1   An evolutionary habitat selection by the plateau pika (*Ochotona curzoniae*) in relation

2   to the niche construction of the livestock management on the Qinghai-Tibetan plateau

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10   ABSTRACT

11   Habitat selection by animals is conventionally linked with nature selection pressures.

12   However, niche construction as a potent evolutionary agent palys a crucial role for

13   many types of evolutionary habitat selection by species and this modifies nature

14   selection pressures.

15   We used data obtained from an 11-year period to observe the evolutionary habitat

16   selection by the plateau pika (*Ochotona curzoniae*) in relation to the niche

17   construction of livestock management. We hypothesized that the niche construction

18   of local nomads affects the evolutionary habitat selection of the plateau pika, and

19   furthermore that the plateau pika does not fit niche conservatism in the *Kobresia*

20   ecosystem of the Qinghai Tibetan Plateau (QTP). In order to verify the above

21   hypotheses, we used the distance to the nearest yak-bedding areas and dung

22   management as the variables that most strongly explain variation in pika occupancy

23   (probability) and detection probability based on free-ranging livestock.

24   Both pika occupancy and detection probability decrease sharply with increasing

25   distance to the nearest yak-bedding area, suggesting that pika population densities are

26   highest closest to yak-bedding areas. There is a strong correlation between dung

27   cover and occupancy of the plateau pika; the more dung drying on the ground, the

28   more plateau pikas occupy the area. Consequently, the plateau pika is frequently

29   detected in damaged grass. Rangeland dominated by *Kobresia* sedges on the QTP is

30   modified by livestock grazing and management, especially by dung management.

31   This is the first research suggesting that local nomads may cause expansion of the

32   habitat of the plateau pika. In sum, the habitat of the plateau pika is expanding and

33   there is strong evidence that it retains its biodiversity on the Qinghai-Tibetan Plateau

34   in spite of exposure to poison as control measure. Still, the current control

35   management of the plateau pika may result in diminished diversity of both fauna and

36   flora species and a collapse of the food web on the QTP.

Keywords

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1. INTRODUCTION

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There is an ongoing trade-off between the gains and loss of energy as animals forage. As described by optimal foraging theory (Rosenzweig, 1981), animals can maximize fitness (and increase chances of survival) by adopting foraging strategies that provide the most energy while also lowering the costs (i.e., energy losses) involved. The linkages between community groups (characterized by genotype) and their environment (evident in their resulting phenotypes) greatly influences the selection of habitat by an organism and is well understood as a basis of evolutionary theory (Oldling-Smee et al. 2003).

54

Other roles of phenotype in evolution, influenced by other factors such as land use and climate change, are not well understood. Oldling-Smee et al. (2003) suggested that niche construction is far more obvious than natural selection and is a potent evolutionary agent through which organisms modify their own niches and those of others. An example of this is the beaver dam. Thus, niche construction is an evolutionary process that has been supported by theoretical and empirical evidence (e.g., Laland & Sterely, 2006). However, the tendency of a species to retain their niche even while facing threats from climate change and habitat change, including shifts in forage quality stemming from non-native (and often invasive) species, is not well understood. A better understanding of niche resilience is necessary to inform niche conservatism and to build upon existing paradigms (Wiens et al. 2010).

67 Human activities can exert a significant degree of control over the environment

68 (Laland & Sterely, 2006). For example Boyer and Bleich's (1984) study detailed the

69 effects of cattle grazing on the habitats of southern mule deer (*Odoncoileus hemionus*)

70 and MacKenzie et al., 2006) studied the impact of habitat change from human land

71 use on certain birds species.

72 In this paper we further explore the assumption that the management of livestock,

73 specifically yak *(Bos grunniens)*, grazing and dung management plays an important

74 role in modifying niches for endemic small mammals. Here we use as a case study the

75 plateau pika (*Ochotona curzoniae*) on the Qinghai-Tibetan Plateau (hereafter QTP).

76 The plateau pika is a diurnal, non-hibernating, burrowing dominant species endemic

77 to the QTP (Smith et al. 1990; Lai & Smith, 2003). The pika's habitat commonly

78 includes alpine steppes, meadows, and deserts (Schaller 1998; Lai & Smith, 2003;

79 Pech et al. 2007; Wangdwei et al. 2013) in the nearly treeless and high altitudinal

80 regions of the QTP. These areas are often used for animal husbandry and grazing.

81

82 Previous research has identified a very strong association between animal species

83 diversity and the plateau pika. For example, several plateau snow-finches including

84 the white-rumped snowfinch (*Pyrgilauda taczanowskii*), rufous-necked snowfinch

85 (*Montifringilla ruficollis*), and Hume's ground tit (*Pseudopodoces humilis*) use the

86 burrows of plateau pikas for breeding and shelter (Smith & Foggin, 1999; Lai &

87   Smith, 2003; Lu et al. 2009). The endemic Tibetan plateau lizard (*Phrynocephalus*

88   *theobaldi*) and several species of frogs (e.g., *Bufo raddei, Nanorana pleskei*; Hogan,

89   2010; *Phylum Arthopoda,* observed by the authors of this study) use the pika burrows.

90   The plateau pika is also an important food resource for various predators, including

91   red fox (*Vulpes vulpes),* the sand fox (*Vulpes ferrilate*), wolf (*Canis lupus*), Tibetan

92   brown bear (*Urus arctos),* and the snow leopard (*Uncia uncia*). Avian predators

93   include the upland buzzard (*Buteo hemilasisus*), golden eagle (*Aquila chrysaetos*) and

94   falcon (*Falco cherug*). In addition to being very important to other animal species, the

95   burrow of plateau pikas provide a habitat for some endemic plant species such as

96   *Microula tibetica* and *lancea tibietica* (Bagchi et al. 2006).

97

98   The plateau pika is now largely regarded as a keystone species (Smith et al. 2019)

99   within the QTP (Hogan, 2010; Wangdwei, 2012; Wison & Smith 2015). .Even though

100 the plateau pika provides many valuable benefits to ecosystems, and contributes to

101 animal and vegetation diversity, is has been assumed to be the primary cause for the

102 increased land degradation occurring within the QTP (Xia, 1976). In response to this

103 assumption, since the 1950s pika communities have been actively poisoned by

104 regional government bureaus in Tibet as a means of population control (Schaller,

105 1998; Fan et al. 1999; Smith & Foggin, 1999; Pech et al.2007; Harris 2010; Smith et

106 al. 2019). Early, and perhaps misguided, research suggested that plateau pikas

107 compete with livestock for forage (Xia 1984). Within the QTP, livestock husbandry is

108 the principal land-use type (Miller 1995; Miehe et al. 2009) and is a major economic

109   driver for the region. However, Jiang and Xia (1985) found evidence that the dietary

110   overlap between grazing livestock and plateau pikas is minor in alpine meadow

111   ecosystems, unless the livestock grazing occurs at very high densities. However, the

112   research of Li et al. (2019) found that livestock grazing can increase the risk of

113   plateau pika outbreaks, which may contribute to localized land degradation. In

114   contrast, a more recent study by Wangdwei et al. (2013) pointed out that the plateau

115   pika is not cause for the land degradation , and that the survival and recruitment rate

116   of plateau pika decreased as yak grazing increased. Even with this more recent

117   evidence, the poison control programs continue.

118   Although the effects of livestock grazing on native biodiversity is a concern globally

119   (Milchunas et al. 1998, Komonen et al.2003, Harries et al. 2016, Li et al. 2019), and

120   locally within the QTP, the effect of yak management on habitat selection by the

121   plateau pika on the QTP is still evolutionarily and ecologically unclear. Tibetan

122   pastoralists have traditionally migrated among known pastures according to seasons,

123   vegetation types and vegetation phenologies for at least 8,800 year (Miehe *et al.*

124   2009). These rotational grazing patterns allowed for pasture recovery, minimized

125   erosion, and limited degradation of pika habitat. However, traditional grazing patterns

126   once observed in nomadic areas have been altered in more recent times (Wu &

127   Richard 1999; Fox *et al.* 2004) in a manner that has increased Yak numbers and

128   residence time.

129   The yak is the main domesticated livestock on the Tibetan plateau and provide

130   nomads with milk, meat, hair, wool, hides and a source of economic revenue. Dried

131 yak dung is also an important source of fuel on the treeless Tibetan plateau (Miller

132 2007, Wangdwei and Tsomo 2009). Yaks are called "nor" in Tibetan, it can be

133 translated into "wealth" in English (Miller 2007, Wangdwei and Tsomo 2009) in

134 terms of economical, cultural and spiritual value to the nomads (Miller 2007,

135 Wangdwei and Tsomo 2009). The dung of livestock is an extremely important energy

136 resource for cooking and heating over the long winter season in the harsh ecosystem

137 of nomadic areas of the QTP (Wangdwei & Tsomo 2010). Rubbing *Korbreisa* turf,

138 trampling grassland, excreting feces and urine by yaks is considered to influence the

139 building of a niche base on the niche construction perspective (Laland and Sterelny

140 2006). According to the definition of the ecosystem engineer by Jones et al (1994,)

141 Berkenbusch and Rouden (2003), yaks may directly or indirectly modulate the

142 available resources to plateau pika, likewise pikas to snowfinches and other species

143 (both flora and fauna), causing physical state changes in both biotic and abiotic

144 materials. As a result,, habitat selection by the pika may be affected by yak grazing

145 and dung management.

146 Therefore, we hypothesize that effects of the niche construction of local nomads

147 managing the livestock and dung (See Photo 1 (a)) on the evolutionary habitat

148 selection by the plateau pika within the QTP does not fit niche conservatism based on

149 its habitat selection responses to livestock grazing management which is irrelevant

150 phylogeny. Generally, we hypothesize that local nomads are a potent evolutionary

151 agent to the entire ecosystem of the QTP in the case of habitat selection by plateau
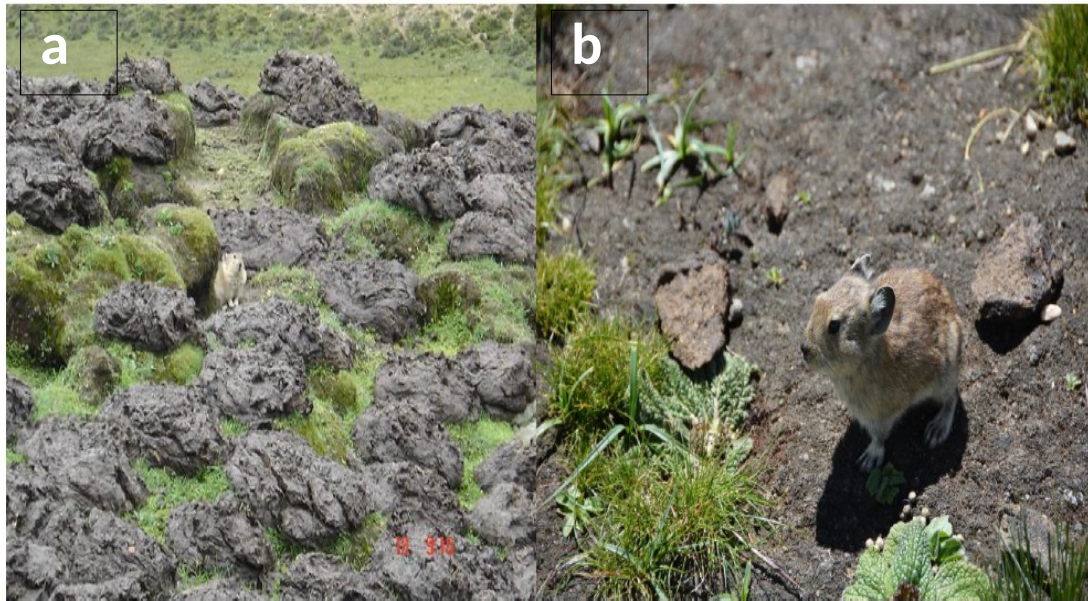
152 pikas.

153   For this study we asked whether the occupancy of plateau pika is related to the

154   distance to the nearest yak bedding areas (where much of the land degradation of the

155   *Kobresia* spp ecosystem occurs) and domestic yak dung management.

156   **2. MATERIAL AND METHODS**

157   **2. 1 Study region**

158   For this research we investigated an approximately 22 km study area located at Rutok

159   (N29°46´,E92°19´) in Lhasa prefecture of Tibet Autonomous Region, China. This site

160   is situated at the upper end of the Nyian Valley, with an altitude ranging from 4,423m

161   to 5,013m. The landscape consists of plateau steppe with interspersed thickets,

162   wetlands, bare mountains, and rocky hillsides (Wangdwei *et al.* 2013). Specific

163   vegetation assemblages in the study area are the *Kobresia*–forb type, *Kobresia*–

164   cushion type, *Kobresia*–shrub type, and mixed stony and shrub type. Native

165   domesticated yak is the primary large grazing herbivore at this site. Though sparse

166   compared to the yak, sheep and goats are also present.

167   We distinguished three main land use types according to yak husbandry: 1) yak

168   feeding/foraging areas; 2) yak bedding areas (pastoralists' tent sites); 3) fenced areas

169   where domesticated yaks and wild ungulates are kept during the non-winter grazing

170   season (Wangdwei & Tsomo, 2010; Wangdwei, 2019). Local herders dry the dung

171   from livestock for fuel near yak bedding areas (Wangdwei & Tsomo 2010;

172   Wangdwei, 2019) (see Photo 1(a)); Photo 1(b), the pika and evidence of dead

173   *Kobresia* spp grass in areas where dried dung is collected by nomads.

174

175 Photo1.(a) Yak dung on the grass near a yak bedding area in Nyian Valley, QTP; (b)

176 The plateau pika (*Ochotona curzoniae*).

177

178 **2.2 Sampling**

179 We randomly selected three sampling locations having a mixtures of yak foraging

180 areas and yak bedding areas (Wangdwei et al, 2013; Wangdwei 2019; Table 1). For

181 each location, we then sampled at set intervals by walking in rectangular-shaped

182 "transects" see Table 1), spanning approximately 22 km in total, over winter, spring

183 and summer seasons from 2008 to 2019 (11 consecutive years).

184 Within each transect, we defined home range sampling units of the plateau pika

185 (following the methods of Smith and Wang, 1991) as the segments of the transect

186 measuring 30m in length and 12m in width (i.e., six meters on either side of the

187 walked transect) and demarcated each site by piles of stones. We obtained 162 sites in

188   total along the three sampling transects, the sites being directly adjacent to each other.

189   Table 1. Number of sample sites at each location, general habitat types, total length of survey

190   walked at each location, and elevation range along the transect.

Sampling Location	Number of Sites	General Habitat Types	Length of Surveys (km)	Elevation (m)
1	37	Alpine steppe in a narrow V-shaped valley. A flat meadow with a steep east-facing slope on one side.	1.14	4,666–4,700
Site 2	74	Alpine steppe with a gentle slope facing southeast. A small stream is running through the area.	2.22	4,712–4,790
Site 3	51	Open alpine steppe with rocky outcrops. Sites of dense Rhododendron shrubs. Numerous small streams.	1.56	4,800–4,844

191

192   To estimate specific habitat probabilities of pika occupancy, and to also account for

193   the possibility of imperfect detection, we followed a species occupancy sampling

194   protocol (see MacKenzie et al., 2006). We repeated each survey several times within a

195   short time span (less than six days) to assure closure (noting if each site remained

196   occupied or unoccupied during the sampling period). We conducted: seven replicate

197 surveys in winter (16 to 21 in January 2009, 2010，2011，2012); seven surveys in

198 spring (14 to 19 in April 2009，2010，2011，2012); and six surveys in summer (14

199 to 19 June in 2009，2010，2011，2012). Five assistant observers participated in the

200 pika counts in winter and two in spring and summer. In addition, we also recorded the

201 number of pika burrows within each site. To quantify the effects of yak bedding areas

202 on the presence of the plateau pika, we measured the distance from each site to the

203 nearest yak bedding area (hereby indicated as DIST).

204 To quantify the effects of dung management by local nomads on the occupancy of the

205 plateau pika, we collected yak dung cover on a per 40x40m^2 basis (Smith and Wang

206 1991) within the line transects that coincided with yak bedding areas, as well as the

207 nearest distance to the bedding areas in 2008, 2013, 2016, 2017, 2018 and 2019. We

208 also collected samples within five random 2x2 m^2 plots to determine vegetation

209 characteristics and plant species, and observation of land degradation and damage

210 done to *Kobresia* species within the plateau pika home ranges using the approach of

211 Smith and Wang (1991). Relevant density of the plateau pika was measured in

212 relation to the damage of vegetation cover on the grass within transects in relation to

213 dung management in July 2016, July 2017, 2018, and 2019.

2. 3 Statistical analysis

Our replicated data on pika observations in the transect segments were obtained by a

standard multi-season species occupancy sampling procedure (MacKenzie et al.,

2006) that enables estimation of the probability that a site is occupied by pika and the

probability of observing pikas at a site given that it is occupied. However, our transect

segments (sampling units) were small and directly adjacent to each other and thus

cannot be regarded as independent. Plateau pikas typically live in extended family

groups with individual home ranges of about 900 to 1400 m^2 (Smith & Wang 1991).

Because our sampling units were only 360 m^2, we expect a strong spatial dependence

in the data. Therefore, in order to make robust inferences about the effects of habitat

variables (which may also be spatially auto-correlated) on pika occupancy, it is

essential to account for the spatial dependence in the statistical modeling of the data.

Failing to do this would result in pseudoreplication (Hurlbert, 1984). To accomplish

this, we used a hieratically formulated occupancy model (Royle & Royle, 2008) fitted

by Bayesian MCMC methods in program OpenBUGS ver. 3.2.1

(http://www.openbugs.info, MacKenzie *et al.* 2003). In this framework, the likelihood

contribution from each observation (pikas observed (success) or failed observation

(failure) is a Bernoulli trial with a success probability depending on the latent

(unobserved) occupancy state of the segment. The probability of observing at least

one pika during the j'th replicated visit to segment i is the product $z_i p_{ij}$, where z_i is

the occupancy state of segment i ($z_i=1$ if the segment is occupied and $z_i=0$ if the

235 segment is not occupied), and p_{ij} is the detection probability given that the segment is

236 occupied. Furthermore, the unobserved occupancy state of the segment, z_i, is a

237 Bernoulli variable with probability Ψ_i. Finally, we constrained both $logit(p_{ij})$ and

238 $logit(\Psi_i)$ to be linear functions of predictor variables.

239

240 To account for the spatial dependence in occupancy probability, we made the

241 occupancy probabilities Ψ_i dependent on the occupancy state of the neighboring

242 segments by adding a component αI_i to the expression for $logit(\Psi_i)$. The indicator

243 variable I_i is 1 if any of the two neighboring segments (only one neighboring segment

244 for the first and last segments of a transect line) were occupied and 0 otherwise, and α

245 is the log odds-ratio measuring the effects of the neighboring segment(s) being

246 occupied. Predicted occupancy probability conditional on the occupancy state of the

247 neighboring segments may be obtained by setting I to either 0 or 1. Predictions

248 unconditional on the occupancy state of the neighboring segments, but conditional on

249 a set of segment covariates, x, may be obtained on a logit-scale as

250 $logit(\Psi|x, I=0)+(P \vee x)\alpha$, where $(P \vee x)$ is the probability of any of the neighboring

251 segment being occupied conditional on x. Here, $P \vee x$ is a derived random variable

252 that may be calculated in the MCMC simulations without affecting the likelihood

253 function.

254 The occupancy states of the sites in successive seasons (winter, spring and summer)

255 are clearly not independent. To account for this, we included a multi-season

256 occupancy model in the OpenBUGS implementation, parameterized with local

257   extinction and colonization probabilities (MacKenzie et al., 2003). Hence, the

258   occupancy probabilities for the first season (winter) were specified as above, while

259   the occupancy probabilities of successive seasons, s, were specified as

260     $\Psi_{is} = z_{i(s-1)}\left(1 - \varepsilon_{is}\right) + \left(1 - z_{i(s-1)}\right)\gamma_{is}$. The ε_{is} is the probability that segment i will be

261   unoccupied in season s given that it is occupied in season $s-1$, and γ_{is} is the

262   probability that segment i will be occupied in season s given that it is unoccupied in

263   season $s-1$. $logit(\varepsilon_s)$ and $logit(\gamma_s)$ were also constrained to be linear functions of

264   predictor variables. Since local extinctions and colonization within the period of the

265   study are relatively rare, and our main interest was to investigate the occupancy

266   pattern rather than the dynamics of small scale extinctions and colonizations (this was

267   modeled primarily to account for the non-independence between seasons), we did not

268   include any spatial dependence in the local extinction and colonization probabilities.

269   The aim of the analysis was to estimate the effects on pika occupancy and detection

270   probability of the three habitat variables described above. Hence, we fitted flexible

271   smooth curves by a method that penalized "second differences" between adjacent

272   points in the curves (Elston & Proe, 1995; Bierman et al. 2006). We first binned

273   (discretized) the covariates in relatively small bins (a total of 16 bins spanned 30

274   meters for DIST). Secondly, the differences between adjacent variables,

275     $d_k = \left(a_{k+1} - a_k\right) - \left(a_k - a_{k-1}\right)$ Eq.1

276   were then penalized in line with likelihood according to

277 $$d_k \quad N(0, \sigma_{smooth}), \quad \text{Eq.2}$$

278 where σ_{smooth} is a free random variable in the model. This method performs well for

279 occupancy models with simulated data. We only fitted models where one habitat

280 variable was included at a time and focused the analysis on how pika occupancy in

281 the study system was related to each of the variables alone. In each model, both

282 occupancy probability and detection probability were constrained by the same habitat

283 variable.

284   In species occupancy models, it is essential to account for the major sources of

285 variation in detection probabilities among sites (transect segments in our case), as

286 unexplained heterogeneity among sites may lead to underestimation of occupancy

287 probability and may bias the effects of site covariates (MacKenzie et al., 2006). We

288 used rather small transect segments in an open landscape and had a good overview of

289 each segment. Hence, it is reasonable to assume that the main source of variation in

290 detection probability among segments were due to variation in local abundance.

291   Royle and Nichols (2003) developed a model for abundance-induced heterogeneity

292 detection by assuming that probability of detection is one minus the probability of

293 observing at least one of N independent individuals (where N is unobserved).

294 However, it is not reasonable to assume that the activities of individual pikas in a

295 group are independent. Hence, we assumed that abundance of pikas in the area was

296 correlated with the number of pika burrows at the segments. We included in the model

297 for detection probability a smooth, unspecified, effect of number of burrows at each

298 segment by the method described above (as the number of burrows is a discrete

299 variable and we did not do any binning of the data).

300   We took care to use as uninformative priors as possible. Whenever possible, we

301 used a 0 to 1 uniform prior on probability parameters and wide but truncated normal

302 priors for parameters on a logit scale. For the standard deviation parameters of

303 penalizing functions of the second differences, we used relatively wide uniform priors

304 constrained by a small positive lower bound to avoid the MCMC chains getting stuck

305 at very low values. We reported the effects and fitted predictions by posterior median

306 and the central 95% credible interval (2.5% and 97.5% quantiles). In terms of the

307 correlation between dung cover and the occupancy of plateau, we checked the

308 normality of data through a Shapiro test (square root transformed to meet the

309 assumption of normality).

310 **3. RESULTS**

311 **3.1 Association between predictor variables**

312 Based on land use types, we found that the vegetation cover and numbers of pika

313 burrows differed amongst the yak bedding areas and forging areas. There was only a

314 weak positive correlation ($\rho = 0.22$) between vegetation coverage and DIST, and a

315 moderate negative correlation between DIST and number of pika burrows at the sites

316 ($\rho = -0.49$). The number of burrows was also more variable at the sites closest to the

317 yak bedding areas (Figure. 1).

3.2 The effect of distance from yak bedding area on pika occupancy

and detection probabilities

Pika occupancy probability declined gradually with DIST during spring and summer (Figure. 2, upper panels). In spring, occupancy probability at the yak bedding areas was 0.84 (95% c.i.: 0.71 to 0.92), but at a distance of 315 meters from the yak bedding areas, occupancy probability was only 0.33 (95% c.i.: 0.19 to 0.53). Detection probability declined even sharper with DIST (Fig. 2, lower panels). During spring, the probability of detecting pikas at a single visit to an occupied site declined from 0.56 (95% c.i.: 0.48 to 0.63) at the yak bedding areas to 0.14 (95% c.i.: 0.08 to 0.20) at a DIST of 105 meters. This means that the odds of detecting pikas at an occupied sampling unit was 8.0 (95% c.i.: 4.7 to 14.8) times higher at the yak bedding areas than at 105 meters from the yak bedding area. In other words, the presence of pike is more likely at yak bedding areas. For comparison, the odds-ratio for detection given occupancy as a function of number of burrows (compared to zero burrows) increased to about 4.1 (95% c.i.: 2.1 to 8.2) at the maximum number of burrows (76 burrows) observed in a sampling unit (Figure. 3). In other words, the effect of DIST on detection probability given occupancy is much stronger than the effect of number of burrows.

3.3 Association between dung cover and the occupancy of the plateau

pika

After collecting dried dung by nomads for fuel, we found the areas of *Kobresia* turf to be degraded and a significantly higher occupancy of plateau pikas relative to nearby sites where dried dung had not been collected. There was a strong correlation of 66% between dung cover and numbers of burrow dug by the plateau pika (CI: 37, 84)(t = 4.2987, df = 23, p= 0.0003) (Figure. 4).

4. DISCUSSION

Our study found that evolutionary habitat selection by the plateau pika was not linked with natural selection pressure, and instead is linked with niche construction, namely local Tibetan pastoralists (irrelevant phylogenictic agents) in this study area. As with Laland and Sterely (2006) who advocated that the human exerts significant degrees of control over the environment, we found that yak bedding areas are supporting much higher densities of the plateau pika (Figure 1, Figure2) and are leading to much lower densities of low *kobresis* spp cover.
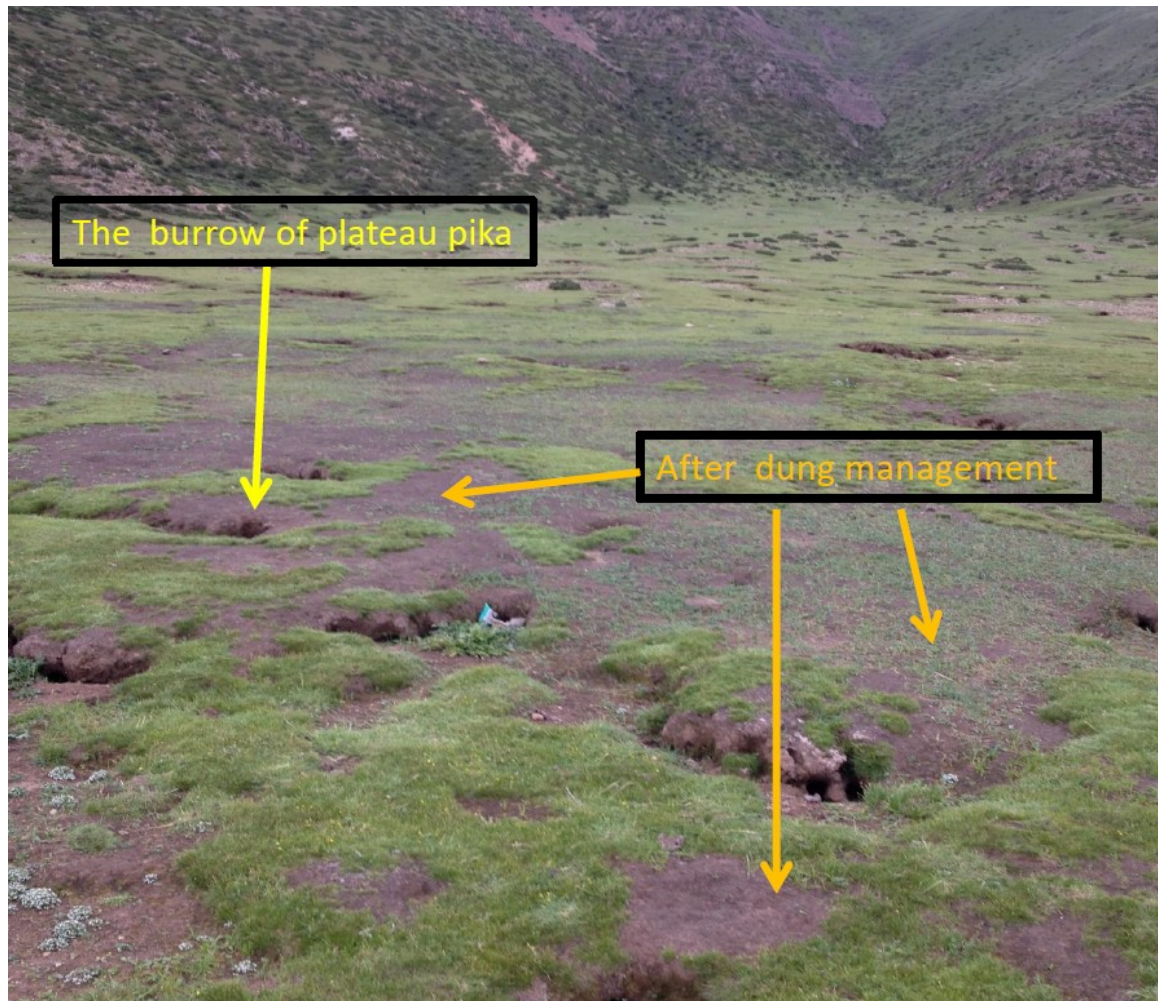
 Our findings are very different from the Milchunas et al. (1998) and Komonen et al (2003) studies in eastern Mongolia which found that the distribution and abundance of the Daurian pika (*Ochotona daurica*) were negatively affected by domestic livestock grazing. The situation of the plateau pika on the Tibetan plateau is vastly different

356 (Wangdwei, 2012; Wangdwei, 2019). The findings of this study and others (e.g.,

357 Arthur et al., 2009; Wangdwei & Hong-Mei, 2013); Wangdwei et al., 2013;

358 Wangdwei 2019) indicate that livestock management, especially yak grazing and

359 management, within the Nyian Valley in the QTP positively affects the pika

360 communities. The increasing density of plateau pika at yak bedding and dung

361 management areas, influenced by the recent changes in grazing management patterns

362 and yak residence times, is accelerating land degradation within the QTP.

363 The plateau pika occupancy in habitats dominated by the sedge *Kobresia* on the QTP

364 was evidently affected by pastoralists' land-use and livestock management. As both

365 occupancy and detection probabilities of pikas decrease with distance to the nearest

366 yak-bedding areas, and the interaction between yak bedding area and dung

367 management, affect the occupancy by the plateau pika. We found that nomads are

368 expanding the fundamental niche habitat of the plateau pika. Thus, according to the

369 concept of niche construction (Oldling-Smee et al. 2003), local nomads are a

370 influential niche constructor within the treeless alpine areas on the QTP.

371 Our study provides new evidence that local nomads are a potent evolutionary agent to

372 the entire ecosystem of the QTP, especially with regard to dung management. Even

373 though the plateau pika ecologically are key engineering species (Smith & Foggin

374 1999, Hogon 2010, Wilson & Smith 2015) to the endemic fauna and flora of the QTP,

375 the endemic livestock/yak grazing and dung management have triggered the

376 expanding habitat of the plateau pika (Fig. 4).

377

The burrow of plateau pika

After dung management

378

379   Photo 2 The sedge species *Kobresia* was altered by the drying of dung by nomads.

380   (Note: The bare land or sparse vegetation land or patches indicated by the arrows

381   were altered by the nomads' drying of dung at study sites.)

382   This adaptation of the plateau pika to the QTP does not fit the niche conservatism

383   (Wiens et al., 2010), but it is associated to the niche construction of nomads. In the

384   recent grazing years, the bedding areas have increased and nomads' constant drying

385   of dung on the *Kobresia sedge species* have triggered extending habitats and

386   occupancy of the plateau pika. This affects the grazing behavior of the plateau pika

387   and may result in a butterfly effect on species. If these findings are corroborated, the

388 continued use of pika control programs (i.e., the poisoning and eradication of pikas)

389 will likely negatively impact many aspects of the QTP ecosystem, through declines in

390 local species diversity and ecosystem function. Even more concerning is that

391 predator–prey dynamic modeling (see Pech *et al*., 2007) indicates that these control

392 programs could actually trigger an increase in the plateau pika population. Past

393 investigations (Pech *et al*., 2007) have also reported that current pika control

394 programs have a limited effect, and there is no evidence that control programs will

395 improve the livelihoods of herders. Therefore, this study suggests that a more holistic

396 and much more effective approach to reducing land degradation in the QTP would be

397 the implementation of alternative methods for dung management, such as use of iron

398 sheets(Generally refers to a thin iron plate) by local nomads, to reduce habitat

399 expansion of the plateau pika.

400 **Conclusion**

401 The *kobresia* ecosystem in the Nyian Valley of the QTP has been modified by over

402 8800 year of domesticated yak grazing and dung management. This history of yak

403 grazing drives evolutionary habitat selection by an endemic burrowing species, the

404 plateau pika. This study provides new evidence that the evolutionary habitat selection

405 by plateau pika does not fit both the natural selection and niche conservatism. Instead,

406 the evolutionary habitat selection by plateau pika is determined by the irrelevant

407 phylogenic niche constructors of nomads. Habitat loss often drives the loss of

408 biodiversity. Yet in the QTP, yak grazing and dung management are expanding the

409 habitat of plateau pika and, as a result, pika populations. The current management of

the plateau pika may result in diminishing the diversity of both fauna and flora

species, threatening the food web on the Qinghai-Tibetan plateau. The plateau pika is

an important keystone species in the Qinghai-Tibetan plateau and our study indicates

that populations of pika might be effectively, and holistically, controlled simply

through improved yak grazing and dung management which will reduce the further

expansion of niche habitat.

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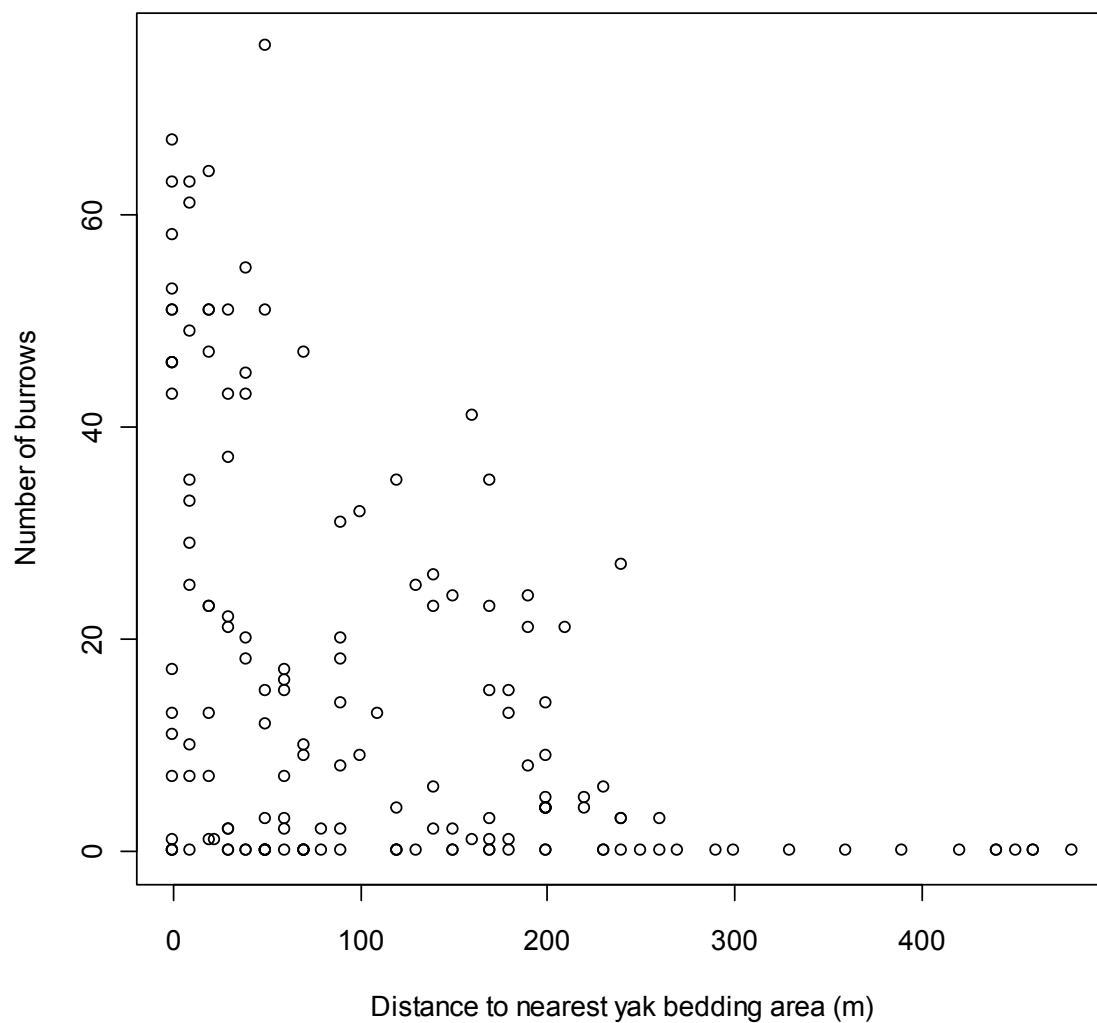
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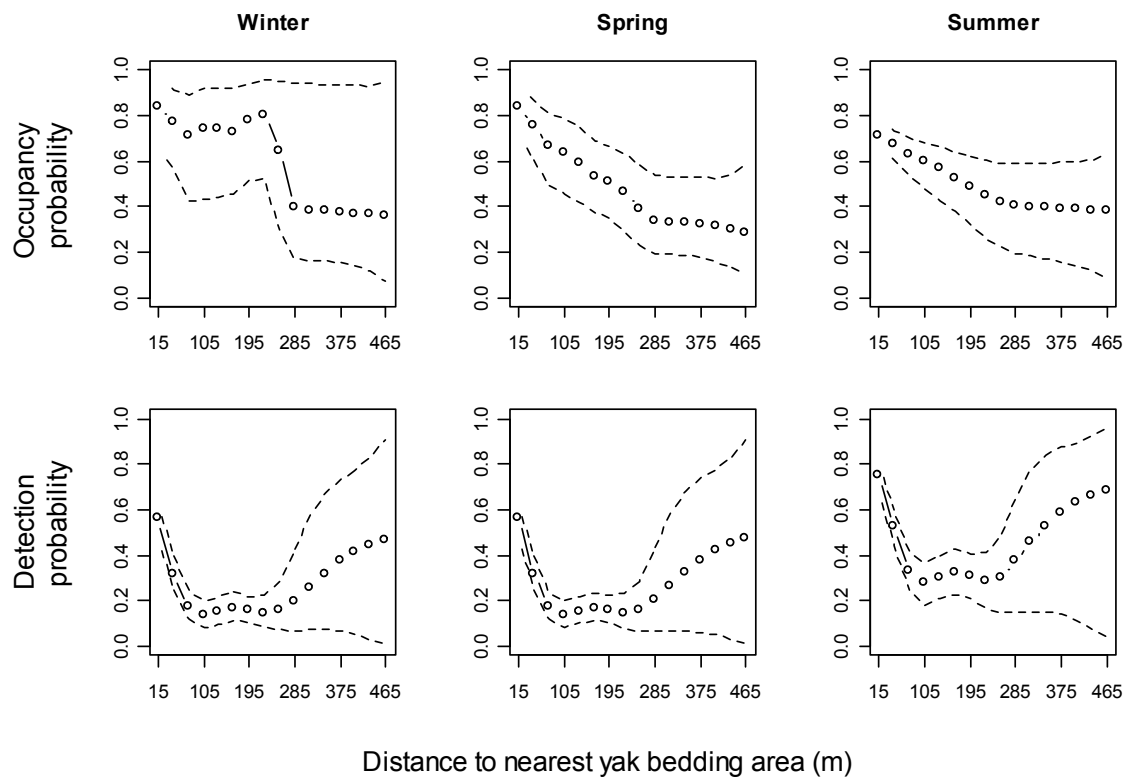
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563   Figure1   Number of burrows at each sampling unit (transect segment) plotted against
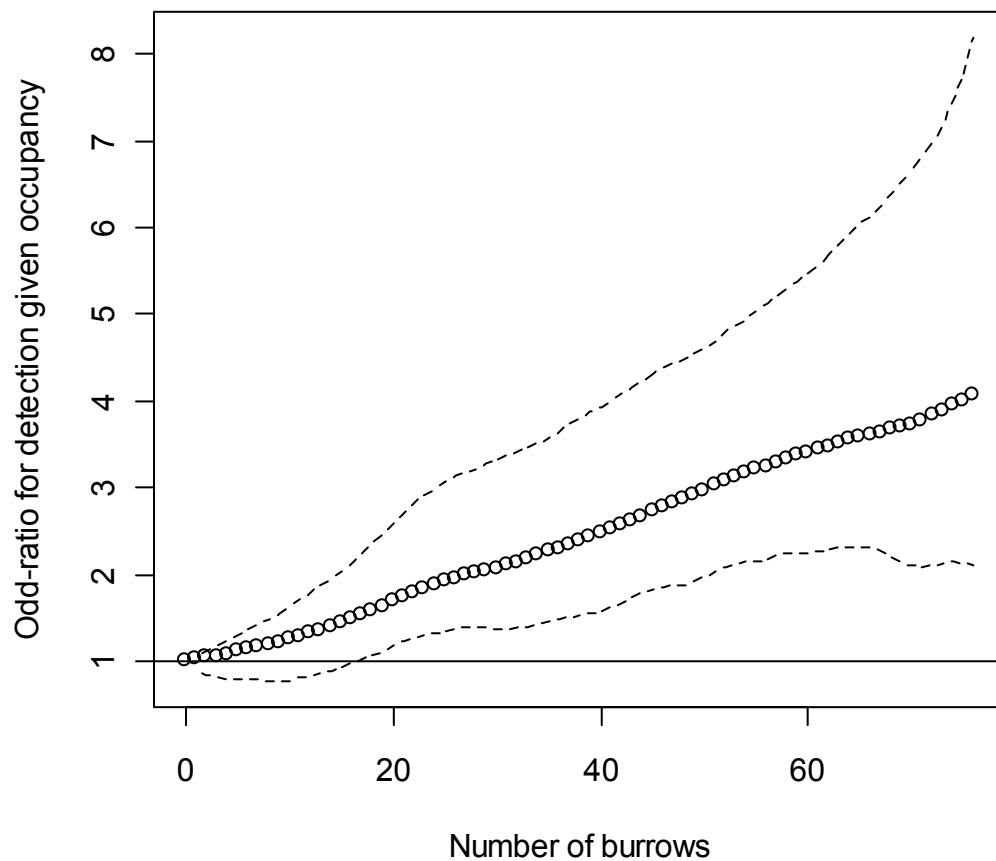
564   distance to the nearest yak bedding area.

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Distance to nearest yak bedding area (m)

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Figure 2   Summary of posterior distributions for occupancy probability (top panels)

and probability of detection given occupancy (lower panels) as a function of distance

to nearest yak bedding area (DIST) for winter (left), spring (middle) and summer

(right). Plotted circles show the median of the distributions for each distance class,

and the stippled lines show the 2.5% and 97.5% quantiles. The plots apply to

sampling site 2 (the site with the highest number of sites); the odds ratio for site 1 vs.

site 2 was about 0.57 (95% c.i.: 0.16 to 1.80), and the odds ratio for site 3 vs. site 2

was about 0.29 (95% c.i.: 0.10 to 0.82). The odds of occupancy was about 10.2 (95%

c.i.: 3.3 to 32.9) times higher when one of the neighbouring sites was occupied than if

unoccupied (occupancy probabilities unconditional on the occupancy state of the

neighbouring site are plotted). The plotted detection probabilities are not conditional

on a given number of burrows, but are instead calculated based on the observed mean

579 number of burrows for each distance class, and hence represent the effect of DIST

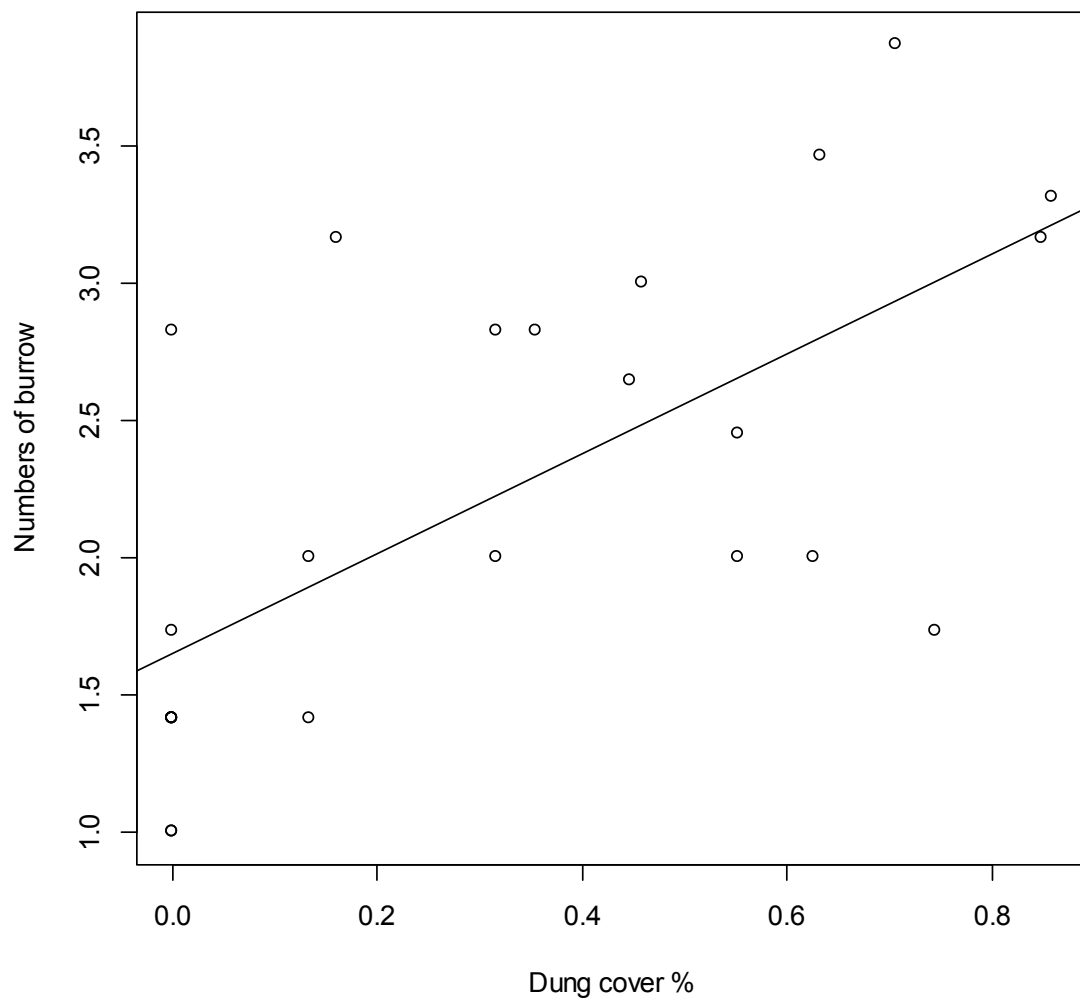580 when not controlling for the effect of number of burrows.

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584 Figure 3   Odds-ratios for the effect of number of burrows on detection given

585 occupancy compared to detection at sampling units with zero burrows.). Plotted

586 circles show the median of the posterior distribution and the stippled lines show the

587 posterior 2.5% and 97.5% quantiles.

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Figure 4   correlation between numbers of burrows and dung cover % (coverage

includes both drying dung and old traces**)**

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