evidence for the unreliability of the former. Iyawe (1989) found no correlation between the position of testes and fecundity in shrew (<u>Crocidiera</u>

Table 33. Linear regression analysis of testes length and body weight in the Murree Vole. T=test No: B=O (R=Correlation between testes length and body weight).

Sampling period	N	R	Mean testes length (X±SD) (mm)	Mean body weight (X±SD) (g)	Slope (b) SE	T	Interc (a)
March-April	13	0.855	4.92±0.59	47.71±5.42	0.093±.017	5.483	0.253
May-June	16	0.67	4.37±0.76	44.34±5.99	0.0859±.025	3.477	0.56
July-August	17	0.912	4.53±0.99	45.48±7.01	0.129±.015	8.604	1.32
September-October	28	0.857	4.77±0.70	46.43±4.95	0.122±.014	8.485	0.87
November-December	19	0.723	4.62±1.23	46.22±7.07	0.127±.029	4.329	1.23

nigeriae) as all the males whether fecund or non-fecund had abdominal testes. Like *C. nigeriae*, the Murree vole also had abdominal testes in the juveniles as well as in the adults.

Fecund males were trapped in all the months during this study. In winter only a few adult males were caught but their testes contained sperms. The testes length ranged from 3 mm to 7 mm. As expected body weight and testes length showed significant correlation. The data of the testes length of 1985 samples are classified into two month period and are presented in Table 33. No significant difference could be detected in the mean testes length in 2-months period ($F = 97$; $df = 4,88$; $P>0.10$). There was also homogeneity among the adjusted testes length in two month period (Table 34). The parameter which were utilized to adjust testes length are given in Table 33. Comparison of adjusted mean length of the adjacent 2-months period also did not show any heterogeneity.

TABLE: 34 Mean length of testes and body weight in the Murree Vole. Adjusted esimates utilize the regressions coefficient (a and b for) of Table 33 to estimate the testes length for 50 gm male.

Sampling period	N	Mean body weight (g)	Mean testes length (mm) (X ± SE)	Slope	Adjusted length(mm) testes (X ± SE)
March-April	13	47.71	4.92±0.164	0.093	4.91±0.141
May-June	16	44.34	4.37±0.19	0.85	4.6±0.128
July-August	17	45.48	4.53±0.24	0.129	5.12±0.218
September-October	28	46.43	4.77±0.132	0.122	5.23±0.113
November-December	19	46.22	4.62±0.282	0.127	5.11±0.207

DISCUSSION

Breeding in small mammals is related to the environment. Normally in temperate region the mammals have a peak breeding season, which usually falls in spring or summer. While in certain desert and semidesert environments breeding can occur any time of the year. In tropical or equatorial regions the season varies so little that there is no optimum specific breeding seasons and young are born throughout the year (Sadleir, 1969).

According to Sadleir (1969), those species which live in unpredictable environment breeding is confined to a particular season, while species of predictable environment breed throughout the year. Though the Murree vole lives in temperate climate but it breeds throughout the year because it lives in burrows, which provide a relatively stable environment. It comes on surface during August and September, when the climatic conditions are favourable and there is a lot of cover. The underground conditions are less variable than above the ground conditions (Nevo, 1979). In winter the temperature of the burrows of rodents is higher than the ambient temperature (Mcnab, 1966). Moreover colony forming habit of the Murree vole also helps them to raise the temperature of the burrows.

Even species well-adapted to temperate climate which are seasonal breeders, when brought to stable environment bred throughout the year (Berry 1970). For example, feral populations of the house mouse are seasonal breeders (Newsome 1969; Pearsons, 1963; Delong, 1967) and commensal populations breed throughout the year (Smith, 1954; Anderson et al., 1977). It breeds continuously under constant laboratory conditions (Lidicker, 1965).

Another factor which affects breeding in temperate regions is light, but light or photoperiod may not affect the breeding of the Murree vole because its eyes are minute (vision is greatly reduced) and lives in dark conditions. So light may not infuence the physiology of reproduction. Even some seasonal breeders, like deer mouse, when kept in darkness for two years bred continuously all this period and 60% incidence of breeding was maintained throughout the year (Whitaker, 1940). Clethrionomys species mature more rapidly during long than short day-lengths (Tahka, 1978). But this effect is easily suppressed by good food supply (Stenseth and Gustaffson, 1985).

The average pregnancy rate in the Murree vole over the two years was 37.8% which could be ranked as one of the lowest among rodents, if not the lowest. Flemming (1979) reported less than 70% pregnancy rate in fossorial rodents. Moreover like some tropical species of rodents, the pregnancy rates in the Murree vole did not differ much in different periods. The only significant difference was found in the periods of September-October and November-December 1986. The high pregnancy rate in September-October was followed by low rate in November-December and average pregnancy rates in the two years did not differ significantly from one another. A relatively constant rate of pregnancy further supports the idea that burrowing environment of the Murree vole is rather simple and stable.

Winter breeding is not a rare phenomenon in small mammals and has been observed in a number of temperate rodent species. In cyclic species the winter breeding is not correlated to temperature but is actually dependent on other factors like their stage in population cycle (Kreb, 1963, 1964), the concurrent quality of the population (Chitty, 1962; Chitty and Chitty 1962) and also the ammount of food available during the late autumn and early winter (Smyth 1966; Zejde, 1964).

In non-cyclic species winter breeding is governed by the temperature. Pearsen (1963) suggested that the warm period during the later part of the previous year has resulted in unusual number of house-mouse in California in 1960. In favourable years, house mouse can continue to breed throughout the year (Hanson, 1984; Jannet, 1984) Barnett and Dickson (1989) reported breeding of wild mice at

-3° C. Semilarly Zejda (1962) described how the winter breeding was less intense during the period of extreme cold in Clethiememye glareolus. However, the direct factor affecting breeding here was food supply as there were local differences, depending upon the type of tree in the stand where the mice were captured. In this case the temperature was not able to inhibit reproduction of those voles completely. Schiller (1956) gave a good account of the effect of extreme cold on Rattus norvigicus living on garbage dump outside, Nome, Alaska. This species normally breeds all the year (Davis, 1953), but under these exceptional conditions reproduction ceased during winter.

It means that winter breeding in small mammals is related to temperature and to some extent food. From the number of voles trapped during March and a few females captured during winter months, it appears that unlike other rodent species the winter breeding in this vole is a common phenomenon and is not affected even by the snow cover. The study area (Galliat) received 120 cm and 40 cm of snow during the winter of 1985 and 86 respectively.

Another attribute of the Murree vole was that its litter size was very small. In fossorial animals the litter size is normalty low. Flemming (1979) reported that in fossorial mammals litter size is less than 4.05. In the Murree vole the average litter size was 1.56. This low litter size might be related to the availability of the food. Though the food was in abundance in the spring and summer, the vole collected food only near its burrows. During August and September it came out from its burrows but it did not go far off from its burrows. Moreover during this period the vole also collected the nesting material and presumely requiring a considerable amount of energy. Eisenberg and Issaq (1963) suggested that smaller litter size in some desert-living rodents like genus Dipodomys may be adapted as this reduces the maternal strain. In majority of rodent the females increases their food intake during lactation and thus deriving a large part of the nutrients in the milk from direct feeding, where as some drain their own body reserve to produce milk to a remarkable degree. Hamilton (1962) reported that reduced litter size in Phenacomys longicaudata would reduce metabolic drain on the mother before parturition and prior to weaning. He further showed how litters of two in this species will always out weigh and outgrow litters of three. The sole diet of P. longicaudata is Douglas fir needles. Though the food is in abundance, it is very low nutritionally and may be the possible cause of relatively low litter size. The Murree vole does not have any reserve of food in the body and is depended on the direct feeding. So maternal strain has been reduced by producing one or two offsprings. Quality offsprings is greater in small litter size than in large litter size (Miller, 1984).

It seems likely from the available evidence that seasonal alteration in litter size has a more uniform pattern. There was no difference in the mean embryo number from March to September of the same year and also between the same period of the two years. Whereas the mean embryo number in November and December was significantly lower, when there was shortage of food. During this period a female had only one embryo and only heavy females were pregnant. In March-April 1986 it was significantly different from other period but it may be a seasonal effect.

A positive correlation between altitude and litter size has been reported in a variety of animals (Lord, 1960; Flemming, 1973; Gutsafsson and Batzli, 1985). But in the Murree vole there is no relation between litter size and altitude. The voles collected at Muksh Puri (2928 m) and Miranjani (3290) had one or two embryos.

CHAPTER-XI

POPULATION STRUCTURE

A. SEX RATIO

Sex ratio plays an important role in the structure of mammalian population especially if it departs from unity i.e. 1:1. However, traps-revealed sex ratio may be biased in favour of one sex, depending upon the type of traps used and habitat of the two sexes (Myers and Kreb 1971). Greenwald (1956) recorded fewer males of Microtus californicus taken by use of museum special traps. However Keller (1968) also using snap traps, caught a slightly higher proportion of males of M. ochragesta and M. pennsylvanicus. In this study snap and gopher traps were used to catch the vole. It was observed that males were in excess in snap traps but the difference was statistically non-significant.

The sex ratios of the Murree voles trapped during 1985 and 1986 are shown in Tables 35 and 36. The data in these tables are classified by two age groups i.e. juveniles and adults and three seasons. The overall sex ratio was 314 (45.4%) females and 377 (54.6%) males. A chi squared test revealed that sex ratios did not vary significantly from 1:1 (X^2=5.2; $P>0.05$).

The juvenile sex ratios did not change with season in 1985 or 1986. The adult sex ratio exhibited significant seasonal variation in 1985 (X^2=6.37; $P<0.05$) but not in 1986

(X^2 =1.33; P>0.05). When sex ratios of the same seasons of the two years were compared (Fig.15), there was a complete homogeneity in the ratios of both juveniles and adults except for summers, when proportion of females in juveniles was significantly higher (57.1%) in 1986 than in 1985 (16.2%) (X^2 =9.48; P<0.05). This discrepansy in the sex ratio during the summer of two years cannot be explained with the present data. It might be due to differential mortality of young one of the two sexes during July and August when they were active above the ground or may be just a chance.

The data was also tested for deviation from the normal sex ratio, i.e. 1:1. Sex ratio in adults favoured females in all the three seasons of the two years but the variations did not deviate statistically from the assumed sex ratio of 1:1. In juveniles, males predominated during spring and autumn seasons of the two years and also in summer 1985 with sex ratios deviating significantly from 1:1. But in summer 1986 the sex ratio was more or less balanced. It may be assumed that in juveniles mortality was higher in males resulting in balance sex ratio in adults.

Table 35. Sex ratios (percentage of females) of samples grouped according to two age groups i.e Juveniles and adults and three seasons of 1985.

	Juveniles			Adults		
Traping period	Number of males	Number of females	Percentage of females	Number of males	Number of females	Percentage of females
Spring	8	2	20.0	30	44	59.50
Summer	31	6	16.2	42	27	39.1
Autumn	32	10	23.8	34	41	54.7
Total	71	18	20.0	106	112	51.4

Table 36. Sex ratios (percentage of females) of samples grouped according to two age groups i.e Juveniles and adults and three seasons of 1986.

	Juveniles			Adults		
Traping period	Number of males	Number of females	Percentage of females	Number of males	Number of females	Percentage of females
Spring	24	12	33.3	40	32	44.4
Summer	15	20	57.1	35	40	53.3
Autumn	20	16	44.4	66	64	49.2
Total	59	48	44.9	141	136	55.1

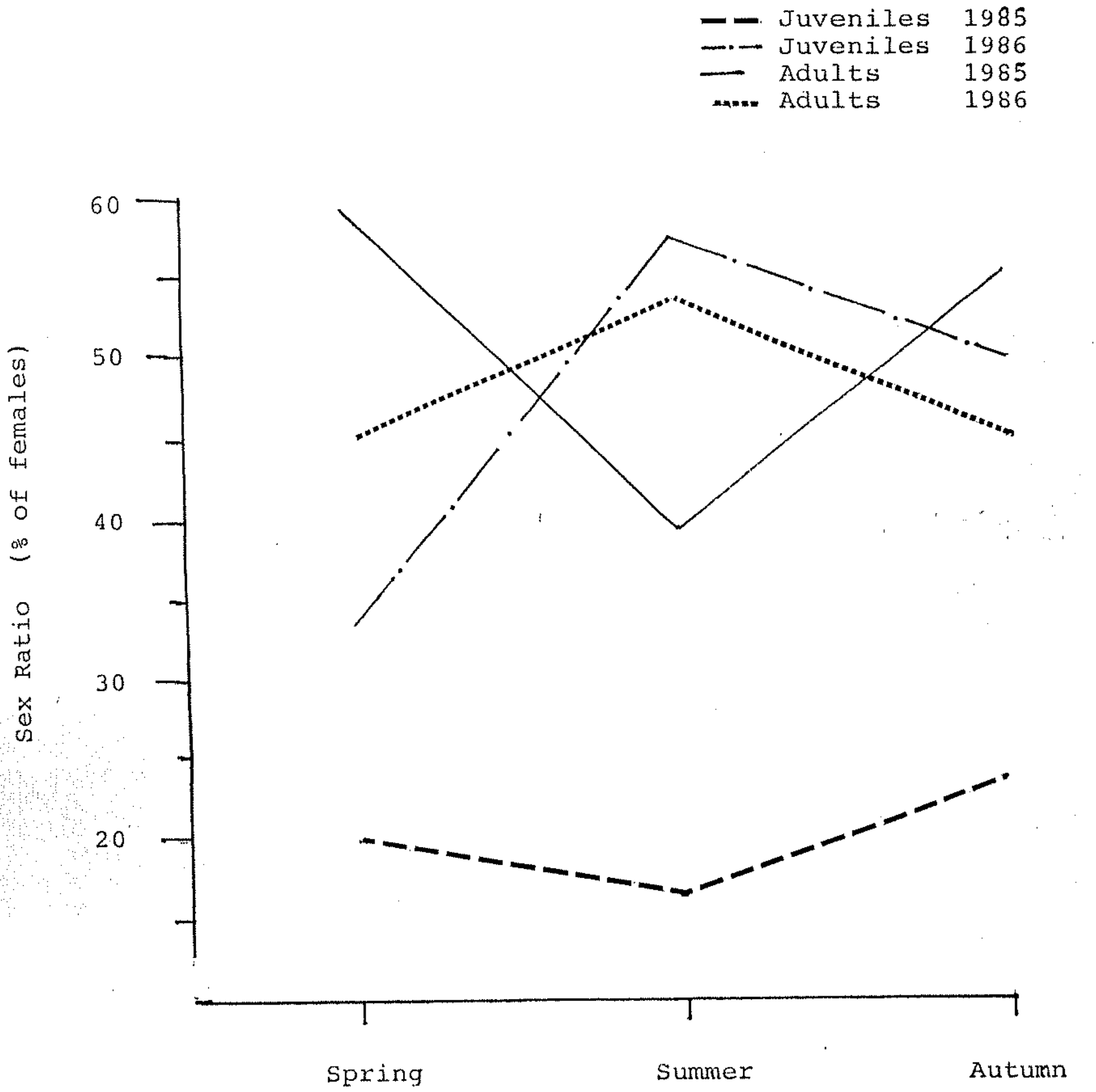

Fig 15. Seasonal changes in sex ratios (expressed in percent of females), of H. wynnei during 1985 and 1986.

B. JUVENILE - ADULT RATIO

Two age classes were established on the basis of weight. Individuals weighing less than 40 gm were considered Juveniles, while individuals with a weight of 40 gm or more were placed in adult group. Tables 37 and 38 show the number, percentage and juvenile - adult ratios. Adults constituted a major portion of the population each year. Out of 691 voles trapped during the two years only 196 were Juveniles. The Juvenile-adult ratio was 0.41 in 1985 and 0.39 in 1986, These ratios did not vary significantly from one another (X^2 =1.1; P>0.1).

When the juvenile-adult ratios of three seasons were compared, no significant difference was observed in 1986 (X^2=5.1; P>0.05) but there was significant variation in the ratios in 1985 (X^2=15.6; P<0.5) which was due to very low number of juveniles (11.91%) in spring. While the ratios in summer and autumn were more or less the same (Fig.16). Low percentage of juveniles in spring, 1985 sample might be due to low snow fall as snow provides not only cover against predators but also protects them from the extreme climatic conditions (Roberts, 1977). Due to low snow fall most of the area from January to April had no snow. Absence of snow cover might have resulted in high mortality of juveniles. However,

Table 37. Number of Juveniles and adults, juveniles percentage and Juvenile/Adults ratios in three seasons of 1985

Period	Total	No.of Juveniles	No.of Adults	% Juveniles	Juvenile/Adult ratio
Spring	84	10	74	11.9	0.14
Summer	106	37	69	34.9	0.54
Autumn	117	42	75	35.9	0.56
Total	307	89	218	28.99	0.41

Table 38. Number of Juveniles and adults, juveniles percentage and Juvenile/Adult ratios in three seasons of 1986

Period	Total	No.of Juveniles	No.of Adults	% Juveniles	Juvenile/Adult ratio
Spring	108	36	72	33.3	0.50
Summer	110	35	75	31.81	0.47
Autumn	166	36	130	21.17	0.47
Total	384	107	277	28.89	0.39

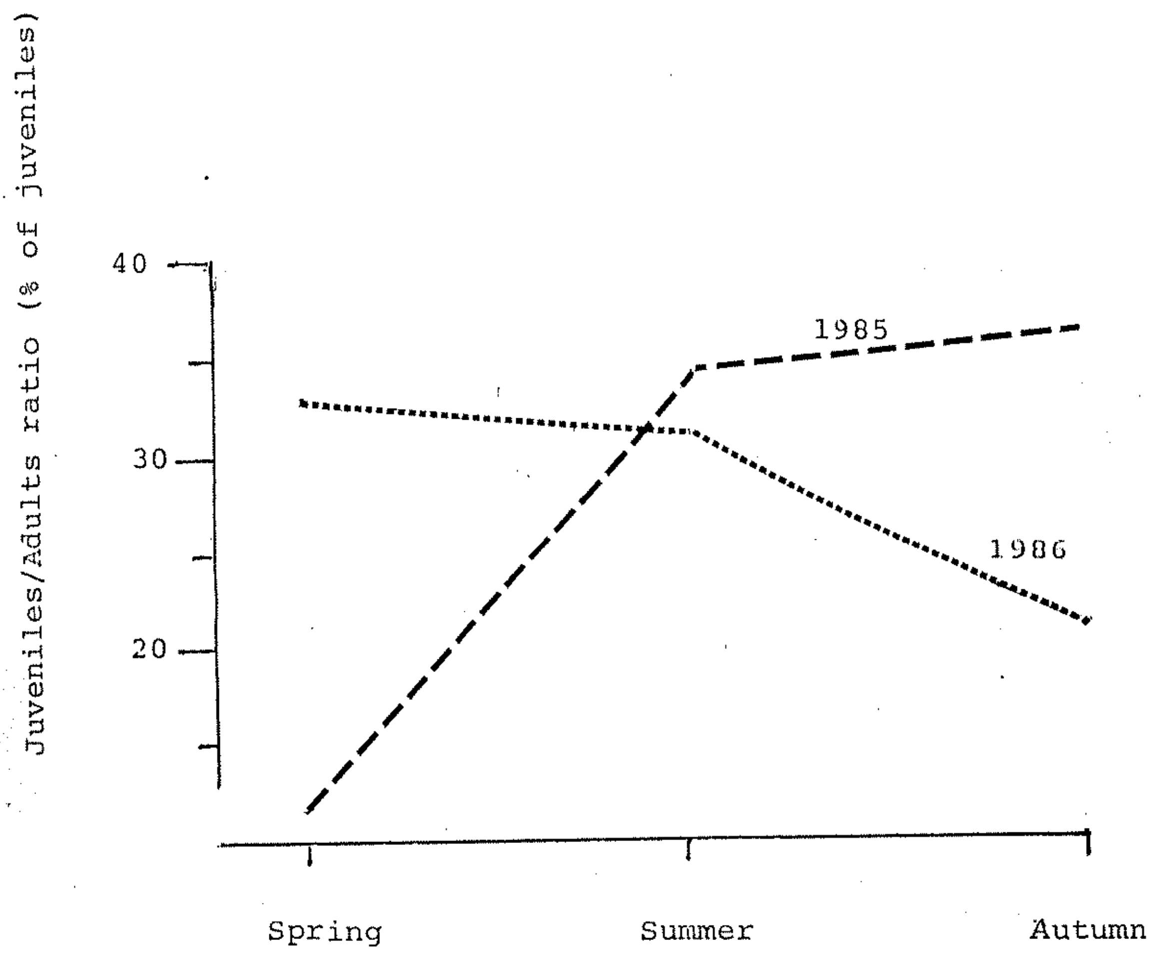

Fig 16. Seasonal changes in Juvenile /adult ratios, of H. *wynnei* during 1985 and 1986.

conditions were different in 1986, when area remained covered with snow upto the end of April.

DISCUSSION

Deviant sex ratios have been reported in a number of animals but the under-lying mechanism is not completely understood. In subterranean herbivorous mammals, adult sex ratios imbalanced in favour of females have been recorded in a number of fossorial mammals. Hill (1937) reported 45% males in Ctenomys peruanus and Jarvis (1978) observed 42% males in Tachoryctus splendens. Saitoh (1989) observed that sex ratios in Clethrionomys rufocanus was strongly female biased.

Several studies indicated a sex ratio in subadults closer to 1:1 than in adults (Wood, 1949; Nevo 1961; Jarvis, 1973). In the Murree vole a quite different situation was found. In adults the sex ratios did not deviate much from 1:1 and remained fairly constant throughout the year. An unbalance sex ratio skewed towards males among juveniles and balance among adults suggest higher mortality in the young males than females during development.

In the Murree vole major portion of different samples comprised of adults while juveniles were only 28.36%. Philips (1969) reported prepondrance of sub-adults in the population of the vole, collected from Kaghan valley.

He classified 14 as adults out of 81 specimens on the basis of cranial characters. His category of sub-adults might have some juvenile as well. Normally equillibrium populations of subterranean mammals contain relatively high proportions of breeding adults (Nevo, 1979). The results of the present study are in conformity with most of the studies carried out on small sub-terranean mammals. Godfrey and Crocroft (1960) reported 47% Juveniles in a population of Talpa europea. Jarvis (1973) trapped out a garden sample of 201 individuals of Tachyoryctes splenodens which contained only 33% juveniles. In Thomomys moticola only 33% juveniles were reported by Ingles (1952). The lower percentage of juveniles in the subterranean mammals is perhaps due to higher mortality rate of juveniles than in adults.

CHAPTER-XII

TEMPORAL CHANGES IN BODY WEIGHT

Mean body weight of rodents have been used as morphological indices to determine the condition of the population and prediction of its future adaptation to environmental conditions (Shvarts, 1975; Lidicker, 1973). When the population is disturbed the body weight of animals is reduced. This chapter deals with temporal changes in mean body weight of the Murree vole during the study period.

Data on the body weight of adults (weighing more than 40 gm) classified by sex and season for 1985 and 1986 are represented in the Tables 39 and 40. Females were further segregated into two categories: Pregnant females (with visible embryos) and non-pregnant females (without visible embryos). Average body weight was slightly higher in summer 1985 and spring 1986. As expected pregnant females were slightly heavier than the males or non-pregnant females in all the seasons. But the differences among the weights of pregnant females, non-pregnant females were not much. Similarly there was no significant difference among the mean body weights of pregnant females in three seasons of either year. Same was the case with the mean body weights of the non-pregnant females and males.

Table.39 Mean body weight,length and body index (body weight/body length) for three seasons of 1985.

Pregnant Females

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	14	48.32	111.6	.43
Summer	15	51.50	121.6	.42
Autumn	13	50.83	118.1	.41

Nopregnant Females

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	31	47.6	113.0	.40
Summer	12	48.33	118.1	.41
Autumn	25	47.85	115.5	.41

Males

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	30	44.77	115.8	.39
Summer	42	47.50	117.4	.40
Autumn	34	45.87	115.7	.40

Table.40 Mean body weight,length and body index (body weight/body length) for three seasons of 1986.

Pregnant Females

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	9	51.4	122.5	.41
Summer	15	50.95	111.5	.45
Autumn	24	50.32	113.5	.44

Nopregnant Females

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	22	49.07	121.6	.40
Summer	23	46.57	117.4	.40
Autumn	32	49.92	111.7	.41

Males

Period	N	Mean body weight(gm)	Mean body length (mm)	Index
Spring	40	49.46	116.5	.43
Summer	35	47.79	116.7	.41
Autumn	66	47.56	116.7	.41

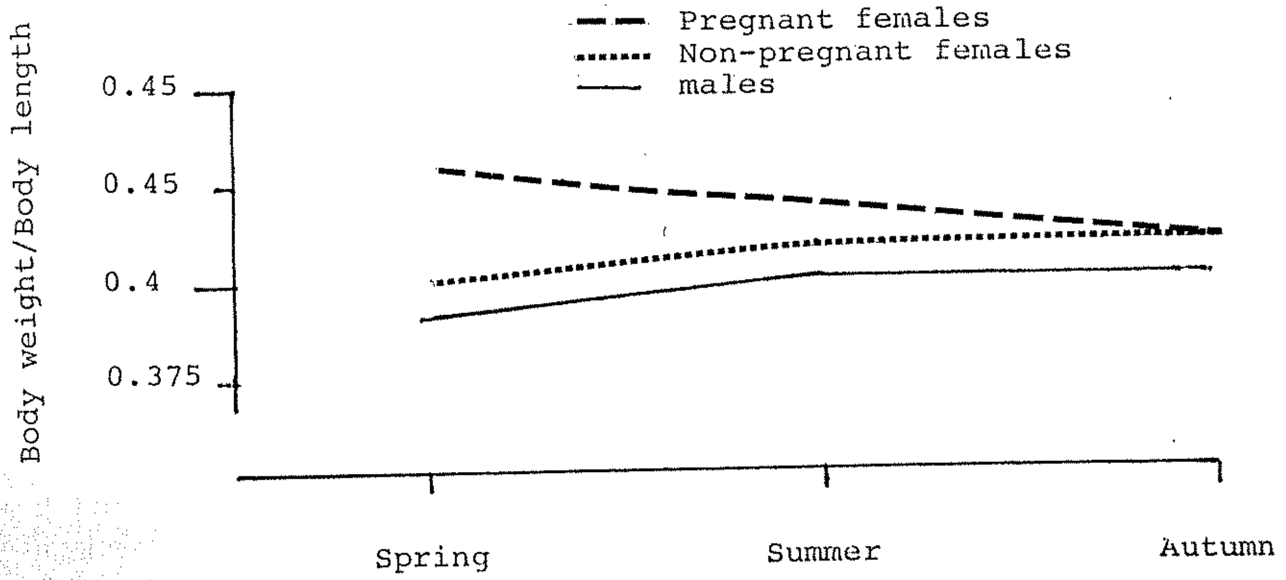

Fig 17. Seasonal changes in body weight over body length of H. wynnei during 1985. Individuals under 40 grams are excluded.

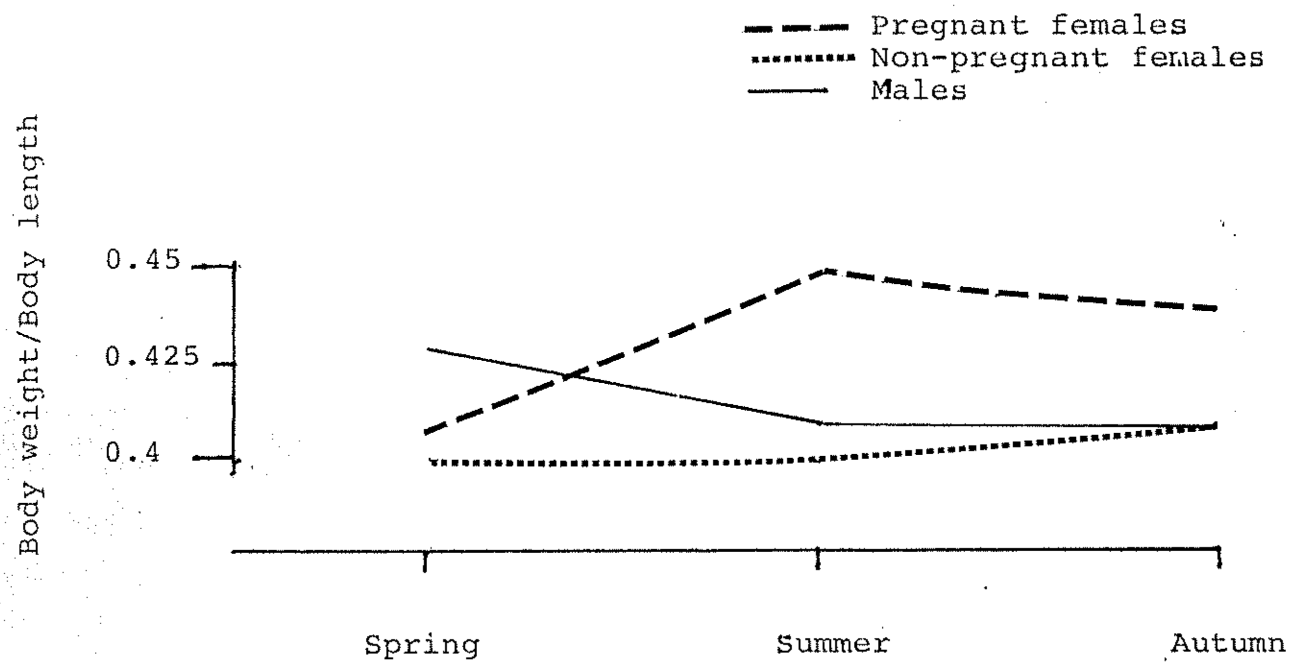

Fig 18. Seasonal changes in body weight over body length of H. wynnei during 1986. Individuals under 40 grams are excluded.

Data on the body weights was also analyzed in relation to body length. This eliminated or atleast reduced the effect of size on body weight and allowed fat individuals of all sizes to give large index and slim ones smaller values (Lidicker, 1973). Hence the ratio of gram body weight to body length (millimeters) was calculated. Body length is the total length minus tail length.

There was no pronounced difference among the indices for pregnant and non-pregnant females, and males (Fig.17) No seasonal pattern of peaks in the two years was observed. For example the index for pregnant females was highest in spring 1985, but lowest in spring 1986. When the indices of the pregnant females were compared with those of non-pregnant females and males the pregnant females scored higher indices than the non-pregnent females and males, except in autumn, 1985 when index for the non-pregnant was higher and in summer of 1986 when the pregnant female index was lower as compared to males. But all these differences were statistically non-significant.

DISCUSSION

Different morpho-physiological indices can be of great importance in solving such ecological problems as determination of conditions of the population and prediction of its future adaptations to environmental conditions, intraspecific variability and speciation (Shvarts, 1975). This author discussed in detail the use of morpho-physiologic characters as indices of population process. Body weight is one of the parameters which can be used to determine the condition of the population.

Normally in small mammals the body weight is related to seasons and breeding period. When a population is disturbed or is under stress, the body weight of the animals is reduced. The Murree vole breeds throughout the year and lives in shallow galleries where there is not any drastic change in the environmental factors. Moreover, being opportunist feeder, it can live on the available food during winter, when most of the ground is covered by snow. Pregnant females were slightly heavier than the non-pregnant females or males. But there was no significant difference in the mean body weight of the three categories.

Lack of seasonal variation in the body weight is another evidence of stable environmental conditions under which the Murree vole is found.

CHAPTER-XIII

PARASITES

In comparison to other radents few parasites have been reported from the Murree vole. During the present study, pentaslomid, nematode, mites and fleas were found.

ENDOPARASITES

Pentastomids have never been reported from the Murree vole. A number of adults were found infested with this parasite. All the parasites were found in the body cavity and sexes were equally parasitized.

Only one nemtode species *Heterakis squmosa* was collected from the caecum of the vole. Out of 40 animals examined only 10 had this parasite. According to Yamaguti (1961) *H. squmosa* is cosmopolition in distribution and has been recorded from *Mus domesticus*, *Crecodomys gambianus*, *Rattus rattus* and *R. norvegicus*. In India it has been reported from the brown rat, *Rattus norvegicus* (Bayles, 1936; Sing, 1962). The Murree, vole is being reported as host of *H. squmosa* for the first time.

ECTOPARASITES

The voles were examined for ecotoparasites periodically throughout the study period by anaesthatising parasites on the dead animals and then combing the pelage of the host specimens. The parasites survey was qualitative recording the presnce and abence of parasites. The parasite secured included fleas and mites. This relatively crude method was fast and quick. This method was not accurate as some individual parasites may have been missed and no separate counts were made for fleas distinction and mites but was sufficently accurate to detect general trends in prevalance of ectoparasites. Batzli and Pitelka (1971) used this method to study the seasonal changes of ectoparasites of Microtus californicus.

At least two species of fleas parasitized the vole in Galliat. Traub and Evan (1967) have reported three species from the Murree vole. These are Paleopsylla setzeri, Xenodaeria telios and Stenischia sp. According to them the Murree vole is a true host of P. setzeri, while Xenodaeria telios is primarily parasite on shrews (Creduria sp). Only two species i.e. Paleopsylla setzeri and Xenodaeria telio were recorded during this study, and mites were not identified.

Tables 41 and 42 show the prevalance of ectoparasites in bi-monthly sample, over the two years. For March-April sample no vole was found infested with fleas or mites and only a few animals carried ectoparasites in May-June. The prevalance of ectoparasites was highest in July-

Table 41. Frequency of ectoparasites on *H. wynnei* during 1985.Number of voles parasitized is given in parenthesis

Traping	Total	Juvenile Number	Juvenile Parasitism %	Adult Number	Adult Parasitism %
March-April	75	8 (0)	0	69	0
May-June	34	5 (0)	0	29 (4)	13.8
July-August	89	34 (7)	20.1	45 (27)	60.0
September-October	104	37 (5)	13.5	67 (21)	31.3
November-December	38	10 (1)	10.0	18 (2)	11.1

Table 42. Frequency of ectoparasites on *H. wynnei* during 1986. Number of voles parasitized in given in parenthesis.

Traping	Total	Juvenile Number	Juvenile Parasitism %	Adult Number	Adult Parasitism %
March-April	82	27 (0)	0	55	0
May-June	65	21 (2)	9.5	44 (8)	18.2
July-August	70	22 (6)	27.3	48 (23)	56.3
September-October	95	21 (3)	14.3	74 (21)	28.4
November-December	23	19 (3)	10.1	62 (67)	11.3

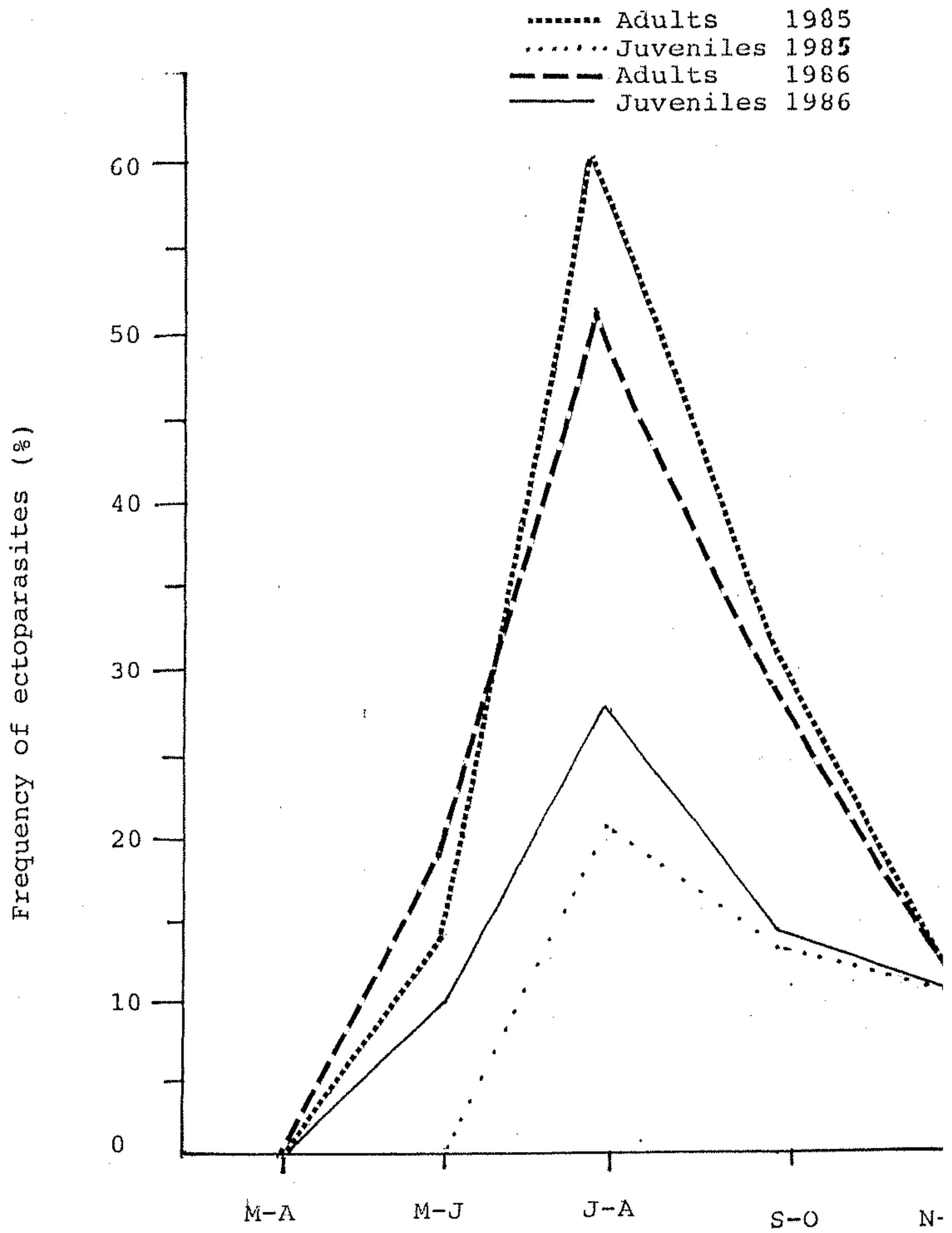

Fig 19. Frequency of ectoparasite on H. wynnei (adults and juveniles) grouped into three season, of 1985 and 1986

August and decreased in the following period i.e. September-October and November-October (Fig.18). Prevalance was low in juveniles in all the seasons.

PREDATION

The sources and magnitude of natural predation on the population of the Murree vole are not known. The hill crow (Corvus macrorhychos) took several trapped animals on the study spot, but its importance as source of population decline was probably minimal because of behaviour pattern of their prey. The vole being entirely fossorial comes on the ground when vegetation cover is maximum, this would greatly limit their vulnerability to the predator. Owls fecal pellets were examined but no bones or hairs of the vole were found. Even if owls fed on the voles their population in the study were not sufficient enough to pose any threat to the vole population. No bird predator was found feeding on live vole.

Pine marten (Martese flavigula) was observed preying on this vole, but when stomach contents of four pine-Martens (Killed by local hunter) were examined, remains of the vole were not found. The only serious predator found in Dungagali, was a domestic cat, kept by a local resident in his potato farm to eliminate the vole. Most of her preys were juveniles and very few adults were caught. The Cat used to sit for hours to catch a vole.

DISCUSSION

Very few endoparasites were collected from *H. wynnei* suggesting that fossorial habits and isolation from other animals, has helped this rodent to harbour only a few parasites in their bodies. Only one species of a pentastomid and another of a nematode were found. The Nematode, *Heterakis squmosa* has been recorded for the first time from this vole.

The important ectoparasites of the Murree vole are fleas and mites. Taxonomic and zoogeographic studies of Siphonoptera from *Hyperacrius* can be correlated with the systematics of the voles of this genus (Traub and Evans, 1967). For example, a species of *Rhadinopsylla* has been reported on *H. fertilis* but not on *H. wynnei*. *Xenodaeria telios* (the primary hosts are shrews), has been found on *H. wynnei* from both sides of the river Indus, but is unknown on *H. fertilis* from each side of the river. Perhaps this underscores the ecological difference between *H. wynnei* and *H. fertilis* (Philips, 1969).

The mites are responsible for the transmission of "Scrub typus". The rickettsia of scrub typhus have been recovered from both the species of *Hyperacrius* (Traub *et* al., 1967). Prior to their studies of natural infection with Rickettsia tsutsugamushi was unknown from high alpine and coniferous forests of Pakistan. According to them, available information is insufficient for the determination of the vector (s) of scrub typhus on Hyperacrius and other mammals, but species of Leptrotromidium have been found on these mammals (Traub et al., 1967). Isolation of Rickettsia from Hyperacrius is important because this pathogen has been recovered from other rodents in Pakistan. According to Philips (1969) knowledge of the ecological distribution of the two species of Hyperacrius might prove to be of epidemiological importance and the distribution of several species of chiggers can be correlated with elevation and habitat and consequently with the distribution of Hyperacrius wynnei and H. fertilis.

Fleas and mites collectively showed a definite seasonal trend in both the years of study. The peak of parasitism occurred in July-August when it was monsoon season in Galliat.

The Murree vole is well protected against predators, only a few predators of this vole were found and number of these predators was very low to pose any threat to the population of the vole.

CHAPTER-XIV

PEST STATUS

The Murree vole is quite abundant in Galliat and where this vole occurs there is usually little cultivation. Main crops are maize and potato. Both of these are sown in May-June and harvested at the end of September. About 70 percent of the cultivated land is used for potato cultivation. Recently due to encouragement by the provincial government, farmers have started sowing pea. A few farmers also had turnips and french beans in the fields. The Murree vole was the only rodent in the agricultural fields. A few specimens of house mouse (Mus musculus) were trapped but their stomach did not contain any crop material. In deep valleys this vole is absent and it has been replaced by another big rodent (most probably Rattus terkenensis).

Four localities viz. Mochidhara, Dungagali, Kozagali and Tauheedabad were selected (in other localities either there were no cultivated fields or the vole was absent from the cultivated fields). To asses the damage to maize and potatoes, 7 fields in each locality were selected. From each field 9 quadrats each of size 1 X 1.5m were examined for the vole damage. Nine quadrates in a field were distributed along three transect lines, each having 3 quadrates; each were spaced proportional to the length of

Table 43. *H. wynnei* damage to maize in different localities of Galliat

Locality	No.of plants examined	No.of plants damaged	Percentage of plants damaged
Mochidhara	2557	115	4.5
Dungagali	3465	163	4.7
Kundla	1986	80	4.2
Tauheed Abad	2305	89	3.9

Table 44. *H. wynnei* damage to potato crops in different localities of Galliat.

Locality	No.of plants exami-ned	No.of plants dama-ged	%of plants dama-ged	No.of potatoes exami-ned	No.of potatoes damag-ed	%age of potatoes damag-ed
Mochidhar	1476	140	9.9	6637	408	6.1
Dungagali	1740	167	9.6	8004	529	6.6
Kundla	1068	95	8.9	4806	297	6.2
Tauheed-abad	2380	219	9.2	10710	675	6.3

Table 45. *H. wynnei* damage to apple trees in Murree area

Diameter of the tree at 2 feet height	No.of trees examined	No.of trees damaged	% of trees damaged
40 Cm	880	42	4.7
40 Cm	540	37	6.9

the field. The Murree vole cut the young maize plant through the stalk just above the ground level and carried the plant into the burrows. In each quadrate the total stems and the number of stems damaged by the vole were counted and percentage damage was determined.

Maize suffered an overall damage of 4.3% at the four localities. Dungagali experienced the highest damage (4.7%) and Tauheedabad the lowest (3.9%) (Table 43). However there was no significant difference in the percentage of damage at different localities. The damage was more severe in June when the plant was young but after attaining certain height (70 cm) maize plant became less susceptible to the vole damage. It might be due to comparatively hard stem and large size of maize plant, which was difficult to be carried to the burrows.

Potato damage was difficult to observe as the vole did not feed the aerial part and consumed the under-ground tuberous portion of the plant through the underground tunnels, leaving the aerial portion intact. The only sign of the attack was the excavated soil near or around the infested plant. An infested plant was removed and soil was dug out to count the number of damaged and undamaged potatoes. In a very few cases all the potatoes under a plant were eaten or damaged. A few dead plants were observed and farmers attributed their death to vole attack but when the soil under the dead plant was removed all the potatoes were intact. Obviously, there was some other cause of death of the plants. The overall damage of potatoes was 6.3% (Table 44).

In Kalabagh, Nathiagali & Dungagali the vole was quite common in the residential areas. Not a single lawn was observed tobe free of the vole. Dahlia was the major ornamental plant in these areas. The stalk was cut by the vole just above the ground level. In addition the tuberous root of dahlia was also damaged. In one bungalow the vole made about 1m of vertical tunnel to reach the roots of dhalia, planted in flower bed above the ground level. In some cases the damage was so severe that the gardener placed wiregauze all along the beds of dhalia to protect it from the attack of the vole.

It was also quite abundant in the forest nurseries & according to the forest people it was quite a serious pest of saplings of forest trees. But during this study no sapling was observed to have been damaged by this vole. Major plants in these nurseries were gymnosperms and walnuts. The field study showed that none of these were food of the vole.

The diet of the Murree vole was green vegetation but from November to March it also fed on the bark of <u>Viburnum grandiflorum</u>. When the ground was covered by snow, the bark of this shrub was the major food of the vole. In apple orchards the shrubs are normally destroyed. The bark of apple tree, like Viburnum spp, is very soft and can be easily detached from the stem, so during winter these voles gnaw the bark of the apple trees, a few inches above the ground surface and frequently trees are ring-barked.

To ascertain the extent of the vole's damage to apple trees, orchards in Murree area were surveyed (in Galliat, where the vole was found there was no apple orchard). Since 1940 about 800 acres land have been brought under apple trees cultivation in Murree sub-division and there are more than 8,00,000 apple trees in the region (Roberts, 1981). But most of the land is free of the vole. The severity of damage was more in the old trees (Table 45). Of the old trees 6.9% were found damaged by the vole while only 4.1% young trees were damaged. The removal of bark, did not kill the tree but it definitely affected the growth of the plant and quality of the fruit. A few adult trees were observed dead and but no external damage was found. According to the local people they died due to the feeding of the vole on the roots. But definite cause could not be determined as in most of the cases no vole activity was found around the dead tree.

DISCUSSION

There are a number of other rodents at high altitudes which feed on the bark of apple trees when the ground is covered by snow and other food plants are not available. In Europe the most important debarker of the trees is the field mouse, Microtus aggrestis (Myllymaki, 1979). Like the Murree vole, this field mouse also constructs runways above the ground and below the snow cover to reach food resource. In Pakistan Ochotona rufescens is a serious pest of apple tree at high altitudes in Balochistan, including the orchard rich valleys of Ziarat. Unlike the Murree vole O. refescens also attacks the branches of the tree. Khokar and Fulk (1976) reported that 55.7% trees were damaged by this rodent in Ziarat alone.

According to Roberts (1981) the Murree vole is becoming increasingly a serious pest of apple orchards as well as of maize and potato crops. He reported that in the Government Fruit Research Farm at Sunny Bank in Murree, seven out of 150 trees of imported bud graftings were seriously damaged by the vole. At Sri in Kaghan valley a farmer lost his entire plantation due to the vole damage (Roberts, 1981).

During this study it was found that wherever this vole is found, very small area is under cultivation. Maize and potato are the major crops. Maize is not effected seriously because only the young plants are damaged and many alternate food plants are available. Potatoe is a preferred food but the vole does not attack the aerial green part, possibly due to distasteful alkaloid in the green parts of this crop. Only 5.3% of the potato tubers were destroyed. The observation suggests that the vole is a major pest of potatoes in Galliat. Its attack to dahlia was more serious and in some cases the whole bed of the flowers was destroyed. As far as apple tree is concerned it is a major problem particularly in old plants. The damage also affects the quality and quantity of the fruit.

CHAPTER-XV

SUMMARY AND CONCLUSION

Ecology of the Murree vole, Hypercrius wynnei, was studied in Galliat from 1985 to 1989. Galliat is an area which undergoes seasonal fluctuation regarding climate and vegetation. Temperature in summer is moderate but in winter it is below freezing point and ground is covered with snow for three to four months. Under such an environment the Murree vole lives an entriely fossorial life in a burrow system, which is structurally simple, more or less sealed, microclimatically relatively stable highly, specialized and presumely low in productivity. The population density, most probably, is constant throughout the year and near its carrying capacity of the environment. This helps the Mrree vole to harvest food efficiently through resources but without overshoot and resource destruction.

The method of study consisted of periodic observations. Attempts to trap the live vole were not successful. A total of 691 voles including juveniles (196) and adults (495) were trapped during two years.

The vole appeared to be well adapted to fossorial life with remarkable morphological adaptions involving particularly the structure of the head, neck, eyes, fore-limbs, pectoral girdle, and tail. Compact rat-like body with round head, short neck and small appendages help the animal to check heat dissipitation. The vole seemed to have limited vision due to small eyes that were sensitive to light . Ears are small in proportion to body size and completely concealed in the fur. The short fore-limbs are strongly developed for digging, each digit is armed with comparatively long claws. There are five digits on the hind-foot and four on the fore-foot with a vestigial thumb. The increased risk of heat loss due to small body size is ameliorated by living in burrows.

Variability of body length ranged from 2.78 to 7.36%. The minimum variability was observed in March-April and maximum was in November-December samples but in males during 1985, maximum variability was observed in March-April, which might be due to low snowfall. Snowless winters are more severe and animals are exposed to frost. Variability in body weight in different periods showed great consistency.

The distribution of the vole was associated with the mixed forest of silver (Pinus excelsa) and blue fir (Abies pindrow). Baragali was the northern limit on the road side and it was recorded upto Barian. It was well distributed in Galliat, wherever suitable habitats existed. The lowest elevation, at which the vole was found was 2075 m (Sunny Bank) and highest elevation was 3290 m (Mirajani).

It was not found in deep valleys and those places where the top soil has been eroded.

The Murree vole is active day and night and its activity is linked with feeding period. During monsoon when the vegetative cover is maximum it comes on the gound and go beyond their burrows to collect food plants but in the rest of the year maximum foraging is done during night.

The vole lives in a burrow system, which is spread over an area of more than 450 m^2. Though it has to expend a lot of energy in the burrowing activities but this energy cost not only increase the foraging efficiency but also protect it against predation.

Though the food is quite abundant during spring and summer but due the fossorial habits it has become opportunist feeder and utilizes what so ever is available near the burrow. To exploit the bulk of the plant biomass, the Murree vole has adapted for processing, leaves, stems, cambium or even bark of the woody plants

The Murree vole's food is entirely composed of vegetation. A few stomachs had insects but their presence might be accidental. Hairs of the vole were also found in the stomach constents and a few stomachs contained striated muscles. The vole might have fed on the dead vole. The Murree vole was a generalist feeder and twenty three plant species were identified in the stomach contents. Rumex *nepalensis* was the most preferred plant consituiting 31.00% of the total diet. The volume and frequency of occurrence of large plants were more than the small plants. During winter the bark of the shrubs compensated for the scarcity of soft vegetation, such as leaves, stems and flowers. Being fossorial it collected the food near the vicinity of the burrow and carried the plants into the underground tunnels.

The vole appeared to be habitat specialist and more responsive to certain habitat features. It was quite common in the grass land, cultivated and non-cultivated fields. Depth of the soil horizon "A" and texture of the soil seemed to be the most important factors for habitat selection. It was not found in those areas where the depth of the soil horizon "A" was less than 10 cm. The distribution of the vole in Galliat is greatly influenced by soil texture. The vole was found in silt-loamy soil. Silt-lomay soil is more porous and easy to dig. Being entirely fossorial the porosity of the soil is important since all the gas requirement of the vole are met by diffusion through the porous soil. Beside soil depth and soil texture, its existence in a habitat also depended on the other factors like grass, slope and presence of rocks. To over-come drainage problem, it required a slope of 10°. Grass was not only its food but it was also nesting material and the vole was restricted to the areas with about 20% grass.

The burrow system was the main quarter and the vole spent most of its life in the closed system of underground gallries. It served the vole for shelter, for protection from enemies, as means for obtaining food and as a place for rearing the young and to protect the voles from rigors of external environment. A system was occupied by a number of youngs, subadults and adults. The burrowing system comprised of branching and anastomosing tunnels with attached nesting and resting chambers. Main tunnels ran parallel to the gound, relatively at shallow depths. About 90% of the tunnels were oberved at 20 cm below the ground. Tunnels were made in any and all directions for the purpose of finding food. Nest chamber was in the middle of the system and one or two resting chambers were also made. Burrowing activities were related to the rains. Before July, little excvation was observed but there was consistent increase during July to peak in August.

The Murree vole did not hibernate and bred throughout the year. Though very few voles were trapped during winter but this small sample contained pregnant females. The trapping of juveniles in March further confirmed the winter breeding. The pregnancy rate was very low (39.39%) and there was no significant difference between the pregnancy rates in the two years. Similarly no significant variation in pregnancy rates in different seasons was observed over the two years. In two-months samples complete homogeneity was recorded in 1985 but 1986 samples showed significant heterogeneity; it was due to high pregnancy rate during September-October period. Pregnancy rate in weight class 3 (more than 50 gm) was higher than the other two lower weight classes.

Litter size was small and number of embryos varied from 1-4 per litter. One or two embryos per litter was a common feature. Rarely a female had more than two embryos. No significant difference in the mean litter size was found in three seasons. However comparison of the mean litter size of 2-months sample showed a significantly lower count in November-December sample. All the females in March had 2 embryos and in November-December had one.

Prenatal mortality was very low. Preimplantation losses were 4.0% and 5.5% in 1985 and 1986 respectively, and only 6 resorbing embryos were found. Testes were abdominal and fecund males were observed in all the months. There was no difference in the mean length of testes during different periods.

Small litter size and low reproductivity may be adapted as these reduce the strain on mother and other individuals of the colony. Both these attributes are relatively constant and do not vary much. In order to maintain the population density at certain level, the vole breeds throughout the year, a number of females breed more than once and there are few mortalities in the uterus or due to predation.

The Murree vole shows trends toward K-selection and attributes of K-selected species: small litter size, low fecundity with high parental investment, itereoparity and low prenatal mortality. Though it lives in those areas, where the external environment undergoes great fluctuation. But its burrow system is simple stable and predictable and presumely lead to K-selection.

The adult sex ratios did not change with the season except in summer, 1986, when more females were trapped. The overall sex ratio did not deviate significantly from 1:1. In juveniles, males predominated in all seasons except summer, 1985, when the sex ratio was more or less balanced. Sex ratio skewed towards males among juveniles and balanced in adults suggest more mortality of the juvenile males. The major portion of different samples comprised of adults, while juveniles were only 28.36%.

Mean body weight of pregnant females was more than the non-pregnant females or males in all the samples but the difference was not significant. Lack of seasonal variation in the body weight is another evidence of stable environment under which the vole lives.

Due to fossorial habits the vole harboured a few parasites. Only one species of a nematode and one of a pentastomid were found. Among the ectoparasites, two species of fleas, <u>Paleopsylla setzeri</u> and <u>Xenodaeria telios</u> infested the Murree vole. The Murree vole is the true host of <u>P. setzeri</u>. A number of mites also parasitized the vole. Fleas and mites collectively showed seasonal trend. The peak of parasitism occurred in July-August. The vole seemed well protected against predators.

In Galliat wherever the Murree vole was found, very small area was under cultivation. Maize and potatoes were the major crops. Maize was not affected seriously but 5.3% of the potatoes were destryoed vole. However it damage to apple trees were more and 6.9% of old trees and 4.1% of young trees were damaged by the vole.

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APPENDIX: 1 The average snow-fall, rainfall and temperature from 1971-1984.

Yearly Average Snow-fall.

Year	Snowfall (in millimetre)
1971	230.34
1972	395.60
1973	481.50
1974	262.99
1975	373.09
1976	707.06
1977	366.02
1978	533.06
1979	509.05
1980	502.01
1981	635.03
1982	648.01
1983	542.01
1984	430.01
Average:	472.77

Monthly average rainfall

Month	Rainfall (in millimetre)
January	7.8
February	15.8
March	19.7
April	112.6
May	85.3
June	170.5
July	344.0
August	321.9
September	134.6
October	53.9
November	33.2
December	24.2
Total	1323.5

(contd.Appendix-I)

Monthly averages of Maximum and minimum temperature.

Months	Temperature (centigrade)
January	0.7
February	0.9
March	3.97
April	9.5
May	13.28
June	16.02
July	15.56
August	15.28
September	13.8
October	10.4
November	6.59
December	2.39

APPENDIX-II. COMMON HERBS AND SHRUBS OF GALLIAT

1. *Germarium nepalense* Sweet.
2. *Scaynachum auriculatum* Royle.
3. *Impatians edgeworthii* Hk.f.
4. *Impatians bicolor* Royle.
5. *Arisaema jacquemontii* Blume.
6. *Plantage depressa* Wild.
7. *Rumex nepalensis*
8. *Anaphalis nubigena* D.E.
9. *Pimpnella dwarsfolie* (Wall) D.E.
10. *Glum urbanum* L.
11. *Prunella vulgaris* L.
12. *Impatians bicolor* Royle
13. *Carpesium Cernuum*.
14. *Leucus lanata* Bth.
15. *Stachys sericea* Wall Ex.Bth.
16. *Cynoglossum lanceolatum* Forssk.
17. *Chrysanthemum leucanthemum* L.
18. *Medicago lufulina* L.
19. *Myractis wallichii* Less.
20. *Polygonum nepalense* Meissn.
21. *Ranunculus hirtellus* Royle.
22. *Aquilegia pubiflora* Wall Ex.Royle.

(Contd.Appendix-II)

23. <u>Veronica mellissifolia</u> Desf expoir.

24. <u>Swartia cordata</u> Royle.

25. <u>Trifolium pratense</u> L.

26. <u>Lamium album</u> L.

27. <u>Poa pratensis</u> L.

28. <u>Senecio chrysanthemoides</u> D.C.

29. <u>Urltica Caea</u> L.

30. <u>Urltica dioeli</u> L.

31. <u>Nepeta laevigata</u> (D.Don).

32. <u>Bachyopodium sylvaticum</u> (Hud.) P.Beauv.

33. <u>Brachyactis robusta</u> Bth.

34. <u>Malva parviflorea</u> L.

35. <u>Strobilanthes attenuattus</u> Nees.

36. <u>Polygonum amplexcaule</u> D.Don.

37. <u>Cordalis stevartii</u> L.

38. <u>Achellea millefolium</u>

39. <u>Nepela erecta</u> Bth.

40. <u>Ariplex laciniata</u> L.

41. <u>Silene vulgatum</u>

42. <u>Bupleurum maginatum</u> Ex.D.C.

43. <u>Erigeron</u> Sp.

44. <u>Scrophularia polyantha</u> Ex.Bth.

45. <u>Fragaria nubicola</u> Lindl. Ex Locaita.

46. <u>Arisaema utile</u> Hook. f.ex Schott.

(Contd.Appendix-II)

47. *Euphorbia wallichii* Hook.
48. *Viola canescens*.
49. *Potentilla napalensis* Hook. f.
50. *Giardiana palmala* (Frosk). Gaud.
51. *Cannibis sativa* L.
52. *Lactuca brunoniana* (Wallex. D.C) Clarke.
53. *Viburnum* Spp.
54. *Barberis lycium*.
55. *Myrsine africana*.
56. *Rosa moschata*.
57. *Punica granatum*.
58. *Onychum contiguum*

SMALL MAMMALS RECORD

Complete
Entered
Verified

APPENDIX-III

Transect No | Locality | Date | Page

ght	Length	H.Foot	Ear	Sex	S/A	N/R	Sp.P.	P/I	Lect.	Act.Tits	T.Vis.	P.sc.	Utrus	E.No.	Length	Width	Corp.	C.Alb.	Col.	Comments