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Seasonal Activity Pattern of Wild Boar (*Sus Scrofa*) and Temporal Overlap with Humans in the Uttarkashi Landscape of Western Himalaya, Uttarakhand

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Abstract: Wild boar is an invasive omnivore and an opportunistic feeder declared as a pest species in many countries. Despite of their invasive nature they play an essential role as ecological engineer in the ecosystem. Currently, very scanty information is available on wild boar ecology, behaviour and crop raiding pattern especially in Indian landscape. The, present study was aimed to understand daily activity pattern of wild boar and their activity overlap with human in Uttarkashi district. The 134 cameras consisted of 6220 trap nights during 2018 to 2020 before and after pre-monsoon season were deployed. The study indicated that wild boar are primarily nocturnal, remain most active during the midnight, and only occasionally interact with humans during afternoon. When compared activity patterns across the seasons, showed nocturnal activity pattern in the summer, spring, and diurnal during the winter. In order to understand their ecology and activity, present study can help to comprehend their activity pattern to avoid conflicts with human and effective population management of wild boar in the studied landscape.

Keywords: Wild boar, Environment, Camera trap, Invasive species, Western Himalaya

Wild boar (*Sus scrofa*) is a widely distributed mammal worldwide and native range extends from Western Europe to Southeast Asia (Massei and Genov 2004, Defra 2005). However, it is a generalist species and adapted for a wide range of habitats such as semi-desert to the tropical rain forest, temperate woodlands, and grassland (Barwal et al 2013). It is an omnivore species of the family Suidae and listed as Schedule V species under the Wildlife (Protection) Act, 1972 of India. Global populations of wild boar are rapidly increasing (Baubet et al 2004) and regroup-living animals, consisting of 4-14 individuals in a group (Allwin et al 2016) and when males join the group, can be larger than 20 individuals (Rosell et al 2004, Focardi et al 2015). Wild boars are highly active animal, opportunistic feeder, feed on variety of plants and animal matter and act as scavenger in the forest ecosystem. In addition to that wild boar also serves as an important prey base for large carnivores such as tiger, leopard and other large carnivores (Barwal et al 2013). Studying the activity pattern of species is essential to understand habitat use, behaviour and ecology (Tobler et al 2009). As internal biochemical processes regulate the species' activity rhythms following to the daily light–dark cycle and used for species classification as diurnal and nocturnal (Mistlberger and Antle 2011). There are many factors associated that changes the mammalian circadian rhythm, such as availability of food resources, light, competition, material behaviour, predation and human disturbances (Mistlberger and Skene 2004, Martin and Reále 2008 and Norris et al 2010).

Globally, there are several studies conducted on activity pattern of wild boar based on radio telemetry (Keuling et al 2015), acoustical detection (Cahill et al 2009), and camera trapping method (Ohashi et al 2013, Stolle et al 2015). On the other hands very few have been tested in India (Srivastava and Khan 2009, Barwal et al 2013). Camera trapping become popular tool in species monitoring, understanding activity pattern, human-wildlife conflict and habitat ecology analysis of elusive species (Bietti et al 2006, Vine et al 2009 and Ohashi et al 2013). Since the wild boar are one key species leading extensive conflict with human and results in huge agricultural loss (Scarcelli et al 2004) and designated as pest species in several parts of world (Meng et al 2009). Knowing the invasive species' activity patterns and their habitat use is essential for making effective conflict mitigation strategies and understand their ecological requirement (Guo and Quan 2017). Therefore, the goal of present study was to comprehend wild boar seasonal activity patterns and temporal overlap with humans, which can help to develop conflict mitigation strategies and population management of invasive species in Himalayan landscape.

MATERIAL AND METHODS

Study area: Uttarkashi is the largest district of Uttarakhand with a total area of 8016 km^2 lies between 38°28′–31°28′N latitude and 77°49′–79°25′E longitude. Two major rivers of India originated from this district, namely Bhagirathi (subsequently know as Ganga from Devparyag) from Gomukh and the Yamuna from the Bandarpuch glacier in Yamunotri. The elevation of district varies from 1158 to 6323 m. The terrain of the landscape is exceedingly mountainous, with tall snow-capped high peaks, small undulating bolder, steep mountains, and high ridges (Fig. 1). A varying range of climate and topography raises a wide range of vegetation and agriculture production. The faunal and floral diversity of the study landscape is diverse and is home for some globally endangered species and elusive species like snow leopard, musk deer, black bear, Himalayan tahr, common leopard etc. This district also has many threatened medicinal and economic flora such as *Taxus wallichiana*. *Myrica esculenta, Bergenia ligulata etc.*

Data collection: The study was conducted from 2018 to 2020 in this landscape. Study area was divided into a 10 km × 10 km and a reconnaissance survey were conducted after that we selected 26 logistically assessable grids of 10 X 10 km for the systematic survey and further divided in 5 km × 5km for intensive sampling.

Camera trapping: The total of 134 camera traps in various habitat types identified through reconnaissance survey and installed camera traps near meadows, natural trails, near water sources, grassland and subtropical and subalpine forest habitat in Uttarkashi district. The camera trap is placed at an average height of 30-45 cm from the ground based on terrain complexity and slop (Sathyakumar et al *2011 and Bashir* et al 2013). Ultra-compact SPYPOINT FORCE-11D trail camera (SPYPOINT, GG Telecom, Canada, QC) and Browning Trail Camera (Defender 850, 20 MP, Prometheus Group, LLC Birmingham, Alabama, <https://browningtrailcameras.com>) camera traps were kept operational for 20-30 days in the field.

Data analysis: The images of Wild boar were sorted and each independent image were considered in the interval of 1 hours (Tobler et al 2008). The species were identified based on expert opinion and images those were of poor quality and difficult to identify were excluded from the analysis. Further, time of each independent capture of human and wild boar from the camera traps were also recorded for the activity pattern analysis. All the captured of human activity were also recorded (Pei 1998). Daily activity pattern of wild boar and human were analysed for the temporal overlap and investigated using overlap package in R environment (Meredith and Ridour 2019). The daily activity index (DAI) was used to examine the daily activity pattern. The overlap coefficient (dhat) represented in scale of 0 to 1, where 0 indicates *'no overlap'* between the species, and 1 indicates '*complete overlap'* within the species.

RESULTS AND DISCUSSION

A total of 134 camera traps were remain operational for 6220 trap nights. In study used 273 individual captures of wild boar and 138 captures of human. Human capture were observed in 43 cameras. Based on activity pattern analysis, most of wild boars were active after the sunset to late at night. The peak time of activity of wild boar was 18:00 to 22:00 hrs. The highest peak showed during the 18:00 hrs, and a shorter peak observed at midnight 12:00 hrs (Fig. 2). The result also suggested that the wild boar was predominantly active during night hours with peak activity from 20:00 to 21:00 hrs (Fig. 2).

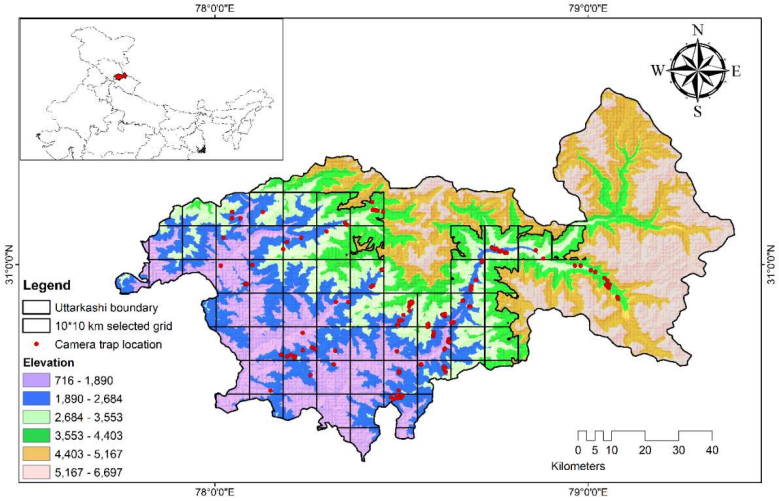

Fig. 1. Study area map showing the placement of camera traps

The activity overlap between wild boar and humans during all season was very low (dhat = Δ0.3; Fig. 3). Therefore, the results depict temporal overlap between wild boar and humans was only 30% in the study landscape. The camera trap data for three seasons: spring, summer, and winter were analysed and observed that the wild boar shows the nocturnal activity pattern, but also exhibit diurnal activity pattern during winter season. In the winter, wild boar is active during the afternoon at 12.00 hrs and increases with peak activity during 18.00 to 19.00 hrs. Wild boar shows high activity overlap with human during the winter (dhat = Δ0.76): Fig. 2). Further, during the spring, wild boar shows complete nocturnal activity pattern with highest activity peak during 18:00 to 19:00 hrs, with limited overlap with humans (dhat = Δ0.14). Similarly, in summer, the nocturnal activity pattern showed a peak between the 4:00 to 5:00 hrs in the early morning before sunrise and the second peak at 20.00 hrs (Fig. 2). Temporal overlap of wild boar with humans in the summer and spring season was avoided (dhat= Δ0.05).

The wild boar showed nocturnal activity pattern with peak activity during 18:00 to 22:00 hrs, which corroborated with previous studies of earlier researchers (Caruso et al, 2018, Oliver et al 2012). While, during the winter, wild boar exhibit daytime activity, especially in highly dense forests, which also observed in earlier studies (Keuling et al 2008, Ohashi et al 2013, Caruso et al 2018). However, the wild boar is a pest species as it destroys much of the agriculture land and leads to high economic losses for farmers (Apollonio et al 2010 and Ficetola et al 2014). Therefore, this species become one of major challenges for conflict mitigations throughout the globe. Present study indicates that wild boar show the less temporal activity overlap with humans and nocturnal activity gave it advantage to invade the agriculture lands during the night hours. However, in last few decades many species of carnivore, omnivore and ungulates became nocturnal due to high anthropogenic activity (George et al 2006, Ensing et al 2014). While in case of wild boar, this species adapted to human dominated areas and may adapted to nocturnal for changing crop raiding pattern or its thermoregulatory behaviour (Apollonio et al 2010). The high level of nocturnal activity is will be observed in wild boar during the summer, possibly due to the behavioural thermoregulation. When compare activity overlap according to the season, observed highest temporal activity overlap with humans during winters and limited during the summer and spring. The wild boar showed a high temporal activity overlap with humans during winter because of lack of availability of food and increased anthropogenic activity in forested areas for wood collection

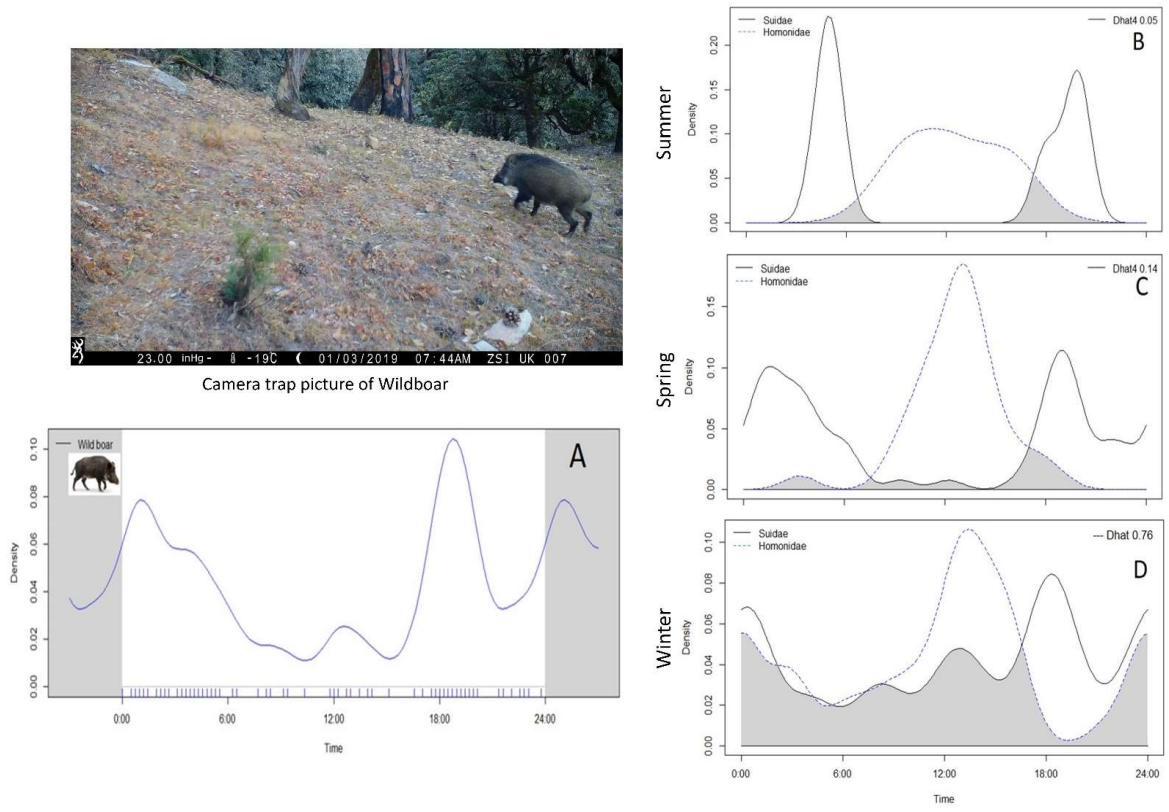

Fig. 2. Camera trap picture and activity pattern of Wild boar. (A) Wild boar (B) Summer (C) Spring (D) Winter

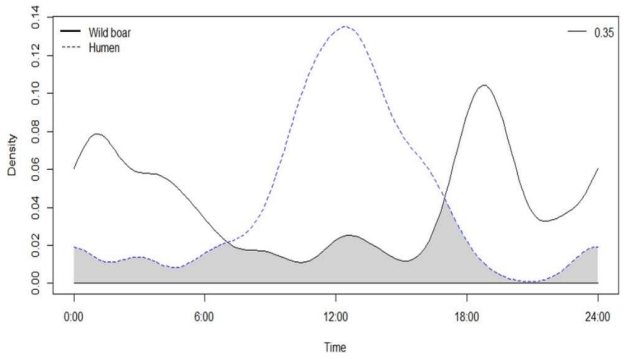

Fig. 3. Overall overlap of wild boar with human in all season

and livestock grazing which also corroborated with the other studies (Johann et al 2020).

In addition, some studies suggested that the wild boar activity changes seasonally due to the area and temperature (Campbell et al 2010). The wild boar's activity patterns vary according to the season in the study area during the summer are most active between the hours of 4:00 to 5:00 hrs and the hours of 20:00 to 21:00 hrs and followed the fully nocturnal pattern. The results are similar to the previous studies on wild boar (Brivio et al 2017, Maloney et al 2017). During the winter, diurnal activity peak was during 12:00-13:00. These results corroborated with study conducted in South Carolina, which indicates the nocturnal activity pattern of wild boar during summer and diurnal activity in the winter.

CONCLUSION

The present study monitored and assessed the activity pattern of Wild boar using camera trapping in the Uttarkashi district of Uttarakhand. The human-wildlife conflict has increased worldwide especially in case of wild boar, and their increasing populations often a major challenge to mitigate human wildlife conflict in India. Despite facing the conflict in majority of areas with wild boar and declared as a pest species, this species also works as an ecological engineer in the forest ecosystem and also an important prey base for large carnivore. Thus, population management required an intensive government intervention both in term of reduce conflict and maintain the ecosystem balances. The study indicates the nocturnal activity pattern of wild boar, which may increase the opportunity to invade in agriculture fields for easy access of food or may be due behavioural thermoregulation, which forced them to be nocturnal. The present study will be helpful for the management of the wild boar population and to mitigate the conflict. The results offered fundamental knowledge on wild boar activity pattern, which can be utilized by wildlife managers to rotate the agriculture crops and use of night deterrents to avoid the wildlife boar in agriculture fields.

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