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Species Complex, Damage Pattern and Efficiency of Rodenticides in Controlling Rodents Attacking Rice (*Oryza sativa* L.) Fields

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Abstract

Rodents principally rats and mice are some of the most bothersome and damaging creatures in the world. Almost every type of food commodity is subjected to rodents attack and losses to cereals are serious problem experienced throughout the sphere. Significantly rodents may affect rice crop production and rodenticides are likely to remain the essential management tool for controlling their damage in the field. This paper reports the results of the field studies to identify and quantify the species complex, damage pattern and efficiency of rodenticides in controlling rodents attacking rice (*Oryza sativa* L.), fields. The replicated trial was arranged according to randomized complete block design, and the samples for rodent species, preference for poison baits and comparative effectiveness of rodenticides in reducing pest populations and damage were taken before, during and after control operation was applied. Present results revealed that a guild of four rodent species viz., the lesser bandicoot rat (*Bandicota bengalensis* Gray), the metad (*Millardia meltada* Gray), the short tailed mole rat (*Nesokia indica* Gray), and the house mouse (*Mus musculus* L.) was observed damaging in the rice fields. However, the bandicoot rat (*B. bengalensis*) was found to be the primary and the most dominant species among the other rodent pests, which was responsible for inflicting severe damage to paddy throughout the rice growing season. Out of two tested rodenticides; Brodifacoum (single dose anticoagulant) was proved more efficient than Warfarin (multiple dose anticoagulant) for rodents management. When compared with additive poison baits, it was found that mixture of Brodifacoum plus egg was preferred by rodents over the other combinations and found most effective to achieve a successful control of these economically important agricultural vertebrate pests. For preventing losses from rodents feeding, growers should also implement a sound integrated pest management (IPM) program in their field crops.

Keywords

Rodent, Rodenticides, Poison Baits Preference, Rice, *Oryza sativa*

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1. Introduction

Rodents are highly troublesome, nuisance, virtually found everywhere, spread disease, destroy crops in the field, consume stored food, damage household property, and spoil forest and fruit trees. Rodents are one of the major problems directly concerning to the production, storage and processing of the agricultural crops and their eventual utilizations by man and his livestock as food (Sarwar et al., 2011; Sarwar, 2015 a; Sarwar, 2015 b). Rice (*Oryza sativa* L.), is the major crop in Pakistan and is cultivated over millions of hectares per year resulting in billions of annual income by selling to overseas markets, primarily in the Middle East and Asia. As a result, growers and other members of the rice industry have

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acquired benefits tremendously. In order to realize these emerging opportunities, the Pakistan's rice industry must continue to support the production and protection of rice that can serve as the foundation for its success (Akbar et al., 2005; Sarwar, 2011; 2012 a; 2012 b; 2012 c; 2012 d; 2013; 2014; Sarwar and Hamza, 2013; Sarwar et al., 2005; 2007; 2010). Amongst the various maladies, the rodents inflict severe damage to rice crop, which varies seasonally and among localities. Factors such as rainfall, soil types, plant cover and availability of food regulate rodent populations. The rodents obviously thriving in the rice fields; as such are competing with man for rice grains that also happens to be one of Pakistan's principal exports. Losses from rodents and birds were estimated to run about 5.1% (Roberts, 1981).

Wagle (1927) reported the seriousness of the problem of rice field rats in lower Sindh. At that time, losses in many areas were calculated to over 5% of the paddy crop. Bandicoot rat was the dominant rat species in the rice fields of lower Sindh. According to Greaves et al., (1975) in each hectare of the rice fields of the Lower Sindh, 10 kg of paddy was found stored in bandicoot's burrows. Whereas, Chakraborty (1977) who was working in the harvested rice fields estimated that an average of 3.2 kg of paddy was stored in each burrow system of bandicoot rat. Fulk and Akhtar (1981) assessed the average yield reduction attributed due to this rodent as 19% and ranged from 2 to 43%. Khan and Beg (1984) noted that the rats are known to concentrate mainly on rice grains when it is near harvest. This ability of the rats to exploit energy rich food quickly seems to lead to the acceleration in their rate of reproduction and these are known to breed at a very high rate. Sayaboc et al., (1984) reported the food consumed by the rats at the rate of 10% of their body weight. During the recent years their food habits had been further studied by some workers like Lathiya (1990), Asif et al., (1992); Hussain et al., (1994) and Workneh et al., 2004, consequent upon these, it was reported that the rats may have access to more than one type of crops during their nightly forging. Ahmad et al., (1995), and Hussain and Iqbal (2002) also reported rats inflicting severe damage. Rat damage was usually concentrated in the rice tiller / stem cutting at maximum tillering and damage intensifies during ripening stage (Islam and Hossain, 2003). In our country the rodents have not been received the keen attention like other agricultural pests. It is the time now for the plant protectionists to get involved in supporting rice to sequence the rice and to use that information to address their own rice interests. So, the present investigation was aimed to find species involved, the damage pattern they inflict and determining the relative toxicity of rodenticides (anticoagulants being chronic in nature, do not pose any bait shyness and additives were used to increase preference of poison baits) against rats and mice invading rice fields.

2. Materials and Methods

An experimental area of canal irrigated rice land near village 26/ E. B.; North to Arifwala (District Pakpattan) was selected. The experimental site was comprised of 15 acres of rice fields. The investigation was started from sowing and was continued till crop harvesting. To identify the rodents' specimen, the experimental area was randomly selected and sampled. To collect the specimens, 3 acres of randomly selected rice fields of experimental area were trapped for three consecutive nights using 3 traps per acre during tillering, booting and maturing growth periods of rice. The snap traps used were consisted of bait material of rice bread pasted with butter oil. The traps were set within a radius of 2 m in front of active burrows to sample both the peripheral and central areas of randomly selected field. The traps were set at dusk and collected next early morning. Traps were reset for the following nights, and trapped rodents collected and counted. The specimens so collected were brought to laboratory for identification by consulting literature. The species trapped near their burrows were considered as owner of that system. The relative abundance of each rodent species was estimated as: - % Population= Number of rodents caught × 100/ Total trap per night. The experimental site was also surveyed to recorded damage pattern and burrows distribution of the rats. To do the needful, sites for all the burrows in the fields and the crop damaged near the burrows were observed.

2.1. Poison Baits Preparation and Their Applications

Brodifacoum Bait		Warfarin Bait	
T1	T2	T3	T4
Corn flour (42.5 %)	Corn flour (42.5 %)	Corn flour (42.5 %)	Corn flour (42.5 %)
Broken rice (42.5 %)	Broken rice (42.5 %)	Broken rice (42.5%)	Broken rice (42.5%)
Brodifacoum (05 %)	Brodifacoum (05 %)	Warfarin (05 %)	Warfarin (05 %)
Sunflower oil (05 %)	Sunflower oil (05 %)	Sunflower oil (05 %)	Sunflower oil (05 %)
Egg (05%)	Minced chicken (05%)	Egg (05%)	Minced chicken (05%)

For comparative evaluation, brodifacoum and warfarin (anticoagulants) rodenticides were used to control rats and mice. The following procedure was followed for the preparation of previously cited poison baits containing corn flour, broken rice grain and sunflower oil as bait base along with egg and minced chicken as additives.

The poison baits containing trailed rodenticides were prepared separately by mixing their ingredients. Rice grains was thoroughly mixed with corn flour, vegetable oil, tested additives (egg, minced chicken), then poison powders were added and mixed thoroughly using an electric blender by adding sufficient water until a stiff dough was formed. From stiff dough, small pellets were prepared with an electric mincer fitted with a sieve having a diameter of about 10 mm. The above mentioned blended baits were dried and stored in plastic bags for use in the experiments.

2.2. Field Applications of Poison Baits

Before the application of poison baits, pre-baiting with plain rice grains was done for 3 days to avoid bait shyness development. In each acre of rice, seven bait stations were established, 4 out of 7 stations were established at four corners (10 paces inside the field), while, the other 3 were in a line in the center of the field. At the end of poison baiting, baits left at each bait station were collected and weighed to know the amount of baits consumed out of 50 gm sample to determine the relative intake of various formulated baits. Each treatment was applied in 1 acre replicated thrice along with a control block of 1 acre. The experimental design of the trial was a randomized complete block design. Baiting was done thrice i.e., during tillering, booting and maturity growth stages of crop. The relative levels of treated and untreated % baits consumption, rodent populations and % damage were recorded as indices for assessing effectiveness of both rodenticides and baits formulations as attractants. Efficacy of the trials was assessed through reduction in counts of live burrows. The active burrows were observed by using sand to close all burrows and then count the opened ones next day in the crop field. The number of rodents was recorded through active burrows method as: - % Population= Number of active entrance × 100/ Total number of entrance. In each treatment 20 samples were collected diagonally using wooden frame (40 × 40 cm), and the numbers of damaged and undamaged tillers inside the frame were counted in each sample. Then percentage of damage was calculated as: - % Damage tillers= Number of damaged tillers × 100/ Total tillers counted.

2.3. Statistic Used to Analyse Experimental Data

Prior to statistical analysis of data, means of all observations recorded were calculated using Statistix 8.1 computer software. Results were compared among all treatments by ANOVA, and means were separate by LSD (P = 0.05) test.

3. Results and Discussion

In this study, the bandicoot rat (*Bandicota bengalensis*) was one of the most devastating pests of rice, reducing its yield and the use of pesticides gave significant differences to pest's management.

3.1. Species of Rodents in Rice Field

Four species of rodents were abundant in the experimental rice fields, in order of their decreasing importance, the lesser bandicoot rat (*Bandicota bengalensis*), the metad (*Millardia meltada*), the short tailed mole rat (*Nesokia indica*), and the house mouse (*Mus musculus*) (Table 1). These species exploited the damage to the rice fields in the following ways:-

3.1.1. The Lesser Bandicoot Rat (*Bandicota bengalensis* Gray)

This pest achieved highest level of population abundance in the experimental area. Bandicoot rat inflicted damage to rice plant chiefly in three stages. During tillering stage, when crop attained a height of a few cm, the rats cut off the tillers at the bottom to feed on the lower sweet pulpy portion of stem. Damaged tillers were noted scattering fairly evenly throughout the fields. During booting stage when panicles were soft and milky, the rates bent over the tillers and fed on the milky pulp. At third stage i.e., maturity a far more serious type of damage was noted when grains started ripening and field dried up. The population of rats increased up to harvest and at that time bandicoots become most abundant species. They cut off ear heads from the tillers and fed on the ripened grains. The striking feature of the bandicoot rat in the immediate pre-harvest period was its underground hoarding of rice panicles. In a typical burrow system of this species, about 2.5 to 3 kg of paddy was found stored. So, this rat species damaged the stems, flowers and grains of rice crop. Their burrows were found both in the embankments and in the fields, but where there was water standing in the fields, they restricted themselves to the embankments.

3.1.2. The Metad (*Millardia meltada* Gray)

This species infested the rice fields in rather lower numbers than bandicoots, and their number remained relatively stable and did not fluctuate like bandicoots. They were observed feeding on flowers, ripening ear heads and grains, but not so heavily as did the bandicoots. There was no any hoarded food material in their burrow system. Their burrow system was shallow and in the embankments. Most of their population was noted in cracks and crevices formed in drying rice fields.

3.1.3. The Short Tailed Mole Rat (*Nesokia indica* Gray)

This pest species was not trapped during initial stage of crop, but attained abundance during subsequent periods before the rice harvested. Near their burrows they were seemed to eat only rice grains, but no any other part of plant was observed eaten. However, during tillering stage they preferred to feed on roots of rice plant. Its burrow system was found in the embankments extending into the rice fields themselves as the water dried. They did not hoard rice when their burrow system was checked internally.

3.1.4. The House Mouse (*Mus musculus* Linnaeus)

This species was most abundant in rice in pre-flowering stage. But during subsequent stages their numbers continually decreased but remained stable. Plant specimens near their burrow system showed that they seemed to consume rice grains only. Their burrow system was very simple and no any hoarded food was seen inside the burrow system.

The main onset of the attack by four rodents' species occurred during early flowering stage and continued until the crop was harvested and removed from the field. It was noted that at the later stage as the damage occurred, the greater reduction in plant growth was observed, while, damage at early stage, have no significant effect on growth at all.

Table 1. Average species complex of rodents trapped per acre in the rice fields.

Crop growth stage	Species Complex			
	Bandicoot rat	Metad rat	Short tailed Mole rat	House mouse
Tillering	1.33 b	0.66 a	0.00 a	0.66 a
Booting	2.00 b	1.00 a	0.66 a	0.33 a
Mature	3.00 a	0.66 a	0.66 a	0.33 a
LSD value	0.75	1.19	1.19	1.19

Means within columns followed by the same letters are not significantly different (*P* = 0.05).

3.2. Poison Baits Preference and Their Effectiveness

The output of results on the preference and effectiveness of poison baits are arranged in Table 2, the findings of the study, suggested that brodifacoum poison comprising different additives had the better potential to enhance the poison baits acceptance to achieve effective control of this nefarious malady. The results ascertained that rodenticides treatments where eggs used as attractants were preferred the most by rodents' species as compared to baits prepared by using minced chicken or the control treatment. The results on feeding acceptance were significant; on average brodifacoum poison baits with egg additive remained highly preferred (90.33%) than that of chicken additive (80.33%). Similar acceptance attitudes were observed with warfarin by having higher consumption strength with egg additive (70.00%) as compared to chicken (60.17%). Studies presented showed that differences existed between the brodifacoum and warfarin poisons treatments for the entire criterion under consideration than the non-additive control baits (15.00%). Brodifacoum also contributed in reducing the pest population and percentage damage over warfarin and untreated plots. Results revealed that brodifacoum with egg combination gave the highest control than with chicken (2.66, 3.33 pests, respectively) and the lowest damage (2.00%, 2.66%, respectively). Warfarin with egg baits treated plots showed higher pest control and % damage as compared to chicken additive (4.33 and 5.66 pest; 3.16% and 3.93%, respectively). Rodent populations and % damage infestation were the highest in the control plots (9.66 pest and 7.66%, respectively).

Table 2. Comparative effectiveness of rodenticides in reducing rodent's population and damage.

Treatments	% Consumption	Population	% Damage
Brodifacoum + Egg	90.33 a	2.66 c	2.00 d
Brodifacoum + Chicken	80.33 ab	3.33 c	2.66 cd
Warfarin + Egg	70.00 bc	4.33 bc	3.16 bc
Warfarin + Chicken	60.17 c	5.66 b	3.93 b
Check	15.00 d	9.66 a	7.66 a
LSD	10.41	2.18	0.95

Means within columns followed by the same letters are not significantly different (*P* = 0.05).

The results of this study yielded four rodents species viz., *Bandicota bengalensis, Millardia meltada, Nesokia indica* and *Mus musculus* on one hand and led insight into the damage pattern inflicted by these rodents' species and reduction in their population on the other side. The bandicoot was the primary rodent pest of rice throughout the crop season. These observations are in confirmation with that of Wagle (1927), who reported the bandicoot rat as the dominant rat species in the rice fields of lower Sindh; and other irrigated crops including rice in the Punjab province (Shahnaz et al., 2006). A typical burrow system analysis had reflected that this species stored about 2.5 to 3 kg of paddy. These results are in agreement with that of Chakraborty (1977), who estimated that on an average, 3.2 kg of paddy was stored in each burrow system of the bandicoot rat. The food hoarded material per burrow system on an average was 0.478 kg which equalled 660 ear heads recovered per burrow (Sidra et al., 2011). General field observations revealed that the rat damage near booting stage was slight; and generally the damage at maturity was appreciably higher. Similarly, losses from rat damage in transplanted rice do not increase appreciably until about the booting stage, as compared with damage occurring in the mature crop. Since rat damage in the tillering stage of rice was negligible, the impact of stem cutting may not have any significant effect on yield. Taking the results of this study into consideration, it is clear that rodent control operation in rice may be uneconomical before booting stage, but most economical at booting stage.

Our experimental results also suggested that for rodents' control, addition of eggs with brodifacoum improved baits acceptance and baits shyness trend was minimum. Some other workers had demonstrated such studies, for example, studies conducted by Mathur and Parakash (1981), reported similar findings after completion of their observations. These researchers reported brodifacoum single dose anticoagulant to be very effective against many rodents' species from different ecological regions. But Parasad et al., (1981) reported a contradictory finding that during assessment of brodifacoum poison baits palatability in choice feeding test, rodents' species consumed significantly less poison baits than the plain alternative. Shafi et al., (1993) found minced meat bait highly preferred over egg when eggshell and egg yolk were offered separately and enhanced its acceptability by 72.71% as compared with non-additive poison bait. Hence, the rats' selected baits in a preferential order, but, availability of baits, distribution, presentation and amount of baits also played an important role. Observing other species while forging may also play a significant part in food selection. Similar to our findings, Pervez et al., (2003) conducted laboratory studies to evaluate the palatability of poison baits by incorporating whole egg, milk yeast, fish meal, and minced beef indicated a liking for various additive baits over plain bait. Egg and milk baits were preferred over other additive combination; egg (3%) under multiple concentrations, enhanced the acceptance of baits containing anticoagulant rodenticides.

Present investigations had revealed that additive poison baits mixture of rodenticide plus egg was preferred and most effective to achieve a successful pest control. It may be assumed that enhanced consumption of these baits combination may be due to the fact that eggs might had made the texture of bait base more attractive and palatable. Thus, behavior modifying components may play a significant role in developing the most attractive baits. Naeem et al., (2011) investigated the behavior revolutionizing effects of taste enhancers (including peanut oil, peanut butter, egg shell and fishmeal) as an exploratory approach of rodents control to ensure maximum intake of poison baits by the pest. Results of the investigations showed that dietary preferences of *B. bengalensis* depend upon many factors including particle size, palatability, taste, flavor and nutritious value of bait base and the taste enhancers. Conversely, baiting techniques should be modified according to the psychological characteristics, bait shyness, feeding behavior, exploratory behavior, transporting, hoarding and territoriality behavior of the target species (Lund, 2008).

4. Conclusion

Effective plant protection in rice field is essential for increasing crop production and productivity, and the present studies have crossed milestone of rodents management paradigm from individual to area wide pest management across the regions. Present results revealed that a guild of four rodent species like, lesser bandicoot rat (*B. bengalensis*), metad (*M. meltada*), short tailed mole rat (*N. indica*) and house mouse (*Mus musculus*) was observed damaging in the rice fields. On the other hand, bandicoot rat (*B. bengalensis*) was found the key and the mainly prevailing pest species. On the basis of present studies, results on effectiveness of rodenticides viz., brodifacoum and warfarin showed that mean population of rodents, varied significantly among treatments and control fields. However, brodifacoum gave comparatively better results in pest controlling than warfarin that remained significant with each other during all observations. The minimum mean % damage by all the rodents was recorded with brodifacoum, a single dose anticoagulant that was lowerly progressed by warfarin, a multiple dose anticoagulant as compared to untreated check. On an average, the relative acceptance of poison baits by rodents was also satisfactory. Although rodent species, their damage pattern and behavior may differ considerably between various regions, but, the present pest management strategy will be equally important for adopting control operation with respect to any crop or rice variety. Adoption of integrated pest management (IPM) uses a range of preventive measures to control pests and it significantly reduces the need to use chemicals through networks of partnerships and collaborations.

References

[1] Ahmad, E., Hussain, I. and Brooks, J.E. 1995. Losses of stored food due to rats at grain markets in Pakistan. Int. Biodet. Biodeg., 125-133.

[2] Akbar, A., Sarwar, M., Ahmad, N. and Tofique, M. 2005. Evaluation of Different Granular Insecticides for the Suppression of Rice Stem Borers. Proce. 25th Pakistan Conger. of Zoology, March 1-3, SAU, Tandojam. 25: 49-55.

[3] Asif, M.M., Brooks, J.E. and Ahmad, E. 1992. The diet of the lesser bandicoot rat, *Bandicoota bengalensis*, in wheat and rice crops in Central Punjab, Pakistan. Pakistan J. Zool., 24: 119-121.

[4] Chakraborty, S. 1977. Field observation on the biology and ecology of the lasser bandicoot rar, *Bandicoota bengalensis*, in West Bangal. All India Rodent Seminar, Ahmadabad, Sep. 23-26, 1975. p. 102-109.

[5] Fulk, G.W. and Akhtar, M.T. 1981. An investigation of rodent damage and yield reduction in rice. Trop. Pest Management, 27(1): 116-120.

[6] Greaves, J.H., Fuld, G.W. and Khan, A.A. 1975. Preliminary investigations of the rice rat problem in Lower Sindh. Proc. All India Rodent Seminar, Ahmadabad, Sep. 23-26 1975. p. 1-5.

[7] Hussan, . and Iqbal, M.A. 2002. Occurrence of rodent filth in grain commodities sampled from ration shops, Rawalpindi. Pakistan J. Zool., 26: 239-122.

[8] Hussan I, Ahmad M and Brooks JE 1994. Effect of seasonal variations in diet and climatic factors on reproduction of the bandicoot rat, *Bandicoota bengalensis*. Pakistan J. Zool., 26: 119-126.

[9] Islam, Z. and Hossain, M.M. 2003. Control of rats at the ripening stage of a rice crop. IRRN 28.1. 49-50.

[10] Khan, A.A. and Beg, M.A. 1984. Repoduction and structure of a *Bandicoota bengalensis* population in agroecosystem. Pakistan J. Agric. Sci., 21: 49-60.

[11] Lathiya, S.B. 1990. Food habits of *Bandicoota bengalensis* in a rice field of Southern Sindh. Pakistan J. Zool., 22: 301-303.

[12] Lund, M. 2008. Rodent behaviour in relation to baiting techniques. EPPO Bull., 18: 185-193.

[13] Mathur, R.P. and Parakash, I. 1981. Evaluation of brodifacoum against *T. indica, M. hurrianae* and *R. rattus*. J. Hyg. Camb., 87: 179-184.

[14] Naeem, M., Ahmed, I., Hussain, I. and Ahmedani, M.S. 2011. Performance of taste enhancers mixed with cereal bases and evaluation of the most preferred bait composition for *Bandicota bengalensis* (Gray). African Journal of Biotechnology, 10 (19): 3938-3944.

[15] Parasad, V.P., Ahmed, N. and Chopra, G. 1981. Laboratory and field evaluation of brodifacoum for rodent control. Int. Biodeter, 21: 107-112.

[16] Pervez, A., Ahmed, S.M. and Rizivi, S.W.A. 2003. Evaluation of some additives to improve poison bait acceptance in the bandicoot rat, *Bandicoota bengalensis*. Pak. J. Zool., 35 (2): 109-113.

[17] Roberts, T.J. 1981. Handbook of vertebrate pest control in Pakistan. Compiled by vertebrate pest control, Karachi. p.216.

[18] Sarwar, M. 2011. Effects of Zinc fertilizer application on the incidence of rice stem borers (*Scirpophaga* species) (Lepidoptera: Pyralidae) in rice (*Oryza sativa* L.) crop. Journal of Cereals and Oilseeds, 2 (5): 61-65.

[19] Sarwar, M. 2012 a. Effects of potassium fertilization on population build up of rice stem borers (lepidopteron pests) and rice (*Oryza sativa* L.) yield. Journal of Cereals and Oilseeds, 3 (1): 6-9.

[20] Sarwar, M. 2012 b. Management of aromatic rice (*Oryza sativa* L.) genotypes using varietal resistance against the prevalence of rice stems borers. International Journal of Agronomy and Plant Production, 3 (8): 295-299.

[21] Sarwar, M. 2012 c. Management of rice stem borers (Lepidoptera: Pyralidae) through host plant resistance in early, medium and late plantings of rice (*Oryza sativa* L.). Journal of Cereals and Oilseeds, 3 (1): 10-14.

[22] Sarwar, M. 2012 d. Study on the non aromatic rice (*Oryza sativa* L.) varietals resistance to rice stem borers (Lepidoptera: Pyralidae) and yield factors. International Journal of Agronomy and Plant Production, 3 (5): 159-163.

[23] Sarwar, M. 2013. Valuation of Some Aromatic Rice (*Oryza sativa* L.) Genetic Materials to Achieve Tolerant Resources for Rice Stem Borers (Lepidoptera: Pyralidae). International Journal of Scientific Research in Environmental Sciences, 1 (10): 285-290.

[24] Sarwar, M. 2014. Implementation of Integrated Pest Management Tactics in Rice (*Oryza sativa* L.) for Controlling of Rice Stem Borers (Insecta: Lepidoptera). Rice Plus Magazine, 6 (1): 4-5.

[25] Sarwar, M. 2015 a. Species Diversity, Seasonal Variation and Abundance of Rodents (Mammalia: Rodentia) Along With Their Burrow Distribution Pattern in Wheat Farmland. Journal of Basic and Applied Research International, 5 (1): 48-55.

[26] Sarwar, M. 2015 b. Pattern of Damage by Rodent (Rodentia: Muridae) Pests in Wheat in Conjunction with Their Comparative Densities throughout Growth Phase of Crop. International Journal of Scientific Research in Environmental Sciences, 3 (4): 159-166.

[27] Sarwar, M. and Hamza, A. 2013. Adoption of Integrated Pest Management Strategy in Rice (*Oryza sativa* L.). Rice Plus Magazine, 5 (9): 6-7.

[28] Sarwar, M., Ali, A., Ahmad, N. and Tofique, M. 2005. Expediency of Different Botanical Products Intended for Managing the Population of Rice Stem Borers. Proce. 25th Pakistan Conger. of Zoology, March 1-3, Sindh Agriculture University, Tandojam. 25: 15-23.

[29] Sarwar, M., Akbar, A., Ahmad, N., Khan, G.Z., Bux, M. and Tofique, M. 2007. Field Performance of Systemic Foliar and Granular Insecticides against Rice Stem Borers (*Scirpophaga* spp.) in Rice Crop. Proce. 26th Pakistan Conger. of Zoology, Multan, March 1-3. 27: 89-94.

[30] Sarwar, M., Ashfaq, M. and Baig, M.Y. 2011. The Species Complex, Damage Pattern and Control of Rodents (Mammalia: Rodentia) in Sugarcane (*Saccharum officinarum* L.) Fields. Intl. J. Agron. Plant. Prod., 2 (4): 145-150.

[31] Sarwar, M., Ahmad, N., Nasrullah and Tofique, M. 2010. Tolerance of different rice genotypes (*Oryza sativa* L.) against the infestation of rice stem borers under natural field conditions. The Nucleus, 47 (3): 253-259.

[32] Sayaboc, P.D., Caliboso, F.M., Bengino, E.A. and Hilario, J.M. 1984. Rodents losses in commercial grain storage. In: 7th Ann. Work. Grain Postharvest Technology, Aug. 21-24, Kuala Lumpur, 27 p.

[33] Shafi, M.M., Pervez, A., Ahmed, S. and Ahmed, S.M. 1993. Some approaches to enhance poison bait acceptance in the lesser bandicoot rats, *Bandicoota Bengalensis*. Trop. Sci., 33: 350-358.

[34] Shahnaz, A.R., Naureen, R., Zafar, M. and Farhan, S. 2006. Seasonal Demographic Variation in Bandicoot Rats, *Bandicota Bengalensis* (Gray) in Irrigated Crops. Pak. J. Agric. Sci., 43 (1-2): 63-68.

[35] Sidra, M., 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 (5): 987-992.

[36] Wagle, P.V. 1927. The rice rates of Lower Sindh and their control. J. Bomby Nat. Hist. Soc., 32: 330-338.

[37] Workneh, G., Afework, B., Gurja, B. and Balakrishnan, M. 2004. Microhabitat choice and diet of rodents in Maynugus irrigation field, northern Ethiopia. Afr. J. Ecol., 42: 315-321.