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Burrowing Characteristics and Food Hoarding Behaviour of *Bandicota bengalensis wardi* Wroughton in Wheat Fields, Muzaffarabad, Azad Jammu & Kashmir, Pakistan

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Abstract.- Studied the burrowing characteristics and food hoarding behaviour of *Bandicota bengalensis wardi* in wheat fields at an outskirts of Muzaffarabad city, Azad Jammu & Kashmir. Lesser bandicoot rat constructed the burrow system according to some common plan wherein the values of the depth of tunnels, number of chambers and diameter of tunnels were similar to values as reported in other studies. However, the length and width of the burrow systems (n=4), number of surface openings and dead ends as recorded in this study, the values were far less than reported in other studies from Bangladesh and India. This may be due to different soil porosity, physical structure and water contents at the present study site. The food hoarded material per burrow system on an average was 0.478±57.9 kg which equaled 660±179 ear heads recovered per burrow. The grain yield loss was estimated at 141.5 kg/ha, the support price of which was Rs. 3361.00 during 2008.

Ket words: *Bandicota bengalensis*, burrowing features, food hoarding, Pakistan, wheat fields.

INTRODUCTION

The lesser bandicoot rat, *Bandicota bengalensis*, has been recorded as a serious rodent pest of rice, wheat and groundnut crops in Pakistan (Wagle, 1927; Fulk *et al*., 1980; Fulk, 1986, Khokhar, 1986; Brooks *et al*., 1988; Hussain *et al*., 2003), and also in Bangladesh and India (Bindra and Sagar, 1971; Poche *et al*., 1982; Prakash and Mathur, 1988; Parshad, 1999). In Pakistan, there are two separate populations of the lesser bandicoot rat, one ranges over central and northern Punjab, and in the southern part of North-Western Frontier Province (now Khyber Pakhtunkhwa, KPK), and the other one is confined to southern Sindh (Smiet *et al*., 1978; Roberts, 1997). Also, its expanded geographic distribution towards south has been recorded in Punjab, Pakistan (Beg and Khan, 1984). A third fragmented population of sub-species *B. bengalensis wardi* Wroughton exists in Jehlum and Neelum valleys of Azad Jammu & Kashmir (Ellerman, 1961; Siddiqi, 1961), which has extended to Srinagar (Malhi and Sheikher, 1986). The second author of this paper trapped this sub-species in 1991 from Ghari Habibullah and Balakot (KPK).

Food hoarding is known in only half a dozen of the approximately 107 genera of Muridae family (Van der Wall, 1990). Murid rodents accumulate food in under-ground chambers, scattered surface caches, or both. Among small mammals, the most thoroughly studied hoarder is the lesser bandicoot rat, a serious agricultural pest in southern Asia from Pakistan to Indonesia. In wheat crop it is a principal pest in Bangladesh, India and Pakistan, and accumulate various amounts of food grains in the burrow system (Sagar and Bindra, 1968; Poche *et al*., 1982; Sheikher and Jain, 1991; Sheikher and Malhi, 1983; Jain, 1985). In rice few food hoarding reports are, also, available (Wagle, 1972; Ayyar, 1931; Roy, 1974; Fulk, 1977, Rao, 1980). Due to its hoarding habits, *B. bengalensis* foraging in wheat fields is most intensive near the burrow, 50% damage occurring within 3.3.m (Poche *et al*., 1982).

Just before harvest, bandicoot rats invade fields of rice 1 or 2 weeks before harvest (after draining out last irrigation water) and quickly establish burrow systems, while in wheat crop, after 3-4 weeks of sowing, move to the interior of the field from the dikes (Chakraborty, 1977; Poche *et al*., 1982; Malhi and Sheikher, 1986). Burrows of *B. bengalensis* are elaborate interconnected tunnels/

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galleries having multiple openings, with a nest chamber and more than one food-stroage chambers (Chanda and Garg, 1981; Poche *et al*., 1982; Sheikher and Malhi, 1983; Malhi and Sheikher, 1986). The sub-surface depth of galleries and chambers are constructed according to a common plan but may vary in relation to soil porosity, physical structure and water contents. It may, also, vary with the age of occupying animal, type and growth stage of crop (Yashoda *et al*., 1966). The burrowing trait in vertebrates evolved as early as the Carboniferous Period (Olsen and Bolles, 1975), and the resulting burrows vary greatly in diameter, depth and complexity: they impact geomorphology, hydrology, soil dynamics, vegetation pattern, etc.

The quantity of grain stored by lesser bandicoot rat has been well documented from Bangladesh, India and Pakistan because of its pest status and economic impact on rice and wheat productivity (Roy, 1974; Chakraborty, 1977; Fulk, 1977; Poche *et al*., 1982). As early as 1927 (Wagle, 1927) and 1931 (Ayyar, 1931) food hoarding by *B. bengalensis* was reported, while Wagle (1927) found 600 ear heads of rice in some burrows studied in lower Sindh. Fulk (1977) found 93 kg of hoarded rice per hectare in Sindh which was equal to 10% of the total yield of the crop. Prakash (1976) reported that up to 450 kg/ha of various grains may be damaged due to food hoarding. In Pakistan, rain fed as well as winter irrigated wheat crops are highly vulnerable to rodent attack, specifically in rice-based wheat cropping system, both in Punjab and Sindh. Lesser bandicoot rat has been identified as the major damage causing rodent species (Fulk *et al*., 1980; Khokhar, 1981). Khokhar (1986) computed a total damage index based on diet and trap success, and found that the lesser bandicoot rat contributed 13.5% of the damage to wheat. In Pakistan, the damage estimates to wheat produced vary from 5 to 7.5% (Fulk *et al*., 1980; Baig and Khan, 1977). Khan *et al*. (1997) recorded *B. bengalensis* as a serious pest of wheat crop in AJ&K.

The present study in AJ&K was conducted to generate further data on burrowing and food hoarding behaviour of *B. bengalensis wardi* in wheat crop and document its economic impact on wheat production. Earlier to this, such information was not available from AJ&K and other parts of Pakistan.

MATERIALS AND METHODS

Study area

The study area was located in Chela Bandi, an out-skirt, 2.5 km north of Muzaffarabad city. The habitat of the area is sub-tropical and crops like maize, wheat and fodder are cultivated. The area is marked with great diversity in physiographic and climatic features which support a wide variety of vegetation and animal life. The soil is sandy-gravel and loamy, and where deep tillage is not practiced for cultivation of crops. At the time of study (May, 2008), the area was fully covered with wheat crop (Inqulab variety) ready for harvest.

Selection of experimental fields and excavation of burrows

Nine wheat fields of various sizes (0.05-0.5 ha) were randomly selected one day after harvesting the crop to estimate burrow density, and quantifying hoarded ear heads from the excavated burrow systems (n=43). Out of 43 burrow systems, four were randomly identified to record burrowing characteristic features. Before excavating of the selected burrows all piles of soil dirt were removed to the ground level. Active entrance was selected as the starting point to excavate the burrow system. The burrows were excavated with the help of a spade, and shallow digging tools. While digging proceeded the hoarded food material was carefully recovered, separated from soil dirt, grass and stalk cuttings, and stored the ear heads in numbered plastic bags. Before weighing, the ear heads were sun dried, counted and weighed at 14% moisture contents. After complete recovery of hoarded material, each burrow system was mapped on a graphic paper, and there after all the necessary measurements of burrowing features were taken as described in Table I.

Assessment of yield loss

The loss in yield due to food hoarding was calculated by taking random samples of 100 ear heads (un-damaged) each from 10 randomly selected harvested stock-piles of wheat before

threshing, and which were removed immediately from experimental fields. Grains were removed manually from these ear heads, sun dried and weighed nearest to the gram. The average weight of grains from 100 ear heads at 14% moisture content was approximated against the number of ear heads recovered from the burrow. By multiplying the average weight of hoarded grain per burrow with the average number of burrows per hectare, the yield loss/ha was calculated due to food hoarding habits of *B. bengalensis*.

Table I.- Characteristic features of lesser bandicoot rat burrow systems (n = 4) recorded in AJ&K at Chela Bandi wheat fields during May, 2008.

Features	Average	Range	SD
Length of burrow system, m	4.13	1.82-5.48	0.84
Width of burrow system, m	1.60	1.21-195	0.15
Depth of burrow system, cm	14.3	12.19-21.58	2.6
Depth of main tunnel, cm	14.3	9.65-21.58	2.6
No. of openings/entrances	2.3	1.0-3.0	0.48
Depth of openings, cm	16.95	16.5-17.27	0.19
Diameter of openings, cm	8.9	8.63-9.14	0.10
Diameter of tunnels, cm	7.2	5.33-8.88	0.74
No. side tunnels	3.0	2.0-5.0	0.71
No. dead ends	2.0	1.0-3.0	0±40
Depth of dead ends, cm	9.5	7.6-10.66	0.67
No. of food chambers	2.5	1.0-5.0	0.86
Depth of food chambers, cm	10.72	8.12-13.2	1.1
Quantity (kg) of hoarded food material per burrow	0.478	0.20-2.62	57.9
Percent burrows containing food caches	100	-	-

RESULTS AND DISCUSSION

Burrow density and distribution

One hundred and four burrow systems of lesser bandicoots were recorded from nine fields (1.65 ha), one day after harvest of wheat crop. Out of these 70% (n = 73) were found in the interior of fields while 30% (n = 31) were located on the field dikes. The average numbers/ha were estimated to be 95 (94.7±30.1), showing medium type of lesser bandicoot rat population on the experimental fields. Based on an estimate of 1.5 rats per burrow (Poche *et al*., 1982), it was concluded that there were 143 bandicoot rats on 1.65 ha study area, or 87 rats/ha. Poche *et al*. (1982) recorded 91 bandicoot rats/ha in wheat fields in Bangladesh while Fulk (1977) calculated 300 bandicoot rats /ha in rice fields of lower Sindh, Pakistan.

Assessment of hoarded grains and economic impact

Out of 95 burrow systems only 43 (41%) were excavated to recover the hoarded food material. According to study plan all were to be dug up but continuous rains prevented further excavation. On the average 0.478±57.9 kg/burrow food material was recorded with a maximum of 2.62 kg in one burrow system, and none of them had less than 200 grams. On the average 660 ± 179 ear heads were found/burrow system. Exceptionally, one complex burrow system contained 8,000 ear heads in five chambers and along the tunnels. We excavated 43 burrows, and all (100%) had stored food material. Fulk (1977), Poche *et al*. (1982), Sheikher and Malhi (1983) and Sheikher and Jain (1991) recoded 26, 60, 95 and 63% of the burrows containing food material, respectively. The ear heads were of various sizes, colours and grain contents. Approximately, 25% ear heads were of small size and of faded green colour, having no grain contents. Probably, these were cut just after the flowering stage. Majority of the ear heads (50%) were severed by *B. bengalensis* at the seed/grain setting stage. Rest of the ear heads had fully developed grains and were of fawn colour. The ear heads in the food chambers were found symmetrically arranged with cut ends towards the blind end of the chamber. Also, in few burrows, at certain points in the main tunnels and inside the surface openings cut stalks and ear heads were found.

The number of accumulated ear heads averaged 660±179 per burrow. The quantity of food material stored by lesser bandicoot rats has been well documented in various studies because of great economic impact. For example, bandicoots in the Garhwal Himalayas (India) hoarded an average of 0.390 kg of wheat ear heads per burrow with as much as 2 kg in one burrow (Sheikher and Malhi, 1983). Similar quantity of 0.389 kg per burrow was recorded by Dahiya (1988) at Hissar, Haryana (India). In Madhya Pradesh, Jain (1985) and Sheikher and Jain (1991) in Himachal Pradesh found 3.69 and 0.486 kg of ear heads of wheat per burrow, respectively. In Bangladesh, bandicoots in wheat fields cached on an average 2.0±1.7 kg/per

burrow (Poche *et al*., 1982). Contrary to these studies in wheat fields, bandicoots hoarded much more food material in rice fields (Chakraborty, 1977; Roy, 1974; Fulk, 1977).

From the available literature, it is not clear whether the food hoarding behaviour of *B. bengalensis* has evolved as a contingency programme ensuring food security for adverse times or for their young ones, without being exposed to predators or fire (Jackson, 1966; Burns *et al*., 1989). Vander Wall (1990) stated that food hoarding by murid rodents is an adaptive response to food shortages or nutritional deficits caused by fluctuations in food availability and energy demand. Most of the times, these caches are not consumed by bandicoots (Roy, 1974, 1980) but are lost to the rats since they either germinate, mould and rot in the burrows or are recovered by the farmers. It is a common practice in Rajastan (India) that gypsy people dug-up the rodent burrows to recover the hoarded grains for utilization.

Table II.- Calculated wheat grain loss/ha and economic impact due to hoarding by *B. bengalensis* wardi at Chela Bandi, Muzaffarabad, AJ&K (Pakistan).

Ave. wt. of grains of 100 ear heads, g	225.30±2.87
Ave. number of hoarded ear heads/burrow	660.0±179
Ave. wt. of hoarded grain/burrow, kg	1.485
Ave.number of burrows/ha	95.0±30.1
Ave. wt. of grain loss/ha, kg	1.485x 95=141.5
Price of 40 kg of wheat (2008)	Rs. 950.00
Price of 141.5 kg of wheat loss/ha	Rs. 3361.00

It was estimated that in wheat fields at Chela Bandi, bandicoots on an average hoarded 1.49 kg of grains per burrow. Being 95 burrows per ha, the significant loss ($t = 8.707$, d. f= 9, $p = 0.05$) in yield was estimated at 141.5 kg/ha, the market value of which was Rs. 3361.00 (Table II). In an other study in Madya Pradesh, bandicoots cached 267.59 kg of wheat ear heads per hectare. In none of the studies, except that of Sheikher and Jain (1991) and the present one, potential weight of grains/burrow was not estimated and hence monetary loss/ha is not available in majority of cases. As done during this study, damage assessment made after one day of harvest appears to be a useful indicator of potential yield loss of wheat due to food hoarding habits of lesser bandicoot rats. However, loss estimates to different wheat varieties may present special problems because it may differ in grain size and the number of grains per ear head.

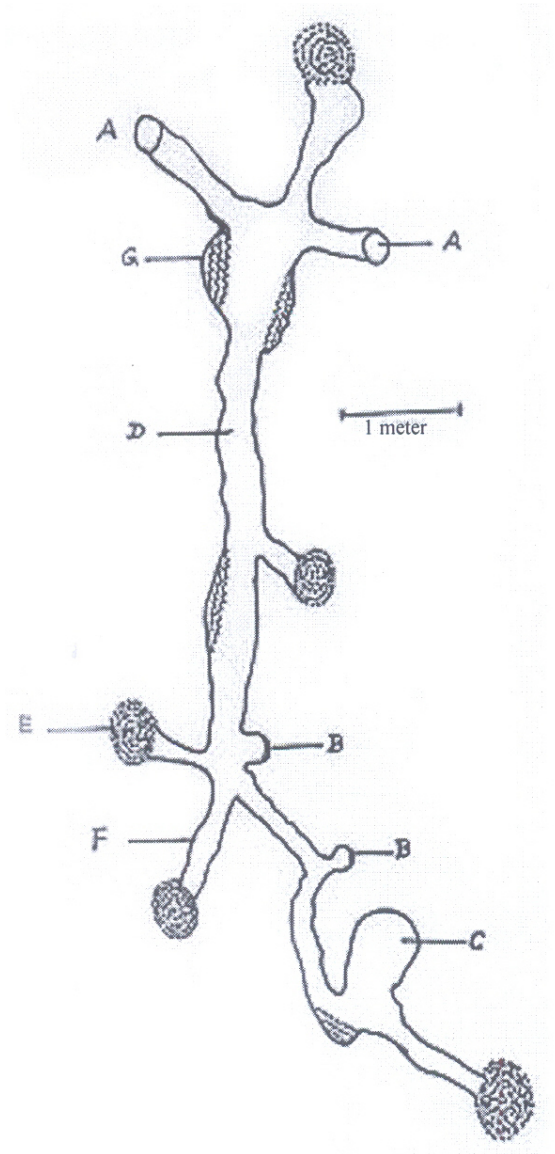

Fig. 1. A top view of internal structure of the burrow system of *B. bengalensis* excavated in wheat field at Chela Bandi, Muzaffarabad, AJ&K. Several features are identified: A, surface opening; B, dead end; C, food chamber; D. main tunnel; E, soil dirt pile; F, exit tunnel branch; G, stack of food material.

Burrowing features of B. bengalensis wardi

Out of 43 burrows excavated, we recorded the burrowing features of only four, randomly selected, burrow systems. Two of them were elaborate; third one was of medium size, and fourth was very simple. Characteristic features of an elaborate burrow system are described in Figure 1. As described in Table I, all observations and measurements were made just after the recovery of hoarded food material. Thirteen burrowing features were recorded during the present study as outlined in Table 1. The other detailed study is from Bangladesh where Poche *et al*. (1982) studied eleven features. Therefore, different values were compared within these two studies. In both studies, values for depth of burrow system, number of food chambers and diameter of tunnels were almost similar. The length and width of burrows as recorded in the present study were far less than recorded by Poche *et al*. (1982) in Bangladesh. Also, the number of surface openings and dead ends were approximately 50% less than found in wheat fields of Bangladesh.

Some extra-ordinary values have been recorded for *B. bengalensis* burrow by various authors. For example, Sheikher and Malhi (1983) reported maximum length of 2030 cm and estimated an area of 50 m^2 of that burrow system. In an other study, a longest burrow system of 2397.6±658.02 cm has been reported from India (Unpublished report of DST Project, 1986). George *et al.* (1981) found a brood chamber in the burrow system of *B. bengalensis* which was absent in the present study or that of Poche *et al.* (1982). Chakraborty (1977) found varied number of surface openings from 1-16, and depth and extension of a burrow system may range from 30 to 100 cm and from 4.3 to 45 m, respectively.

Keeping in view the generated information in this study and other similar studies, it is suggested that the burrowing habits of *B. bengalensis* may be studied in relation to soil porosity, physical structure and water contents. Variation within burrow structure may be related to physical properties of soil (Reichman and Smith, 1990). In some studies, soil structure variables have been identified as the main features affecting distribution of Wagner's gerbil in Israel (Shenbrot *et al*., 1997). Also, it will be very interesting to study this aspect in rice-based wheat cropping system.

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