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High relative abundance of wild ungulates near agricultural croplands in a livestock-dominated landscape in Western Bhutan: Implications for crop damage and protection

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ABSTRACT

There is little information on the underlying causes of wildlife crop damage, especially in agro-pastoralist communities situated close to, or inside, protected areas that are frequented by domestic livestock. Knowledge on wild ungulate distribution near crop field boundaries, and how it is affected by cattle that dominate the landscape, may offer insights into methods for reducing wildlife damage. In 2012, we investigated the distribution of three wild ungulates, sambar (*Rusa unicolor*), muntjac (*Muntiacus muntjac*), and wild pig (*Sus scrofa*), and domestic cattle (*Bos taurus*) in Jigme Dorji National Park, western Bhutan, at varying distances from croplands. At each of the 20 study villages, three transects were laid parallel to cropland boundaries at 500 m intervals. Transects were seasonally surveyed for wild ungulate and cattle scats, and scat frequency was used as a relative abundance index of wild ungulates and cattle. We also interviewed 111 household members from the 20 villages with crop fields situated near a forest edge, and recorded the seasonal frequency of crop damage. We used a generalized linear mixed model (GLMM) to evaluate how relative abundance of each ungulate species differed across transects and seasons. We also performed a one-way ANOVA to compare seasonal differences in frequency of crop damage, along with a simple linear regression to determine if there were significant relationships between crop damage frequency and relative ungulate abundance at transects situated closest to croplands. The relative abundance of wild herbivores was significantly higher in transects closest to croplands, and lower for transects located farther away in deep forests. An increased concentration of wild herbivores near agricultural fields during spring, which is the crop-growing period, explained the observed persistent damage to crops. Because of their very low overall densities in Bhutan, culling of wild herbivores is not recommended. Alternatively, cost-effective fencing methods for crop protection during spring are needed in the short term. In the long term, interdisciplinary solutions should involve enhancing the populations of natural predators, or habitat enrichment programs for ungulates, in concert with livestock intensification programs.

1. Introduction

There has been an increase in the number of global wildlife crop damage studies focused on understanding the nature and extent of crop losses (Fungo, 2011). Such studies range from estimating the quantities and types of crops damaged by wild animals (e.g., Naughton-Treves, 1998) to assessing the efficacies of different crop protection measures (e.g., Bomford and O'Brien, 1990; Davies et al., 2011). However, there has been little attention on the underlying causes of wildlife crop damage. While it is important to invest time in assessing crop damage and potential protection methods, it is equally vital to investigate the underlying causes of wildlife damage. In order to accomplish this, a

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Fig. 1. The map of the study area inside Jigme Dorji National Park (JDNP) showing 20 randomly selected villages. The inset shows the map of protected areas and biological corridors of Bhutan.

comprehensive multi- and inter-disciplinary understanding of agro-ecosystem dynamics is needed. Addressing these causes will assist in devising effective long-term countermeasures, thereby saving cost and time invested in temporary or tangential solutions which often fail.

In most developing countries, rural subsistence agriculturalists live in close proximity to, or within the boundaries of nature reserves. Most farmlands are located close to, or in the middle of, extensive tracts of natural forests. Bhutan, for instance, has 72% natural forest cover and approximately 50% designated as protected areas and biological corridors (DoFPS, 2015). About 70% of the human population live in rural areas, engaging in subsistence agriculture (MoA, 2009). Such a landscape mosaic creates an extensive agriculture-wildlife habitat interface and an increased potential for wildlife crop damage. In fact, human-wildlife conflicts tend to occur near protected areas and remote mountainous regions (Pettigrew et al., 2012).

Several studies across Asia, Africa, and Europe have shown the relationship between crop damage and proximity to adjacent forests. All these studies reported that the intensity of wildlife damage was highest at the cropland-forest interface. For example, severity of wild pig (*Sus scrofa*) damage to vineyards increased with decreasing distance from a forest boundary in southern France (Calenge et al., 2004). Similarly, greater wild pig damage was observed closer to forest edges in southern Sweden (Thurfjell et al., 2009). Through interviews with farmers in Ethiopia, Lemessa et al. (2013) also found that visitation rates to agricultural fields by olive baboons (*Papio anubis*) and bush pigs (*Potamochoerus larvatus*) were strongly linked to distance from forest edges. From a similar social survey in Sumatra, Indonesia, crop damage by wild pigs, pig-tailed macaques (*Macaca nimestrina*), and Malayan porcupines (*Hystrix brachyura*) was most frequent in farmlands situated closest to the forest edge (Linkie et al., 2007) and also linked to the length of forest edge. Moreover, a positive correlation was reported between crop damage by red deer (*Cervus elaphus*) and wild boar with the length of forest edge in Hungary (Bleier et al., 2012). Furthermore, Honda (2007) found a positive correlation between the ratio of forested lands and extent of crop damage by wild pigs in Japan.

However, fewer studies report on the relationship between crop damage and wild animal density (Bleier et al., 2012). Because frequency of crop raiding could potentially be higher in areas near high ungulate densities (Fungo, 2011), an understanding of varying ungulate densities in relation to distances from cropland boundaries is needed, particularly for villages situated next to, or surrounded by large forests tracts. This will assist wildlife managers in formulating relevant management recommendations particularly if some ungulate density patterns are a threat to crop production.

Additionally, there are few studies (e.g., Bergstrom and Skarpe, 1999) on the relationship between wild animal density and livestock density which can assist wildlife managers in understanding the causes of wildlife crop damage. Hence, it is not known how wild ungulate density is affected by domestic livestock, which frequently dominate the landscape surrounding agro-pastoralist communities. In most developing countries, agro-pastoralism is the major source of livelihood, whereby farmers own large quantities of livestock without regard to the quality of the stock (Brandström et al., 1979). In rural villages near extensive forest cover as in Bhutan, farmers release their cattle into these forests for free-range grazing (Tshering and Thinley, 2017). Thus, wild ungulates face competition with domestic cattle for natural forage and habitat, a situation that may force them to seek alternative food sources such as croplands (Fritz et al., 1996; Gordon, 2009; Wang, 2010).

In this study, we investigated how wild ungulates were distributed