Local villagers' perceptions of wolves in Jiuzhaigou County, western China

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While there have been increasing numbers of reports of human-wolf conflict in China during recent years, little is known about the nature of this conflict. In this study, we used questionnaires and semi-structured interviews to investigate local villagers' perceptions of wolves in Jiuzhaigou County, western China. We sampled nine villages with more frequent reports of wolf depredation to the local government, but included three villages near alpine pastures in which reports of depredation were less frequent. We sampled 100 residents, a subset of the local population who were more likely to have had experience with wolves. During the preceding three years, most families of the respondents grazed livestock on alpine pastures, and most of them reported that their livestock suffered from depredation by wolves. The mean value of the reported annual livestock loss rates was considerably higher in villages that reported depredation more frequently than in those with less frequent reports of depredation. Most respondents in the more frequently depredated villages perceived an increase in wolf populations, whereas many in the less frequently depredated villages perceived a decrease in wolf populations in their areas. People's attitudes towards wolves did not differ significantly between these two village categories. The majority of the respondents were negative in their attitude to wolves, despite a prevalent Tibetan culture that favors the protection of wildlife. People's negative attitude was directly related to the number of livestock owned by their family. Those with a larger number of livestock were more likely to have a negative attitude towards wolves. Factors such as village category, ethnicity, age and education level did not influence people's attitudes to wolves. We suggest that improved guarding of livestock and provision of monetary support on human resources and infrastructure may mitigate human-wolf conflicts in this region.

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14 Introduction

15 Conflicts between wolves and humans are common worldwide, because of human fear of wolves and

16 in particular, financial loss due specifically to injury to and loss of livestock that wolves cause (Mech

17 & Boitani 2003; Treves & Karanth 2003; Bisi et al. 2007). As wolf populations expand or humans

18 encroach on their habitats, economic losses to wolves increase and conflicts have become increasingly

19 likely, presenting unique challenges for the conservation and management of wolves (Mech & Boitani

20 2003; Naughton-Treves, Grossberg & Treves 2003; Bisi et al. 2007; Lescureux & Linnell 2013).

21   To conserve wolves, many researchers have conducted studies aimed at understanding the

22 conflicts. Managers need to know the perceptions and attitude of local people to wolves and their

23 conservation programs. In particular, by determining which people are more negative towards wolves,

24 managers are potentially able to find solutions to improving people's tolerance towards wolves (Treves

25 & Karanth 2003; Suryawanshi et al. 2013). It has been pointed out that people's attitude depends

26 mainly on their residence, age, gender, education and income level, and former experience with wolves

27 (for a review of 38 surveys see Williams, Ericsson & Heberlein 2002; Ericsson & Heberlein 2003;

28 Naughton-Treves, Grossberg & Treves 2003; Røskaft et al. 2007; Skogen & Thrane 2007). Yet, it is

29 hard to find a widely accepted management policy, because of regional variation and different factors

30 affecting attitudes (Bjerke, Reitan & Kellert 1998; Bisi et al. 2007). Given this, one has to learn more

31 about the characteristics of human-wolf conflicts and human attitudes towards wolves, especially for

32 regions where conflicts have been reported frequently but available knowledge is very scarce.

33   China has a large wolf population which is mainly distributed in areas with relatively few

34 anthropogenic changes, in the Qinghai–Tibet Plateau, the Mongolia Plateau and the Northeast Plain. In

35 1998, the number of wolves in China was estimated as about 6,000 individuals (Wang 1998, Yang

36 2008). In this year, wolves were listed as a vulnerable species in the China Red List (Wang 1998), and

37 since then, all hunting has been banned for this legally protected animal. In 2003, China was estimated

38   to have a population of as many as 12,500 individuals (Mech & Boitani 2003). We are not aware of

39   any more recent estimates, although the number is likely to have increased substantially in recent years.

40   In recent years in China, there have been increasing reports of injury and loss wolves caused especially

41   to livestock, resulting in increase in human-wolf conflicts (Yang 2008; Zhang et al. 2010; CNC 2012;

42   Li et al. 2013; ScienceNet 2013). Yet, the published literature on this topic is scarce. There have not

43   been any national policies relating to wolves other than some with indirect implications such as

44   auctions of licenses for hunting wild animals (BBC News, 2006) and eco-compensation to mitigate

45   human-wildlife conflicts (Xinhuanet 2014; Yunnan.cn 2014).

46   In this study, we examined local villagers' perceptions of wolves in Jiuzhaigou County, where

47   wolf depredation on livestock has been reported increasingly and the local government is considering

48   management plans for wolves. We aimed to determine wolf population trends, since there have been no

49   data available on the wolf populations in this area. Furthermore, we aimed to determine the level of

50   livestock depredation caused by wolves, and then how people's attitude toward wolves was related to

51   socioeconomic variables, specifically religious belief (e.g., Liu et al. 2011) and livestock ownership

52   (e.g., Tuğ 2005), which are poorly understood.

53

54   Methods

55   Ethics statement

56   The study conformed to the Declaration of Helsinki, and the Ethics Committee of Pingdingshan

57   University approved the research protocol (Ref: 2012003). Verbal informed consent was obtained from

58   all the subjects prior to participation.

59   Study area

60   We conducted the study in Jiuzhaigou County (N 32°53'–33°43', E 103°27'–104°26'; Fig. 1), Aba

61   Tibetan and Qiang Autonomous Prefecture of northwestern Sichuan Province, western China. The

62   county lies at the northeastern edge of Qinghai–Tibet Plateau and is famous for its Jiuzhai Valley

63   National Park and the traditional cultures of its inhabitants. The area is 5,290 km^2, with an elevation

64   ranging from 1,000 m to 4,500 m. The climate is subtropical to temperate monsoon with a mean annual

65   temperature of 12.7 °C. Total annual rainfall is 550 mm, with 80% of rainfall occurring between May

66   and October. The county comprises 17 townships and 120 villages, inhabited by Tibetan, Qiang, Hui,

67   Han and other ethnic groups. In 2011, the county's population was 66,246, with a minority population

68   (ethnic groups other than Han) of 25,090.

69   Jiuzhaigou County has 3,570 km^2 of forested lands (covering about 67% of the total area), and

70   is the second largest forest area in Sichuan Province. It is rich in alpine grasslands, especially in the

71   northern part, with an area of about 1,200 km^2 (Chen 2011). Livestock grazing occurs mainly in the

72   northern region. Yaks are the most common livestock species grazed, but there are a few sheep and

73   goats. Livestock are herded to alpine pastures except during extreme winter weather when they are

74   herded in the cropland around the villages or are stall-fed inside the villages. Livestock of each village

75   graze in exclusive pastures. Families take turns at herding the entire village's stock. Commonly, a

76   couple of people herd the livestock, with the use of one or two shepherd dogs occasionally. The

77   livestock are usually left to range freely on the daytime. At night, the herders bring them back to

78   protective corrals, which are poorly built with low walls and no roof.

79   Wolves are one of the most important animal species in the local ecosystems. Their large

80   natural prey species are ungulate animals including *Elaphodus cephalophus*, *Capreolus capreolus*,

81   *Capricornis sumatraensis*, *Naemorhedus goral*, and *Pseudois nayaur*; smaller prey include *Marmota*

82   *himalayana*, *Lepus oiostolus*, and *Ochotona thibetana* , and some Galliformes such as *Tetraogallus*

83   *tibetanus*, *Tetraophasis obscurus*, *Perdix hodgsoniae*, *Ithaginis cruentus*, *Pucrasia macrolopha*, and

84   *Chrysolophus pictus*. However, prey abundance is low (SPAFS 2004; SCUSLS 2011). In the area,

85   livestock depredation by wolves has been reported frequently in recent years, whereas there are few

86   reports on wolf attacks on humans. The local people reported that wolves usually traveled in groups,

87   and attacked livestock during both the day and night.

88   Fieldwork

89   We carried out the fieldwork in April and May 2012. Following advice from the local forestry bureau,

90   we conducted an interview survey in the northern region where many villages reported frequently

91   livestock depredation by wolves to the local government. We sampled nine villages with frequent

92   reports of depredation. For comparison, we also sampled three villages near alpine pastures in which

93   reports of depredation were less frequent (Fig. 1). The people we interviewed were those who were 16

94   years or older and who grazed their livestock, collected herbs or mushrooms, or carried out other

95   activities in forests and pastures, as they had a better knowledge of the population and activities of

96   wolves (Gros 1998). To foster a comfortable, non-intimidating information exchange process with

97   local residents, the interviews did not include any government staff, and we explained to local residents

98   that the interview was for scientific research purposes only (Kvale 1996).

99   During interviews, we used a semi-structured questionnaire to minimize the influence of the

100 questions on the response (Wengraf 2001). Interviews were performed orally with responses recorded

101 immediately post-interview into the standardized questionnaire. First, we recorded respondents'

102 personal characteristics, including ethnicity (a variable correlated with the religious belief system),

103 gender, age and education level (three levels: "illiterate", "elementary school", and "secondary and

104 above"). We did not ask their household incomes, because a pilot survey found it difficult to get the

105 true value from respondents. Second, we asked for information about livestock in the past three years,

106 including the annual number of livestock grazed by each family and the annual number of livestock

107 depredated by wolves. Third, we asked their opinions about wolf population trends in their areas over

108 the past 10 years ("increasing", "stable", and "decreasing"). Finally, we assessed their attitudes towards

109 wolves. We included three questions as proxy measures for attitude: (1) "What do you think of

110   wolves?"; (2) "What do you intend to do in response to livestock depredation by wolves?"; (3) "Do

111   you think that wolves should be protected? If a person thought wolves were bad and detrimental,

112   wanted to kill wolves who were attacking their livestock, and did not wish to protect wolves, we

113   considered that the person was negative towards wolves; if the opposite were the case, we considered

114   the person to have a positive attitude towards wolves. If a person had no strong opinion to the questions,

115   we considered the person to have a neutral attitude towards wolves. If the respondent showed a positive

116   attitude in response to some questions and a negative attitude in response to others, we defined this as a

117   mixed response.

118   Data analysis

119   We first calculated descriptive statistics of responses to analyze the basic information from the

120   interviews. We used to T-tests and Chi-squared tests of independence (Fisher's exact tests were

121   employed if any expected frequency was below 1 or more than 20% of expected frequencies were less

122   than 5) to compare differences of responses between two village categories, those with more frequent

123   reports of wolf depredation and those less frequent reports of wolf depredation.

124   Then, we examined how people's attitudes towards wolves were affected by variables of

125   personal characteristics (including ethnicity, age, and education level; gender was not included in the

126   analysis because of only a few respondents were women), and by variables relating to livestock (i.e.

127   annual number of livestock grazed and annual percentage of livestock depredated by wolves). We

128   included all villages but used village category as an additional prediction factor. We excluded one

129   sample with mixed opinion about our measures and pooled positive and neutral attitudes due to the

130   small number of responses in these categories. We also excluded two samples with missing values. We

131   conducted a binary logistic regression, where a totally negative attitude was scored as 1 while a

132   positive or neutral attitude was scored as 0. In the regression, annual percentage of livestock

133   depredated was considered 0 if there was no livestock grazed (note that this applied only to the

134   regression and not to the previous descriptive statistics). Categorical variables including village

135   category, ethnicity and education level were converted into a set of dichotomous, dummy-coded

136   variables. We set "villages with more frequent reports of wolf depredation" as the reference for village

137   category, "Tibetan" as the reference for ethnicity, and "illiterate" as the reference for education level.

138   We used the Akaike information criterion corrected for small sample size (AICc) to compare

139   statistical models constituting different combinations of variables. We calculated ΔAICc, which means

140   the difference between the model with the lowest AICc and the other models in the model set. The

141   model with the lowest AICc was considered as the best model, when ΔAICc between it and the next

142   best model was larger than two (Burnham & Anderson 2002). However, if there were some models

143   whose ΔAICc was ≤ 2 (which means that these models had equivalent support to explain the data), we

144   used a normal model averaging approach over all candidate models to get parameters and error

145   estimates (Burnham & Anderson 2002; Anderson 2008). We calculated the 95% confidence interval

146   (95% CI) of parameter estimate and the odds ratio (OR) of the effects for each variable. We also

147   estimated the relative importance (w_+) of a given variable by summing the Akaike weights of all

148   models containing the variable, and compared variables by examining the ratio of w_+. Variables were

149   considered as associated statistically with the response variable, when their 95% CIs excluded the zone

150   value (Grueber et al. 2011). All analyses were performed on R 3.0.0 (R Development Core Team,

151   2013).

152

153   Results

154   In total, we interviewed 100 residents, of which 81 belonged to villages that reported wolf depredation

155   more frequently, and 19 to villages with less frequent reports of depredation. The respondents'

156   personal characteristics did not differ significantly between the two village categories (Table 1).

157 Overall, they averaged 44 years of age, with 36% illiterate, 44% with elementary education, and 20%

158 with secondary or higher education. Half of the respondents were Tibetan, and the other half were Han.

159   During the preceding three years, most families of the respondents owned livestock that they

160 grazed on alpine pastures. Most of them reported that their livestock suffered from depredation by

161 wolves (Table 2). The two village categories we defined did not differ significantly in livestock

162 ownership and percent of families experiencing depredation; however, there was a trend toward higher

163 mean annual livestock loss rate in villages that reported depredation more frequently compared with

164 those with less frequent reports of depredation (Table 2).

165   Most respondents in the more frequently depredated villages perceived an increase in wolf

166 populations, whereas more than half of respondents in the less frequently depredated villages perceived

167 a decrease in wolf populations in their areas (Table 3). With respect to people' attitudes towards

168 wolves, there was no significant difference between the two village categories (Table 3). The majority

169 of the respondents were negative in their attitude to wolves. All the people who were negative towards

170 wolves mentioned that livestock loss caused by wolves was the main reason for their attitude.

171 Therefore, they wanted to kill wolves and did not wish to protect them. Only very few (3.6%, 3/84)

172 people talked about fear of wolves, and no one mentioned an event of wolves attacking humans.

173   We constructed 64 candidate logistic regression models with six variables, where we excluded

174 one sample with mixed opinion towards wolves and two samples with missing values, to predict

175 variation of people' attitudes towards wolves. As there were 13 models with ΔAICcs ≤ 2, we used a

176 model averaging approach to calculate estimates for variables. The results showed that the number of

177 livestock owned was the most important predictor, with the other five variables having lower relative

178 importance to it (Table 4). Only the number of livestock owned was statistically related to attitudes of

179 the respondents towards wolves, as its 95% CI of the parameter estimate excluded the zero value.

180 People with a more negative attitude towards wolves owned larger numbers of livestock, on average

181 (Fig. 2). For each additional animal owned, people were, on average, 1.032 times more likely to have a

182 negative attitude towards wolves (Table 4). Variation of attitudes towards wolves was not predicted by

183 village category, the percentage of livestock depredated by wolves and factors associated with personal

184 characteristics (i.e. ethnicity, age, and education level).

185

186 Discussion

187 Understanding the perceptions of local people living adjacent to wildlife habitats of wildlife-human

188 interactions is important in the conservation of large carnivores, because they are apt to provide

189 reliable information about wildlife (Treves & Karanth 2003; White et al. 2005). However, it is difficult

190 for the public to estimate wolf population sizes (Bjerke, Reitan & Kellert 1998). In this study, we

191 instead asked local people's opinions about wolf population trends. Similar studies have been

192 previously conducted on other large carnivores, for example the Asiatic black bear *Ursus thibetanus*

193 (Liu et al. 2011).

194  Most of the people we interviewed reported an increase in wolf populations in their areas in the

195 preceding 10 years. The apparent increase in abundance may reflect effective protection and population

196 recovery of the wolf in the wild since the prohibition of guns in 1996. This may have resulted in the

197 increased livestock depredation and human-wolf conflicts as reported. Increase in human-wolf conflict

198 may also be a result of human encroachment on wolves' natural habitats (Naughton-Treves, Grossberg

199 & Treves 2003) and ongoing degradation or loss of habitat (Yang 2008). In this case, wolves may more

200 frequently encounter and prey on livestock as their natural prey populations have declined.

201 Nevertheless, more than half of respondents in the less frequently depredated villages perceived a

202 decrease in wolf abundance in their areas. Insights that we have gained in these villages indicate that

203 some people illegally killed wolves in their areas. It should be noted that livestock losses were self-

204 reported in the interviews, and the reported magnitude of losses may differ from reality. It was hard to

205 verify the magnitude of these reported losses in the present study, and thus we suggest that additional

206 research is needed on this topic.

207   As reported by some previous studies in other regions (e.g., Ericsson & Heberlein 2003;

208 Naughton-Treves, Grossberg & Treves 2003; Tuğ 2005; Røskaft et al. 2007), the local population had

209 a negative attitude to wolves. Attitudes toward wolves are strongly driven by physical and behavioral

210 characteristics of wolves as well as by some cultural and historical associations such as human fear of

211 wolves (Kleiven, Bjerke & Kaltenborn 2004; Bisi et al. 2007; Suryawanshi et al. 2013). In our study,

212 the local people's explanation for negative attitude was livestock loss due to wolves, while very few

213 indicated fear of wolves. Despite widespread fear of wolves, attitudes may differ between areas and

214 groups as a result of different awareness of the biological characteristics of wolves, including

215 avoidance of humans (Bisi et al. 2007; Yang 2008).

216   However, our finding, that variation of attitudes was not explained by personal characteristics,

217 is inconsistent with previous studies in which people's attitudes towards wolves differed significantly

218 according to their age, education level and income (e.g., Ericsson & Heberlein 2003; Naughton-Treves,

219 Grossberg & Treves 2003; Tuğ 2005; Røskaft et al. 2007). We found that Tibetan people were as

220 negative as Han people, and this was not expected, as Tibetan groups, being Buddhist, find it easier to

221 accept the protection of wildlife than Han people who have no dominant religion (Eckel 1998). A

222 similar result was also reported by Liu et al. (2011) in the study on human-bear conflicts of western

223 Sichuan. It is possible that increase in conflicts between wolves and the local villagers at our study area

224 might have resulted in negative public opinion. We suspect, though, that Tibetan people would be less

225 likely to attack wolves in response to livestock loss or to engage in poaching, because of their belief

226 that killing wildlife could negatively affect their resurrection in the afterlife (Eckel 1998; Liu et al.

227 2011).

228   Little research has examined the potential links between attitude and variables concerning

229   livestock. This study revealed that people with relatively large numbers of livestock were more likely

230   to have a negative attitude towards wolves than those with smaller numbers of livestock. To our

231   knowledge, there is no previous literature that has reported this phenomenon. In addition, we did not

232   find that people who had lost a larger percentage of their livestock to wolf depredation showed a more

233   negative attitude to wolves, as concluded by some previous studies concerning the wolf conflicts

234   (Williams, Ericsson & Heberlein 2002; Ericsson & Heberlein 2003; Naughton-Treves, Grossberg &

235   Treves 2003; Tuğ 2005). We acknowledge that assigning zero predation to informants who had no

236   livestock would artificially reduce the predation intensity, thus may have affected the relationship

237   between livestock losses and attitude towards wolves. Unfortunately, because of small samples, we

238   cannot further test the effect of percent loss using only those informants who had livestock.

239   As an explanation, we suggest that the current finding might be associated with the fact that the

240   local people were impoverished and had seldom been compensated for their losses, while livestock

241   mortality by wolves was a relatively common occurrence. It is expected that people who grazed a

242   larger number of livestock and whose main source of income was from livestock, would be negative

243   towards anything that may cause loss of their livestock and threaten their income. Even if wolves had

244   not killed their livestock in the past, they would still have a negative attitude to wolves as they felt that

245   no one could guarantee the safety of their livestock in the future. In contrast, people with a smaller

246   number of livestock would expected to be neutral or positive in their attitude to wolves, as usually they

247   were able to obtain income from other sources and the economic benefits from livestock accounted

248   only for a small part of their incomes.

249

250   Management implications

251   To mitigate future human-wolf conflicts, we must reduce livestock losses of local people who

252   suffer from wolf depredation. In our study site and related areas, a large livestock group is herded

253   commonly by a couple of people. Younger people are not willing to take up this lifestyle. Furthermore,

254   existing corrals are poorly built. Ineffective guarding of livestock might have facilitated depredation by

255   wolves (Jackson 2000; Treves & Karanth 2003; Li et al. 2013). Therefore, we suggest that the best

256   approach at present should be to improve guarding of livestock in the context of local cultures and

257   conditions, for example, increasing the number of herders, developing expertise in herding, and

258   building wolf-proof corrals using local materials (see Namgail, Fox & Bhatnagar 2007).

259   Eco-compensation in mitigating human-wildlife conflicts has been increasingly emphasized by

260   the government in recent several years (Xinhuanet 2014; Yunnan.cn 2014). Public education on wolf

261   conservation has been conducted in our study area, but there has been no any provision of monetary

262   compensation for herders who lost livestock to wolves. The local forestry department mentioned many

263   obstacles, such as the difficulty of verifying the magnitude of livestock losses reported by local

264   villagers. As an alternative approach, we could invest these monies in human resources and

265   infrastructure, such as training herders and improving corrals. This will distribute the benefit equitably

266   (Namgail, Fox & Bhatnagar 2007). Furthermore, initiation of a livestock insurance program guided by

267   the government, a measure that has proved effective in the India's Trans-Himalayan region (Mishra et

268   al. 2003), is encouraged for a long-term management.

269   There are other alternatives such as relocation or limited removal of problem wolves (e.g.,

270   Mech & Boitani 2003; Treves & Karanth 2003; Bradley et al. 2005), and change of local livelihood

271   (e.g., Jackson 2000; Conforti & de Azevedo 2003; Li et al. 2013). The local government is considering

272   employing armed police to kill problem wolves. Although a reported increase in the wolf populations

273   and in livestock depredation by wolves in our study area, causal relationships between them are not

274   clear. In addition, there is no scientific information on wolf population sizes. Therefore, this measure

275 will require further data on wolf population sizes and their relations with livestock depredation. The

276 local government is also assisting herders to attempt to increase incomes from alternative sources, for

277 example eco-tourism and the cultivation of economically important alpine plants, aiming to reduce

278 their dependency on livestock. Two of the 12 villages we interviewed seemed to have been moving

279 toward a more positive attitude towards wolves. However, it should be noted that local people might

280 resist directions from authorities. Shift to other areas may also have different environmental impacts.

281 The forms of income generation should be implemented and sustained selectively through existing

282 institutions (Jackson 2000).

283

284 Conclusions

285 To conclude, this study investigated local villagers' perceptions of wolves in Jiuzhaigou County,

286 western China. Most people, especially in villages with more frequent reports of wolf depredation to

287 the local government, reported an increase of wolf population and thus increased livestock losses to

288 wolves. People were generally negative towards wolves, despite a prevalent Tibetan culture that favors

289 the protection of wildlife. These with a larger number of livestock were more likely to have a negative

290 attitude towards wolves. In term of conservation management, we suggest that improved guarding of

291 livestock and provision of monetary support on human resources and infrastructure may mitigate

292 human-wolf conflicts in this region. Our study provides insights into management of human-wolf

293 conflicts in western China.

294

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304

305   References

306   Anderson DR. 2008. *Model based inference in the life sciences: a primer on evidence*. New York, NY:

307   Springer.

308   BBC News. 2006. China to promote wild animal hunt. *Available at http://news.bbc.co.uk/2/hi/asia-*

309   *pacific/4775335.stm* (accessed 23, February 2015).

310   Bisi J, Kurki S, Svensberg M, and Liukkonen T. 2007. Human dimensions of wolf (*Canis lupus*)

311   conflicts in Finland. *European Journal of Wildlife Research* 53:304-314.

312   Bjerke T, Reitan O, and Kellert SR. 1998. Attitudes toward wolves in southeastern Norway. *Society*

313   *and Natural Resources* 11:169-178.

314   Bradley EH, Pletscher DH, Bangs EE, Kunkel KE, Smith DW, Mack CM, Meier TJ, Fontaine JA,

315   Niemeyer CC, and Jimenez MD. 2005. Evaluating wolf translocation as a nonlethal method to

316   reduce livestock conflicts in the northwestern United States. *Conservation Biology* 19:1498-

317   1508.

318   Burnham KP, and Anderson DR. 2002. *Model selection and multimodel inference: a practical*

319   *information-theoretic approach*. New York, NY: Springer-Verlag.

320   Chen LB. 2011. Overview of Jiuzgaigou County. *Available at*

321   *http://www.jzg.gov.cn/meilijzg/jzggk/jibxq/201103/t20110308_386680.html* (accessed 15 March

322   2013).

323   CNC. 2012. Wolf Attacks in N China. *Available at*

324   *http://www.cncworld.tv/news/v_show/30143_Wolf_Attacks_in_N_China___.shtml* (accessed 20

325   March 2013).

326   Conforti VA, and de Azevedo FCC. 2003. Local perceptions of jagurs (*Panthera onca*) and pumas

327   (*Puma concolor*) in the Iguacu National Park area, south Brazil. *Biological Conservation*

328   111:215-221.

329   Eckel MD. 1998. Is there a Buddhist philosophy of nature? In: Cohen RS, and Tauber AI, eds.

330   *Philosophies of Nature: The Human Dimension, vol.195*. Dordrecht, The Netherlands: Kluwer

331   Academic Publishers, 53-70.

332   Ericsson G, and Heberlein TA. 2003. Attitudes of hunters, locals, and the general public in Sweden

333   now that the wolves are back. *Biological Conservation* 111:149-159.

334   Gros PM. 1998. Status of the cheetah *Acinonyx jubatus* in Kenya: a field-interview assessment.

335   *Biological Conservation* 85:137-149.

336   Grueber CE, Nakagawa S, Laws RJ, and Jamieson IG. 2011. Multimodel inference in ecology and

337   evolution: challenges and solutions. *Journal of Evolutionary Biology* 24:699-711.

338   Jackson R. 2000. Managing people-wildlife conflict on alpine pastures in the Himalayas. In: Richard C,

339   Basnet K, Shah JP, and Raut Y, eds. *Grassland Ecology and Management in Protected Areas of*

340   *Nepal, Volume 3: Technical and Status Papers on Grasslands of Mountain Protected Areas*.

341   Kathmandu: ICIMOD (International Centre for Integrated Mountain Development), 98-118.

342   Kleiven J, Bjerke T, and Kaltenborn BP. 2004. Factors influencing the social acceptability of large

343   carnivore behaviours. *Biodiversity and Conservation* 13:1647-1658.

344   Kvale S. 1996. *Interviews: an introduction to qualitative research interviewing*. London: Sage.

345   Lescureux N, and Linnell JDC. 2013. The effect of rapid social changes during post-communist

346   transition on perceptions of the human-wolf relationships in Macedonia and Kyrgyzstan.

347   *Pastoralism* 3:1-20.

348   Li XY, Buzzard P, Chen YC, and Jiang XL. 2013. Patterns of livestock predation by carnivores:

349   Human-wildlife conflict in northwest Yunnan, China. *Environmental Management* 52:1334-

350   1340.

351   Liu F, McShea WJ, Garshelis DL, Zhu XJ, Wang DJ, and Shao LK. 2011. Human-wildlife conflicts

352   influence attitudes but not necessarily behaviors: Factors driving the poaching of bears in China.

353   *Biological Conservation* 144:538-547.

354   Mech LD, and Boitani L. 2003. *Wolves: Behavior, Ecology, and Conservation*. Chicago, IL: University

355   of Chicago Press.

356   Mishra C, Allen P, McCarthy T, Madhusudan MD, Bayarjargal A, and Prins HHT. 2003. The role of

357   incentive programs in conserving the snow leopard. *Conservation Biology* 17:1512-1520.

358   Namgail T, Fox JL, and Bhatnagar YV. 2007. Carnivore-caused livestock mortality in Trans-Himalaya.

359   *Environmental Management* 39:490-496.

360   Naughton-Treves L, Grossberg R, and Treves A. 2003. Paying for tolerance: Rural citizens' attitudes

361   toward wolf depredation and compensation. *Conservation Biology* 17:1500-1511.

362   White PCL, Jennings NV, Renwick AR, and Barker NH. 2005. Review: questionnaires in ecology: a

363   review of past use and recommendations for best practice. *Journal of Applied Ecology* 42:421-

364   430.

365   R Development Core Team. 2013. *R: a language and environment for statistical computing*. Vienna,

366   Austria: R Foundation for Statistical Computing.

367   Røskaft E, Händel B, Bjerke T, and Kaltenborn BP. 2007. Human attitudes towards large carnivores in

368   Norway. *Wildlife Biology* 13:172-185.

369 ScienceNet.cn. 2013. Wolves attacked frequently livestock on pastures. *Available at*

370 *http://news.sciencenet.cn/htmlnews/2013/6/278621.shtm* (accessed 23, February 2015).

371 SCUSLS (Sichuan University School of Life Sciences). 2011. *Comprehensive scientific survey report*

372 *of Gonggangling Nature Reserve*. Chengdu, China.

373 Skogen K, and Thrane C. 2007. Wolves in context: Using survey data to situate attitudes within a

374 wider cultural framework. *Society and Natural Resources* 21:17-33.

375 SPAFS (Sichuan Provincial Academy of Forestry Sciences). 2004. *Comprehensive scientific survey*

376 *report of Jiuzhaigou Nature Reserve*. Cheng, China.

377 Suryawanshi KR, Bhatnagar YV, Redpath S, and Mishra C. 2013. People, predators and perceptions:

378 patterns of livestock depredation by snow leopards and wolves. *Journal of Applied Ecology*

379 50:550-560.

380 Treves A, and Karanth K. 2003. Human-carnivore conflict and perspectives on carnivore management

381 worldwide. *Conservation Biology* 17:1491-1499.

382 Tuğ S. 2005. Conflicts between humans and wolf: A study in Bozdağ, Konya Province, Turkey. M. Sc

383 thesis. Middle East Technical University.

384 Wang S. 1998. *China red data book of endangered animals: Mammalia*. Beijing: Science Press.

385 Wengraf T. 2001. *Qualitative research interviewing: biographic narrative and semi-structured*

386 *methods*. London: Sage.

387 Williams CK, Ericsson G, and Heberlein TA. 2002. A quantitative summary of attitudes toward wolves

388 and their reintroduction (1972-2000). *Wildlife Society Bulletin* 30:575-584.

389 Xinhuanet. 2014. Tibet spent over $14.5 billion RMB on eco-compensation during the past 10 years.

390 *Available at http://news.xinhuanet.com/local/2014-05/03/c_1110508831.htm* (accessed 26,

391 February 2015).

392   Yang HJ. 2008. Home range and habitat selection of wolf in the eastern grassland of the Inner

393   Mongolia. Ph.D. thesis. Northeast Forestry University.

394   Yunnan.cn. 2014. Yunnan province has been innovating eco-compensation measures and insurance

395   indemnity for wildlife damage will be extended to the whole province. *Available at*

396   *http://yn.yunnan.cn/html/2014-04/13/content_3171049.htm.* (accessed 26, February 2015).

397   Zhang HH, Zou YA, Dou HS, Liu XP, Zhang CD, and Liu ST. 2010. Preliminary analysis on the

398   habitat selection of wolf (*Canis lupus*) in Dalai Lake Natural Reserve in Inner Mongolia. *Acta*

399   *Ecologica Sinica* 30:3637-3644.

Comparison of respondents' personal characteristics between villages with more frequent reports of wolf depredation and those with less frequent reports of wolf depredation

Village category	Mean age (range)	Proportion of ethnic groups		Proportion of education levels		
		Tibetan	Han	Illiterate	Elementary school	Secondary and above
Villages with more frequent reports of depredation (n = 9 villages, and 81 respondents)	44 (16-81)	49.4% (40/81)	50.6% (41/81)	34.6% (28/81)	45.7% (37/81)	19.8% (16/81)
Villages with less frequent reports of depredation (n = 3 villages, and 19 respondents)	46 (23-77)	52.6% (10/19)	47.4% (9/19)	42.1% (8/19)	36.8% (7/19)	21.1% (4/19)
Statistical tests	t = -0.536, df = 98, P = 0.593	χ^2 = 0.065, df = 1, P = 0.799		χ^2 = 0.529, df = 2, P = 0.768		

Comparison of estimates of livestock ownership and livestock depredation between villages with more frequent reports of wolf depredation and those with less frequent reports of wolf depredation

Village category	Percentage of families with livestock grazed	Average annual number of livestock owned per family (range)	Percentage of families with livestock depredated by wolves	The reported annual livestock loss rate to wolves (range)
Villages with more frequent reports of depredation (n = 9 villages, and 81 respondents[a])	86.3% (69/80)	41 (4-200)	82.6% (57/68)	21.7% (0-70%)
Villages with less frequent reports of depredation (n = 3 villages, and 19 respondents)	73.6% (14/19)	53 (3-200)	64.3% (9/14)	11.7% (0-30%)
Statistical tests	Fisher's exact test P = 0.184	t = -0.981, df = 81, P = 0.330	Fisher's exact test P = 0.134	t = 1.180, df = 80, P = 0.074

2   [a] no data values were recorded for livestock ownership and livestock depredation in one sample, and there is one missing value for livestock

3   depredation in another sample.

Comparison of respondents' opinions about wolf population trends and attitudes towards wolves between villages with more frequent reports of wolf depredation and those with less frequent reports of wolf depredation

Village category	Proportion of opinions about wolf population trends			Proportion of attitudes towards wolves			
	Increasing	Decreasing	Stable	Negative	Positive	Neutral	Mixed
Villages with more frequent reports of depredation (n = 9 villages, and 81 respondents)	79.0% (64/81)	16.0 % (13/81)	4.9% (4/81)	86.4% (70/81)	7.4% (6/81)	4.9% (4/81)	1.2% (1/81)
Villages with less frequent reports of depredation (n = 3 villages, and 19 respondents)	47.4% (9/19)	52.6% (10/19)	0 (0/19)	73.7% (14/19)	26.3% (5/19)	0 (0/19)	0 (0/19)
Statistical tests	Fisher's exact test P = 0.005			Fisher's exact test P = 0.116			

Model-averaged coefficients and relative importance calculated for variables explaining variation in attitude of respondents towards wolves

Variable	Estimate	SE	Lower 95% CI	Upper 95% CI	OR	z value	wi+
Intercept	0.175	1.115	-2.010	2.360	1.191	0.156	
ANL	0.032	0.016	0.001	0.062	1.032	2.018	0.93
Ethnicity_Han[a]	1.082	0.747	-0.382	2.546	2.951	1.432	0.53
Village category_less frequent reports of wolf depredation[b]	-0.945	0.687	-2.293	0.402	0.389	1.358	0.46
APL	2.144	1.806	-1.395	5.683	8.534	1.173	0.44
Age	0.025	0.024	-0.022	0.072	1.025	1.038	0.38
Education level_secondary and above[c]	0.370	0.870	-1.335	2.075	1.447	0.42	0.32
Education level_elementary school	0.599	0.674	-0.721	1.920	1.821	0.878	-

2 [a] "Tibetan" was the reference category

3 [b] "Villages with more frequent reports of wolf depredation" was the reference category

4 [c] "Illiterate" was the reference category

5 Abbreviations: ANL, annual number of livestock the respondent's family grazed; APL, annual percentage of livestock depredated by wolves;

6 OR, the odds ratio.

1

Map showing the study area, Jiuzhaigou County, Sichuan Province, western China, as well as locations of villages investigated in the study

The dark circles represent villages with more frequent reports of wolf depredation, and the dark squares villages with less frequent reports of wolf depredation

103°30'0"E
104°0'0"E

●Yuwa

●Batun
▲Yuwa
●Dashe

●Shimen
▲DaLu
●Donggou ●Bili

33°30'0"N
▲Heihe
33°30'0"N

●Dongbei
●Daye

▲Lingjiang
●Qianghuo

▲Baihe

■Yatun
■Taiping
▲Zhangzha

■Zhongcha

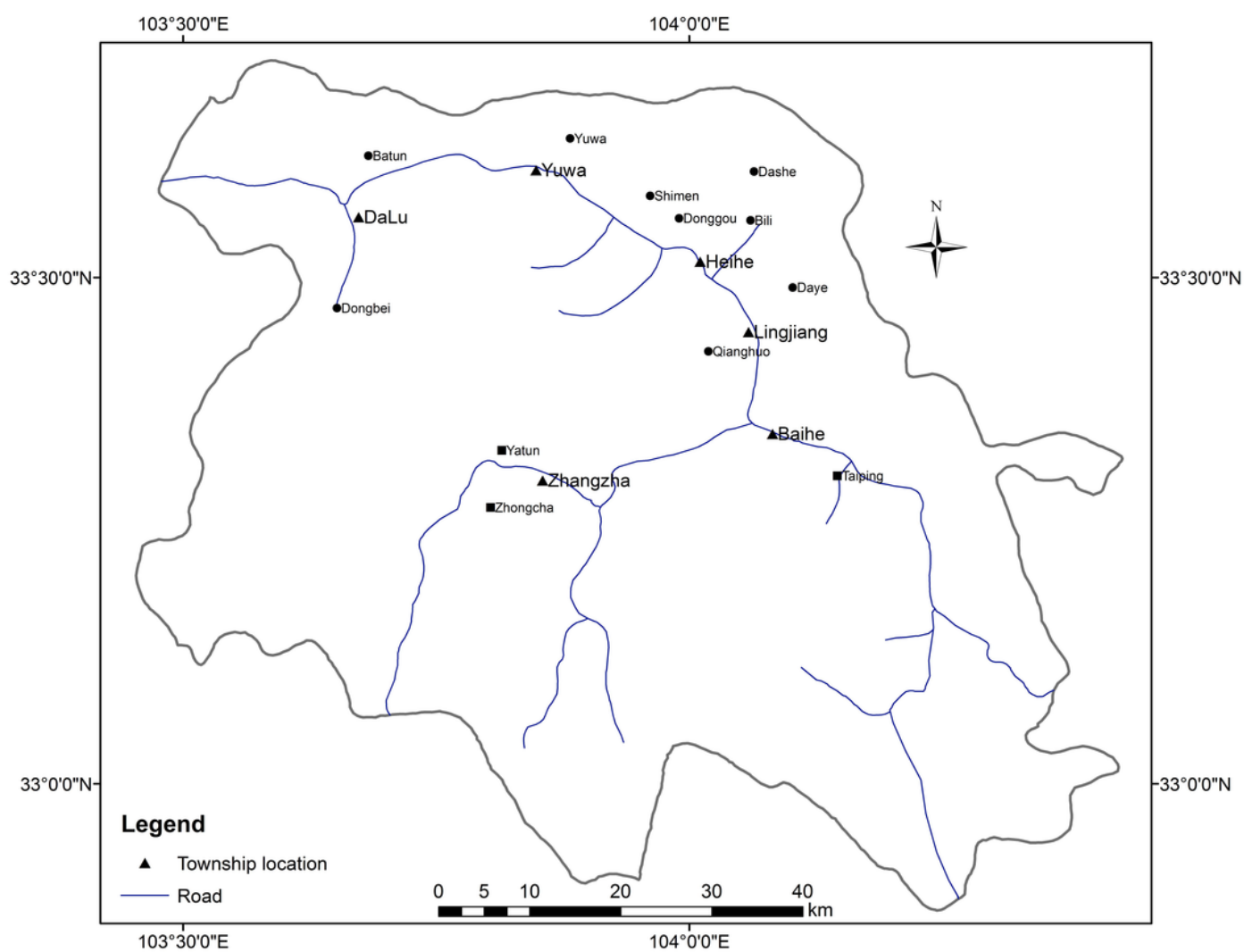
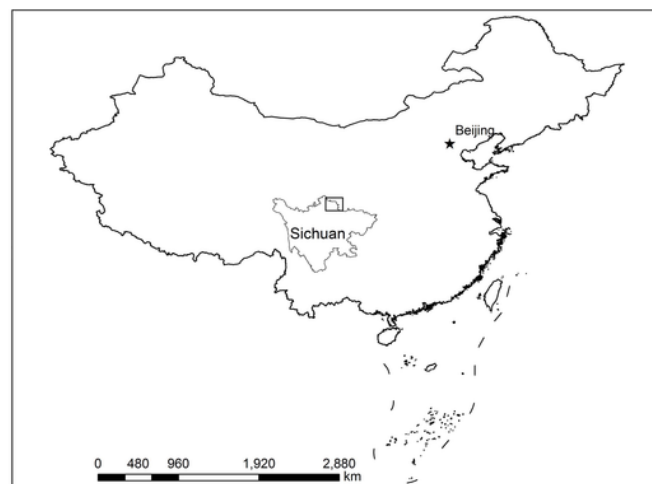
33°0'0"N
33°0'0"N

N

Legend

▲ Township location

— Road

0 5 10 20 30 40
km

103°30'0"E
104°0'0"E

Mean annual number of livestock ± 1 SE grazed by families of respondents who had different attitudes towards wolves