Predator-Prey Dynamics: The Role of Predators in the Control of Problem Species

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Abstract

A study was conducted to look at the relationship between presence and numbers of wild dog (*Cuon alpinus*) and presence and abundance of wild boar (*Sus scrofa*). This was corroborated with scat analysis to get percentage of the prey consumed by wild dogs and other predators. A preliminary nationwide presence-absence survey of *C. alpinus* population showed that with the exception of Trashigang, Samdrup Jongkhar and Pemagatshel, all the other dzongkhags reported presence of wild dogs. Wild dog density was then compared with relative wild boar density using a simple linear regression analysis.

A negative relationship between increasing wild dog numbers and decreasing wild boar density was detected. The R^2 value for the regression was 0.60 — meaning that about 60% of the relative amount of variance in wild boar density is explained by the number of wild dogs present in an area. The unexplained 40% could be due to other factors such as habitat conditions, food availability, control measures, other large predators, diseases, and so on.

An analysis of variance (ANOVA) carried out on the relationship gave a significant value ($F = 12.30 >> F_s = 0.007$), meaning that the average number of boars in the different study areas are significantly different from each other, or that different pack sizes of wild dogs have significantly different effects. The slope of the regression line was negative 0.1. Thus for every unit increase in wild dogs presence there is a 0.1 unit decrease in relative wild boar density.

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About 37% of wild dog diet consists of domestic animals such as cattle and horses. The other 63% is wildlife. Of this 63%, 65 numbers of scat found contained wild boar remains. This indicates that from the wild herbivores preyed, about 58% of wild prey consumed are wild boar. Overall, including domestic animals, wild boars make about 36% of the wild dog's diet.

In terms of resource partitioning based on sign densities, the three predators (tiger, leopard, and wild dog) avoid conflict with wild boars by using different habitats and through engaging in vastly different hunting behaviour. For instance, leopards have more fixed and stable home ranges, closer to human habitation while tigers have larger home ranges but well away from any human settlement. Wild dogs are more transient and travel frequently over a large distance; their home ranges overlap with that of tigers and leopards. Since their presence is fleeting, they rarely come in conflict with the other predators.

Introduction

As tertiary consumers predators play an important role in regulating prey species such as herbivores and omnivores (Carbone et al, 1999.) Such predator-prey dynamics maintain the health and balance of ecosystems. Any disturbance of this balance due to human or other interventions lead to population explosions or crashes. One significant event in the ecological history of Bhutan has been the poisoning of wild dogs (*Cuon alpinus*) in the early 1980s and the subsequent explosion of wild boar (*Sus scrofa*) population (Wangchuk, 1996). Though the wild boar continues to be the main enemy in Bhutan's agrarian societies, a little is understood about the dynamics of this predator-prey system.

There is an urgency to understand the *C. alpinus–S. scrofa* dynamics and find sustainable solutions to the prey population boom all over the country.

Anecdotal information and a small scale survey in Jigme Dorji National Park (Wangchuk, 1996) suggest that there is no crop depredation issues due to wild boars and other herbivores in places where there are wild dogs. A clear understanding of this particular predator-prey dynamics is essential to quantify the impact of *C. alpinus* in regulating *S. scrofa* population.

This study complements an ongoing project financed by the Bhutan Trust Fund for Wildlife Conservation (BTF) which is testing the effectiveness of culling by trapping and shooting wild boars at two pilot sites. The present study looks at the effectiveness of predators such as *C. alpinus* in regulating prey population like *S. scrofa*. A natural regulatory mechanism backed by trapping and culling, where necessary, may provide a sustainable and long-term solution to the *S. scrofa* problem.

Recent news stories report the re-emergence of the wild dog in certain parts of Bhutan and the subsequent loss of livestock to wild dogs. Understanding the impact of predators on prey in the forests of Bhutan has become more critical in light of this evidence before another mass predator eradication programme is done, formally or otherwise.

A little hard data on the predator-prey dynamics of *C. alpinus* and *S. scrofa* exists at the moment. Therefore, it is difficult to assess the impacts of *C. alpinus* in controlling *S. scrofa* population. Should the anecdotal reports prove true, it is critical to ensure that wild dogs are not killed, mainly through poisoning of carcasses. However, if livestock losses are high and there is no reduction in wild boar population, then the wild dog may simply be a menace to both farmers and wildlife.

Studies of the wild dog or Dhole in south India indicate that preferred prey species of *dhole* (more than 70% of kills) are smaller than 50 kg in size (Johnsingh, 1992; Venkataram et al. 1994, Karanth and Sunquist, 1995). Since chital (*Axis axis*) was the most abundant prey species in the study area and wild pigs were the least abundant in the less than 50 kg prey class (ratio of 23 chital to 1 wild pig), it is possible that in Bhutan wild boars may substitute the chital as the most abundant preferred prey class. Johnsingh (1992) also found that 69% of leopards that kill in the same area were of prey in the less then 50 kg class. Tigers, however, preferred prey that was greater than 100 kg.

In Bhutan too where these three predators exist in sympatry, it is possible that a similar resource partitioning takes place. However, none of these questions have been answered for the wild dog and other predators in Bhutan.

The present study attempts to address this data gap. A preliminary nationwide survey of *C. alpinus* populations was conducted. Details such as number of wild dogs, location of packs, and reported loss of livestock were collected. Based on this information, a representative field sites in Zhemgang, Gasa, Punakha, Paro, and Thimphu dzongkhags were visited and surveyed. Relative densities of both wild dog and wild boars by habitat types were estimated.

Ten study sites for intensive monitoring were selected in Gasa, Zhemgang, Thimphu, Paro and Punakha based on the preliminary work. In the study areas predator scat was collected from the monitoring sites to analyze the prey content. The study mapped the over-lapping ranges of tigers and leopards, and wild boars. Transects for scat and sign collection were laid in these areas. Habitat and resource use partitioning among these three top carnivores were mapped. Correlation of wild dog presence and numbers with wild boar presence, abundance, and crop damage reported by farmers were also done. This was corroborated with scat analysis which showed percentage of prey consumed by wild dogs and other predators.

Methods

The initial stage of this preliminary nationwide survey was conducted by contacting the offices of parks, wardens, divisional, ranges, dzongkhag forestry and beat officers in the country by phone, fax and email. Sixty-seven such interviews were conducted between September and October 2003. Concurrent visits to 18 villages in Trongsa, Zhemgang, Wangdue, Punakha, Gasa, Thimphu, Paro were made as part of the preliminary survey. The details such as presence of wild dogs, leopards and tigers in the areas, location of the wild dog packs, reported losses of livestock, and reported reductions in wild boar crop depredation were collected using *Data Form 01* (see annex).

The second part was to verify these reports by visiting representative sites in the country. Detailed surveys of the sites and predator presence/absence were conducted, and counts authenticated through use of local informants and transect-laying in the reported areas. The sites were chosen on the basis of the number of wild dogs reported. Some villages reported a high incidence of wild dog occurrence while there was a medium or low wild dog activity in other areas.

Data Forms 02 and *03* (see annex) were used to collect relative mammal sign abundance and scat content. The forms recorded animal sign such as footprint, scat, wallow, rubbings, etc by species. Detail of the habitat types was recorded where each mammal sign was observed. Animal sign information was collected along transects that were randomly selected within a 10 km radius of the study villages. Agricultural areas around villages were excluded from the survey area and the 10 km radius was measured from the edge of agricultural fields. This had the advantage of covering a reasonable amount of forest around the villages. 10 km was an adequate distance to move away from scrub forests to undisturbed forests at the top of ridges or valley floors and away from disturbance as well.

However, in some instances tiger sign may have been missed since tigers prefer to stay away from human settlement. It may not come within the 10 km radius of the survey area. Topo sheets (1:50,000) were used to generate the random transects to cover a minimum of 25% of the area (78,500m^2). Transect lengths varied between 400 m to 1000 m, although an ideal length of 1000 m was preferred. Some transects were shorter since steep cliff, gorges, or dense bamboo thickets were inaccessible after a certain length. Therefore, the number of transects in each study village varied by conditions but care was taken to ensure a minimum coverage of 25% of the area. Also, randomization allowed coverage of all habitat types in the area to a certain degree. Transect width was maintained at 10 m (5 m on either side) to cover an area of 10,000 m^2 in each transect. Eight random transect of 1000 m length and 10 m width were aimed in each study area to cover an area of 80,000 m^2 per study area since the total area surveyed per study area was 314,000 m^2.

In each plot, the number of sign made by different species was recorded. These sign were then used to generate a relative density per transect for the area by species. Special attention was paid to wild dogs and wild boars. Wild dog density was then compared against wild boar density in the selected areas and a linear regression analysis was done to see the functional relationship between the density of wild dogs and wild boars. Since wild dog numbers were available through actual sightings and observations by villagers, the actual number of wild dogs present in an area was used rather than the relative density estimates based on sign. Also, the relative density estimate of wild dogs fit well with the actual numbers of wild dogs in the area, indicating that transects accurately recorded animal sign.

The following villages listed in Table 1 were visited for detailed field surveys and verification.

Table 1: Survey Sites

Location	*Reported Wild Dog Abundance*	*Dominant Vegetation*
Goenshari, Punakha	Low	Warm/Cool Broadleaf
Sha Gangshikha, Wangdue	None	Warm Broadleaf
Tamey Damchu, Punakha	Medium	Warm/Cool Broadleaf
Kuenga Rabten, Trongsa	None	Cool Broadleaf
Remee, Gasa (Revisited in March 2004)	High	Cool Broadleaf
Chamayna, Thimphu	Medium	Mixed Conifer
Helela/Talakha, Thimphu	Medium	Mixed Conifer
Kharibjee, Paro	Low	Mixed Conifer
Dunmang, Zhemgang	Medium	Warm/Cool Broadleaf
Langdurbi, Zhemgang	High	Warm / Cool Broadleaf

Sign from other predators such as leopard and tiger were recorded and mapped by relative density by location to derive habitat use patterns. The habitat and resource partitioning of the three main predators in two selected study areas (Dunmang and Tamey Damchu) were done since these two areas had sign made by all three predators. In each area relative sign density in a transect that fell close to a village, another that fell midway (about 5 km) and a third close to the outer limits of the survey area were selected to study distribution. Habitat use patterns of tiger, wild dog and leopard could be done to a certain extent through the distribution of sign in these selected transects. However, this provides only a general and preliminary distribution pattern and in-depth analysis was avoided. It was simply assumed that where sign were present, the particular species was active in that area and where there was no sign, the particular species avoided that habitat.

This also allowed estimation of home range size through sign distribution and density analysis. In south India the home range size for dholes varied between 54.2 and 83.3 km^2 (Venkataram et al. 1994). In Bhutan based on anecdotal information, in some areas 2 or 3 packs may have overlapping ranges with a rough estimate of 50 km^2 home range size (Wangchuk, 2003).]

Another important determinant has been the diet analysis of wild dogs, tigers, and leopards. This was done by collecting predator scat along transects and analyzing scat contents for prey species using Data Form 02. Scat found along transects were identified by species. Predator scat were analyzed for prey content on the basis of indigestible animal remains in the scat such as hair, bones, hooves, feathers, and skin. In scat, hair is a good indicator of prey consumed (Schaller, 1967), and it was compared against a reference collection of hairs from the Bhutan Natural History Collection (BNHC).

Results

The preliminary survey of *C. alpinus* populations in all 20 dzongkhags showed that with exception of Trashigang, Samdrup Jongkhar and Pemagathsel, other dzongkhags reported wild dog presence. The last report of wild dog in Trashigang was in Wamrong in 2002. Nine wild dogs were killed by poisoning and their tails handed over to the Nature Conservation Division (NCD). Interestingly, these three dzongkhags lie east of the Drangmichhu which may have acted as a barrier. The river certainly prevented further colonization of the areas by dispersing wild dogs from other dzongkhags where wild dogs are present. Recolonization may take some time as wild dogs have to either find their way across the Drangmichhu or from the neighbouring Indian states of Assam and Arunachal Pradesh.

The other 17 dzongkhags reported presence of wild dogs. The wild dog packs were distributed in patches and did not cover entire dzongkhags. For instance in Wangdue, there is no wild dog in villages along the Dangchhu, unlike higher villages like Phobjikha and Gogona which reported the presence of a pack of 13 wild dogs. Surveys in the Dangchhu area revealed that most cattle were at the summer pastures in the higher altitude areas of Phobjikha and Gogona. The cattle move down to the Dangchhu area in the winter (Ninth Bhutanese month). Farmers reported that they have been having wild boar problems for the last 20 years, beginning 1983. Interestingly, the last wild dogs were extirpated from the area by poisoning that same year. Since then the people have to guard their paddy fields. The usual practice in the past had been to transplant the paddy and return to Phobjikha. But with the presence of wild boars, farmers are compelled to stay behind to guard their crops.

In Trongsa too, some areas reported presence of wild dogs while others did not. For instance, wild dogs were present about 15 years ago in Kuenga Rabten area, but the last pack was killed by using rat poison distributed by agriculture officers. About 10 years ago, wild boars became a major problem in the area. Some agricultural fields above the village and close to the forests had been abandoned since they could not guard crops from wild boars. However, in the Chendebji area, two packs of 4 and 8 wild dogs are present. The packs have killed cattle and yaks in the area in November 2003 when the survey was conducted.

Lhuntse and Trashiyangtsi seemed to share the same pack. When wild dogs appeared in Yangtse, there was no report in Lhuntse, and vice versa.

Gasa and Zhemgang reported the highest cases of wild dog depredation of livestock (and therefore, its presence). Even in Gasa some areas in Khatey reported high occurrence, while others such as Lunana and Khamey reported occasional presence only. Likewise in Zhemgang, Bardo reported high occurrence while there was no report in villages around Zhemgang Dzong.

Farmers in all survey areas report that there is a direct correlation between presence of wild dogs and wild boars. Where there are many wild dogs, there are a few wild boar numbers and vice versa. This is further corroborated by farmers' reports of reduced crop depredation by wild boar, but increased livestock loss to wild dogs. Farmers have responded by changing their animal herding behaviour. Many said that they now have a full time cattle herder, while horses and mules are stabled and corralled at night. Such changes have reduced loss of livestock to wild dogs. Farmers complain that employing full time cattle herder is an additional burden to their already strained manpower. Also, mule and horse owners complained of the loss of night time foraging opportunity when animals are kept in stables. Loss of mules and horses in Gasa and cattle in Zhemgang are huge losses of income for the people. In Gasa, portage by horses and mules are the main source of income and a loss of these animals meant a big loss to the family. In Zhemgang cattle provide valuable diary products that are sold or bartered.

In Khatey Gewog of Gasa, a pack of 15 wild dogs have been active since 2002. In 2001 only a male and female dogs were sighted. Within a short span of two years the pack had multiplied to 15 in 2003. The highest density of sign, including group defecation sites or communal latrines, was found in the forest around Remee, about three kilometers from Gasa Dzong; this suggests that the animals have a denning site near Remee village. In Khamey Gewog, a pair has been sighted since last year near Tashithang. Likewise, another pair has been sighted this year in Laya Gewog. It is possible that these will grow over the subsequent years. Farmers in Khatey Gewog, with the highest density of wild dogs, reported that in the spring of 2003 they had a good wheat harvests, which in normal years would have been ravaged by wild boars. Disturbingly, in March 2004, a revisit to Remee village revealed the presence of old wild dog sign only. The wild dogs had either moved to another location, or perhaps been poisoned since the economic damage in terms of horses and mules loss was too severe. The officials of District Animal Husbandary, Gasa, reported that villagers had made a request for a stringent poison tablets. The villagers denied making any such requests.

In Bardo and Nangkor Gewog of Zhemgang, wild dog densities were highest in Langdurbi village where at least three packs were reported. Two packs (seven and 14 respectively) seemed to remain on the east bank of the Chamkharchhu basin, roving between Khomshar, Langduribi, and Digala, while another pack of 12 dogs traveled back and forth between Dunmang/Kamjang and Langdurbi/Digala. During interviews farmers reported the loss of more than 70 livestock, mostly cattle and a few horses. In one instance, wild dogs came right up to the doorstep and killed a pig.

It was interesting to note that some wild boars were still present in the Langdurbi area (a herd of four was sighted), but farmers reported that they did not lose any crops to wild boars this year.

In Khengkha, wild dogs are called *Tsa Wa Reng* and nick named *A-shang Gelong* because of their red coats. A pair is called *omrang* and usually omrang is reported colonizing an area and producing a litter in the following year. Livestock owners in Kamjang reported the presence of an omrang this year. The people believe they arrived from the Langdurbi.

A pack of 10 wild dogs share the forests above the villages of Chamayan and Kabjisa in Thimphu. In 2003 people did not have to guard their potato. Wild dogs appeared this year only and last year people suffered sever loss of potato to wild boars. It seems that the pack may be a transient between other side of Sinchula which might have migrated from the Kabji-Punakha area.

The anecdotal information collected from villagers especially about the presence relationship between wild dogs and wild boars is verified through the transect sign survey data. Transect sign survey from 10 study sites in Zhemgang, Gasa, Thimphu, Paro, and Punakha dzongkhags revealed the following relative densities of wild dogs and wild boars (Table 2). Table 2 also shows the actual numbers of wild dogs confirmed from the study sites.

Table 2: Relative densities of wild boars and wild dogs and confirmed number of wild dogs by study site

Location	Relative Density Wild Boar Avg. # sign/m^2	Relative Density Wild Dogs Avg. # sign/m^2	Actual # Wild Dogs
Goenshari	1.40	0.40	4
Gangshikha	2.90	0.00	0
Kuenga Rabten	3.10	0.00	0
Kharibjee	1.00	0.22	2
Dunmang	0.80	0.75	8
Tamey Damchu	0.70	0.65	6
Chamayna	0.70	0.99	10
Talakha	0.90	1.00	10
Remee	0.10	2.10	18
Langdurbi	0.05	2.76	26

Gangshikha in Wangdue had the highest wild boar sign recorded with an average of 2.90 sign/m^2 of transect area surveyed, while Langdurbi in Zhemgang had the lowest with 0.05 sign/m^2. Contrarily, Langdurbi had the highest number of wild dog sign and Gangshikha had the lowest.

Since actual wild dog numbers in the study areas could be confirmed through corroborated observations by villagers, the actual number of wild dogs present in an area could be compared against the relative density of wild dogs in the same area estimated through sign. A Pearson correlation coefficient was generated to test for the fit between observed and estimated wild dog numbers. The correlation coefficient $r_{actual-rel.density}$ is 0.996542 indicating an almost perfect positive association.

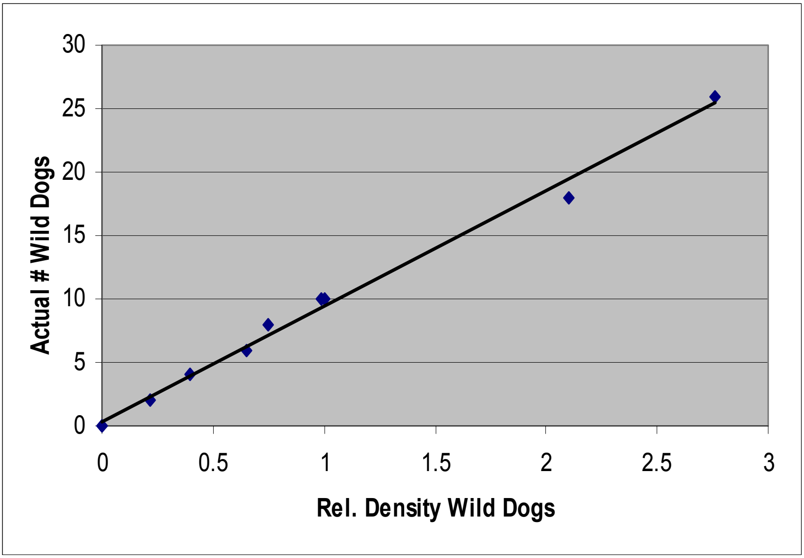


Figure1: Close fit between actual number of wild dogs observed and the relative density of wild dogs estimated from sign ($r_{actual-rel.density}$ = 0.996542)

Figure 1 shows the close fit between actual number of wild dogs observed and the relative density of wild dogs estimated from sign. This close fit between observed and estimated numbers indicates that transects accurately recorded animal sign. Wild dog density was then compared against relative wild boar density using a simple linear regression analysis.

Figure 2: Negative relationship between increasing wild dog numbers and decreasing wild boar density (R^2 = 0.60, b = -0.09857)

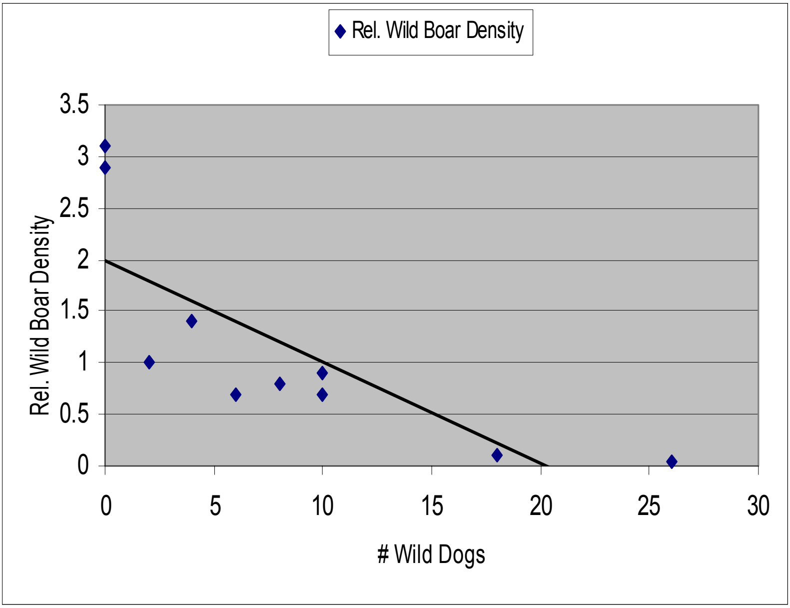


Figure 2 shows the negative relationship between increasing wild dog numbers and decreasing wild boar density. The R^2 value is 0.60 meaning that about 60% of the relative amount of variance in wild boar density is explained by the number of wild dogs present in an area. The unexplained 40% could be due to other factors such as habitat conditions, food availability, control measures, other large predators, diseases, and so on.

An analysis of variance (ANOVA) carried out on the relationship gave a significant value ($F= 12.30 >> F_s = 0.007$), meaning that the average number of boars in the different study areas are significantly different from each other or that different pack sizes of wild dogs have significantly different effects; larger size has a larger effect and vice versa. The slope of the regression line is – 0.09857 or close to – 0.1. Thus for one unit increase in wild dogs there is a 0.1 unit decrease in relative wild boar density. As the ANOVA significance test showed, this is a significant relationship.

In terms of resource partitioning based on sign densities, the three predators (tiger, leopard, and wild dog) avoid conflict by using different habitats and by engaging in vastly different hunting behaviour. For instance, leopards have more fixed and stable home ranges, closer to human habitation, while tigers have larger home ranges but well away from any human settlement. Wild dogs are more transient and frequently travel over large distances; their home ranges overlap with those of tiger and leopard. But they rarely come in conflict with the other predators due to their fleeting presence. In any case, they were known to kill leopards and even tigers if the pack is big.

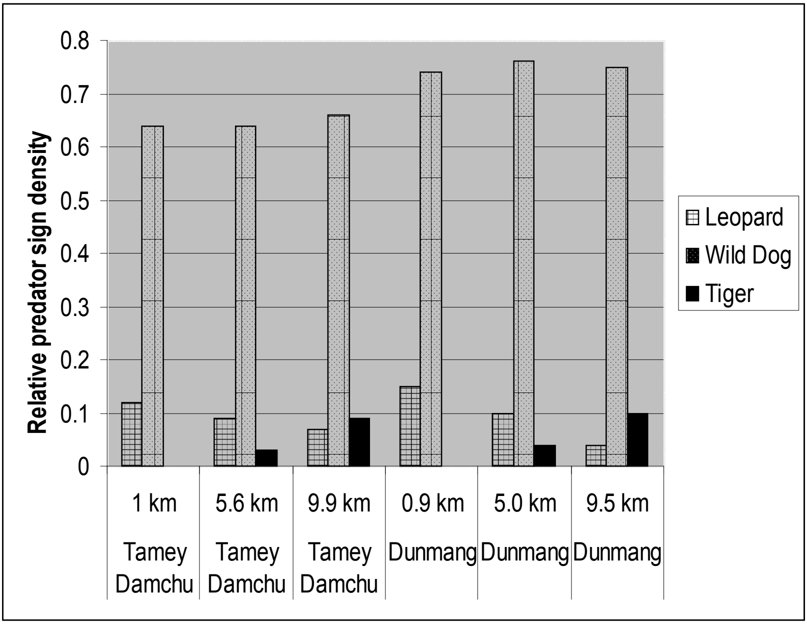
Table 3 and Figure 3 show the sign density by species in two of the study areas. More detailed and long term studies are necessary to understand this complex relationship.

Table 3 Relative sign density by predator species in Tamey Damchu and Dunmang

Location	Distance from village	Predator sign density / m^2
Tamey Damchu	1 km	L= 0.12, W = 0.64,T= 0.00
	5.6 km	L= 0.09, W=0.64, T=0.03
	9.9 km	L= 0.07, W=0.66, T=0.09
Dunmang	0.9 km	L= 0.15, W = 0.74,T= 0.00
	5.0 km	L= 0.1, W=0.76, T=0.04
	9.5 km	L= 0.04, W=0.75, T=0.1

L= Leopard, W = Wild Dog, T = Tiger

Figure 3 Relative sign density by predator species in Tamey Damchu and Dunmang



Scat Content

Of 178 wild dog scats that were found, 112 contained remains of wild herbivores, one Kaleej pheasant and 65 domestic animals. This shows that about 37% of wild dog diet consists of domestic animals such as cattle and horses. The other wildlife constitutes 63%. Of this 63%, 65 numbers of scat found contained wild boar remains. This indicates that from the wild herbivores preyed, about 58% of wild prey consumed is wild boar. Overall, wild boars, including domestic animals, make up about 36% of the wild dog diet.

Since less than 10 tiger scat was encountered, tiger scat analysis is excluded from the present study. Fifty eight leopard scats were found along transects. Of this, 76%

consisted of wild game, mostly of muntjac. No wild boar remains were found in the leopard scat. The remaining 24% consisted of domestic animals.

DISCUSSION

The study shows that wild dogs are making a slow comeback in Bhutan. They are present in all dzongkhags with the exception of three eastern dzongkhags east of Drangmechhu. There is much speculation within the farming community that the reemergence of the wild dogs is due to a government predator release programme.

The wild dogs are called *zhungi phou* or government wild dogs, released to control the wild boars. However, to my knowledge there is no record of a predator release programme in Bhutan. Some farmers contend that the new wild dogs look different from the old ones. They are said to be smaller in size, more reddish in colour and has a different repertoire of vocalizations from the old ones. Given this observation, it is possible that after the eradication of wild dogs in the 1980s in Bhutan, wild dogs from the Indian plains could have re-colonized the vacant niche.

The sub-species in Bhutan are generally thought to be *Cuon alpinus primevus* (Hodgson, 1833, Ellerman and Morrisson-Scott, 1966) distinguished by their furrier coat, larger body size, and grayish-reddish pelage. Specimens from the Bombay Natural History Society Collection show that there is a clinal variation in appearance with wild dogs from the Indian Duars which have shorter hair. The India subspecies *C. a. dukhunensis* is found south of the Ganges and is probably not the one that re-colonized vacant niches in Bhutan. Rather it is likely that the Duars variety of *C. a. primevus* climbed up into Bhutan.

Whatever the origin, the present study revealed that the reemergence of the wild dogs is having a significant ecological and social impact. The carrying capacity for wild dogs of the community is extremely low since they kill valuable livestock. Yet the positive role of the wild dog in controlling wild boars cannot be ignored. As the results indicate, wild dogs have a significant impact in reducing wild boar numbers.

The regression analysis showed a strong negative relationship between increasing wild dog numbers and decreasing wild boar density. The R^2 value of 0.60 is statistically significant and tells that about 60% of the relative amount of variance in wild boar density is explained by the number of wild dogs present in an area. Another way to interpret this result in layman's terms would be that the presence of a pack of wild dogs in an area can result in a 60% reduction in wild boar numbers. The slope of the regression line was close to negative 0.1. Thus for one unit increase in wild dogs there is a 0.1 unit decrease in relative wild boar density. As the ANOVA significance test showed, this is a significant relationship. Wild dogs can effectively control wild boar numbers.

This is further corroborated by the scat test which revealed that wild boars make up about 58 % of wild prey consumed by wild dogs. However, the scat test also showed that overall, about 37% of wild dog diet consists of domestic animals such as cattle and horses. However, these figures are observations from a single point in time and can change due to livestock care and guarding provided by farmers. For instance in Remee, Gasa, scat content of domestic animals was more than 50% in November 2003. By February 2004, the figure had dropped to about 30% largely because livestock owners changed their herding behavior. Many said that they now have a full time herder with cattle, while horses and mules are stabled and corralled at night. Earlier livestock were set free in the forest and rounded up only when needed. Such changes have reduced loss of livestock to wild dogs.

Regarding other predators, the scat test also showed that leopards have a significant impact on domestic animals but that they had little or no impact on wild boars.

Tiger scat results were inconclusive. Future studies could be designed to cover larger areas and better represent tiger habitat than the present study did. Also, as pointed out above, as preying behavior can change over time in response to herding behavior, longer term studies are recommended to monitor these dynamics. Longer term studies are also recommended to better understand the relationship between the three top carnivores of Bhutan. The present study was barely able to scratch the surface regarding this important relationship which may have significant consequences for wild boar numbers. A multi-varied analysis will be possible if better data are available and deeper understanding of predator-prey relationships in Bhutan gained.

Based on the results and discussions above, the following recommendations are made:

1. Avoid mass predator eradication schemes as was done in the 1980s through poisoning since this can have severe consequences such as the wild boar epidemic. However, in certain areas with a big wild dog numbers in a limited local carrying capacity, targeted predator control schemes could be conducted. For instance, if there are three or four packs in any single area (Langdurbi in Zhemgang), a pack could be relocated or removed. This would have to be done by trained professionals, not through random carcasses poisoning since any animal eating the poison are killed.

2. Encourage livestock owners to better guard their livestock in wild dog prone areas as in Gasa areas. However, formal government acknowledgement of the problem faced by livestock owners and repeated public announcements can inform the people that the problem is recognized, and that the solution lies with owners themselves.

3. A livestock compensation scheme for livestock killed by wild dogs, despite their best efforts at guarding, may increase tolerance for wild dogs especially, since farmers already

understand the relationship between wild dogs and wild boars and do not have to be educated about such realities.

4. In areas with large numbers of wild boars, targeted culling which is ongoing in Thinleygang and Bumdeling areas could be done. As this study showed, wild dogs can at the most result in a 60% reduction in wild boar numbers in any given area. The other 40% can be addressed through trapping and shooting of wild boars if conditions are favourable.

This combination of actions may result in a balanced approach to the human-wildlife conflicts caused by wild dogs and wild boars.

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Annexure

Data Form O1

Questionnaire for Presence /Absence Survey of Wild Dogs

Phone Interview
Forest Division _____________
Park/Wildlife Sanctuary_____________
Range Office_____________
Warden Post_____________
Beat Office_____________
Guard Post_____________
Dzongkhag Forest Office (Dzongkhag/ RNR Center)__________________
Dzongkhag Agricultural Office (Dzongkhag / RNR Center)_____________

Phone/ WT Interview
Gup Office (Gewog and Dzongkhag):______________________

Site Visit Interview
Village / Gewog / Dzongkha:_______________
Informant name_________________
Date:_________________
Enumerator:_____________________

1) Are wild dogs (phou) present in your area?
2) If so in which areas (Gewog, Village) are they found?
3) How Many packs are there? How many individuals are there in each pack?
4) What are the areas covered by the packs (Villages, gewogs).
5) Is there livestock loss to predators in your area? What are the main predators?
6) How many livestock losses have occurred within the last one year? What type of livestock was lost (cows, calves, bulls, horses etc) and what were the responsible predators? (Enumerator to fill out the form below)

Type of Livestock Lost	Numbers	Village	Predator	Approximate Dates

7) Are there reports of crop loss in your area? How severe is the problem and where are the reports of heaviest loss? (Enumerator to fill out the form below)

Type of Crop Lost	Loss intensity (High, Medium, Low)	Village	Responsible Wild life (deer, wild boar, *shou* etc)	Approx. Dates

Data Form.02

Scat Analysis

Transect #______________________ Location____________________________

Habitat Type:____

Date:_____________________ Enumerator:______________________________

Scat Content: Prey Species	Numbers	Percentage	Comments

Data Form.03

Relative Mammal Sign Abundance

Transect No:_________________

Transect Length:__________________ Location:____________

Date:_________________ Weather: Rain/Cloudy/Sun

Enumerator:_________________ Local Informant:___________________

No.	Mammal Species	Sign (footprint, scat, wallow, rubbing) and number of sign	Comments (habitat type, substrate, other relevant observations)

Notes:____