



Dispersal Patterns and Ecological Impacts of Wild Boar (*Sus scrofa*) in Ayubia National Park, Pakistan

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SUMMARY

The wild boar (*Sus scrofa*) is listed as the world's worst invasive species (IUCN) and is recognized as a potential driver of ecosystem extinction. The wild boar is mainly responsible for crop damage and water pollution and acts as a vector for the transmission of many zoonotic diseases to humans and other domestic and wild animals. The present study was conducted to investigate the incidence of wild boar in Ayubia National Park (ANP) from August 2018 to August 2019. Questionnaire-based interviews were conducted to confirm the first presence record of wild boar, followed by a camera trapping survey to identify the movement corridors used by the species for their dispersal in the protected area. Site occupancy surveys confirmed the potential locations, which were afterwards selected for camera trapping to identify the current distribution of wild boar in the park area. Scat samples of leopards were collected and analyzed to investigate the contribution of wild boar to the diet composition of leopards in ANP. We also studied the ecological linkages and impacts of wild boar on the rest of the ANP's flora and fauna. A total of 107 respondents were interviewed, covering 10% of each village located in the vicinity of the species occurrence range. The study's results show that the first sighting of wild boar was recorded in 2008 on the edge of the park, and that the species was confirmed to be living in the park in 2011. We also found four possible movement corridors that helped the species spread throughout the park area: Kunhar Kas Nallah, Bakol Nallah, Satora-Haro River Nallah, and Namli Mera Water Tributary. The key drivers that enhanced the dispersal of the wild boar population are open dumping sites around tourist spots, mass infrastructural construction, and poorly managed tourism-based activities. The current distribution map of the species was developed in ArcGIS 10.3 using presence points obtained from camera trapping and sighting record information.

Keywords: Wild boar, Noninvasive study techniques, Impact on biodiversity

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INTRODUCTION

The wild boar (*Sus scrofa*) (Linnaeus, 1758) is an ungulate species belonging to the Suidae family of the order Artiodactyla, representing eight species of wild boar (Massei and Genov, 2004). It is a widely distributed species of mammal and inhabits a wide range of habitats all over the world (Pittiglio et al., 2018). The wild boar has

one of the largest geographic ranges among all terrestrial mammals. It is native to Northern Africa and Western Europe, and is now extending to Southeast Asia, including Japan, Java, Taiwan, Sri Lanka, Malaya, and Korea (Choi et al., 2014). The wild boar prefers to live in swamps, mountainous areas, marshlands, deciduous and coniferous woodlands, coastal zones, river edges, moist temperate forests, and shrublands (Ashraf et al., 2013). Pakistan lies within the geographic range of the wild boar, mainly inhabiting areas that include Punjab province, the lower region of Khyber Pakhtunkhwa, coastal areas, and along the Indus River and Sindh province. The occurrence of the wild boar up to 1,000 m in Pakistan was reported by Roberts (1977), while the presence of wild boar was recorded at 914.4 m in the Margalla slopes around Kahuta and Murree (Ashraf et al., 2013).

The wild boar is an omnivore and feeds on a variety of food depending on availability and seasonal variations (Crooks, 2002). The habitat preference of wild boar depends on the availability of feeding materials and climatic conditions (Schley and Roper, 2003; Cuevas et al., 2016). Plants (leaves, seeds, fruits, tubers) are the main food items (87 to 99%) of the wild boar diet (Crooks, 2002). Feeding of wild boar on reptiles, birds, and garbage has also been reported in different parts of the world (Massei and Genov, 2004). Another important feeding behavior in wild boar is rooting behavior. They have a specific behavior of digging in the soil to obtain feeding material, including tubers, roots of plants, and insects (Crooks, 2002).

Wild boar are responsible for damaging agricultural crops, killing poultry, reducing crop yields, and polluting water resources (Masterson, 2007). They also serve as vectors for the transmission of numerous zoonotic diseases to humans as well as domestic and wild animals (Altaf, 2020). These include Aujeszky's disease (mad itch) in cattle, rats, dogs, horses, and other wild animals; leptospirosis; foot-and-mouth disease; and Japanese encephalitis. Additionally, they facilitate the spread of parasites such as *Toxoplasma gondii*, and *Trichinella spiralis* in humans (Hampton et al., 2004; Bártová et al., 2006).

In recent decades, a healthy population of wild boar has been reported in Ayubia National Park, but there remains a mystery regarding when and how the species reached the moist temperate zone and what factors are driving its dispersal at a higher rate. It is also necessary to answer questions about how the presence of wild boar will help minimize attacks on livestock by leopards, and which of the two species—wild boar or leopard—causes the most pronounced economic loss to the local community. The present study was conducted in Ayubia National Park, aiming to investigate the presence, movement, dispersal patterns of wild boar, and its impact on biodiversity.

MATERIALS AND METHODS

This study was conducted in Ayubia National Park, Abbottabad, in Khyber Pakhtunkhwa (Figure 1). The park lies between 34°00'48" - 34°06'23" N latitude and 73°22'54" - 73°27'15" E longitude, covering the reserved forests of Galliat. Initially, the total area of the park was 1,684 hectares, which increased to 3,322 hectares in 1998. The core area spreads over 33 square kilometers, while the surrounding reserved forests cover an area of 150 square kilometers (Farooque, 2007). The purpose of the park is to protect and conserve the unique and threatened biodiversity

of the area (Lodhi, 2007). The park has an altitudinal range from 1,050 m at Lahur to 3,027 m at Miranjani. The park represents a moist temperate ecological zone and also includes elements of subalpine meadows (Miranjani and Mukshpuri) and sub-tropical pine forest (Lahur Kas village) (Farooque, 2007). The months from December to February are generally the coldest, with a mean air temperature of around 4.2°C. May and June are the warmest months, with a mean air temperature of about 26°C. The mean annual rainfall in Ayubia National Park varies between 1,065 mm and 1,424 mm, while the overall mean annual precipitation ranges from 1,200 mm to 1,640 mm. Humidity is relatively high, especially during the monsoon season (Farooque, 2007; Khan, 2015).

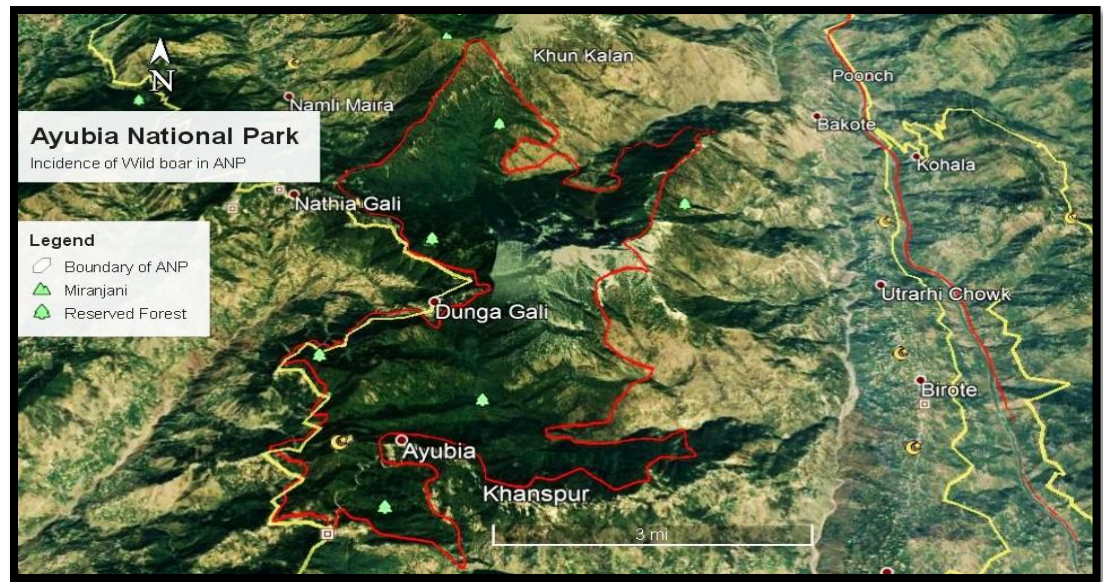


Figure 1: Map of Ayubia National Park, red line shows the boundary of park, green colored trees symbol shows the Reserve Forest in the study area.

Ayubia National Park is rich in biodiversity, including birds and mammals (Farooque, 2007). The park represents 410 species of combined vegetation belonging to various taxonomic classes, including fungi, lichens, and pteridophytes (Shafique, 2003), and 200 herb species reported by Shinwari (2010). A significant number of plant species have medicinal and economic importance. *Abies pindrow*, *Cedrus deodara*, and *Pinus wallichiana* are dominant species of coniferous trees in Ayubia National Park, while *Panthera pardus*, *Macaca mullata*, *Petaurista petaurista*, *Sus scrofa*, and *Paguma larvata* are key fauna of Ayubia National Park (Shafique, 2003).

DATA COLLECTION

Questionnaire-based interviews were conducted with the local community to collect baseline data on sighting records and information about wild boar and negative interactions between wild boar and the local community. The indigenous community was asked about the first sighting record of wild boar within the park boundary and the factors that facilitated the successful dispersal of wild boar throughout the study area. Information was also collected on the negative impact of wild boar on local

biodiversity and the livelihoods of the local community. A total of 107 respondents were interviewed, belonging to different backgrounds and sources of income, including farmers, government employees, private employees, and shopkeepers. We covered ten percent of households in 18 villages located around and within the boundary of Ayubia National Park.

SITE OCCUPANCY SURVEY

The site occupancy surveys were conducted from June 2018 to September 2018 to investigate the area occupied by wild boar within the park boundary. We plotted 33 grids (2 x 2 km²) using ArcGIS software (10.3), and randomly established survey points were taken within each grid. We marked a two-kilometer area around the park boundary to locate the movement corridors used by wild boar. Each survey point was searched within a 50-meter radius. The minimum distance between two survey points was 100 m. Each survey point was searched, and information was collected on various aspects including sign type, sign age, topography, terrain, habitat type, and elevation.

CAMERA TRAPPING

Based on site occupancy surveys, the most potential sites were selected for camera trapping to confirm the current presence of wild boar in Ayubia National Park. Within each selected grid, we plotted a single camera (Reconyx, HC 500 Hyperfire) and targeted the most potential locations, including trails and tracks used by wild animals. We also targeted the crop fields where the presence of the species was reported by the local community. The location of each camera was marked using a Geographic Positioning System (GPS) (GARMIN 64S). The cameras were positioned at the stem of trees at a height of 40-60 cm (Jackson and Hunter, 2006). They were placed in such a position that the camera could not be triggered by vegetation in the foreground (Caravaggi et al., 2016). Multiple detections at the same camera-trap station within 30 minutes were removed from the dataset to ensure the independence of detections (Linkie and Ridout, 2011; Xiao et al., 2018; Haswell et al., 2020; Chaudhuri et al., 2022).

SCAT COLLECTION AND ANALYSIS

Scat analysis was performed to study the contribution of wild boar to the diet composition of the common leopard in Ayubia National Park. Scat analyses have been successfully used by different researchers to determine prey remains and the prey profile of leopards (Henschel et al., 2005). For diet analysis, scat samples of leopards were searched for and collected from the study area. Only fresh leopard scats were collected and kept in polythene bags for the analysis of wild boar as a prey species of the common leopard. The date, name of the location, and Geographic Positioning System coordinates for each sample were recorded. Leopard scats were distinguished from the scats of other species occurring in the region based on their diameter, pointed ends, size, shape, odor, and adjacent field signs (Lovari et al., 2009, 2015). Scats were carefully cleaned, and all prey remains were isolated. The undigested prey remains, such as hair, bones, claws, and other materials, were separated and stored in polythene bags for further examination. For slide preparation,

a minimum of 20 hairs from each sample (Mukherjee, Goyal, and Chellam, 1994) were placed on a blank slide, and cross-sections of the hair structures were made by embedding the hair samples in wax (Mukherjee, Goyal, and Chellam, 1994). The cross-sections and cuticle patterns were recorded and compared with published material and hair keys at PMNH and Quaid-e-Azam University.

RESULTS AND DISCUSSION

Interviews with the local community were conducted to investigate the sighting locations, population, movement patterns, and negative impact of wild boar on the local community. We surveyed and covered five union councils comprising 18 different villages in and around Ayubia National Park. The people living around the park and depending on its natural resources are more knowledgeable about issues related to biodiversity conservation, the presence of wildlife species, and their impact on the livelihoods of the indigenous community. Village-wise information on demographic, social, and economic aspects provided a better understanding of the impact of wild boar on the local economy and resources (Figure 2).

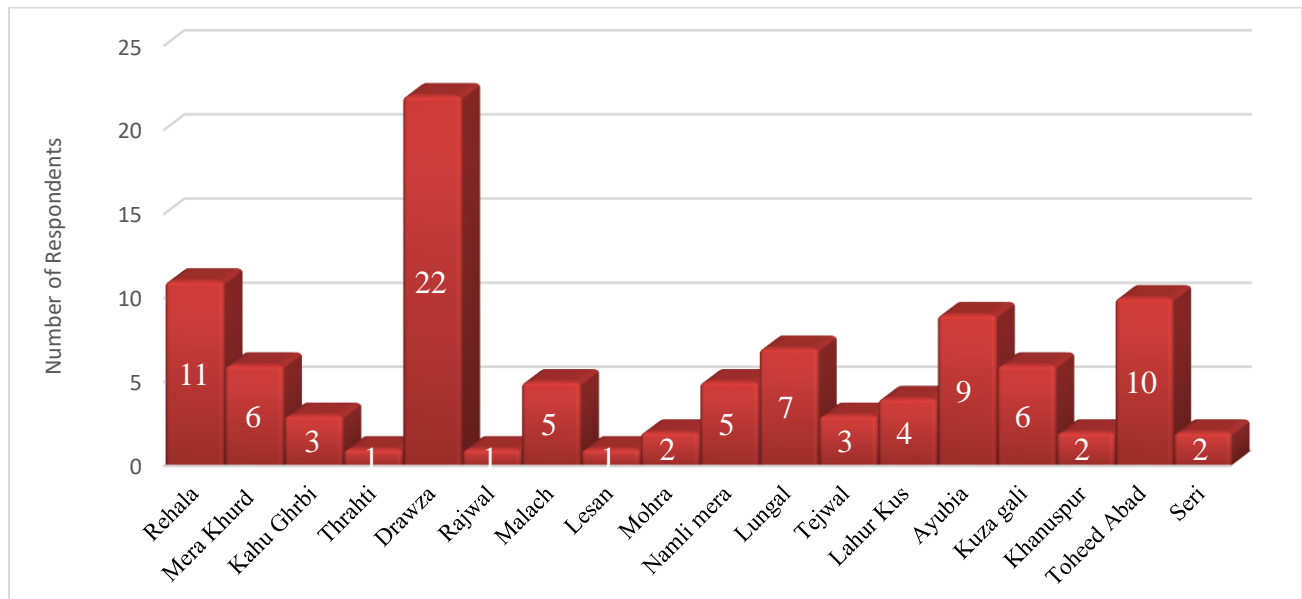


Figure 2: Number of respondents from different villages located in and around the Ayubia national park, 2018-19.

INCIDENCE OF WILD BOAR IN AYUBIA NATIONAL PARK

In order to confirm the first presence record of wild boar in Ayubia National Park, we reviewed and studied all available literature on wild boar and asked all stakeholders when they first sighted or encountered wild boar in and around the vicinity of Ayubia National Park. The wild boar was first sighted in the periphery of Ayubia National Park in 2008, when local villagers from Rehala hamlet first saw this species in the forest area. It was also recorded in Ayubia National Park territory in 2011 when a male individual was found dead on a roadside, probably attacked and killed by a common leopard. The first photo-captured record of wild boar was documented in

2016 by WWF-Pakistan, while the Khyber Pakhtunkhwa Wildlife Department photo-captured this species in 2017 (Figure 3).



Figure 3: Photo-captured record of wild boar in 2017 (Data Source: Wildlife Department Khyber Pakhtunkhwa).

During the questionnaire survey, information on the presence of wild boar in Ayubia National Park was collected. Fifty-five percent of respondents answered that the very first time they sighted wild boar was in 2012, and the majority reported the same duration between 2012 and 2014. The other respondents reported sightings of this invasive species from 2014 to 2019. Now, the species is widely distributed throughout the national park, posing alarming threats to local biodiversity (Figure 4).

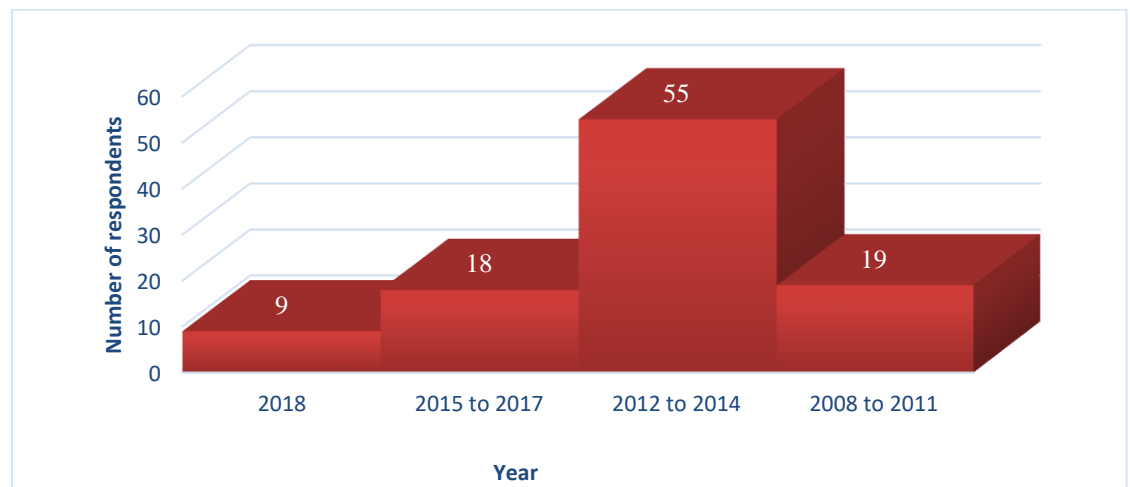


Figure 4: First sighting record information of wild boar in Ayubia National Park.

MOVEMENT CORRIDORS USED BY WILD BOAR

We also identified the movement corridors used by wild boar to gain entrance to Ayubia National Park. We identified four potential movement corridors, namely Kunhar Kas Nallah, Bakol Nallah, Satora-Haro River Nallah, and Namli Mera Water Tributary, through which the species traveled, facilitating their dispersal within the park area (Figure 5). We observed that wild boar followed the streams and narrow valleys covered with thick vegetation. Similarly, R. Castillo-Contreras et al. (2018) investigated that wild boar primarily used streams as corridors for entering new areas

in Barcelona. The current distribution map of the species was developed in ArcGIS 10.3 using presence points obtained from camera trapping and recorded sightings.

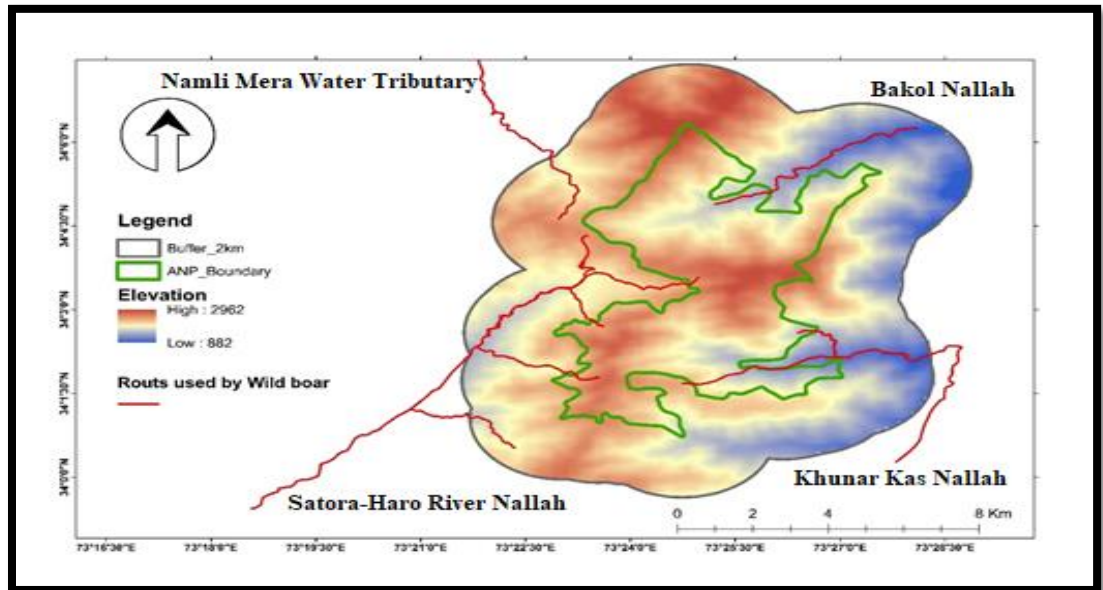


Figure 5: Map of movement corridors used by wild boar in Ayubia national park.

The first route was Khunar Kas Nallah, and the second one was Bakol Nallah, which facilitated the movement of this problematic species within the park boundary, leading up to Mukshpuri top. In order to access the pipeline track, the wild boar followed the Satora-Haro river nallah and its adjoining tributaries. The key drivers that enhanced the dispersal of the wild boar population are open dumping sites around tourist spots, mass infrastructural construction, and poorly managed tourism activities. Ashraf et al. (2013) reported that the garbage sites are a key source for wild boar distribution in the study area. They also reported that factors like the availability of food and suitable climatic conditions enhanced the successful dispersal of wild boar into new areas.

CURRENT DISTRIBUTION OF WILD BOAR IN AYUBIA NATIONAL PARK

Field-based collected data revealed that wild boar is abundant and widely distributed in the study area (Figure 6). The high fecundity rate of wild boar and its adaptability to survive in various environmental conditions have led it to thrive almost all over the world (Choi et al., 2014). Pakistan lies within the native range of wild boar, and here it is regarded as an agricultural pest, causing damage to edible crops (Hafeez et al., 2012). Signs of wild boar, including their movement patterns, rooting remains of food contents, and scratches on trees, were observed, and locations were marked using the Global Positioning System. A map of the current geographic distribution of wild boar was developed. The current distribution map identified locations with healthy populations of wild boar in and around the park area, which can help monitor the existing population of this invasive species.

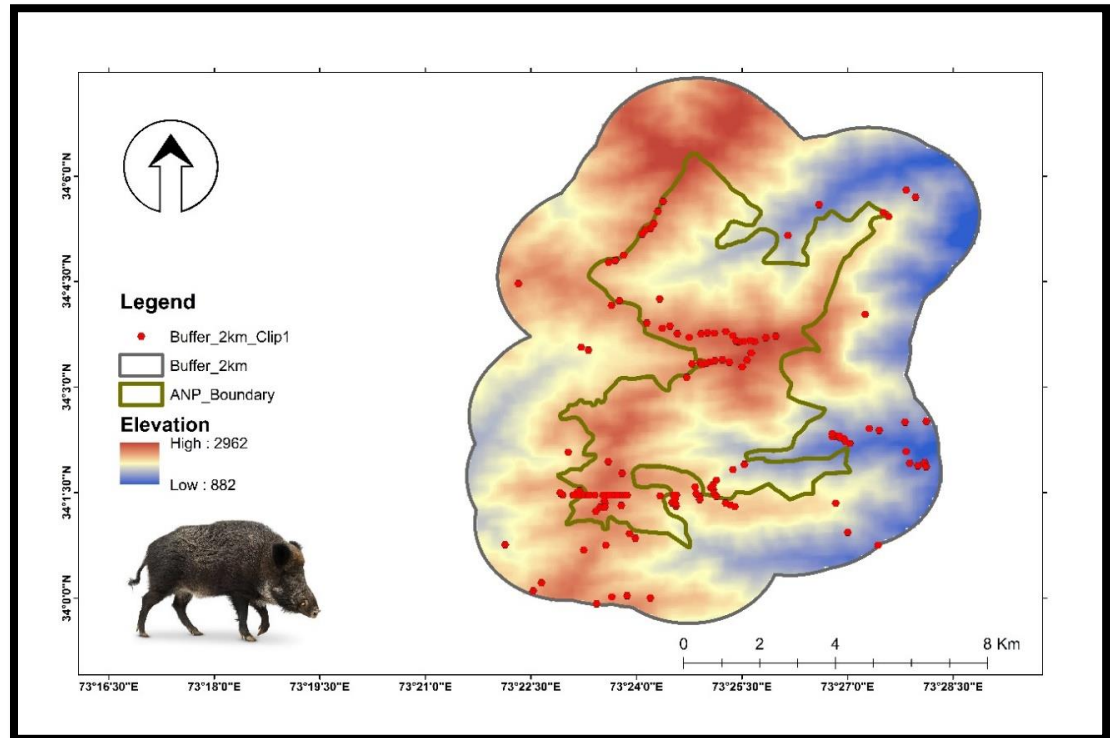


Figure 6: Presence points of wild boar in around the Ayubia National Park, presenting wide distribution of species.

Wild boar presence was recorded from the highest points, such as Miranjani and Mukshpuri, of Ayubia National Park (Figure 7). It is a really alarming situation if we are unable to monitor and control the fast-growing population of this species. In the future, it could become more problematic, and its presence may not be sustainable over a long period. Previously, Roberts (1997) confirmed the presence of wild boars at 1000 m elevation in the upland areas of Pakistan and at lower elevations throughout Punjab and parts of Khyber Pakhtunkhwa. Similarly, Ashraf et al. (2013) reported the presence of wild boar at 915 m elevation in the Margalla Hills, around Kahuta and the Murree foothills, and throughout Punjab.

In recent years, there has been an increase in the occurrence of disease outbreaks, crop damage, car accidents, and human conflicts with wild boars, thus creating a need to manage their population and requiring accurate and detailed information on their distribution and abundance. To manage the population, baseline data for population density is needed. Unfortunately, baseline data is not available to study the density and distribution of wild boar population dynamics for effective management (Pittiglio et al., 2018).

IMPACTS ON NATURAL VEGETATION/HABITAT

Due to the rooting and nudging behaviors of this species, it has also been observed that wild boar has badly damaged several species of medicinal plants (Figure 8) in Ayubia National Park, i.e., *Arisaema flavum*, *Podophyllum peltatum*, *Fragaria nubicola*, etc., resulting in soil erosion. The same kind of damage was reported by Hone (2002) in Australia as well as by Schley and Roper (2003) in Western Europe.

There is a need to study and monitor the plant species scratched and uprooted by wild boar in Ayubia National Park. Every species, whether native or introduced, poses some ecological, environmental, social, and economic impacts on the region it inhabits.



Figure 7: Photo-captured record of wild boar in the study area in 2018-2019.

Wild boars also pose significant impacts—both positive and negative—on the plant and animal communities, crop and livestock production, and the livelihoods of the areas they inhabit (Massei and Genov, 2004). In addition, they have been reported to be in feeding symbiosis with birds (common crow) that feed on their ectoparasites (Baber and Morris, 1980). Furthermore, wild boars also act as a hunting substitute for native wildlife species, e.g., peccaries (*Tayassu sp.*), deer (*Mazama sp.*), tapir (*Tapirus terrestris*), and capybara (*Hydrochaeris hydrochaeris*) (Desbiez et al., 2007).

WILD BOAR AS PREY SPECIES OF COMMON LEOPARD

Scat analysis confirmed the presence of wild boar in the diet composition of leopards (Figure 9). The scale replication technique is the most efficient non-invasive method to identify unknown prey species (Xiang et al., 2009). The results of scat and diet analysis revealed that wild boar constituted 20% of the leopard's diet in Ayubia National Park. This is positive, as it can help minimize the attacks of leopards on domestic stock.



Figure 8: Remains of uprooted plants by wild boar in Ayubia National Park.

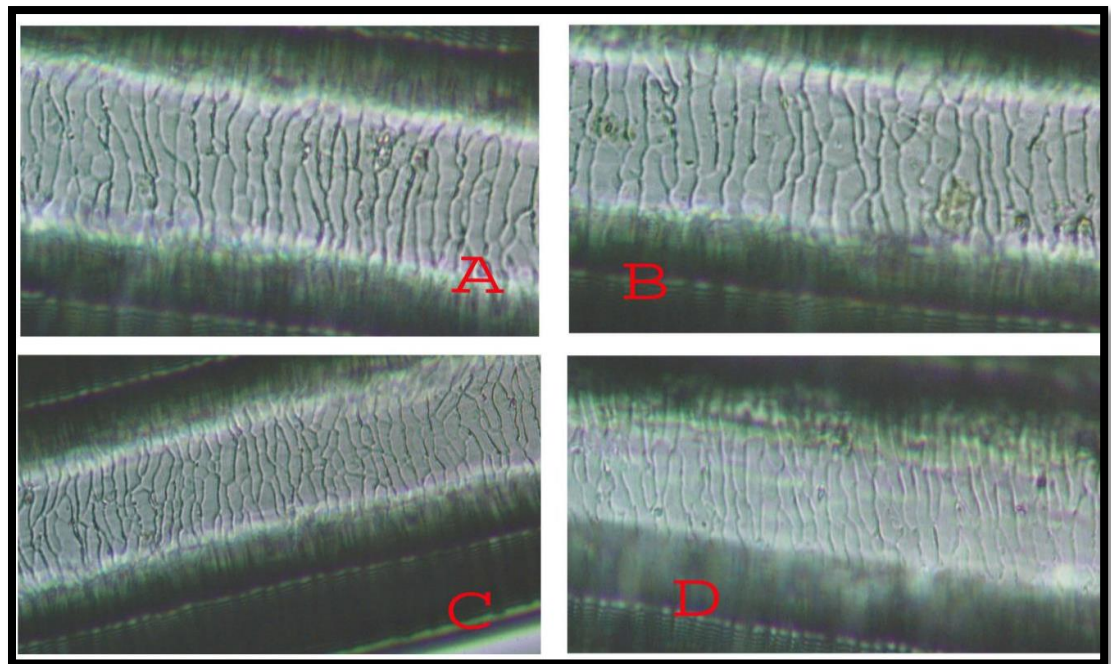


Figure 9: Study of scale pattern of hairs of different species. A is the reference key of wild boar. While B, C and D are the identified sample of wild boar hair collected from leopard scats from Ayubia National Park.

Wild boar is known as the most problematic and destructive animal, causing massive economic loss of approximately \$11,625 per annum to the local community in Ayubia National Park. In the wild, it is also identified as one of the most damaging agents of natural vegetation, causing habitat degradation, and is known as a disease carrier, which is harmful to local wildlife species of Ayubia National Park. Therefore, the confirmation of wild boar as a prey species of leopards will also help control its population, ultimately contributing to the reduction of economic loss for the local community. This will also benefit the local community by reducing the rate of leopard attacks on livestock while leopards consume wild boar as a potential prey species.

The addition of wild boar to the leopard's diet has positive effects on the perception of the local community towards leopard conservation. The common leopard, being a top predator in the study area (Khan, 2015), feeds on a variety of prey species, which include both wild and domestic animals (Shehzad et al., 2015). Wild boar was an important part of the leopard's diet, as previously reported by Lovari et al. (2013) in Nepal and Taghdisi et al. (2013) in Iran. Another study conducted by Göttingen (2016) in Iran reported that wild boar formed 50.2% of the leopard's diet composition. This is the very first scientific study confirming the presence of wild boar in the leopard's diet in Ayubia National Park, Pakistan.

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Authors' contributions: Data collected and MS written by Ahmad; supervised by Kabir; and critically reviewed and approved as final by Kanwal.

