



This is a repository copy of *Evaluation of economic loss caused by Indian crested porcupine (Hystrix indica) in agricultural land of district Muzaffarabad, Azad Jammu and Kashmir, Pakistan.*

White Rose Research Online URL for this paper:
<https://eprints.whiterose.ac.uk/178193/>

Version: Published Version

Article:

Ashraf, R.Z., Ahmad, B., Shafique, F. et al. (7 more authors) (2023) Evaluation of economic loss caused by Indian crested porcupine (*Hystrix indica*) in agricultural land of district Muzaffarabad, Azad Jammu and Kashmir, Pakistan. *Brazilian Journal of Biology*, 83. e249847. ISSN 1519-6984

<https://doi.org/10.1590/1519-6984.249847>

Reuse

This article is distributed under the terms of the Creative Commons Attribution (CC BY) licence. This licence allows you to distribute, remix, tweak, and build upon the work, even commercially, as long as you credit the authors for the original work. More information and the full terms of the licence here:
<https://creativecommons.org/licenses/>

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

Original Article

Evaluation of economic loss caused by Indian crested porcupine (*Hystrix indica*) in agricultural land of district Muzaffarabad, Azad Jammu and Kashmir, Pakistan

Avaliação da perda econômica causada pelo porco-espinho de crista indiano (*Hystrix indica*) em terras agrícolas dos distritos de Muzaffarabad, Azad Jammu e Caxemira, Paquistão

R. Z. Ashraf^a , B. Ahmad^a , F. Shafique^b , M. U. Hassan^{c,d,*} , N. Asim^e , M. W. Muhammad^f , S. Khawaja^g , S. Butt^c , N. Akbar^h  and N. Sheikh^a 

^aUniversity of Azad Jammu and Kashmir, Department of Zoology, Muzaffarabad, Pakistan

^bUniversity of Sheffield, Department of Biomedical Science, Sheffield, UK

^cShaheed Benazir Bhutto Women University, Department of Microbiology, Peshawar, Pakistan

^dUniversity of Sheffield, Department of Molecular Biology and Biotechnology, Sheffield, UK

^eThe University of Agriculture, Institute of Biotechnology and Genetic engineering, Division of Genomics and Bioinformatics, Peshawar, Pakistan

^fInstitute Peshawar, Division Pakistan Forest, Peshawar, Pakistan

^gUniversity of Azad Jammu and Kashmir, Department of Biotechnology, Muzaffarabad, Pakistan

^hHazara University Manshera, Department of Biotechnology and Genetic Engineering, Hazara, Pakistan

Abstract

The Indian crested porcupine (*Hystrix indica*) is a vertebrate pest of agricultural lands and forest. The study was aimed to report the damage to local crops by the Indian crested porcupine (*Hystrix indica*) in the Muzaffarabad District. A survey was conducted to identify the porcupine-affected areas and assess the crop damage to the local farmers in district Muzaffarabad Azad Jammu and Kashmir (AJK) from May 2017 to October 2017. Around 19 villages were surveyed, and a sum of 191 semi-structured questionnaires was distributed among farmers. Crop damage was found highest in village Dhanni where a porcupine destroyed 175 Kg/Kanal of the crops. Regarding the total magnitude of crop loss, village Danna and Koomi kot were the most affected areas. More than half (51.8%) of the respondents in the study area suffered the economic loss within the range of 101-200\$, and (29.8%) of the people suffered losses in the range of 201-300\$ annually. Among all crops, maize (*Zea mays*) was found to be the most damaged crop ranging between 1-300 Kg annually. In the study area, porcupine also inflicted a lot of damages to some important vegetables, including spinach (*Spinacia oleracea*), potato (*Solanum tuberosum*) and onion (*Allium cepa*). It was estimated that, on average, 511Kg of vegetables are destroyed by porcupine every year in the agricultural land of Muzaffarabad. It was concluded that the Indian crested porcupine has a devastating effect on agriculture which is an important source of income and food for the local community. Developing an effective pest control strategy with the help of the local government and the Wildlife department could help the farmers to overcome this problem.

Keywords: economic loss, agricultural land, porcupine, crop destruction.

Resumo

O porco-espinho de crista indiano (*Hystrix indica*) é uma praga vertebrada de terras agrícolas e florestais. No estudo atual, o dano às plantações locais pelo porco-espinho de crista indiano (*Hystrix indica*) foi relatado pela primeira vez no distrito de Muzaffarabad. O estudo foi projetado para investigar a perda econômica causada pelo porco-espinho de crista indiano (*Hystrix indica*) nos distritos de Muzaffarabad, Azad Jammu e Caxemira (AJK) de maio de 2017 a outubro de 2017. Um estudo baseado em pesquisa foi conduzido para identificar as áreas afetadas por porcos-espinhos e avaliar os danos às colheitas para os agricultores locais. Cerca de 19 aldeias foram pesquisadas e um total de 191 questionários semiestruturados foi distribuído entre os agricultores. Os danos às colheitas foram encontrados mais intensamente na aldeia Dhanni, onde um porco-espinho destruiu 175 kg / Kanal das colheitas. Em relação à magnitude total da perda de safra, as aldeias Danna e Koomi Kot foram as áreas mais afetadas. Mais da metade (51,8%) dos entrevistados na área de estudo sofreu perdas econômicas na faixa de 101-200 \$, e 29,8% das pessoas sofreram perdas na faixa de 201-300 \$ anualmente. Entre todas as culturas, o milho (*Zea mays*) foi

*e-mail: muhassan1@sheffield.ac.uk

Received: March 14, 2021 – Accepted: April 21, 2021



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

considerado a cultura mais danificada, variando entre 1-300 kg anualmente. Na área de estudo, o porco-espinho também causou muitos danos a alguns vegetais importantes, incluindo espinafre (*Spinacia oleracea*), batata (*Solanum tuberosum*) e cebola (*Allium cepa*). Estimou-se que, em média, 511 kg de vegetais são destruídos pelo porco-espinho todos os anos nas terras agrícolas de Muzaffarabad. Concluiu-se que o porco-espinho de crista indiano tem um efeito devastador na agricultura, que é importante fonte de renda e alimento para a comunidade local. O desenvolvimento de uma estratégia eficaz de controle de pragas com a ajuda do governo local e do Departamento de Vida Selvagem pode ajudar os agricultores a superar esse problema.

Palavras-chave: perda econômica, terras agrícolas, porco-espinho, destruição de safra.

1. Introduction

Indian crested porcupine (*Hystrix indica*) is a very widespread species with no major threats, hence it is assessed as Least Concern and is considered as a pest (Amori et al., 2016). It belongs to order Rodentia and family Hystricidae. It is a large rodent having average weight of 11 to 18 Kg and an average lifespan of 27.1 years (Voss et al., 2013). Its body measures between 70 and 90 cm with a tail adding an additional 8 to 10 cm (Vasudeva et al., 2017; Voss et al., 2013). The Indian porcupine is found throughout the south east, central Asia and in parts of the Middle East, Africa, America and Europe (Mohamed, 2011; De Oliveira et al., 2013; Dor, 1975; Walker, 1999; Amori et al., 2016).

In Pakistan, Porcupine is distributed in Punjab, Sindh, mountainous areas of Khyber Pakhtunkhwa and in steppe mountain regions of Baluchistan up to 2,750 m elevation (Lovari et al. 2017; Chattha et al., 2013; Roze, 2012; Mushtaq et al., 2013; Mushtaq et al., 2012). In Azad Kashmir, it is found in the upland valleys of Jhelum and Neelum, in deciduous forests of Machiara National Park at 3,200 m elevation (Mushtaq et al., 2013).

Porcupine has a broad habitat tolerance occupying rocky hillside, tropical and temperate shrubland, grasslands, forests, arable land, plantations and gardens (Amori et al., 2016). It lives in natural caves or in excavated burrows because this species does not climb or jump. No specific measures for its conservation are in place or needed (Amori et al., 2016).

Indian crested porcupine is a semi fossorial and a generalized herbivore (Kelt, 2011). It feeds on forest plantations, ornamental trees, fruit orchards and on human articles containing salts (Oriens, 2020). It utilizes plant tissues such as bark, roots, tubers, bulbs, corms and rhizomes either by up-ground debarkation, clipping or by digging the subterranean parts, the vegetation thus affected includes shrubs, geophytes, hemi cryptophytes (Lovari et al. 2017; Witmer and Pitt, 2012; Kelt, 2011; Roze, 2012). Porcupines also feed on commercial crops and grasses of grazing thus leading to a significant loss for agriculture in Pakistan (Laurenzi et al., 2016). Altogether, it is estimated that vertebrate pests cause economic losses directly or indirectly to the tune of 17 million US \$ annually based on the production statistics (Govt support price, 1984-85).

Crop and tree damage by porcupines has been documented in Asia, Africa and in the British Isles. It destroys trees in yards, golf courses, forest plantings, ornamentals, nursery plants and orchards vegetation on the agricultural property (Lovari et al., 2017). It causes the greatest damage in winter when porcupines feed on the inner bark of trees (Witmer and Pitt, 2012), but according to Van (2009), winter is often the worst time for porcupine

tree damage, as they have no or smaller vegetation to eat but in the summer, porcupines feed more on fruits, vegetables and succulent plants.

In some areas, damage to fruit and nut orchard plantations by porcupines can be extensive. The species can be extremely destructive to crops such as maize, groundnut, wheat, fruits, sugar cane and melon (Lovari et al. 2017; Laurenzi et al., 2016; Roze, 2012; Mushtaq et al., 2013). It is a serious pest of vegetables such as potato, okara, pumpkin, bitter gourd and onions, flowering plants and grasses (Laurenzi et al., 2016; Roze, 2012; Hafeez et al., 2011).

Porcupine crop raiding is reported to be the major causes of crop losses inflicted by wildlife (Lemessa et al., 2013). It was reported that 3.80% of total crop damage in agriculture regions is caused by a porcupine (Wellsmith, 2011). Timber companies frequently cite porcupines for extensive damage to commercial plantations (Reidinger Junior and Miller, 2013). In Kashmir, no study has ever been conducted to report the economic loss due to crops/vegetables damage. The present study has been designed to explore the Indian crested porcupine (*Hystrix indica*) affected areas, to identify the magnitude of crop damages and to evaluate the economic loss in the district Muzaffarabad of Azad Jammu and Kashmir, Pakistan.

2. Materials and Methods

2.1. Study area

The study was conducted in agriculture lands of district Muzaffarabad, the capital of Azad Jammu and Kashmir. The district lies at N 34° 20.755 and E 73° 27.923 between the elevation of 737 m and 1103 m above sea level, covering an area of 1642 km² (Umar et al., 2018). The district has a population of 650,370 people per census 2017 (The Nation, 2017). The average annual rainfall is 1457 mm, and the average annual temperature is 20.2°C. The maximum temperature is 45°C, and the minimum is below 0°C. Snow falls on mountains and sometimes in the city also (Mahlstein et al., 2013; Umar et al., 2018).

The study area has a diverse habitat in the form of rivers, green fields and thickly vegetated areas. People have their own agricultural lands, where crops like maize, wheat, vegetables, rice etc., are cultivated. Maize is the major crop people cultivate in their lands, along with wheat which is cultivated in the winter season (Iqbal and Khan, 2014).

2.2. Study design

The surveys were conducted during July and September in the year 2017, after the harvest. The study was carried out in nineteen villages and their corresponding sub-villages, which were divided into grids of 5X5 km (Figure 1) to

ensure even distribution of the survey, 191 persons were interviewed out of which 184 were males, and 07 were females (Figure 2).

Data of questionnaire survey conducted in the respective grid was used to gather information about the nature and extent of porcupine related economic loss to important crops and farmers' knowledge, attitudes and practices to their management in the study area. The questionnaire data were augmented with guided interviews, participatory observations and focus group discussions with farmers in the villages where people have a large area of agricultural lands. Interviews were conducted primarily with the head of the households, mostly males. However, in case of the absence of the head of the family, other family members (females) were interviewed.

For confirmation and accuracy, direct surveys of the affected fields in the study area were conducted to monitor the losses in crop season (July-September).

2.3. Field surveys

Affected ears of maize, damage remains of vegetables and grasses were physically inspected in the field. Porcupine burrows were inspected and measured, a distance of fields from burrows was measured, and quills of porcupine were collected to confirm its presence in a specific place. Global Positioning System (GPS), digital camera, light sources, measuring tape were used during data collection. ArcGIS 10.3 was used to create the descriptive maps of the study area. Geographic coordinates taken from the main villages

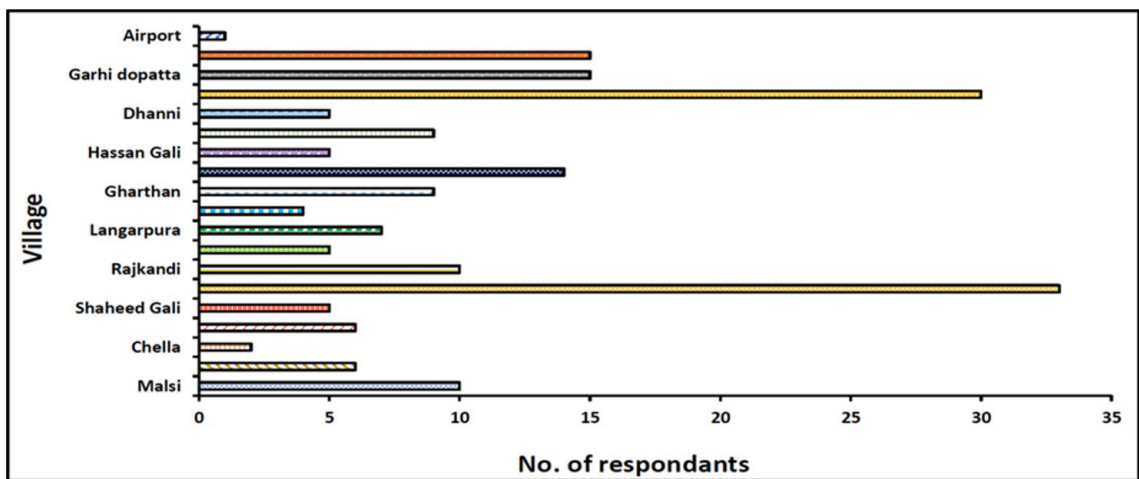


Figure 1. Map of the study area (district Muzaffarabad) divided into grids of 5x5 km.

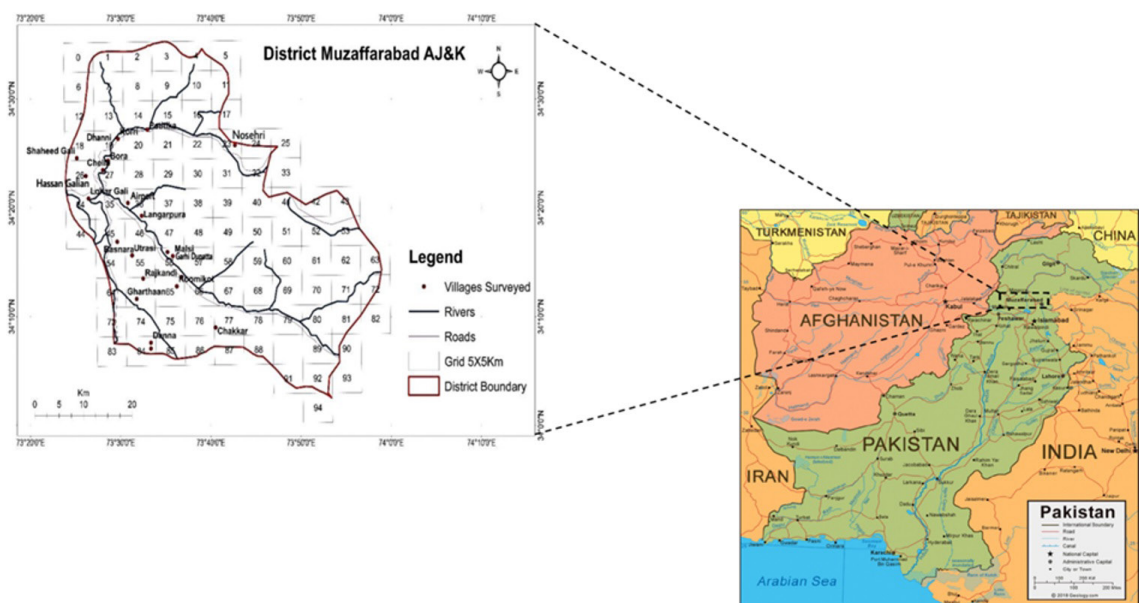


Figure 2. Responses collected from the villages affected by the porcupine.

affected due to porcupine crop damage were charted on the map to see the distribution patterns of damages in the area.

2.4. Statistical analysis

The data were analyzed using statistical software SPSS Inc. 2016.

3. Results

The results indicated that economic loss and magnitude of crop damage was considerably high enough to affect the socio-economic condition of the local community.

3.1. Crop cultivation pattern

The present study was conducted in nineteen villages affected by a porcupine, where maize, wheat and vegetables were cultivated. Most people (n=186) cultivate maize during the summer season and wheat in the winter season. Results showed that 53% of respondents (n=101) of affected people cultivated all types of vegetables, including spinach (*Spinacia oleracea*), mustard leaves (*brassica juncea*), potato (*Solanum tuberosum*), and onion (*Allium cepa*). Fruits and rice production is minimum as only 5%, and 4% of the respondents cultivate these crops, respectively (Figure 3).

Most of the respondents (94.2%) cultivated maize each year. Forty percent of respondents yielded between 1-200 Kg of maize per year. Similarly, 15.5% had the maize yield between 301-400 Kg/year, and 7.7% of respondents had the yield in the range of 2001-3000 Kg/year. Most of the respondents (n=178) cultivate wheat annually in the study area, out of which 40.9% get the yield within the range of 1-200 Kg/year, and 13.4% get gross yield within 301-400 Kg/year. People were also cultivating vegetables such as spinach (*Spinacia oleracea*), mustard (*brassica juncea*), and potato (*Solanum tuberosum*), and onion (*Allium cepa*). Fifty-three percent of respondents (n=101) cultivate vegetables each year. Forty-five percent of respondents got the yield within the range of 1-500 Kg/year. Rice and

fruits were cultivated by only 4.7% (n=9) and 5.2% (n=10) of respondents, respectively. People have fewer amounts of irrigated lands, and there is no water system for the irrigation of rice crops; hence people are unable to produce more rice (Figure 4).

3.2. Cost of crops grown in the study area

Around 34.9% of the respondents claimed the cost of their crops (wheat and maize) ranged between \$201 to \$300, similarly to 21.4% respondents, who claimed \$301-\$400 for these crops, and about 14% of people in the study region produce the crops having cost lying in the range of \$401-\$500 annually (Figure 5).

3.3. Time of crop-raiding by porcupines

It was observed that the porcupines raided the fruiting or rooting stage of the crops growing cycle, according to 91% of the respondents. During summers, almost all the crops were destroyed in some areas and nearly half of the crops in most regions of the study area. It is also known that during winter, it feeds on tree bark and debarks berry tree, pine tree rosewood. Attacks on the crops vary during a season; in some cases, this rodent visits daily for feeding, while in some cases, it forages after several months (Table 1). The Indian crested porcupine stuck to its nocturnal habit in the study area, and mostly it raided crops during the night, as explained by the respondents (n=181).

3.4. Evidence of porcupine raids

Porcupine burrows were inspected during the study to confirm their existence in the area. The average length of the burrow was recorded at 1.5 feet, and the width was between 10 to 12 cm. Site of the burrows was so challenging to reach in the fields; this tactic of burrow construction helps porcupine avoid predators. Proof of the damages was observed by inspecting the fields and observing and collecting the quills (Supplementary Data). The distance of the burrows from fields was also noted; the average distance from fields was between 100 to

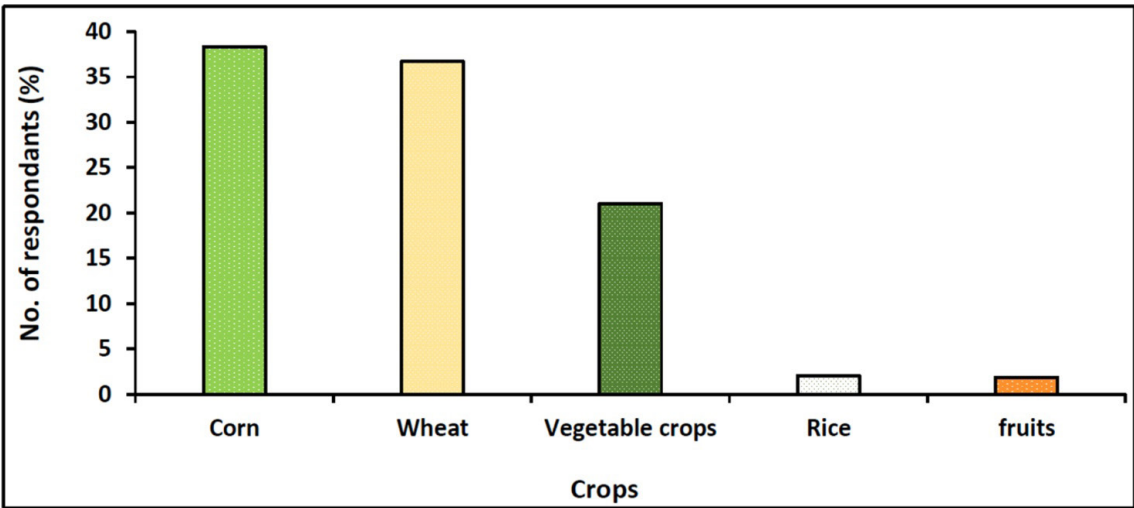


Figure 3. Crops cultivated in the study area.

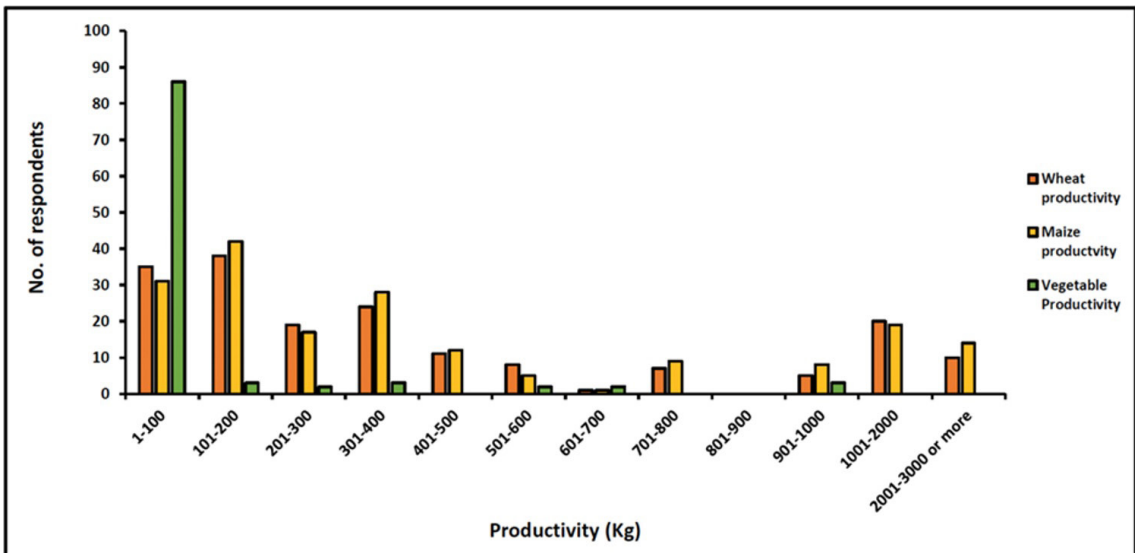


Figure 4. Annual gross productivity of crops in the study area.

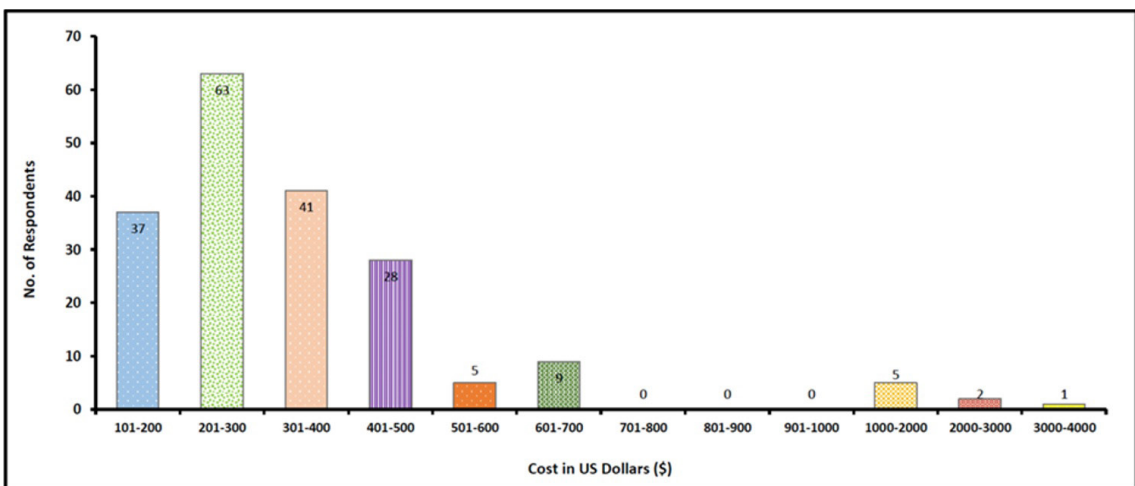


Figure 5. Cost of crops cultivated in the study area.

Table 1. Time of crop raided by porcupine.

During growing cycle				
Germination		Seedling	Flowering	Fruiting/Rooting
No. of respondents (%)	2	1	6	91
During a Season				
Summer and Winter		Summer	All four seasons	
No. of respondents	23	107	61	
During a Calendar Year				
Annually		Weekly	Monthly	Daily
No. of respondents (%)	13	8	39	40

300 feet. A significant relationship was observed between the distance of burrows from the fields and the crop loss.

3.5. Most affected areas

During the current study, data were collected from nineteen different villages. The village which was most affected in terms of crop loss was Danna (n=15) and its adjacent villages (Kachili, Darbang, Haryolla and Timbi); the estimated maize crop loss was reported to be in the range of 15,000-20,000 Kg/year. At the same time, the vegetable loss in this area lies between 500-1000 Kg/year. In terms of loss per unit area, Dhanni mai sahiba was the most affected village where 175 Kg/kanal crops were lost every year by the porcupines. In contrast, the amount of crop loss here was far less because people in this area had less agricultural land as compared to other areas (Table 2).

3.6. Relation of elevations with agricultural land and crop loss

The correlation was considered significant at the 0.05 level. Study area villages (N = 19) are on higher elevation as the region is hilly. There was a positive correlation (0.415, > 0.05) between elevation and maize loss and for elevation and vegetable loss (0.173, > 0.05). People have more agricultural land as the elevation increases, and here we observed a positive correlation (Correlation coefficient = 0.526).

3.7. The magnitude of crop loss

Present research reveals that every night on average, 2 kilograms of maize ears were damaged and destroyed by the porcupine. Ninety-four percent (n=186) of the respondents in the study area cultivated maize crop out of which 55.5% (n=100) suffered the damage within the range of 1-100 Kg/year, followed by 15% (n=27) who lost 101-200 Kg/year, and 4.4% (n=08) faced the crop loss ranging between 401-500 Kg/year in the study area. On average, 2,745 Kg of the maize crop was destroyed by porcupines in every village of Muzaffarabad per year.

The magnitude of vegetable damage was less as compared to maize. The average vegetable loss was recorded

to be 511.1 Kg/year in every village of Muzaffarabad. This was because people in the grow fewer vegetables regularly for business purposes. In the present study, 52.8% of respondents (n=101) cultivated the vegetables, 6.2% (n=12) did not give any information about the vegetable loss due to uncertainty. In comparison, 46% of respondents (n=75) had the vegetable damage magnitude lying within the range 1-100 Kg/year. In contrast, 4.9% had a vegetable loss in the range of 201-300 Kg/year (Figure 6). The magnitude of crop loss per Kanal of the agricultural land was evaluated, highest in Dhanni, where 175 Kg/Kanal of the crop was lost every year. These crops were mostly vegetables which local people sell for earning the livelihood. Crop cultivation was less compared to other villages since people own less agricultural land in this village. Moreover, in village Danna, crop loss was reported to be 45 Kg per Kanal annually due to porcupine raiding (Table 3).

3.8. Altitudinal variation in crop loss

Different elevations had a different magnitude of crop loss. Since the rural areas were on the elevation in district Muzaffarabad, crop loss was recorded more on high altitudes. With respect to the elevation village, Danna, which lies in the elevation range of 1501-1600m above sea level, was the most affected village losing 45 Kg of the crop per Kanal (Table 4).

3.9. Spatial variation in crop loss

According to a recent study, 60,632 Kg of the crops were lost due to porcupine in the area, including maize and vegetables. Most of the crop loss was recorded in Danna, which was 34.5%, followed by Koomi Kot where damage was 19.3% of the total crop loss in the study area. The least affected villages were Airport and Korri, where 0.19% and 0.20% of the total crop loss was recorded, respectively (Figure 7).

3.10. Evaluation of economic losses

According to the current study, 51.8% of people in the study area faced an economic loss within the range of 101-200\$ each year while 29.8% people suffered the

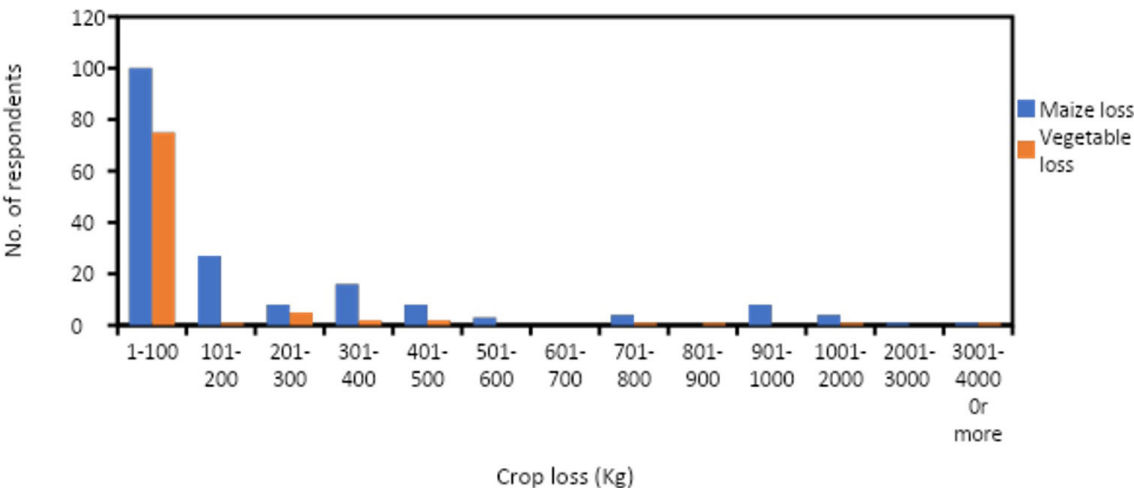


Figure 6. Annual crop loss in the study area.

Table 2. Spatial pattern of porcupine affected areas and the magnitude of crop damage.

Villages and sub villages	GPS coordinates	Elevation (m)	Crop loss per annum (kg)	
			Maize	Vegetable
Bura	N34° 24.124 E73° 28.541	719	820	100
Chella	N34° 23.449 E73° 28.001	759	270	0
Korri	N34° 26.335 E73° 29.686	762	125	0
Garhi Dopatta (Thotha, Bagh, Sultanabad)	N34° 14.097 E73° 36.856	822	3470	900
Dhanni	N34° 24.344 E73° 28.541	841	470	1640
Langarpura	N34° 19.377 E73° 32.166	844	950	0
Airport	N34° 20.442 E73° 30.784	866	120	0
Basnara (upper and lower)	N34° 16.092 E73° 29.283	875	460	130
Malsi (Pain, Bala)	N34° 15.563 E73° 35.774	931	5400	0
Lohar Gali	N34° 20.824 E73° 26.429	1104	1700	344
Gharthan	N34° 15.185 E73° 30.001	1190	1000	35
Hassan Galian	N34° 22.952 E73° 26.176	1220	1560	0
Nosehri	N34° 25.811 E73° 42.603	1247	1010	266
Rajkandi	N34° 13.730 E73° 32.821	1289	2320	400
Koomi Kot (Buthani, Koomi, Kot. Kandi, Banjosa, Saway)	N34° 12.769 E73° 36.215	1344	8450	3170
Shaheed Gali	N34° 24.558 E73° 25.133	1379	1140	95
Danna (Kachili, Darbang, Haryolla, Timbi, Rarra, Matyae)	N34° 7.600 E73° 33.361	1555	20150	597
Utrasi	N34° 15.185 E73° 31.500	1610	2170	405
Chikaar	N34° 8.9901 E73° 40.512	1616	350	219

loss in the range of 201-300\$ moreover 12% had the financial damage between the range of 301-400\$. Very few people (2.6%) had a large of land for farming, so the

loss exceeded the range and ranged between 401-500\$ every year. Similarly, 2.09% of people faced a loss in the range of 501-600\$ per season. Mean loss in the study

Table 3. Crop loss (Kg/Kanal) inflicted by a porcupine in the agricultural land.

Villages and sub villages	Agricultural land (in Kanals)	Crop Loss per kanal (Kg)
Malsi (Pain, Bala)	138	39.1
Bura	44	20.9
Chella	6	45
Basnara (upper and lower)	100	5.9
Shaheed Gali	55	22.4
Utrasi	550	4.6
Rajkandi	165	16.4
Chikaar	39	14.5
Langarpura	139	6.8
Korri	38	3.2
Gharthan	153	6.7
Nosehri	263	4.8
Hassan Galian	58	26.8
Lohar Gali	133	15.3
Dhanni	12	175.8
Koomi Kot (Buthani, Koomi, Kot. Kandi, Banjosa, Saway)	1125	10.32
Garhi Dopatta (Thotha, Bagh, Sultanabad)	247	17.69
Danna (Kachili, Darbang, Haryolla, Timbi, Rarra, Matyae)	460	45.1

Table 4. Crop loss due to porcupine with respect to different elevation ranges.

Elevation Range (m) above sea level	Names of villages falling in elevation range	Total agricultural land (Kanal)	Total crop loss (Kg)	Loss per kanal (Kg)
700-800	Chella, Bura, Korri	88	1315	14.9
801-900	Basnara, Langarpura, Dhanni, Garhi Dopatta, Airport	506	8,140	16
901-1000	Malsi	138	5,400	39.1
1001-1200	Lohar Gali	286	3,079	10.7
1201-1300	Hassangalian, Nosehri, Rajkandi	486	5,952	12.2
1301-1400	Shaheedgali, Koomikot	1180	12855	10.89
1401-1500		0	0	
1501-1600	Danna	460	20,747	45.1
1601-1700	Chikar, Utrasi	589	3,144	5.3

area due to porcupine was in the range of 101-200\$ every year (Figure 8).

4. Discussion

During the present study, the porcupine was reported to cause severe economic damage to the local population. Economically important crops are severely damaged in agricultural lands of all regions. Moreover, the species is enormously destructive to gardens and crops such as maize

and vegetables such as okra, pumpkin, onions, potato, bitter gourd, mustard leaves and spinach. In the present study, 55.5% of respondents (n=100) bear the maize damage lying within the range of 1-100 Kg/year, followed by 15% (n=27) who have maize loss of 101-200 Kg/year while 4.4% of farmers (n=08) face the crop loss ranging between 401-500 Kg in the study area. Similarly, 74.2% (n=75) had the vegetable damage magnitude lying within the range 1-100 Kg per year while 4.9% have the vegetable loss in the range of 201-300 Kg per year due to porcupine raiding, and this loss ranges up to 4000 Kg/year. In rangelands,

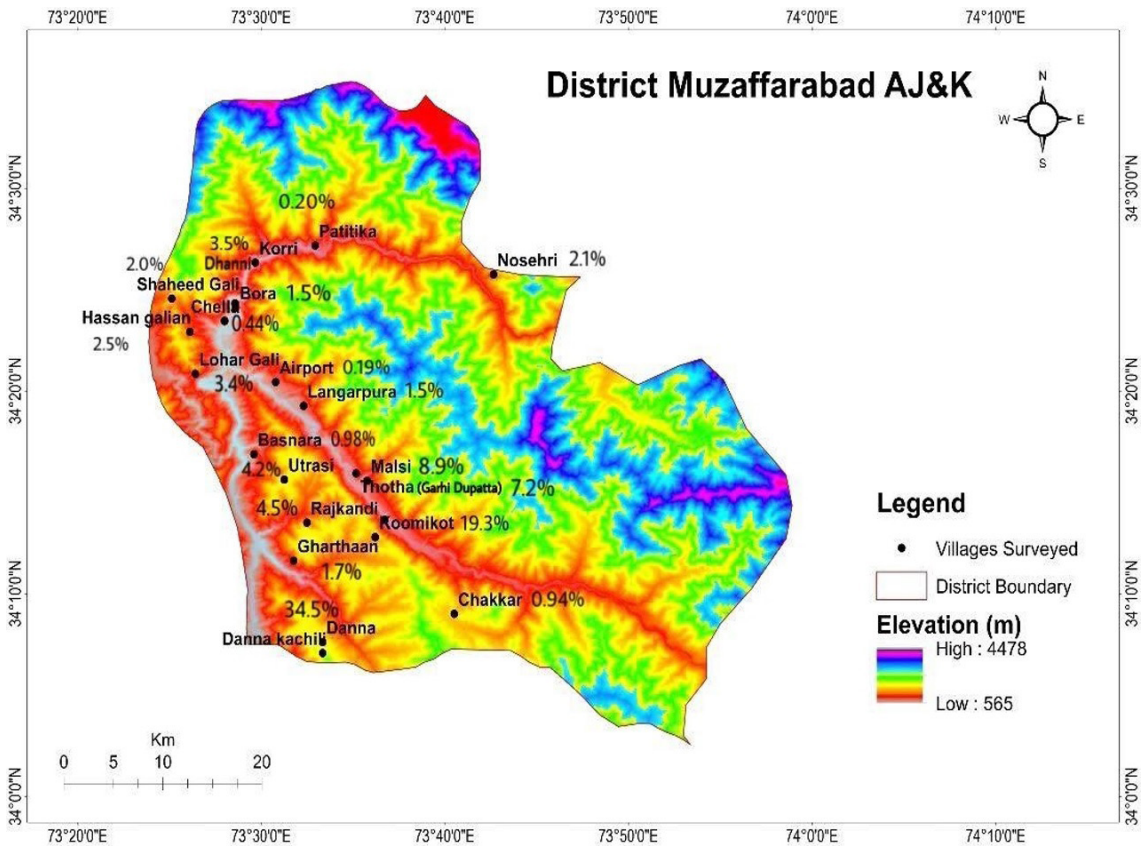


Figure 7. Map showing the percentage of crop (Maize and Vegetable) damages in different villages of the study area.

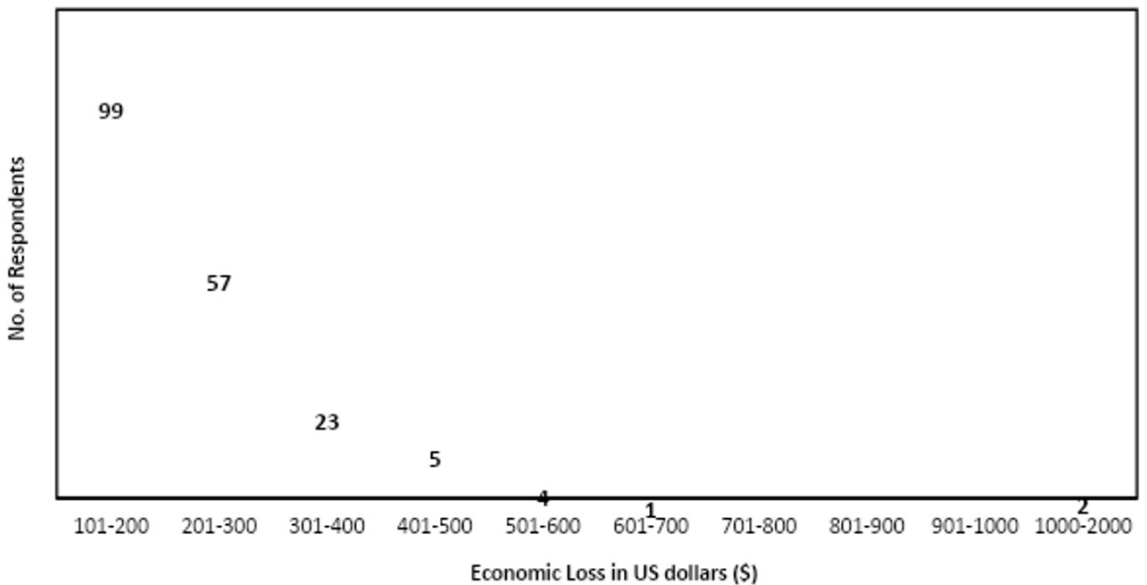


Figure 8. Economic loss caused by porcupines in the study area.

different species of grasses such as *Pennisetum* sp., *Cenchrus ciliaris* and *Cymbopogon jawarancusa* are uprooted, which severely affects the sustainable grazing of cattle. The same

behaviour was reported by many other authors (Oriani, 2020; Lovari et al., 2017; Laurenzi et al., 2016; Roze, 2012; Mushtaq et al., 2013; Hafeez et al., 2011).

Shafi (1990) reported that this vertebrate pest causes economic losses directly or indirectly to the tune of Rupees 1893 million annually based on the production statistics Govt support price (1984-85); recent evaluation supports this fact as it was evaluated that porcupine causes loss in the range of 101 to 200 US dollars to every local farmer annually in the study region (n=191). This loss seems less as compared to the report mentioned above reason being that the study area has far less population than that of the study area mentioned in the report. Still, this loss is enough for the economic instability of the local middle-class population of the area.

Witmer and Pitt (2012) reported that the porcupine is usually nocturnal and is active throughout the year. The current study also confirmed the nocturnal habit of a porcupine. According to the respondents (56%), it was found to be more active for foraging during the summer season in the study area.

Indian porcupines can cause some medical problems and the possibility that humans or, more significantly, pets may encounter their quills (Rasheed et al., 2020). There were no reports of any medical problems in the study area in the recent investigation; however, this study confirms that quills cause injuries to people and pet dogs if they come in contact with the quills of a porcupine, as one individual was reported injured by porcupine quills and pet dogs were more frequently injured by porcupine quills.

People have their agricultural land where crops, like maize, wheat, vegetables, rice etc., are cultivated. In a recent study, it was confirmed since above 90% of people in the area cultivate maize and wheat crop while more than 50% cultivate vegetables in the area moreover only 4% people cultivate rice in the area this is because of less irrigated agricultural lands since water deficiency is a recent problem people are facing they only rely on rainwater mostly for irrigation, which seems to be not enough moreover Awan et al. (2000) and Iqbal and Khan (2014) reported that some of these crops are used for selling to earn a livelihood, and some are used domestically this is also confirmed in a recent study, and it was known that 10.9% people in the area cultivate crops and use for both selling and domestic use and 86.3% people use their crops only for domestic purposes.

5. Recommendation

The agricultural and wildlife departments of Azad Jammu and Kashmir should make effective policies to combat these threats of crop loss, leading to huge economic loss to local farmers. More research is needed to evaluate the economic losses caused by other pests in Azad Jammu and Kashmir. Awareness is needed to be given to local farmers to minimize the economic loss by using advanced methods of eradicating the crop loss by the pests.

Ethical approval and consent to participate

The study was approved by the Agriculture University of Peshawar, which have the authority to approve research

topics, and it also deals with ethical issues at the University of Agriculture Peshawar.

Funding

This study was completely supported by the Department of Zoology, University of Azad Jammu and Kashmir Muzaffarabad.

Acknowledgements

A heartfelt acknowledgement to the team of Hepatitis Society University of Azad Jammu & Kashmir Muzaffarabad and the University of Sheffield for their active involvement during field study and data collection.

References

- AMORI, G., HUTTERER, R., KRYŠTUFK, B., YIGIT, N., MITSAIN, G. and PALOMO, L.J., 2016 [accessed 14 March 2021]. *Hystrix indica* [online]. The IUCN Red List of Threatened Species. Available from: www.iucnredlist.org
- AWAN, M.N., AWAN, M.S. and AHMAD, K.B., 2000. A preliminary study on distribution of avian fauna of Muzaffarabad Azad Jammu and Kashmir, Pakistan. *International Journal of Agriculture and Biology*, vol. 6, no. 2, pp. 300-302.
- CHATTHA, S.A., IQBAL, S., RASHEED, Z., RAZZAQ, A., HUSAIN, M. and ABBAS, M.N., 2013. Human-leopard conflict in Machiara National Park (MNP), Azad Jammu and Kashmir (AJ and K), Pakistan. *Pakistan Journal of Zoology*, vol. 47, no. 1, pp. 222-228.
- DE OLIVEIRA, S.V., ESCOBAR, L.E., PETERSON, A.T., GURGEL-GONÇALVES, R., 2013. Potential geographic distribution of hantavirus reservoirs in Brazil. *PlosOne*, vol. 8, no. 12, pp. e85137. <https://doi.org/10.1371/journal.pone.0085137>.
- DOR, M., 1975. *Zoological lexicon: vertebrata*. Tel Aviv: Dvir, p. 47.
- HAFEEZ, S., KHAN, G.S., ASHFAQ, M. and KHAN, Z.H., 2011. Food habits of the Indian crested porcupine (*Hystrix indica*) in Faisalabad, Pakistan. *Pakistan Journal of Agricultural Sciences*, vol. 48, no. 3, pp. 205-210.
- IQBAL, M.F. and KHAN, I.A., 2014. Spatiotemporal land use land cover change analysis and erosion risk mapping of Azad Jammu and Kashmir, Pakistan. *The Egyptian Journal of Remote Sensing and Space Sciences*, vol. 17, no. 2, pp. 209-229. <http://dx.doi.org/10.1016/j.ejrs.2014.09.004>.
- KELT, D.A., 2011. Comparative ecology of desert small mammals: a selective review of the past 30 years. *Journal of Mammalogy*, vol. 92, no. 6, pp. 1158-1178. <http://dx.doi.org/10.1644/10-MAMM-S-238.1>.
- LAURENZI, A., BODINO, N. and MORI, E., 2016. Much ado about nothing: assessing the impact of a problematic rodent on agriculture and native trees. *Mammal Research*, vol. 61, no. 1, pp. 65-72. <http://dx.doi.org/10.1007/s13364-015-0248-7>.
- LEMESSA, D., HYLANDER, K. and HAMBÄCK, P., 2013. Composition of crops and land-use types in relation to crop raiding pattern at different distances from forests. *Agriculture, Ecosystems & Environment*, vol. 167, pp. 71-78. <http://dx.doi.org/10.1016/j.agee.2012.12.014>.
- LOVARI, S., CORSINI, M.T., GUZZINI, B., ROMEO, G. and MORI, E., 2017. Suburban ecology of the crested porcupine in a heavily poached area: a global approach. *European Journal of Wildlife*

- Research, vol. 63, no. 1, pp. 1-0. <http://dx.doi.org/10.1007/s10344-016-1075-0>.
- MAHLSTEIN, I., DANIEL, J.S. and SOLOMON, S., 2013. Pace of shifts in climate regions increases with global temperature. *Nature Climate Change*, vol. 3, no. 8, pp. 739-743. <http://dx.doi.org/10.1038/nclimate1876>.
- MOHAMED, W.F., 2011. The crested porcupine, *Hystrix cristata* (Linnaeus, 1758) in Misurata, Libya. *Journal of Ecology and the Natural Environment*, vol. 3, no. 7, pp. 228-231.
- MUSHTAQ, M., HUSSAIN, I. and MIAN, A., 2012. Effectiveness of Groundnut-Maize Bait as Carrier of Coumatetralyl Against Indian Crested Porcupine, *Hystrix indica* Kerr. *Pakistan Journal of Zoology*, vol. 44, no. 2, pp. 579-581.
- MUSHTAQ, M., HUSSAIN, I., MIAN, A., MUNIR, S., AHMED, I. and KHAN, A.A., 2013. Field evaluation of some bait additives against Indian crested porcupine (*Hystrix indica*) (Rodentia: hystricidae). *Integrative Zoology*, vol. 8, no. 3, pp. 285-292. <http://dx.doi.org/10.1111/1749-4877.12014>. PMID:24020467.
- ORIAN, G.H., 2020. *Some Adaptations of Marsh-Nesting Blackbirds (MPB-14)*. Nova Jersey: Princeton University Press. vol. 14. <http://dx.doi.org/10.2307/j.ctvx5wbjd>.
- RASHEED, S., BASHIR, M., and JADDON, A., 2020. Diversity and status of mammalian fauna of Abbaspur, Azad Jammu and Kashmir, Pakistan. *Journal of Wildlife and Ecology*, vol. 4, pp. 85-93.
- REIDINGER JUNIOR, R.F. and MILLER, J.E., 2013. *Wildlife damage management: prevention, problem solving, and conflict resolution*. Maryland: JHU Press.
- ROZE, U., 2012. *Porcupines: the animal answer guide*. Maryland: JHU Press.
- SHAFI, M.M., 1990. A review of vertebrate pest problems in Pakistan and their impact on agricultural economy. In: J.E. BROOKS, E. AHMED, I. HUSSAIN, S. MUNIR and A.A. KHAN. *Training manual of vertebrate pest management*. Islamabad: Pakistan Agricultural Research Council, vol. 1.
- THE NATION, 2017 [accessed 14 March 2021]. *Census 2017: AJK population rises to over 4m*. Available from: <https://nation.com.pk/27-Aug-2017/census-2017-ajk-population-rises-to-over-4m>
- UMAR, M., HUSSAIN, M., MURTAZA, G., SHAHEEN, F.A. and ZAFAR, F., 2018. Ecological concerns of migratory birds in Pakistan: a review. *Punjab University Journal of Zoology*, vol. 33, no. 1, pp. 69-76. <http://dx.doi.org/10.17582/pujz/2018.33.1.69.76>.
- VAN, T.K., 2009. *Wild animals of Western Canada*. Canada: Rocky Mountain Books Ltd.
- VASUDEVA, R.V., NARESH, B., TRIPATHI, R.S., SUDHAKAR, C. and REDDY, R.V., 2017. Reduction of wild boar (*Sus scrofa* L.) damage in maize (*Zea mays* L.) by using castor (*Ricinus communis* L.) as barrier. *Journal of Entomology and Zoology Studies*, vol. 5, pp. 426-428.
- VOSS, R.S., HUBBARD, C. and JANSAN, S.A., 2013. Phylogenetic relationships of New World porcupines (Rodentia, Erethizontidae): implications for taxonomy, morphological evolution, and biogeography. *American Museum Novitates*, vol. 3769, no. 3769, pp. 1-36. <http://dx.doi.org/10.1206/3769.2>.
- WALKER, E.P., 1999. Class Mammalia. In: R.M. NOWAK, ed. *Walker's Mammals of the World*. 6th ed. Baltimore: Hopkins University Press, pp. 1004-1009.
- WITMER, G.W. and PITT, W.C., 2012. Invasive rodents in the United States: ecology, impacts, and management. In: J. BLANCO and A. FERNANDES, eds. *Invasive species: threats, ecological impacts and control methods*. New York: Nova Science Publishers, Inc.

Supplementary Data

Supplementary material accompanies this paper.

Figure S1-Holes made my porcupine

This material is available as part of the online article from <http://www.scielo.br/bjb>