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Human Disturbance is the Major Determinant of the Habitat and Prey Preference of the Bengal Tiger (*Panthera tigris tigris*) in the Chitwan National Park, Nepal

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ABSTRACT

We studied the impact of human disturbances on the habitat and prey preference of tiger by walking along transects in different sites of the Chitwan National Park, Nepal. The study found that tiger mostly preferred successional forests, grasslands and floodplains while avoiding the *Shorea* forests. Tiger strongly preferred prey abundant areas and strongly avoided the human disturbed areas. The prey preference of tiger obtained through scat analysis showed the highest preference of medium sized prey and less preference of large sized prey while avoidance of small, very small sized prey and domestic mammals. Tiger utilized higher numbers of domestic prey in the areas where there was high disturbance and less abundance of wild prey. The low preference of large sized prey and high preference of medium sized prey might be due to the low availability of large prey (e.g., sambar, gaur) and comparatively high availability of medium sized prey (e.g., chital, wild boar) in this area. For the effective use of habitat and prey, a predator like tiger needs considerable behavioural plasticity with the lonely wilderness. The regular disturbances caused by human activities could invite a dramatic change in the behavior of such predators which consequently increases conflict with people and declines in prey population. Hence, the habitat and prey preference of tiger not only depends on prey abundance but also depends on the degree of habitat disturbances in the human dominated landscapes like Chitwan. Proper management of parks by delineating the core areas as the prohibited zone and having only the buffer zone area as the free access zone for the local people to accommodate their daily needs, could help minimize the human disturbance in this park.

KEYWORDS

Bengal tiger, prey preference, prey, Chitwan, conservation, human disturbances

INTRODUCTION

The Bengal tiger *(Panthera tigris tigris)* is considered as an icon and umbrella species of the terrestrial wildlife community in all the ecosystems wherever it occurs. So, conservation of Tigers can be thought of as the conservation of whole ecosystem and wildlife community (Seidensticker et al. 1999; Karanth et al. 2003). Study on the status and distribution of tiger is an integral approach to develop conservation strategies and programs to safeguard the wild tiger populations in the terai arc landscape (Dhakal et al. 2014). The ecology of such a predator is positively related to prey abundance and density, particularly wild ungulates. The wild ungulate communities in the CNP include various species of cervids, bovid and suid, and are especially preyed upon by tiger and leopard (Johnsingh 1992; Smith 1984; Stoen & Wegge 1996). Common leopard is an ecologically sympatric predator that competes with tigers for the same prey and habitat in this area. These predators play a vital role for the maintenance of the wildlife communities (Schaller 1967; Karanth & Sunquist 1995; Karanth et al. 2004). The decline in prey population due to the result of change in habitat condition, habitat degradation, wildlife-people conflict and widespread poaching (Smith et al. 1998) can modify the overall ecology and distribution of carnivores, especially large carnivores like tiger and leopard. The lack of sufficient prey in the wild, especially in the isolated small patches of protected areas (Smith et al. 1987) is insufficient food requirements of predators. Consequently, they tend to resort to the new prey like livestock (or sometimes human) and low populated threatened wildlife. Furthermore, the continued depletion of prey base, habitat loss, poaching for trade and retaliatory killing by aggrieved farmers are further reducing tiger and other large carnivore populations and can also intensify sympatric competition for food and space in predator guilds (Weins 1993). Such conservation issues can be studied with the aid of estimating prey abundance, habitat and prey preference by the predators.

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Generally, carnivore species use habitats and prey in proportion to its availability in the study area (Alldredge & Ratti 1986; Otis 1997) and the habitat use is generally considered to be selective, if an animal makes choices rather than wandering randomly through its environment (Garshelis 2000). The preference of any particular prey type and habitat by carnivores depends upon the reliable analysis of diet and presence of signs of predators in the respective habitat (Khan & Chivers 2007). The analysis of either stomach contents or scats (Reynolds et al. 1991; Mukherjee et al. 1994a; Biswas et al. 2002) and the presence of signs of predators to estimate prey and habitat preference have become the fundamental tools in carnivore research. Since information is easy to collect and does not involve destruction of animals from the study population for solitary, elusive and shy animals like tiger, prey and habitat preference have become the fundamental tools in carnivore research. These methods provide the type and dimension of prey species eaten and habitat utilized by tiger. Furthermore, such study can also be the tool for studying the intra and interspecific competition as well as resource partitioning among sympatric carnivores in a multi-predation system (Meriggi et al. 1991, 1996; Meriggi & Lovari 1996; Karanth and Nichols 2000), sizes (Gittleman 1985), foraging habits (Palomares et al. 1996), activity patterns (Fedriani et al. 1999), territory (Palomares et al. 1996; Durant 1998) and evolution of different anatomical adaptations for prey selection (Ewer 1973; Biknevicius & Van Valkenburgh 1996).

The enumerations of the frequency of the signs of tiger to determine the habitat preference and scats analysis to determine the prey preference were used. Habitat preference of tiger depends on the abundance of wild prey and lonely wilderness. In the human disturbed areas, these large carnivores are forced to feed on domestic prey. No such study has been conducted in this area that considers habitat and prey preference of tiger in terms of human disturbances. Hence, the present study was designed for the better understanding of prey and habitat preference of tiger in terms of disturbances in multivariate ways and such study can be used as a cornerstone to make sustainable management strategies of such an endangered species like tiger.

1. MATERIALS AND METHODS

1.1. Study area

Chitwan National Park (952.63 km^2) comprises mainly of Sal forest and savanna type grasslands that falls into one of the high priority tiger conservation units (Wikramanayake et al. 1998) and is included among the World heritage sites by UNESCO. It is located in the lowland terai region of Nepal. The park consists of diverse ecosystems ranging from early succession stage of the alluvial floodplains along the rivers and their feeder streams to the climax stage of Sal (*Shorea robusta*) forest on the foothills and slopes of the Churia range. Vegetation in the area is characterized by subtropical moist deciduous forest with tall grassland (Stainton 1972). Sal forest including riverine forest and mixed hardwood forest covers 80% of the park. Similarly, grasslands (both tall and short grasslands – 12%), riparian flood plain and exposed areas (5%) and water bodies (3%) (Thapa 2011; Bhattarai & Kindlmann 2012). The successional forests (i.e., riverine forest) are stretched along the river courses with the large tracks of Khair-sissoo forest on the old riverbeds of the Narayani and Rapti rivers (Dhakal et al. 2014). CNP is important for the heterogeneous habitats (riparian flood plains, grasslands and forests) that provide year-round food and water sources for wild herbivores (Bhattarai & Kindlmann 2012). Barandabhar Corridor Forest (BCF) is one of the most important forest corridors that connects CNP to the Midhill landscape (key part of Chitwan-Annapurna Landscape) functioning as a bio-corridor. About 56.9 km^2 of BCF is under the buffer zone of CNP and remaining 31 km^2 is under-protected. This forest is mostly dominated by the climax *Shorea* forest with interspersed short grasslands in many parts (Dhakal et al. 2014).

The Park has one of the highest densities of large mammals, including tigers and rhinoceroses in the South Asia. It is also a part of the Terai-Duar Savanna and Grasslands which is listed among the 200 globally important areas of biodiversity, due to its large mammal assemblage (Wikramanayake et al. 2002). Chitwan National Park (CNP) provides home for at least 68 species of mammals including the prominent species like tiger (*Panthera tigris*), sloth bear (*Ursus ursinus*), gaur (*Bos gaurus*) greater one-horned rhinoceros (*Rhinoceros unicornis*), and Asian elephant (*Elephas maximus*). It also supports a high diversity of ungulates (Stoen and Wegge 1996) that are the major tiger prey species, such as gaur bison (*Bos gaurus*), sambar (*Rusa unicolor*), chital (*Axis axis*), hog deer (*Axis porcinus*), northern red muntjac (*Muntiacus vaginalis*), wild boar (*Sus scrofa*), and two species of primates- common langur (*Semnopithecus entellus*) and rhesus monkey (*Macaca mulatta*) (Smith 1984; Stoen & Wegge 1996; Bhattarai & Kindlmann 2012; CNP 2018).

1.2. Methods

The study aims to demonstrate the factors determining the habitat and prey preference of tiger in the CNP. The expected proportion of use of prey and habitat are interpreted as evidence of resource selection. We used line-transect sampling (Buckland et al. 2004) to record the frequency of tiger signs such as pugmarks, scrape marks, scent marks and so on (transects with fixed width – 5m to right and left side) and to estimate the abundance of prey species in the CNP, we measured perpendicular distance from the observer (obtained from sighting distance and angle). Similarly, the abundance of domestic mammals (livestock) was also recorded as the number of individuals along the transect walk. We walked 80 transects twice in the year 2013 that covered 1154 km. The fixed width for sign survey was adopted in order to minimize the sampling bias, which can be a potential problem in measuring habitat use based on signs (Garshelis 2000). We avoided less visible and unclear pugmarks of tigers, as the occurrence of this sign may vary markedly among the habitat types according to the ground substratum. Therefore, the pugmark signs were mainly taken from firelines, tracks, floodplains, banks of waterholes and so on. Floodplains usually have a large number of pugmarks because of the substratum. Therefore, only fresh pugmarks were noted from the floodplains. In the same time, the pugmarks were also measured to avoid duplication of same individual. There was also confusion of the tiger signs with the common leopards' signs and we discriminated the signs followed by the first author's personnel experiences and as suggested by previous literature (McDougal 1977; Johnsingh 1983; Smith et al. 1989, Karanth & Sunquist 1995). The prey species were classified in terms of their body weight: gaur and sambar deer as large sized (LP), chital, hog deer and wild boar as medium sized (MP), muntjac and primates as small sized (SP), other small wild prey as very small sized prey (VSP), while all the domestic animals (Mammals only) were combined together as domestic mammals (DM). Similarly, habitats were classified into four major habitat types as climax *Shorea* forest (CSF), successional forest (SuF), grasslands (GL) and floodplains (FP). Other predictor variables were distance to the water holes (DW), presence of prey (Prey) and disturbance variables such as-presence of livestock (domestic mammals) (DM), presence of local people (Peop) and presence of lopped and logged trees (LopT).

To determine the prey preference of tiger, we collected their scats along transects as well as from tracks of elephants, rhinoceroses and also opportunistic surveys. Tiger and leopard coexist in this area, which makes it difficult to discriminate the scats of tiger and leopard as they are ecologically sympatric species. The leopard scats were identified on the basis of field experience and other general criteria described in literature as characteristic 'segmented' shape with mean diameter 2.7 cm (range 2.0–3.0 cm) and pointed ends with many lobes (Edgaonkar & Chellam 1998). Likewise, tiger scats were distinguished from leopard scats by the size of the scat and presence of associated evidence, like pugmarks and size of scrape (Karanth & Sunquist 1995). Also, tiger scat is less coiled and has a larger distance between two successive constrictions within a single piece of scat, when compared to leopard scats, which are mostly coiled and have a smaller distance between constrictions. Tigers mostly prefer to use firelines, roads and other large animal trails as travel roots (Smith et al., 1989), where they leave scats, tracks and other signs of territorial marking (scrape, scratch marks, etc.). Diameter of each scat was also measured using the Vernier Scale to avoid problems of duplication of scats from same tiger or leopard. Loose scats were avoided as imperfect detection. Tiger and leopard scats were mostly found deposited in one place on the side or middle of the roads or tracks on grass strips as compared to other small predators such as dogs and jackal, which mostly deposited scats on the bare soil of the road (Johnsingh 1983; Karanth & Sunquist 1995). The unidentified scats were excluded from the analysis. We collected 40–50 hairs from each of the scats (Mukherjee et al. 1994a, b), and compared them with reference hairs of prey collected from the study area (Johnsingh 1992; Karanth & Sunquist 1995; Støen & Wegge 1996). The reference hair was collected from all potential wild and domestic mammals, primates and carnivore prey species. If this was not enough to identify them, we used Koppikar and Sabnis' (1975) descriptions of hairs from different Indian mammals. Some of the scats contained very few numbers of hairs, which had very low reliability for identification, and were excluded from further analysis.

Habitat and prey preferences of tigers were estimated for each category of prey species by comparing abundance (prey abundance from transect walk) and their utilization data (prey utilization from scat analysis). We used the presence of predator species (tiger or leopard) as a response variable, and different habitat characteristics and disturbance indicators of the predator's sign locations as explanatory variables. We used multivariate analysis to determine the habitat and prey preference of tigers in relation to the habitat types and different degrees of human disturbance. Here, we used a generalized linear model (GLM) and Discriminant function analysis (DFA) to see the key factors that determine the preference of habitat and prey of tiger. The GLM provides the relationship of tiger presence and prey preference with predictor variables: habitat features, human disturbances and prey species abundance. The discriminant function analysis gives the canonical correlation coefficient, which provides the strength of preference of habitats and prey species. In addition, we also used the Canonical Correspondence Analysis (CCA) in CANOCO (CANOCO v. 4.5; Ter Braak & Šmilauer 2002; MacFaden and Capen 2001) and plotted the species response curves fitted with GLM to see the relationship between the distributions of tiger in relation to the prey abundance and human disturbances.

2. RESULTS

2.1. Interactions with habitat and disturbance factors

The result shows the relationship of tiger presence with habitats, prey abundance and human disturbance factors. Prey abundance was the highest in block three (BCF) followed by block six, two, seven, four, one and least in block five (Figure 1 & 2). The best model for the distribution of tiger signs shows that there were positive relationship with the successional forest, grasslands, prey abundant areas, while negative relationship with domestic mammals and higher frequencies of lopped trees, suggesting that the distribution of tiger was limited by human disturbance and positively related to prey abundances and grassland and successional forests (Table 1). Likewise, tiger slightly positively preferred floodplain areas. Pugmarks were more common in these areas as compared to other signs of tiger. Low preference might be due to avoidance of old pugmarks. Tiger negatively preferred human disturbance indicators such as livestock grazing sites with people and sites of firewood and timber collection (Figure 2 and 3). However, the preference was biased towards climax *Shorea* forest that might

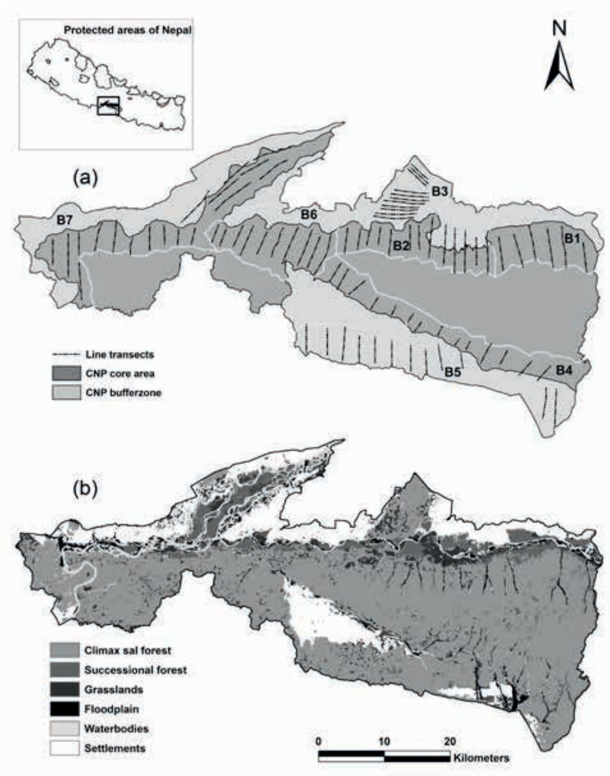

Figure 1. (a) Study area and location of transects in different study blocks and (b) distributions of the habitats of tiger

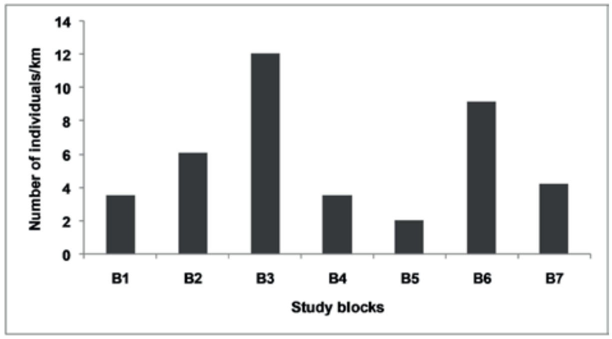

Figure 2. Abundance of prey species (number of individuals/km of transect in seven study blocks) of tiger in different parts of the study area. For details of blocks see block design map in Figure 1

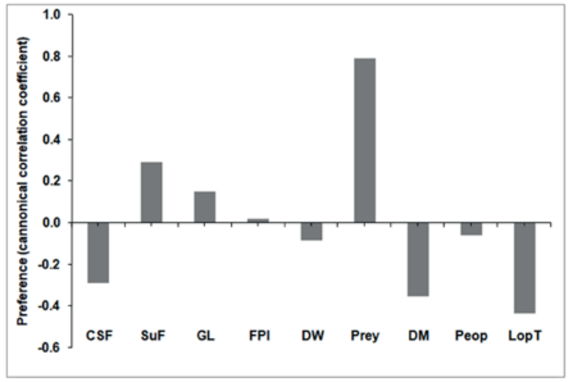

Figure 3. Strength of interaction of tiger with the habitat characteristics and indicators of human disturbances in the CNP. Canonical correlations indicate the strength and direction of selection. Tiger showed a negative correlation with climax Shorea forest and human disturbances. The positive correlation for successional forest, grasslands and prey abundance indicates that tiger positively preferred these habitats as such habitats are also rich in prey abundance. F-values of Wilks' Lambda test: F = 18.11, P < 0.0001. For details of the variables, see Table 1

be the cause of less visibility of the signs. Figure 3 shows that the presence of tiger was decreased with increasing human disturbance index, while the signs of tiger more common in the prey abundant areas.

2.2. Prey preference of tiger

We collected 212 scats of tiger during the year 2013. Based on these scats, we estimated the prey preference of tiger in the CNP. The large and medium sized prey were the most preferred prey of tiger, compared to the small and very small sized prey in the CNP. However, very small sized prey and domestic mammals were included in the best models of tiger prey preferences, suggesting that either the presence or the absence of these species in the scats of tiger were the best predictors (Table 2). We also performed a discriminant analysis to obtain the canonical correlation coefficients for the degree of prey preference of tigers, revealing that it strongly avoided very small prey and domestic mammals, while it strongly preferred medium sized and large sized prey (Figure 5). We also found negative effects of human disturbance on prey availability (R^2 = 0.35) and positive effects on domestic prey (livestock) utilization by tigers. Domestic prey was utilized higher in the disturbed areas with low prey abundance, while tigers utilized domestic mammals lower in the less disturbed areas with high prey abundance (R^2 = 0.31) (Figure 4 & 6).

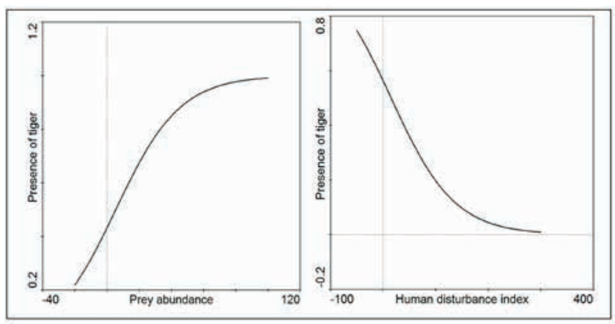

Figure 4. Species response curves: response of tiger to the abundance of prey and human disturbance index (DM+Peop+LopT), fitted with generalized model in CANOCO. The figures show that the presence of tiger increases (F = 44.52, P < 0.0001) with prey abundance and decreases (F = 11.68, P = 0.0006) with the human disturbance index

3. DISCUSSION

The distribution and habitat preference of tigers was not only affected by the abundance of prey but also by human disturbances. For example, the buffer zone part of Barandabhar Corridor Forest (BCF) had a high density of prey species as compared to the other parts of the CNP, but there were very few signs of tigers recorded in this area, revealing that tigers avoided

*Table 1. Generalized logistic models of the factors influencing the presence of tiger in the Chitwan National Park. We modelled the binomial-dependent variable, i.e., presence/absence of tiger, with the predictor variables, i.e., habitats (four habitats- climax Shorea forest, CSF; successional forest, SuF; grassland, GL; floodplain, FPl), distance to the water hole (DW), presence of prey (Prey) and disturbance variables such as-presence of livestock (domestic mammals) (DM), presence of people (Peop) and presence of lopped and logged trees (LopT). R2 (Nagelkerke) is the coefficient of determination for logistic regression, AIC is the Akaike information criterion (Burnham and Anderson 2002), ΔAIC for each model is obtained by the AIC of each model minus the smallest AIC among all models. W is the Akaike weight. Int is the intercept and significance levels are indicated by * (p<0.05), ** (p < 0.01) and *** (p < 0.001). The best model was the model having the highest AIC weight (W) (Burnham and Anderson 2002)*

Model terms and parameter estimates (SE)	R2	AIC	ΔAIC	W
0.17 (0.098) Int + 0.54 (0.08) Prey*** - 0.92 (0.03) LopT**	0.02	1185.14	10.98	0.0024
0.12 (0.099) Int + 0.61 (0.05) Prey*** - 0.27 (0.11) DM* - 0.09 (0.030) LopT*	0.07	1178.26	4.09	0.074
0.26 (0.18) Int + 0.26 (0.156) SuF*+0.45 (0.008) Prey*** - 0.34 (0.11) DM* - 0.08 (0.030) LopT*	0.09	1177.70	3.54	0.098
0.43 (0.13) Int + 0.48 (0.16) SuF*+0.40 (0.18) GL* + 0.92 (0.01) Prey*** - 0.31 (0.12) DM* - 0.09 (0.03) LopT*	0.16	1174.14	0.00	0.572
0.35 (0.12) Int + 0.41 (0.16) SuF*+0.38 (0.20) GL*+0.51 (0.08) Prey*** + 0.02(0.001) FPl - 0.26 (0.19) DM* - 0.07 (0.04) LopT	0.12	1176.86	2.71	0.148
0.23 (0.15) Int+0.36 (0.18) SuF* + 0.34 (0.25) GL*+0.46 (0.12) Prey*** +0.003 (0.002) CSF-0.001 (0.002) Peop - 0.20 (0.09) DM* -0.065 (0.05) LopT*	0.09	1178.76	4.60	0.057
0.11 (0.15) Int+0.35 (0.18) SuF*-0.42 (0.15) CSF*+0.29 (0.17) GL*+0.32 (0.18) Prey*** +0.02 (0.001) FPl - 0.001 (0.002) Peop - 0.16 (0.10) DM*-0.067 (0.04) LopT*	0.09	1179.71	5.56	0.037
0.33 (0.14) Int+0.31 (0.17) SuF*+0.39 (0.19) GL*+0.67 (0.57) FPl + 0.003 (0.002) CSF-0.009 (0.001) DW+0.06 (0.008) Prey***-0.2 (0.01) DM*-0.03 (0.01) Peop-0.6 (0.03) LopT	0.07	1181.73	7.57	0.013

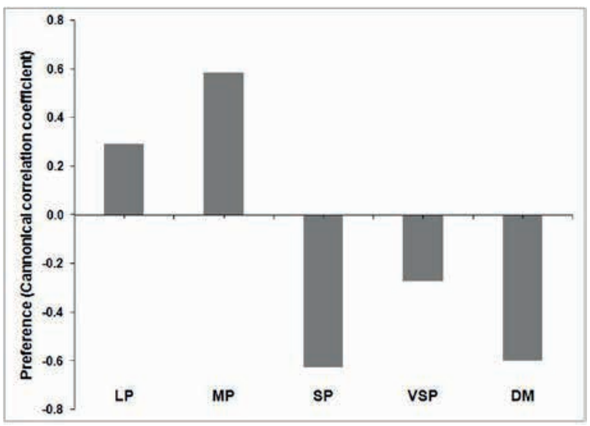

Figure 5. Strength of prey preference of tiger in the CNP. Canonical correlations indicate the strength and direction of selection. Tiger showed a negative correlation with small, very small prey and domestic mammals, while it showed a positive correlation with large and medium sized prey (F-values of Wilks' Lambda test: F = 17.102, P <0.0001). For details of the variables, see Table 2

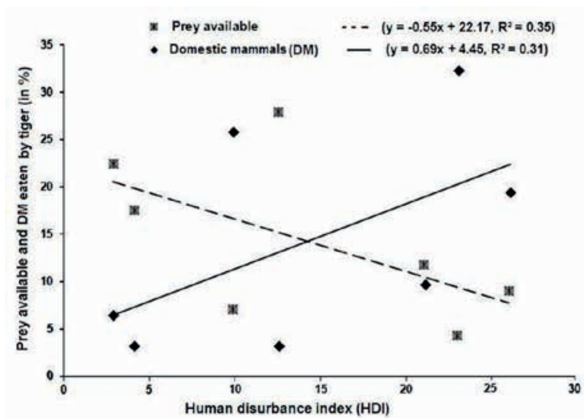

Figure 6. Relationship between human disturbance index (HDI in %) with prey availability and domestic prey preference of tiger. Here, we compared human disturbance with prey availability and preference of domestic mammals in different sites (blocks-B) of the CNP (Fig. 1). The seven symbols inside the figure are the blocks. These sites are: far eastern (B1), middle part (B2), buffer zone area of northern part (B3-Barandabhar Corridor Forest), western part (B6), far western part (B7), southern part (B4) and the buffer zone area of southern part (B5- Someshwar Hill Range). These blocks possess different degrees of disturbances. The B1, B7, and B5 are the most disturbed sites as compared to other sites

the areas where there were regular human disturbances (e.g., Khorsor area, Rapti river banks, Beeshazari lake areas, Batulpokhari areas, tourists vehicle tracks, etc.) as BCF is surrounded by two large settlements (east and west Chitwan) of people. Besides, it also might be due to less frequent visit of tigers from the core areas of the park. The elongated shape of this forest might be another reason of edge effects (Nams 2011). So, edge effects can be also considered as the major limiting factor for tiger occurrence in this area. However, a recent study by Carter et al. (2012) suggested temporal separation between humans and tigers using the same areas at a fine spatial scale in the CNP. Edge effect can lower in properly fenced areas (i.e., buffer zone part of BCF) as compared to unfenced or weak fenced areas such as the eastern (Khagendramalli-Sunachuri areas), southern (Madi valley sites) and western (Amaltari-Triveni areas) parts of the CNP. Practically, fence works for wildlife movement towards human settlements but not for human intervention inside the forests. In these fenced areas, there are ladders or open tracks for local people to visit forests for collecting forest products (pers. obs.). Furthermore, the study of Odden et

*Table 2. Generalized logistic models of the prey preferences of tiger in the Chitwan National Park. We modelled the binomial-dependent variable with the predictor variables, that is, based on the remains of prey items in the scats, LP- large sized prey, MP- medium sized prey, SP- small sized prey, VSP- very small sized prey and DM- domestic mammals as prey. R^2 (Nagelkerke) is the coefficient of determination for logistic regression, AIC is the Akaike information criterion (Burnham and Anderson 2002), ΔAIC for each model is obtained by the AIC of each model minus the smallest AIC among all models, W is the Akaike weight. Int is the intercept and significance levels are indicated by * (p < 0.05), ** (p < 0.01) and *** (p < 0.001). The best model was the model having the highest AIC weight (W) (Burnham and Anderson 2002)*

Model terms and parameter estimates (SE)	R^2	AIC	ΔAIC	W
0.76 (0.20) Int + 3.60 (0.63) LP*** + 2.57 (0.31) MP***	0.44	283.02	18.01	0.00
2.53 (0.26) Int - 2.68 (0.34) SP*** - 2.04 (0.48) VSP*** - 3.93 (0.53) DM***	0.49	268.08	3.07	0.10
2.27 (0.38) Int+1.34 (0.67) LP* - 2.46 SP*** - 2.03 (0.51) VSP*** - 3.73 (0.53) DM***	0.54	265.00	0.00	0.47
1.57 (0.56) Int + 1.81 (0.74) LP* + 0.68 (0.49) MP - 1.89 (0.52) SP*** - 1.73 (0.56) VSP** - 3.09 (0.70) DM***	0.51	265.22	0.22	0.42

al. (2010) suggested that the avoidance of human-dominated areas by tigers was creating a potential competition refuge for leopards. Such contradictory findings about tiger's behaviour and their interactions with local inhabitants have created a debate among the conservationists and general public about the coexistence of such predators and people (Harihar et al. 2013). We found a negative relationship between tiger signs and human disturbances, which meant that tigers need relatively large and undisturbed areas with a healthy natural prey base (Karanth et al. 2004). Likewise, the habitat preference of tigers showed that it was positively related with successional forest and grasslands, and negatively associated with floodplains and *Shorea* forests. The number, habitat preference and prey preference of predator species are greatly influenced by the relative abundance of different size-classes of prey species in the assemblage (Karanth & Sunquist 1995; Karanth & Sunquist 2000; Karanth et al. 2004). Tiger signs were positively associated with prey abundance. Furthermore, the successional forest and grassland areas were also very rich in prey abundance as compared to the sal forest and floodplain because the sal forest is mostly dry and flood plain areas were located near human settlements and were highly disturbed by people. The dense cover of the successional forests also supports the tiger's ambush capture behaviour to hunt prey (Johnsingh 1983). They do not normally kill prey in open habitats such as flood plain and short grasslands (Schaller 1967; Johnsingh 1983), but not in the tall grasslands (this study). We found most of the scratch marks of tigers on the trees of successional forest as compared to the sal forest, which might be due to the soft nature of the bark of the trees (e.g., *Bombax ceiba*, *Trewia nudiflora,* etc.) in the successional forest. Sal forest is dominated by sal (*Shorea robusta*), which has a hard bark and tiger rarely scratch this type of tree.

In our study area, the prey community was dominated by deer species, especially chital, followed by suids, primates and bovids. Among the deer species, chital were frequently encountered in the CNP as compared to the other species – sambar, hog deer and muntjac. The prey preference of tigers showed that it mostly preferred medium sized prey as compared to the large-sized prey and it avoided very small sized prey and domestic mammals. However, Karanth and Sunquist (1995) and Andheria et al. (2007) found selective predation of tigers towards large-sized prey in South India, contrary to our study. Similar results were also reported by Biswas and Sharkar (2002) in the Pench National Park of India. The preference of large-sized prey was mainly due to sambar deer because another large sized prey in this area, gaur, occurred just three times in the tiger's scat. In the CNP, gaur is sparsely found in the Churia hills and it visits lower lands less frequently and mainly in the winter season. During dry seasons, they migrate towards lowlands where new shoots of grasses in grasslands were available (Pers. obs). This might be the cause of low record of this species. In contrast, the evolutionary and predatory behaviours (Seidensticker & McDougal 1993; Bhattarai & Kindlmann 2012) of tigers enable them to kill large-sized prey along with medium sized prey classes. The consumption of large sized prey by tiger in other areas found a similar result in Kanha (Schaller 1967) and the opposite result in Pench (Biswas and Shankar 2002). Such predation on large prey might have happened if there was lower predation of medium-sized prey by tigers. When compared to earlier studies, there was no record of gaur in the diets of tiger and leopard (McDougal 1977), which might be due to the smaller sampling area and lower number of scats than our study. In some parts of the Indian subcontinent, gaur occurred significantly in the predator's diet (Karanth & Sunquist 1995), probably due to a higher density of gaur in Nagarhole as compared to CNP (Bhandari et al. 2017). The preference of medium-sized prey (mainly chital and wild boar) was positively related with their abundance in the CNP and increased the chances of predation, similar to the study of Bhandari et al. (2017). Generally, predators utilize prey species with reference to the availability of prey species (Flux 2017). Earlier studies (Johnsingh 1983; Karanth & Sunquist 1995; Stoen & Wegge 1996) have reported an underutilization of chital by tigers when compared to its availability. The gregarious nature of chital (group size solitary to 56 individuals – this study) is also considered to be one of the reasons for the reduction in tiger predation (Karanth & Sunquist 1995). The small and very small sized prey of tigers includes muntjac and two species of primates. The avoidance of muntjac by tigers was mainly due to the small body size with low density and the fact that they were mainly confined to the habitat lying near the village-forest border where there were higher human disturbances (Bhattarai &

Kindlmann 2013). It might be due to antipredatory behaviour or avoiding competition among other deer species with larger body sizes numbers (e.g., chital, sambar, etc.). While, compared to the two species of primates in the study area, both species were also avoided by tigers, which might be due to the arboreal nature of primates and it tends to explain its under-representation in the diet of tigers (Karanth & Sunquist 1995).

The avoidance of domestic mammals was also supported by the results of habitat preference because tiger avoided the human disturbed areas; however, the preference of domestic mammals in different sites of the CNP was higher in the sites with higher disturbances (Bhattarai & Kindlmann 2013). Avoidance of domestic mammals can be linked to the restriction on free grazing in many areas. Domestic mammals were mostly killed by leopards and their signs were mostly recorded at the periphery of the park (this study, unpublished data). However, there was prohibition of livestock grazing inside the park; people graze their livestock mainly in the village forest border areas such as far eastern, western and southern parts of the park. These trends facilitate these predators to kill the domestic livestock. Since tigers are wide ranging in nature (Karanth & Nichols 2000), the occurrence of livestock in predators scats was the consequences of accidental predation nearby the village-forest border. In Chitwan, human activity has already modified most of the habitats where tigers occur; leading to a drastic decline in the prey distribution and abundance. The regular human originated disturbances could dramatically change the behaviour of such predators that consequently increases conflict with people and local extinction of large body sized prey (Smith et al. 1998). Our results showed that the human disturbance negatively affected the prey availability and tiger distribution and furthermore forced tigers to feed on the domestic mammals or even people. Comparatively, high density of tigers in the core areas of the park attributed to the displacement of leopards from core areas towards the periphery (Odden et al. 2010). This might cause bias towards tigers as conflict causing carnivores (various reports of buffer zone management offices). The metapopulation of tigers in Nepal's lowland tropical areas are under grave threats compared to the temperate highlands due to the higher density of people that ultimately puts continuous pressure inside the forest or any other natural resources (Smith et al. 1998). The human disturbance is not only responsible for deteriorating prey and predator abundances but also accelerates the human-carnivore conflict in such human dominated protected areas like CNP so that it could be considered as a major obstacles for park management.

In conclusion, the findings of this study revealed that the habitat and prey preference of tigers was greatly influenced by the prey abundances and human disturbances. The presence of tiger is positively related with prey abundance, while negatively related with human disturbance. Tigers mostly preferred successional forests, grasslands and slightly floodplain areas where there were sufficient numbers of prey. Likewise, tigers preferred medium and large sized prey as compared to small sized and domestic mammals. The preference of domestic mammals by tigers was higher in the areas with high disturbances. Human disturbances not only affect the tigers but also affect the abundance of the different sized classes of prey. We conclude that prey abundance is the major determinant of tiger abundance only if there is low human disturbances. Such large predators need a considerable behavioural plasticity with the lonely wilderness. Also, the prey preference of tigers depends on the prey availability, which depends on human disturbances. Hence, for an effective and sustainable conservation of tigers in the CNP, human disturbance should be minimized by delineating the core area of all parts of the park as a prohibited zone for collection of forest products and have only some selected parts as buffer zone areas as the free access zone in selected seasons to support the requirements of the local people. Alternatively, park management can provides incentives to establish new livelihood options for local people.

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