Pakistan J. Zool., pp 1-5, 2022. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20200504090547

Impact of Ecological Manipulation on Rodent Population Inhabiting Croplands of District Chakwal

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Article Information
Received 04 May 2020
Revised 05 April 2022
Accepted 21 April 2022
Available online 10 June 2022
(early access)

Authors' Contribution
SM and BAR conceived and design the study. SM, AA and NM conducted field work. MSA and TM proofread the manuscript.

Key words
Ecological manipulation, Chakwal, Pothwar, Maturity, Cover

ABSTRACT

Present study was designed to determine impact of ecological manipulation on rodent density inhabiting croplands in district Chakwal, Pothwar Pakistan. Rodent density and crop damage were assessed in treated and reference sites each of about 2.5 ha. Four rodent species was investigated in following order of dominance: *Bandicota bengalensis* > *Nesokia indica* >*Tatera indica* > *Golunda ellioti.* Maximum ($P<0.05$) rodent density was found in reference sites (2.03 ± 0.04 ha^{-1}) as compared to treated sites (1.18 ± 0.05 ha^{-1}). However, at each study sites, maximum activity ($P<0.05$) of rodents was recorded inside of the crop field (1.75 ± 0.02 ha^{-1}) in relation to the boundary (1.46 ± 0.04 ha^{-1}) of the field. 6.20%, 1.30% and 0.77% crop damaged was calculated at maturity, tillering and sowing stage respectively. Ecological manipulation has resulted in remarkable reduction ($P<0.05$) in the density of rodents in treated areas compared to reference sites. Present study concluded that removing cover from field boundaries control rodent population in subsequent growing stages of crops.

INTRODUCTION

Rodents are identified as major vertebrate pests at global level (Cuong *et al*., 2002) and damaged standing crops, fruits, orchards, stored grains and poultry farms (Singleton *et al*., 1999). They have limited requirements and are generalist in their feeding habits and can survive in all terrestrial habitats and even manmade environments. Order Rodentia is the largest mammalian order comprising of 30 families and almost 2,700 species (Aplin *et al*., 2003). In Pakistan, the total loss to crop amounts 19 billion/ year due to rodents. Only in Punjab, the annual loss to wheat crops by rodents costs about 52 billion (Beg *et al*., 1985).

The major crops of the area are wheat and groundnut. In Pothwar plateau rodents cause considerable damage to wheat and groundnut crops making 3.4% loss to groundnut crop and 10% loss to wheat crop respectively (Fulk *et al*., 1980). The utmost target in agricultural system is to control rodents to reduce crop losses by applying cost-effective techniques, which increase the quantity of marketable product and post-harvest cost lower. In Pakistan, the only practical technique in work is to remove the vegetation from field boundaries (Khan *et al*., 2009). However, many other methods have been employed to control rodents and application of rodenticides is one of them (Singleton, 2003). Poison baits are used commonly in Pakistan for control of rodents. Rodenticide which is used commonly for control of rodents by farmers is zinc phosphide. Due to its higher operational costs, it is difficult for farmers to use it in fields, so it poses problems to poor farmers. However, rodenticides are commonly available in the local market, but due to ignorance of farmers, use of inappropriate dose and bait shyness, rodent populations are normally seen.

Ecological manipulation is an ecologically based, cost effective and hazard free control measure for controlling rodents compared to rodenticides (Whisson, 1996). The removal of vegetation covers in the dry season by cattle grazing, burning, ploughing, hand cutting and machine cutting are approaches of ecological manipulation to reduce rodent populations (Green and Taylor, 1975). Hence the present study was designed to analyze the impact of ecological manipulation (removal of vegetation cover) on

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0030-9923/2022/0001-0001 $ 9.00/0

rodent population in wheat cropping system in Pothwar area and its impact on sowing, tillering and maturity of wheat cropping system in Chakwal, Pothwar Pakistan.

MATERIALS AND METHODS

Study area

The present study was conducted in district Chakwal (32° 56' N, 72° 54' E) of the Pothwar plateau. District Chakwal covers total area of 6,524 km² while only 3181 km² used for agriculture purposes. Maize, millet, sorghum, wheat and groundnuts are major cropping system of the area. Mean annual rainfall of the area is about 519 mm while mean annual temperature is 22.3 °C.

Study design

Through reconnaissance survey, 3 treated and 3 reference/control study sites were selected each having an area of 2.5 ha (158m x 158m). Distance between treated and reference sites were at least 200m to prevent rodents movement between sites. These sites were selected on basis of rodent infestation, logistic approach and fallow land patches associated with boarder vegetation. Sites included: Dhokh chingi (N 32° 52.826', E 072° 23.275'), Khair pur (N 32° 44.041', E 072° 48.664') and Kotira (N 32° 56.603', E 072° 36.121'). Live burrow counts were used to assess rodent density at boundary and inside crop field.

Manipulation of treated sites

Wild vegetation on the crop field boundaries was removed by cutting grasses/herbs, shrubs, forbs and flowering plants as described by Fox *et al*. (2003) before two weeks of sowing wheat. The impact of vegetation removal on treatment and control blocks was evaluated by active/live burrow count method.

Assessment of rodent activity

Live and inactive burrow counts of rodent species were carried out in the wheat crop. Burrow systems that carry no dirt/fresh soil were considered as inactive while burrows with fresh soil particles, faecal pallets in front of the burrow mouths were taken as active burrows. Burrow identification of each rat species was carried out as suggested by Brooks *et al*. (1988). The burrow of the bandicoot rat was characterized by the larger soil particles, visible burrow openings, visible runways having crops residues scattered and spindle-shaped fecal droppings while *Nesokia indica* burrows have generally smaller soil particles pushed up from the tunnels and characterized by capsule-shaped fecal droppings mixed into the mounded soil. The burrows of the *Tatera indica* were simple and have one or two surface openings while those of *Golunda elioti* makes nest like structure in exclusively on field edges.

Rodent damage assessment

Rodent damage assessment was conducted in three growth stages of wheat crop as suggested by Sarwar (2015). At each study sites, 20 wooden quadrates (1m x 1m) were taken after every two weeks. The total number of tillers and number of tillers damaged by rodents inside wooden quadrate were counted and given as damaged (%) as suggested by Sarwar (2015).

$$\text{Damage (\%)} = \frac{\text{No. of tillers damaged}}{\text{Total number of tillers}} \times 100$$

Percentage reduction

Impact of habitat manipulation in treated sites were calculated on basis of reduction in number of burrows at sowing, tillering and maturity stage of wheat crop by using following formula as described by (Henderson and Tilton, 1955).

Reduction = No. of active burrows in reference sites - No. of active burrows in treated sites.

However, Percentage reduction was calculated by the following formula;

$$\text{Percentage Reduction} = \frac{\text{Reduction}}{\text{No. of active burrows in reference sites}} \times 100$$

Statistical analysis

The data are presented as mean ± SEM. The data on ecologically based manipulation at different crop stages (sowing, tillering and maturity) and study sites (treated/ reference) were analyzed by two factor factorial design of ANOVA using (MSTAT-C®; version 1.42, Michigan State University, East Lansing, MI, USA). When F-ratio was significant ($P<0.05$), post hoc comparison between the means was carried out through Fisher's protected LSD test.

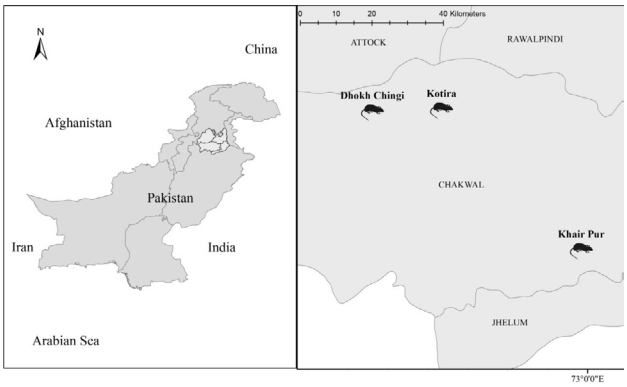

Fig. 1. Map of Pothwar Plateau, Pakistan showing location of study sites selected at district Chakwal.

RESULTS

Rodent activity after manipulation

The data on the number of rodent activity in treated sites (boundary and inside of field) and reference sites (boundary and inside of field) at wheat crop stages (sowing, tillering and maturity) are given in Figure 2. At each study site, maximum (P<0.05) rodent activity was recorded at inside of the crop field (1.75 ± 0.02 ha^{-1}) compared to boundary (1.46 ± 0.04 ha^{-1}) of the field (F = 7.07, 15.04, 0.03, 3.62, 43.83, 44.41, 14.51, 2.14, 16.04, 42.07, 1.42, 6.92, d.f.= 1; P<0.05).

Higher (P<0.05) rodent activity was observed at maturity (1.87± 0.03 ha^{-1}) (F=77.12, 96.79, 18.98, 160.2; d.f.=1) compared to tillering (1.12± 0.02 ha^{-1}) (F=3.03, 0.007, 3.283, 22.64; d.f.=1) and sowing (0.89± 0.02 ha^{-1}) (F=18.66**,** 9, 0.0563, 17.34; d.f.=1) stage of wheat crop. Maximum (P<0.05) numbers of rodent burrows were observed in the reference fields (2.03± 0.04 ha^{-1}) as compared to treated fields (1.18± 0.05 ha^{-1}).

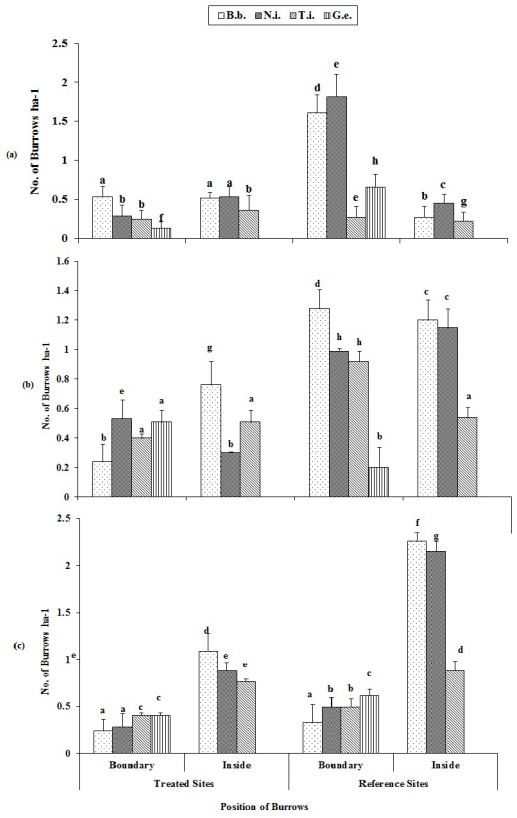

Fig. 2. Rodent activity in treated and reference sites at sowing stage (a), tillering (b) and maturity (c) of wheat crop in study area. Bars with different letters showed statistically significant differences (P<0.05) among the treated and reference sites.

Rodent damage assessment

The data on the rodent damage assessment at growth stages (sowing, tillering and maturity) of wheat crop are given in Figure 3. It showed that rodents cause less (P<0.05) damage at sowing stage (0.77 %) compared to tillering (1.30 %) and maturity (6.20 %) stage of crop.

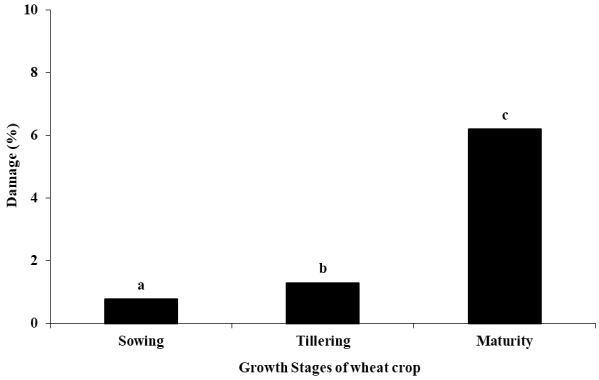

Fig. 3. A comparison of damage in wheat farmland by different rodent species at various growth stages of crop. Bars with different letters showed statistically significant differences (P<0.05) among the treated and reference sites.

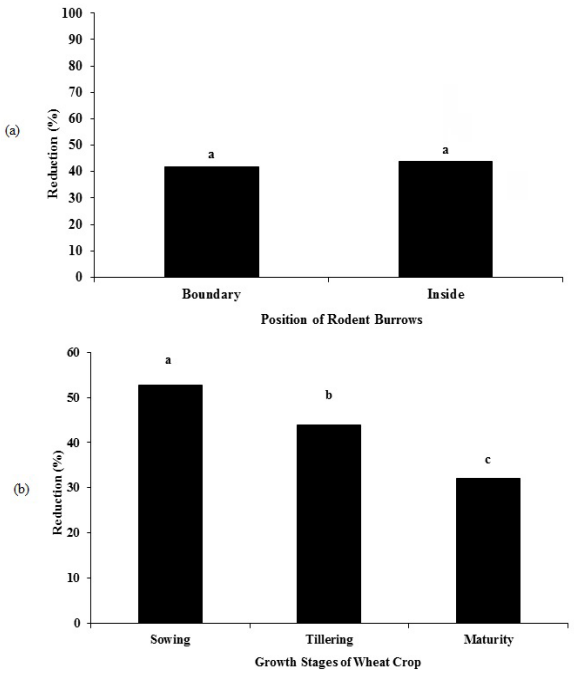

Fig. 4. Impact of ecological manipulation on reduction (%) in rodent activity at boundary and inside (a) and growth stages of wheat crop (b). Bars with different letters showed statistically significant differences (P<0.05) among growth stages of wheat crop.

Percent reduction in rodent activity after manipulation

The data on ecologically based management of rodent species in the treated fields are given in Figure 4. It shows that maximum (P>0.05) reduction (%) was found similar at inside of the crop field (43.7%) and boundary (41.8%) of the wheat crop. However, percentage reduction in the number of rodent activity was significantly higher (P<0.05) at sowing (52.7%) compared to tillering (43.9%) and maturity (32%) stage of wheat crop.

DISCUSSION

Rodents are distributed worldwide and a serious agricultural pest in Pakistan. Rodenticides provide an immediate solution to the rodent problem and form major component of rodent control strategies in Pakistan (Hussain *et al*., 2003). The difficulties, hazards, cost, and apparent inefficiency of widespread use of rodenticides have led to consider habitat manipulation as control measure (Stuart *et al*., 2013). Habitat manipulation by reducing the vegetation height is an old approach a management tool for farmers. Little published data is available on relationship between vegetation density and rodent population. Hence present study was designed to analyze the impact of habitat manipulation on rodent population at district Chakwal.

Four rodent's species were reported in study area during data collection that included *B. bangalensis, N. indica, T. indica* and *Golunda ellioti*. Study conducted by Hussain *et al*. (2003) revealed presence of five species of rodents in the croplands of Pothwar plateau that were *B. bangalensis, N. indica, T. indica, Golunda ellioti* and *Mus musculus*. Murids are considered as the major activists in wheat-sugarcane based crops in central Punjab (Beg *et al*., 1980). They cause damage to agricultural crops by spoiling, gnawing and hoarding activities while synchronizing with the cropping system and breeding during growing period of crops (Sarwar *et al*., 2011). It has been reported that vertebrate pests are responsible for causing much loss to not only the stored food but also the standing crops in many ways. The damage caused by rodent pests is irreversible as they directly damage seeds, growing seedlings and roots (Singleton *et al*., 1999; Makundi *et al*., 2010).

Present study reveals maximum (P<0.05) rodent burrows was present at maturity stage of wheat as compared to tillering and sowing. It is clear that rodents cause significant damage in terms of stem cutting at ripening/ maturity stage compared to other growth stages of wheat crop**.** This was due to the fact that maturity stage of wheat crop provides both food and shelter to the rodents which are crucial for their growth and reproduction and rodents directly correlates breeding pattern with growth stage of crop (Cuong *et al*., 2002; Khan *et al*., 2009; Munawar *et al*., 2018). Higher (P<0.05) numbers of rodent burrows were observed in the reference fields as compared to treated fields. Our results suggested that rodent's burrows decrease in number at treated fields as removal of cover from field boundaries exposed rodents to predators which in turn decrease crop damage (Stuart *et al*., 2013) and increase crop yield (Pusineus and Schmidt, 2002).

Current study also reveals that reduction (%) did not differ significantly (P>0.05) at inside and crop boundary (41.8-43.7%). However, at sowing stage, more reduction (P<0.05) in number of rodent burrows were observed as compared to tillering and maturity stage of wheat. This was due to the fact that during sowing stage of wheat, rodents move to crop boundary which provides good cover and food. During tillering and maturity, rodents move inside crop field as maturity stage of crop provides good sustainability (Fulk *et al*., 1980).

Habitat manipulation by reducing the vegetation height had considerable effect in limiting rodent population. This decline was ascribed mainly due to predation as they were being exposed to environment (Fox *et al*., 2003; Monamy and Fox, 2010). This technique should be carried out in a large area 3-4 weeks prior to sowing stage of crop. The dry season is the only time when these methods can be effective; in this season there are no crop and rodent populations are concentrated along field edges and in relatively small patches of uncultivated land. It is concluded that removal of wild vegetation from the crop field boundaries before sowing had negative impact on rodent population in subsequent crop growth.

ACKNOWLEDGEMENTS

The authors are thankful to Higher Education Commission, Pakistan for providing funds and this work was carried out under a research project "Ecologically-based rodent Management in Croplands of Pothwar Plateau, Pakistan (20-2547/NRPU/R& D/HEC/13).

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Aplin, K.P., Brown, P.R., Jacobs, J., Krebs, C.J. and Singleton, G.R., 2003. *Field methods for rodent studies in Asia and the Indo-Pacific*. ACIAR Monograph No. 100, pp. 223.

Beg, A.R., Baig, M.S., Ali, Q. and Khan, C.M.A., 1985. *Agro-ecological zonation of Pothwar: A wheat, B-Maize*. National Agricultural Research Centre, Islamabad; Pakistan Forest Institute, Peshawar; Siol

Survey of Pakistan, Lahore. pp. 68.

Brooks, J.E., Ahmad, E. and Hussain, I., 1988. Damage by vertebrate pests to groundnut in Pakistan. In: *Proceedings 13th vertebrate pest conference* (eds. A.C. Crabb and R.E. Marsh). University of California, Davis, USA, pp. 129-133.

Cuong, L.Q., Chien, H.U., Han, L.U., Duc, V.H. and Singleton, G.R., 2002. Relationship between rodent damage and yield loss in rice in Mekong Delta. In: *Rats, mice and people, rodent biology and management* (eds. G.R. Singleton, U. Chien, L.U. Han, V.H. Duc and L.Q. Cuong). Australian Center for International Agriculture Research, Australia. pp. 217-219.

Fox, B.J., Taylor, J.E. and Thomson, P.T., 2003. Experimental manipulation of habitat structure: A retrogression of the small mammal succession. *J. Anim. Ecol*., **72**: 927–940. https://doi.org/10.1046/j.1365-2656.2003.00765.x

Fulk, G.W., Smiet, A.C. and Khokhar, A.A., 1980. Movements of *Bandicota bengalensis* and *Tatera indica* as revealed by radio telemetry. *J. Bombay Nat. Hist. Soc.,* **76**: 457-462.

Green, M.D., and Taylor, K.D., 1975. Preliminary experiments in habitat alteration as a means of controlling field rodents in Kenya. *J. Ecol. Bull*., **19**: 175-186.

Henderson, C.E. and Tilton, E.W. 1955. Test with acaricides against the brown wheat mite. *J. Econ. Ent.,* **48**: 157-161. https://doi.org/10.1093/jee/48.2.157

Hussain, I., Cheema, A.A. and Khan, A.A., 2003. Small rodents in the crop ecosystem of Pothwar plateau, Pakistan. *Wildl. Res*., **30**: 269-274. https://doi.org/10.1071/WR01025

Khan, A.A., Hussain, I. and Munir, S., 2009. Control of rodent damage to groundnuts in the Pothwar Plateau region of Pakistan. *Pakistan J. Zool*., **41**: 203-207.

Makundi, R.H., Massawe, A.W., Mulungu, L.S. and Katakweba, A., 2010. Species diversity and population dynamics of rodents in a farm-fallow field mosaic system in Central Tanzania. *Afr. J. Ecol.,* **48**: 313-320.

Monamy, V. and Fox, B.J., 2010. Responses of two species of heathland rodents to habitat manipulation: Vegetation density thresholds and the habitat accommodation model. *J. Austral. Ecol.,* **35**: 334-247. https://doi.org/10.1111/j.1442-9993.2009.02042.x

Munawar, N., Hussain, I. and Mahmood, T., 2018. Occurrence of rodent species in agricultural lands during cropping and non-cropping seasons of Pothwar Plateau, Pakistan. *Pakistan J. Zool*., **50**: 1663-1669. https://doi.org/10.17582/journal.pjz/2018.50.5.1663.1669

Pusenius, J. and Schmidt, K.A., 2002. The effects of habitat manipulation on population distribution and foraging behavious of mesdow voles. *OIKOS*., **921**: 251-262. https://doi.org/10.1034/j.1600-0706.2002.980207.x

Sarwar, M., Ashfaq, M. and Baig, M.Y., 2011. The species complex, damage pattern and control of rodents (Mammalia: Rodentia) in sugarcane (*Saccharum officinarum*) fields. *Int. J. Agron. Pl. Prod*., **2**: 145-150.

Sarwar, M., 2015. Pattern of damage by rodent (Rodentia: Muridae) pests in wheat in conjunction with their comparative densities throughout growth phase of crop. *Int. J. Sci. Res. environ. Sci.,* **3**: 159-166. https://doi.org/10.12983/ijsres-2015-p0159-0166

Singleton, G.R., 2003. *Impacts of rodents on rice production in Asia*. International Rice Research Institute, Los Banos, Philippines. pp. 30.

Singleton, G.R., Leirs, H., Hinds, L.A. and Zhang, Z., 1999. *Ecologically based management of rodent pests: Re-evaluating our approach to an old problem*. Australian Center for International Agriculture Research, Australia. pp. 17-29.

Stuart, A.M., Prescott, C.V. and Singleton, G.R., 2013. Habitat manipulation in lowland rice coconut cropping systems of the Philippines an effective rodent pest management strategy. *Pest Manag. Sci.*, **70**: 939–945. https://doi.org/10.1002/ps.3631

Whisson, D., 1996. The effect of two agricultural techniques on population of canefield rat (*Rattus sordidus*) in sugarcane crops of North Queensland. *Wildl. Res*., **23**: 589-604. https://doi.org/10.1071/WR9960589