



Spatio-temporal patterns of wildlife attacks on humans in Chitwan National Park, Nepal

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Abstract

In this study, we investigated the rate of wildlife attack incidence in and around Chitwan National Park in Nepal during the period of 2014-2018. Our findings indicated that the attacks from different animals ranged from 27 to 56, with an average of 38.8 attacks annually. Among the seven attacking animals, the highest or nearly half of the attacks were caused by rhinos (43.8%), followed by wild boars, tigers, sloth bears, elephants, and crocodiles. Only one incident of the leopard was recorded. The attacks were inversely related to the distance from the forest boundary. Of all the attacks studied, more than three-fourth of the attacks (77%) occurred within one km of the forest boundary. The forest boundary here refers to the closest distance from the site of attack either to the park area or the buffer zone forest lying outside the core area of the Park. The occurrence of conflicts was less intense with increasing distance from the forest, 16% between one to two km, and only 7% beyond two km of the forest. Conflict species beyond two km were rhino, wild boar, and crocodile. To mitigate such conflicts, there is a need to develop programs and invest in fisheries development at the community level, which could be an appropriate strategy to deter wild animals from entering the human-dominated landscapes. Care should be taken to ensure that animal preventive infrastructures built up to safeguard people and their property do not pose a threat to wildlife and their mobility.

Keywords: Animal attacks, human activities, wildlife reserves management, wildlife-human conflicts management



Introduction

Conservation biology is much concerned with human-wildlife conflict these days as human-wildlife is posing critical threats to many wildlife species (Jackson 2010). The conflict arises in both ways. On the one hand, wildlife damage the life and property of human beings, and on the other hand, humans affect wildlife (Madden 2008) and creates a negative relationship between humans and wildlife. Such conflict in and around the protected areas is becoming a pressing issue these days and has created obstacles to gain support for conservation in landscapes where resource use by people and wildlife overlaps (Silwal *et al.* 2017). Therefore there is need of apt actions and strategies for the peaceful co-existence of wild animals and people.

Chitwan National Park (CNP) is a biological hotspot and is internationally recognized for its unique features and high biological diversity of native flora and fauna of Siwalik and Inner Terai ecosystem. With the changed time and development, the rise in the human population at an alarming rate has created enormous pressure to park resources (CNP 2015). People enter the forest areas for resource extraction that would impose a greater risk of encountering tigers (Gurung *et al.* 2008) or other dangerous animals. The CNP and buffer zone management plan also mentions that HWC is more likely to occur due to the increased wildlife population in the Park and the human population in the buffer zone. The Park supports the largest populations of the species most commonly involved in attacks on people in Nepal (605 rhinoceros *Rhinoceros unicornis*, 60 elephants *Elephas maximus*, 250 sloth bears *Melursus ursinus*, 93 tigers *Panthera tigris* (CNP 2012, DNPWC 2012, CNP 2018, DNPWC and DFSC 2018, GON/DNPWC 2017)

In and around CNP, there has been an increase in encounters between people and wildlife, particularly rhinoceros, tigers, sloth bears, elephants, and wild boar, sometimes with life-threatening results (CNP 2015). Nine wildlife species were found to be involved with an average of 30 attacks per year from 2003 to 2013 (Silwal *et al.* 2017) and an annual average of 9.3 human death and 31.3 human injuries between 1998 and 2016 (Lamichhane *et al.* 2018). Most of the attacks were caused by rhinoceros, sloth bear, tiger, elephant, wild boar, and leopard (Silwal *et al.* 2017, Lamichhane *et al.* 2018). The human-wildlife conflict is believed to rise more in the coming days due to recovery efforts for doubling the wild tiger populations by 2022. Nepal's tiger count 2018 shows 235 tigers that have nearly approached to meet the government's commitment to double the tiger population from 121 tigers in 2009 to 250 tigers by 2022 (DNPWC and DFSC 2018). Thus, one of the significant challenges to conservation is how to enhance and sustain co-existence between people and wild animals (Makindi *et al.* 2014) in the human-dominated buffer zone area in the coming days.

Participatory conservation and habitat restoration programs in the periphery of the Park was implemented in the 1990s with the buffer zone initiatives legally lunched for integrated conservation and development programs (GON 1973, DNPWC 1996, Budhathoki 2004, Silwal *et al.* 2016) which aims to abate conflict with people and damage to livestock and property. It may not be possible to eliminate the risk of wildlife attacks, and thus the objective is to reduce it to a level that people can accept. The fourth amendment to the Nepal National Parks and Wildlife Conservation Act 1973 aims to address some of these issues by accommodating a community based integrated conservation and development approach and increasing the level of tolerance of damage caused by wildlife through sharing 30-50% of the revenue collected by



parks with buffer zone communities (GON 1973, DNPWC 1996, CNP 2018). Buffer zone management committees are legally elected to mobilize local communities to implement conservation and development programs, with overall responsibility for planning, resource distribution, and conflict mitigation (DNPWC 1999, CNP 2018). Communities have been actively involving in the management of buffer zone forests, which becoming extending available wildlife habitat beyond park boundaries (Budhathoki 2004, Gurung *et al.* 2008) and providing dispersal corridors for tigers (Sharma *et al.* 2011, Silwal *et al.* 2017), rhinoceros, elephants and other wildlife (CNP 2015, NTNC-BCC 2016, CNP 2018). Several studies (e.g. (Gurung *et al.* 2008; Carter *et al.* 2013; Pant *et al.* 2015) mostly focused on the single species, have investigated attacks by wildlife on people, and suggested improving the conservation practices in and around the Park. To our knowledge, minimal studies in Chitwan National Park have been investigated major attacking species, the spatial and temporal factors that influence attacks, or the impacts of attacks by the specific species on victims' sex, age, and ethnicities. We analyzed incidents of attacks by wildlife on humans in and around the CNP from 2014 to 2018 to record spatial patterns and temporal trends of wildlife attacks, to assess the social characteristics of the victims, to identify appropriate mitigation measures for easing human-wildlife co-existence.

Study Area

The study was carried out in Chitwan National Park (CNP) and its buffer zone. The geographical location of the Park is between 27° 20' N to 27° 43' N latitude and 83° 44' E to 84° 45' E longitude. In contrast, the geographical location of the buffer zone is between 27° 28' N and 27° 70' N latitude and 83° 83' E and 84° 77' E longitude and having an area of 953 km² and that of the buffer zone is 729 km² (Fig. 1). The Park is Nepal's first National Park established in 1973. CNP is internationally recognized as UNESCO World Heritage Site, Ramsar Site. It has become the first site accredited as Conservation Assured Tiger Standard (CATS), for demonstrating its excellence in tiger conservation and protection (CNP 2018).

The Park is famous for its biodiversity, with nearly 70 species of mammals, 576 birds, 55 herpetofauna, and 120 fish species (CNP 2018). CNP is also an extraordinary home to the world's largest terrestrial mammal, the Asian wild elephant, and the world's smallest terrestrial mammal Pygmy shrew. The Park is home of the last surviving population of rhino, and other endangered species like tiger, leopard (*Panthera pardus*), wild dog (*Cuon alpinus*), Gangetic dolphin (*Platanista gangetica*), gaur (*Bos gaurus*), hispid hare (*Caprolagus hispidus*), gharial crocodile (*Gavialis gangeticus*), wild pig (*Sus scrofa*), sloth bear (CNP 2018)). The highest population of wildlife species such as rhino, tiger, sloth bear, occur in this Park and mostly blamed for being responsible in conflict cases, including attacks on human lives (Silwal *et al.* 2017).

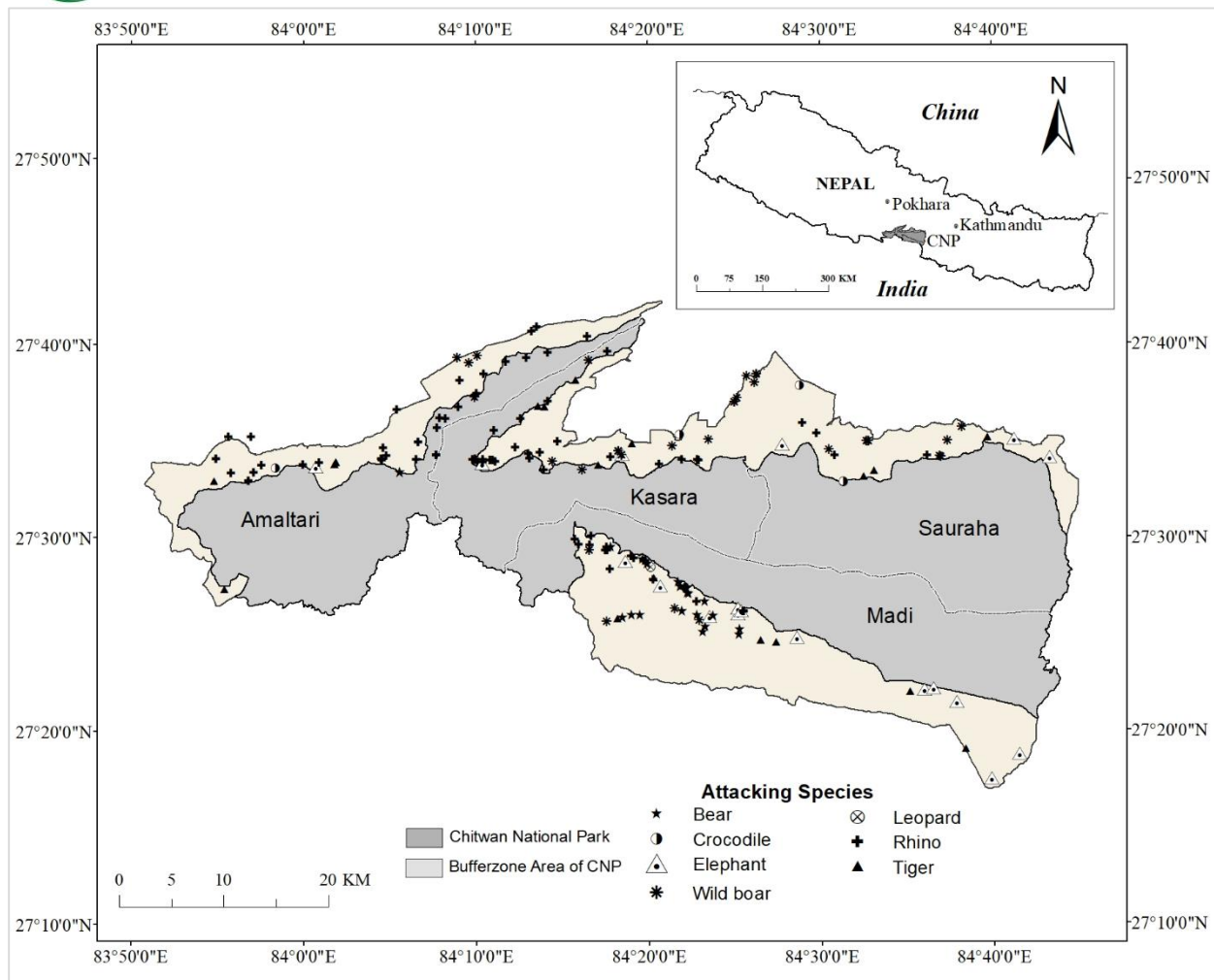


Figure 1: Chitwan National Park in Nepal (in-set) and location of wildlife attack by management sectors

Park has 16 land cover types, which include four types of Sal (*Shorea robusta*) forest associations, three types of riverine forest associations, two types of short grassland associations, three types of tall grassland associations, two types of wetlands, exposed surface, and the cultivated lands. The climax vegetation of the Inner Terai is Sal forest, which alone covers >70% of the Park. Grasslands cover 12%, riverine forests, exposed surface, and water bodies cover 7%, 5%, and 3% of the parking area, respectively (CNP 2015). The Park has several lakes and rivers. The Rapti River demarcates the northern boundary; the Reu River separates the Park from farmland on the south while the Narayani River forms its western borders. It is only on its eastern side that the NP is contiguous to the forests through Parsa National Park (CNP 2018), which makes the pristine habitats to the wildlife. To the south of the Park, it connects to the wildlife habitat of the Valmiki Tiger Reserve in India.

For the administration and management purposes, CNP and its buffer zone have been divided into four management sectors (Fig. 1): Kasara (Central), Sauraha (Eastern), Amaltari (Western), and Madi (Southern) (CNP 2018). A total of 22 Buffer Zone User Committees (BZUCs) around the Park



incorporates ~60,000 households with a population of ~300,000 (CNP 2018). The tribe communities primarily Tharu people who have been living in the area for centuries despite the epidemic of Malaria (CNP 2015). Bote, Musahar, Majhi, Kumal, Darai, and Chepang are other indigenous groups to the Chitwan. These ethnic tribe communities are generally more impoverished and dependent on the forest resources than other activities due to limited alternative livelihood options.

Many people from the hilly area migrated into the Chitwan Valley after eradicating malaria in the mid-1950s though this was previously occupied with tribe Tharu, Bote, and Darai communities (Subedi *et al.* 2013). Now the community is a mixture of indigenous tribe people and 'Hills migrants' (Brahmin, Chhetries), 'Ethnic migrants' (Tamang, Gurung, Magar, etc.), 'Dalit' or so-called untouchables (Kami, Damai, Sarki, etc.) and other minorities (Madhesi, Muslim, etc.) (CBS 2011). People primarily depend on subsistence agricultural practices, although many new economic activities such as tourism and commercial farming are gradually increasing. Livestock keeping is an integral part of subsistence agriculture, and grazing was common in the buffer zone till the early 2000s, but it shifted swiftly towards stall feeding (Lamichhane *et al.* 2018).

Methods

We collected records on wildlife attacks on humans and property loss reported to the Chitwan National Park (CNP) Office and respective Buffer Zone User Committees (BZUC: legally elected people's entity at the sector level to maintain records and recommend for relief schemes of the victims) during the period of 2014 to 2018. We collected information about the location of the attacks, date and time of the attacks, attacking animals, and consequence of attacks e.g., death and extent of injury: severe or minor as described in wildlife damage relief guidelines (Silwal *et al.* 2017, GON/MFSC 2013).

We administered semi-structured questionnaires to the victims by visiting their respective households. The victims are either the injured people themselves or the family member of the death cases who were requested to participate in the interview. Of the 188 victims interviewed, 112 were attacked individuals, and 76 were family members/ or witnesses. None of them denied the interview. We recorded perceptions of the respondents on the probable causes of such incidents and perceived ways of minimizing wildlife attacks on humans. The information on attacking animals, incident sites, the demography of the victims, date, and time when the incident took place were collected. The part of the day when the attack took place was not classified according to the clock time because the daylight conditions vary according to the seasons. Therefore, the light conditions when the incident occurred was acquired based on the subjective judgment of the victims.

We also interviewed park staffs (n=11), office bearers of the BZUCs (n=24), and people's representatives at the local level (n=5) as key informants on the issues, trends, and threats of conflicts involving attacks on humans. This also helped to find the causes of negative human-wildlife interactions.

There were a total of 194 sites where the wildlife attacked in the study period. Among these, we visited the incident sites lying inside the Buffer Zone Community Forests with the help of forest guards. At the same time, we observed the areas lying within the croplands and village through the assistance of the victims and the witnesses. In this way, we directly observed 186 sites of attacks, two from a distance, and the situation of the six sites by asking the victims. The GPS coordinates of the site of the attack were also



recorded. The characteristics of the incident sites like road, forest, grazing land, cropland, home yard, etc. were recorded (Silwal *et al.* 2017).

We analyzed the data making different categories of attacks: i) attacking animals: rhinos, wild boars, tigers, sloth bears, elephants, and crocodile; ii) victims' characters: sex and age groups; iii) location of attacks: buffer zone forests, croplands, grazing lands, village roads, victims' house, and water bodies; iv) seasons: winter, spring, summer, autumn; v) time: morning, day, evening and night. The data were visualized and analyzed using simple statistical tools. The location map of the attacking sites was prepared using ArcMap 10.4.

Results

The overall pattern of wildlife attack

There were a total of 194 incidents of wildlife attacks in and around CNP during the period of 2014-2018 (Table 1). The attacks ranged from 27 to 56, with an average of 38.8 attacks annually. Among the seven attacking animals, the highest or nearly half of the attacks were caused by rhinos (43.8%), followed by wild boars, tigers, sloth bears, elephants, and crocodiles. Only one incident of the leopard was recorded.

Table 1: Annual number of wildlife attacks in and around CNP, Nepal, during 2014-2018.

Year	Wild		Sloth		Elephant	Crocodile	Leopard	Total
	Rhino	Boar	Tiger	Bear				
2014	13	4	8	6	1	0	0	32
2015	16	5	1	4	0	1	0	27
2016	26	12	11	1	6	0	0	56
2017	11	4	2	6	4	0	0	27
2018	19	8	4	7	8	5	1	52
Total	85	33	26	24	19	6	1	194
%	43.8	17.0	13.4	12.4	9.8	3.1	0.5	100.0

The attacks were inversely related to the distance from the forest boundary (Fig. 2). Of all the attacks studied, more than three-fourth of the attacks (77%) occurred within 1 km of the forest boundary. The forest boundary here refers to the closest distance from the site of attack either to the park area or the buffer zone forest lying outside the core area of the Park. The occurrence of conflicts was less intense with increasing distance from the forest, 16% between 1 km to 2 km, and only 7% beyond 2 km of the forest. Conflict species beyond 2 km were rhino, wild boar and crocodile.

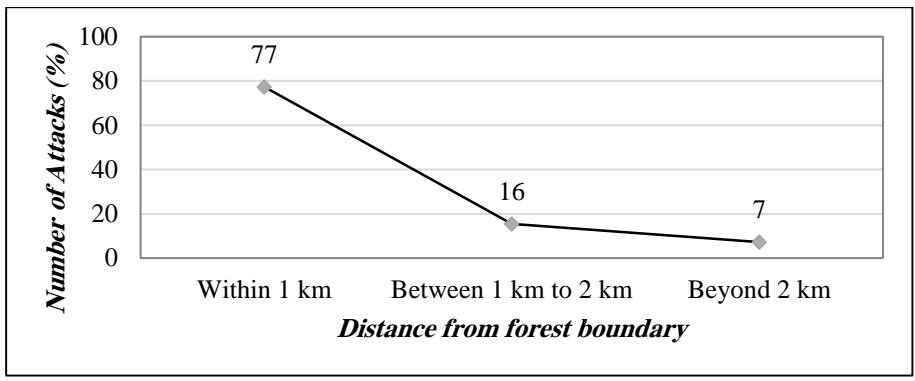


Figure 2: Patterns of wildlife attacks with increasing distance from the forest

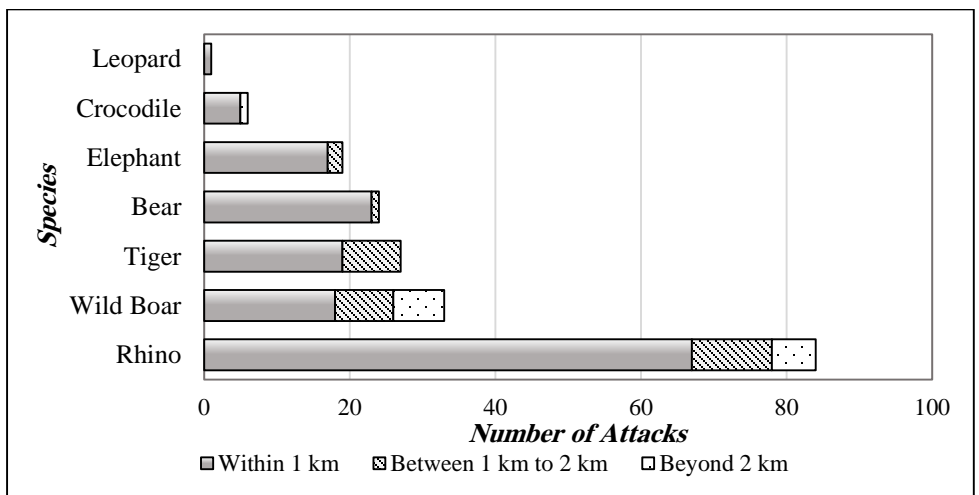


Figure 3: Attacking species and proximity of the site of attack from the forest boundary

Figure 4 shows most of the attacks occurred inside buffer zone forests (22%), followed by the croplands (20%), grazing lands (18%), and village roads (16%). Similarly, 15% of the incidents occurred at victims' houses, while only 10% of such attacks were incident near water bodies.

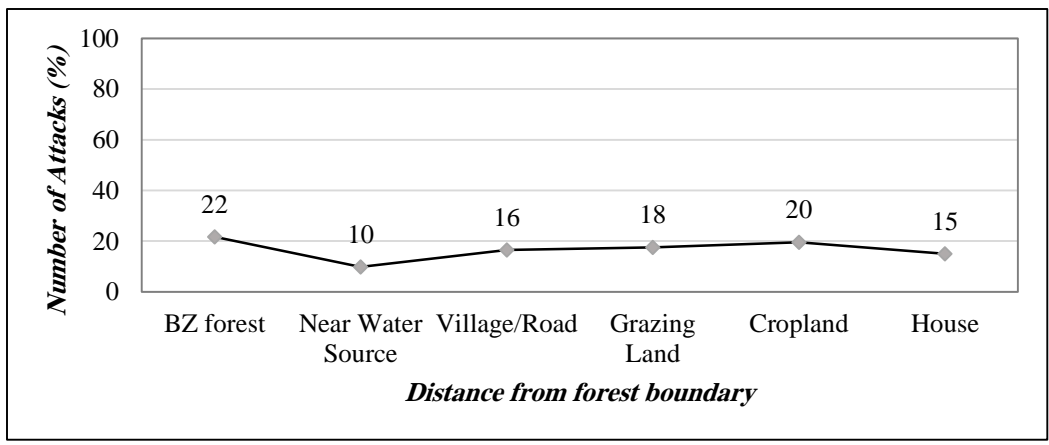


Figure 4: Incidence of wildlife attacks on different land uses



Figure 5 shows the highest number of attacks in the Madi sector, one third (33%) of all the attacks. The least frequency of attacks (14%) was observed in the Sauraha sector. There were 28% and 25% of the attacks in the Amaltari and Kasara sectors, respectively.

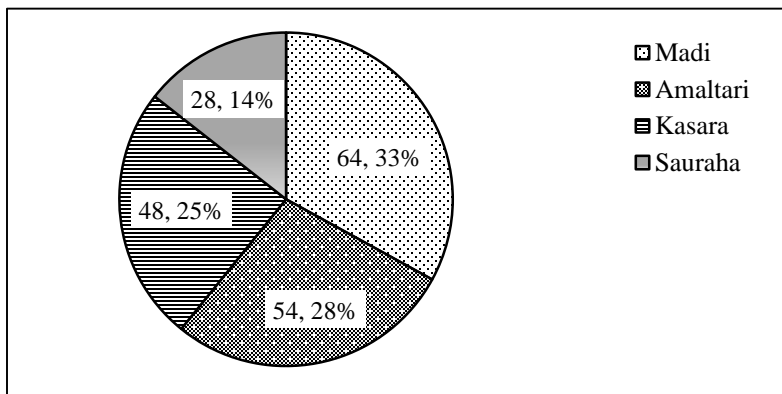


Figure 5: Sector-wise occurrence of wildlife attacks

The attacks happened almost uniformly in all forms of land use in the Kasara sector. However, the Madi sector has the highest number of incidents at grazing land (36%). Likewise, more attacks occurred inside buffer zone forests in Sauraha (36%) and the Amaltari sector (325%) (Fig. 6).

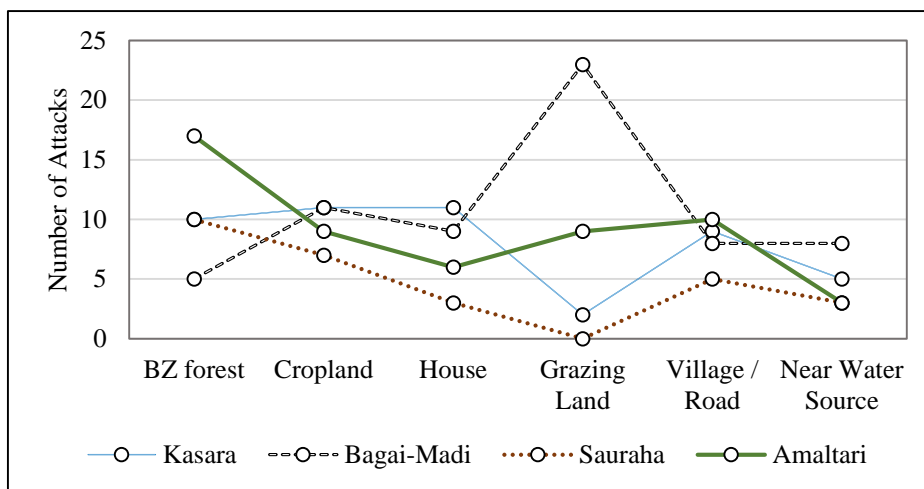


Figure 6: Spatial patterns of wildlife attacks on people in four different sectors of the Park

Rhino and tiger attacks are observed to be expected in all the sectors. Wild boars are more problematic in the Kasara sector. All kinds of significant attackers except crocodiles are challenging in the Madi sector. Madi sector alone suffered 22 of 24 attacks by a sloth bear and 13 of 19 attacks by elephant (Fig. 7). The only case of human attacked by leopard also occurred in the Madi sector.

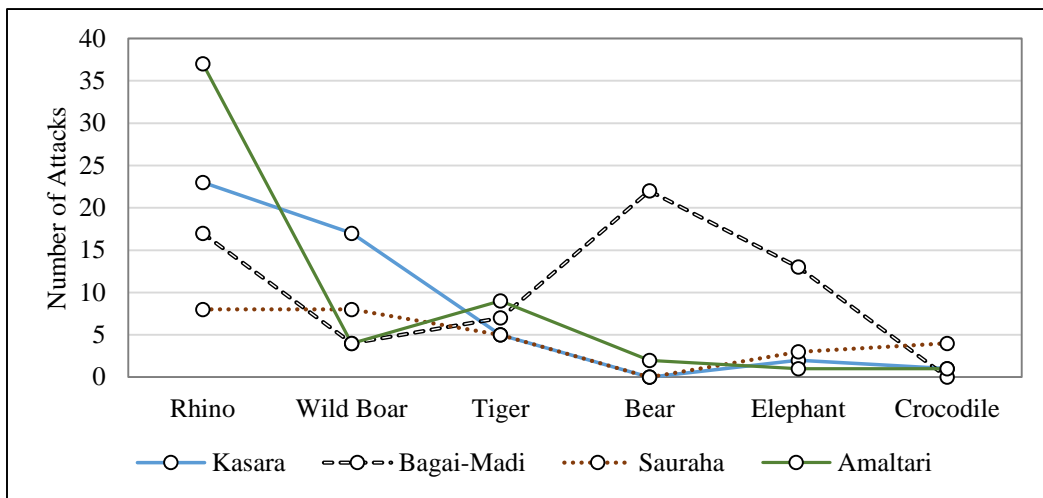


Figure 7: Occurrence of wildlife attacks by sectors

The attacks of rhinoceros were observed to occur in all kinds of land forms, mostly inside the bufferzone community forests (33%, n=28), while the most of the attacks of tiger (46%, n=12) and sloth bear (38%, n=9) occurred in grazing lands. More than one-third (37%, n=7) of the elephant attacks occurred at the victims' house. The attacks of wild boar mainly occurred at croplands (33%, n=11) (Fig. 8). Five of the six attacks of crocodile happened nearby the water sources whereas the only one case of leopard attack was reported to occur at the victim's house.

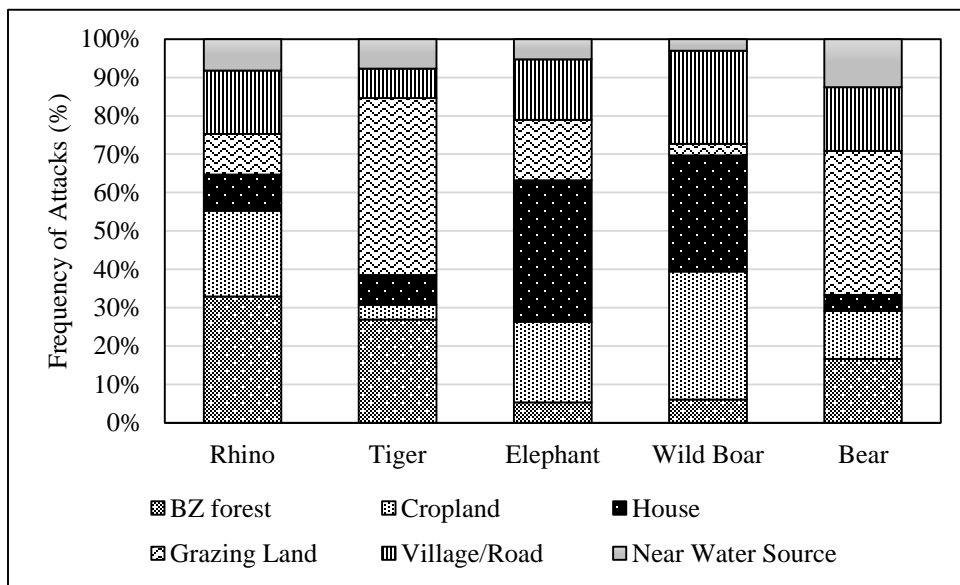


Figure 8: Species-specific location of attacks



Temporal Patterns of Wildlife Attacks

There was significant difference in attacks among seasons ($\chi^2=13.92$, $df = 3$, $p=0.003$) and time of day ($\chi^2=88.68$, $df=3$, $p<0.001$). More than one-third of attacks (35%) occurred in the winter season and lowest in the summer season (17%). (Fig. 9) Similarly, about nearly half (46%) of the attacks occurred during day time and the lowest in the evening time (7%) (Fig. 10).

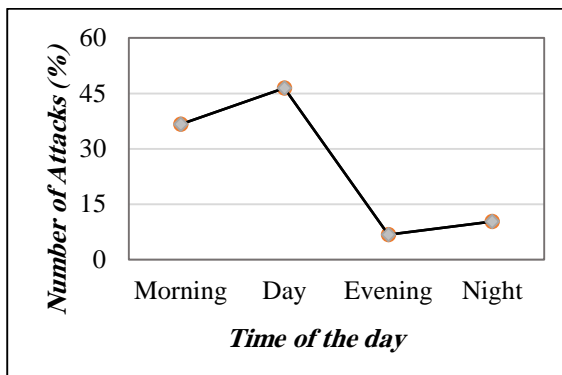
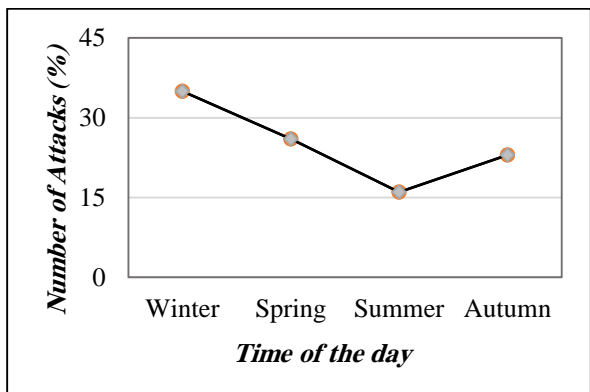


Figure 9: Temporal patterns of wildlife attacks by season

Figure 10: Temporal patterns of wildlife attacks by the time

Most of the attacks of rhinoceros (39%, $n=33$) and sloth bear (46%, $n=11$) occurred in winter. Similarly, 46% ($n=12$) of total attacks of tiger and 49% ($n=16$) of the attacks of wild boar occurred in spring. The attacks of elephants mainly occurred in autumn (37%, $n=7$) and winter seasons (37%, $n=7$). The marsh crocodile occurred equally in summer (50%) and the autumn season (50%) (Fig. 11). The only case of an attack by a common leopard occurred during the summer season.

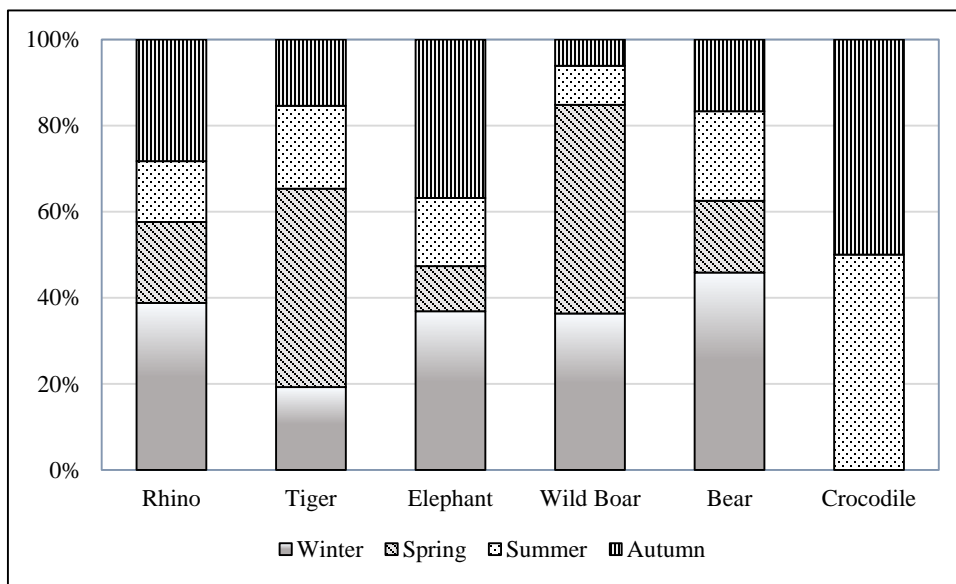


Figure 10: Species specific seasonal occurrence of attacks



The attacks of rhinoceros mostly occurred during day (49%, n=42) and morning time (38%, n=33). The attacks of tiger (65%, n=17) and sloth bear (50%, n=12) were higher during day time. Two-third (67%, n= 22) of the total attacks of wild boar occurred in the morning times. Majority of the attacks by elephants (53%, n=10) occurred in the night time and the attacks of crocodile mainly occurred at day times (67%, n=4) (Fig. 12). The case of attack by common leopard was reported to happen in the night time.

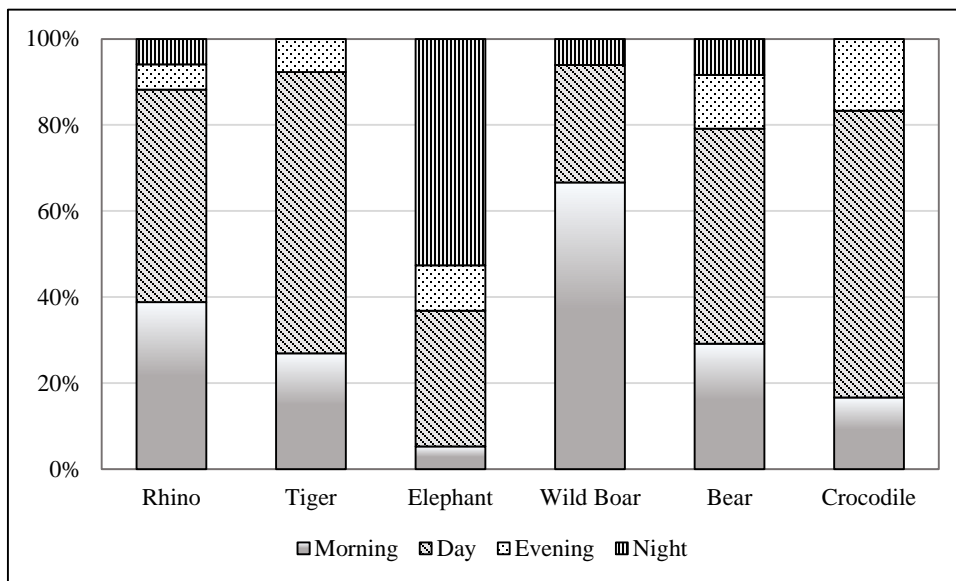


Figure 11: Species-specific occurrence of attacks by the time

More than one-fourth (27%) of the attacks in the morning occurred at croplands, 21% at the victim's house, and 21% at roads in the village. Buffer zone community forests and grazing lands experienced the highest intensity of attacks at day time, 32% at each of those sites. During the evening time, 38% of the attacks occurred on roads in the village. Similarly, half of the attacks that occurred at night were incident at victims' houses. (Fig. 13)

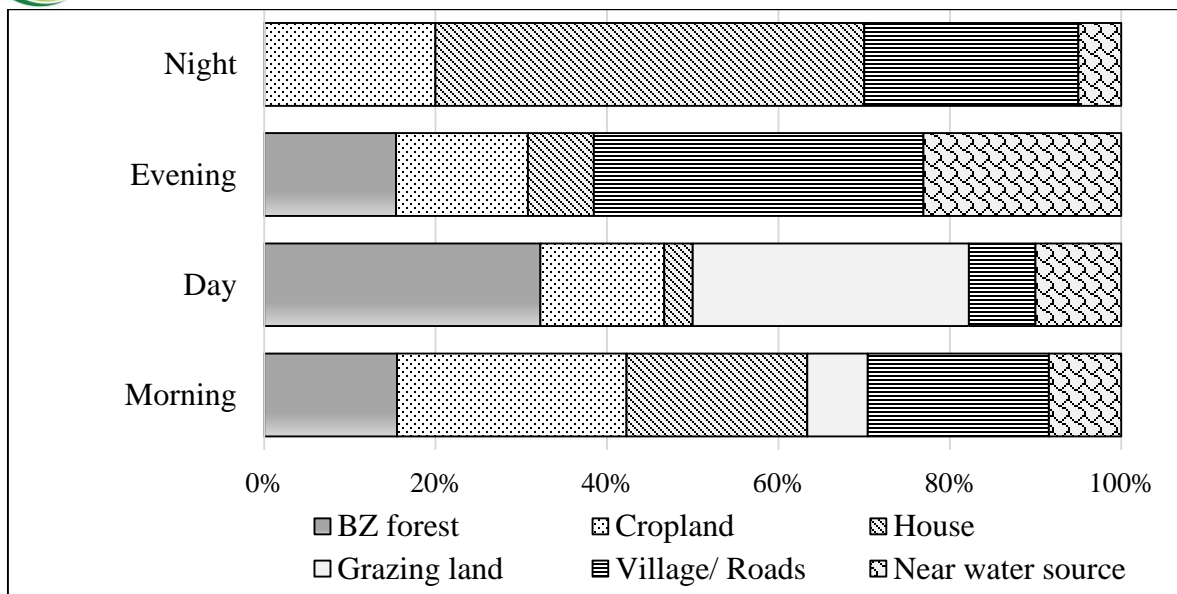


Figure 12: Wildlife attacks by time and site of incidence

Characteristics of victims and injury severities

The wildlife attacks occurred in 127 males and 67 females, of which 26 males and 19 females were killed. These fatalities occurred in 6 children, 13 youths, 13 adults, and 13 older people. (Table 2)

Table 2: Extent of severity and age-groups of attacked people

Severity Level	Female	Male	Child (1-18 years)	Youth (19-40 years)	Adult (41-60 years)	Senior adults (above 60)
Death	19	26	6	13	13	13
Severe Injury	27	38	2	13	37	13
Minor Injury	21	63	5	24	33	22
Total	67	127	13	50	83	48

We found no significant relations between the frequency of attacks by primary attackers and the social association of the victim. In total, 63% (n=123) of the attacks occurred in two or more people. More than half of the attacks in every attacking species of animal occurred when victims were with a friend or in a group (Fig. 14). The severity level of attack and the social association of the attacked individual was not found to be correlated.

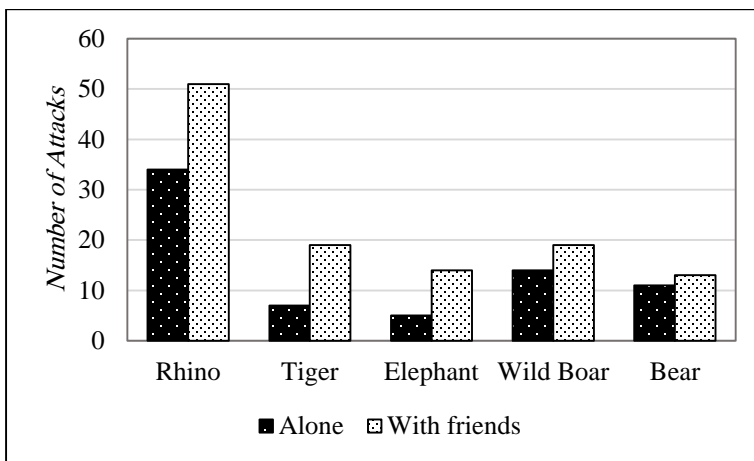


Figure 13 Wildlife attacks and social association

Figure 15 shows the highest number of human deaths was caused by rhinos (n=20), followed by elephant (n=12), tiger (n=22), and crocodile (n=2). The attacks of wild boar, sloth bear, and leopard caused no human fatalities. 63% of the elephant's attacks were fatally, followed by 42% of the tiger attacks, 33% of the crocodile attacks and 24% of the rhinos.

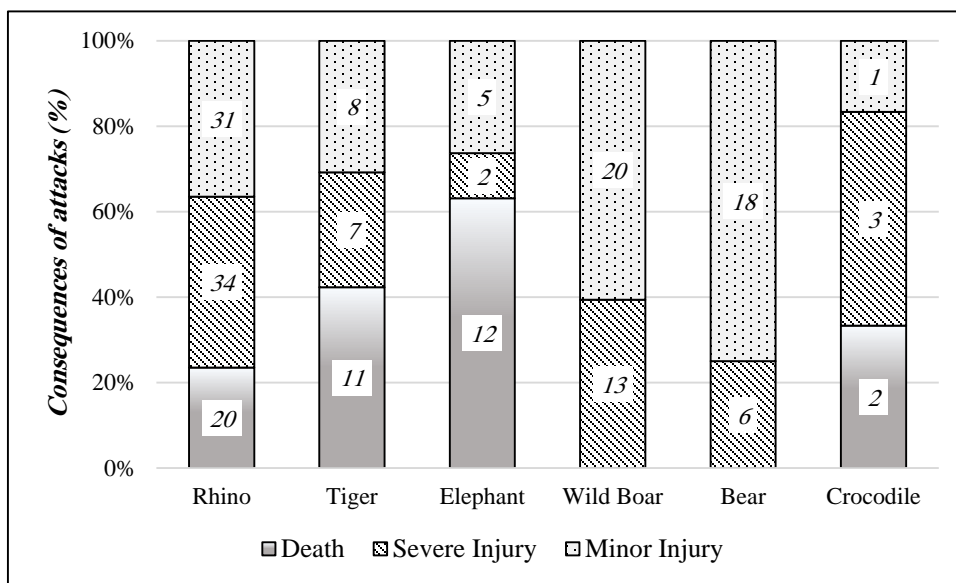


Figure 14: Species-specific injury severity level

The victims of wildlife attacks belonged to different ethnic groups (Table 3). We tried to assess the relationship between the severity of the attack and the ethnicity of victims and found no such relation exists. It would be irrational to draw the conclusion such as Chepang are the least affected, and Brahmin/Chhetri is the most affected amongst all ethnic communities.

Table 3: Extent of severity and ethnicity of attacked people

Severity Level	Brahmin / Chhetri	Dalit	Darai/Bote/ Musahar/Kumal	Tharu	Chepang	Others	Total
Death	10	10	0	0	0	0	20
Severe Injury	14	10	0	0	0	0	24
Minor Injury	17	10	0	0	0	0	27
Total	41	30	0	0	0	0	71



Death	9	5	6	12	2	11	45
Severe Injury	19	5	14	11	2	14	65
Minor Injury	28	6	14	19	0	17	84
Total	56	16	34	42	4	42	194

Discussions

Human Death and Injuries

The annual wildlife attacks occurred at 38.8 in and around Chitwan National Park (CNP) during 2014-2018. The number of attacks fluctuated (Table 1) and resulting in minor to fatal injuries. The result does not coincide with others' results from CNP. Lamichhane *et al.* 2018 reported an annual average of 40.6 attacks from 1998 to 2016, but Silwal *et al.* (2017) found 30 attacks on a yearly average between the period 2003 and 2013. The potential causes include the increasing number of main attacking wild animals like rhinoceros, which numbers reached from 408 in 2008 to 605 in 2015 (GON/DNPWC 2017). The rhinoceros was alone responsible for more than 43% of the total attacks. CNP is one of the National Parks supporting the highest abundance of tigers; the population of the tiger had reached to 120 in 2013, which was 91 in 2009 (CNP 2015). However, a more recent census in 2018 identified only 93 tigers in CNP (DNPWC and DFSC 2018).

Reduction in wildlife crime after the end of armed insurgency in Nepal (Karki *et al.* 2013) and increment in wildlife populations in response to conservation activities (Lamarque *et al.* 2009) has attributed to increased conflicts. Similarly, grazing restrictions in the Park has reduced the previously available domestic prey, reduced the number of cattle, increased fodder cutting for stall feeding, and, at the same time, helped the forests and wild prey foster (Gurung *et al.* 2008, Gurung *et al.* 2010). This has made buffer zone forests an attractive habitat to wildlife and increased human-wildlife interaction. The incidents of conflicts are more than the records kept by the park authority, and BZUCs as the incidents that occur from the unauthorized entry of the people in the core area of the forest aren't eligible to receive the relief amounts (GON/MFSC 2013, Lamichhane *et al.* 2018). There are no provisions for providing relief amounts to a foreigner who is attacked in Nepal. This also may be due to better communications and filing cases of the attacks for the relief payments from the park authority. There was some news of the attacks that occurred within the core areas of the National Park. Since these happened due to the illegal entry of the locals, the cases are not considered for the compensation or relief procedure and are beyond this study. Still, there were some incidents that actually occurred inside the core area of the Park, yet the BZUC couldn't resist the public pressure and declared the site of attack be outside the core areas to help the local people receive compensation amounts (Key Informant).

According to a key informant, who is also the elderly from the indigenous Tharu community, relatively very few cases of collision between people and wildlife used to be observed and heard some decades ago. Unlike now, there was no practice of cutting grass and feeding the livestock; instead, people used to visit forests more frequently to graze the livestock and to derive forest products. People were mindful of the nature of wildlife, and the wildlife was aware of people's presence and activity within the Park. The strange reality regarding escalated levels of HWC is that the wildlife is not as abundant as they used to be some decades ago, but the cases of human attacks are often heard. At present, the National Park is opened for at least two days a year to collect the grasses, thatch, and reeds to support the livelihoods of the local residents (DNPWC 2018). The area of grassland in CNP has shrunk to 9.6% from 20% between the period of 1970 to 2016 (CNP 2016) due to invasive intrusion and the natural process of succession, which could be more accelerated in the absence of anthropogenic disturbances.



Spatial Pattern of Attacks

More than three-fourth of the attacks (77%) occurred within 1 km of the forest boundary. It was evident that the closer the forest boundary, the higher are the chances of accidental encounters with wildlife.

Rhino seems to be significant conflict species in all sectors of NP and in almost all kinds of land use. This might be due to its rising population and increased adaptability in natural habitats as well as in human-altered habitats. In recent years, rhinos are frequently reported to be roaming on the streets and villages lying within Park BZ. We found the majority of attacks occurred in buffer-zone forests and croplands, which satisfies with findings of Acharya *et al.* 2016, Silwal *et al.* 2017, and Jnawali 1989.

Most of the attacks of the tiger (46.2%) and sloth bear (37.5%) occurred at the grazing lands. Tiger density is very high in the alluvial floodplain, and grasslands habitat (CNP 2016) were they co-occur with their prey species, which are mostly herbivores.

Bear attacks were observed mostly on grazing lands, followed by buffer zone forests, villages, and croplands. More than 90% (22 among 24) of the sloth bear attacks reported in and around CNP occurred in the Madi valley alone. Also, the sloth bear was solely responsible for more than one-third (34%) of the conflicts in Madi valley. Thus, our finding conflicts with the findings of Acharya *et al.* (2016), which found sloth bears attacking mostly in farmlands and mentions sloth bears as one of the least pronounced conflict species in Nepal. Bushlands, grasslands, and water sources are the more preferred habitat of sloth bears (Silwal *et al.* 2017), and this is abundantly available in the Madi region. Bears frequently visit places with multiple lands uses, especially close to the edge of forests (The Corbett Foundation 2017), and this could be why sloth bear attacks are so intense in Madi valley, which is surrounded by forests in all directions.

The attacks of wild boar mainly occurred at croplands, houses, and village roads. Yadav *et al.* 2017 explained that wild boars prefer human-dominated areas due to convenience in obtaining of food material. A respondent from Barandabhar BZUC mentioned that the villagers used to hunt the wild boars entering into the village a few years back and the problematic wild boars were in control. According to him, the widespread access to mobile phones and internet networks in recent years has made people aware as well as scared to involve in hunting the wild boars. They fear that their deeds might get leaked to the public and park administration by some such means.

Elephants' attacks are more concentrated in the Madi sector (68%), with infrequent events in the Sauraha sector (n=3) and Kasara sector (n=2). Likewise, a case of elephant attack was recorded in the Amaltari sector for the first time in May 2017. Parsa National Park, which is home to 25-30 resident elephants (DNPWC/MoFSC/GoN 2009) is adjacent to the Madi sector in the east; this closeness to Parsa National Park may be the reason behind frequent attacks of elephants in the Madi sector. Buffer zone in the Amaltari sector lies to the west of river Narayani, and no elephants were ever reported to cross and reach the lands to the west of this river before. The event might be due to the accidental reach of the elephant across the river when the water levels in the river were shallow during the dry season. Only one among 19 cases of elephant attack was identified within the buffer zone forest. The rest occurred outside the forest areas. This finding corresponds to the findings of Acharya *et al.* 2016, which found the attacks by elephants were mostly outside protected areas in the human settlements. Elephant Conservation Action Plan of Nepal mentions electric fences as successful means to curtail elephant movement in human settlements, park authority, and buffer zone development programs are investing in it. However, the barriers sometimes at some places are connected with a live electric wire leading to fatal consequences to both wildlife and humans.

Crocodile attacks are more intense at the Sauraha sector because Rapti River, which hosts a good population of mugger crocodiles, is located within the BZ forest and is open for the public boating and fishing purposes. On the contrary, the Rapti River flowing through the Kasara sector lies within the core area of the Park, and it is restricted for the local peoples to visit, swim, or fish.



Our study revealed that one-third of the incidents occurred in the Madi sector alone. This finding is in line with Silwal (2016), who recorded the highest number of attacks (30%) in the Madi sector, followed by Kasara, Amaltari, and Sauraha of CNP. Park surrounds Madi Valley in the northeast and BZCF to the south-west, which has made it an isolated island of human settlement (Gurung 2008), which might be a significant factor behind the more intense attacks of all kind of species in this region. A vast landmass of the people is converted into grasslands by the regularly occurring floods in the Madi sector. These flooded and abandoned lands of Madi and Thori are often used as the grazing lands (kans-ghari) by the local people who are dependent on agriculture and livestock farming in the area, resulting in a decreased dependency on BZCF. The people, particularly in the Madi-Thori area, have a negative attitude towards the National Park and hence, don't feel that they should be the partners along with the national park authority for the conservation. There are relatively fewer buffer zone community forests in the Madi sector (CNP 2018) despite the vast area of forest within the adjacent buffer zone area. This may be why there is a lesser number of the conflicts involving human attacks within the buffer zone forests of the Madi sector.

The least number of conflicts were observed in Sauraha sector. This may be due to the reduced dependency of people relying upon forest resources to make their livelihood and development of tourism business and related employment opportunities.

Temporal Pattern of Attacks

We found that the conflict events peaked in the winter season, and this finding agrees with the results of Acharya *et al.* 2016 and Silwal *et al.* 2017. In the summer season, grazing is not practiced as the agricultural lands are occupied by crops, and during this period, the rivers and the grazing lands nearby them are flooded. At the same time, there exists an abundant amount of grass within CNP. Thus, wildlife remains within the core areas of the Park and BZ forest. On the contrary, the core areas of the Park are filled with tall, dense, and dry grass, and the crops are abundant and are ready to harvest in the agricultural lands during the months of winter. The quality and quantity of forage in forages are low during winter (Laurie 1982, Acharya *et al.* 2016) due to which the herbivores shift towards the outskirts of the core area as well as the prey species of the carnivores. Also, immediately after harvesting the crops in November/December, few crops are grown, and households allow livestock to graze more on the agricultural land and on the grazing grounds. These may be a few of several reasons for the higher occurrence of the attacks during winter. Silwal *et al.* 2017 stated the foggy weather to be a cause of increased collision between humans and animals due to reduced visibility during the months of winter.

In March 2016, a single tiger attacked seven people in Nandabhauju BZUC of the Amaltari Sector. This is the reason for the highest frequency of tiger attacks in the spring season. Similarly, wild boars forage on potato and maize (Pandey *et al.* 2015), and these crops are mainly grown during the spring season. That must be why the cases of attacks of wild boar are high during the spring season.

The attacks by rhinos were mostly observed at day times and the buffer zone forests. This suggests that people enter the buffer zone forests to collect forest resources during day time. Similarly, more number of tiger attacks occurred in the day time and the grazing lands. It could be linked with the practice of people taking their livestock to graze in the grasslands and riverbanks during the day time. Elephant attacks are high during night time, and it may be due to the comfort in raiding the paddy fields during the months of winter. People need to spend sleepless nights trying to drive the wildlife off their farm (Santiapillai *et al.* 2010), and thus, there are higher chances of encounters. Likewise, other herbivores are also involved in crop-raiding during the night time. This results in increased opportunities for local people being attacked at their house yard or in their fields while safeguarding their crops. Two-third of the wild boar attacks



occurred in the morning time. Even most of the attacks that happened in the early morning periods were caused by the animals leaving the croplands after foraging on paddy, wheat, or lentils (Silwal *et al.* 2017) or got lost within the croplands being unable to track its path back to the forest.

Severity Level and Social Association of Attacks

The frequency of attacks due to different species was not found associated with the presence of an individual or a group of individuals. Elephant attacks mainly occur at home or the croplands, and hence the attacked person is more likely not to be alone. Similarly, wild boars are generally chased to drive it away from the forest or take it in control, and therefore, most of the attacks occur in the presence of family members or the villagers. The attacks don't occur unless when the particular animal involved in the attack feels threatened or gets an abrupt change in its behavior. Hence, no statistical relations exist between the severity level of attack and the social association of the attacked individual.

The injury severity is generally dependent on the type of causative species, except when the injury worsens due to the lack of immediate rescue or treatment. However, their social association helps the attacked individuals acquire defense against the attacking animal and immediate rescue and treatment and prevents them from losing a life. Regarding the fatalities, Silwal (2016) found the highest rate in case of elephant attacks (68%), followed by tiger (57%) and rhinoceros (29%), which corroborates to the findings of our study. Acharya *et al.* (2016) also found the kill ratio highest in elephant attacks, followed by leopards and then rhinoceros. The severity of the attack was not found significantly associated with gender. Neither the level of seriousness was found significant with the different age groups. However, the attacks on the male are high because of their role in grazing, defending their crops and property against wild animals, fishing, and farm works. Male members in the family have an active role in supportive household activities like collecting forest products, farm work, fishing, cattle herding, etc. (Silwal 2016). Therefore, they are more exposed to such encounters.

The findings of our research are different from the studies of Lamichhane *et al.* (2018), which identified more than two-thirds of the human killings was caused by tiger (38.3%) and rhinoceros (32.1%) during 1998 to 2016. It's because no man-eater tiger was causing The majority during 2014-2018.

The habitat conditions within the core area of the Park are deteriorating, and several types of research have explained this. The shrinkage of the available grasslands due to the invasion of alien species (*Mikania macarantha*) (CNP 2016) and the natural process of succession have driven wildlife in the outskirts of the park area and thus contributing to an escalated number of wild animals roaming around the croplands. Even the electric fencing, which was proven to be effective in Rhinoceros during the years of installation, is now out of function. It is also noteworthy that the population of the wild animals is rising (CNP 2015, DNPWC and DFSC 2018) despite the habitat deterioration. On the other hand, the human population in the buffer zone (Bharatpur Metropolitan, Madi Municipality, and Sauraha) is also steadily increasing. These existing shreds of evidence illustrate that the trend of attacks would further get intensified in the days to come.

Conclusions

Despite the adopted mitigation measures, the trend of wildlife attacks is increasing. A significant amount of budget of CNP is spent on infrastructure development annually to prevent the entry of wild animals into human settlements. Still, again the intensity of conflicts has not been minimized yet. Therefore, the quality of the infrastructures, their sustainability, and their effectiveness seems to be questionable.

This study can assume that the cases of human-wildlife conflicts will further continue to rise if the current practices prevail at this level. Regular maintenance of the existing barriers between the buffer



zone forest/ core area and human settlement is necessary. The embankments and trenches under construction along the Reu River in Madi is expected to control the flood as well as the entrance of wild animals into villages. From the other point of view, the state authorities don't seem to be careful about safeguarding the human settlements, and when the locals are compelled to leave the area, and the rich people buy a huge extent of the abandoned land at a cheap price, the government prioritizes the plans and investments for the construction of embankment and dams to defend the lands of rich from floods and animals. People of the Madi region are considered the foes of NP as the wildlife attacks are more intense in this region. The negative sentiment is further aggravated by the BZ Management Guidelines, which demands the consent of warden of NP to build even the basic and tiny infrastructures within the BZ area of NP. Thus, necessary revisions need to be made if possible, without compromising the values of conservation. Grassland and wetland management is the most crucial management option to accommodate the existing populations within the core area of the Park. Waterholes and lakes within core area of Park need to be protected from the invasion of grassland and the invasive species so that wild animals won't frequently visit along the rivers which border with the human settlements. The residents of buffer zone who are most exposed to the chances of wildlife attacks should be provided knowledge about the ecology and behavior of major attacking animals and skills in order to adapt or escape those events. The human settlements lying within the core areas of NP should be evacuated. A total of 1208.49 hectares of the NP is occupied by approximately 2330 households at 12 different places (CNP 2018). Some of the human settlements which are at high risk of wildlife attacks as well as possess threats to wildlife conservation also need to be shifted. Simara is a small village in the Baghauda, which is trapped in between the core area of CNP and the Reu River, and the village lacks road access and other development infrastructures. There are several communities settling at the edge of the Park and buffer zone forest in Madi, and they usually suffer the problems of livestock depredation and crop-raiding. On the individual level, the people of Madi are practicing fisheries over conventional agricultural practices. The BZ programs need to develop programs and invest in fisheries development at the community level, which could be an appropriate strategy to deter wild animals from entering the human-dominated landscapes. Care should be taken to ensure that animal preventive infrastructures built up to safeguard people and their property do not pose a threat to wildlife and their mobility. The management of habitats is a must to ensure enough availability of food and water resources required for wildlife.

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