J. Exp. Zool. India Vol. 20, Supplement 1, pp. 1371-1376, 2017 | www.connectjournals.com/jez | *ISSN 0972-0030*

DIVERSITY AND DISTRIBUTION OF RODENT COMMUNITY IN COLD ARID ECOSYSTEM OF LEH, JAMMU & KASHMIR, INDIA

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(Accepted 30 July 2017)

ABSTRACT : Present investigation is the first systematic study to assess the diversity of rodents across the altitude in different habitats in Leh district (Jammu & Kashmir). A total of 132 individuals belonging to three families and five species were collected during 2015-16 (June to September). The distribution and diversity of rodent fauna was significantly different (X^2= 85.18; df =5; p<0.01) across the study habitats. The Little Indian filed mouse, *Mus booduga* was the most abundant (66.67%) and widely distributed species recorded from five habitats followed by Turkish rat, *Rattus turkestanicus* (18.94%). The collection of individuals during different months was also significantly different (X^2= 43.09; df=3; p<0.01) as it was maximum in September (25.42%) at the time of crop harvesting, followed by June (11.25%). Diversity of species was influenced by vegetation, availability of food, shelter and extent of human interference. Diversity was highest in the habitat, like grass land and barren lands at foothills (0.69) and lowest in crop fields and horticulture plantations (0.25). The species richness was highest in crop fields and horticulture plantations as compared to other habitats as conducive climate and green vegetation sustained more individuals at a time.

Key words : Diversity, rodents, cold arid, Leh, habitats.

INTRODUCTION

Rodents are the most predominant and diverse group of Mammals having great diversity in ecology, morphology, physiology and behavior. There are 2277 species of rodents categorized under 481 genera and 33 families in the world (Wilson and Reeder, 2005). India is represented by 103 species of rodents under 46 genera belonging to 7 families (Pradhan and Talmale, 2009). About a dozen species are designated as pests due to economic losses they cause to agriculture, storage and public health (Parshad, 1999; Tripathi, 2014). Desert is a unique ecosystem, characterized by dry climate, low and erratic rainfall, extremes of diurnal and annual temperatures, low humidity and high wind velocity. Both hot and cold deserts are reported in India. The cold deserts cover a total geographical area of approximately 74,809 sq. km. in state of Jammu and Kashmir, Himachal Pradesh, Uttrakhand and Sikkim with maximum area of 68,321 sq. km in Leh & Kargil districts of Jammu & Kashmir (Tewari and Kapoor, 2013). Hot desert (The Great Indian Desert or Thar desert), extends over 3,20,000 million km^2 forming approximately 10% of the total geographic area of the country. More than 60% of the hot desert lies in the State of Rajasthan, followed by 20% in Gujarat. The rodents of Thar desert are well studied for diversity and distribution (Prakash, 1974; Tripathi *et al*, 1992; Chakraborty, 2005). The information about diversity and distribution of rodents in cold arid region of India (especially Leh-Ladakh) is very meager. Except for some scattered reports of Chakraborty (1983); Pfister (2004), Tak & Sharma (2003), Alfred *et al* (2006) and Ahmed *et al* (2016) no systematic work on has been done on rodent diversity in this region. In the present study diversity and abundance of rodents in different habitats in Leh district across the altitude was assessed through trapping and observational surveys.

MATERIALS AND METHODS

Study area

The study was conducted during 2015-16 (June-September) in Leh, one of the coldest and most elevated places of the world, is situated in the Ladakh region of Jammu and Kashmir in Indian Trans-Himalaya zone. It is located between $32^0$15' to 36^0 N Latitude and $75^0$15' to $80^0$15' E Longitude with an altitude ranging from 2900 to 5,900 m above the mean sea level (amsl) and covers an area of 45,110 sq. km. The region is characterized by harsh climatic condition *i.e.* dry and cold weather, heavy snowfall, low temperature, which sometimes goes down to as low as -35°C in winters and to as high as +35°C in summers (Meena *et al*, 2015). Annual average rainfall of Leh is 100 mm, which mainly occurs during May-September. The soil is sandy or sandy-loam and is

generally poor in organic matter and nitrogen content (Murti, 2001). The vegetation is desert-like, consisting of low shrubs and herbs. Some trees like poplar, *Populus* spp. and willow, *Salix* spp. grow along river-valleys. The rangelands of the region are also characterized by low graminoid biomass. Snowfall during winter (November to March) is a common weather phenomena and therefore only one crop is grown in a year. Naked barley, locally known as 'grim' is the major cereal crop of the district. Wheat, pulses, oil seeds and other millets are also grown in scattered areas. Whole of the cultivated area is irrigated mainly through water streams originated from glaciers.

Survey sites and habitats

Six habitats were identified in the survey area of Leh District along Ladakh range across the altitude from 3000 to 5000 m amsl. The habitats identified were: Crop fields and horticulture plantation, Field stores, Poly houses, Grassland and barren land at foothills, Godowns and shops and Poly houses and Fallow land in Leh city area.

Data collection

Data on species composition in different habitats was collected through (i) trapping by laying Sherman traps randomly in field and storage (Godowns, shops and field stores) and a trap line on bunds in fields. In fields traps were fixed at a distance of 10m and in storage the taps were laid on the basis of sign of infestation of rodents, (ii) direct capturing by digging burrows (voles in grassland) and (iii) direct observation through trails in mountains and locating active burrows.

Statistical analysis

I. Trap success for each habitat and month was computed using following formula (Jackson, 1952).

Trap success (TS) = Number of individuals/number of traps x trap nights x100

II. Diversity of rodents in different habitats was computed using following indices:

a) Margalef's Diversity Index (d): Species richness was estimated using the following formula as given by Clifford and Stephenson (1975).

$$d = \frac{(S-1)}{\ln N}$$

Where,

d = Species richness index

S = Number of species in a population

N = Total number of individuals in S species

b) Shannon-Wiener diversity index $(\underline{H'})$: This measures faunal diversity and gives the degree of uncertainty involved in predicting the species identified from randomly selected individuals. It was calculated using the following equation as given by Magurran (2004).

$$H' = -\sum\left[\left(\frac{ni}{N}\right) x\, ln\left(\frac{ni}{N}\right)\right]$$

Where,

ni = number of individuals or amount of each species (the *ith* species)

N = total number of individuals for the site

c) Simpson's Index (D) : It indicates ecological dominance and was worked out using the formula of Simpson (1949).

$$D = \sum \frac{ni\,(ni-1)}{N\,(N-1)}$$

Where,

ni = number of individuals or amount of each species (*i.e.*, the number of individuals of the *ith* species) and

N = total number of individuals for the site.

This was then transformed into a measure of species heterogeneity using the complement of D as recommended by Lande (1996): 1-D.

d) Species Equitability or evenness Index (*J*) : It refers to the degree of relative dominance of each species in the collection. It was calculated according to Pielou (1966) as

$$J = \frac{H'}{\ln S}$$

RESULTS

Species composition

A total of 132 individual rodents belonging to three families and five species were captured/recorded from six habitats. The species identified were: Little Indian field mice, *Mus booduga* (Gray), Turkish rat, *Rattus turkestanicus* (Satunin) (=*Rattus pyctoris* (Hodgson)), Blyth's voles, *Pitymys leucurus* (Blyth) (=*Phaiomys leucurus* Blyth), Himalayan marmot, *Marmota himalayana* (Hodgson) and an unidentified *Rattus* spp.

The Himalayan marmots were observed at an altitude ranging from 3200 to 5000 m amsl in grassland and barren land at the foothills. The activities of marmots were noticed along the roadsides. The Blyth's voles were confined to grassland at an altitude ranging from 4000-

5000 m amsl and were captured by digging their burrow complexes. Little Indian field mice were collected from the crop field, field stores, Polyhouse, Godowns & shops and Urban fallow. This was the most abundant species collected from the cold arid region of Leh (3350 to 3750 m amsl). Signs of presence of lesser bandicoot rat, *Bandicota bengalensis* like mounds of soil near burrow openings in crop fields were observed at an altitude of 3200 m amsl, however the same could not be confirmed as the species could not be trapped. Therefore, *B. bengalensis* is not reflected in species composition. Turkish rat was collected from godowns and shops in city of Leh, kitchen garden and horticulture plantation at an altitude ranging from 3300-3650 m amsl. Besides, a single specimen of *Rattus* spp. (yet to be identified) was also collected from crop field at an altitude of 3600 m amsl.

Distribution, abundance and activity pattern

The distribution and abundance of rodents was significantly different ($X^2 = 85.18$; df=5; $p<0.01$) across the habitat. The little Indian field mouse, *M. booduga* was widely distributed, as it was recorded from five habitats followed by Turkish rat, *Rattus turkestanicus*, recorded from two habitats during all the study months (June-September). The population of *M. booduga* (88) was maximum in all the habitats. Maximum number of individuals were recorded from crop fields (40.90%), followed by godowns and shop (28.03%), grassland and barren land at foothills (13.64%) urban fallow (7.58%) and polyhouses (4.55%) (Table 1).

There were significant differences ($X^2= 43.09$; df=3; $p<0.01$) in proportion of individuals collected during different months. The trap success in the month of September was maximum (25.42%) followed by June (11.25%), July (10.19%) and August (4.58%) (Table 2). Maximum collection of *M. booduga* during September is attributed to its large capture from crop field during harvesting stage when all the field mouse congregate in the field below the heaps of harvest crop for food and shelter.

The species abundance data was plotted on line graph as rank abundance curve from highest to lowest proportions following Whittaker (1965) (Fig. 1). The relative abundance of collected rodent showed maximum occurrence of *M. booduga* (66.67%), followed by *R. turkestanicus* (18.94%) (Table 2).

Diversity

Diversity of rodent species is largely influenced by the characteristics of the habitat i.e. vegetation cover, availability of food and safe shelter and extent of human

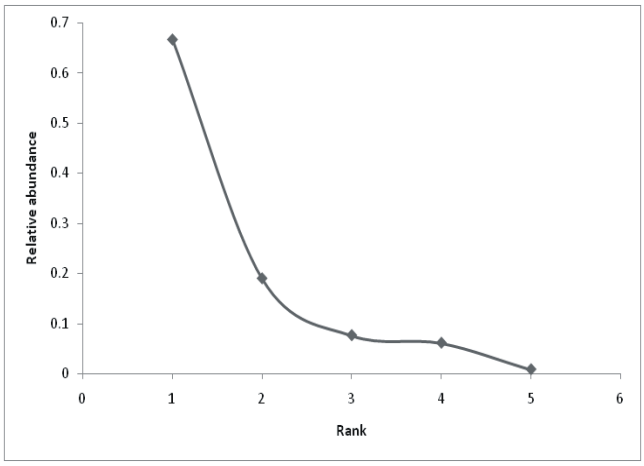

Fig. 1 : Rank abundance curve rodents in Leh district.

interference. Among six habitats sampled, the grass land and barren lands at foothills had the highest diversity (0.69) and evenness indices (0.99) with lowest ecological dominance indices (0.51) probably due to least human disturbance, loose soil, vegetation cover and availability of moisture It was followed by godowns and shops in urban area with respective indices of 0.66, 0.95 and 0.53 because food and safe shelter was available abundantly round the year in the habitat. Lowest diversity (0.25) along with lowest evenness indices (0.23) and highest ecological dominance indices (0.89) was recorded in crop fields as the habitat was most disturbed area due to frequent human interference during agricultural operations. The diversity index (H') is the measure of stability of the community. It is highest when every single individual belongs to a different species and evenness is also more due to most equal distribution. The species richness was highest in crop field (0.50) as three species were recorded with 54 individuals followed by grass land and barren lands at foothills (0.35) and godown (0.28) where two species each were captured with 18 and 37 individuals, respectively. The reason attributed for species richness in crop field may be the availability of conducive climate and green vegetation, sustaining more individuals at a time (Table 3). The diversity in rest of the three habitats was zero as only single species was captured from Field stores, Poly houses and Urban fallow with 7, 6 and 10 individuals, respectively.

Monthly rodent species diversity indices as presented in Table 4 revealed highest diversity (1.35) and evenness (0.97) with lowest dominance (0.27) in the month of July. However, the lowest diversity (0.38) and evenness (0.35) with highest dominance (0.83) was recorded in the month of September. The species richness was maximum in August (1.17) and minimum in September (0.48). Monthly species heterogeneity was in order of July> August>

Table 1 : Rodent species collected from different habitats from cold arid region of Leh.

Family	Species	Crop field	Field storage	Godown & shop	Poly house	Urban fellow	Grassland/barren land on foot hills	Total
Muridae	*Mus booduga*	51 (38.64)	7(5.30)	14(10.61)	6(4.55)	10(7.58)	0	88
	Rattus turkestanicus	2(1.52)	0	23(17.42)	0	0	0	25
	Rattus sp	1(0.76)	0	0	0	0	0	01
Cricetidae	*Pitymys lecurus*	0	0	0	0	0	8(6.06)*	8*
Sciuridae	*Marmota himalayana*	0	0	0	0	0	10(7.58)*	10*
Trap success (%)		**21.18**	**5.83**	**15.42**	**5.00**	**4.17**	**-**	**-**
Trapping nights (Nos)		**255**	**120**	**240**	**120**	**240**	**-**	**-**

$X^2 = 85.18$; df = 05; $p < 0.01$

*Rodents captured by method other than trapping not considered for TS (%) calculation.

Percent occurrence in each habitat is shown in parenthesis.

Table 2 : Rodent species collected during different months from cold arid region of Leh.

Family	Species	June	July	Aug	Sept	Total	Species %	Family %
Muridae	*Mus booduga*	14	10	6	58	88	66.67	86.36
	Rattus turkestanicus	12	6	4	3	25	18.94	
	Rattus sp	0	0	1	0	1	0.76	
Cricetidae	*Pitymys lecurus*	0	6*	2*	0	8*	6.06	6.06
Sciuridae	*Marmota himalayana*	2*	5*	0	3*	10*	7.58	7.58
Trap success (%)		**10.19**	**11.25**	**4.58**	**25.42**	**11.69**	-	-
Trapping nights (Nos)		**255**	**240**	**240**	**240**	**975**	-	-

$X^2 = 43.09$; df = 3; $p < 0.01$

*Rodents captured by method other than trapping not considered for TS (%) calculation.

Table 3 : Diversity indices of rodent species in different habitats in cold arid region of Leh.

Months	No. of species	No. of individuals	Species Richness index (d)	Shannon Weiner Index (H')	Evenness index (J)	Simpson's Index (D)	Species Heterogeneity (1-D)
Crop field	3	54	0.50	0.25	0.23	0.89	0.11
Field stores	1	7	0	0	0	1	0
Godown & shop	2	37	0.28	0.66	0.95	0.53	0.47
Poly houses	1	6	0	0	0	1	0
Urban Fellow	1	10	0	0	0	1	0
Grassland/barren land on foot hills	2	18	0.35	0.69	0.99	0.51	0.49

June> September.

DISCUSSION

A total of 132 individual rodents were captured in 975 trapping nights with an overall trap success of 11.38%. The vegetation (food), soil and altitude played an important role in species abundance (Mulungu *et al*, 2008). Dueser and Shugart (1978) and Isabirye-Basuta and Kasenene (1987) has also reported that food and shelter influenced the abundance and distribution of small mammals. In present study, the trap success was maximum in crop field and horticultural plantation followed by godowns and shops, due to availability of plenty of food and safe shelter. The lowest trap success was in urban fallow, which is a exposed surface with less vegetation, that allows the rodents to get exposed to several biotic and abiotic factors that decrease the population (Yihune and Bekele, 2012). At higher altitude (4000 m and above) in grassland and barren land the abundance of rodents were high due to least anthropogenic interventions (Alfred *et al*, 2006; Armitage 2000). Marmot and voles were recorded from these

Table 4 : Monthly diversity indices of rodent species in cold arid region of Leh.

Months	No. of species	No. of individuals	Species Richness index (d)	Shannon Weiner Index (H')	Evenness index (J)	Simpson's Index (D)	Species Heterogeneity (1-D)
June	3	28	0.60	0.90	0.82	0.44	0.56
July	4	27	0.91	1.35	0.97	0.27	0.73
August	4	13	1.17	1.20	0.87	0.34	0.66
September	3	64	0.48	0.38	0.35	0.83	0.17

habitats in fair numbers.

The distribution of rodents varied across the habitats. *M. booduga* was recorded from almost all the habitats in the study area except grass and barren lands. It was primarily most abundant in crop fields and horticultural plantations followed by godowns and shops. This mesic species has country wide distribution, but from cold arid region it has been reported for first time. In hot arid regions its abundance has been reported from crop fields (Idris *et al*, 2003). Blyth's vole was strictly limited to grass land at an altitude 4250 m and above near banks of water streams. Molur *et al* (2005) and Smith and Xie (2008) recorded the voles from grassland near banks of streams and lakes and rocky crevices. Himalayan marmots inhabited grass land and barren land both and encroached crop fields at lower altitudes (3200 m amsl). The marmots were encountered from 3200 to 5050 m amsl. Alfred *et al* (2006) also recorded maximum population of Himalayan marmot from Tangtse-Chushul sector of Eastern Ladakh. Armitage (2000) reported that Himalayan marmots most often occur between timberline and snowline. Niethammer and Martens (1975) reported Turkish rats from residential areas like the present study which recorded its presence from godowns, shops, houses, kitchen gardens etc., however the species have been reported to inhabit varied habitats, such as montane habitats (Smith and Xie, 2008), rocky areas and cultivated lands (Sarker *et al*, 2005).

Diversity indices of catch data of small mammals from cold arid region of Leh revealed that habitat with maximum trap success (21.18%) were least in species diversity and evenness. Prakash *et al* (1996) also recorded least species diversity in the habitat of maximum trap success in their study of small mammal diversity from Aravali hills of Rajasthan, India. The species diversity was maximum in grass and barren lands, though only two species were recorded, however due to uniformity in collection of individuals of two species in the habitat, their diversity was higher. In godowns and shops, though only two species were recorded, their diversity index was lower (0.60) due to variance in collection of individuals in the habitat. Similar observations were recorded by Prakash *et al* (1996) and Prakash and Singh (2001) in their study of small mammals in hilly tract in Rajasthan.

ACKNOWLEDGEMENTS

The authors are thankful to Director, Central Arid Zone Research Institute, Jodhpur for providing facilities and support in conducting the study. We are also thankful to S/Sh Ramesh Chand Meena and Surjeet Singh, Senior Technical Officers for their support in recording various observations during the course of study. The authors declare that they have no conflict of interest.

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