



Understanding Human–Canid Conflict and Coexistence: Socioeconomic Correlates Underlying Local Attitude and Support Toward the Endangered Dhole (*Cuon alpinus*) in Bhutan

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Specialty section:

This article was submitted to
Human–Wildlife Dynamics,
a section of the journal
Frontiers in Conservation Science

Received: 06 April 2021

Accepted: 15 June 2021

Published: 19 July 2021

Citation:

Thinley P, Rajaratnam R, Norbu L,
Dorji L, Tenzin J, Namgyal C,
Yangzom C, Wangchuk T, Wangdi S,
Dendup T, Tashi S and Wangmo C
(2021) Understanding Human–Canid
Conflict and Coexistence:
Socioeconomic Correlates Underlying
Local Attitude and Support Toward
the Endangered Dhole (*Cuon alpinus*)
in Bhutan.
Front. Conserv. Sci. 2:691507.
doi: 10.3389/fcosc.2021.691507

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Understanding human–canid conflict and coexistence must focus on documenting human–canid interactions and identifying the underlying drivers of reciprocal human attitude which enables appropriate strategies to minimize conflict and forge coexistence. The dhole (*Cuon alpinus*), Asia’s most widely distributed wild canid, is highly threatened by human persecution and anthropogenic activities. Despite its “endangered” status, its ecological role as an apex predator, negative interactions with humans, and dhole-specific attitude studies are limited, thus hindering the development of a comprehensive dhole-conservation strategy. Here, we investigate the influence of socioeconomic factors of age, gender, income, residency inside/outside a protected area (PA), and other variables (cultural beliefs, livestock loss, and quantity of livestock loss) on the attitudes of local people and support for dhole conservation in the Himalayan Kingdom of Bhutan. We conducted a semi-structured questionnaire survey of 1,444 households located within the PA and non-PA from four representative regions in the country. Using R programming, we ran Pearson’s chi-square test of independence to test the overall difference in the attitude and support for dhole conservation, followed by recursive partitioning through a conditional inference regression tree to identify its significant covariates with the highest explanatory power. Majority (79.1%) of respondents ($\chi^2 = 488.6$; $df = 1$; $p < 0.001$) disliked the dhole over those who liked it. More than half (57.7%) ($\chi^2 = 412.7$; $df = 2$; $p < 0.001$) opposed dhole conservation over those who either supported or remained neutral. Experience of livestock loss to dholes was the primary ($p < 0.001$) factor influencing the negative attitude and opposition to dhole conservation, despite an acknowledgment of the ecological role of the dhole in controlling agricultural crop predators. Our study,

which is the first-ever survey in Bhutan, solely focused on investigating human attitudes and perceptions toward the dhole, indicating that livestock loss to dholes transcends all positive attitudes to the species and drives a predominant dislike and opposition to its conservation. To improve the attitude and support toward the dhole and to foster dhole–human coexistence, livestock predation by dholes needs alleviation by improving the existing animal husbandry, in conjunction with promoting conservation awareness on this species.

Keywords: attitude toward wildlife, dhole conservation, endangered canid, human-canid conflict, livestock depredation, socioeconomic correlates, human-wildlife coexistence

INTRODUCTION

Canids are globally widespread and face management and conservation challenges (Lamb et al., 2020) from large geographic ranges interspersed with human-modified landscapes (Srivathsa et al., 2019). Livestock predation is the main source of conflict between humans and canids (Srivathsa et al., 2020), resulting in persecution (Torres et al., 2018), population reduction (Boitani et al., 2004), and even eradication (Karanth et al., 2014; Ugarte et al., 2019) of canids. Notable examples include extermination of the Mexican wolf (*Canis lupus baileyi*) from its natural range (Brown, 1983), extirpation of the African wild dog (*Lycan pictus*) from 64% of the countries where it historically occurred (Woodroffe et al., 1997), eradication of gray wolves (*Canis lupus*) from most of the United States and Europe (Mech, 1995), and extinction of the Falkland wolf (*Dusicyon australis*; Sillero-Zubiri, 2015).

Ten canid species are from Asia (Din et al., 2013), of which, the Asiatic wild dog or dhole *Cuon alpinus* (Pallas, 1811) is the most widely distributed. This hypercarnivorous (Van Valkenburgh, 1991) pack-hunting apex predator primarily inhabits South and Southeast Asian forests in India, Nepal, Bhutan, China, Myanmar, Thailand, Cambodia, Laos, Malaysia, and Indonesia (Kamler et al., 2015). To aid their movement and dispersal, dholes also use unprotected secondary forests, multi-use forest fragments, and agro-forests adjoining the protected forest reserves (Gangadharan et al., 2016). Although deemed shy and elusive with infrequent interactions with humans (Srivathsa et al., 2020), this species has disappeared from ~82% of their former range (Wolf and Ripple, 2017) through habitat loss and human persecution (Karanth et al., 2010). For example, dholes in India were deemed vermin and hunted to near extinction (Cohen, 1978), while in Nepal, dholes were poisoned and shot as pests (Khatiwada et al., 2011). Similarly, dholes in Bhutan were considered pests and subjected to mass poisoning in the 1970s and 1980s (Wang and Macdonald, 2006; Thinley et al., 2011). Recently, dholes in Vietnam have been deemed close to local extinction from hunting, prey decline, and habitat destruction (Hoffmann et al., 2019). The International Union for Conservation of Nature (IUCN) currently lists the dhole as “endangered” based on a population estimate of 4,500–10,500 individuals, of which, only 949–2,215 are mature individuals persisting in small, isolated metapopulations (Kamler et al., 2015).

Dholes in Bhutan have recovered from near extermination (Wang and Macdonald, 2009; Thinley et al., 2018). They have now become widely distributed in the country, with distribution spanning across all districts, PAs, and biological corridors (Thinley et al., 2021). Despite its globally endangered status and ecosystem role as an apex predator (Thinley et al., 2018, 2021), the dhole is not listed in Schedule I of the Forest and Nature Conservation Act of Bhutan which affords maximum legal protection (Namgyal and Thinley, 2017). Conversely, livestock predation by dholes continues to be a contemporary issue with some local persecution of this species (Tshering and Thinley, 2017). Given the endangered status of the dhole, preventing localized extinctions of dholes and promoting dhole–human coexistence requires a better understanding of human–dhole conflict.

However, recent literature on human–predator conflict argues that relevant conflict studies should really be framed as a conflict between humans over wildlife issues (Pooley et al., 2017). Furthermore, assessing the influence of socioeconomic factors on the occurrence and intensification of human–canid conflict substantially contributes to species conservation by providing conflict mitigating decision-making information (Torres et al., 2018). Therefore, understanding this conflict must focus on documenting canid interactions with humans, and identifying the underlying drivers behind reciprocal human attitude (Li et al., 2015; Thinley et al., 2019; Sangay et al., 2020). Identifying these drivers further enables appropriate strategies to minimize conflict (Manfredo, 2008; Mir et al., 2015) and forge coexistence (Bencin et al., 2016). Notable drivers of human attitude toward canids in Asia include socioeconomic correlates of gender (Kusi et al., 2020), occupation (Khan et al., 2019), education (Din et al., 2017), income (Din et al., 2017; Khan et al., 2019), and livestock loss (Srivathsa et al., 2020). Additional drivers include perceived cultural significance (Li et al., 2015) and residence relative to protected area landscapes (Kusi et al., 2020).

Regional attitude studies on large canids in the Indian subcontinent (Din et al., 2017; Khan et al., 2019) tend to focus on the gray wolf, which is of least concern to IUCN. Despite being endangered, the dhole has received less conservation attention (Widodo et al., 2020), including discerning socioeconomic correlates driving attitude toward the dhole. Although Srivathsa et al. (2019) examined human–dhole interactions in Central India, their study concurrently included other sympatric canids with an overall emphasis on socioeconomic impacts

from livestock loss, without addressing human attitudes and perceptions. Similarly, Katel et al. (2015), Wang and Macdonald (2006), and Tshering and Thinley (2017) investigated dhole-induced livestock predation in Central Bhutan and interviewed local pastoralists to discern socioeconomic correlates from livestock loss. However, their studies also encompassed sympatric carnivores and did not report local perceptions and attitudes specifically toward the dhole. Such attitude studies should also be solely focused on dholes because perceptions of people can be influenced by the presence of sympatric carnivores (Srivathsa et al., 2020). This enables a better understanding of driving factors underlying the human–dhole conflict to avoid a reoccurrence of historic mass persecutions previously documented in the Indian sub-continent (Cohen, 1978; Wang and Macdonald, 2006; Khatiwada et al., 2011; Thinley et al., 2011).

The objectives of our study were to document the attitude and support of people toward the dhole in Bhutan, including identifying the underlying socioeconomic driving factors, given the involvement of the species in livestock predation and consequential persecution by locals (Sangay and Vernes, 2008; Thinley et al., 2011; Rajaratnam et al., 2016). We additionally investigated the roles of livestock predation, gender, protected area (PA) residency, and cultural belief in influencing the attitude and support of people toward the dhole. We predicted negative influences from livestock predation and feminine gender on driving the attitude and support for dhole conservation because livestock loss fuels negative attitude toward canid conservation (Wang et al., 2006b; Dressel et al., 2015) and more men exhibited positive attitudes toward large carnivores as in the case of Nepal (Kusi et al., 2020). Protected area residency can positively influence the attitude of people toward wildlife from increased conservation awareness (Thinley et al., 2019). We predicted a positive impact from PA residency similar to more PA residents liking the endangered golden langur (*Trachypithecus geei*) in Bhutan because of their exposure to more conservation awareness programs (Thinley et al., 2019). In addition, PA residents are often more familiar with wildlife conservation efforts because benefits from natural resources provide authorities with an incentive to promote conservation education (Karanth and Nepal, 2012). Cultural and religious beliefs can influence the attitude of people toward wildlife (Dickman, 2010). We predicted a positive influence of cultural beliefs associated with the dhole, based on the premise that dholes would be associated with some local cultural figures that foster positive attitude, such as in the case of the locals in western Nepal positively viewing the tiger (*Pantheratigris*) that is believed as the vehicle of Hindu goddess Durga (Bhattarai and Fischer, 2014).

MATERIALS AND METHODS

Study Area

Bhutan covers a small geographical area of $\sim 38,394$ km² in the eastern Himalayas and in the Indian subcontinent (Figure 1) with extensive forests encompassing 71% of the country [Forest Resources Management Division (FRMD), 2016]. It is a stronghold for dhole conservation based on its extensive distribution (Thinley et al., 2021). Its forests support rich biodiversity comprising 11,248 species, which include 5,369

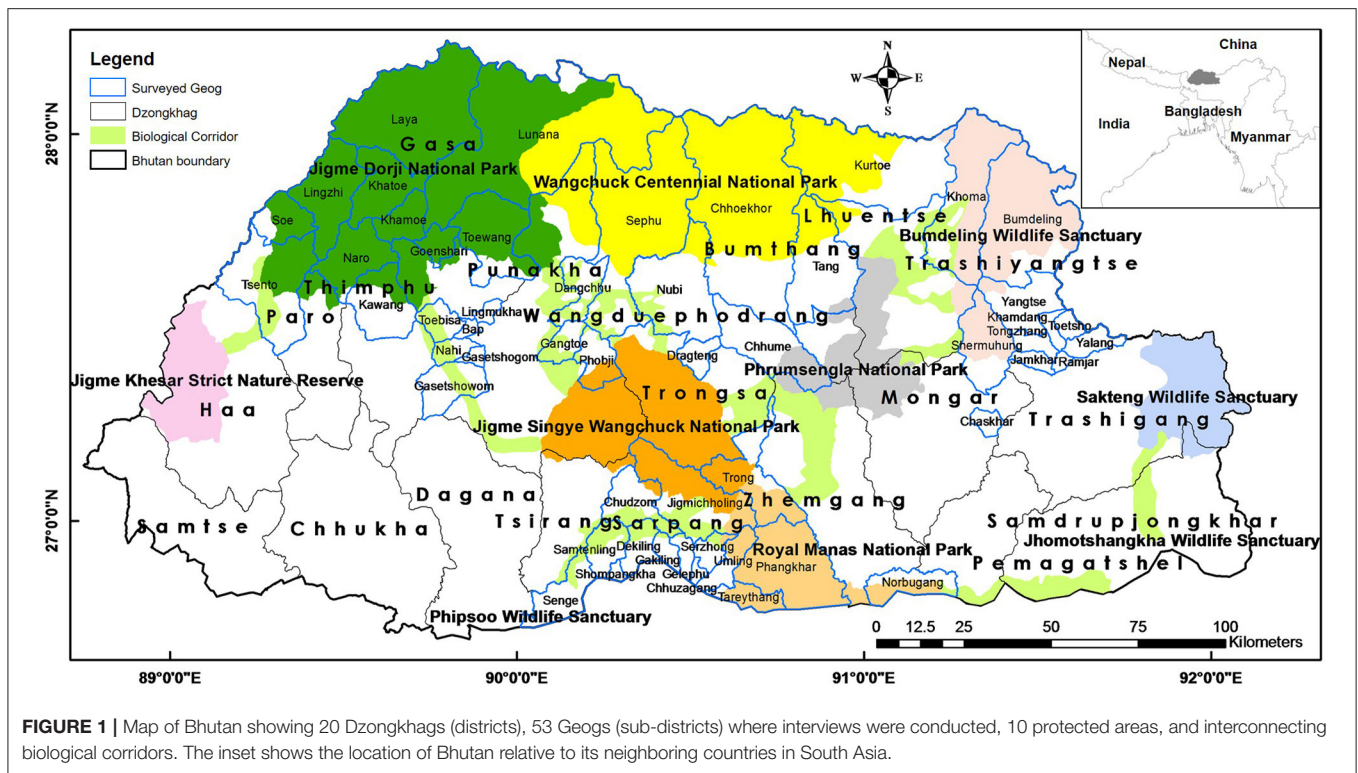
and 129 plant and mammal species, respectively [National Biodiversity Centre (NBC), 2017]. The mammalian carnivore community includes four wild canid species: Tibetan wolf (*Canis lupus chanco*), golden jackal (*Canis aureus*), and red fox (*Vulpes vulpes*) (Wangchuk et al., 2004). Prominent livestock predating carnivores include the tiger (*Panthera tigris*), snow leopard (*Panthera uncia*), common leopard (*Panthera pardus*), dhole, Tibetan wolf, Himalayan black bear (*Ursus thibetanus*), clouded leopard (*Neofelis nebulosa*), marbled cat (*Pardofelis marmorata*), golden cat (*Catopuma temmincki*), leopard cat (*Prionailurus bengalensis*), and yellow-throated marten (*Martes flavigula*) (Wangchuk et al., 2004).

Bhutan is divided into 20 *Dzongkhags* (administrative districts; Figure 1) and 205 *Geogs* (sub-districts) with $\sim 51\%$ of the country protected through a network of PAs and biological corridors (Dorji et al., 2019). People live inside PAs based on the traditional land rights where PA governance is shared: local governments administer people while PA management oversees natural resources. The majority of Bhutanese are Buddhists (80%) with the remaining comprising Hindus, Christians, and other faiths (Thinley et al., 2019). The general topography of the country is steep and rugged (Tshering et al., 2020), resulting in scattered rural settlements housing the majority (62.2 %) of 735,553 people [National Statistics Bureau (NSB), 2017] in the country. Agro-pastoralists subsisting on agricultural farming and livestock rearing (Tshering and Thinley, 2017) occupy areas below 3,500 m. Pastoralists raising yak occupy areas above 3,500 m (Thinley et al., 2017). We conducted our study in four representative regions collectively encompassing 13 dzongkhags, 53 geogs, and four PAs of Bumdeling Wildlife Sanctuary (BWS), Jigme Dorji National Park (JDNP), Royal Manas National Park (RMNP), and Wangchuck Centennial National Park (WCNP; Figure 1).

Survey Design and Data Collection

We designed semi-structured questionnaires (Supplementary File) to elicit unambiguous responses (Vodouhê et al., 2010) and gather information on the perception, attitude, and support toward the dhole. The questions were drafted in English which trained survey enumerators verbally translated into local dialects wherever appropriate. Responses were translated back into English. Questionnaires were initially field-tested in a non-study area, prior to application (Thinley et al., 2019). Field testing enabled identification and reframing of key questions to improve efficiency. Questionnaires were divided into two parts. The socioeconomic profile of a respondent was initially recorded in terms of age, gender, locality (village, geog, dzongkhag, and PA residency), education level (tertiary, secondary, primary; monastic, and none), and annual income in US dollars [low (<\$1,400), medium (\$1,400–\$13,000), and high (>\$13,000)]. Next, the following information was then discerned:

1. Encounter with dholes (seen/not seen);
2. Attitude (like/dislike) toward dholes and reasons;
3. Cultural beliefs associated with dholes (yes/no) and specifics;
4. Livestock loss to dholes in the last three years (yes/no);
5. Quantity of livestock lost to dholes (if “yes” to 4);



- Nomination of the top livestock predator species; and
- Support increase (yes/no) of dhole populations and reasons.

The perception and attitude of people toward wildlife are influenced by social values and motivational factors, such as economic benefits and innate human tendencies (Kellert, 1993). Therefore, elicited reasons for Question 1 were segregated by physical appearance (cute/ugly/fearful), conservation benefits (beneficial/destructive), aesthetics (does/does not beautify surroundings), rarity (rare/abundant), economics (high/low economic value), religion (has/no religious value), compassion, and peer influence (others like/dislike dholes). We deemed respondents to: (a) “support” dhole conservation if they responded “yes” to population increase (in 7 above); (b) “oppose” dhole conservation if they responded “no” to population increase; and (c) remain “neutral” if no opinion was forthcoming.

To obtain representative samples, the country was stratified into four geographic regions comprising one PA and non-PA per region: JDNP and Wangdue Forest Division in the west; WCNP and Bumthang Forest Division in the center; BWS and Trashigang Forest Division in the east; and RMNP and Sarpang Forest Division in the south (Figure 1). Trained enumerators opportunistically conducted face-to-face interviews on the available households in each region from September to November 2019. Following Thinley et al. (2019), household heads were primarily interviewed, and if unavailable, the next eldest member was interviewed.

Data Analysis

Data were analyzed in program R version 4.0 (R Core Team, 2020). We first performed a Pearson’s chi-square test of independence with Yates’ continuity correction using the R package “MASS” version 7.3–15.5 (Venables and Ripley, 2002) and function “chisq.test,” to test the overall differences in the attitude toward dholes and support for their conservation. We subsequently conducted binary recursive partitioning based on conditional inference trees (Tighe et al., 2012) using the R package “party” version 1.3–4 and the “ctree” function (Hothorn et al., 2006). These regression trees iteratively compare response variables with each explanatory variable, and identify significant covariates with the highest explanatory power through adjusted Bonferroni tests at $p < 0.05$ (Hothorn et al., 2006; Tighe et al., 2012). We chose this method because it provides a more intuitive tool to identify the hierarchical importance of explanatory variables in explaining variations in the dichotomous categorical response variables (Tighe et al., 2012), as recently demonstrated by Thinley et al. (2019) and Sangay et al. (2020). We initially tested “attitude toward dholes” (response variable) against explanatory variables of “age,” “gender,” “annual income,” “education level,” “PA residency,” “dhole encounter,” “local belief on dholes,” “experience of livestock loss to dholes,” and “quantity of livestock lost to dholes.” Next, we reran the analysis to test “support for dhole conservation” (response variable) against the same set of explanatory variables but with “attitude” as an additional explanatory variable.

TABLE 1 | Socioeconomic variables of 1,444 respondents in rural Bhutan with respect to attitude and support toward the dhole (*Cuon alpinus*), based on a questionnaire survey from September to November 2019.

Socioeconomic variables	Levels	Attitude toward dholes		Support toward dhole conservation		
		Like	Dislike	Support	No support	Neutral
Gender	Male	(15.1) 218	(47.2) 681	(23.2) 335	(32.8) 474	(6.2) 90
	Female	(5.8) 84	(31.9) 461	(13.1) 189	(20.7) 299	(3.9) 57
Age	18–19 (teen)	(0.1) 1	(0.4) 6	(0.1) 2	(0.2) 3	(0.1) 2
	20–29 (twenties)	(2.4) 34	(10.7) 154	(4.1) 59	(7.5) 109	(1.4) 20
	30–39 (thirties)	(4.5) 65	(17.9) 258	(8.4) 121	(12.3) 178	(1.7) 24
	40–49 (forties)	(5.5) 80	(20.4) 294	(9.2) 133	(13.8) 199	(2.9) 42
	50–59 (fifties)	(4.4) 64	(13.5) 195	(7.1) 102	(9.1) 132	(1.7) 25
	60–69 (sixties)	(3.0) 43	(12.0) 173	(5.7) 82	(7.5) 109	(1.7) 25
	70–79 (seventies)	(1.0) 15	(3.7) 53	(1.7) 24	(2.6) 37	(0.5) 7
Education	80–89 (eighties)	(0.0) 0	(0.6) 9	(0.1) 1	(0.4) 6	(0.1) 2
	College	(0.3) 4	(0.6) 8	(0.5) 7	(0.2) 3	(0.1) 2
	High school	(1.5) 22	(4.0) 58	(1.5) 22	(3.5) 50	(0.6) 8
	Primary school	(2.6) 38	(8.9) 128	(4.7) 68	(5.3) 76	(1.5) 22
	Non-formal	(4.6) 67	(17.7) 256	(7.5) 108	(12.3) 177	(2.6) 38
Income	None	(11.8) 171	(47.9) 692	(22.1) 319	(32.3) 467	(5.3) 77
	Low (<1,400/year)	(11.7) 169	(45.2) 652	(21.3) 307	(30.1) 434	(5.5) 80
	Medium (1,400–13,000/year)	(9.0) 130	(33.7) 486	(14.8) 214	(23.3) 336	(4.6) 66
Location of residence (with respect to a protected area)	High (>13,000/year)	(0.2) 3	(0.3) 4	(0.2) 3	(0.2) 3	(0.2) 3
	Inside	(11.8) 171	(39.5) 570	(15.4) 223	(29.9) 432	(6.0) 86
	Outside	(9.1) 131	(39.6) 572	(20.8) 301	(23.6) 341	(4.2) 61
Encounter (seen a dhole)	Yes	(14.4) 208	(54.6) 788	(22.5) 325	(41.2) 595	(5.3) 76
	No	(6.5) 94	(24.5) 354	(13.8) 199	(12.3) 178	(4.9) 71
Local belief on dhole	Yes	(3.9) 57	(10.1) 146	(5.5) 80	(7.7) 111	(0.8) 12
	No	(17.0) 245	(69.0) 996	(30.7) 444	(45.8) 662	(9.3) 135
Experienced livestock loss to dholes	Yes	(7.3) 105	(38.5) 556	(11.9) 172	(33.9) 489	(0.0) 0
	No	(13.6) 197	(40.6) 586	(24.4) 352	(19.7) 284	(10.2) 147

Values are shown as (percentage of respondents) and number of respondents. Annual income is in U.S. dollars.

RESULTS

Socio-Demography

We interviewed respondents from 1,444 households, of which, 62.3% were men and 37.7% were women, with similar proportions residing inside (51.3%) and outside (48.7%) PAs (**Table 1**). Ages ranged from 18 to 84 with most belonging in the age class 40–49 years (25.9%), followed by 30–39 years (22.4%), 50–59 years (17.9%), and 18–19 years (0.5%). More than half (59.8%) had no education while the rest were educated formally (17.9%) and informally (22.4%) (**Table 1**). Most households (56.9%) earned less than US \$1,400 per year while 42.7% earned between US \$1,400 and US \$13,000 per year (**Table 1**). Only 0.5% earned more than US \$13,000 per year. More respondents had encountered a dhole (69%) than those who had not (31%) (**Table 1**).

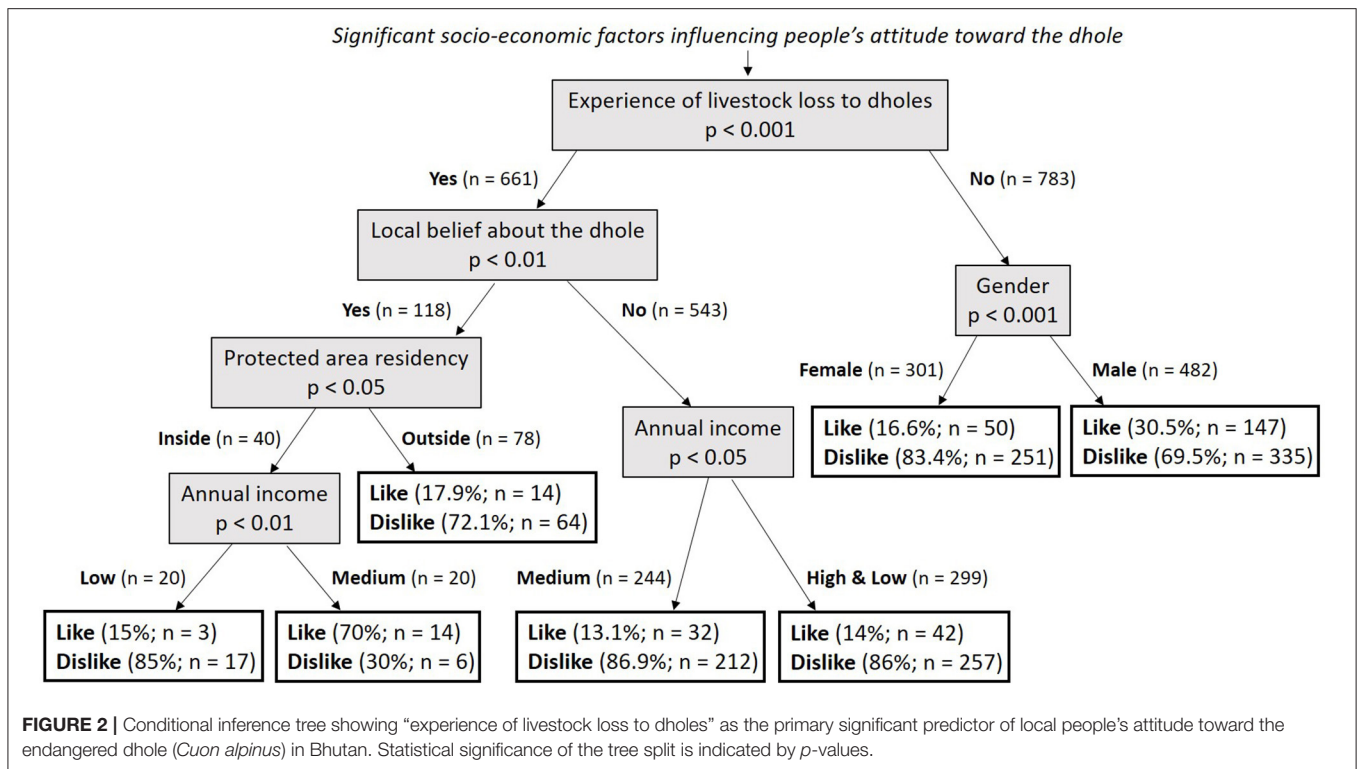
Local Beliefs Associated With Dholes

Only 14% ($n = 203$) of respondents held local beliefs associated with dholes (**Table 1**). The majority (90.1%) of beliefs were associated with deities. These portrayed dholes as hunter dogs of local (60.1%) and national deities (21.7%);

manifestation of local deities (3%); and retribution from unappeased deities (5.4%). Some believed dholes to indicate good luck (0.5%), good harvest (2%), and misfortune (2%). A few revered dholes as guard dogs of Hindu Lord Rama (1.5%), equated their red coat to monks (2%) and perceived them as farm protectors (0.5%).

Livestock Depredation by Wild Carnivores

Less than half (45.8%; $n = 661$) of households experienced livestock loss to dholes in the last 3 years (2017–2019). Among those who lost livestock to dholes, some lost more than one livestock type such that 80.6% lost 1,433 cattle; 18.5% lost 255 horses; 12.4% lost 312 yaks; 3.8% lost 59 others (poultry and pets); 1.8% lost 49 sheep; and 1.5% lost 15 goats. On average, a household lost 3.2 livestock heads to dholes. Dholes were identified as the top livestock depredator by 41.1% of the total respondents, followed by common leopards (22%), tigers (11.6%), snow leopards (8.1%), small felids (marbled cat, golden cat, and leopard cat) as a collective group (5.5%), Himalayan black bears (5.3%), yellow-throated martens (4.8%), Tibetan wolves (1.4%), and clouded leopards (0.2%).



Drivers of Attitude Toward Dholes

The majority of respondents (79.1%; $n = 1,142$) significantly disliked dholes ($\chi^2 = 488.6$; $df = 1$; $p < 0.001$) over those who liked them (20.9%; $n = 302$). The primary reasons were livestock predation (79.9%) followed by non-religious significance (8.8%). Secondary reasons included its fearful appearance (6.4%) and a plain dislike (2.8%). Lack of aesthetic (0.9%), abundant in nature (0.3%), and economic values (0.3%) were other minor reasons. Reasons encompassing legal restrictions and the stigma of a bad omen constituted 0.8% dislike for dholes. Conversely, respondents primarily liked dholes for their ecological role (51%). Other major reasons for liking dholes were the perceptions that dholes had a cute and cuddly appearance (10.3%), are rare (7.3%), have aesthetic value (6.3), and have religious significance (6%), and due to innate fondness for the species (5.6%). Compassion (2.3%) and economic value (2%) were minor reasons for liking dholes. Additional collective reasons included inquisitiveness about dholes and their non-harm to both crops and humans (9.3%).

“Experience of livestock loss to dholes” was the primary significant ($p < 0.001$) determinant of the attitude toward dholes (like/dislike; **Figure 2**). Among those who experienced livestock loss (45.8%; $n = 661$), with or without “local beliefs on dholes” (17.9%; $n = 118$) significantly ($p < 0.01$) further drove attitude. However, for the majority without holding any beliefs (82.1%; $n = 543$), “annual household” income significantly ($p < 0.05$) influenced attitude, whereby, the majority of all income groups (86.4%; $n = 469$) disliked the species (**Figure 2**). Among those holding local beliefs, “PA residency,” significantly ($p < 0.05$)

influenced attitude (**Figure 2**). For PA residents (33.9%; $n = 40$), “annual income” further determined attitude ($p < 0.01$). Majority (85%; $n = 17$) of low-income households disliked dholes while the majority (70%; $n = 14$) of medium income households liked dholes. Similarly, the majority (72.1%; $n = 64$) of non-PA residents with holding local beliefs disliked dholes. Among respondents who did not experience livestock loss to dholes (54.2%; $n = 783$), “gender” significantly ($p < 0.001$) influenced attitude. Both sexes disliked dholes with women (83.4%; $n = 251$) professing more dislike than men (69.5%; $n = 335$; **Figure 2**).

Drivers of Support for Dhole Conservation

Majority (57.7%; $n = 834$) of respondents significantly opposed dhole conservation ($\chi^2 = 412.7$; $df = 2$; $p < 0.001$) over those who supported it (35.7%; $n = 515$) and remained neutral (6.6%; $n = 95$). Fear of increased livestock predation by dholes (88.6%) primarily drove opposition to dhole conservation (**Figure 3**). Lack of government compensation for dhole-induced livestock loss (6.5%) contributed to a much lesser extent. A small proportion of respondents also listed the lack of economic value of the dhole (1.4%), its increased threat to humans (1.7%), and its fearful appearance (1.4%) as additional factors (**Figure 3**). Other collective minor reasons for opposing dhole conservation included an inherent dislike and reference to an established high population of dholes (0.4%; **Figure 3**). Less crop damage from wild herbivores (82.1%) was the main reason for supporting dhole conservation (**Figure 3**).

“Experience of livestock loss to dholes” was again the primary significant ($p < 0.001$) predictor of support for dhole

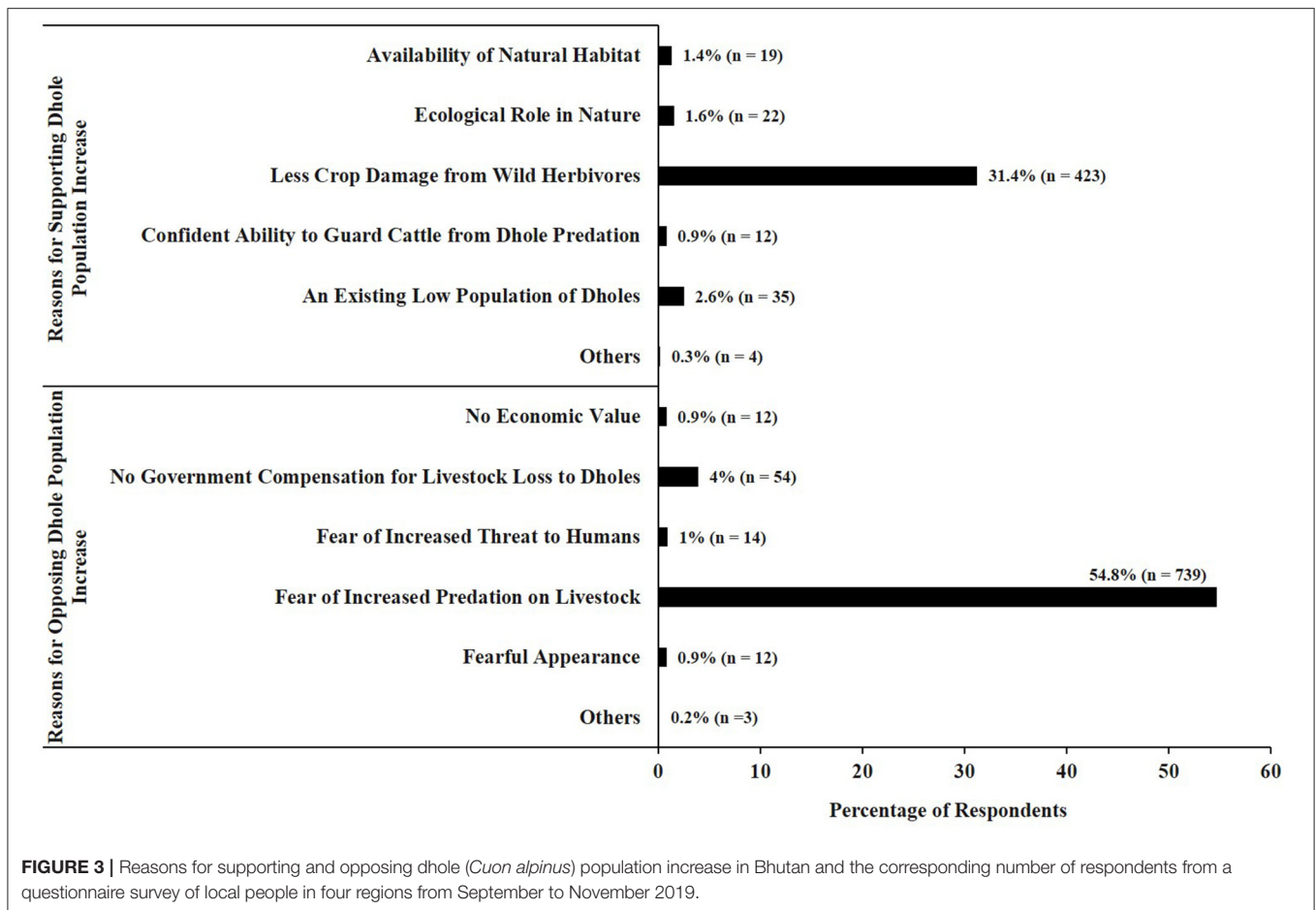


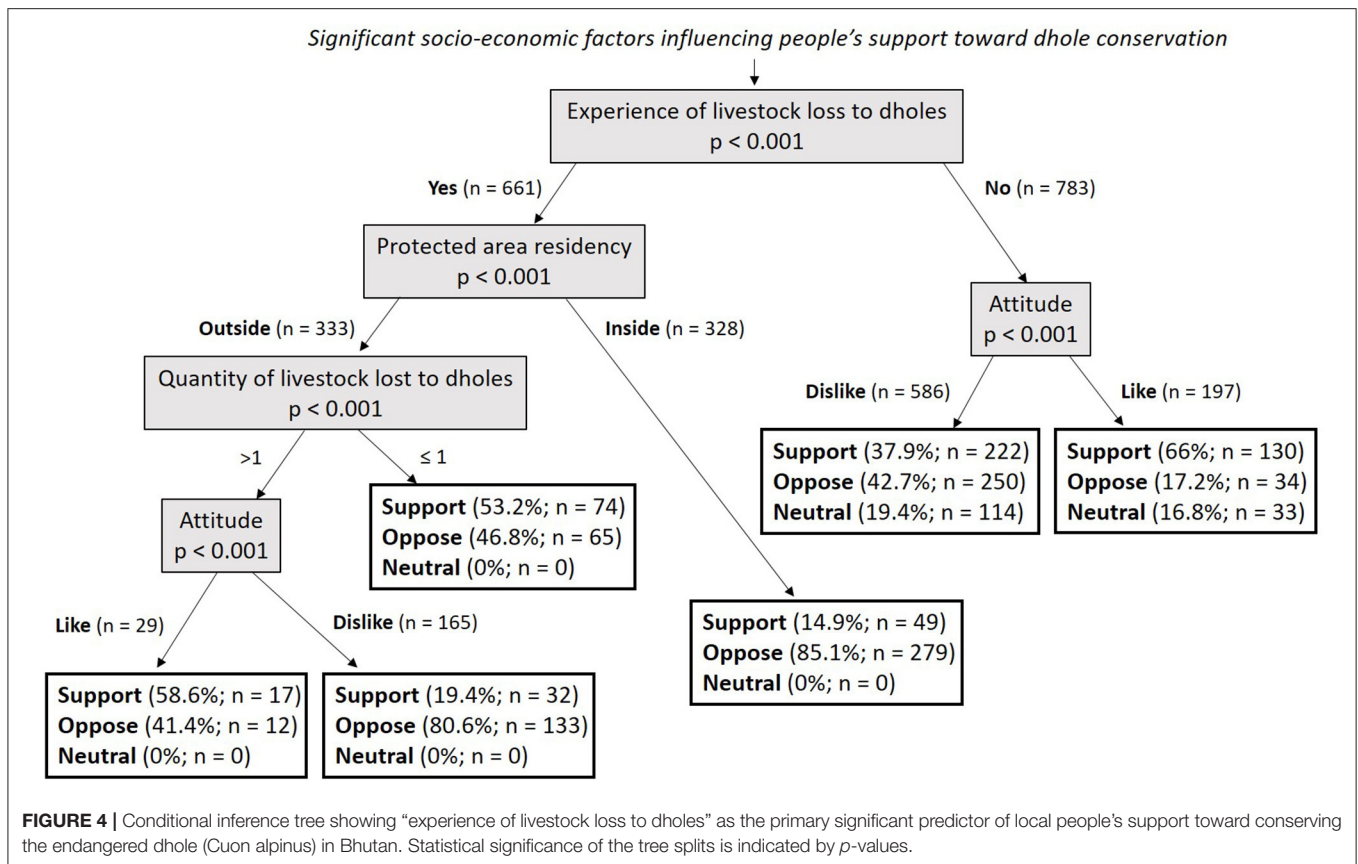
FIGURE 3 | Reasons for supporting and opposing dhole (*Cuon alpinus*) population increase in Bhutan and the corresponding number of respondents from a questionnaire survey of local people in four regions from September to November 2019.

conservation (Figure 4). Among those who experienced livestock loss, “PA residency” significantly ($p < 0.001$) impacted local support particularly among non-PA residents (50.4%; $n = 333$) in terms of “quantity of livestock lost to dholes” (Figure 4). Those who lost >1 livestock (58.3%; $n = 194$) were significantly ($p < 0.001$) further influenced by their attitude, whereby, majority (80.6%; $n = 133$) of those disliking dholes ($n = 165$) opposed dhole conservation. Of the remaining 15% ($n = 29$) who liked dholes, 41.4% ($n = 12$) still opposed dhole conservation (Figure 4). Similarly, almost half (46.8%; $n = 65$) of non-PA residents who lost ≤ 1 livestock to dholes opposed dhole conservation. Opposition to dhole conservation was also substantial among PA residents who experienced livestock loss to dholes (49.6%; $n = 328$) with an overwhelming majority (85.1%; $n = 279$) opposing dhole conservation (Figure 4). Support for dhole conservation among respondents not experiencing livestock loss to dholes (54.2%; $n = 783$) was significantly ($p < 0.001$) influenced by “attitude” (Figure 4). The majority (74.8%, $n = 586$) disliked dholes, of which, 42.7% ($n = 250$) opposed dhole conservation; 37.9% ($n = 222$) supported dhole conservation; and 16.8% ($n = 114$) remained neutral. Of the minority (25.2%; $n = 197$) who liked dholes, 66% ($n = 130$) supported dhole conservation; 17.2% ($n = 34$) opposed dhole conservation; and 16.8% ($n = 33$) remained neutral (Figure 4).

DISCUSSION

Attitude and Support Toward the Dhole

We conducted the first-ever survey in Bhutan solely focused on investigating human attitudes and perceptions toward dholes, by interviewing 1,444 rural residents across protected and non-protected landscapes. To date, only Jenks et al. (2014) had conducted a similar attitude survey on dholes in south eastern Thailand involving 791 rural people residing outside PAs. In their study, negative local attitude to dholes was largely influenced by fear of personal attack. We also discerned a negative attitude among the majority of respondents (79.1%; $n = 1,142$), which contrastingly, was primarily driven by livestock predation as anticipated. Respondents listed dholes as the top livestock predator as observed in western Bhutan (Katel et al., 2015) and the neighboring Indian state of Arunachal Pradesh (Lyngdoh et al., 2014). In our study, 661 households lost 2,123 livestock to dholes from 2017–2019, constituting an average loss of 3.2 livestock per household. Previous studies in Bhutan (Norbu, 2014; Dorji, 2017; Tshering and Thinley, 2017) also documented high levels of dhole-related livestock predation over comparable timeframes, ranging from 35 to 82% loss in livestock comprising cattle, yak, and horses. This livestock loss resulted in a substantial negative



attitude to dholes (Wang and Macdonald, 2006; Katel et al., 2015).

A similar negative attitude toward dholes stemming from livestock loss also exists across their distributional range in a current review by Srivathsa et al. (2020) which linked dhole diet with livestock consumption and human–dhole interaction. It supports the premise of Bickley et al. (2019) which stated that people who experienced livestock predation by wild canids were more likely to dislike them due to economic loss (Lindsey et al., 2005). Our study showcases this dislike because livestock loss presents a significant socioeconomic setback to rural farmers in the predominantly agrarian society of Bhutan (Sangay and Vernes, 2008; Rajaratnam et al., 2016). Yak loss results in sizable income loss to upland pastoralists, while cattle loss compromises agricultural production and nutrition for lowland agro-pastoralists.

Ahmad et al. (2016) noted that pastoral communities experiencing human–carnivore conflict tend to have low income with low tolerance to carnivores and their conservation, as observed in our study. Consequentially, a prevalent negative attitude driven by livestock predation precluded local support for dhole conservation as we postulated. Approximately 53.5% ($n = 773$) of our respondents opposed conserving dholes because of socioeconomic impacts from livestock predation. Katel et al. (2015) also noted hostility to conservation by farmers in western Bhutan who experienced severe (82%) livestock loss to dholes.

Similarly, locals in the neighboring Indian Arunachal Pradesh supported reducing dholes because of livestock loss (Lyngdoh et al., 2014). As observed in our study, human intolerance and opposition to canid conservation due to socioeconomic loss from livestock predation has been established elsewhere: the Indian gray wolf in the Hindu Kush region (Din et al., 2013; Khan et al., 2019) and Pamir Mountains (Din et al., 2017) of Pakistan; Himalayan wolf in Nepal (Kusi et al., 2020); endangered Ethiopian wolf (*Canis simensis*) in south Wollo, Ethiopia (Eshete et al., 2018); gray wolf in the Carpathian Mountains, Slovakia (Rigg et al., 2011); African wolf (*Canis lupaster*) in Guassa Highlands, Ethiopia (Atickem et al., 2017); African wild dog in Kenya (Woodroffe et al., 2005); and chilla (*Lycalopex griseus*) in Chile (Silva-Rodriguez et al., 2009).

Effect of PA Residency on Attitude and Support

Contrary to our expectation, PA residency was inconsequential in driving the positive attitude to dholes and supporting dhole conservation. Dislike for dholes and their conservation was evident across the majority of the respondents, but more so among PA residents. Substantial intolerance by PA residents is because grazing in PAs increases the risk of livestock loss (Li et al., 2017) as alternate prey to predators (Karanth et al., 2013). For example, residents in Kanha, India, experienced substantive livestock predation through grazing activities in

PAs (Karanth et al., 2012). Recently, Letro and Fischer (2020) found that biological corridor residents in Bhutan deemed tiger conservation unimportant due to livestock predation, while the majority of residents in Musk Deer National Park, Pakistan wanted to eliminate carnivores from the park due to socioeconomic loss from livestock predation (Ahmad et al., 2016). Non-PA residents experience livestock predation because dispersing wildlife from PAs (Woodroffe et al., 2005) create conflict outside reserve boundaries (Karanth et al., 2013). This creates animosity as exemplified by the majority of residents near Tarangire National Park in Tanzania desiring a reduction in carnivore populations to reduce threats to livestock and humans (Mkonyi et al., 2017).

Contrastingly, residents in the Kanchenjunga Conservation Area of Nepal had higher tolerance to carnivores than non-residents despite suffering livestock predation, largely due to a community-owned conservation approach (Kusi et al., 2020). Residents outside Kalakkad-Mundanthurai Tiger Reserve in India regularly experienced livestock predation by leopards but exhibited a positive attitude from heightened conservation awareness (Krishnakumar and Nagarajan, 2020). Estifanos et al. (2020) also noted PA agro-pastoralists wanting to conserve and increase endangered Ethiopian wolf populations in the Bale Mountains National Park of Ethiopia, due to financial incentives from wolf-related tourism. However, a large proportion of non-park residents observed in the study by Estifanos et al. (2020) did not support wolf conservation due to a perceived notion of not accessing rewards from wolf-based tourism.

Influence of Gender on Attitude and Support

Although most male and female respondents disliked dholes and opposed their conservation (Table 1), our premise that more women than men will dislike dholes and oppose their conservation was upheld. Indeed, our data revealed more men liked dholes (15.1%; $n = 218$) and supported dhole conservation (23.2%; $n = 335$) than women (like: 5.8%, $n = 84$; support: 13.1%, $n = 189$). Kusi et al. (2020) stipulated that fewer men favored large predators in Nepal because men were seasonally migrating to cities for work and were not experiencing livestock depredation by wild predators as much as women were. In our study, both men and women were residents all year and were engaged in outdoor activities, such as crop cultivation and collection of fuelwood and non-timber forest products (Thinley et al., 2019), and were thus considered to be equally exposed to livestock predation. It is likely that the prevalent negative attitude of women to dholes reflects a greater fear of carnivores (Mir et al., 2015) and dislike of fearsome species (Schlegel and Rupf, 2010). Such profound negativity can also be attributed to the lack of aesthetic appeal of dholes compared to other predators (Khatiwada et al., 2011).

Role of Cultural Belief on Attitude

In our study, only 14.1 % ($n = 203$) of respondents held beliefs associated with dholes. A majority believed dholes as hunter dogs for local and national deities amidst an entrenched Buddhist reverence for deities (Allison, 2019), whereby, regular

rituals are undertaken in pursuit of good health, bountiful crops, and livestock protection. For those culturally aware, livestock predation by dholes was viewed as retribution by unappeased deities. In a previous study, Katel et al. (2015) noted religious tolerance by Bhutanese farmers amidst strong prejudice toward dholes because of their predisposition to disemboweling and feeding on alive prey (Wangchuk, 2004). While we anticipated some acceptance (Srivathsa et al., 2019) through this legacy of cultural reverence (Karanth et al., 2013), but a strong negative attitude still prevailed. This contrasts Buddhist pastoral communities in the Qinghai-Tibetan Plateau being highly tolerant of livestock predating carnivores (Suryawanshi et al., 2014) by the virtue of sacred mountains around Buddhist monasteries being safe havens for snow leopards and wolves (Li et al., 2015). Similarly, local residents in the South-Western Ghats of India viewed leopards positively and refrained from religiously forbidden lethal retaliation (Krishnakumar and Nagarajan, 2020). Bagchi and Mishra (2006) noted that despite resentment to large carnivores in Nepali pastures, people did not actively persecute them because of cultural and religious reasons. Contrastingly, residents of Musk Deer National Park in Pakistan bitterly detested Indian gray wolves, which was further exacerbated by a cultural perception of wolf tyranny, cowardice, and cruelty (Ahmad et al., 2016). In this study, we can only surmise that pervasive socioeconomic effects from livestock loss overshadowed any cultural and/or religious beliefs on dholes. This was especially evident in the severe dislike of dholes by culturally aware low-income PA residents, and strong opposition to their conservation by those who lost more than one livestock to dholes.

Role of Age and Education Level

The age of respondents in our study did not influence attitude to dholes, despite older generations elsewhere negatively viewing carnivores (Lindsey et al., 2005) from bad interactions (Bencin et al., 2016). For example, Røskaft et al. (2007) found that older, poorer Norwegian men exhibited more negative attitudes toward European wolves. Zimmermann et al. (2005) also noted older cattle ranchers in Brazilian Pantanal exhibiting entrenched negativity to jaguars (*Panthera onca*). We also did not determine any influence from education level on the attitude to dholes and their conservation, although education has driven positive attitudes on the notable livestock-depredating large canids like the European wolf (Røskaft et al., 2007), Ethiopian wolf (Eshete et al., 2018), and Indian gray wolf (Din et al., 2017; Khan et al., 2019). Instead, negative attitudes to dholes expressed by educated respondents in our study were primarily driven by livestock loss.

Importance of Knowledge on the Ecological Role of Dhole

Some respondents experienced livestock loss to dholes but still liked the species (7.3%; $n = 105$) and supported its conservation (11.9%; $n = 172$). They acknowledged the ecological role of the dhole in controlling crop raiders like wild pigs (*Sus scrofa*), sambar (*Rusa unicolor*), and muntjacs (*Muntiacus muntjac*). The wild pig is the principal crop raider across Bhutan (Wang et al., 2006a) and studies (Wangchuk, 2004; Thinley et al., 2018)

show dholes effectively preying on wild pigs as pack hunters against this gregarious and prolific breeder. It is believed that wild pig populations surged with subsequent increased crop loss several years after a mass poisoning campaign that almost extirpated the dholes in the 1970s and 1980s (Wangchuk, 2004; Thinley et al., 2011). Dholes in concert with common leopards are known to predate on crop raiding ungulates at village cropland peripheries when tigers are present in the environs (Thinley et al., 2017, 2018). A recent study by Bickley et al. (2019) also demonstrated support by local residents for conserving Cerrado canids, such as hoary fox (*Lycalopex vetulus*), crab-eating fox (*Cerdocyon thous*), and maned wolf (*Chrysocyon brachyurus*), ecologically controlling rodent and insect pests in the central Brazilian ranches. Indeed, the dhole is deemed as the top keystone carnivore in Bhutan and elsewhere in its range (Thinley et al., 2021).

Conservation Implications

Our study indicates that livestock loss to dholes transcends all positive attitudes to dholes and drives a predominant dislike and opposition to their conservation, as noted by Srivathsa et al. (2020) in parts of the distributional range of the dhole. Lax herding primarily contributes to livestock predation throughout protected and non-protected Bhutanese landscapes (Wang and Macdonald, 2006; Rajaratnam et al., 2016; Tshering and Thinley, 2017). In the wet season, when grass is abundant, farmers, particularly the agro-pastoralists, freely graze their untended cattle and horses in forests during the day whilst tending to crops and retrieve them in the evening. Livestock is thus prone to successful predation (Tshering and Thinley, 2017) because they are easy to catch (Palmeira et al., 2008) when dholes are most active, as evidenced by Woodroffe et al. (2005) for African wild dogs. Livestock predation rarely occurred in the dry season when livestock was tethered near homesteads and fed with crop residue (Thinley et al., 2011). Untended livestock grazing has also been noted as a key factor behind livestock predation by Indian gray wolves in Hindu Kush, Pakistan (Khan et al., 2019), common leopards in Maharashtra, India (Donikar et al., 2011), and snow leopards in Mongolia (Johansson et al., 2015).

To improve the human attitude, support for conserving dholes, and foster dhole–human coexistence in Bhutan, it is imperative to minimize livestock predation by addressing prevailing lax herding practices among rural agro-pastoralists. It is so because improvements in livestock husbandry can minimize livestock loss to predators and mitigate human–carnivore conflicts (Ogada et al., 2003; Gusset et al., 2009). Katel et al. (2015) recommend stall-feeding and cooperative herding of livestock in the forests during the day. Customized livestock corrals (Loveridge et al., 2017) and non-grazing of livestock in depredation-prone areas (Sangay and Vernes, 2008) are other plausible solutions. These measures are feasible based on the willingness of some of the respondents to modify traditional herding practices. Compensation and insurance schemes can also offer some economic offsets to livestock loss, but have inherent issues in the misuse and/or equitable market value of livestock (Torres et al.,

2018; Kusi et al., 2020). The ecological role of the dhole in controlling crop predators also needs wider promotion to rural agro-pastoralists to improve attitude, harness greater support for dhole conservation, and ensure harmonious co-existence.

An expanding human footprint poses increasing challenges to ensure the persistence of carnivores in human-dominated landscapes (Lamb et al., 2020), and this especially resonates for global canids. Our study indicates that dholes in Bhutan may be at the crossroads between persistence and increasing adversity from humans. Given the higher propensity of studies on human–felid interactions over those on human–canid interactions (Srivathsa et al., 2020), we advocate more dedicated attitude studies on dholes throughout their range to ensure the survival of this globally endangered canid. This approach is equally applicable in discerning conservation measures for other globally endangered canids in human-dominated landscapes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Department of Forest and Park Services, Bhutan. The interview respondents provided their verbal informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PT: conceptualization, study design, data curation, formal analysis, and writing the original draft. RR: conceptualization, validation, writing, review, and editing. LN, LD, JT, CN, CY, TW, SW, TD, and ST: data collection and data entry. CW: data curation, formal analysis, writing, and review. All authors contributed to the article and approved the submitted version.

FUNDING

This study was funded by the Royal Government of Bhutan.

ACKNOWLEDGMENTS

We would like to thank Lobzang Dorji, Director of the Department of Forests and Park Services for administrative and funding support, and Sacha Dorji, Head Specialist of the Ugyen Wangchuck Institute for Conservation and Environmental Research for administrative and logistic support. This study was carried out as per the Annual Performance Agreement (for the financial year June 2019–July 2020) of the Department of Forests and Park Services (reference number UWICER/ADM-18/2019/Camp Thimphu dated 10/01/2019).

We also thank the Chief Forestry Officers of involved Territorial Forest Divisions and protected areas for assistance with data collection. We would like to specifically thank field data collectors, namely Tempa Nima and Sonam Rinzin, for assisting with data collection in Bumthang Dzongkhag and Trongsa Dzongkhag, respectively.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2021.691507/full#supplementary-material>

Supplementary File | Study Questionnaire.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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