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Effect of abiotic factors on burrow density of Indian gerbil, *Tatera indica* (Hardwicke) (Rodentia: Muridae) in Punjab

Abha Sharma and Rajwinder Singh

Abstract
The burrow density of Indian gerbil, *Tatera indica* was studied in relation to different abiotic factors like maximum and minimum atmospheric temperatures, relative humidity, soil temperature and soil moisture in agro-ecosystem of Ludhiana, Punjab. There was no clear-cut pattern of dependence of burrow density with both soil and atmospheric temperatures, but percent relative humidity somehow get co-vary with burrow number. Both maximum and minimum atmospheric temperatures have direct correlation with soil temperature at 1% level of significance. Maximum atmospheric temperature has inverse relation with soil moisture, whereas soil moisture has direct relation with percent relative humidity. Total number of live burrow count was maximum during spring season and minimum during summer season. Total number of live burrow count during monsoon, post-monsoon, winter and spring seasons recorded were 77.44, 67.76, 14.52 and 96.80% higher as compared to summer season. During monsoon, post-monsoon and spring seasons, sex ratio was in favour of males while it was in favour of females during winter season, which leads to increase in population during winter season. *T. indica* was pre-dominant species over *M. booduga* and *B. bengalensis* in selected area of study. So, it is concluded that control measures by rodenticides should be done during spring and winter seasons to check the population of *T. indica* to reduce its damage to crops.

Keywords: Abiotic factors, rodents, soil moisture, soil temperature, *Tatera indica*

Introduction

In our agro-ecosystem, rodent species are among pests which cause direct and in-direct damage to our crops at field and storage level [6]. In Punjab, there are eight species of rodents which are surviving in fields and commensal conditions [5]. Rodents live in burrows having complex network of tunnels dug in different habitats having variable biotic and abiotic conditions [19, 11, 8]. The density of burrows varies between various habitats and seasons [21]. Different studies were made on burrow densities of rodents in relation to abiotic and biotic facors in North India [43, 23]. Abiotic factors interact with each other in several complex ways to influence biotic factors. Both biotic and abiotic factors affect the activity patterns of burrows of rodents and influence both times and place for the activity of rodents [17, 10]. Among abiotic factors, temperature and humidity stand out as the most important ones constraining abundance and distribution of insect. Furthermore, it is well documented that abiotic factors, especially temperature, regulate the ecology of insect communities [24]

Indian gerbil, *Tatera indica* is more adaptable than other desert and wild rats [13, 26, 30, 38]. *T. indica*, also known as "Antelope rat" belong to family "Muridae" and Sub family "Gerbillinae". *T. indica* constitutes 41.6% of rodents found in the sandy biome of the Indian desert [29]. It is omnivorous, known to eat seeds, plants, roots, grasses, parts of standing crops, food grains and insects [28]. It is light brownish in colour dorsally and pure white to off white ventrally. The eyes are large and ears are round. The sole of hind-feet are naked and tail is of bicolour with a tuft of black hairs at the end of the tail. Tail is longer than head and body length. They have 8 mammae and body weight ranges from 100-250g (male) and from 70-200g (female) [35, 30]. Subterranean rodents construct burrow through the soil, consuming above and below ground plant material [14]. Thus, burrowing activity of rodents is affected by both the physical characteristics of the soil and the availability of food [39]. Generally, rodents escape heat imposed by solar radiation and high soil and air temperature by remaining below ground in burrows during heat of the day [12, 20]. The population dynamics may allow predicting changes in rodent numbers, which is of major importance for the development of management strategies. Studies on the burrowing habit of rodent pests are required to understand their social organization and behaviour of dominance [7, 32]. They also help to distinguish rodents from other burrowing animals for population estimation, placing poison baits and physical control [25]. In our present study, the data on burrow density of *T. indica* and related abiotic factors like atmospheric and soil temperatures, relative humidity have been analyzed by using simple correlation and path co-efficient analysis and a comparison of the two methods has been made for causal factors.

Materials and methods

The material and methods used during study are discussed below:

Selection of site

The study was carried out in the fields of village Ladhowaal, District Ludhiana (Punjab) (Ludhiana 30.91°N, 75.85'E). The main crops grown in this area were wheat, paddy, maize, bajra and vegetables etc.

Selection of seasons

Observations were recorded on monthly basis and months were grouped into five seasons as summer, monsoon, post-monsoon, winter and spring. In summer season May and June, in monsoon July and August, in post-monsoon September to November while in winter December to February and in spring March to April months were included according to Punjab (India) weather conditions.

Abiotic factors

Different abiotic factors recorded from areas of selected village were relative humidity, atmospheric temperature (minimum and maximum) and soil temperature. Monthly recordings of the relative humidity and atmospheric temperature were made one meter above the soil surface by dry and wet bulb thermometer. Gravimetric method [36] was used to determine percent soil moisture from different depths (0, 1 and 2 feet). Digital soil thermometer (R-Tek™) was used to measure the soil temperature at different depths. Generally, soil temperature was measured at 5, 10 and 30 cm depths. Each thermometer was installed at required depth and then soil temperature was recorded. It takes about 7-10 minutes to record temperature reading of one thermometer. Soil moisture and soil temperature were recorded from 20 different sites each (per month) in selected area.

Population dynamics: Population dynamics of *T. indica* was studied in selected field areas having different crops in soil by trapping method for the whole year. Trapping was carried out at monthly interval for consecutive three trap nights from selected field areas. Various other species of rodents like *Bandicota bengalensis*, *Milardia meltada* and *Mus booduga* were also trapped along with *T. indica*. There were three replications each having one acre area. Sixteen wooden traps per acre were used for trapping rats. Traps were placed in selected areas near the burrow openings. Number of burrows of different rodent species (per acre) was also recorded from fields from where trapping was done to observe the pre-dominance of rodent species. Since most of rodents being nocturnal, the burrows were plugged with soil, late in the evening and freshly re-opened burrows on next day were counted as live burrows.

The population was counted by calculating trap index.

$$\text{Trap index (\%)} = \frac{\text{Total no. of species trapped}}{\text{Total no. of traps} \times \text{trap nights}} \times 100$$

The trapped species were analyzed to record other parameters like number and kind of species trapped, sex (male or female) and body weight of species trapped (g).

Damage assessment in different crops

Assessments of rodent damage at pre-harvest stage of different field crops were recorded. Rodent damage (per acre) was assessed by taking five samples of 1m^2 per field of one acre in two diagonal lines to cover center as well as all the four geographical sides of a field. In each sample, total number of tillers and tillers cut by rodents were counted.

$$\text{Percent damage (\%)} = \frac{\text{Average number of cut tillers/m}^2}{\text{Total number of tillers/m}^2} \times 100$$

Results and discussion

The results recorded during study are discussed below:

Effect of abiotic factors on burrow count

Monthly recordings of the mean number of burrows in the study area revealed that there was a fluctuation in number of burrow count during all the months in a year. The analysis of monthly recordings of the average burrow number (per acre) of *T. indica* found was highest (Fig. 1) during September (27.33) and minimum during May and October (8.33). There was no clear-cut pattern of dependence of burrow density with soil or atmospheric temperatures, but the percent relative humidity somehow get co-vary with burrow number. This is supported by the fact that minimum percent relative humidity (37%) was obtained during the month of May coincided with the minimum peak of burrow number (8.33) recorded during the same month (Fig. 1). Similarly, the peaks of relative humidity and burrow number were higher during August and September months. There is significant difference of maximum atmospheric temperature with minimum atmospheric temperature at 1% level of significance (Table 1). Study shows that both maximum and minimum atmospheric temperatures has direct correlation with soil temperature i.e. when there is high temperature in atmosphere there is more temperature within soil and vice versa at 1% level of significance. There is inverse relation between maximum atmospheric temperature and soil moisture i.e., at high atmospheric temperature there is reduction in soil moisture, whereas soil moisture has direct relation with percent relative humidity (Table 1).

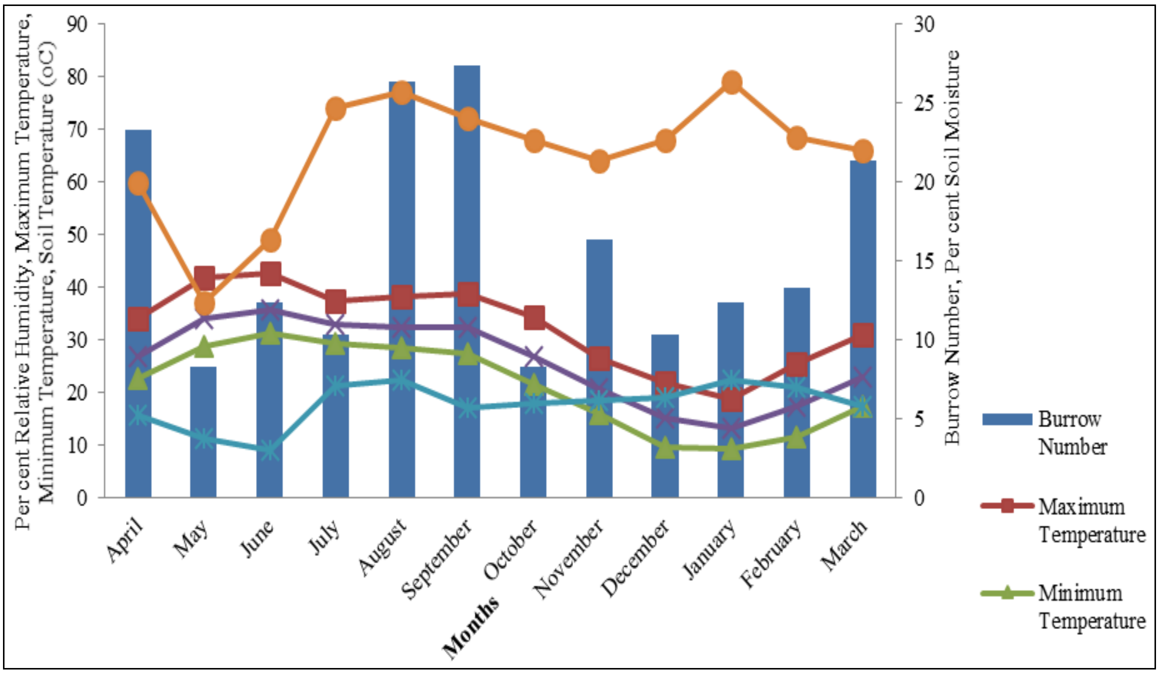

Fig 1: Relationship between burrow number and abiotic factors

The correlation matrix also shows that some of the abiotic factors interacted mutually among themselves (Table 1). Kumar and Pasahan [21] observed that soil moisture was the only abiotic factor which correlate significantly with number of burrows while other factors such as maximum and minimum temperature, soil temperature and relative humidity shows non-significant results. Another group of subterranean rodents, African mole rats (Bathyergidae), show this pattern of enlarging the burrow system as soon as the soil becomes moist, and they extend their burrows mainly as they forage for vegetation [9].

Table 1: Correlation matrix showing relationship between burrow density and abiotic factors

S. No.	Parameters	Max. temp. (ºC)	Min. temp. (ºC)	Soil temp. (ºC)	Soil moisture (%)	R.H. (%)
1	Burrow number	0.183	0.207	0.189	0.164	0.321
2	Max. temp.		0.976**	0.990**	-0.597*	-0.495
3	Mini. temp.			0.996**	0.489	-0.378
4	%Soil temp.				0.531	-0.424
5	%Soil moisture					0.904**

*significant at 5% level of significance
**significant at 1% level of significance

Study of population dynamics

Total number of live burrow count recorded during summer, monsoon, post-monsoon, winter and spring seasons were 10.33±1.41, 18.33±5.65, 17.33±4.49, 11.83±1.06 and 20.33±0.70, respectively (Table 2). Total number of live burrow count was maximum during spring season (20.33±0.70) and minimum during summer season (10.33±1.41). Total number of live burrows count during monsoon, post-monsoon, winter and spring seasons recorded were 77.44, 67.76, 14.52 and 96.80% higher as compared to summer season.

The trap index of trapped *T. indica* along with different trapped species of rodents like *Bandicota bengalensis*, *Mus booduga* and *Milardia meltada* was recorded during trapping at monthly interval in selected village. Total trap index (including all trapped rodent species) in different crops during summer, monsoon, post-monsoon, winter and spring seasons recorded was 13.89±6.08, 7.37±0.79, 4.49±2.20, 3.35±1.45 and 4.13±1.44, respectively having maximum in summer and minimum during winter seasons. The mean total trap index of all the trapped species throughout the year was recorded to be 6.64. Total trap index during monsoon, post-monsoon, winter and spring seasons was 46.90, 67.60, 75.80 and 70.20% lower as compared to summer season. Trap index of *T. indica* during summer, monsoon, post-monsoon, winter andspring seasons ranges from 0.0 to 35.72±15.86, being maximum in post-monsoon season while nil in summer and spring seasons (Figure 2). While another study Parkash; Parkash and co-workers [31, 33] revealed that by trapping *T. indica* for two nights per month for whole year, the population was found to be lowest during winter season and starts building up from summer season and reaches a peak during monsoon season and these results were similar with *M. hurrianae*. The sex ratio (male: female) of trapped *T. indica* recorded during summer, monsoon, post-monsoon, winter and spring seasons was 0:0, 1:0, 1:0.5, 2:0 and 1:0, respectively (Table 2). During monsoon, post-monsoon and spring seasons, sex ratio was in favour of males while it was in favour of females in winter season, which leads to increase in population during winter. The weight (g) of trapped *T. indica* male during monsoon, post-monsoon, winter and spring seasons ranged from 105.0 to 140.0 (Table 2). *T. indica* female was trapped during post-monsoon and winter seasons with weight ranged from 117.0-135.0g. The weight of *T. indica* was maximum during winter season (138.0g for male) and minimum during post-monsoon season (105.0g for male). Total weight (g) during summer, monsoon, post-monsoon, winter and spring ranged from 119.56 to 140g, respectively. It was maximum during monsoon season while minimum in post-monsoon season (Table 2). Similar results were reported by Rao [37] who reported that mean sex ratio (male: female) of trapped rodents varied from 1:0.64 to 1:0.98 showing more number of males over females and average weight of trapped males varied between 147.10 to 208.40g while females from 112.60 to 145.0g. In a study by Jain [15], during trapping of various rodent species found that *R. rattus* forms about 45.0% of the total rodent population followed by *M. musculus* (34.0%) and *B. bengalensis* (8.0%) in North-Eastern hill region.

Table 2: Percent trap index and different parameters of trapped *T. indica* during different seasons

Seasons	Area of trapping	(Total burrow count)	Total trap index	Sex ratio (male: female) of *T. indica*	Weight of *T. indica* (g) (min-max)		Total weight (g)
					Male	Female	
Summer	Fallow land, mung bean	10.33±1.41	13.89±6.08	0:0	0	0	0
Monsoon	Maize	18.33±5.65	7.37±0.79	1:0	140.0	0	140.0
Post-monsoon	Paddy, fallow land	17.33±4.49	4.49±2.20	1:0.5	105.0-130.0	117-135	119.0
Winter	Wheat, fallow land	11.83±1.06	3.35±1.45	2:0	116.0-138.0	0	128.0
Spring	Wheat, berseem	20.33±0.70	4.13±1.44	1:0	125.0	0	125.0
Mean	--	15.63±1.96	6.64±1.73	--	--		--

Values are Mean±SE. min-max represents minimum to maximum range of data.

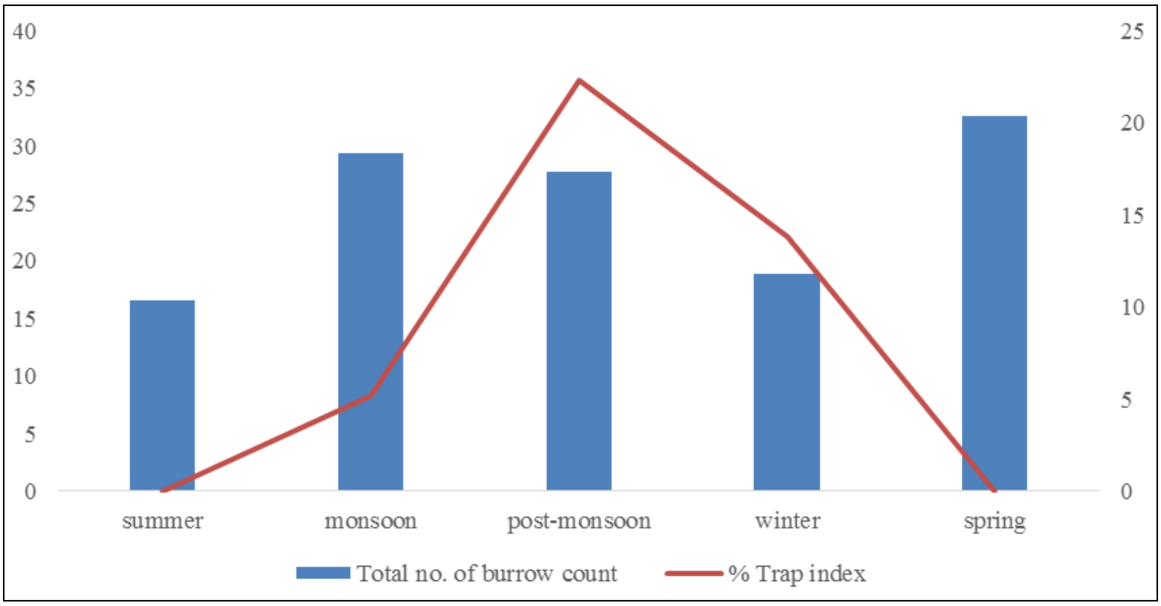

Fig 2: Relationship of trap index and number of burrow count of *T. indica* in loamy-sand soil

Damage assessment of different crops during pre-harvest stage

Percent damage (per acre) during pre-harvest stage of different field crops like wheat (sown with happy seeder), paddy and mung sown in loamy-sand soil was 1.68±0.19, 2.06±0.29 and 2.67±0.65, respectively (Table 3). No damage was observed in maize and bajra crops as these are taller crops. Highest percent damage (per acre) by rodents was recorded in mung crop (2.67±0.65) followed by paddy crop (2.06±0.29) and minimum in wheat crop (1.68±0.19). Jain and Tripathi [16] recorded rodent damage pre-dominated by gerbils in various vegetable crops in the range from 8.70-10.0% whereas in water melon crops, the damage sometimes reaches from 70-80% in sandy soils of Rajasthan and Gujarat. While other studies on damage by rodents in wheat crop analysis differences between damage levels showed minor differences during seedling (0.83% stems cut), tillering (0.98% stems cut) and booting (1.24% stems cut) growth stages but the stems cut differences between the seedling and the booting stages were not significant [42]. Pre-harvest damage survey conducted in nearly 1,600 rice fields distributed throughout the Philippines revealed rat damage in about 90.0% of the surveyed rice fields [41].

Table 3: Percent damage and burrow count (per acre) during pre-harvest stage of different field crops sown in loamy-sand soil

Crop	Damage (%)	Burrow count (per acre)				
		Bandicota bengalensis	*Mus booduga*	*Tatera indica*	*Millardia meltada*	Total
Wheat (happy seeder)	1.68±0.19	3.33±1.52	8.33±1.18	12.66±2.06	0.0±0.0	24.32±3.15
Paddy	2.06±0.29	1.66±0.35	5.66±0.78	9.33±1.14	0.0±0.0	16.65±1.41
Maize	0.0±0.0	2.33±0.70	4.66±1.06	5.33±1.42	1.33±0.6	13.65±1.77
Bajra	0.0±0.0	1.66±1.08	3.66±1.10	7.33±1.75	0.0±0.0	12.65±1.80
Mung	2.67±0.65	2.33±0.95	4.33±1.09	9.66±1.10	1.66±0.54	17.98±2.67
Fallow land (grass vegetation)	0.0±0.0	0.66±0.41	10.33±1.54	18.33±1.08	0.0±0.0	29.32±1.78
Mean	--	2.00±0.33	6.16±0.97	10.44±1.76	0.49±0.29	19.09±2.42

Values are Mean±SE, No superscript represents non-significant difference between the values of burrow count of different species.

Burrow count (per acre) of different crops during pre-harvest stage

Total burrow count (per acre) during pre-harvest stage of different crops like wheat (happy seeder), paddy, maize, bajra, mung and fallow land in loamy-sand soil was 24.32±3.15, 16.65±1.41, 13.65±1.77, 12.65±1.80, 17.98±2.67 and 29.32±1.78, respectively. Burrow count was highest in fallow land (29.32±1.78). Among crops, it was highest in wheat crop (24.32±3.15) and lowest in bajra crop (12.65±1.80). Mean total burrow count (per acre) during pre-harvest stage of different field crops was 19.09±2.42 in loamy-sand soil. The mean burrow count of *B. bengalensis*, *M. booduga*, *T. indica* and *M. meltada* was 2.00±0.33, 6.16±0.97, 10.44±1.76 and 0.49±0.29, respectively. *T. indica* was pre-dominant species over *M. booduga* and *B. bengalensis* in selected area (Table 3). For the damage assessment, analysis of variance shows non-significant difference between the burrow counts of different species. Singla and Babbar [40] reported *B. bengalensis* as a pre-dominant species followed by *M. booduga* and *T. indica* in sandy-loam soil. Similarly, the variations in the predominance of species in different regions related to the cropping patterns reported *B. bengalensis* as a pre-dominant in fields of paddy-wheat rotation, *R. meltada*, *T. indica* and *M. booduga* in cotton and groundnut-wheat rotations and *B. bengalensis*, *R. meltada* and *T. indica* in millet and maize-wheat rotations [27]. Lathiya and co-workers [22] observed rodent damage indices in rice and wheat crops in the tune of 17.80 and 28.30%, respectively. Rodent damage observed in paddy crop sown in Uttar Pradesh (U.P.) and Madras was reported to be 7.10-21.50% and 5.20-65.30%, respectively. This damage reduced the yield of paddy up to 59.50% and yield of straw up to 45.70% while rodent damage to wheat and barley crops at Kanpur during rabi season was found to be 11.0% in both seeding and growth stages [18]. Another study of 15 villages representing five districts revealed that during post-harvest stage of wheat and rice crops, the number of rodent burrows/ha ranged from 12.50±3.15-110.55±28.52, respectively [40].

Conclusion

Our study shows that *T. indica* pre-dominates in study area. Percent relative humidity somehow positively correlates with burrow number. Maximum and minimum atmospheric temperatures has direct correlation with soil temperature. There is inverse relation between maximum atmospheric temperature and soil moisture, whereas soil moisture has direct relation with percent relative humidity. Live burrow count of *T. indica* was maximum during spring season and minimum during summer season. During monsoon, post-monsoon and spring seasons, sex ratio was in favour of males while it was in favour of females in winter season, which leads to increase in population during winter. So, control measures by using rodenticides should be done during spring season and winter season to check the *T. indica* population during whole year to reduce its damage to crops.

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