INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
**Volume-7, Issue-3 July-Sept-2017 Coden:IJPAJX-CAS-USA, Copyrights@2015ISSN-2231-4490**
***Received: 5th June-2017 Revised: 18th July-2017 Accepted: 19th July-2017***
***DOI: 10.21276/Ijpaes http://dx.doi.org/10.21276/ijpaes Research Article***

# SOIL CHARACTERISTICS AND BURROW STRUCTURES OF ONE IMPORTANT RODENT PEST, THE WILD RAT (*Rattus sikkimensis*) IN SOME DISTRICTS OF WEST BENGAL, INDIA

Debiprasad Chattopadhyay and Chanchal Kumar Manna*

Endocrinology Laboratory, Department of Zoology, University of Kalyani, Kalyani- 741235, Nadia, West Bengal, INDIA

**ABSTRACT:** One of the characteristic features of the rodents, the preparation of burrows within the soil for the purpose of living, hoarding of procured food and protection from the predators. They prepare the burrow in such a way that they can come out of the burrows at any time they require. For the study of burrow structures detailed studies of soil are required. In this investigation soil samples of four districts surrounding the burrow areas of the wild rats were collected, taken to the laboratory and analyzed properly. Amongst the four districts, two districts i.e., districts Nadia and North 24-Parganas are situated in the Gangetic plane and the other two districts, i.e., the districts Bankura and Purulia in the non- Gangetic plane of West Bengal, India. Analysis of the soil clearly indicates some characteristic features (i.e., Alluvial and Laterite) of these four districts. The detailed studies of the soil structures and burrow pattern of these four districts will help to understand the nature of damages of the crops and the presence of specific rodents in these areas.

**Key words:** Burrow pattern, soil analysis, alluvial, laterite, predators, crop pattern

*Corresponding author: Chanchal Kumar Manna, Endocrinology Laboratory, Department of Zoology, University of Kalyani, Kalyani- 741235, Nadia, West Bengal, INDIA, E-Mail: chanchal.manna49@gmail.com



## INTRODUCTION

Rodents are among the most important pests not only in India, but in other parts of the globe [1]. There are numerous species of rats in various parts of West Bengal, INDIA. Amongst them two species of rats e.g., *Rattus rattus* and *Rattus norvegicus* usually live in close association with man's activities. Extensive damages have been noted for various corners. However, the pattern of rodent infestation and the extent of damages vary in different crops and geographical regions [2]. A wide variety of crops are being damaged by Rattus sp. The rodent causes damage to the standing crops due to burrowing, cutting and hoarding activities [3]. There is a rich literature in the survey of rodent burrows and the way they relate to land forms and surface attributes [4-10]. Most of these works have focused on rodents survival and soil suitability for burrowing.

Burrow system can range from temporary to semi-permanent and the length of usage by the animal is often depicted by the burrows complexity. Simple burrows often consists of little more than a single tunnel with a blind ended chamber often used for nesting purposes [11]. Complex burrow systems comprise of numerous temporary foraging tunnels that are used to locate food resources and are generally multilayered and shallow with several more permanent deeper tunnels that are used for nesting. There are often numerous chambers within a burrow system used for different purposes such as lattrices, food storage areas and nesting areas. Burrows provide effective protection against many predators [11].

Soil texture, topography, and other edaphic and microclimatic factors are important in producing patches of variable size and species composition at ecotones [12-16]. Banner-tail kangaroo rats (*Dipodornys spectabilis* Merriam) are heteromyid New World rodents, occurring primarily in arid shrub lands and grasslands, that construct complicated subterranean chambers and tunnels [17]. Each burrow is capped by a large mound, sometimes over 1 m high and 1.5 - 4.5 m in diameter [17].
It has been reported that in solitary subterranean rodents, a high burrow system dynamics were documented [18,19]. Burrow systems of social species are expected to be more stable than those of solitary species, and families are supposed to be residents in the same area for many years [20]. For example, colonies of *H. glaber* and *F. damarensis* were reported to be residents in one area for more than 7 years [21, 22].

In the eastern region of India the river Ganga flows from the northern to the southern portion of West Bengal, India. Soil structures of the plane nearer to the river are known as alluvial soil whereas the distant part, known as the Rarh region which is intervened with laterite soil. Both these regions are affected by one serious rodent pest, the wild rat, *Rattus sikkimensis*. Throughout the year various types of crops are cultivated in the field. Naturally, the damages made by variousRattus sp. are quite remarkable. Their presence in the field are noted with the presence of soil particles surrounding the burrow opening. Naturally, study of soil pattern and burrow structures in these two regions i.e., Gangetic and non-Gangetic planes will be the outmost importance of the present topic.

## MATERIALS AND METHODS

## STUDY AREA

In West Bengal, four districts have been selected for the soil structures and burrow pattern of one important rodent pest , i.e., the wild rat, *Rattus sikkimensis.* Amongst these four districts two districts i.e., district Nadia and North 24-Parganas are situated in the Gangetic plane and the other two districts i.e., district Bankura and Purulia are situated in the Non-Gangetic plane ( marked in the figure ) of West Bengal .

District Nadia is situated between 22°53´ and 24°11´ North latitude and 88°09" and 88°48"East longitude and about 3927 square Kms. in area.

North 24-Parganas district is situated in southern West Bengal. North 24-Parganas extends in the tropical zone from latitude 22°11´ to 23°15´ North and from longitude 88°20´ to 89°5´ East and covers about 4094 square Kms in area.

The district Bankura is located in the western part of the State of West Bengal and is bounded by latitude 22° 38' N and longitude 86 °36' E to 87 ° 47' E and covers about 6882 square Kms.

Purulia lies between 22 °60 ´and 23 °50 ´ degrees N latitudes and 85.75 degrees and 86.65 degrees E longitudes and the district is 6259 square Kms in area.

### Excavation of the burrow

During the time of field survey live burrows were detected and then excavated by standard excavating procedures and using some important instruments. Then we measured different parameters like number of opening, total length of the burrow, length of the burrow by its long axis, depth of the burrow, types of hoarded materials within the burrow, different chambers within the burrow, branch angle, turn angle of the burrow, temperature within and outside the burrow, diameter of the burrow opening. Soil and hoarded materials were collected and were presented for further study. Photographs were taken and outline sketches of the burrow pattern were done finally. During dugout of burrows from different districts, soil samples were collected. Collected samples were air dried and kept at 4°C temperature. Soil pH, organic carbon, available nitrogen and phosphorus were measured [23,24] alkaline permanganate and Bray method respectively).

Meteorological data (temperature, humidity and rainfall) of 2008 and 2009 were recorded and were presented graphically.

### Key to statistical analysis

All the data were presented properly. Six sample areas were selected from each zone (Gangetic and non-Gangetic).T-test and one way ANOVA were performed at 5% and 1% level of significance.

A Post Hoc test for multiple comparison of mean was performed.

Mean differences were calculated, Correlation matrix were studied among different parameters and were presented graphically.

In the table, data were presented with mean ± standard deviations. For the statistical analysis we used SPSS-17, Statistica-7 and QI macro 2010 for MS Excel software package.

## OBSERVATIONS

### Climatic conditions

Temperature, rainfall and relative humidity of these regions (Gangetic and non-Gangetic plain) were observed. The average maximum temperature of the Gangetic plain was 39 ± 2.74°C and in the non-Gangetic plain was 44.5 ± 0.84°C. The minimum average temperature was 10.7 ± 2.62°C in the Gangetic plain while 7.8 ± 0.91°C in the non-Gangetic plain (Table 1).

The relative humidity of the Gangetic plain was maximal in the months of July, August, September, and October and was minimal in the months of February, March, April and May in both the Gangetic and the non-Gangetic plain of West Bengal.

The average rainfall was 1339.07 ± 135.92mm and 1266.71 ± 116.85mm in the Gangetic and non-Gangetic plain respectively.

### Soil structures

The Gangetic plane was mainly constituted of the alluvial soil but the non-Gangetic plane was dominated with lateritic soil. We observed that the average pH of the soil of the Gangetic plane which ranged from 6.52 ± 0.06 to6.99 ± 0.46 while in the non-Gangetic plane it was 5.68 ± 0.23 to6.19 ± 0.12 (Table 3).

Clay and the sand percentage in the soil was 24.2 and 33.2 in the Gangetic plane and in the non-Gangetic plane was 15.3 and 78 respectively (Table 2).

Available nitrogen percentage was 0.03 in the Gangetic and 0.01 in the non-Gangetic planes respectively.

Organic carbon content in the soil of the Gangetic plane was 0.50 ± 0.02 and 0.6 ± 0.03. In the non-Gangetic plane was 1.08 ± 0.02 and0.19 ± 0.01.

$K_2O$ percentage in the soil of the Gangetic plane ranged from 3.11 ± 0.10 to3.63 ± 0.38 while it was 2.02 ± 0.16 to2.18 ± 0.13 in the non-Gangetic plane.

Different parameters of the soil composition did not differ significantly in the districts of Bankura and Purulia (Table 4). Differences of soil composition of the district 24- Paraganas (N) and Nadia were not significant (Table 5).

In between Gangetic and the non-Gangetic plane of West Bengal different studied parameters were significantly different.

**Table-1. Various environmental features in the Gangetic and non-Gangetic plain of West Bengal.**

| | | Gangetic plain | | | Non-Gangetic plain | | |
|---|---|---|---|---|---|---|---|
| | | Nadia | N - 24PGS | Average | Bankura | Purulia | Average |
| Rainfall (Millimeter) | | 1309.71 ±178.13* | 1368.42 ±79.26 | 1339.07± 135.92 | 1292.71± 80.72 | 1240.71± 146.59 | 1266.71± 116.85 |
| Temperature (°C) | Max | 41.4 ±1.51 | 36.6±0.54 | 39±2.74** | 44.2 ±0.83 | 44.8 ±0.83 | 44.5±0.84** |
| | Min | 8.6 ±1.67 | 12.8±1.30 | 10.7±2.62** | 7.8 ±1.09 | 7.8 ±0.83 | 7.8 ±0.91** |

*Mean± SD, ** Significant at 5% level.

**Table 2. Basic soil composition of the Gangetic (Alluvial) and non- Gangetic (Laterite) plane of West Bengal**

| | **Alluvial Soil (%)** | **Laterite Soil (%)** |
|---|---|---|
| Sand | 33.2 | 78 |
| Silt | 38 | 15.5 |
| Clay | 24.2 | 15.3 |
| Loss on solution | 2 | 0.003 |
| Organic matter | 0.54 | 0.18 |

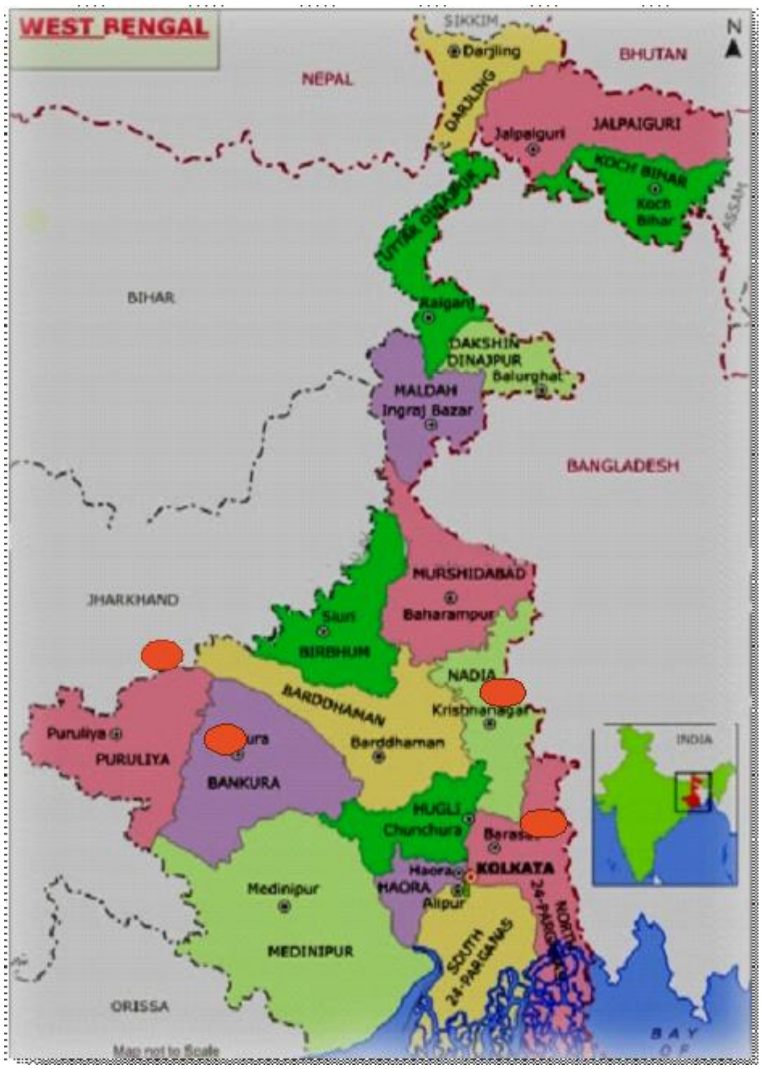


**Fig-1. Pointed studied area**

**Table 3. Soil characteristics of different districts of the Gangetic and non-Gangetic plane of West Bengal.**

| | Districts | pH | Organic Carbon% | Available Nitrogen% | $K_2O$% |
|---|---|---|---|---|---|
| Gangetic plane | Nadia(6) | 6.99 ± 0.46 | 0.50± 0.02 | 0.02 ± 0.00 | 3.63 ± 0.38*** |
| | 24- Paragans (N)(6) | 6.52 ± 0.06 | 0.6± 0.03 | 0.04 ± 0.00 | 3.11 ± 0.10 |
| non-Gangetic plane | Bankura (6) * | 5.68 ± 0.23*** | 1.08 ± 0.02*** | 0.01 ± 0.00 | 2.02 ± 0.16 |
| | Purulia(6) | 6.19 ± 0.12** | 0.19± 0.01 | 0.01 ± 0.00 | 2.18 ± 0.13 |

* Number of samples, ** Mean ± SD, *** significant at 1% level.

**Table 4. Multiple Comparisons of different studied soil parameters of the districts Nadia and 24- Parganas (N) of the Gangetic plane of West Bengal.**

| Nadia**(6) | 24-Paraganas (N)**(6) | Mean Difference | Std. Error | Sig | 99% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| pH | pH | 0.46833 | 0.12605 | .013 | -0.0123 | 0.9489 |
| Organic C% | Organic C% | -0.09667 | 0.12605 | .994 | -0.5773 | 0.3839 |
| Available Nitrogen % | Available Nitrogen % | -0.02233 | 0.12605 | 1.000 | -0.5029 | 0.4583 |
| $K_2O$ % | $K_2O$ % | 0.52167(*) | 0.12605 | .004 | 0.0411 | 1.0023 |

* The mean difference is significant at the .01 level, ** 6 samples were taken from each district.

**Table 5. Multiple Comparisons of different studied soil parameters of the districts Bankura and Purulia of the non-Gangetic plane of West Bengal.**

| Bankura**(6) | Purulia**(6) | Mean Difference | Std. Error | Sig | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| pH | pH | -.51833(*) | 0.0689 | 0 | -0.7389 | -0.2978 |
| Organic C% | Organic C% | 0.89667(*) | 0.0689 | 0 | 0.6761 | 1.1172 |
| Available Nitrogen % | Available Nitrogen % | -0.00267 | 0.0689 | 1 | -0.2232 | 0.2179 |
| $K_2O$ % | $K_2O$ % | -0.16333 | 0.0689 | 0.285 | -0.3839 | 0.0572 |

* The mean difference is significant at the .01 level, ** 6 samples were taken from each district.

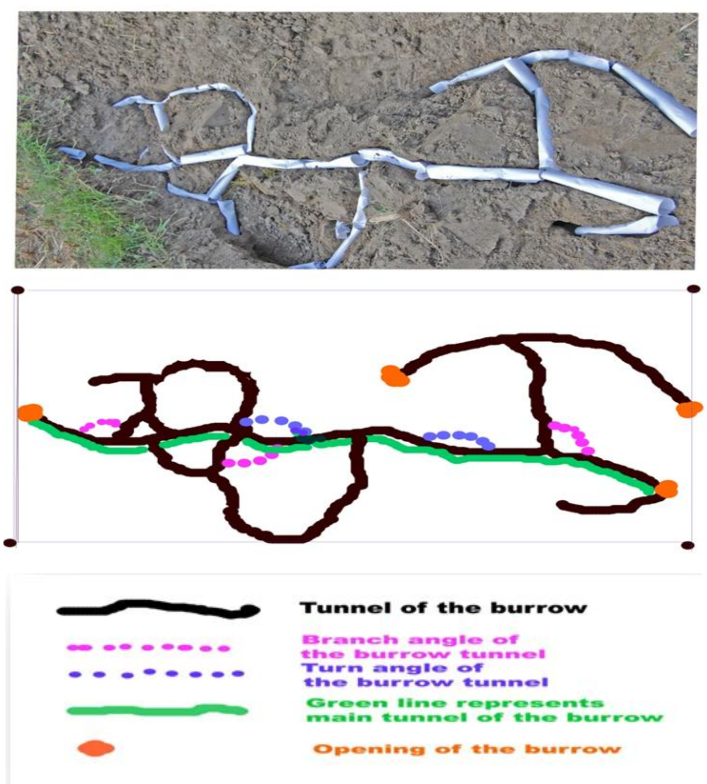


**Fig.2 A complex burrow structure from the district Nadia (Gangetic plane) West Bengal.**

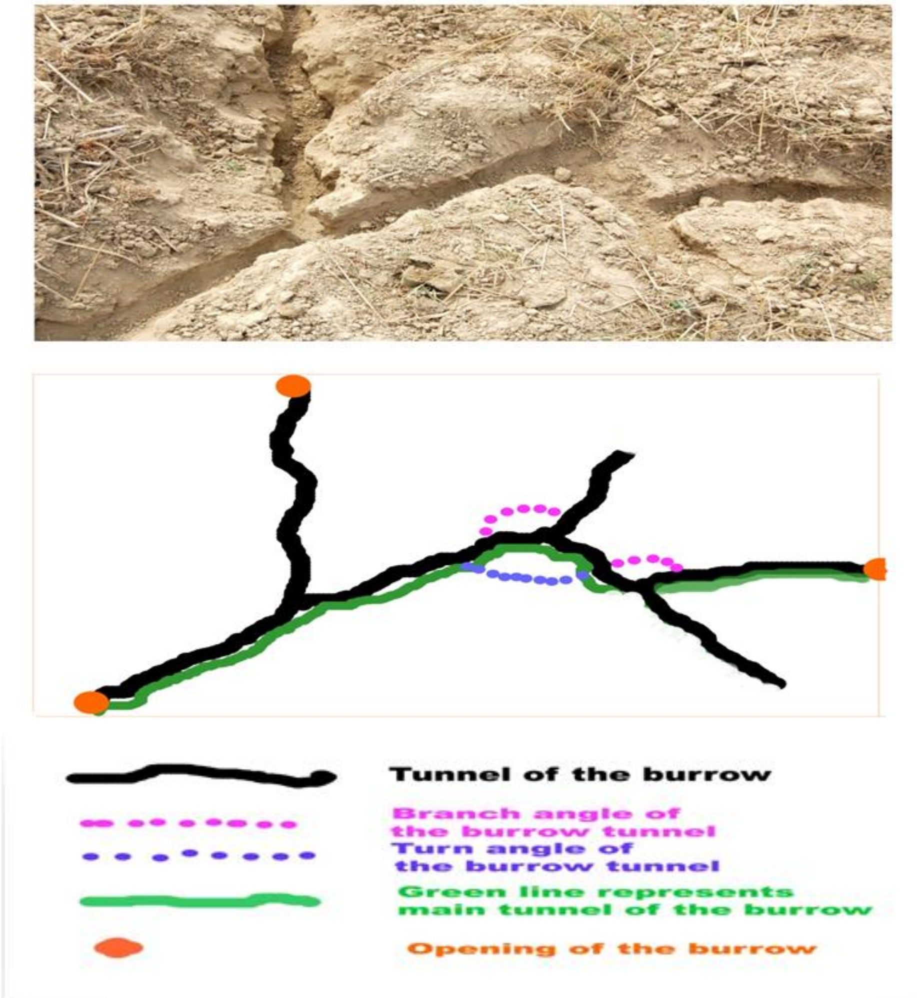


**Fig. 3 A simple type of burrow structure from the district Bankura (non-Gangetic plane), West Bengal.**

## DISCUSSION

A huge amount of crops are being damaged by the *Rattus sp.* every year in the Gangetic and the non-Gangetic plains of West Bengal, India. But no effective control measures were available which could lead the farmers to rescue themselves from this huge economic loss.

The study of the burrow structure of the *Rattus sikkimensis* would reveal the underground behavior of this species as well as their instinct behavior which could help to find out suitable control measures. The present experimental data could also add some new avenues to the future study.

In both the regions (i.e., Gangetic and non-Gangetic plains) the number of opening of the burrow was positively correlated with rainfall (r=0.9302*). A negative correlation was observed in between maximum temperature and the number of openings may be to regulate the inner temperature to their micro habitat. A strong positive correlation was observed in between the rainfall and the depth of the burrow (r = 0.9553*). This may probably help them to protect their stored food particles as well as to protect their nest chamber from the rain water. Rainfall and the length of the burrow were also positively correlated.

It was observed that when the percentage of sand was increased the clay content was decreased (r=-0.9955). The number of opening of the burrow was increased with that of the increasing concentration of sand in the soil. We found that the length of the burrow was negatively correlated with that of the sand content of the soil(r=-0.9139) while it was positively correlated with that of the clay content of the soil (r=0.8922).

District Nadia and 24-Paraganas (N) of the Gangetic plain of West Bengal produced cereals like rice, wheat, pulses like Gram, tur; oil seed like rape seed, linseed; jute, mesta; vegetables like sugarcane, potato, chilies, ginger. Almost all the crops were found to be damaged by the *Rattus sp.* [25]. Rice, wheat, maize, potato, sugarcane and mustard oil seed were found to be damaged heavily in respect to the other crops.

In the non-Gangetic plane of West Bengal, rice, wheat, potato, mustard and sugarcane were heavily damaged by the *Rattus sikkimensis* in this region also. In comparison to rice, wheat was more affected [26].

Beside other demographic attributes, investigations on burrow characteristics and hoarding behavior of the rodent have been reported only from rice crops of lower Sindh [27,28] and wheat crops of AJ & K [29]; groundnut and wheat crops [30]. Both of these locations are at extreme limits of the bandicoot rat distribution in Pakistan, and are primarily in rice-wheat cropping systems.

Burrow pattern can also be affected by additional physical consideration such as hill slope angle [31] and needs for respiratory gas exchange [32]. In our study we didn't consider those factors because of their uniformity in these regions.

In the present study it was observed that the length of the burrow was significantly different in the Gangetic and the non-Gangetic plains of West Bengal. The length of the burrow was also determined by some factors like the surface area required for sufficient oxygen to diffuse in to the burrow [33].

The results of various parameters clearly indicate that the depth of burrow and the number of openings also differ significantly in these regions. Significant differences are also found in case of rice and wheat in both the Gangetic and the non-Gangetic plains of West Bengal.

Now the question arises regarding the damages caused by the *Rattus sikkimensis* and other rodent species and their behavior pattern within the complex burrow system in various soil conditions. Analysis of the soil clearly indicates that the burrow pattern depends on the nature of clay. Whatever the factors prevail, the complex burrow pattern has a clear correlation to their survival strategies in various environmental conditions.

## ACKNOWLEDGEMENTS

The authors are greatly indebted to the tribal people of the four districts of WestBengal,who actually helped during the time of collection of soil samples in the dug out areas and digging the various fields to demarcate the burrow structures. The authors also acknowledge the help and co-operation f the scientists, soil chemistry laboratory, Vidhan Chandra Krishi Viswavidyalaya,Nadia, W.B., India for analysis of the soil. Sincere thanks are also given to the Taxonomy division ( Mammal section ), ZSI, Kolkata , for identification of the rodent species.

## REFERENCES

[1] Prakash I, Mathur RP. 1988. *Rodent problems in Asia*. Rodent Pest Manag, CRC Press, Florida, USA. 67-84.

[2] Rao, A.M.K.M., Joshi, N.C. 1986. Crop losses due to rodents: an overview. Ind J Entmol, 48: 366-371.

[3] Advani, C.R. and Mathur, R.P. 1982. Experimental reduction of rodent damage to vegetable crops in Indian villages. Agro ecosys ., 8: 39-45.

[4] Reichman, O.J., Wicklow, D.T. and Rebar, C. 1985. Ecological and mycological characteristics of caches in the mounds of *Dipodomys spectabilis.* J. Mammol. , 66(4): 643-651.

[5] Goyal, S.P. and Ghosh, P.K. 1993. Burrow structure of two gerbil species of Thar desert, India. Acta Theriol 38: 453-456.

[6] Randall, J.A. 1993. Behavioural adaptations of desert rodents (Heteromyidae). Animal Behaviour , 45 : 263–267.

[7] Laundre, J.W. and Reynolds, T.D. 1993. Effects of soil structure on burrow characteristics of five small mammal species. Great Basin Naturalist, 53; 358–366.

[8] Davidson, A.D., Lightfoot, D.C. and McIntyre, J.L. 2008. Engineering rodents create key habitat for lizards. Journal of Arid Environments, 72: 2142–2149.

[9] Mora, M.S., Mapelli, F.J., Gaggiotti, O.E., Kittlein, M.J. and Lessa, E.P. 2010. Dispersal and population structure at different spatial scales in the subterranean rodent *Ctenomys australis*. BMC Genetics, 11: 9.

[10] Naderi, G., Hemami, M.R., Mohammadi, S., Riazi, B., Karami, M., Kaboli, M. and Alesheikh, A.A. 2011. Effect of vegetation and soil conditions on burrow structure and site selection of rare desert rodent – Iranian jerboa (Allactaga Firouzi). Polish Journal of Ecology, 59: 403– 411.

[11] Lacey, E.A. 2000. The subterranean niche. In: Lacey, E.A., Patton, J.L. & Cameron, G.N. (eds) Life underground, the biology of subterranean rodents. The University of Chicago Press, Chicago, USA.

[12] Neilson, R.P. 1991. Climatic constraints and issues of scale controlling regional biomes. In: Holland, M.M., Naiman, R.J. & Risser, P.G. (eds) *Role of landscape bouizdaries iiz the rnanagerneizt aizd restoratio?z of changing environmeizts*, pp. 3 1-5 1. Chapman & Hall, New York, NY.

[13] Gosz, J.R. 1992. Ecological functions in a biome transition zone: translating local responses to broad-scale dynamics. In: Hanson, A.J. & di Castri, F. (eds.) *Landscape boundaries: consequences for biotic diversity and ecological fluxes,* pp. 55-75. Springer-Verlag, New York, NY.

[14] Gosz, J.R. 1993. Ecotone hierarchies. *Ecol. Appl.* 3: 369-376.

[15] Brown, D.G. 1994. Predicting vegetation types at treeline using topography and biophysical disturbance variables. J. Veg. Sci., 5: 641-656.

[16] Breck, S.W. & Jenkins, S.H. 1997. Use of an ecotone to test the effects of soil and desert rodents on the distribution of Indian ricegrass. Ecography, 20: 253-263.

[17] Van der Wall, S.B. 1990. *Food-hoarding nzammals.* University of Chicago Press, Chicago, IL.

[18] Zuri, I, Terkel, J. 1996. Locomotor pattern, territory and tunnel utilization in the mole-rat *Spalax ehrenbergi*. J Zool (London) 240:123–140.

[19] Skliba, J., Sumbera, R., Chitaukali, W.N., and Burda, H. 2009. Home range dynamics in a solitary subterranean rodent. Ethology, 115 (3): 217 – 226.

[20] Nevo, E. 1999. Mosaic evolution of subterranean mammals: regression, progression and global convergence. Oxford University Press, Oxford.

[21] Brett, R.A. 1991 . The ecology of naked mole-rat colonies: burrowing, food and limiting factors. In *The bilogy of the naked mole-rat* (eds P.W. Sherman, J.U.m. Jarvis and R.D. Alexander), pp, 97 – 136. Princeton University Press. NJ.

[22] Jarvis, J.U.M., Bennett, N.C. and Spinks, A.C. 1998. Food availability and foraging by wild colonies of Damaraland mole-rats (*Cryptomys damarensis*): implications for sociality. Oecologia, 113: 290–298.

[23] Baruah, T.C., Barthakur, H.P. 1997. A text book of soil analysis. Vikas publishing, PVT Ltd, New Delhi.

[24] Walkley, A. and Black, I. A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci, 37: 29-37.

[25] Santra, K.B. and Manna, C.K. 2008. Studies of some aspects of rodent ecology in the four districts of the gangetic plain of West Bengal, India. Univ J Zool Rajshahi Univ., 27: 85-90.

[26] Chattopadhyay, D., Madhu, N.R, Manna, C.K. 2010. Burrowing pattern and damage caused by the rodent pest, Indian house rat, *Rattus rattus* in the Gangetic and Non Gangetic plain of West Bengal, India. Univ J Zool Rajshahi Univ., 28 : 57-60.

[27] Fulk, G. 1977. Food hoarding of *Bandicota bengalensis* in rice field. Mammalia, 41: 59-61

[28] Fulk, G.W., Lathiya, S.B. and Khokhar, A.R. 1981. Rice field rats of lower Sind: abundance, reproduction and diet. J. Zool., 193: 371-390.

[29] Maqbool, S., Khan, A.A. and Awan, M.S., 2011. Burrowing characteristics and food hoarding behaviour of *Bandicota bengalensis wardi* Wroughton in wheat fields, Muzaffarabad, Azad Jammu & Kashmir, Pakistan. Pakistan J. Zool., 43: 987-992.

[30] Hussain, I., Qureshi, N.A., Anwar, M. and Mushtaq, M. 2016. Burrow Characteristics of Lesser Bandicoot Rat (*Bandicota bengalensis*) in the Agro- Ecosystem of Pothwar Plateau, Pakistan.lPakistan J. Zool., 48(3):631-638.

[31] Seabloom, E.W. , Reichman, O.J., Gabet, E.J. 2000 . The effect of hillslope angle on pocket gopher (*Thomomys bottae*) burrow geometry. Oecologia, 125:26–34.

[32] Wilson, K. J., and D. L. Kilgore, JR. 1978. The effects of location and design on the diffusion of respiratory gases in mammal burrows. J. Theoret. Biol., 71:73-101.

[33] Kennerly, T. E. 1964. Micro environmental conditions of the pocket gopher burrow. Texas J. Sci. 16: 395–441.

INTERNATIONAL JOURNAL OF
PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

# International Journal of Plant, Animal and Environmental Sciences