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Short Communication

Impact of Soil Types on the Abundance of Murid Population in North Punjab, Pakistan

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ABSTRACT

The present study was conducted to study impact of soil types on rodent distribution and abundance in North Punjab. The survey was conducted from February to December, 2015 using snap traps by applying line transect technique in wild area by using over 3840 trap nights in eight type of soil (sand, loamy sand, sandy loam, sandy clay loam, loam, clay loam, silt loam, silty clay loam). A total of 1571 animals were captured belonging to species of *Nesokia indica, Mus musculus, Mus budooga, Millardia meltada, Tatera indica* and *Golunda elliotti*. The maximum number of rodents was captured in loamy soil type with population density (53.3±19.8) per hectare. The lowest rodent population density was captured in silty clay loam soil type with population density (22.5±5.7) per hectare. The population density in other soil types differ significantly (P≤ 0.05). The statistical results of this study found the following habitat preference of the species: clay loam for *N. indica*, sand for *Mus musculus* and *Mus booduga,* respectively, loam *for Tatera indica* and silty clay loam for *Golunda ellioti* and *Millarda meltada,* respectively. The PCA results indicate loam as a preferred soil type for *N indica* and *T. indica*). The species *G. elliotti* and *M. meltada* prefer soil containing silt and clay (silty clay loam). The species *M. musculus* and *M. booduga* prefer sand and positively correlated with two soil type (sandy loam and sandy clay loam). The present study provides baseline abiotic soil data for conservation needs and harboring of studied species.

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Authors' Contributions
FA presented the main idea of study and arranged funds for the research. AHF conducted field work. LZF compiled data and performed the lab work.

Key words
Trapping success, Soil types, Soil texture, Murids, Rodents.

The ecosystems are shaped by its key functional groups of social, fossorial, semi-fossorial, and herbivorous mammals which serve as ecosystem engineers (Zhang *et al*., 2003). The burrowing mammals play diverse roles, as prey for predator and predator of insects (Sieg, 1987). The large iconic species are considered important for conservation but burrowing mammals little studied (DiMinin *et al*., 2014). The burrowing mammal populations are declining due to human impacts in the form of extensive agricultural and livestock production, habitat fragmentation and use of rodenticide (Rodriguez, 2009). There are 49 species of rodents recorded from within the territorial limits of Pakistan, most being burrowing (Roberts, 1997). Studies are available on population dynamics (Beg *et al*., 2010) diversity and abundance (Faiz *et al*., 2015; Faiz and Abbas, 2016) of small mammals in Pakistan. The present study was designed to find abundance of rodents in different soil types and to study relationship of rodent populations with soil profile.

Materials and methods

North Punjab (Pakistan) includes hilly undulates of Pothwar Plateau and northern Parts of the Indus Plain is land of two major rivers Indus and river Jhelum, several seasonal streams, ravine belts and cultivated areas. The study area has various mountain ranges, such as, Kala Chitta Range, Margalla Hills Range, Salt Range and Khairi Murat (www.dawn.com/weekly/herald/herald33.htm). The climate is sub-humid to semi-arid, annual rainfall varies from 38 cm in southwest to 150 cm in the northeast (Anonymous, 1976).

The small mammals were trapped from 8 randomly selected localities from four districts, *viz.,* Attock (Chura Sharif, Makhad Sharif, Mankur), Chakwal (Bharpur, Noor pur Sethi, Khokherzer), Rawalpindi (Dullah), Jhelum (Sroba). In each location uncultivated wild land was selected, where four trap lines transect were set trapping rodents over some 100 hectare following (Cunningham and Moors, 1996). A trap-line transect consisting of 30 trap stations laid on a straight line at of distance of 17 m from each other. At each station three snap traps (2 Rat and one mouse) were set and trapping executed for three nights consecutively. Each trap was baited with bread with application of vegetable ghee (Cunningham and Moors, 1996). Trapping nights were calculated by multiplying number of traps with number of nights. The traps were set late in the evening and checked next morning, specimen removed and identified to species level using key (Robert, 1997) and recorded separately for sampling site and day.

Three soil samples (total 24 from eight villages) were

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taken from each locality from at a depth of 30 cm, which were packed in plastic bags for laboratory processing.

The texture class was determined as relative proportions of different soil fractions (dried and grinded sand, silt and clay) using the USDA textural triangle. The soil samples (10g) were taken in a 600 ml beaker to which 60 ml of dispersing solution (40 g of sodium hexametaphosphate, 10 g of sodium carbonate dissolved in distilled water and the volume made up one liter) was added and left for 24 h. The contents of beaker were transferred into soil-stirring cup, and the cup was filled with water to about three-quarters. The suspension was stirred at high speed for 3 min using the special stirrer, when stirring paddle was rinsed in the cup and was allowed to stand for 1 min. The suspension was transferred into a 1-L hydrometer jar and distilled water added to make a volume of 1 L (Bouyouces, 1962). The heights of clay, silt and sand layers was recorded and relative proportions calculated by dividing each height with total thickness of the solid layers and converted into percentiles for the proportional representation of each soil component.

The saturation paste prepared by dissolving soil sample in KCl solution (0.7456 g in 1 liter of distilled water). was passed through moist filter paper and extract obtained by applying pressure. The electrical conductivity determined by passing the extract through conductivity meter in mS cm^{-1} or dS m^{-1}. Saturated paste of soil (10 g) was prepared by adding deionized water and allowed to equilibrate for 18-24 h, pH was measured with pH meter (PHS-3D-02 pH Meter) (Schofield and Taylor, 1955).

Principal components analysis (PCA) was used to find association between rodent population abundance and soil content (sand, silt and clay).

Results and discussion

Table I shows a total of eight soil types recognized on the basis of relative proportions of three basic soil components, *i.e.,* clay, silt and sand The percentage of sand varies from 20% to 85%, silt from 7% to 55%, and clay from 8% to 25%. The soil samples were normal to alkaline with pH ranging from 6.9 to 8.0 and EC varied from 0.3 to 0.92 EcdS m^{-1}.

We captured 1571 samples which belonged to the following 6 species *Nesokia indica, Mus musculus, Mus budooga, Tatera indica, Millardia meltada* and *Golunda ellioti* trapped over 3840 trap nights (Table II). Trapping success was the highest in loam (66.6%), consecutively followed by clay loam (55.2%), sandy (42.7%), loamy sand (35.4%), clay loam (34.3%), sandy loam (33.3%), clay loam (34.3%), silt loam (31.4%) and the lowest trapping success in silt clay loam (28.1%) (Table II).

The house mouse (*Mus musculus*) prefers sand soil type (22%) followed by loamy sand (19%), sandy loam (17%) sandy clay loam 14%, loam 11%, clay loam 8%, silt loam 6% and least preferred soil was silty clay loam (3%) (Table III). This species shows negative relation with silt and clay and no relation with EC and pH, in correlation matrix of principal component analysis. The most preferable habitat

Table I.- Characteristics of the soil and coordinates of at different localities.

Locality	Soil type	Components (%)			EC (dS m^{-1})	pH
		Sand	Silt	Clay		
Chura Sharif	Sand	85	7	8	0.58	7.6
Bharpur	Loamy sand	75	10	15	0.35	7.4
Makhad Sharif	Sandy loam	70	20	10	0.87	7.52
Mankur	Sandy clay loam	50	30	20	0.83	7.12
Sroba	Loam	40	35	25	0.92	6.92
Noor Pur Sethi	Clay loam	30	30	40	0.80	7.8
Khokherzer	Silt loam	25	50	45	0.30	8.0
Dullah	Silty clay loam	20	55	25	0.61	7.0

Table II.- Trapping success of rodents in different soil types.

Locations	Coordinates	Soil Type	Total trap nights	Capturing night			Total capture	Capture per night
				1	2	3		
Sroba	32°34'17.53"N, 72°49'22.88"E	Loam	480	120	109	91	320	0.6
Noor Pur Sethi	32°40'8.07"N, 72°34'50.74"E	Clay loam	480	103	88	74	265	0.55
Chura Sharif	33°27'24.29"N, 72° 6'33.25"E	Sand	480	90	70	45	205	0.4
Bharpur	32°51'0.94"N, 72°33'58.10"E	Loamy Sand	480	65	55	50	170	0.4
Mankur	33°28'18.58"N, 71°54'47.14"E	Sandy clay loam	480	64	58	43	165	0.34
Makhad Sharif	33° 2'9.51"N, 71°47'13.40"E	Sandy loam	480	60	55	45	160	0.3
Khokherzer	32°48'59.24"N, 72°50'4.92"E	Silty clay loam	480	60	48	43	151	0.31
Dullah	33° 9'27.81"N, 72°41'4.17"E	Silt Loam	480	55	45	35	135	0.2
			3840					

Table III.- Relative abundance of different rodent species in different soil types.

Soil type	*M. musculus*	*M. booduga*	*T. indica*	*N. indica*	*G. ellioti*	*M. meltada*
Sand	80	60	55	10	0	0
Loamy Sand	70	50	0	50	0	0
Sandy loam	60	40	0	60	0	0
Sandy clay loam	50	30	0	70	5	10
Loam	40	25	140	80	20	15
Clay Loam	30	20	80	90	25	20
Silt Loam	20	10	20	46	30	25
Silty clay loam	10	10	10	40	35	30

of Indian field mouse (*Mus booduga*) was sand (24%), followed by loamy sand (20%), sandy loam (16%), sandy clay loam (12%), loam (10%), clay loam (8%) and lowest preferred soil type was silt loam (4%) and silty clay loam (4%). This species also show similar behavior like *Mus musculus* and show negative relation with silt and clay and no relation with EC and pH, in correlation matrix of principal component analysis.

The Indian gerbil (*Tatera indica)* prefers loam soil (46%), followed by clay loam (26%), sand (18%), silt loam (7%) and least preferred soil was silty clay loam (3%). There was no capturing of *T. indica* in soil type, loamy sand, sandy loam and sandy clay loam (Table III).

The order of preferred soil by fossorial rodent species the short-tailed rat (*Nesokia indica*) was clay loam (20%), (Loam (18%), sandy clay loam (16%), sandy loam (14%), loamy sand (11%), silt loam (10%), silt clay loam (9%) and sand (2%) (Table III).

The complete absence of Indian Bush Rat or coffee rat (*Golunda ellioti*) in soil type sand, loamy sand and sandy loam was registered. The most preferred soil for this rat species was silty clay loam (30%) followed by silt loam (26%), clay loam (22%), loam (17%) and least preferred soil was sandy clay loam (4%) (Table III). The species show negative relation with sand, silt and clay in correlation matrix of principle component analysis (Supplementary Table I).

The eigenvalues was the highest in F_1 (6.663), consecutively followed by F_2 (2.094), F_3 (1.144), F_4 (0.729), F_5 (0.285), F_6 (0.055), and F_7 (0.030) (Supplementary Table I). The eigenvalue corresponds to a factor in one dimension. The eigenvalues correspond to a high % of the variance; ensure that the factors are a good quality projection (Fig. 1).

The correlation circle on axes (F_1 and F_2) shows a projection of variables in the factors space. The variables *Nesokia indica, Tatera indica* density (loam are far from the center, and are significantly positively correlated (r close to 1). The variables (*G. elliotti, M. meltada*) density (silty clay loam) are also far from the center and are significantly positively correlated (r close to 1). The distribution of *Mus musculus* and *Mus booduga* and sand concentration are also far from the center, and are significantly positively correlated (r close to 1) (Fig. 2).

The study revealed six species of rodents (Table III) in six type of soil (sand, loamy sand, sandy loam, sandy clay loam, loam, clay loam, silt loam, silty clay loam). We identified three type of rodent communities: *Mus musculus* and *Mus booduga* (Community 1), *Nesokia indica* and *Tatera indica* (Community 2), *Glounda elliotti* and *Millardia meltada* (Community 3). The composition of rodent community varies in different soil types. The Community one is widely distributed and abundant in sand soil type, while the community two is widely distributed and abundant in loamy soil type. The distribution and

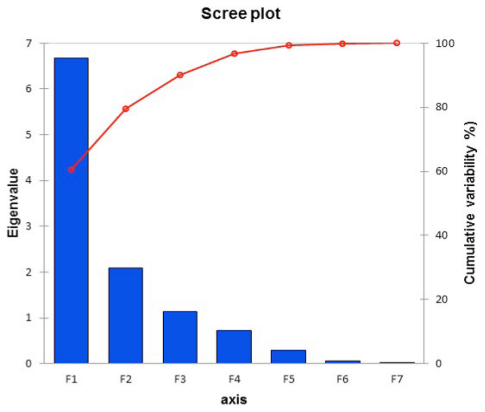

Fig. 1. PCA plot showing eigenvalues.

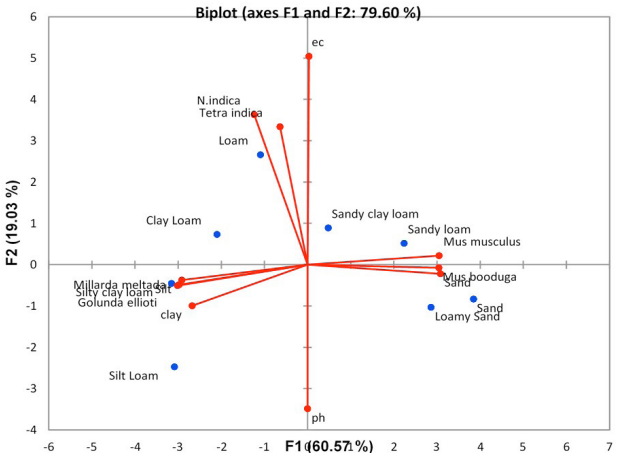

Fig. 2. PCA plot showing the distribution of different species in different soil types.

abundance of third rodent community is limited to silty clay loam soil type. The results support the conclusion that soil type is limiting factor in distribution and abundance rodents according to the findings of Massawe *et al*. (2008).

The Indian bush rat (*Glounda elliotti*) is widely distributed and abundant in silt clay loam soil type and the complete absence in soil types such as sand, loamy sand and sandy loam, indicates that soil texture (sand, silt, clay) directly affect the distribution and abundance of these rodent species and is support the results according to finding of (Reichman and Smith, 1990). The distribution of (*G. elliotti* is already reported in silty soil (http://www.iucnredlist.org2017). The samples of the species was captured from vicinity of rocky and hilly tracts and analysis of soil result (silty clay loam) is also confirmed by previous findings (Molur *et al*., 2005)

The species *Millardia meltada* is widely distributed in south Asia (Sri Lanka, India and Nepal) and is Least Concern (http://www.iucnredlist.org2017), with no major threats known affecting its population (Molur and Nameer, 2008). The results of our study indicate that the species shows similar habitat association like *Glounda elliotti* and is distributed in silty clay loam soil types at cultivated crop arid lands and our results are also conform the findings of Molur *et al*. (2005).

The species *Tatera indica* is widely distributed in south Asian countries (Molur and Nameer, 2008) and is reported in abundance at Pothwar (Punjab) (Faiz *et al*., 2015). The results of our study also indicate burrowing rodent *Tatera indica* prefers loamy soil (Fig. 2) of dry river slopes which is mostly loamy and confirm our findings.

The species *Nesokia indica* is also widely distributed in south Asian countries but there are no study on its population abundance known to date (Molur *et al*., 2005). The results of our study also indicate that it is an example of another one species which prefers loamy soil (Fig. 2).

The house mouse (*Mus musculus*) is widespread, abundant and commonly regarded as a pest species (Giovanni Amori, 2007). The results of present study indicate that the species show direct relation with soil type (sandy loam) and an inverse relationship with the percentage of silt and clay (Feldhamer, 1979). It was captured from all soil types.

The mouse *Mus booduga* is another widespread, abundant rodent native to South Asian countries (India, Sri Lanka, Pakistan, southern Nepal, Bangladesh) (Molur *et al*., 2005). The results of present study indicate that it is also shows direct relation with soil type (sandy) and an inverse relationship with the percentage of silt and clay (Feldhamer, 1979). It was as well captured from all soil types.

Supplementary material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.pjz/2018.50.1.sc8.

Statement of conflict of interest

Authors have declared no conflict of interest.

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