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Title

Spatial distribution and dietary niche breadth of the leopard *Panthera pardus* (Carnivora: Felidae) in North-Eastern Himalayan region of Pakistan

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Abstract: Knowledge of a predator's diet is important for understanding its ecology and for predicting its influence on the dynamics of prey populations. We investigated the spatial distribution and diet composition of the leopard *(Panthera pardus*) in a north-eastern Himalayan region of Pakistan. We used molecular scatology technique to identify scats of common leopard collected from the field. The leopard was recorded at thirty different surveyed sites with an altitudinal range between 757-1891 m. Its diet comprised of 17 prey species including both wild and domestic prey. Frequency of occurrence of wild prey was approximately 35% of total leopard diet whereas domestic prey contributed approximately 59%. The dietary niche breadth of leopard was found broad during spring season but narrow during winter season. Prey species diversity index was high during summer but low during winter. Results of current study highlight that common leopard is mainly subsisting on domestic animals, which may result in negative human-leopard interactions. We suggest that local communities should be educated to conserve the leopard and its wild prey species.

Keywords: diet composition, leopard, dietary niche breadth, prey species availability

1. Introduction

Distribution range of the leopard (*Panthera pardus*), one of the top predators in an ecosystem, is widest among all other felid species (Bailey 1993; Nowell and Jackson 1996). It occurs in Africa, Russia to Java (Stein and Hayssen 2013). In Pakistan, it is distributed in the provinces of Punjab, Baluchistan, Sindh, Khyber-Pakhtoonkhwa, and Azad Jammu and Kashmir (Roberts, 1997). It also occurs throughout Waziristan, Baluchistan and Sindh Kohistan (Roberts 1997). However, increased human settlements and firearms have resulted in decreased distribution range of leopards in Pakistan

(Roberts 1997). The leopard is listed as "Vulnerable" by IUCN (IUCN 2016) whereas the species is "Critically Endangered" in Pakistan (Sheikh and Molur 2004).

Baseline data on diet composition of a predator is vital first step to understanding its ecology and to understand its impact on regulation of prey species (Oli 1993). Mammalian scats have been commonly used in biological studies to record distribution patterns or species richness (Dalén, et al. 2004), composition of diet, seasonal changes in diet (Aragona and Setz 2001), prey species inventory (Camardella, et al. 2000). In many cases, it is assumed that scats are correctly identified, but it is difficult using scat morphology alone (Davison, et al. 2002; Prugh and Ritland 2005). It becomes more difficult when sympatric species have similar body features, behavior and feeding habits, and so the visual identification of scats becomes error prone (Ruiz-González, et al. 2008).

Faecal components of carnivores can comprise of feathers, bones, hairs, teeth, claws, scales, arthropod chitin, plant matter, mucus cells, and bacteria (Bang and Dahlström 1975; Bujne 2000). Whereas, the quantity and size of carnivore scats can be different based on age of individuals, prey species consumed and absorption capacity (Bang and Dahlström 1975). Carnivores often inflict economic losses to local communities by predation on domestic livestock and as a result carnivores are often persecuted (Gusset, et al. 2009; Treves and Karanth 2003).

Albeit the abundance of domestic livestock exceeds those of wild prey species in many areas, carnivores prefer to kill wild prey to avoid human revenge (Khorozyan, et al. 2015; Loveridge, et al. 2010). However, when wild prey becomes scarce, carnivores predate on livestock for their survival (Khorozyan, et al. 2015; Mondal, et al. 2011; Zhang, et al. 2013). Carnivores predate on domestic livestock during wet season when

wild prey disperses in lush woods to gain more fitness. Thus, wild prey becomes less available to carnivore species. Meanwhile, domestic livestock enters these lush vegetative areas for uncontrolled grazing (Kissui 2008; Patterson, et al. 2004). In many areas livestock depredation is less during winter season when density of prey become high (Dar, et al. 2009) or depredation is high during dry season when vegetative cover decreases, wild prey migrates and domestic livestock concentrates around limited water resources (Schiess-Meier, et al. 2007).

The relation between availability of wild and domestic prey species and their predation by carnivores can vary in different landscapes. Suryawanshi, et al. (2013) reported that livestock depredation by snow leopard may be more intense when wild prey is abundant, as more wild prey will support high density of predator. Therefore, carnivores can kill more livestock. To evaluate if dichotomy between scarcity of wild prey and increase depredation by carnivores such as common leopard on domestic livestock is true? we designed current study to investigate availability and consumption of wild and domestic prey by common leopard and seasonal variation in its diet in a human-dominated landscape located in north-eastern Himalayan region of Pakistan.

2. Materials and methods

2.1 Study Area

The current study was conducted in and around Pir Lasura National Park (PLNP; 33°29' 20'' N and 74° 3 ' 9 '' E), District Kotli, Azad Jammu and Kashmir, north-eastern part of Himalayan Region in Pakistan (Figure 1). The park encompasses 1580 ha area with elevation ranging between 1000 – 2000 m above sea level. The valleys of the park consist of subtropical pine vegetation, with the tops/mountains having sub-tropical dry

evergreen forest. Average annual rainfall in the study area is 1500 mm (Akrim, et al. 2017). The study area experiences four different seasons including Summer (May-July), Autumn (August-October), Winter (November-January), and Spring (February-April). Major wildlife species in the park include Common leopard (*Panthera pardus*), Rhesus monkey (*Macaca mulatta*), Asiatic jackal (*Canis aureus*), Red fox (*Vulpes vulpes*), Small Indian Mongoose (*Herpestes auropunctatus*), Indian grey mongoose (*Herpestes edwardsii*), Barking deer (*Muntiacus muntjak*), Indian pangolin (*Manis crassicaudata*) and Kaleej pheasant (*Lophura leucomelanos*) (Akrim, et al. 2017). However, there are no previous studies reporting the population status of the leopard or abundance of its prey species in the National Park.

Local people keep a variety of animals including domestic cows, buffalos, goats, dogs, horses, poultry birds and rabbit. A reasonable majority of people are associated with professions of doing agriculture, government jobs, labor and shop keeping with average household income per month ranging from US$ 100-200. Farmers, shopkeepers and labor usually keep livestock for milk and meat production and they depend on livestock for subsistence.

2.2 Methods

2.2.1 Distribution of the leopard

Field surveys to the study area were conducted to document distribution of common leopard in and around Pir Lasura National Park, during 2014 to 2016. The distribution was studied by recording direct (direct sightings) and indirect signs of the species in the whole study area, like scats (morphological followed by molecular identification) in the study area (Wemmer, et al. 1996). Data were also collected from local community living

in and around the park and field staff of Department of Fisheries and Wildlife AJ&K. Data on site, geographic location, elevation, date and species identification for each scat recorded were processed in Quantum GIS (Version 2.2.3) and Arc GIS (Version 10.1) to produce distribution map.

2.2.2 Diet composition

Diet composition of common leopard was investigated by analysis of its scat samples. For this purpose, field surveys were conducted to collect scats of common leopard on monthly basis and then assigned them in four different seasons including Summer (May-July), Autumn (August-October), Winter (November-January) and Spring (February-April) during 2014-2016 using area searches technique. All preexisting scat samples were remove from study area and were not part of analysis. Three people participated in survey and only one (author) was responsible for identification of leopard scats. When any scat was encountered, the field identification was determined based on its morphology including diameter, length, shape, color, odor, physical appearance such as characteristics contents (hairs, bones and plant material) (Jackson and Hunter 1995; Seton 1925). Additional criteria included nature of scat deposit site, and presence of tracks or signs of activity of the species under study (Mahmood, et al. 2013). The diameter at widest point, length, disjoint segments and weight of each scats sample was measured and samples were preserved in 95% ethanol for molecular identification and further analysis(Shehzad, et al. 2012).

2.2.3 Molecular Identification of leopard scats

We extracted fecal DNA from collected leopard scats in "Non-invasive & Environmental DNA Lab (NIEL)", Conservation Genomics Group (CGG) dedicated to DNA extractions in University of Montana, Missoula, USA. We used QIAamp DNA Stool Mini Kits (Qiagen, INC., Valencia, CA) for extraction of DNA from scats. We used negative control to keep track of cross contamination during extraction (Beja-Pereira et al. 2009). The total volume of DNA extracts from each scat sample were 100 µL.

The PCR for all scats samples was carried out in a total volume of 50 µL. The recipe of our master mix (MM) per sample was 20.375 µL H_2O, 5 µL buffer (, 7 µL MgCl2, 0.375 µL BSA, 2 µL dNTP, 2.5 µL 12S/V5 primer F, 2.5 µL 12S/V5 primer R, 0.25 µL Taq polymerase and 10 µL DNA as extract template for each scat sample. The PCR condition were denaturation at 95 °C for 5 min then 40 cycles of PCR starting at 95 °C for 1 min then annealing at 55 °C for 1 min and elongation at 72 °C for 1:30 min. Then a final elongation at 72 °C for 5 min at the end and 4 °C for infinity till product was removed from PCR. All PCRs were conducted on Eppendrof vapo. protect Master cycler® pro and all reactions included a negative and positive control. All sequences were then run on 3130 genetic analyzer and sequences were read using Finch TV software. The sequences were then subjected to NCBI Blast for species identification. All fail samples were discarded and were not part of analysis.

2.2.4 Scat Analysis

Based on molecular identification performed, only confirmed and correctly identified scat samples of common leopard were processed, for diet analysis. For disintegration, scat samples were soaked in warm water and then washed under tap water

in a sieve to remove dust and mucus and to segregated different prey items such as hairs, bones, insects and bird feathers (Mahmood, et al. 2013).

We used hairs for identification of mammalian prey species. For this purpose, light microscopic slides of the hairs of prey species were prepared. Hairs were washed in carbon tetrachloride 15-20 minutes). Long hairs were cut into small pieces and jumbled up hairs were separated. For whole mount preparation, we used transparent nail polish. Prey species of carnivores were identified using medullary pattern and cuticle cast pattern of the hairs recovered from scat samples as described by Moore et al., (1974). Prepared light microscopic slides were then compared with reference hair slides for identification. Similarly, other parts recovered from scats samples were identified such as bones, feathers of birds, invertebrates such as insects. The hairs of prey species were identified using Light microscope, having objectives of 10x, 40x and 100x magnification, respectively.

Cuticular scale patterns of mammalian hair were identified by slightly modifying procedure of Lavoie (1971). Two to three drops of transparent nail polish were placed and spread evenly on glass slide. A small hair was placed in vertical position along axis of slide so as one end of hair projected out of slide. After the nail polish was dry the end of hair projecting out was plucked with single attempt using forceps to get cast of hair on nail polish. The cast of hair prepared was exact duplicate of scales of the hair and was studied under microscope against reference for identification.

2.2.5 Abundance estimates of prey species

Abundance of carnivore prey species in the study area was estimated to establish their availability to the leopard at ten sites (Figure 2).

To record the abundance of mammalian prey species, "signs survey method" was applied. Direct and indirect signs like direct sightings, burrows (Begon 1979) and faecal material (White and Eberhardt 1980; Wood 1988) of prey species were recorded in specified area by area searches at different sampling sites of the Pir Lasura National Park to assess abundance of prey species. Furthermore, trapping was performed for small mammals following Erlinge (Erlinge, et al. 1983; Sutherland 1998). We used live Sherman traps to capture small mammals. The numbers of captured animals were divided by the numbers of trapping nights to get index of abundance. We used 10 traps used in 4 days total trap nights were 40 and area was 100mx100m.

For recording abundance of bird species as prey of leopard, line transect (Burnham, et al. 1980) method was used. Twenty transects were established in ten different sites (Two transects in each study site. Each transect was 200 m wide (100 on each side) and 500 m long. Total area of each transect was 0.1 km^2. Abundance of amphibians and reptiles was assessed using "Visual Encounter Method" along line transect within each sampling site (Campbell and Chiristman 1998; Fellers and Freel 1995; Heyer, et al. 1988). Abundance of snails was recorded by area search method and insect abundance was recorded using pitfall traps (Greenslade 1964; Luff 1975) method in a specified area in sampling sites (5 box used each was 22 inch circumference and A= 38.51 inch sq.) (area of 5 boxes 192.55) (1m=1550 sq inch).

2.2.6 Statistical analysis

Prey Species Richness (S) was calculated as total number of prey species consumed by common leopard during each season. Diversity Index (H') (Mahmood, et al. 2013) was calculated by using the formula:

$$\mathbf{H'} = -\Sigma\ [p_i \times \ln p_i]$$

Where p_i is prey index,

The Evenness Index (E) was calculated by using the formula:

$$\mathbf{E} = H'/\ln \text{ of } S$$

Where, S represents the prey species richness and H' represents diversity index.

We measured dietary niche breadth of common leopard, using niche breadth (L) and standardized Levins index (0-1) (L_{st}) (Colwell and Futuyma 1971; Levins 1968) using formula:

$$L = \left(\sum_{i=1}^{n} p_i^2 \right)^{-1} \quad \text{and} \quad L_{st} = L - 1 / n - 1$$

Where p_i is the relative percentage of food item i and n is the number of food items.

L_{st} is standardized niche breadth and its value ranges from 0 to 1. A higher L_{st} indicates broader diet niche of the animal.

To compare seasonal variation in diet composition of common leopard, we used general linear model (GLM). Similarly, we compared seasonal variation in consumption of wild prey species, domestic prey species, and plant matter. The consumption of prey

species was compared with the availability of prey species in the study area using regression analysis. The analysis was performed by considering population of poultry kept by locals at homes and poultry farms and we found very weak relation between consumption and availability of prey species. However, when analysis was repeated by excluding population of poultry at poultry farms our results were significant. All analysis was conducted in (SPSS version 23).

3. Results

3.1 Spatial distribution

The leopard was recorded at all surveyed sampling sites (N=30), with an altitudinal range between 757 - 1891 m (Figure 1). Scats of the felid species (n = 39) were identified at 7 different sites including Kothian (N=4; 10.2%), Palani (N=1; 2.5%), Panagali (N=8; 20.5%), Pir Kana (N=8; 20.5%), Pothi sairi (N=3; 7.7%), Sairi (N=12; 30.7%) and Supply (N=3; 7.7%). Livestock depredation by common leopard was reported from 22 different sites of the study area, while the species was directly field observed at one sampling site "Sairi" and its sightings were reported by local people from 6 other sites in the study area.

3.2 Diet composition

In general, diet of the leopard comprised of 17 prey species, including mammals (n=14 species) and birds (n=3 species). It included 10 wild prey (mammals 8; birds 2) and 7 were domestic (6 mammals; 1 bird) animals. Frequency of occurrence of wild prey was 34.85% whereas domestic prey contributed 59.1% of leopard diet (Table 1). Among wild prey, frequency of occurrence of Rhesus Monkey was highest (10.61%) while that

of goat was highest (28.79%) among domestic prey. Comparison of dietary items using GLM showed that consumption of different diet items significantly differed F = 9.26, *df* = 17, *p* <0.001. The model explained 74.53% (R squared = 0.745) of variation in diet of leopard (Table 1; Figure 3).

Frequency of occurrence of wild prey was high during spring (40%) and low during winter season (27.27%). The consumption of domestic prey species was high during winter season (72.73%) but low during autumn season (52.63%). GLM showed no significant difference in seasonal diet of the leopard F = 0.904, *df* = 3, *p* = 0.443.

3.3 Diversity Index, Richness and Evenness of Prey Species

Prey species diversity index in the diet of the leopard was high during summer season (2.27) but low during winter season (1.85). Prey richness was high during summer (13), and low during winter (7 species). Prey evenness was high during winter season (0.95) and low during spring and summer (0.88 each) (Figure 4).

3.4 Dietary niche breadth

The dietary niche breadth of common leopard was broad during spring season (14.76) but narrow during winter season 9.33. Total niche breadth of the leopard was 13.88 (Figure 5).

3.5 Prey species availability

Abundance of wild prey species was estimated to be 57.4/km^2 whereas availability of domestic prey species was found to be 747.36/km^2. Major wild prey species of the leopard was Rhesus Monkey and this species was most abundant in the study area. Abundance of goats and sheep in the study area was also high as compared to other ungulate species and it was 95.17/km^2 and 10/ km^2 respectively **(Table 1).** The regression analysis showed that

consumption of prey species strongly corelated with their availability (when considering poultry kept by locals only) R= 0.7, R^2 = 0.49, p=0.002, df= 16. However, when poultry kept at poultry farms was included this relation was very weak.

4. Discussion

In the face of ever shrinking habitat of wildlife due to increasing human population, growing agricultural needs and unsustainable use of wild resources, carnivore conservation is challenging problem. People living in and around protected areas are often dependent on livestock for their livelihood (Mishra, et al. 2004). Throughout the distribution range of leopards, a dietary shift from wild prey species to domestic species has been reported by various researchers (Judas, et al. 2006; Spalton and AL-Hikmani 2006).

In Pakistan, the leopard has been reported to predate on prey species like snakes, lizards, rodents, Sindh ibex, markhor, urial, rhesus monkeys, and porcupines. In the regions where, wild prey is limited, common leopard is known to attacking domestic livestock including; cows, calves, donkeys, ponies, goats and sheep. As a result, the felid species has been ruthlessly persecuted by local communities whenever encountered and has been always considered symbol of fear and contempt in Pakistan (Roberts 1997).

During present study, the leopard was recorded in and around Pir Lasura National Park (PLNP), a north-eastern Himalayan region of Pakistan. The direct and indirect signs of the species were field recorded widely in both wild and human habitated areas. The elevational range of common leopard occurrence in the study area ranged between 757 m- 1891 m. The Common leopard was found evenly distributed in the study area. No previous published studies are available that report on the distribution of common leopard

in the study area. Roberts (1997), had reported four sub-species of *Panthera pardus* to occur in Pakistan including; firstly, *Panthera pardus saxicolor* (Pocock, 1927) found in Baluchistan (also found in Persia), secondly, *Panthera pardus sindica* (Pocock, 1930) occurring in Kirthar, Sindh, thirdly, *Panthera pardus fusca* found in whole of India and fourth sub species *Panthera pardus millardi* (Pocock, 1930) occurring in the state of Kashmir. Siddiqui (1961) stated that all above four sub-species occur in Pakistan although at present it might be hard to distinguish individual specimens into sub-species while population from Sindh and Baluchistan are so small as compared to northern Himalayan population. Throughout its range, there is considerable variation in the pattern and density of rosettes or spots on the body of leopards since leopards in Swat and Hazara districts have longer and more luxuriant pelage during winter season. (Roberts 1997) described the distribution of the leopard in Pakistan is confined to the forest of Himalayan region up to tree line or at lower altitudes in valleys which are more arid hilly regions in the north. It also occurs in hilly areas associated with *Acacia modesta* and *Acacia Senegal* scrub forests of Waziristan, Baluchistan and Sindh Kohistan. It was once inhabitant of the" Salt Range" and still survives in Kala Chitta Hills but is not found in human settlement areas, cultivated lands, riverain tracts for many decades. But during the current study, signs of leopard have been recorded near human habitations. This might be because of the reason that scarcity of wild prey in forests is now resulting in leopards' interaction with human populations and it is known to predate on their livestock. It is also distributed in Kirthar Hills, Kalat and Mekran, Ziarat, Murree Hills, Margalla Hills, Chitral, and the Chilas district of Gilgit-Baltistan,

In diet of the leopard, we recorded more domestic prey as compared to wild prey species, including mammals, birds, and anthropogenic items. We found that consumption

of domestic prey was high as compared to wild prey and domestic prey species comprised of goat, sheep, cow, buffalo, horse, poultry and dogs. The consumption of goat was high followed by dog and our findings are in line with other studies conducted in distribution range of leopard. According to Shehzad et al., (2015) diet of the leopard comprised of mainly domestic prey species and consumption of goat was highest (64.9%), followed by dog (17.5%) and cow *Bos taurus* (12.3%). Leopard has been reported to kill massive numbers (n=22) of livestock such as sheep in a single attack (Sangay and Vernes, 2008). Athreya, et al. (2016) reported that diet of leopard consisted of livestock, and 39% domestic dogs. There were few wild species recorded from diet of leopard.

Among wild prey species, rhesus monkey was more frequently and heavily consumed. Similar findings have been reported by some other studies, predation of common leopard on primates has been reported from Asia and Africa (Cowlishaw 1994; Hayward, et al. 2006; Isbell 1994; Kummer, et al. 1981; Nowell and Jackson 1996; Zuberbühler and Jenny 2002). Leopard predation on rhesus monkey has also been reported by (Lodhi 2007; Mukherjee and Mishra 2001).

Pir Lasura National park is such a landscape surround by human population and the number of livestock in and around the park is over a million. In such a landscape availability of domestic prey is more than that of domestic prey species, therefore, it is quite logical for such as a species to predate on prey which is abundant in the area and requires less effort. Carnivore density in natural or semi-natural ecosystems is related to biomass of prey species available (Karanth and Nichols 2010). Recent studies have demonstrated that large carnivores can persist in human-dominated landscapes by predating fully or partially on domestic livestock (Athreya, et al. 2013; Yirga, et al. 2012). The potential of human dominated landscape to support large carnivore species must be

investigated in terms of availability and abundance of wild as well as domestic prey species (Boitani and Powell 2012). In human-dominated landscapes biomass of domestic prey species can be higher than wild prey species (Mizutani 1999) .

Livestock depredation by common leopard has resulted in antagonistic interaction between local communities and leopard in Pir Lasura National park. Interaction between felids and human is complex and spectrum of such relation ranges from fascination to fear (Loveridge, et al. 2010). From conservation of large felids, they are often represented as flagship species (Treves and Karanth 2003) but antagonistic interaction of large felids occurs in areas where these species live in human-dominated landscapes, where presence of these species can result in livestock depredation and loss of human life (Treves and Karanth 2003). As a result, large felids are killed in retaliation which is significant cause of their mortality (Inskip and Zimmermann 2009). During current study, we found goat as major prey of leopard followed by dog, which could be due to high availability of goat, or poor guarding and penning conditions. Dogs are used for guarding livestock and they become easy prey for leopards. Many studies have reported leopard predating on dogs such as (Daniel 2009).

A wider dietary niche breadth of common leopard during spring season is indicative of the fact that more prey species were available to this top predator in the study area during spring season. But during winter season, the narrow dietary breadth of common leopard indicates availability of less prey species.

Conclusion

The leopard is uniformly distributed in and around PLNP in human dominated landscape. Major part of the common leopard's diet comprises of domestic animals while

the contribution of wild prey is much lower, indicative of depleting wild prey in the area. The increased dependence of common leopard on domestic prey might result in negative human-leopard interactions in the study area. We suggest local communities be educated to conserve common leopard as well as and its prey species in the study area.

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Table 1. Percent Frequency (%F) of occurrence of prey items in the scats of common leopard (*Panthera pardus*) collected from the PLNP, AJ&K.

Prey species	Summer (n=13)	Autumn (n=11)	Winter (n=6)	Spring (n=9)	% Frequency	Prey availability /km^2
Wild prey						
Barking deer (*Muntiacus muntjac*)	4.76	5.26	0	0	3.03	2.5
Kashmir hill fox (*Vulpes Vulpes griffithi*)	4.76	0	0	0	1.52	1.1
Rhesus monkey (*Macaca mulatta*)	4.76	10.53	9.09	20	10.61	11.1
Indian Gerbil (*Tetra indica*)	4.76	0	0	0	1.52	20
Wild boar (*Sus scrofa*)	0	5.26	9.09	0	3.03	5.4
Indian crested porcupine (*Hystrix indica*)	0	5.26	9.09	0	3.03	8.5
Asian palm civet (*Paradoxurus hermaphroditus*)	4.76	0	0	6.67	3.03	0.6
Desert hare (*Lepus nigricollis dayanus*)	0	0	0	6.67	1.52	0.7
Kalij pheasant (*Lophura leucomelanos*)	4.76	5.26	0	6.67	4.55	5
Indian/common peafowl (*Pavo cristatus*)	4.76	5.26	0	0	3.03	2.5
Total wild prey	**33.33**	**36.84**	**27.27**	**40**	**34.85**	**57.4**
Domestic prey						
Goat (*Capra hircus*)	28.57	31.58	27.27	26.67	28.79	95.17
Dog (*Canis lupus familiaris*)	19.05	10.53	18.18	13.33	15.15	22
Sheep (*Ovis aries*)	4.76	0	0	0	1.52	10
Cow (*Bos taurus*)	4.76	0	18.18	6.67	6.06	43.07
Buffalo (*Bubalus bubalis*)	4.76	10.53	0	0	4.55	28.27
Horse (*Equus ferus caballus*)	0	0	0	6.67	1.52	0.16
Poultry (*Gallus gallus domesticus*)	0	0	9.09	0	1.52	548.69* /62**
Total domestic prey	**61.9**	**52.63**	**72.73**	**53.33**	**59.1**	**747.36* / 260.5****
Anthropogenic matter	4.76	10.53	0	6.67	6.06	

* Including population in poultry farms; **population kept by local community in houses