Multiple factors influence local perceptions of snow leopards and Himalayan wolves in the central Himalayas, Nepal

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An understanding of local perceptions of carnivores is important for conservation and management planning. In the central Himalayas, Nepal, we interviewed 428 individuals from 85 settlements using a semi-structured questionnaire to quantitatively assess local perceptions and tolerance of snow leopards and wolves. We used generalized linear mixed effect models to assess influential factors, and found that tolerance of snow leopards was much higher than of wolves. Interestingly, having experienced livestock losses had a minor impact on perceptions of the carnivores. Occupation of the respondents had a strong effect on perceptions of snow leopards but not of wolves. Literacy and age had weak impacts on snow leopard perceptions, but the interaction among these terms showed a marked effect, i.e. being illiterate had a more marked negative impact among older respondents. Among the various factors affecting perceptions of wolves, numbers of livestock owned and gender were the most important predictors. People with larger livestock herds were more negative towards wolves. In terms of gender, males were more positive to wolves than females, but no such pattern was observed for snow leopards. People's negative perceptions towards wolves were also related to the remoteness of the villages. Factors affecting people's perceptions could not be generalized for the two species, and thus need to be addressed separately. We suggest future conservation projects and programs should prioritize remote settlements.

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2 **in the central Himalayas, Nepal.**

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16 **Abstract**

17 An understanding of local perceptions of carnivores is important for conservation and

18 management planning. In the central Himalayas, Nepal, we interviewed 428 individuals from 85

19 settlements using a semi-structured questionnaire to quantitatively assess local perceptions and

20 tolerance of snow leopards and wolves. We used generalized linear mixed effect models to

21 assess influential factors, and found that tolerance of snow leopards was much higher than of

22 wolves. Interestingly, having experienced livestock losses had a minor impact on perceptions of

23 the carnivores. Occupation of the respondents had a strong effect on perceptions of snow

24 leopards but not of wolves. Literacy and age had weak impacts on snow leopard perceptions, but

25 the interaction among these terms showed a marked effect, i.e. being illiterate had a more marked

26 negative impact among older respondents. Among the various factors affecting perceptions of

27 wolves, numbers of livestock owned and gender were the most important predictors. People with

28 larger livestock herds were more negative towards wolves. In terms of gender, males were more

29 positive to wolves than females, but no such pattern was observed for snow leopards. People's

30 negative perceptions towards wolves were also related to the remoteness of the villages. Factors

31 affecting people's perceptions could not be generalized for the two species, and thus need to be

32 addressed separately. We suggest future conservation projects and programs should prioritize

33 remote settlements.

35 **Keywords:** *Panthera uncia, Canis lupus chanco*, perceptions, large carnivores, trans-Himalayas.

37 **INTRODUCTION**

38 Large carnivore co-existence with humans remains a global challenge (Athreya et al., 2013), and

39 mitigation of human-carnivore conflicts requires multiple approaches and disciplines (Redpath et

40 al., 2013). Among the various aspects of carnivore conflict management, understanding local

41 perceptions is crucial for establishing long term conservation strategies (Bagchi & Mishra, 2006;

42 Conforti & Azevedo, 2003), especially in multi-use landscapes where animal husbandry is the

43 main source of income. An assessment of local perceptions helps in identifying groups of people

44 or villages that are negative towards protection of carnivores, and thus aids conservation

45 authorities to find suitable strategies to improve their tolerance (Suryawanshi, 2013; Treves &

46 Karanth, 2003). Further, assessments form a basis for quantifying the effects of conservation

47 management interventions and aid in formulating new strategies if opinions towards

48 conservation change (Dressel, Sandström & Ericsson, 2015).

49

50 Globally, local perceptions and attitudes towards large carnivores are complex and vary

51 markedly between regions (Røskaft et al., 2007). Multiple factors influence local perceptions,

52 including animal behavior, risk of negative encounters, and the length of the period of co-

53 existence (Dickman, 2010; Dressel, Sandström & Ericsson, 2015; Kellert et al., 1996;

54 Zimmermann, Wabakken & Dötterer, 2001). Local perceptions also vary among ethnic groups,

55 and are linked to religious- and cultural beliefs (Ale, Shah & Jackson, 2016; Dickman et al.,

56 2014; Kellert et al., 1996; Li et al., 2013; Mkonyi et al., 2017). Socio-demographic variables

57 such as age, sex, income, occupation, literacy, number of livestock owned and loss to predators

58 have all shown to be associated with local perceptions and attitudes of large carnivores (Caruso

59   et al., 2020; Fort et al., 2018; Kellert & Berry, 1987; Kideghesho et al., 2007; Naughton-Treves,

60   Grossberg & Treves, 2003; Oli, Taylor & Rogers, 1994; Røskaft et al., 2007; Trajçe et al., 2019).

61

62   In the central Himalayas, Snow leopards (*Panthera uncia*) and Himalayan wolves (*Canis lupus*

63   *chanco*) are the two most important predators involved in conflicts with people (Chetri et al.,

64   2019a). A recent study from the region revealed that snow leopards were responsible for the

65   majority of predation losses (61.9%); the remaining were from Himalayan wolf (16.8%) and

66   other predators (21.3%) including feral dogs (*Canis lupus familiaris*), brown bear (*Ursus arctos*),

67   black bear (*Ursus thibetanus*), Eurasian lynx (*Lynx lynx*), golden jackal (*Canis aureus*) and

68   common leopard (*Panthera pardus*) (Chetri et al., 2019a). The snow leopard is categorized as

69   Vulnerable in the IUCN red list of threatened species (McCarthy et al., 2017), whereas wolf is

70   considered as Least Concern (Boitani, Phillips & Jhala, 2018). However, in the national Red

71   Data List of Nepal, wolves are considered as Critically Endangered and snow leopards are

72   considered as Endangered (Jnawali et al., 2011). A recent fecal DNA study reported that the

73   snow leopard density within our study area in the central Himalayas was 0.95 (SE 0.19) animals

74   per 100 km^2 (Chetri et al., 2019b), but density estimates of wolves from the area are still lacking

75   (WWF, 2015; Chetri et al., 2016; Chetri, Odden & Wegge, 2017). The species has received little

76   conservation attention due to its lower conservation status in the IUCN Red list, which has made

77   it difficult to acquire necessary funding for population monitoring. According to Chetri (2014),

78   Himalayan wolves are rare in the region and mostly solitary. The wolves that thrive in this

79   landscape are genetically unique to the region as revealed by recent DNA analysis, and they are

80   considered different from the grey wolf lineage (Chetri et al., 2016). Both species range widely

81   and often encounter pastoralists.

82

83   Although information on livestock depredation by snow leopards and wolves exists from Nepal's

84   Himalaya (Aryal et al., 2014; Chetri, Odden & Wegge, 2017 ; Chetri et al., 2019a; Oli, Taylor &

85   Rogers, 1994; Wegge, Shrestha & Flagstad, 2012; Werhahn et al., 2019), limited information is

86   available regarding variation in local perceptions and tolerance to these species on a large spatial

87   scale (Hanson et al., 2019; Kusi et al., 2019; Oli, Taylor & Rogers 1994). Hence, in our study,

88   we examined local communities' perceptions of snow leopards and wolves in a large area of

89   ~5000 km^2 where livestock depredation has been a main concern in recent decades. The survey

90   covered two protected areas, Annapurna Conservation Area (ACA, hereafter) and Manaslu

91   Conservation Area (MCA, hereafter), where ecological studies of snow leopard and wolf had

92   recently been conducted (Chetri, 2018). These studies showed that snow leopard density was far

93   lower than previously assumed, and consequently, average annual livestock losses were low

94   (ca.1%) even though livestock constituted large proportions of the diet of both snow leopards

95   and wolves (ca.25%). Despite the low levels of livestock depredation, perceptions of wolves are

96   often negative. Similarly, incidents of mass killings of livestock by snow leopards decreases

97   local tolerance towards their conservation, which in turn may lead to retaliatory killing of

98   carnivores (Jackson, 2015; Mishra, Redpath & Suryawanshi, 2016; Mishra et al., 2004;

99   Suryawanshi et al., 2014; Woodroffe et al., 2005). Surplus killings and injuries of high valued

100   livestock (e.g. horses, milking yaks and cows) not only outrage local communities (Oli, Taylor &

101   Rogers, 1994), but also have negative repercussion that can spread even to distant villages.

102

103   Integrated conservation and development efforts that were initiated in ACA and MCA in the

104   1990-ies included conservation awareness campaigns principally targeting snow leopard, but not

105 wolves. Due to the relatively low livestock losses and the considerable conservation efforts in the

106 study area, we expected perceptions of carnivores to be more positive than reported from

107 previous studies from the Himalayan range. Furthermore, we expected perceptions to vary

108 geographically as well as between species due to a bias in the impact of conservation awareness

109 campaigns, i.e. tolerance of wolves should be lower, and perceptions could potentially depend on

110 the remoteness of villages. Lastly, we expected perceptions to be affected by socioeconomic and

111 demographic factors, e.g. livestock losses and ownership, gender, age, education and occupation.

112

113 **MATERIAL AND METHODS**

114 **Ethics statement**

115 Approval and relevant permits required to carry out this research were obtained from the

116 National Trust for Nature Conservation (Ref.no.291), Nepal.

117 **Study area**

118 We conducted the study in the Annapurna – Manaslu Conservation landscape in the central

119 Himalayas (N28 – 29°, E83 – 85°; Fig.1). Both ACA and MCA are located within this landscape

120 and are the largest community-based conservation areas in Nepal (ca.9292 km^2). It is located in

121 the rain shadow area of the Himalayas. Together with Bhimthang valley, it is the priority

122 landscape for snow leopards conservation in the country (DNPWC, 2017). The human

123 population density is 1 per km^2 (CBS, 2012), and agro-pastoralism is the main source of

124 livelihood, although some households are also involved in eco-tourism related entrepreneurs.

125 The overall livestock density in the study area is 35.74 ± 0.10/km^2 (Chetri, Odden & Wegge,

126 2017). All accessible areas are used for livestock grazing following the seasonal traditional

127 Tibetan calendar (Chetri et al., 2019a). Grazing areas are designated for seasonal grazing as

128   summer and winter. Areas close to villages are used for year-round grazing (Fig. 1). Livestock,

129   for example sheep, goats and cows are usually herded and periodically moved among different

130   pastures according to seasons (Chetri, Odden & Wegge, 2017). Small stocks (sheep and goats)

131   are herded and sometimes accompanied by herding dogs. They are released in the morning and

132   brought back to corrals/pens in the afternoon on a regular basis. Similarly, milking cows and,

133   yaks are brought back to corrals/pens in the afternoon or in the morning for milking. Livestock

134   are kept in corrals/pens for protection against predators corrals are traditionally made of mud

135   walls and stones.

136

137   Over the last decade there have been considerable changes in the lifestyle of the local people due

138   to the development of roads in ACA. Despite these changes, traditional agro-pastoral lifestyles

139   remain intact, and most importantly, traditional livestock grazing and collective village level

140   decision making and implementation is still functional. In ACA, most farmers prefer to raise

141   goats (*Capra hircus*) and sheep (*Ovis aries*) due to abundant pastureland, whereas in MCA

142   farmers prefer cattle-yak hybrids (dzo, Jhopas, *Bos* spp.) as they are both grazers and browsers.

143   Similarly, in the central part of ACA, farmers prefer yaks (*Bos grunniens*) due to dominant scrub

144   vegetation. Lulu cows (*Bos taurus* sp.) and horses (*Equus ferus caballus*) are common in all

145   areas. Among the main wild ungulates, bharal (*Pseudois nayaur*) and Himalayan tahr

146   (*Hemitragus jemlahicus*) are widespread, whereas Tibetan argali (*Ovis ammon hogdsoni*), kiang

147   (*Equus kiang*), and Tibetan gazelle (*Procapra picticaudata*) have overlapping grazing areas with

148   livestock in the north-western parts of ACA.

149

150   Apart from snow leopards and wolves, other carnivores include golden jackal, red fox (*Vulpes*

151   *vulpes*), Himalayan black bear, Tibetan sand fox (*Vulpes ferrilata*), brown bear, Eurasian lynx

152   and several species of weasel (*Mustela* spp.), and marten (*Martes* spp.).

153   **Figure 1: Study area with location of survey villages and grazing areas.**

154

155   **Semi-structured questionnaire survey**

156   To assess local perceptions and tolerance towards snow leopards and wolves, we administered a

157   semi-structured questionnaire (see supplemental materials for questionnaire structure, Appendix

158   S1). We randomly selected 428 households scattered over 85 settlements within 21 Village

159   Development Committee (VDC) units from July to September 2014. A VDC is the lowest rural

160   administrative unit and usually encompasses 7-9 small clustered villages or settlements know as

161   a ward. Recently, with the promulgation of the new constitution, the Nepal government dissolved

162   the VDC structure and established a new local body known as gaun palika or rural municipality.

163   But in this study we will use VDC as the data was collected prior to this change.

164   Each VDC has separate designated grazing areas. Among the 21 VDCs in the study area (6621

165   km^2), 2934 km^2 (44.3%) was used for livestock grazing (summer 55.6%, winter 24.6% and

166   19.8% year-round). The remaining areas (ca.3687 km^2) were inaccessible for livestock grazing

167   due to rugged terrain and high altitude (Fig. 1). Our survey covered 13% of the total number of

168   households within the survey villages (CBS, 2012). Due to scattered settlements/villages, vast

169   landscape and remoteness of the area, most of the questionnaires were conducted using locally

170   trained community members, managed through the Unit Conservation Offices (UCOs) of ACA

171   and MCA (Chetri et al., 2019a). Before the initiation of the survey, each interviewer was briefed

172   about the purpose of the study and trained in how to conduct the semi-structured questionnaire,

173   and verbal consent was obtained from all subjects. The survey households were selected

174   following the main village trails. We approached the household closest to the main village trail

175   and selected every third household thereafter for interviews. If the inhabitants were absent, we

176   selected the nearest neighbor. For each respondent, we recorded the number of livestock owned,

177   herd composition and livestock loss to snow leopards and wolves during the previous year. We

178   also recorded respondent age, gender, education and occupation. We asked their opinion about

179   the presence of snow leopards and wolves near their grazing areas and homesteads, and

180   categorized their answers as positive, neutral and negative. We considered questionnaires as

181   invalid when respondents stated that they did not know about the species presence and conflict

182   (i.e., neutral responses). These questionnaires were excluded from the analyses. Hence, although

183   we administered similar questionnaire sets to assess perceptions of snow leopards and wolves,

184   the sample size for wolf perceptions became smaller due to a larger proportion of invalid

185   questionnaires (Table 1). This was mainly because wolves are found only in the northwestern

186   section of ACA and MCA (see Fig. 1).

187   **Data analysis**

188   We used generalized linear mixed effects models (GLMMs) to determine the relationship

189   between response and potential predictor variables with two separate sets of models, one for

190   snow leopards and one for wolves. GLMMs take into account random effects and provide a more

191   flexible approach for analyzing non-normal data (Bolker et al., 2009). As a binomial response

192   variable, we categorized opinions of presence of snow leopards and wolves as either positive or

193   negative, as described previously. As explanatory variables, we included factors and covariates

194   that were identified as important predictors of livestock losses in a previous study conducted in

195   the region (Chetri et al., 2019a), as well as demographic and socioeconomic variables that have

196 been linked to perceptions of carnivores in previous studies (see e.g. Caruso et al., 2020; Kellert

197 & Berry, 1987; Kusi et al., 2019; Oli, Taylor & Rogers 1994; Suryawanshi et al., 2014): (i)

198 Ownership (number of livestock owned), (ii) herd composition (proportion of large stock relative

199 to all livestock owned, see Chetri et al., 2019a, (iii) number of livestock lost to snow leopards or

200 wolves, (iv) occupation (agro-pastoral, livestock herding, and others, i.e. respondents benefitting

201 from tourism, such as traders, hotel owners, tourist guides and porters), (v) literacy (ability to

202 read and write), (vi) gender, (vii) age, and (viii) distance to the nearest conservation office

203 (number of walking days required to reach nearest conservation field office - standardized to 8

204 hrs. walking/day). We did not include religion as a predictive factor as all the locals residing in

205 the region are Buddhist, only a few outsiders who are working as labor or teacher are non-

206 Buddhist. We standardized all numeric explanatory variables by two standard deviations,

207 following Gelman & Hill (2007). VDC was used as a random effect in all models. We checked

208 correlation among (continuous) predictors before carrying out the regression analysis, and we did

209 not include collinear variables (rho > 0.6) into the same model. We analyzed the data using R

210 version 3.4.2 (R CoreTeam, 2017).

211

212 **RESULTS**

213 We used only 395 and 327 questionnaires in our analyses regarding snow leopards and wolves,

214 respectively (Table 1), due to the exclusion of respondents that were neutral or unaware of

215 species presence or conflicts. In terms of gender, more than 80% of the respondents were male

216 (Table 1), and approximately 50% of the respondents were illiterate. Among occupations, most

217 respondents belonged to the agro-pastoralist category (Table 1). An analysis of respondents'

218   perceptions in general revealed that local people were more negative towards wolves (n=276,

219   84.4%) than towards snow leopards (n=209, 52.9%) (Table 1).

220

221   **Table 1: Overview of respondent characteristics in the Annapurna-Manaslu landscape,**

222   **central Himalayas, Nepal.**

223

224   **Local perceptions of snow leopards**

225   We compared 22 candidate models to assess perceptions of snow leopards (Table S1). The two

226   highest ranking models had a small difference in AICc value (ΔAICc = 0.27) and Akaike

227   weights (0.45 and 0.39). Both models included the predictor variables occupation, sex and the

228   interaction between age and literacy (Table 2). The top ranking model in terms of AICc also

229   included ownership, but due to the marginal effect of removing this variable, we present here the

230   simpler second ranking model (Fig. 2). The occupation of the respondents had a strong effect on

231   their perceptions of snow leopards. Among the three categories of occupation, there was only a

232   slight difference in perceptions between agro-pastoralists (income from both agriculture and

233   livestock) and herders (income solely from livestock herding). On the contrary, respondents with

234   other additional sources of income (e.g. tourism) were far more positive towards snow leopards

235   (i.e. OCCOTHER, Fig. 2). Furthermore, sex was included in the model, but the effect was weak,

236   i.e. men were more positive towards snow leopards than women. The main effects of literacy and

237   age had very weak impacts on perceptions, but the interaction between these terms showed a

238   marked effect. As illustrated in Fig. 2, being illiterate had a more marked negative impact among

239   the older respondents.

240   **Local perceptions of wolves**

241   We compared 24 candidate models to assess perceptions of wolves (Table S2). The highest

242   ranking model performed far better than the other candidates (Akaike weight = 0.70, Table 2).

243   This model included different predictors than the model for snow leopards, i.e. sex and

244   ownership (Fig. 3). In this case, male respondents were markedly more positive than females.

245   Other predictor variables were livestock loss (numbers lost to wolves), herd composition,

246   distance to the nearest conservation field office and livestock ownership. The latter predictor had

247   a marked effect on perceptions, i.e. respondents with larger herds were more negative.

248

249   **Table 2: Model selection for perception towards the snow leopard and the wolf.**

250

251   **Figure 2: Parameter estimates based on Generalized Linear Mixed-Effects Models of**

252   **factors affecting perceptions of snow leopards.**

253

254   **Figure 3: Parameter estimates based on Generalized Linear Mixed-Effects Models of**

255   **factors affecting perceptions to Himalayan wolves.**

256

257   **DISCUSSION**

258   In our study landscape, a far larger proportion of respondents were negative towards wolves than

259   to snow leopards. This was also observed by Kusi et al. (2019) in upper Dolpa and Humla areas,

260   located in the western region of Nepal. This perception is common in areas where wolves coexist

261   with other large predators, for example brown bear and lynx (Trajçe et al., 2019). A possible

262   cause is related to the difference in behavior of wolves compared to other carnivores. Snow

263   leopards are cryptic, avoid humans and are more nocturnal than wolves (McCarthy, Fuller &

264   Munkhtsog, 2005; Mech & Boitani, 2010). Wolves are more active during the day and attack

265   livestock both during day and night (Xu, Yang & Dou, 2015). Furthermore, research has shown

266   that greater visibility and howling behavior of wolves may reinforce negative perceptions

267   (Kellert et al., 1996).

268

269   Social norms and cultural beliefs also play an important role in perceptions of the two carnivores.

270   Cultural sentiments, religious belief and folklore associated with snow leopards have a strong

271   positive influence on their conservation (Ale, Shah & Jackson, 2016; Li et al., 2014). Further, the

272   local practice of non-violence (e.g. Tsum valley of MCA) and protection of forest and landscape

273   in the name of monasteries (Li et al., 2014) have also played an important role in snow leopard

274   conservation. The Buddhist communities to which most of our respondents belong traditionally

275   do not kill wildlife because it was considered a sin in their religion (Li et al., 2014). The snow

276   leopard is often considered as a symbol of the mountains, and the charisma of the species

277   promotes attention both in terms of research and conservation efforts from global and national

278   conservation authorities (McCarthy et al., 2016). In contrast, wolves are traditionally depicted as

279   merciless and evil creatures in legends and folklore (Dingwall, 2001; Marvin, 2012). A recent

280   study from Spiti, India showed that more than 98% of the survey respondents claimed that

281   wolves were not safe for livestock and their presence was highly disliked by the communities

282   (Lyngdoh & Habib, 2019). Similar trends have been observed in parts of Europe (Dingwall,

283   2001; Marvin, 2012) and America (Grima, Brainard & Fisher, 2019). This is not surprising as

284   dislike to wolves is common across the globe (Bhatia et al., 2016; Dressel, Sandström &

285   Ericsson, 2015; Kansky, Kidd & Knight, 2014; Kusi et al., 2019; Lyngdoh & Habib, 2019;

286   Suryawanshi et al., 2014). The negative perceptions of the wolf in our study area thus probably

287   due to fear and cultural bias as reported in many other studies (Linnell et al., 2002; Prokop, Usak

288   & Erdogan, 2011), an issue to be considered in future conservation plans in ACA and MCA.

289

290   In our study area, analysis of livestock depredation revealed higher losses from snow leopards

291   compared to wolves (Chetri et al., 2019a), but still the tolerance level of local communities

292   towards snow leopards was higher. Tolerance to snow leopards in ACA has changed to become

293   more positive compared with an earlier study (Oli, Taylor & Rogers, 1994), probably as a result

294   of continued efforts to increase awareness as part of an ongoing conservation program (DNPWC,

295   2017). No such efforts have targeted wolves, or other coexisting carnivores in this area.

296

297   Our model revealed that literacy, age, occupation, number of livestock owned and gender

298   affected perceptions towards snow leopards and wolves. However, the predictors for the two

299   species were different (see Fig. 2 and 3), i.e. the latter two appeared in the best model for wolf

300   perceptions and the former three for snow leopard. Regarding literacy and age, only the

301   interaction between these terms had an influence on perceptions of snow leopards, but not the

302   main effects. Being illiterate was associated with negative perceptions among older respondents.

303   Possibly, younger people had more exposure to snow leopard conservation campaigns,

304   regardless of literacy. Several earlier studies have shown that older people are more negative

305   towards large predators and usually less supportive of their conservation than the younger

306   generation (Bencin, Kioko & Kiffner, 2016; Kellert & Berry, 1987; Kleiven, Bjerke &

307   Kaltenborn, 2004; Røskaft et al., 2007; Williams, Ericsson & Heberlein, 2002).

308

309   Occupation influenced perceptions of snow leopards, i.e. people with sources of income other

310   than animal husbandry were more positive. Elsewhere, it was also reported that people having

311   smaller landholdings and few economic opportunities other than livestock herding are more

312   negative towards snow leopards and wolves (Bagchi & Mishra, 2006; Din et al., 2017). In a

313   study of jaguars (*Panthera onca*), Caruso et al. (2020) found a similar pattern; people's

314   perceptions and attitudes were strongly influenced by occupation and economic benefits through

315   ecotourism. In Ladakh, India snow leopard based ecotourism has become popular and provides

316   income generation opportunities to the local communities (Jackson, 2015; Maheshwari &

317   Sathyakumar, 2019; Vannelli et al., 2019).

318

319   Regarding perceptions of wolves, males were more positive than females. This pattern was also

320   reported in earlier studies (Kellert & Berry, 1987; Røskaft et al., 2007; Suryawanshi et al., 2014),

321   and has been explained by women having less contact with conservation agencies (Gillingham

322   & Lee, 1999). Another study suggested that the negative attitudes of women might be a result of

323   greater perception of risk or fear (Prokop & Fančovičová, 2010). As suggested by Kusi et al.

324   (2019), men in the Himalayas often migrate outside of villages for seasonal work and may thus

325   have been more exposed to alternative attitudes to nature and conservation. In addition, men

326   frequently venture into the pasture for livestock grazing activities and presumably had more

327   encounters with wolves, which make them understand their behaviour and threats. High

328   encounter rates with wolves either in the wild or in captivity, may promote more positive

329   perceptions of the animals (Arbieu et al., 2020).

330

331 People holding large livestock herds were more negative towards wolves, which agrees with a

332 study from western China (Xu, Yang & Dong, 2015). A possible explanation is that owners with

333 larger herds have a higher risk of suffering losses in the central Himalayas, especially farmers

334 having a larger herd of goat/sheep (Chetri, Odden & Wegge, 2017). It is, however, notable that

335 having experienced losses did not affect perceptions of snow leopards, and the effect of

336 perception on wolves was weak. This is in contrast with a recent study from the Nepal

337 Himalayas where livestock depredation by wolves is the main predictor of the negative attitude

338 towards wolves (Kusi et al., 2019). However, such a pattern was not recorded in our study area

339 and may be due to the fact that average losses in our study area were quite low (~1% of all

340 livestock holdings).

341

342 In our study area, the National Trust for Nature Conservation (NTNC) has been implementing

343 community-based conservation projects and programs since 1992. The overall goal is to

344 conserve biodiversity of global significance with the active participation of local communities.

345 Integrated conservation and development efforts have therefore addressed the communities'

346 needs and demands while actively mobilizing local people in conservation efforts. However,

347 even after 2-3 decades of conservation initiatives, local perceptions and tolerance towards

348 carnivores are still rather negative, particularly towards wolves. We therefore recommend a

349 wider perspective of future awareness campaigns to include a broader specter of species and

350 conservation issues with particular efforts to the Himalayan wolf. During interviews, we

351 observed that remote settlements had rarely been visited by conservation authorities, and the

352 inhabitants there had limited knowledge of compensation policies for livestock losses and human

353 injury. Local perceptions on wolves tended to be more negative with increasing distances from

354   conservation field offices, and this has been reported in earlier research in parts of ACA (Oli,

355   Taylor & Rogers, 1994). The factors underlying negative perceptions of distant settlements are

356   probably due to a limited local involvement in community conservation programs. In the future,

357   distant and remote settlements require more rigorous conservation outreach and awareness

358   activities.

359

360   **CONCLUSIONS**

361   This study has investigated local villagers' perception of snow leopards and wolves in the central

362   Himalayas, Nepal. In general, the perceptions of locals were more positive towards snow

363   leopards than to wolves. People having larger herds of livestock (goat/sheep) with limited access

364   to conservation programs were more likely to have negative perceptions towards wolves. Our

365   results showed that multiple factors influence local perceptions of the two carnivores and that

366   perception factors cannot be generalized for the two species. Thus, they need to be addressed

367   separately. We suggest that future conservation projects and programs prioritize remote

368   settlements. Furthermore, considering the substantial influence of occupation on people's

369   perceptions of carnivores, certain parts of the landscape, for example Manang of ACA and Tsum

370   valley of MCA, should be tested for the development of wildlife based ecotourism.

371

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588

Figure 1

Study area with location of survey villages and grazing areas.
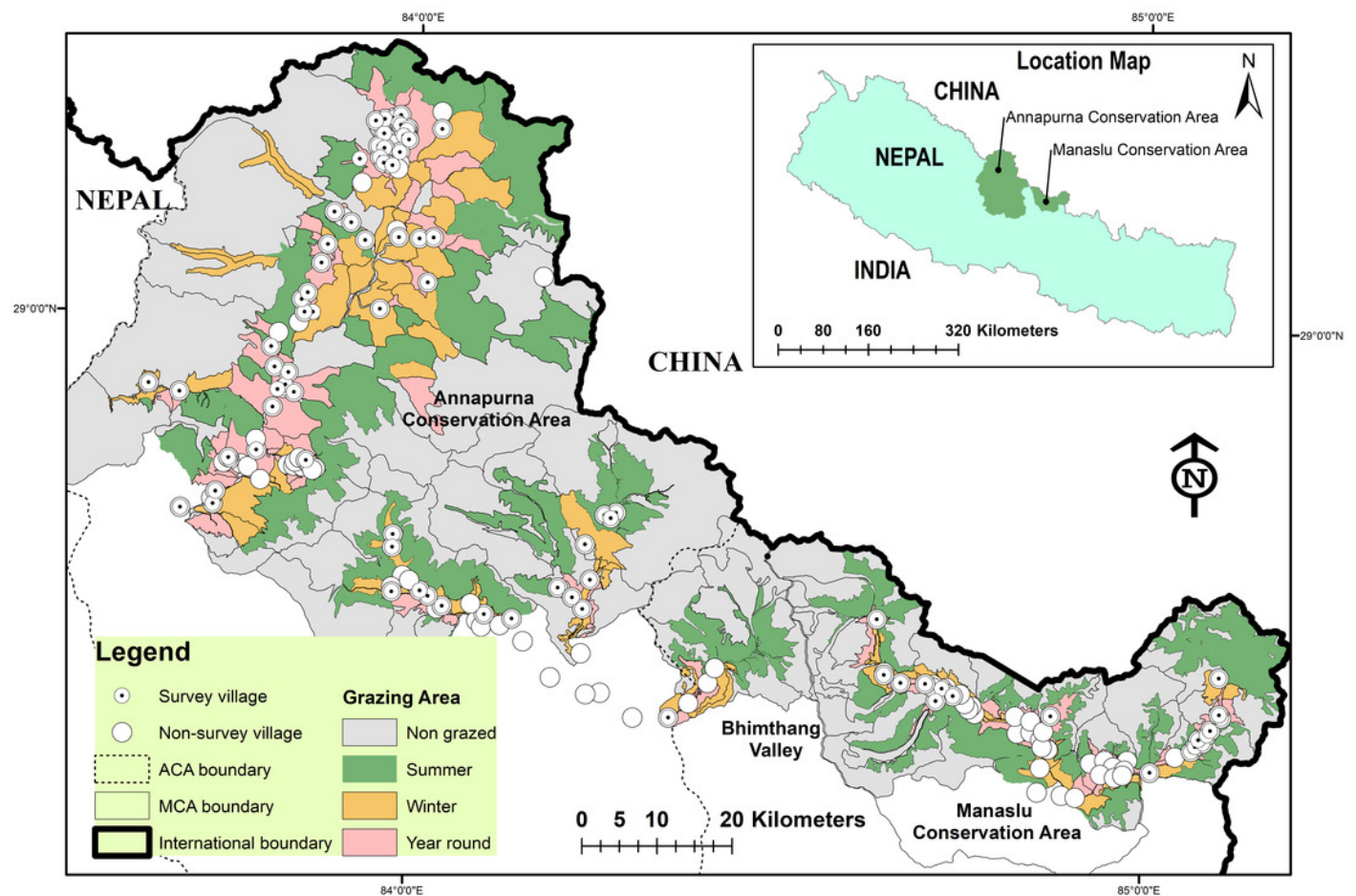
Figure 2

Figure 2 Parameter estimates based on Generalized Linear Mixed-Effects Models of factors affecting perceptions of snow leopards.

Dots and solid lines represent parameter estimates and 95% CI. The estimates are on the logit scale. The strength of the effect of parameters is indicated by the distances between the solid horizontal lines and the dotted vertical line. VDC (Village Development Committee) is included as a random effect. OCCOTHER=Occupation-Others, LITyes= Literate (read and write), OCCHERD= Occupation-Herding, SEXM=Male, OWN=Total livestock holding, AGE=Age of the respondent, AGE:LITyes= the interaction between the respondent's age (AGE) and literacy (LITyes).
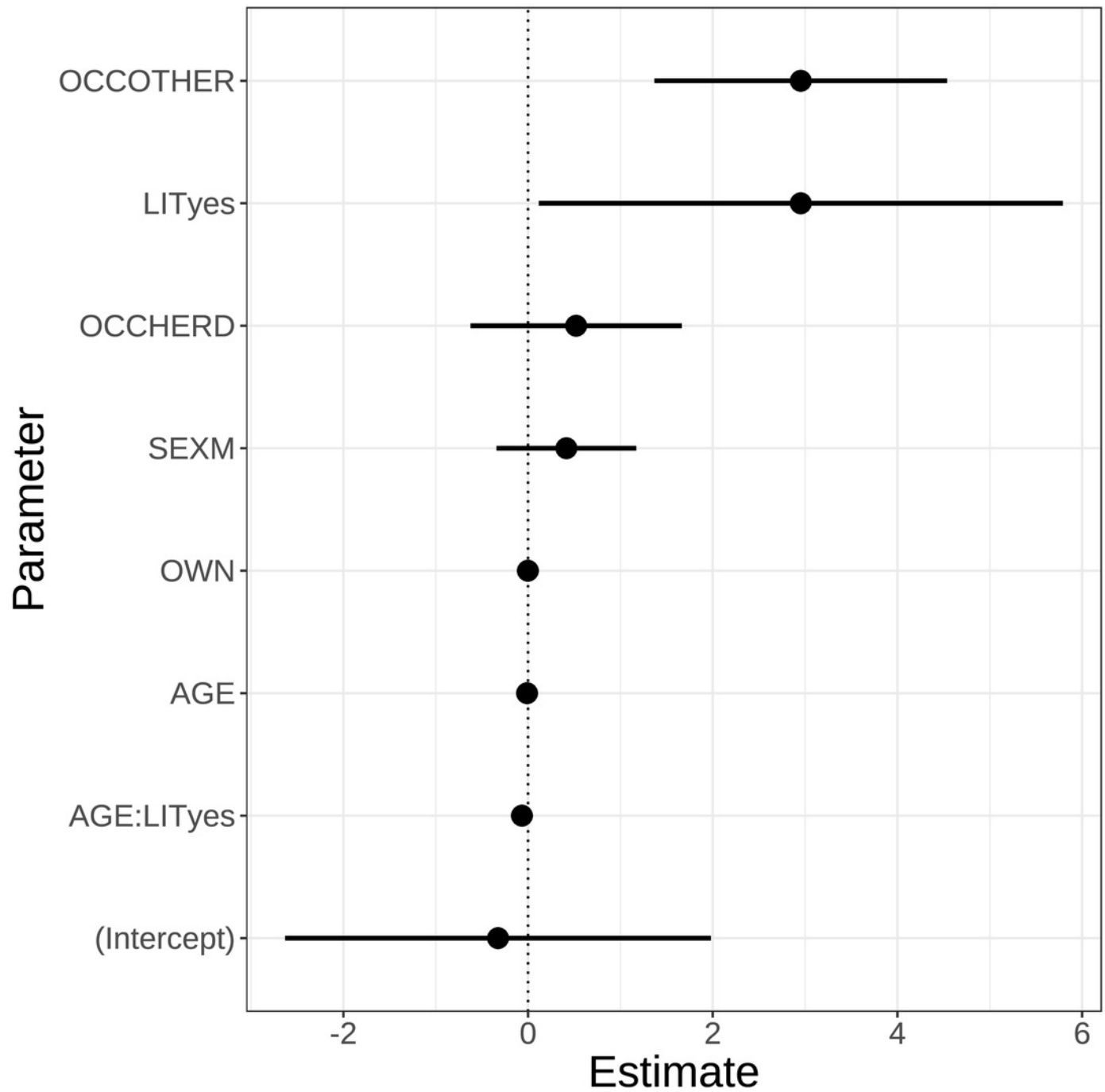
Figure 3

Figure 3 Parameter estimates based on Generalized Linear Mixed-Effects Models of factors affecting perceptions to Himalayan wolves.

Dots and solid lines represent parameter estimates and 95% CI. The estimates are on the logit scale. The strength of the effect of parameters is indicated by the distances between the solid horizontal lines and the dotted vertical line. VDC (Village Development Committee) is included as a random effect. SEXM=Male, LOSS=Total livestock loss, COMP=Proportion of large livestock, DIST=Distance from the nearest conservation field office to respondent household, OWN=Total livestock holding.
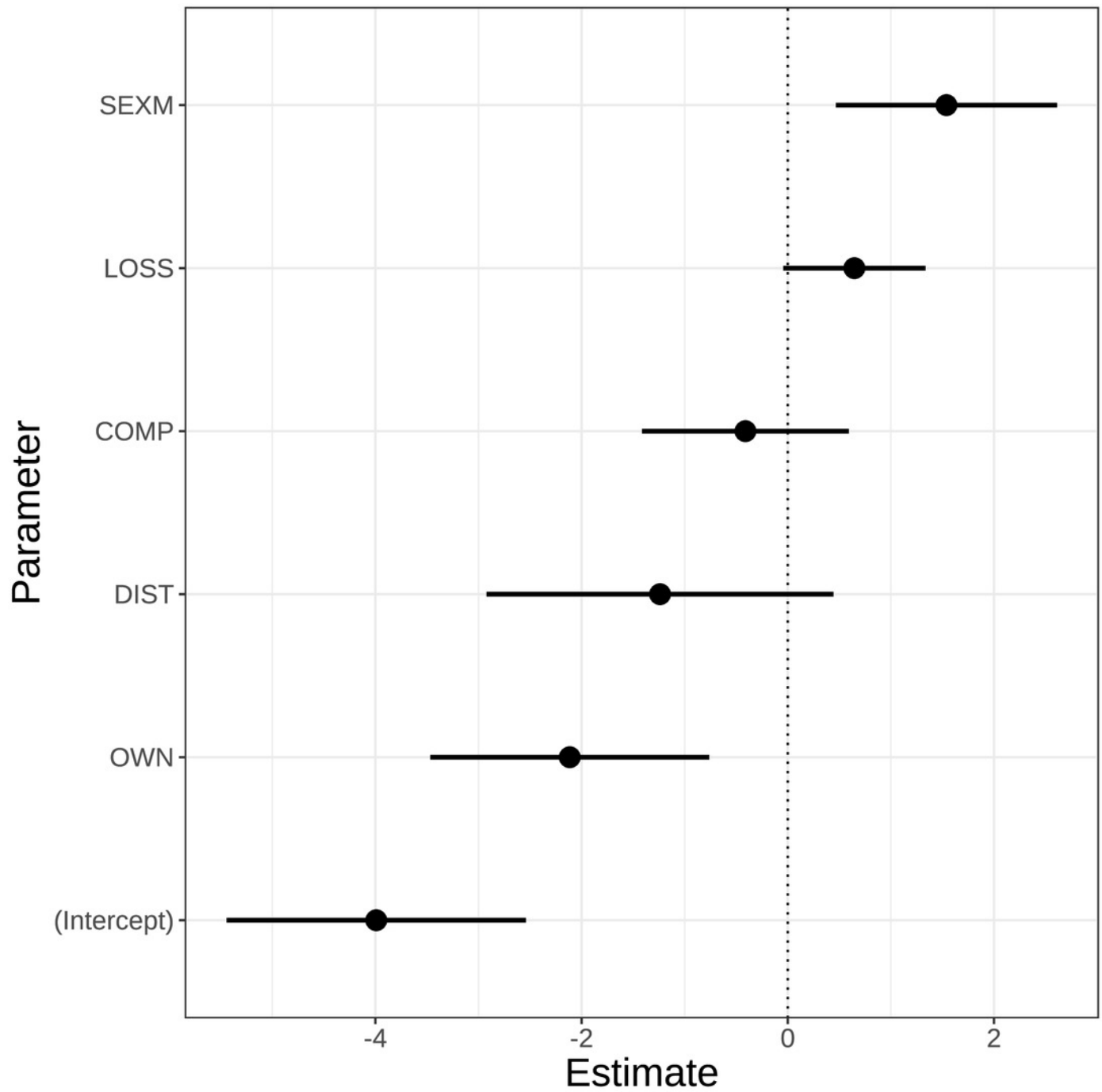
Table 1 Overview of respondent characteristics in the Annapurna-Manaslu landscape, central Himalayas, Nepal.

Only respondents that responded to perceptions and share their experiences were included. Number in parenthesis indicates percentage of individual respondents in each category. ACA, Annapurna Conservation Area; MCA, Manaslu Conservation Area.

1 **Table 1: Overview of respondent characteristics in the Annapurna-Manaslu landscape,**

2 **central Himalayas, Nepal.**

		Snow leopards	Wolves
Number of questionnaires		428	428
Number of included/valid questionnaires		395 (92.3)	327 (76.4)
Number of invalid/excluded questionnaires		33 (7.7)	101 (23.6)
Village Development Committee (VDC)		21	14
Respondent age range (years)		20-87	20-87
Mean age (years)		46	46
Region	ACA	353 (89.4)	296 (90.5)
	MCA	42 (10.6)	31 (9.5)
Gender	Male	331 (83.8)	270 (82.6)
	Female	64 (16.2)	57 (17.4)
Education	Literate	213 (53.9)	180 (55.0)
	Illiterate	182 (46.1)	147 (45.0)
Occupation	Agro-pastoralist	341 (86.3)	291 (89.0)
	Livestock herding	30 (7.6)	13 (4.0)
	Others	24 (6.1)	23 (7.0)
Perceptions	Positive	186 (47.1)	51 (15.6)
	Negative	209 (52.9)	276 (84.4)

3 **Notes.**

4 Only respondents that responded to perceptions and share their experiences were included.

5 Number in parenthesis indicates percentage of individual respondents in each category.

6   ACA (hereafter), Annapurna Conservation Area.

7   MCA (hereafter), Manaslu Conservation Area.

Table 2 Model selection for perception towards the snow leopard and the wolf.

All continuous variables were standardized by 2 standard deviations (as per Gelman and Hill, 2007) and all models included a varying intercept on VDC (Village Development Committee). VDC is included as a random effect. AGE: age of the respondent, COMP: composition of the herd, i.e. proportion of large stock animals, LIT: literacy (yes / no), LOSS: number of domestic animals lost to the carnivore, OCC: respondent's occupation (Herding, Agriculture, Other), OWN: number of domestic animals owned, SEX: gender of the respondent. DIST=Distance from the nearest conservation field office to respondent household. Only the top 10 models are presented for each analysis.

1 **Table 2: Model selection for perception towards the snow leopard and the wolf.**

Model	df	logLik	AICc	delta	weight
Snow Leopard					
OWN + OCC + SEX + AGE * LIT	9	-233.24	484.9	0	0.45
OCC + SEX + AGE * LIT	8	-234.42	485.2	0.27	0.39
COMP * LOSS + OWN + OCC + SEX + AGE * LIT	12	-231.64	488.1	3.15	0.09
COMP * LOSS + OCC + SEX + AGE * LIT	11	-233.63	490	5.02	0.04
COMP * LOSS + OWN + OCC + SEX + AGE	10	-234.74	490	5.11	0.04
OCC	4	-245.06	498.2	13.28	0
COMP * LOSS + OWN + OCC	8	-241.52	499.4	14.47	0
COMP * LOSS + OWN + OCC + SEX	9	-240.97	500.4	15.46	0
AGE	3	-247.76	501.6	16.64	0
LIT	3	-251.48	509	24.08	0
Wolf					
COMP + DIST + LOSS + SEX + OWN	7	-104.38	223.1	0	0.7
COMP * LOSS + OWN + OCC + SEX	9	-104.88	228.3	5.22	0.05
SEX	3	-111.33	228.7	5.62	0.04
OWN	3	-111.63	229.3	6.22	0.03
COMP + LOSS + OWN	5	-109.59	229.4	6.26	0.03
COMP + LOSS + OWN + DIST	6	-108.75	229.8	6.65	0.03

COMP * LOSS + OWN + OCC + SEX + AGE	10	-104.86	230.4	7.31	0.02
OWN + OCC + SEX + AGE * LIT	9	-106.05	230.7	7.56	0.02
COMP + LOSS * OWN	6	-109.26	230.8	7.67	0.02
COMP * LOSS + OWN + LIT	7	-108.3	230.9	7.83	0.01

2 **Notes.**

3 All continuous variables were standardized by 2 standard deviations (as per Gelman and Hill,

4 2007) and all models included a varying intercept on VDC (Village Development Committee).

5 VDC is included as a random effect. AGE: age of the respondent, COMP: composition of the

6 herd, i.e. proportion of large stock animals, LIT: literacy (yes / no), LOSS: number of domestic

7 animals lost to the carnivore, OCC: respondent's occupation (Herding, Agriculture, Other),

8 OWN: number of domestic animals owned, SEX: gender of the respondent. DIST=Distance from

9 the nearest conservation field office to respondent household. Only the top 10 models are

10 presented for each analysis.