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Population characteristics of *Suncus murinus* in rural commensal habitats of Pothwar, Pakistan

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Abstract

The present study was aimed to determine the population characteristics of the House shrew, *Suncus murinus*, in rural commensal habitats of Pothwar, Pakistan. The trapping campaign was conducted in four village sites of Pothwar on a seasonal basis from March 2012 through February 2014. In each village, snap traps were set in three types of structures (including, village households, shops and farm houses). The results showed that the shrew population in the rural human habitations had an unbiased sex ratio. Reproductively active individuals were present throughout the year. Reproductively active females outnumbered the inactive individuals. The species was predominantly eating animal food (mainly insects) in its diet along with the sufficient amount of plant matter. Overall, these results indicated that in commensal conditions shrew populations had diversity in their diet with the relatively continuous reproductive activity.

Keywords: Ecology, Food Habits, House Shrew, Indoor Habitats, Villages

Introduction

The house shrew, *Suncus murinus*, is a small mammal species present worldwide in different types of habitats. The species belongs to the family Soricidae, order Soricomorpha (Hutterer, 2005). It has spread out of its natural range in Asia to different islands of Pacific and Indian oceans (Ruedi et al., 1996). As an invasive species, *S. murinus* has been reported to cause loss of endemic fauna on islands (Fritts and Rodda, 1998, Solow et al., 2008). In indoor conditions, the negative impact of the species is often overlooked as compared to the rodent pest species. Generally, the species is considered useful to man, in eliminating insects, particularly cockroaches or is said to discourage rats from inhabiting the houses (Roberts, 1997). However, *S. murinus* is also known to be the vector and/or reservoirs of various types of pathogen, such as Salmonellae and Severe fever with thrombocytopenia syndrome virus (SFTS virus) (Joseph et al., 1984, Liu et al., 2014), Also, the species is reported to damage garden lawn through eating bulbils of the grass (Roberts, 1997).

In Pakistan, *S. murinus* is widely distributed in different habitats (Roberts, 1997). We have limited information about the biology of the species, except for a single study on its biology in crop fields in central Punjab (Khokhar, 1991), with no such information from the commensal habitats. In the commensal conditions, the species occurs in close association with human beings, and can pose a serious threat to human health through spreading different pathogens (Tung et al., 2013). Worldwide, the knowledge of the biology of house shrews is very limited. Understanding the status and biology of the species is important to determine its impact, and to develop effective management strategies for its control. Therefore, the present study was aimed to determine the population characteristics of *S. murinus* species based on the specimens trapped for two years snap trapping of commensal small mammals in a rural area. This study will generate useful information about the biology of

the *S. murinus* species present in the rural commensal habitats and will be a little contribution towards the ecology of this species in the indoor habitats.

Materials and Methods

The study was conducted in Pothwar region (32.5°N-34.0°N and 72°E-74°E), Pakistan from March 2012 through February 2014. Pothwar is a rain-fed area, comprising four districts of Punjab province (including, Attock, Jhelum, Chakwal and Rawalpindi) and Islamabad capital territory (ICT). The area has an altitude ranging from 350 to 575 m above sea level and experiences a semi-arid to humid climate with an annual rainfall of the area ranging from 450 to 1750 mm. About 70% of the rainfalls occur during the monsoon months from July to September (Tariq, 2004, Rashid and Rasul, 2011). The total area of Pothwar is 2.2 mha, of which 1 mha is used for various agricultural activities. The major crops grown in the area are wheat (*Triticum aestivum*), groundnut (*Arachis hypogaea*), maize (*Zea mays*), millet (*Pennisetum typhoides*), barley (*Hordeum vulgare*) and gram (*Cicer arietinum*). Wheat is the major winter crop (November-May) with inter cropping of grams, lentils and mustard, while the important crops of summer are ground nuts and millets (May-October). The two major cropping systems adapted in the Pothwar region are: Wheat-groundnut and Wheat-maize/millet (Arif and Malik, 2009).

During a trapping campaign conducted for commensal small mammals in rural areas of Pothwar, we captured house shrew specimens along with the commensal rodent species from the indoor habitats. In Pothwar, four village sites, namely Kisran (Site I), Makhial (Site II), Ahmedabad (Site III) and Usmanzada Adra (Site IV) were randomly selected for animal trapping (Figure 1). Wheat-groundnut cropping system was adapted in Kisran and Makhial village, and Wheat-maize/millet cropping system was adapted in Ahmedabad and Usmanzada adra village.

In each of the village sites, trapping was conducted on a seasonal basis in spring (March to April), summer (May-September), autumn (October to Mid-November) and winter (Mid-November to February). At each site, three types of structures (households, shops and farm houses) were randomly selected for trap setting. Here, a household refers to the residence with in the main village either located in center, middle, or peripheral part of the village. A village house is generally made up of mud, bricks, and concrete and covers an area of 1316- 2276 sq ft, including courtyard; a village shop refers to the small general store which sells different type of food items, daily used products, fruits, and vegetables. Generally, a shop size is about 10 x 15 feet. In shops, rodents have access to plenty of food items, as well as several hiding places; a farm house refers to the rural residence build away from the main village, where the villagers keep their animals and perform different agriculture activities. With the adjacent field crops and a limited human population, farm houses are expected to provide shelter for field rodent species.

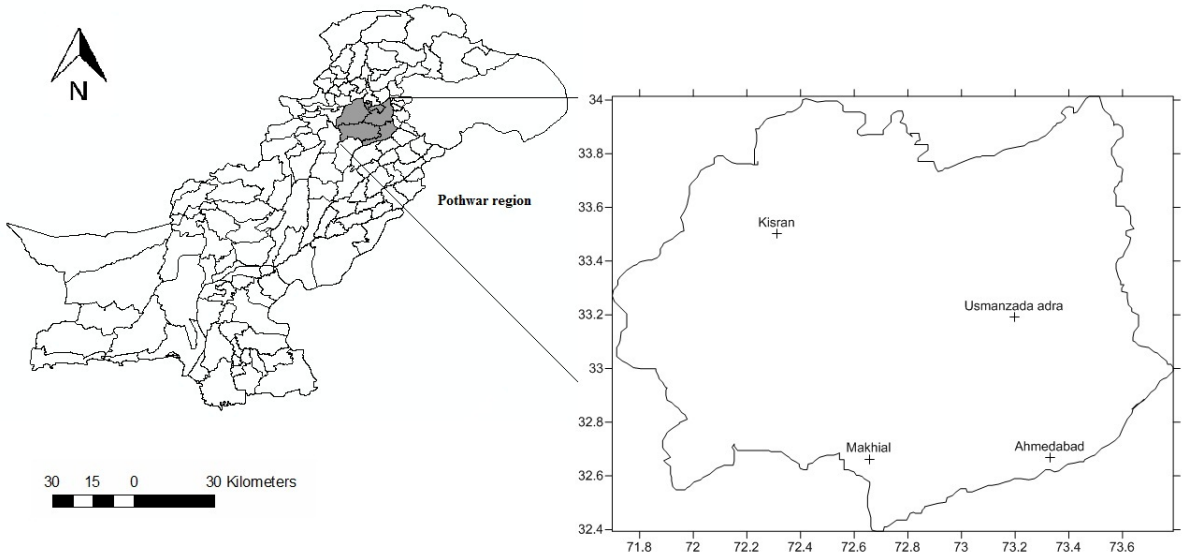

Fig. – 1: The map of Pakistan showing the location of the Pothwar region and the four study villages.

At each site, ten structures, comprising six households, three shops and one farm house were selected for setting traps. Animals were trapped using snap traps baited with bread (roti) soaked in vegetable oil. In each trapping session, sixty traps (6 traps/structure) were set per night for four consecutive nights. Each trapped animal was assigned a field number and transferred to the laboratory for further analysis. The research was performed following the protocol of ethics and animal handling approved by the ethics committee, PMAS Arid Agriculture University Rawalpindi.

In the laboratory, house shrews were weighed, sexed and standard body measurements (viz. head to body length, tail length, hind foot and ear length) were taken. To study sexual size dimorphism, head body length (HBL) was considered as criteria, because the weight of an animal may vary with the different breeding conditions. Pelage color was assessed using Munsell soil color chart (Munsell, 2009). Based on the body weight, individuals were classified into two age classes (juveniles and adults). Following Chang et al. (1991a, 1999b), juvenile class included individuals weighing ≤ 23 for females and ≤33g for males. The adult class was composed of reproductively active individuals, weighing > 23g and > 33g for females and males, respectively.

Animals were autopsied to study the reproduction pattern and food habits. In females, number of scars, number of embryos was noted and uterine horns were categorized following criteria described by Aplin et al. (2003). In males, testes weight, length, width and volume were noted. The volume of the testes was calculated by using the formula for ellipsoid given as follows:

$$V= 3/4\pi ab^2$$

Where "a" is half the maximum length and "b" is half the maximum width (Woodall and Skinner, 1989).

For food analysis, reference slides of the candidate food items were prepared to facilitate identification of the food items present in the stomachs. Candidate food items included mainly legumes, stored grains present in the trapping structures (houses, shops and farm houses), plants present around trapping structures, fruit trees or vegetable plants present in the houses or farms where the trapping was conducted. Food items including grains, cereals and dried plant parts were soaked overnight and finely ground using a mortar and pestle and tissue homogenization. Ground tissues were soaked in 100% sodium hypochlorite solution (NaOCl) for 20-30 minutes and washed with distilled water. Then, dilute acetic acid (30%) was added to neutralize the basic effect of NaOCl. After 15-20 minutes, the material was washed with distilled water and placed in hematoxylin stain. Slides were fixed for long term storage using canada balsam. The stomachs were removed after autopsy, placed in freezer until the contents were examined and analyzed. A similar procedure of slide preparation was used for the stomach content analysis except for grinding, as the contents have already gone through digestion. On the slide, 15 fields with identifiable material were noted to quantify the food contents in the diet.

For food items, the percentage frequency of occurrence (the number of stomach containing specific food item divided by the total number of stomach analyzed x 100) was calculated. Also, the relative abundance as a percentage (the number of locations in which a particular food item was recorded divided by the total number of location examined x 100) of each food item was noted (Jobling et al., 2001). Chi square goodness of fit test was used to check the deviation from 1:1 sex ratio. Independent *t*-test was used to check for difference in the morphological characteristics of male and female individuals. The data from four trapping sites were pooled to check for sexual differences in morphological characteristics. Kruskal-Wallis test was used to check for seasonal variation in the testicular measurements (i-e weight, length, width and volume of testes). For the diet analysis, variations in the frequency occurrence (FO) of major food categories across trapping sites, seasons, and sexes was assessed using Pearson's Chi square test. Kruskal-Wallis test was used to check the difference in the relative abundance of different food categories across trapping sites and seasons. Mann-Whitney's (U) test was used to check for difference in the relative abundance of different food categories between male and female individuals. Comparison across different trapping sites and seasons was performed only for the dietary studies as the data were sufficient for that analysis. All differences with $P > 0.05$ were considered non-significant, while for diet analysis, because of the multiple χ^2 and Kruskal-Wallis tests on related data, Bonferroni correction was applied to adjust alpha value for each hypothesis. All the analyses were performed using IBM Statistical Package for Social Sciences (SPSS) software (version 16.0).

Results

A total of 746 individuals of small mammals was captured from the village structures. These captures included eight rodent species with the relative abundance of 92.8%. The trapped rodent species included: house mouse (*Mus musculus*) (n=436), black rat (*Rattus rattus*) (217), Indian gerbil (*Tatera indica*) (20), soft-furred field rat (*Millardia meltada*) (9), Indian bush rat (*Golunda ellioti*) (7), lesser bandicoot rat (*Bandicota bengalensis*) (1), short-tailed bandicoot rat (*Nesokia indica*) (1), and little Indian field mouse (*Mus booduga*) (1). Fifty-four individuals belonged to *S. murinus* were captured with the relative abundance of 7.2%. The shrews were mainly captured in village households and shops, and only a single individual was captured in a farm house during the two year study.

Population structure:
There were 31 (57%) female and 23 (43%) male specimens of *S. murinus* in the trapping. Except for site I, the females outnumbered males, yet their ratio did not deviate significantly from 1:1 ratio (χ^2 = 1.18, df = 1, P =0.27; Figure 2). Based on the body weight, house shrews were classified into two age classes, adults and juveniles. Of the 54 shrews, 50 were adults and the remaining four juveniles.

Morphology:
No significant difference was found in body weight (*t* = 0.93, df= 46, P = 0.35), head to body length (*t* = 0.57 df= 46 P = 0.57), tail length (*t* = -0.59, df= 46, P = 0.55), hind foot length (*t* = -0.24, df= 46, P = 0.81), and ear length (*t* = 0.47, df= 46, P = 0.63) of adult male and female shrews. The morphological characteristics of males and females, respectively are: body weight (28.2-53.3g; 25.7-50.2g), head to body length (87-138mm; 79-140mm), tail length (56-72mm; 51-85mm), hind food length (16-22mm; 16-23mm), and ear length (10-17mm; 10-17mm). It was observed that pelage color of shrew in the present study was dark grey dorsally and light grey ventrally.

Reproduction:
There was no significant seasonal difference in the testes weight (Kruskal-Wallis $H_{3,\ 22}$= 2.5 P=0.46), testes length (Kruskal-Wallis $H_{3,\ 22}$= 6.7 P=0.80), testes width (Kruskal-Wallis $H_{3,22}$= 2.1 P=0.53), and testes volume (Kruskal-Wallis $H_{3,22}$= 4.6 P=0.23). The mean testes weight was 46.4 ± 10.5 mg (range= 30.0-62.5), mean testes length was 4.8± 0.6mm (range = 4-6), testes width was 3.2 ± 0.3mm (range= 3.0-3.7) and the mean testes volume was 26.8± 7.9 mm^3(range= 18.8-44.6).
Of the 28 adult females, only five were found reproductively inactive. The rest of the individuals (82.1%) were either pregnant (6 out of 23 individuals; class III horns), having placental scars (8 out of 23 individuals; class IV/V horns) or entering in the first breeding cycle, having class II uterine horns (9 out of 23 individuals). Overall, pregnancy rate was low (26%) in the shrew population. The six pregnant females carried 24 embryos in their uteri. The mean embryonic litter size was 4.0 ±1.8 (range =4-7).

Food habits:
In total, 48 stomachs of *S. murinus* (including 17 from the site I, 12 from the site II, 7 from the site III and 12 from the site IV) were processed to study the diet of the species. Empty or decomposed stomachs were discarded. To check for any differences in the consumption of various food types, food items were divided into five major categories as cereal grains, legumes, oil seeds, arthropods, and miscellaneous. From the 48 analyzed stomachs, eight types of food items were recorded, including arthropods and seven plant species. Arthropods (mainly insects) were found in 83%, and plant matter in 63% of the stomachs.
The frequency of occurrence and relative abundance of major food categories did not differ significantly between trapping sites (P> 0.003; Figure 3a). The results showed that arthropods were the most abundant food item (relative abundance (RA) = 64.9%) in the diet of shrews at all sites. The highest consumption of animal food was at the site IV (RA =83.9%) and its consumption was lowest at the site III (RA =48.6%). Among plant foods, wheat (*Triticum aestivum*) was eaten at all sites and was the second most frequent (52.1%) and abundant food item (RA=26.4%). It was consumed most intensively at the site III (RA= 35.2%) and least intensively at the site IV (RA=13.9%) (Table I).
No significant seasonal differences were found in the frequency of occurrence and relative abundance of major food categories (Figure 3b). In all seasons, animal food was the chief component of the shrew's diet. Animal food was consumed more intensively in winter (RA=75.1%) and least intensively in autumn (RA=54.2%) (P> 0.003; Table II). Among the plant foods, wheat was consumed in all seasons, with its relative abundance ranging from 20.0% in summer to

35.0% in autumn. The other plant items were eaten sparsely and not in all seasons. For instance, oilseeds (including *Brassica campestris* and *Arachis hypogaea*) were totally absent from the diet in autumn (Table II).

Female shrews (n=28) consumed animal food more frequently (Frequency of occurrence (FO)= 92.9%) than males (FO= 70%, n=20), but the differences were not statistically significant. Animal food was more consumed (RA= 73.8%) by females as compared to males (RA= 52.3%), but the differences were not statistically significant (P> 0.006; Figure 3c). Among the plant food, *T. aestivum* was more consumed (36.3%) by the male shrews as compared to females. Overall, female shrews had seven types of plant food items in their diet, and males had only three types of plant food items (Table III).

Table IV shows that the diet of household shrews was relatively more diverse than those of the other structures. The household shrews ate arthropods and six plant items. The relative abundance of arthropods in the diet of the shrews was 61.6%. The shrews of the village shops consumed arthropods more intensively (RA= 73.3%) and the plant based food items reduced to about half (Table IV). The only single shrew captured from the farmhouse had solely arthropods in its stomach (Figure 3d).

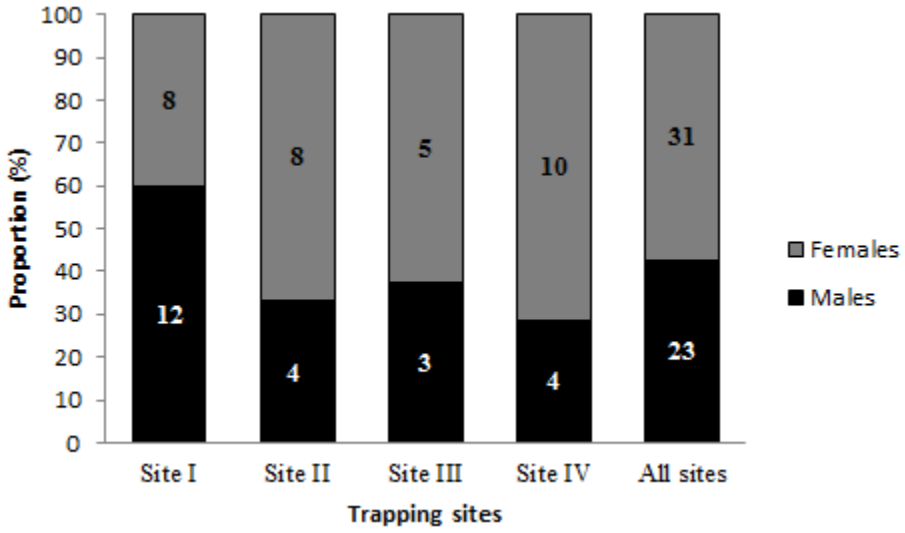

Fig. – 2: Proportion of sexes in *S. murinus* captured at four sites in rural Pothwar, Pakistan. Percentages are based on the number of individuals shown within the bars.

Table – 1: Frequency of occurrence (FO) and relative abundance (RA) of different food items in the diet of *S. murinus* at different sites of Pothwar, Pakistan.

Food items	Site I (n=17)		Site II (n=12)		Site III (n=7)		Site IV (n=12)		All sites (n=48)	
	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)
Arthropods	76.5	61.6	83.3	60.0	85.7	48.6	91.7	83.9	83.3	64.9
Triticum aestivum (C)	52.9	30.6	58.3	27.8	57.1	35.2	41.7	13.9	52.1	26.4
Brassica campestris (O)	11.8	3.1	8.3	0.6	28.6	4.8	-	-	10.4	1.9
Sorghum bicolor (C)	-	-	16.7	2.2	-	-	-	-	4.2	0.6
Lens culinaris (L)	11.7	4.7	16.7	8.3	14.3	8.6	-	-	10.4	5.0
Arachis hypogaea (O)	-	-	-	-	14.3	2.9	-	-	2.1	0.4
Polypogon fugax(Misc.)	-	-	-	-	-	-	8.3	2.2	2.1	0.6
Cicer arietinum (L)	-	-	8.3	1.9	-	-	-	-	2.1	0.3

C- Cereal grains, O- Oilseeds, L- Legumes, Misc- Miscellaneous, n-number of stomach.

Table – 2: Seasonal variations in the frequency of occurrence (FO) and relative abundance (RA) of different food items in the diet of *S. murinus* present in Pothwar, Pakistan.

Food items	Spring (n=15)		Summer (n=10)		Autumn (n=8)		Winter (n=15)		All seasons (n=48)	
	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)
Arthropods	73.3	54.7	90.0	73.3	75.0	54.2	93.3	75.1	83.3	64.9
Triticum aestivum (C)	46.7	32.0	60.0	20.0	50.0	35.0	53.3	20.4	52.1	26.4
Brassica campestris (O)	13.3	2.7	20.0	4.0	-	-	6.7	0.9	10.4	1.9
Sorghum bicolor (C)	-	-	10.0	1.3	-	-	6.7	0.9	4.2	0.6
Lens culinaris (L)	20.0	9.3	10.0	1.3	12.5	10.8	-	-	10.4	5.0
Arachis hypogaea (O)	6.7	1.3	-	-	-	-	-	-	2.1	0.4
Polypogon fugax (Misc.)	-	-	-	-	-	-	6.7	0.9	2.1	0.6
Cicer arietinum (L)	-	-	-	-	-	-	6.7	1.8	2.1	0.3

C- Cereal grains, O- Oilseeds, L-Legumes, Misc- Miscellaneous, n-number of stomach.

Table – 3: Frequency of occurrence (FO) and relative abundance (RA) of food items in the diet of two sexes of *S. murinus* present in Pothwar, Pakistan.

Food items	Males (n=20)		Females (n=28)	
	FO (%)	RA (%)	FO (%)	RA (%)
Arthropods	70.0	52.3	92.9	73.8
Triticum aestivum (C)	50.0	36.3	53.6	19.3
Brassica campestris (O)	10.0	2.3	10.7	1.7
Sorghum bicolor (C)	-	-	7.1	1.0
Lens culinaris (L)	20.0	9.0	3.6	2.1
Arachis hypogaea (O)	-	-	3.6	0.7
Polypogon fugax(Misc.)	-	-	3.6	1.0
Cicer arietinum (L)	-	-	3.6	0.5

C- Cereal grains, O- Oilseeds, L-Legumes, Misc- Miscellaneous, n-number of stomach.

Table – 4: Frequency of occurrence (FO) and relative abundance (RA) of food items in the diet of *S. murinus* across different types of village structures in Pothwar Pakistan.

Food items	Households (n=37)		Shops (n=10)		Farm houses (n=1)		All structures (n=48)	
	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)	FO (%)	RA (%)
Arthropods	81.1	61.6	90.0	73.3	100	100	83.3	64.9
Triticum aestivum (C)	56.8	29.2	30.0	18.0	-	-	52.1	26.4
Brassica campestris (O)	13.5	2.5	10.0	0.6	-	-	10.4	1.9
Sorghum bicolor (C)	5.4	0.7	-	-	-	-	4.2	0.6
Lens culinaris (L)	10.8	4.9	10.0	6.0	-	-	10.4	5.0
Polypogon fugax (Misc)	2.7	0.7	-	-	-	-	2.1	0.4
Cicer arietinum (L)	2.7	0.4	-	-	-	-	2.1	0.6
Arachis hypogaea (O)	-	-	10.0	2.0	-	-	2.1	0.3

C- Cereal grains, O- Oilseeds, L-Legumes, Misc- Miscellaneous, n-number of stomach.

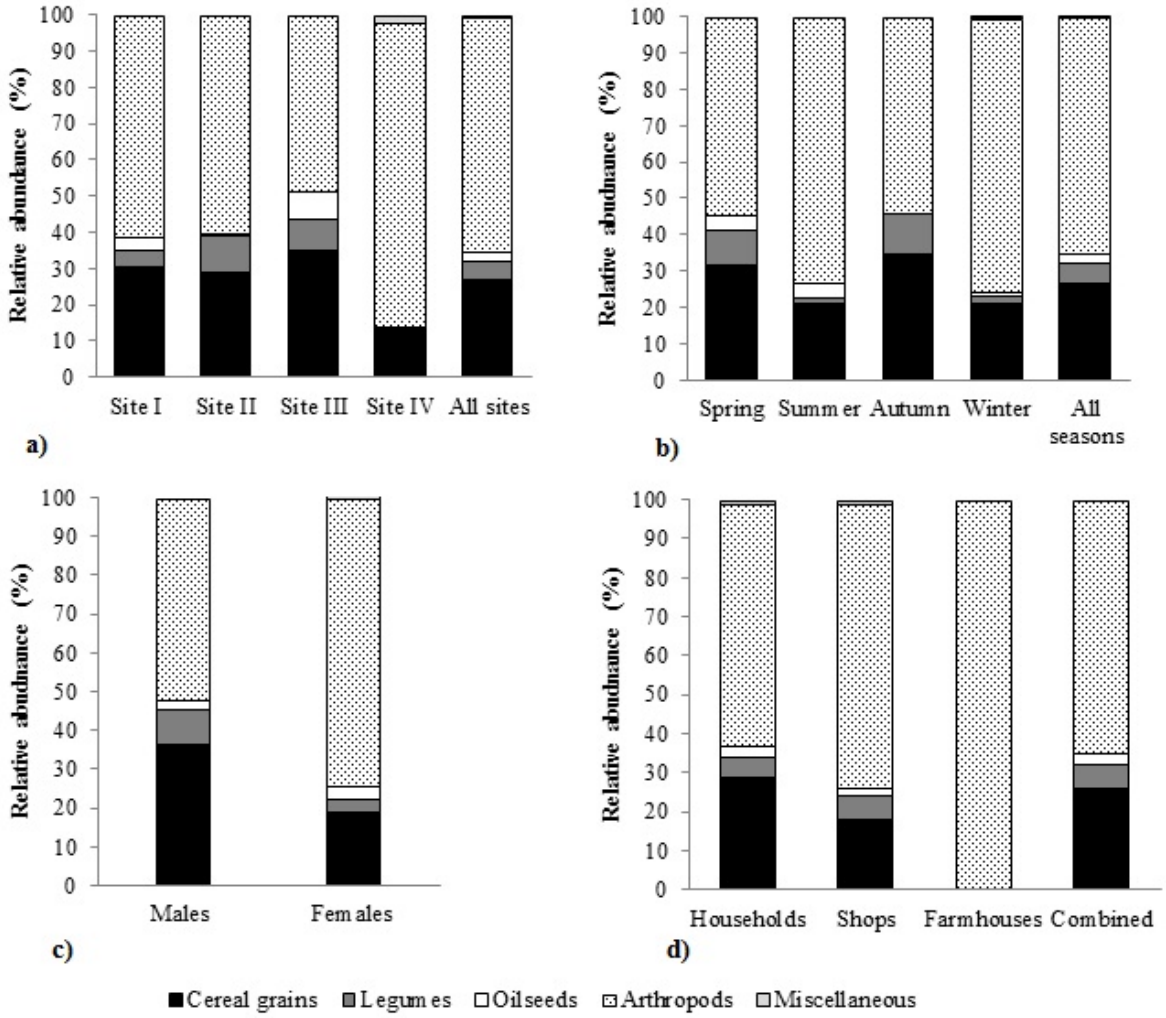

Fig. – 3 : Relative abundance of major food categories occurring in the diet of *S. murinus* a) at four sites b) in four seasons c) between sexes d) in different trapping structure.

Discussion

This study revealed that females out-numbered males, but this difference in the number was not statistically. The indoor *S. murinus* population living in the villages of Pothwar had an unbiased sex ratio and adult individuals were predominant. Previous studies reported female-biased (Mushtaq-ul-Hassan et al., 1998), male-biased (Varnham et al., 2002), or unbiased/equal (Louch et al., 1966, Khokhar, 1991) sex ratios in *S. murinus* populations. The sex ratio of 1:1 is favored in the polygamous species when there are abundant and available food resources (Wright et al., 1988). Perhaps, the indoor habitats provided mild climatic conditions along with the abundant food resources, and therefore, *S. murinus* populations in the area maintained the expected 1:1 sex ratio.

Age structure showed that *S. murinus* population in the area was mainly comprised of adult individuals, as very few juvenile individuals were trapped. Low capture of juvenile individuals could probably be due to heterogeneity in trap response. Previous studies on small mammals showed that trap response of an animal depends on its social status. And as the adults are more active, dominant, and aggressive than juveniles or subadults, therefore, they are more prone to be captured than juveniles or subadults individuals (Tanaka and Kanamari, 1969; Drickamer et al., 1999; Khairuddin et al., 2011).

There was not significant variation in the head body length (HBL) between male and female individuals in this study, indicating absences of sexual size dimorphism (SSD) in the *S. murinus* population present in the area. HBL in the present study is smaller

than reported elsewhere (Louch et al., 1966; Khokhar, 1991; Chang et al., 1999a, 1999b). Variations have been reported in the adult head body length in this species across different geographical regions, and HBL of males and females in the present study is closer to the one reported by Khokhar (1991). The pelage color of the shrews in the present study was in line with the previous studies where different pelage colors have been reported ranging from light grey to brown or black (Ishikawa et al., 1987; Smith and Xie, 2008).

The shrews mainly fed on invertebrates and predominantly on insects. In the present study, arthropods (mainly insects) were the major food item in the diet of *S. murinus*. Among the plant items, *T. aestivum* was the best consumed item of the shrew's diet. At all sites and in different seasons, insects and wheat were the main staples of the shrews. Overall, oilseed abundance was low (2.3%) in the shrews' diet, and oilseeds were totally absent from the diet in autumn season. Similarly, shrews captured from the rice godowns of Karachi (Pakistan) were eating mainly insects (Lathiya et al., 2008). In previous studies, insects comprised the main food item in the diet of shrews captured in outdoor habitats (Prakash and Singh, 1999), while, they accounted for only 8.64% of the shrew's diet in desert rangeland of India (Advani and Rana, 1981). In a laboratory study, the shrews consumed insects, beef, worms, rodents and small frogs provided in laboratory conditions (Balakrishnan, 1977). Thus, the house shrews appear to be an "opportunistic omnivore", to increase their chances of surviving in the environment (Prakash and Singh, 1999).

In relation to sex, the diet of female shrews comprised about 74% animal food and 26% plant food, while the diet of male shrews comprised about 52% animal food and 48% plant food. Such difference could probably be due to differences in energy requirements of both sexes. In mammals, breeding females require more protein-rich diet as compared to non-breeding females and males (Altman and Dittmer, 1974). Sex related difference in food consumption has been previously reported in other small mammals. For instance, there are reports of female rats consuming more arthropods than seeds and fruits, probably to meet high protein demand for the breeding activities (Gales, 1982). Also, sex related differences have been reported in the consumption of particular food items in a rat population on Galapagos Island, Ecuador, where male rats were consuming less protein-rich food probably to maximize its availability to the breeding females (Clark, 1980).

Shrew population bred throughout the year. Although, pregnancy rate was low (26%), the presence of females with placental scars or females entering their first breeding phase indicates a continuous breeding activity in the population. Lack of seasonality in the breeding activity could probably be due to a constant supply of food in the mild climatic conditions of the indoor habitat (Bronson and Heideman, 1994). *S. murinus* may either be a continuous breeder or non-continuous breeder depending on the climatic conditions and ecological factors of the locality (Chang et al., 1999a, 1999b). In previous studies, round the year breeding activity has been reported in the *S. murinus* populations present in wild, around residential areas, and crop fields (Louch et al., 1966, Ishikawa et al., 1987, Khokhar, 1991; Chang et al., 1999a, 1999b).

In this study, litter size recorded in *S. murinus* population was 4.0±1.8 (Mean± SD) embryos. Litter size in the present study is greater than reported elsewhere (Barbehenn, 1962; Louch et al., 1966; Brooks et al., 1980; Ishikawa and Namikawa, 1987; Chang et al., 1999a). A marked variation in the size of shrew litter has been reported across different geographical regions, and the litter size of shrew in the present study is closer to the one reported by Khokhar (1991) from the crop fields of Punjab, Pakistan. The variations in litter size could occur due to various factors such as environmental conditions, availability of food resources rate of mortality, and animal body conditions.

In conclusion, *S. murinus* population of the present study had an unbiased sex ratio. In the trapped samples, adults out-numbered the juveniles. Throughout the year, individuals were consuming almost similar type of food items at all the sites, arthropods (mainly insects) being the chief staple of their diet. Breeding activates lasted all the year round and reproductively active females were greater than that of reproductively inactive females. This indicates that commensal conditions were providing sufficient food resources and stable environment for shrews to breed throughout the year. This information generated on the biology of shrews will be helpful for its management in the commensal habitats. For instance, based on their food habits, we can develop targeted baits and lures for the species control.

Acknowledgments

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