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Mammals roadkill in communication road and choll region (the extent of the spread of thrown debris) resulting from the great Seymareh Landslide

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ABSTRACT

This research aims to investigate mammals' roadkill between 18/01/2021 and 11/05/2022 on the Darrehshahr -Poldokhtar-Majhin road that passes through the Choll region. In the sampling period, 73 roadkill belonging to 5 mammal species were recorded. By comparing the number of roadkill in different seasons, it was found that the highest casualties were recorded in the cool seasons of the year and the lowest casualties were recorded in the three very hot months of the year. The highest roadkill related to the jackal species was recorded outside the Choll region, where the nature of the studied area is a mixture of plains and hills. By examining the map of the hotspots of roadkill obtained from the kernel function using GIS software, it was found that the jackal species has the highest casualties around the aviculture and near the residential areas. Because two hotspots of jackal deaths were observed in other places between the aviculture, it can be concluded that the aviculture attracted jackals to this area of the road due to improper disposal of dead chickens. According to the map of hotspots of roadkill related to the fox species, the highest casualties were observed in the Choll region in a hilly area in nature and around residential areas. Considering the concentration of roadkill of jackals around aviculture, the basic disposal of lost chickens effectively reduces these losses to a large extent.

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1. Introduction

Over the past century, many changes caused by human events have led to the destruction, reduction, or disappearance of biodiversity worldwide. The development of human societies is strongly influenced by roads, one of the most important human-made phenomena (Silva et al., 2020). Currently, road construction is expanding worldwide at an unprecedented rate (Kroll, 2015; Alamgir et al., 2017). It is projected that 25 million kilometers of new asphalt roads will be built by 2050 at a cost of more than $70 trillion, and approximately 90% of the world's new roads will be built in developing countries (Caro, 2015; Venegas, 2018; Silva, 2021). The past century has seen drastic changes in the natural landscape, and road networks now span most landscapes on Earth (Ibisch et al., 2016; Meijer et al., 2018).

Expanding the road network is a serious and comprehensive human need for development. On the other hand, it is a serious threat to the population of species that live along the roads (Ramp et al., 2005). Interest in the environmental effects of roads has increased since the middle of the 20th century with the formal recognition of a new discipline, Road Ecology, by Forman and Alexander in 1998 (Forman and Alexander, 1998). This branch of ecological research has revealed the extensive role that roads play in the direct and indirect destruction and change of habitats. Traffic noise, light pollution, and chemical pollution (Salt, heavy metals, herbicides) are all identified as important contributors to habitat alteration, fragmentation, and changes in animal movement in road-dominated environments (Coffin, 2007).

Perhaps the most obvious impact of roads is wildlife collisions with vehicles, which kill billions of animals worldwide each year (Seiler et al., 2006). The number of wild animals killed in road accidents is more than wild animals killed by poachers (V. D. Ree et al., 2021). Even without mortality, when animals cannot cross roads, their dispersal is prevented and they are isolated in populations that may be affected by random extinction with little chance of saving the population (Laurance et al., 2017). Animals have been victims of high-speed vehicles since the invention of chariots in the ancient Middle East more than 5,000 years ago (Pinto et al., 2020). Vehicle collisions with animals accelerated dramatically as motorized vehicles became common in the 1920s (Kroll, 2015). Animal biological characteristics (e.g., age, sex, and locomotion), biological factors (e.g., time of day, season), traffic and road characteristics (e.g., traffic volume, road width, curves), and environmental characteristics (e.g., topography, adjacent habitat structure) all interact to form a specific spatiotemporal distribution of each vehicle-wildlife collision (Morelle et al., 2013). The consequences of road deaths are usually of two categories: 1) direct removal of individuals from a population or 2) fragmentation of populations and reduction of gene flow (Trombulak and Frissell, 2000; Hill et al., 2020; Roofs, 2021). Importantly, these consequences can alter metapopulation structure and population fitness, in turn increasing the risk of local extinction (Dexter et al., 2017). Therefore, roads are responsible for reducing the number of certain species across the country and are considered a limiting factor in the recovery of other species (Carvalho and Mira, 2011; Meijer et al., 2018). The development of road ecology issues has mainly resulted from wildlife encounters with vehicles that are of legislative or conservation concern, or that cause economic or human safety issues (Dexter et al., 2017). There have been several studies on road fatalities of mammals, and Moore et al., in a review titled effects and potential reduction of road mortality on hedgehogs in Europe, showed that road fatalities can cause a significant decrease in population size, mainly adult males. They were wasted on the roads (Moore et al., 2020). Bakaloudis et al. (2023) in a study on wildlife mortality on roads crossing a protected area concluded that vehicle collision was the highest cause of mortality in this study (83.9%) among five Recorded categories included poison poisoning, electrocution, drowning, vehicle collision, and unknown causes (Bakaloudis et al., 2023). Surveys indicate that the vast majority of road ecology studies originate in North America and Europe (Hill et al., 2020). In North America, mammal deaths from vehicle collisions increased by 400% as traffic volume tripled between 1965 and 2017 (Pinto et al., 2020; Silva et al., 2021). Some methods may be used to reduce the number of such cases, such as wildlife crossings, which researchers believe is one of the best initiatives that could be used. Wildlife crossings are facilities that allow animals to safely cross human-made barriers. Examples of wildlife crossings are underpass tunnels or wildlife tunnels (Van der Ree et al., 2021) green corridors, overpasses, or bridges (England, 2021) amphibian tunnels, fish ladders, canopy bridges, and green roofs (M. A. G. Roofs, 2021). This research aims to investigate the road casualties of mammals, to determine the hotspots of casualties using the kernel function and the factors that attract mammals to these spots between 01/18/2021 and 05/11/2022 in Darrehshahr-Poldokhtar-Majhin road. This road passes through the Choll region (The area of spreading debris thrown by the great Seymareh landslide).

2. Material and Methods

2.1. Seymareh landslide

Seymareh Landslide overlooking Navdisi Seymareh Valley and on the large northeast edge of Kabirkoh anticline at coordinates $32^0$55'07" to $33^0$08'22" North latitude and $47^0$28'10" to $47^0$52'32" East longitude It happened 5 km south of Poldokhtar city, west of Khorramabad-Andimshek asphalt road and 15 km east of Darrehshahr city, south of Karkhe river between Ilam and Lorestan provinces. Seymareh and Kashkan rivers, after they meet in the northeast of Seymareh Valley, form the Karkheh River. The Seymareh landslide occurred in the middle of Kolkani dehistan of Majhin district and Ermo dehistan of the central part of Darrehshahr county, so today the area of the landslide is located in the south of the Karkheh River and the area of Darrehshahr City, However, the main part of the spreading area of the debris caused by the landslide is located in the north of the Seymareh River and the Lorestan province (Mazahari, 2018). In many sources, the Seymareh landslide has been called the biggest landslide in history.

2.2. The study area

The studied area is the connection road between Darrehshahr-Poldakhtar-Majhin, where a part of the investigated road passes through the spreading area of the thrown debris resulting from the great Seymareh landslide (Local name of this area is the Choll). The occurrence of landslides has caused topographic diversity and habitat diversity in this area, which has different characteristics from the areas before and after the area of debris expansion area so that many wetlands and many hills have been created in this area (Figs 1 and 2).

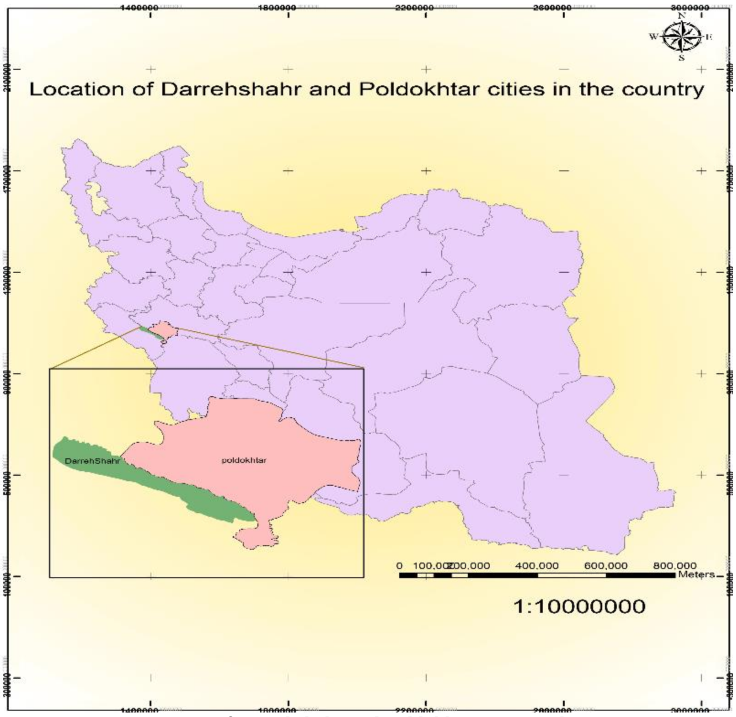

Fig. 1. Location of Darrehshahr and Poldokhtar cities in the country

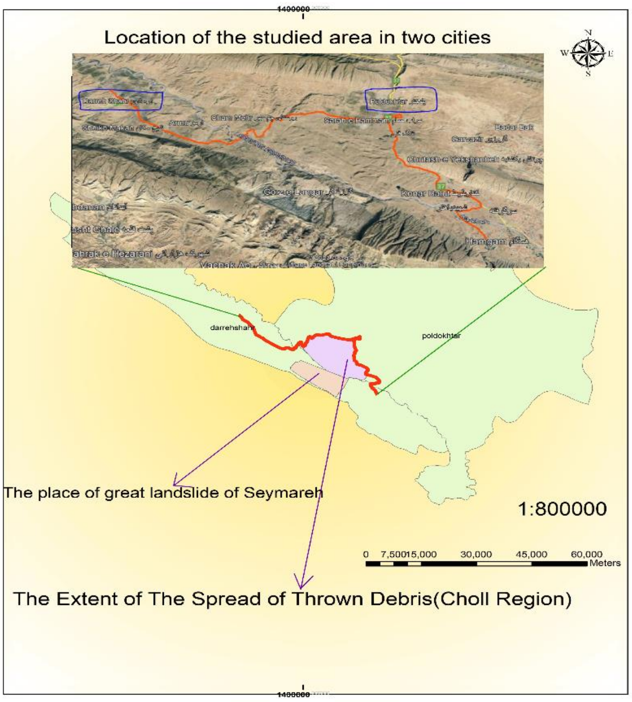

Fig. 2. Location of the studied area in two cities

2.3. Data collection method

In the time frame under study, two people traveling by car daily along the Darrehshahr - Poldokhtar-Majhin road and in case of any road casualties, the type of species and geographical coordinates, the name of the desired area and some other information such as the presence of bridges and the presence of carcasses of domestic animals, and atmospheric conditions will be recorded at the scene of the accident and after registering the casualties, the carcasses of the animals were moved outside the road in order not to be registered again.

2.4. Preparation of maps

The registered coordinates of the lost species were recorded in Google Earth daily to check the exact location, and in this software, the location of the incident was matched on the road, and in case of any error, the coordinates of the accident location were recorded again by referring to the region. In the next step, a map of the points that had the highest losses (Hot spots) was prepared for each of the species through GIS software using the kernel function.

2.5. Comparison of the number of deaths of species and the statistics of roadkill by season

Road casualty statistics were recorded in Excel software daily to compare the highest road casualty related to which species and what seasons were observed, and finally, a graph of this information was extracted.

2.6. Determining hotspots of roadkill

Kernel density function (Density Estimation Kernel) determines the danger range of road casualties by placing a cellular network on the points of road casualties of wildlife and considering an optimal radius. In this function, a hypothetical circle is formed around each observation point based on the defined radius, and the density is calculated in its unit. The closer the points are to the center of the circle, the greater the weight. The final value of each cell is obtained from the sum of the values of all circles that overlap with each other. The results of this method determine the areas that have the greatest probability of road accidents. One of the most important steps in the kernel function is determining the optimal radius.

The kernel density function will determine the hotspots as follows (Equation 1):

$$\lambda(s) = \sum_{t=1}^{n} \frac{1}{\pi r^2} k \left(\frac{\text{dis}}{\text{r}}\right) \quad (1)$$

In this equation, λ (S), is the density of points in the location S. Only the points that fall within the selected radius or bandwidth are estimated for density. K, in this equation, is the kernel function, which is the weight of point i at the distance (dis) from location S. In this equation, K is a function of dis/r, which is the distance from point i to location S, and r is the radius or width of the band. As a result, instead of choosing an identical and uniform function that gives equal or equal weight to all the points located in the corresponding radius. This function considers the distance between the points to the location S. Therefore, all the points in the respective radius or bandwidth are weighted according to the distance they have from the location S, the smaller the distance, the more weight, and the greater the distance, the less weight. In this study, the nearest neighbor method was used to determine the optimal radius (radius from the center of a circle on the cells of a grid, which includes points that help estimate density). In this method, the optimal radius is estimated through the average k (number of effective neighbors) or the average closest distance between neighboring points. For example, if dij is the distance from point i to neighbor j, the average distance of the nearest neighbor is determined through the following equation (Equation 2):

$$\lambda(s) = \left(\sum_{i=1}^{n} \sum_{j=1}^{n} \text{dij}\right) / KN \quad (2)$$

In this equation, R is the optimal radius, K is the average closest distance between neighboring points, N is the number of roadkill (Mohammadi et al., 2017)

3. Results and discussion

Roads undoubtedly have many advantages for human transportation. They can even create environmental benefits when they pass through intensive agricultural areas (Forman, 2000). On the other hand, they also affect wildlife habitat qualitatively and quantitatively, mainly through fragmentation. However, vehicle traffic on roads can be a direct cause of wildlife mortality, and in some cases, these losses are even catastrophic for animal populations (Reijnen et al., 1995; Psaralexi et al., 2022). During the sampling period, a total of 73 roadkill belonging to 5 species of mammals were recorded. These mammals include jackal (Canis aureus), fox (Vulpes vulpes), Small Indian Mongoose (Herpestes javanicus), European Hare (Lepus europaeus), and Indian Crested Porcupine (Hystrix indica). The highest number of road casualties in the study area was related to jackals with 35 observations (48% of the total recorded), foxes with 21 observations (29%), and Small Indian Mongoose with 14 observations (19%) (Table 1). A map was prepared for each of the species lost on the road separately in GIS software (Figs 3-6). By comparing the number of roadkill in different seasons, it was found that the highest casualties were recorded in the cool seasons of the year and the lowest casualties were recorded in the three very hot months of the year (Fig. 7).

Table 1. The number of roadkill registered in the study area

No	English Name	Scientific Name	Quantity
1	Golden Jackal	Canis aureus	35
2	Small Indian Mongoose	Herpestes javanicus	14
3	European Hare	Lepus europaeus	1
4	Common Fox (Red Fox)	Vulpes vulpes	21
5	Indian Crested Porcupine	Hystrix indica	2

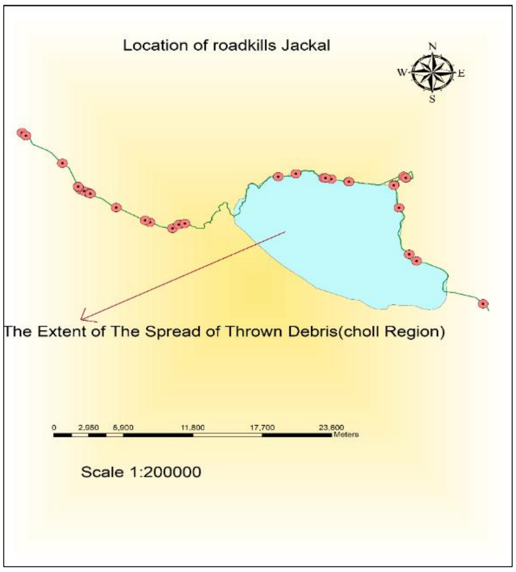

Fig. 3. Location of roadkills Jackal

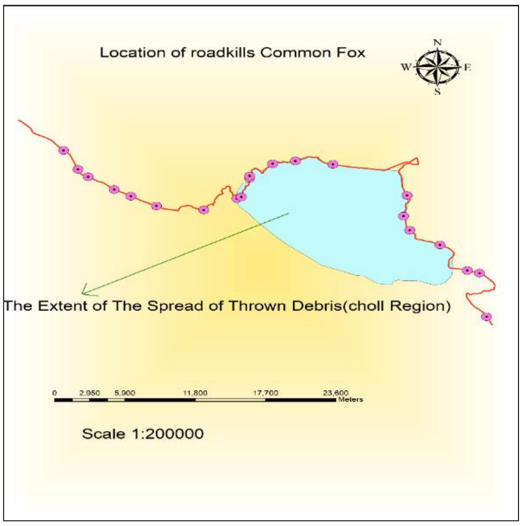

Fig. 4. Location of roadkills Common Fox

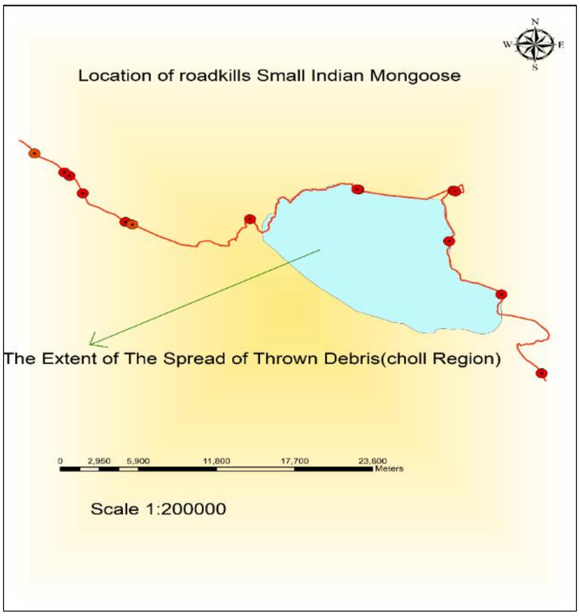

Fig. 5. Location of roadkills Small Indian Mongoose

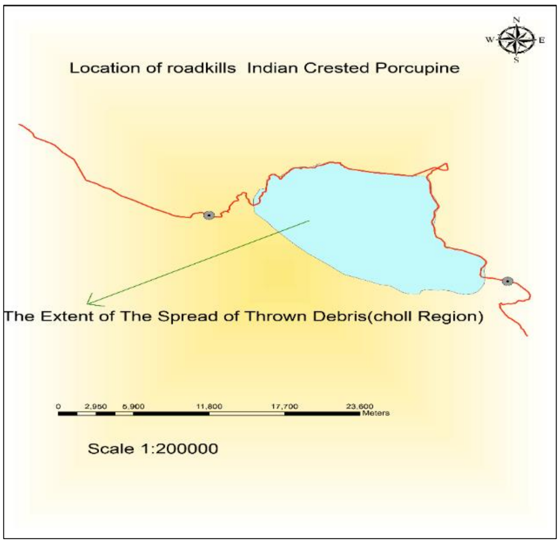

Fig. 6. Location of roadkills Indian Crested Porcupine

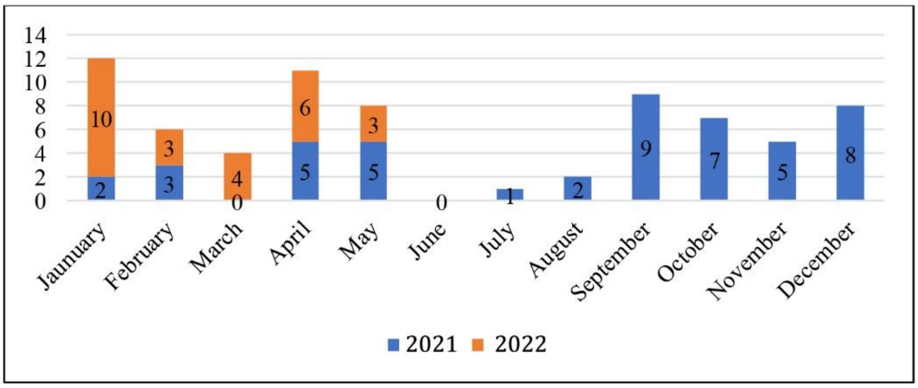

Fig. 7. Number of roadkill recorded in each month

3.1. Preparation of maps of hotspots of roadkill

To determines the range of the highest road losses known as hotspots, a map of the total recorded losses was prepared using the kernel function in GIS software. Then, a map of hotspots of roadkill was prepared and according to these hotspots, factors that attract mammals to the road were determined (Figs 8-11). The nature of the studied area is a combination of plains and hills, and in some places, the hills cover a larger area. The highest losses related to the jackal species were recorded in the areas where a combination of the plains and the hill covered the region and outside the Choll region, and the highest losses of the fox species were recorded in the areas that had the nature of the hill and are located in the Choll region. According to the map of hotspots, it was determined that roadkill of jackal species is more on the roads around aviculture and residential areas, especially around aviculture, and the highest roadkill of fox species was observed around residential areas.

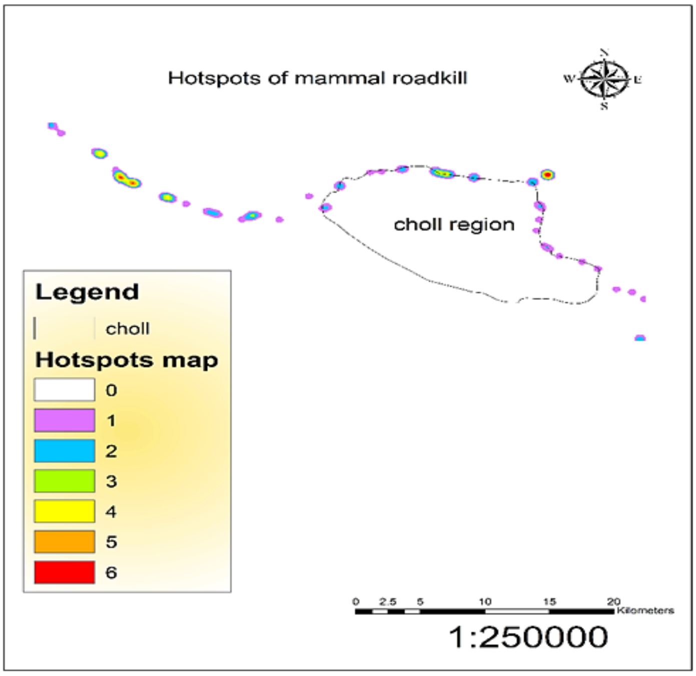

Fig. 8. Hotspots of mammal roadkill

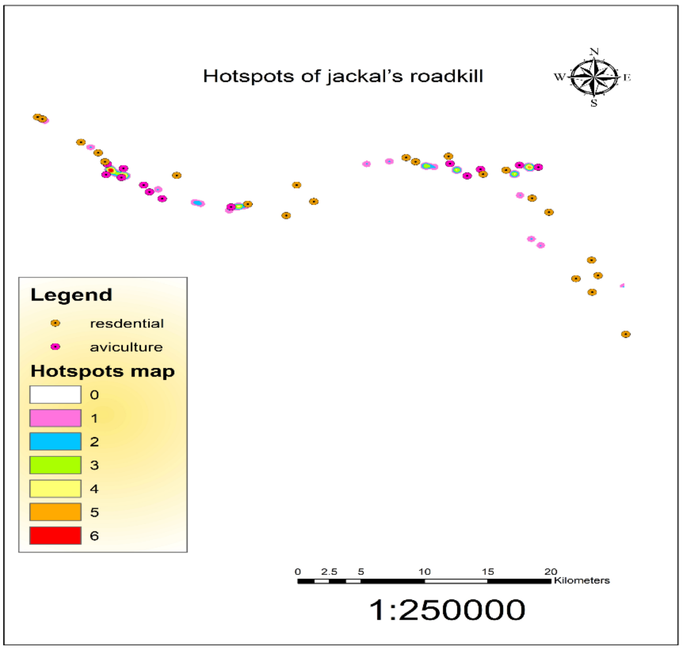

Fig. 9. Hotspots of jackal's roadkill

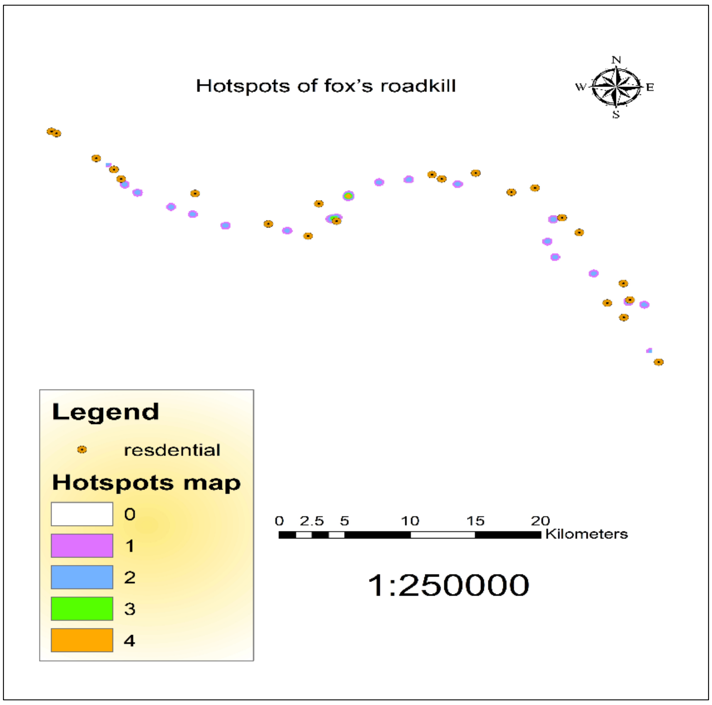

Fig. 10. Hotspots of fox's roadkill

4. Conclusion

In certain areas where the most roadkill is observed, these losses can be reduced through various ways such as the construction of an overpass that is uniform with the environment, the construction of an underpass, and the installation of traffic signs. In this study, the highest losses were recorded in the cool seasons of the year and the lowest losses were recorded in the three very hot months of the year. The highest roadkill related to the jackal species was recorded outside the Choll region, where the nature of the studied area is a mixture of plains and hills. By examining the hotspot map of roadkill resulting from the kernel function, it was determined that jackal species had the highest casualties around the aviculture and near residential areas. Of course, it should be pointed out that at a distance of 1.5 km from one of the hotspots of casualties, the landfill site of the city of Darrehshahr is located, which had an impact on the rate of collisions of jackals with vehicles according to the type of their diet. In two other places between the aviculture, two hotspots of jackal deaths were observed, so it can be concluded that jackals tend to wander around aviculture and consume the dead chickens due to the improper disposal of dead chickens near the aviculture, and aviculture has been the reason for attracting jackals to this area of the road. According to the map of the hotspots of roadkill related to the common fox species, the highest casualties were observed in the Choll region, which is an area with many hills and around residential areas. According to the map of hotspots of roadkill of mongoose species, it was found that this species has no hotspots of casualties in this area, and with field investigation, the highest casualties of this species were observed near seasonal water crossing bridges. In some places, especially on the road near Poldokhtar City, carcasses of domestic animals such as horses, sheep, and goats were observed, and these carcasses left around the road were the cause of jackals and foxes' road deaths. Some methods can be used to reduce the number of road fatalities, such as wildlife crossings, such as underpasses, and overpasses. Considering the concentration of roadkill of jackals around aviculture, monitoring the basic disposal of dead chickens effectively reduces these losses to a large extent. In addition, by monitoring the roads, it is possible to collect and bury the carcasses of domestic animals left around the roads to prevent the transmission of disease to wildlife and to reduce a factor that attracts animals to the road.

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