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DIETRY HABITS OF SHORT TAILED MOLE RAT (*Nesokia indica*) IN AGRO-ECOSYSTEM OF POTHWAR PLATEAU, PAKISTAN

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ABSTRACT

Rodents are important component of biodiversity of the agricultural land being prey species to snakes, raptor birds, as well as mongooses. However, these have been identified as destructive pests of agricultural crops at the same time. In the current study, we investigated the dietary habits of short tailed mole rat (*Nesokia indica*) inhabiting croplands of Pothwar Plateau. The rodent specimens were trapped from four selected sampling sites (one each from district; Rawalpindi, Attock, Jhelum, and Chakwal), of the Plateau, from groundnut and wheat fields, from the fallow lands inside the crop fields and on the field boundaries, by using both kill and live baited traps. The stomach contents of the captured specimens were analyzed using micro histology technique. Results revealed higher trapping success during cropping season of wheat (n= 18), followed by peanut (n= 12) while during non-cropping season capturing success was low and specimens were mostly caught from field boundaries. The rodent species mostly consumed wheat and groundnut during their cropping seasons. Simultaneously, it also consumed fodder crops (millet, barley and sorghum), along with supplementation with varying proportions of wild vegetation. The proportion of wild vegetation in the total diet of the rodent species varied from approximately 20% to 43% (by volume) and a higher consumption of wild vegetation during spring and summer seasons was noticeable. The study concludes that although short tailed mole rat consumed cultivated crops mainly, yet wild vegetation of the study area in significant proportion served as its staple food sustaining it throughout the year, especially during the non-cropping seasons of wheat and groundnut crops.

Keywords: Short tailed mole rat; dietary habits; stomach contents; Pothwar; cropping and non-cropping seasons; wild vegetation.

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INTRODUCTION

The rodents, small mammals belonging to order "Rodentia", are consistently dispersed everywhere throughout the world, except in Antarctica (Nowak, 1999). They are considered generalists in their feeding habits and can survive in all terrestrial habits and even man-made environments. The short-tailed mole rat *(Nesokia indica*) is largely a Palearctic rodent, least concerned (LC), having a wide distribution, occurring in East Asia, north Africa, south and southeast Asia, west and central Asia, found in forest, shrubland, grassland and artificial terrestrial ecosystems, with unknown population trend (Boitani and Molur, 2016). In Asia, it is also widely distributed in India, Pakistan, Iran, Iraq, Afghanistan, Bangladesh, Syria, Northern Arabia, Chinese Turkistan, and Southern Russian Turkistan (Poche *et al.,* 1982; Roberts 2005). This rat species is economically an important pest species in Pakistan, causing comprehensive losses to wheat, rice and sugarcane crops (Greaves *et al.,* 1975; Beg *et al.,* 1981; Fulk *et al.,* 1981). However, at the same time this rodent species is ecologically important by being a prey species to snakes, raptor birds, mongooses etc. According to Fulk *et al*. (1981) in Pakistan, this rodent species is extremely widespread all over the cultivated fields where there is irrigation in Sindh and Punjab and in the greater part of the more extensive valleys of Baluchistan. Roberts (1997) also recorded its occurrence around Bannu, Kohat, Mardan, Peshawar and possibly in the valley of Swat.

The short tail mole rat lives mainly in moist areas and or along streams and canals. It also occurs in dry lands, grasslands, crops, and forests. The species select sections of the soil with great vegetation but if the soil gets dry, then it may move towards the softer soil (Prakash, 1992). The short-tailed mole rat is nocturnal and fossorial in habits and digs extensive burrows with averaged range of 3.5-11.5 cm in diameter and 17- 34 cm in length. When it is out of burrows for feeding or any other purpose, it covers holes of tunnels with approximately 16-59 cm soil (Prashad, 1999). A single rat species inhabits each burrow (Nowak, 1991).

A few earlier studies conducted on diet composition of short-tailed mole rat in different areas of the country have revealed this species is mainly herbivorous in feeding habits in Baluchistan's non-crop soil (Ahmad *et al.,* 2007). In Baluchistan's orchards, crops account for about 93 percent of this species diet and left-over insects account for over 7 percent of the diet (Mian *et al*., 1987). It feeds mainly on wheat, groundnut, along with consumption of sorghum, potato, brinjal and watermelon, and some natural vegetation (Prashad, 1999). It occasionally stocks grains (Nowak, 1991). According to Taber *et al.* (1967), because of the introduction of irrigational canal systems, the cultivated parts turned into a suitable habitat for short-tailed mole rat which is then the utmost plentiful rodent followed by *Bandicota bengalensis.*

Roberts (1997) reported that the Pothwar area is home to 7 different species of rodents; the lesser bandicoot rat, the short-tailed mole rat, the Indian gerbil, the soft-furred field rat, the desert jird, the bush rat and the *Mus* species. However, Brooks *et al.* (1988) observed mostly the occurrence of lesser bandicoot rat, short tailed mole rat and Indian gerbil in peanuts crops. Some other studies such as by Hussain *et al.* (2003) have shown the occurrence of 5 pests' species including the Indian gerbil, the lesser bandicoot rat, the short-tailed mole rat, the bush rat and the house mouse. Hussain *et al.* (2002) reported that short-tailed mole rat was one of the most widespread pests in the wheat and groundnut field but trapping information showed it is one of the fewest species with respect to its prevalence and wide spread species based on its burrow movement.

Munawar *et al.* (2020) reported that livestock grazing, cutting, harvesting (for fuel wood and animal feed) and burning of field boundary vegetation are common practices in the Pothwar plateau that affect rodents and their habitat. During crop season, local farmers in the Pothwar agro-ecosystem in Pakistan do not manage wild vegetation on the field edges, and that may impact rodent populations near their fields. Although the short-tailed mole rat is reported to occur widely in the Pothwar Plateau and is associated with the agricultural ecosystem, yet no comprehensive studies so far have focused on its dietary habits. Therefore, the current study aimed at investigating the dietary habits of short tailed mole rat in the agricultural lands and studying variation in its food consumption, especially how much proportion of its diet comprises of wild vegetation, during cropping and non-cropping seasons of the Pothwar Plateau.

MATERIALS AND METHODS

Study area: The current study was carried out in the Pothwar Plateau, located between the latitudes 32° 33 - 34° 3 N and longitudes 71° 89 - 73° 37 E. Its altitude ranges from 1,000 to 2,000 m (Fig. 1). The climate of the study area is semi-arid, warm to hot with monsoon and subtropical winter. Average annual rainfall is around 500-600 mm, most of which falls in the monsoon season (Punjab Barani Commission, 1976).

The study covered all four districts of the Plateau including Attock, Rawalpindi, Chakwal and Jhelum. Dry farming is the dominant land use while wheat is a major winter crop with inter-cropping of grams, lentils and mustards. Dominant summer crops include sorghum, millet and groundnut (Beg *et al.,* 1977; Ahmad, 1990). The Pothwar ecosystem includes both non-cultivated (scrub forest and range land) and cultivated croplands.

Study Design: Four sampling sites viz. Jatli (district Rawalpindi), Khairi Maurt (District Attock), Ahmed Abad (district Jhelum) and Chinji (District Chakwal) having populations of short tailed mole rat were selected through reconnaissance survey and visited on fortnightly basis from September 2018 to July 2019 for data collection (Table 1). Due consideration was given to; population of short tailed mole rat, level of infestation, cooperation of the farmers, and logistic (roads etc.) approach, while selecting the sampling sites. The research activities were conducted in two major field crops; wheat and groundnut, at various growth stages and in the fallow lands during non-crop seasons at the field boundaries.

Table 1. Details of the four selected sampling sites in the study area (Pothwar Plateau).

Site #	Site Name/District	Habitat Type	Sample's size (n=40)	Latitude	Longitude	Elevation (m)
1	Jatli (Rawalpindi)	Cropland & Non-cropland	5	N33°11.067',	E073°05.579'	542
2	Khairi Maurt (Attock)	Cropland & Non-cropland	8	N33°29.626',	E072°48.061'	564
3	Ahmed Abad (Jhelum)	Cropland & Non-cropland	7	N32°31.400',	E072°51.768'	193
4	Chinji (Chakwal)	Cropland & Non-cropland	20	N32°52.826',	E072°23.275'	498

Trapping methodology: The short-tailed mole rat specimens were trapped from the fields by using locally designed kill- as well as live traps, baited with the pieces of guava, peanut butter, bread, tomato, and chapatti with pickle. At each sampling site, the traps were set near the burrow system of the rat species for its capturing. The traps

were placed near the short-tailed mole rat burrows, inside as well as outside the croplands. To optimize trapping efforts, most successful food bait, that is, guava was used during the trapping session (Munawar, 2018). The traps were set in the field at evening time and checked next morning except live traps that were monitored after three hours.

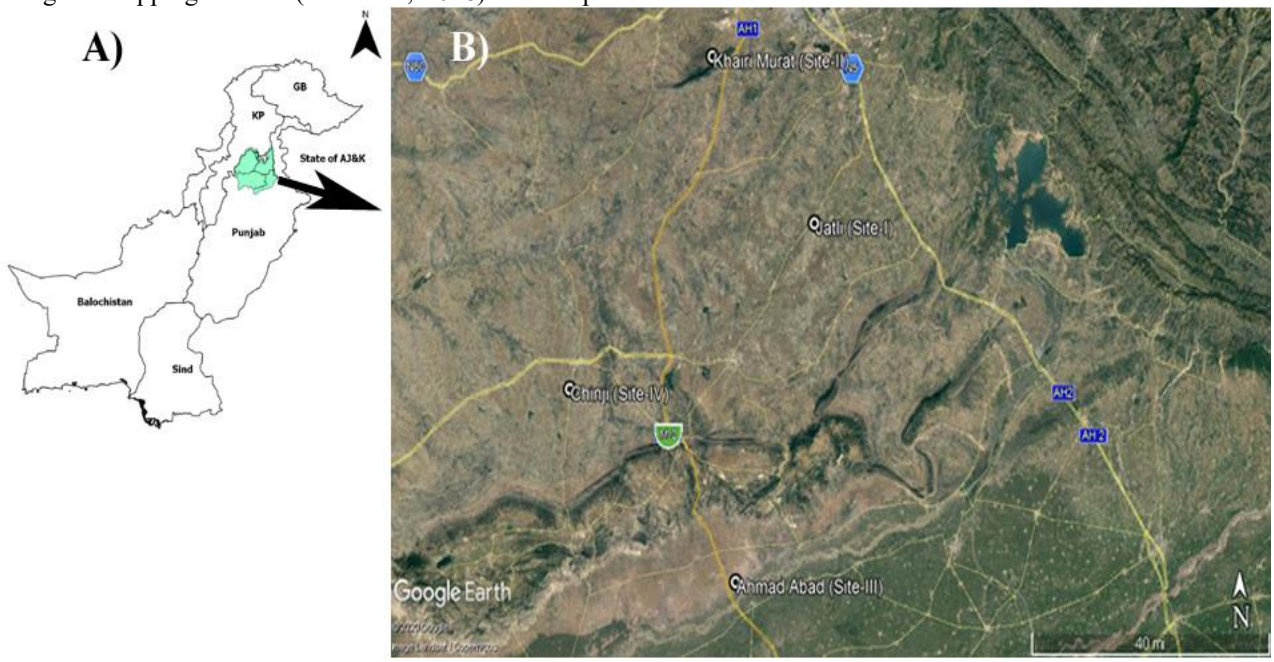

Fig. 1. A) Map of Pakistan showing location of the Pothwar Plateau, Pakistan, B) locations of four selected sampling sites in the study area.

Dissection and morphometry: The trapped rat specimens (N = 40) were tagged and carried to the laboratory for dissection. The tags carried the specimen number along with other data like the name of area, date of trapping and gender of the specimen. In the laboratory, body weights of captured specimens were measured using a digital weighing balance while other body measurements (including, head - body length, head to tail length, tail length, hind limb, fore limb and the length of ear) of all captured specimens were recorded using a Vernier caliper, following Aplin *et al.* (2003). Then the specimens were dissected to collect their stomach samples. For each specimen, the stomach was removed by cutting the esophagus approximately 1 cm above the stomach and 1 cm below the duodenum and was preserved in 70% alcohol. Wet and dry weights of each stomach sample were recorded before the contents were analyzed. Then the stomach samples were examined for recovering the undigested food components for analysis.

Food habitats Investigation: Dietary habits of the short-tailed mole rat were investigated following the method used by Sparks and Malechek (1978). For light microscopic analysis, the stomach contents were dried in oven and weighed, then segregated with the help of hand lens and sorted into animal-based (hairs, insects) and plant-based materials (seeds etc.). Then the contents were sieved (having a mesh size of 1mm), remaining residue were ground up with help of pestle and mortar. The ground material was moved to the test tubes and then washed by the help of soaking solutions (H_2O + ethyl alcohol + glycerin) with same quantity and left for overnight. Next morning, the mixture was homogenized by using vortex homogenizer (ESB-500 Lab homogenizer) for 10 minutes for each sample to further reduce its size and then 50% of the sample were transferred to the labelled test tube. Sodium hydroxide solution (NaOH; 5%) was added into test tubes containing the samples and heated for 5 to 6 minutes, before removing the supernatant dark fluid, the particles in a test tube were allowed to settle, then again washed with warm water to remove animal's materials from the test tubes. The samples were evaporated with help of alcohol gradients using (25 %, 50 %, 75%, and 100 %) for ten min at each concentration and distilled water mixture. By preparing alcohol and xylene mixture, alcohol was removed from sample in a test tube through this 25 %, 50 %, 75 %, (for each ten minutes) and 100 % left it for overnight. The sample material was then transferred to light microscopic glass slide and fixed using a drop of DPX (Distyrene Plasticizer and xylene) mountant, and then covered over by a cover slip. For each sample, five slides were prepared, which were examined under the light microscope (IM-900). The cells from prepared reference slides were used to match the cells in the sample slides and frequency of occurrence of plant species was calculated.

Occurrence of different food contents was calculated by the following formula;

$$\text{Occurrence of food content} = \frac{\text{No. samples with food content}}{\text{Total No. samples}} \times 100$$

Frequency determination: The data obtained from reading of micro-histology slides were expressed as percent of frequency of each plant species. It was calculated by the following formula;

$$\text{Frequency} = \frac{\text{No. of times a plant species is recorded}}{\text{Total No. of observations}} \times 100$$

Reference material collection: Plant species from the same sampling sites where the rat specimens were trapped from, were collected (as reference material) for preparing light microscopic reference slides, for identifying the stomach contents of the rat specimens. Keeping in view the early literature on the feeding preference of short tailed mole rat species (Tousif 2006: Harrison and Woodvillie, 2008), different parts of the plants (seed, stem, root, and leaf) were selected for the preparation of microscopic slides of the reference material. For each reference sample, 3-4 slides were prepared.

The light microscopic slides of stomach contents as well as reference materials were observed under light microscope (Olympus CH 20, 100 x). All the necessary details of different plant cells from the slides were noted, captured and identified by comparing with reference slides.

Statistical Analysis: The data were statistically analyzed by using Two-way Analysis of Variance (ANOVA) and least Significance Difference (LSD) test was applied for the comparison of the means. The 95% level of significance was used in all tests.

RESULTS

A total of 40 specimens of short tailed mole rat were captured from four selected sampling sites, trapping success was higher in cropping season of wheat (n= 18), followed by groundnut season (n= 12). However, some specimens were also captured from the field boundaries of wheat (n=6), and groundnut (n=4) crops. Trapping success during non-cropping season was low whereby the rodents specimens were trapped from the field boundaries only.

Average body measurements of the short- tailed mole rat specimens trapped are shown in Table 2. The specimens (N = 40) were measured, on average, to be 120.05 ± 1.62 g in body weight and 274.88± 2.48 mm in total body length. Average wet and dry weights of collected stomach samples were 4.58 ± 0.04 g, and 1.78 ±0.10 g, respectively (Table 2).

Diet composition: Analysis of 40 stomach samples of short tailed mole rat captured from the Pothwar Plateau revealed that it mainly consumed cultivated crops (wheat and groundnut) during cropping seasons and roots of wild vegetation (grasses weeds/shrubs) during the non-cropping season (Table 3).

Among crops consumed, were eight different species (Table 2), of which most frequently (%F) and most heavily (%V) consumed were wheat (*Triticum aestivum*; 11.91%F and 13.36%V) and groundnut (*Arachis hypogaea*; 11.23%F and 10.54%V). The short-tailed mole rat also consumed less frequently some other crops of the area including brassica, sorghum, millet, maize, barley and chick pea.

Table 2. Body measurements (mean ± S.E) of the Short-tailed mole rat specimens trapped from Pothwar region during 2018-19. N=40.

Body Parameters	Mean ±S.E
Total body length (mm)	274.88 ± 2.48
Head and body length (mm)	159.88 ± 1.69
Tail Length (mm)	115 ± 0.876
Ear Length (mm)	17.76 ± 0.26
Hind Foot Length (mm)	26.70 ± 1.08
Body Weight (g)	120.06 ± 1.63
Weight of Stomach (g)	6.46 ± 0.04
Total wet stomach content weight (g)	4.58 ± 0.25
Total dry stomach content weight (g)	1.78 ± 0.11

Among wild vegetation consumed by short tailed mole rat were five different plant species; the most frequently and heavily consumed included Baroon dhab (*Desmostachya bipinnata*; 9.61 %F and 9.19%V), followed by grass roots (7.31%F and 8.46%V) and Cane grass *(Eragrostis cynosuroides;* 7.44%F and 6.66%V), along with relatively less consumed Sea barley (*Hordeum marinum*), and Khbal gha (*Cynodon dactylon*) (Table 3).

Table 3. A list of dietary components (% F) and (% V) recovered from the stomach samples of the short-tailed mole rat trapped from the Pothwar Plateau during the study period (2018-19).

Food items	% F	% V
Crop food consumed		
Wheat *(Triticum aestivum)*	11.91	13.36
Groundnut *(Arachis hypogaea*)	11.23	10.54
Brassica *(Brassica campestris*)	6.63	7.35
Sorghum (*Sorghum bicolor*)	6.90	6.25
Millet (*Panicum miliaceum)*	7.31	6.74
Maize (*Zea mays*)	5.41	4.90
Barley (*Hordeum vulgare*)	6.50	6.86
Cheakpea (*cicer arietinum)*	2.30	2.45
Total		**58.45**
Wild vegetation		
Baroon dhab (*Desmostachya bipinnata*)	9.61	9.19
Sea barley (*Hordeum marinum*)	6.63	6.21
Grass roots	7.31	8.46
Khbal gha (*Cynodon dactylon*)	5.82	6.13

Cane grass *(Eragrostis cynosuroides)*	7.44	6.66
Total		**36.65**
Sand/Soil/Stone	2.44	2.21
Unidentified items	2.57	2.57

If we look at the contribution of crops sand wild vegetation in the diet of short-tailed mole rat, approximately 37% of its diet comprises of wild vegetation throughout the year, while the crop species contribute approximately 59% (Table 3). One wild vegetation species, Baroon dhab (*Desmostachya bipinnata*) was represented in the overall diet of short-tailed mole rat approximately in similar percentage to wheat and groundnut.

Seasonal Variation in diet consumption: For studying seasonal variation in diet composition, the stomach samples of the short-tailed mole rat were pooled in four different seasons including autumn, winter, spring and summer seasons.

During autumn season, the short-tailed mole rat consumed four crops and five wild vegetation species (Table 4; Fig. 2). Among crops, the groundnut was the most frequently consumed food item, along with moderate consumption of maize, sorghum, and millet (Fig. 2) whereas among wild vegetation, the most frequently consumed was baron dhab, along with moderate consumption of cane grass, khbal gha, grass root and least by sea barley (Table 4; Fig. 2). Statically, there was significant difference in food items consumed in autumn season ($P < 0.05$; $F = 12.36$; $df = 3$) with winter and spring, however, diet among autumn and summer did not differ significantly ($P > 0.05$).

During winter season, short tailed mole rat utilized seven crops and three wild vegetation species (Table 4; Fig. 2). Among crops most frequently utilized crop food was wheat, along with moderate consumption of other available crops including mustard, groundnut, sorghum, millet, maize and least consumption of chickpea. Among wild vegetation, the rodent species most frequently consumed baron dhab, with least contribution of grass root. There was a significant difference in winter food consumption ($P < 0.05$) with autumn, spring and summer food (Table 5). During spring season, this rodent species consumed four crops and five wild vegetation species (Table 4; Fig. 2). Among crops, wheat was most frequently consumed food item, followed by mustard, along with moderate consumption of barley, and chickpea (Fig. 2). Among five wild vegetation species baron dub was most frequently consumed while khbal gha contributed least (Table 4; Fig. 2 & 3). The spring diet consumption showed a significant difference ($P<0.05$) from autumn, winter and summer food (Table 5).

During summer season, short tailed mole rat in the Pothwar Plateau, consumed seven crop species and five wild vegetation species (Table 4; Fig. 2 & 3). The most frequency eaten crop food item was the groundnut, followed by millet, along with moderately consumed sorghum, maize, barley, chickpea and mustard. Among four wild vegetation species consumed, baron dub was most frequently consumed, followed by cane grass, with least frequently consumed khbal gha. The summer food consumption significantly differed from winter and spring but showed non-significant difference with autumn food.

Results of the current study have revealed 8 species of agricultural crops and 5 species of wild vegetation consumed by short tailed mole rat in the Pothwar Plateau. No doubt, the rodent species most frequently consumed wheat and groundnut during their respective cropping seasons. However, six other crops were also utilized by the rodent species. In addition, it also consumed five different species of wild vegetation during the year, simultaneously. The agricultural crops, overall, contributed approximately 58% of the total diet of the rodent species, with approximately 37% share from wild vegetation all the time. This fact indicates the importance of wild vegetation in the diet of short tailed mole rat, along with the crops of the area. In the cropping season, wheat was observed to be the most frequently and most heavily consumed food item by short tailed mole rat and in this context, it indicates that the rodent species causes extensive damage to the wheat crop.

Utilization of wild vegetation: Results have revealed, among wild vegetation, a higher consumption of baron dubh during spring, autumn and summer, with least utilization in winter season (Table 4; Fig. 2).

Sea barley was most frequently consumed by short tailed mole rat during spring, higher consumption of grass root during spring, Khbal gha was most frequently consumed during spring but less frequently in autumn, summer, and least in winter season (Table 4; Fig. 2). The Cane grass was also frequently consumed during spring but less frequently during other seasons (Fig. 2).

Statistical Analysis: During different seasons, consumption of wild vegetation was variable along with crops utilization (Fig. 3). The consumption of wild vegetation varied from 19.85 % (winter) to a maximum of 41.01% (summer), with maximum utilization in summer and spring (Fig. 3). Rather its summer diet comprises more of wild vegetation than that of crops. In general, it is evident that in the agricultural fields of Pothwar plateau, short tailed mole rat consumes wild vegetation throughout the year, during all seasons, however, utilization of some wild vegetation species is more frequent during non-cropping season of wheat or groundnut. Thus, wild vegetation of the agricultural field of the study area constitutes an important component of the diet of short tailed mole rat, which also serves as its staple food in the area, by being present throughout the year.

Multiple comparisons through Post Hoc test followed by LSD (Table 5), showed that seasonal food

consumption by short tailed mole rat differed significantly, as autumn food consumption showed

Table 4. Seasonal consumption of food items (% F and %V) by short tailed mole rat during different seasons of the year in the Pothwar Plateau.

Food items	Autumn		Winter		Spring		Summer	
	% F	%V	%F	%V	%F	%V	%F	%V
Crops consumed								
Wheat	-	-	4.50 ± 1.26	6.23 ± 1.26	12.0 ± 1.50	16.75 ± 1.11	-	-
Groundnut	6.75 ± 1.01	7.55 ± 0.11	2.25 ± 0.63	3.76 ± 0.75	-	-	9.50 ± 0.87	12.11± 0.11
Mustard	-	-	2.50 ± 1.19	5.23 ± 0.22	8.75 ± 1.50	10.55 ± 0.55	1.00 ± 0.41	1.00 ± 0.34
Sorghum	4.25 ± 1.02	5.22 ± 0.22	2.00 ± 0.68	4.66 ± 0.53	-	-	6.50 ± 0.90	7.40 ± 0.44
Millet	3.75 ± 1.00	5.23 ± 1.00	1.25 ± 0.25	3.62 ± 0.36	-	-	8.25 ± 1.38	10.11 ± 0.11
Maize	4.50 ± 1.00	6.331±1.00	1.25 ± 0.48	3.26 ± 051	-	-	4.75 ± 0.55	4.22 ± 0.22
Barley	-	-	-	-	7.25 ± 0.95	8.11 ± 0.11	2.25 ± 0.61	5.23 ± 0.56
Chickpea	-	-	0.75 ± 0.75	5.14 ± 0.23	2.25 ± 0.63	3.25 ± 0.22	1.00 ± 0.41	3.67 ± 0.89
Wild vegetation consumption								
Baron Dhab	4.75 ± 1.04	6.33 ± 1.04	2.00 ± 0.82	4.88 ± 0.38	7.50 ± 0.87	8.55 ± 0.87	3.75 ± 1.03	4.77 ± 1.03
Sea barley	2.00 ± 1.00	3.00 ± 0.1	-	-	5.50 ± 0.96	6.5 ± 0.96	3.00 ± 0.41	6.43 ± 0.51
Grass root	2.75 ±1.00	4.23 ± 0.22	1.50 ± 0.65	4.86 ± 0.66	6.00 ± 1.08	9.25 ± 1.22	3.25 ± 0.25	4.48 ± 0.25
Khabal gha	2.75 ± 0.79	4.66 ± 0.25	1.50 ± 0.29	4.97 ± 0.29	4.25 ± 0.48	5.21 ± 0.48	2.25 ± 0.75	6.66 ± 0.75
Cane grass	3.50 ± 0.65	5.22 ± 0.75	-	-	6.00 ± 1.47	8.25 ± 0.34	4.50 ± 1.55	6.77 ± 0 .77
Sand/Soil/Stone	2.50 ± 0.71	4.99 ± 0.66	-	-	1.25 ± 0.75	3.11 ± 0.75	-	-
Unidentified	2.25 ± 0.00	4.88 ± 0.11	0.5 ± 0.50	2.7 ± 0.5	-	-	-	-

Values are expressed as mean ± SE.

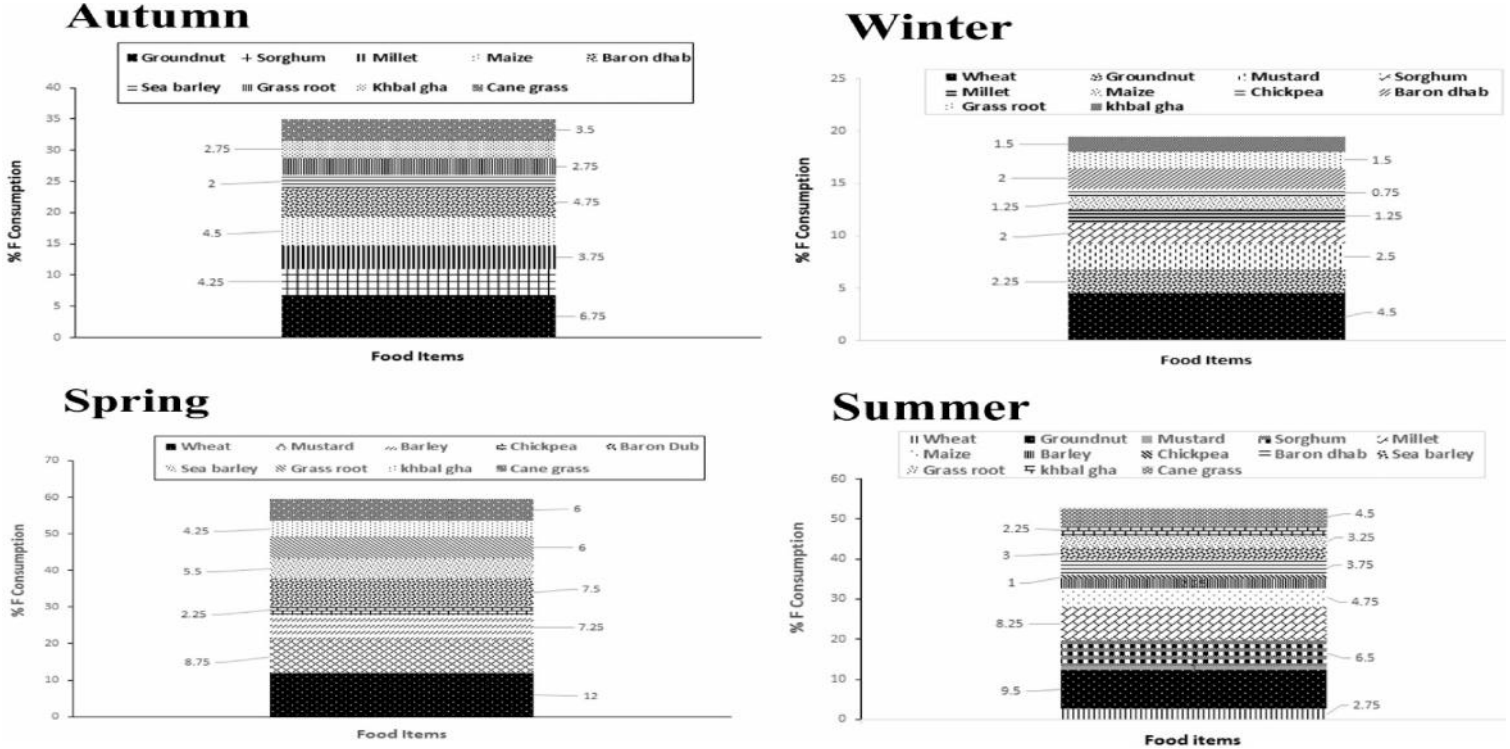

Fig. 2. Seasonal variation (% Frequency) in consumption of crops and wild vegetation by short tailed mole rat in the Pothwar Plateau.

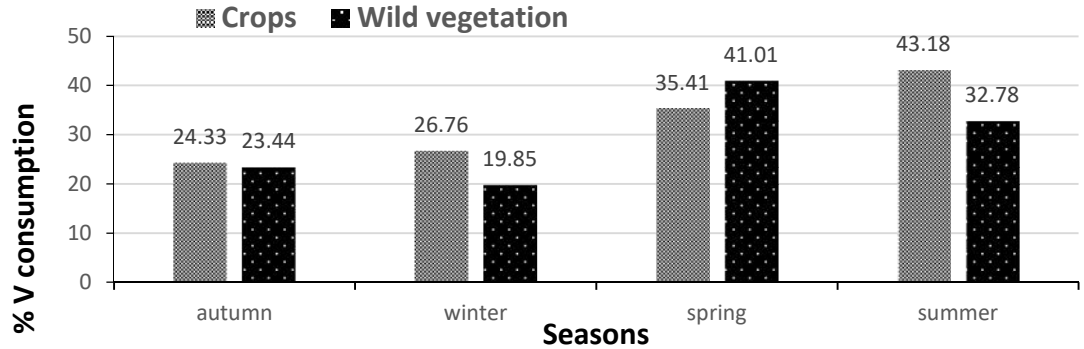

Fig. 3. Comparison between consumption (% Volume) of agricultural crops and wild vegetation by short-tailed mole rat during different seasons of the year in the Pothwar Plateau.

significant difference from winter food (p = 0.02), spring (p = 0.04). Similarly, winter food differed significantly from that of summer food (p = 0.005), autumn and (p = 0.02) and spring food (p = 0.00). Spring food consumption showed significant difference form autumn (p = 0.004), winter (p = 0.00) and summer food (p = 0.01) (Table 5).

Among crops, wheat consumption was significantly different from maize (p < 0.05), and chick pea (p = 0.002). Similarly, groundnut consumption was significantly different from chickpea (p = 0.003), sorghum, millet and barley were consumed significantly differently from that of chickpea (p < 0.05) (Table 5).

Table 5. Statistical analysis for multiple comparison among different seasons, and food items, using Post Hoc test and LSD.

Comparison among seasons				
I) Season	**(J) Season**	**Mean Difference (I-J)**	**Std. Error**	***P* value**
Autumn	winter	1.7955*	.76875	.027
	Spring	-2.4614*	.78774	.004
	summer	-.4441	.73860	.553
Winter	Autumn	-1.7955*	.76875	.027
	Spring	-4.2568*	.78774	.000
	Summer	-2.2395*	.73860	.005
Spring	Autumn	2.4614*	.78774	.004
	Winter	4.2568*	.78774	.000
	Summer	2.0173*	.75833	.013
Summer	Autumn	.4441	.73860	.553
	Winter	2.2395*	.73860	.005
	Spring	-2.0173*	.75833	.013
Comparison among food items				
(I) Food items	**(J) Food items**	**Mean Difference (I-J)**	**Std. Error**	***P*-value**
Wheat	Maize	2.9167	1.47205	.058
Chickpea		5.0833*	1.47205	.002
Groundnut	Maize	2.6667	1.47205	.081
Chickpea		4.8333*	1.47205	.003
Mustard	Chickpea	2.7500	1.47205	.073
Sorghum	Chickpea	2.9167	1.47205	.058
Millet	Chickpea	3.0833*	1.47205	.046
Maize	Wheat	-2.9167	1.47205	.058
Barley	Chickpea	3.4167*	1.64580	.048
Chickpea	Wheat	-5.0833*	1.47205	.002
Groundnut		-4.8333*	1.47205	.003
Sorghum		-2.9167	1.47205	.058
Millet		-3.0833*	1.47205	.046
Barley		-3.4167*	1.64580	.048
Baron dhab	Chickpea	3.1667*	1.37698	.029
Sea barley	Wheat	-2.9167	1.47205	.058
Groundnut		-2.6667	1.47205	.081
Grass roots	Wheat	-3.0417*	1.37698	.036
Groundnut		-2.7917	1.37698	.053
Khabal gha	Wheat	-3.7292*	1.37698	.012
Groundnut		-3.4792*	1.37698	.018
Cane grass	Chickpea	3.3333*	1.47205	.032

Among wild vegetation consumed, baron dhab showed significant difference with chickpea (p = 0.02), sea barley with wheat (p = 0.05), grass roots with wheat (p = 0.03) and groundnut (p = 0. 05), khabal gha with wheat (p = 0.01) and groundnut (p = 0.01) and cane grass with chickpea (p = 0.03) (Table 5).

Overall, Two-way Analysis of Variance was used to determine variation in the occurrence of major food items in the diet, across different seasons. Analysis of Variance (ANOVA), followed by Least Significance Difference (LSD) revealed that consumption of wheat by short-tailed mole rat differed significantly (p < 0.05) from chickpea, grass roots, and khabal gha, however, wheat

consumption showed non-significant difference ($p > 0.05$) with groundnut, mustard, sorghum, millet, maize, barley, and baron dhab. Similarly, consumption of groundnut showed significant difference ($p < 0.05$) with chickpea and khabal gha, but non-significant ($p > 0.05$) difference with wheat, mustard, sorghum, millet, maize, barley and baron dhab (Table 5).

DISCUSSION

Food plays important role in the maintenance of body functions and reproduction. Food availability impacts animal's growth rates, reproductive success, recruitment as well as the population density (Desy and Batzli, 1989). Diets are highly important for determining animal development, life-history patterns and environmental characters. For best significant measurements, habitat information on the diet is important and nearly a basic requirement for environmental studies (Kreb, 1989). Studying animal's feeding habits are vital for appreciative association among the animals (Zimmerman, 1965) and the association among the species and its environment. All such relations can describe the organization of the society, variety of species, the isotopic ratios and the division of resources between animals (Connell, 1975). Food habits research is essential for biodiversity protection, such as managing national parks, understanding the implications of game animal's translation (Cole *et. al.,* 1995).

The short-tailed mole rat is considered omnivorous in its feeding habits, but the main objective of our study was to investigate the total diet composition of this rodent species in agricultural ecosystem of the Pothwar Plateau, with a focus on how much in terms of percentage its diet comprises of agricultural crops and how much proportion of its diet is contributed by wild or natural vegetation. Moreover, how its diet composition varies seasonally?

The current study results showed that short-tailed mole rat in the Pothwar Plateau consumed eight different cultivated crops, but mainly fed on wheat and groundnut during cropping seasons. It also fed less frequently on some other crops of the area including brassica, sorghum, millet, maize, barley and chickpea. However, the rodent species consumed roots of wild vegetation (grasses weeds/shrubs) during the non-cropping season. Overall, 59% diet composition of the short-tailed mole rat comprised cultivated crops while 37 % share was by wild vegetation. If we compare these findings with previously published few studies available in the country, in Baluchistan province, crops account for about 93 percent of this species diet and left-over insects account for over 7 percent of its diet (Mian *et al.,* 1987). Similarly, Nowak (1991) and Prashad (1999) reported that short-tailed mole rat feeds mainly on wheat, groundnut, along with consumption of sorghum, potato, brinjal and watermelon, and some natural vegetation Its occasionally stocks grains. These studies justify findings of our current study. We did not find any evidence of consumption of insects in its diet. Earlier on, Greaves *et al.* (1975), Beg *et al.* (1981) and Fulk *et al*. (1981) had reported that in Pakistan, short-tailed mole rat seriously damages wheat, rice and sugarcane crops. Similarly, during the cropping season of groundnut, short mole rat consumed groundnut most frequently and most heavily. In the previous studies conducted by different researchers, it was reported that at the nut formation stage, short tailed mole rat moves inside the agricultural area, forms wide burrows system (Malhi and Sheikher 1986; Brooks *et al*. 1988).

The short-tailed mole rat consumed five different species of wild vegetation in the study area; among those, baron dhab (*Desmostachya bipinnata*), cane grass *(Eragrostis cynosuroides*), and khabal gha (*Cynodon dactylon*) were frequently consumed during all seasons of the year. This fact indicates that wild vegetation not only provides shelter but also important nutrients to the short-tailed mole rat in the agricultural landscapes. Roots of grasses/shrubs such as khbal gha, sorghum, baroon dubh play an important role in the diet of short tailed mole rat when crops fields are not present (Ahmed *et al.,* 2007). In addition, wild vegetation also provides shelter, nutrients, especially at the time when there are no standing crops in the fields. Some earlier studies conducted on diet composition of short tailed mole rat in other areas of the country have revealed this species is mainly herbivorous in feeding habits in Baluchistan's non-crop soil (Ahmad *et al.,* 2007).

The results of the current study also highlight that wild vegetation consumption is a consistent pattern of short tailed mole rat diet composition, varying from approximately 20 % (lowest) to approximately 43% (maximum). In general, the rodent species relied more on wild vegetation during spring and summer seasons. However, utilization of some wild vegetation is more frequent during non-cropping season of whet or groundnut (when wheat and groundnut are not available). Thus, wild vegetation of the agricultural fields of the study area constitutes an important component of the diet of short tailed mole rat, which also serves as its staple food in the area, by being present throughout the year.

It is also evident from the results of current study that in the autumn season baroon dhab (*Desmostachya bipinnata*) species of wild vegetation was second most frequently consumed food items in the diet of short tailed mole rat. This fact had also been previously reported by Hussain *et al.* (2003) that the short-tailed mole rat disperses all over the land and preferred to live in agricultural area mostly on the grass baroon dhab. Roots of grasses/shrubs such as khbal gha, sorghum, baroon dubh play an important role in the diet of short tailed mole rat when crops fields are not present (Ahmed *et al.,* 2007). In addition, wild vegetation also provides home, nutrients at

the time of crops development during no crops standing in the fields.

In spring season, one captured female specimen of *Nesokia indica* dissected in the laboratory was found pregnant having 5 young ones developing in the uterus showed that at that time presence of food quantity were high. Coincidently, it is also the maturing stage of the wheat crop in the study area, ensuring the food supply for the coming generation.

Conclusion: The study concludes that short tailed mole rat consumed both cultivated crops as well as the wild vegetation. The wheat and groundnut are the main crops consumed during cropping seasons. However, the short-tailed mole rat also consumed wild vegetation throughout the year, during all seasons, so the wild vegetation constitutes an important component of the diet of short tailed mole rat, and in this context, it serves as its staple food. Therefore, it is recommended that removing wild vegetation during the non-cropping season can be helpful in controlling population of short tailed mole rat in agricultural land.

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