

1 An evolutionary habitat selection by the plateau pika (*Ochotona curzoniae*) in relation to
2 an irrelevant phylogeny agent of the livestock management on the Qinghai-Tibetan
3 plateau

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7 **ABSTRACT**

8 Misunderstanding of the function of the plateau pika (*Ochotona curzoniae*) results in
9 diminishing the diversity of both fauna and flora species and collapse of the the food on
10 the Qinghai-Tibetan plateau. We used data obtained during an 11-year period to observe
11 evolutionary habitat selection by the plateau pika in relation to an irrelevant phylogeny
12 agent of livestock management. We hypothesized that local nomads are the irrelevant
13 phylogeny agent in the *Kobresia* ecosystem of the Qinghai-Tibetan plateau. In order to
14 verify the above hypothesis, distance to nearest yak-bedding areas and dung management
15 are the variables that most strongly explains variation in pika occupancy probability and
16 probability of occupancy detection based on free-ranging livestock. Both occupancy and
17 detection probability of pikas decrease sharply with increasing distance to nearest yak-
18 bedding area, strongly suggesting that pika population densities are highest closest to
19 yak-bedding areas. There is a strong correlation between dung cover and occupancy of
20 the plateau pika—namely, the more dung drying on the ground; the more plateau pikas
21 occupy the area. After the dung has damaged the grass, plateau pikas are apparently
22 detected there. Thus, rangeland dominated by sedges of the genus *Kobresia* on the

Qinghai-Tibetan Plateau is modified by livestock grazing and management, especially dung management. This is the first reported evidence that local nomads may cause expansion of the habitat of the plateau pika and its occupancy.

Keywords

Evolution, *Ochotona curzoniae*, niche construction, yak grazing

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INTRODUCTION

Even though livestock husbandry is the principal land-use type (Miller 1995, Miede *et al.* 2009) on the Qinghai-Tibetan Plateau (hereafter QTP) (Miede *et al.* 2009), the steppes of the QTP are widely used by livestock, wildlife (Schaller 1998, Fox *et al.* 2004, Harries 2008). Impact of human activities on wildlife is constrained to niche conservatism (Wiens *et al.*, 2010), yet the interaction between and among species occurs in unrelated phylogenetic levels in relation to the concept of niche construction (Oldling-Smee *et al.* 2003) and commonly takes place in different ecosystems. As Oldling-Smee *et al.* (2003) suggested, the niche construction is far more obvious than natural selection and is a potent evolutionary agent. Irrelevant phylogeny occurs within the species based on the niche construction.

The effect of livestock management on the evolutionary habitat selection by the plateau pika (*Ochotona curzoniae*) on the QTP is distinct. It is an endemic, diurnal, non-

hibernating, dominant species of the QTP (Smith *et al.* 1990, Lai and Smith 2003) commonly detected in alpine steppes, meadows, and deserts (Schaller 1998, Lai and Smith 2003, Pech *et al.* 2007, Wangdwei *et al.* 2013) in the nearly treeless high altitudinal areas of animal husbandry. There is a strong association between biodiversity and the plateau pika: several plateau snow-finches, such as the white-rumped snowfinch (*Pyrgilauda taczanowskii*), rufous-necked snowfinch (*Montifringilla ruficollis*), and Hume's ground tit (*Pseudopodoces humilis*) use the burrows of plateau pikas for breeding and shelter during the non-breeding season (Smith and Foggin 1999, Lai and Smith 2003, Lu *et al.* 2009). The endemic Tibetan plateau lizard (*Phrynocephalus theobaldi*) and several species of frogs' use of the pika burrows (e.g., *Bufo raddei*, *Nanorana pleskei*) have been documented (Hogan 2010).

However, early research suggested that pikas compete with livestock for forage (Xia 1984) whereas Jiang and Xia (1985) suggested that dietary overlap is minor in alpine meadow ecosystems unless at very high densities. The plateau pika has been assumed to be the primary cause for the degradation of the QTP (Xia 1976), and since the 1950s, it have been poisoned by government bureaus as a mean of population control (Schaller 1998, Fan *et al.* 1999, Smith and Foggin, Pech *et al.* 2007, Harris 2010, Smith *et al.* 2019). These control programs continue, even though research confirms that plateau pika is regarded as the keystone species (Smith *et al.* 2019) and key engineering species to the QTP (Hogan 2010).

Although the effects of livestock grazing on native biodiversity is a global concern (Milchunas *et al.* 1998), the adaptation by plateau pikas to the livestock management or niche construction of the QTP is evolutionarily and ecologically unknown. Therefore, we

hypothesized that the irrelevant phylogeny of local nomads affects the evolutionary habitat selection by the plateau pika on the QTP.

For this study, we asked whether the seasonal occupancy of plateau related to the distance to the nearest yak bedding area, and what is the correlation is between the occupancy of the plateau pika and yak dung management.

MATERIAL AND METHODS

Study region

The study area was located at Rutok (N29°46′, E92°19′) in Lhasa prefecture of Tibet Autonomous Region, China. The landscape consists of typical plateau steppe with interspersed thickets, swamp steppe, bare mountains, and rocky hillsides (Wangdwei *et al.* 2013). Apart from sheep and goats, native domesticated yak was the main large grazing herbivore. We distinguished three main land use types according to yak husbandry: yak feeding/foraging areas, yak bedding areas (pastoralists' tent sites), and fenced areas where domesticated yaks and wild ungulates were kept excluded during the winter season (Wangdwei and Tsomo 2010, Wangdwei 2019). Local herders dry the dung from livestock for fuel (Wangdwei and Tsomo 2010, Wangdwei 2019) (Fig. 1).



Fig. 1 Drying dung on the grass and the plateau pika (*Ochotona curzoniae*)

The dung of livestock is an extremely important energy resource for cooking and heating over the long winter season in the harsh ecosystem of nomadic areas of the QTP (Wangdwei and Tsomo 2010).

The study area spanned 22 kilometers of the upper part of the Nyian Valley, and the altitude ranged from 4,423m to 5,013m (Fig. 2).

Sampling

We selected three sampling areas with a mixtures of yak foraging areas and yak bedding areas (Wangdwei et al, 2013, Wangdwei 2019) (table 1). We sampled by walking in rectangular-shaped “transects,” covering approximately 22 km² at the study area (Fig 2).

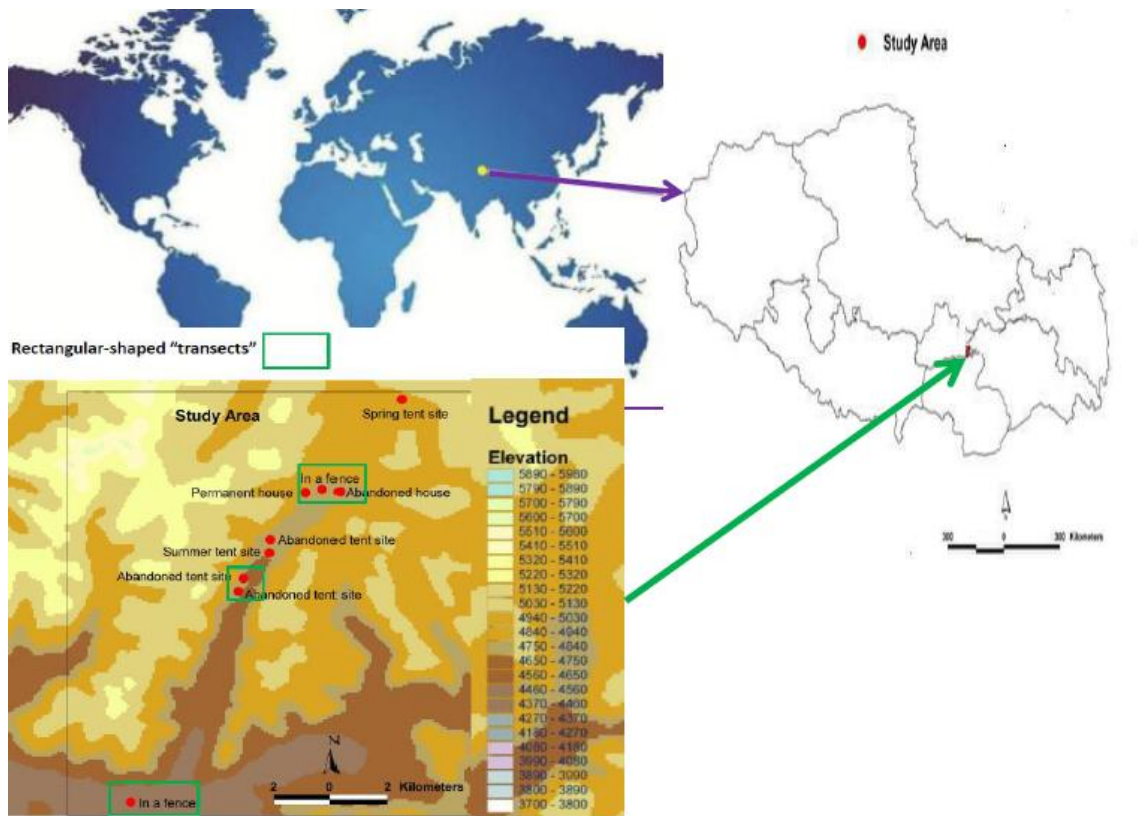


Fig. 2 Transects and drying yak dung cover in % with relevant plateau pika (red circles)

Within each transect, we defined home range sampling units of the plateau pika (Smith and Wang 1991) as segments of the transect measuring 30m in length and 12m in width (i.e., six meters on either side of the walked transect), demarcating each site by piles of stones. We obtained 162 sites in total at the three sampling transects, the sites being directly adjacent to each other within each sampling transect.

To estimate specific habitat probabilities of pika occupancy and also accounting for imperfect detection, we used a species occupancy sampling protocol (MacKenzie *et al.* 2006). We repeated each survey several times within a short enough time span (less than six days) to assure closure (each site remained either occupied or unoccupied during the sampling period). We conducted seven replicate surveys in winter (16 to 21 January in 2009), seven surveys in spring (14 to 19 April in 2009), and six surveys in summer (14 to

19 June in 2009). Five observers were used in winter and two in spring and summer. We also tallied the number of pika burrows within each site in January 2009. The burrows are easily seen, so it is reasonable to assume that these counts are accurate. To quantify the effects of yak bedding areas on the presence of the plateau pika, we measured the distance from each site to the nearest yak bedding area (variable DIST).

To quantify the effects of dung management by local nomads on the occupancy of the plateau pika, we collected yak dung cover per 40x40m² based on the home range of the plateau pika (Smith and Wang 1991) within line transects from the bedding areas, as well as the nearest distance to the bedding areas in 2016, 2017, and 2018. We also randomly collected five data samples of a 2x2 m² on vegetation characteristics, and on the damage done to *Kobresia* species within a plateau pika home range.

Relevant density of the plateau pika was measured in relation to the damage of vegetation cover on the grass within transects in relation to dung management in July 2016, July 2017, and the summer of 2018.

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 both 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 m² (Smith and Wang 1991) . Because our

sampling units were only 360 m², 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 and 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 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 segment is not occupied), and p_{ij} is the detection probability given that the segment is occupied. Furthermore, the unobserved occupancy state of the segment, z_i , is a Bernoulli variable with probability Ψ_i . Finally, we constrained both $\text{logit}(p_{ij})$ and $\text{logit}(\Psi_i)$ to be linear functions of predictor variables. To account for the spatial dependence in occupancy probability, we made the occupancy probabilities Ψ_i dependent on the occupancy state of the neighboring segments by adding a component αI_i to the expression for $\text{logit}(\Psi_i)$. The indicator variable I_i is 1 if any of the two neighboring segments (only one neighboring segment for the first and last segments of a transect line) were occupied and 0 otherwise, and α is the log odds-ratio measuring the effects of the neighboring segment(s) being occupied. Predicted occupancy probability conditional on the occupancy state of the neighboring segments may be obtained by setting I to either 0

or 1. Predictions unconditional on the occupancy state of the neighboring segments, but conditional on a set of segment covariates, \mathbf{x} , may be obtained on a logit-scale as $\text{logit}(\Psi|\mathbf{x}, I = 0) + (P|\mathbf{x})\alpha$, where $(P|\mathbf{x})$ is the probability of any of the neighboring segment being occupied conditional on \mathbf{x} . Here, $P|\mathbf{x}$ is a derived random variable that may be calculated in the MCMC simulations without affecting the likelihood function.

The occupancy states of the sites in successive seasons (winter, spring and summer) are clearly not independent. To account for this, we included a multi-season occupancy model in the OpenBUGS implementation, parameterized with local extinction and colonization probabilities (MacKenzie *et al.* 2003, 3: chapter 7.3]. Hence, the occupancy probabilities for the first season (winter) were specified as above, while the occupancy probabilities of successive seasons, s , were specified as

$\Psi_{is} = z_{i(s-1)}(1 - \varepsilon_{is}) + (1 - z_{i(s-1)})\gamma_{is}$. ε_{is} is the probability that segment i will be unoccupied in season s given that it is occupied in season $s - 1$, and γ_{is} is the probability that segment i will be occupied in season s given that it is unoccupied in season $s - 1$.

$\text{logit}(\varepsilon_s)$ and $\text{logit}(\gamma_s)$ were also constrained to be linear functions of predictor variables. Since local extinctions and colonizations within the period of the study are relatively rare, and our main interest was to investigate the occupancy pattern rather than the dynamics of small scale extinctions and colonizations (this was modeled primarily to account for the non-independence between seasons), we did not include any spatial dependence in the local extinction and colonization probabilities.

The aim of the analysis was to estimate the effects on pika occupancy and detection probability of the three habitat variables described above: distance to the nearest yak bedding area (DIST). Hence, we fitted flexible smooth curves by a method that penalized

178 “second differences” between adjacent points in the curves (Elston, M.F. Proe, 1995,
179 Bierman *et al.* 2006). We first binned (discretized) the covariates in relatively small bins
180 (a total of 16 bins spanned 30 meters for DIST). Secondly, the differences between
181 adjacent variables, $d_k = (a_{k+1} - a_k) - (a_k - a_{k-1})$ were then penalized in line with
182 likelihood according to $d_k \sim N(0, \sigma_{smooth})$, where σ_{smooth} is a free random variable in
183 the model. This method performs well for occupancy models with simulated data
184 (unpublished results). We only fitted models where one habitat variable was included at a
185 time and focused the analysis on how pika occupancy in the study system was related to
186 each of the variables alone. In each model, both occupancy probability and detection
187 probability were constrained by the same habitat variable.

188 In species occupancy models, it is essential to account for the major sources of
189 variation in detection probabilities among sites (transect segments in our case), as
190 unexplained heterogeneity among sites may lead to underestimation of occupancy
191 probability and may bias the effects of site covariates (MacKenzie *et al.* 2006). We used
192 rather small transect segments in an open landscape and had a good overview of each
193 segment. Hence, it is reasonable to assume that the main source of variation in detection
194 probability among segments were due to variation in local abundance. Royle and Nichols
195 (2003) developed a model for abundance-induced heterogeneity in detection by assuming
196 that probability of detection is one minus the probability of observing at least one of N
197 independent individuals (where N is unobserved). However, it is not reasonable to
198 assume that the activities of individual pikas in a group are independent. Hence, we
199 therefore assumed that abundance of pikas in the area was correlated with the number of
200 pika burrows at the segments. We included in the model for detection probability a

smooth, unspecified, effect of number of burrows at each segment by the method described above (as the number of burrows is a discrete variable, we did not do any binning of the data).

We took care to use as uninformative priors as possible. Whenever possible, we used a 0 to 1 uniform prior on probability parameters and wide but truncated normal priors for parameters on a logit scale. For the standard deviation parameters of penalizing functions of the second differences, we used relatively wide uniform priors constrained by a small positive lower bound to avoid the MCMC chains getting stuck at very low values. For the exact prior specification, see the OpenBUGS code in Appendix A. We reported the effects and fitted predictions by posterior median and the central 95% credible interval (2.5% and 97.5% quantiles).

In terms of the correlation dung cover and the occupancy of plateau, we checked the normality of data through a Shapiro test (square root transformed to meet the assumption of normality).

RESULTS

3.1 Association between predictor variables

There was only a weak positive correlation ($\rho = 0.22$) between vegetation coverage and DIST, and a moderate negative correlation between DIST and number of pika burrows at the sites ($\rho = -0.49$). The number of burrows was also more variable at the sites closest to the yak bedding areas (Fig. 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 (Fig. 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. 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 (Fig. 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

There was a strong correlation of 66% between dung cover and numbers of burrow dug by the plateau pika (CI: 37, 84)($t = 4.2987$, $df = 23$, $p = 0.0003$) (Fig. 4) .

DISCUSSION

Even though the effects of livestock grazing on native biodiversity is a global concern (Milchunas *et al.* 1998), Komonen's *et al* (2003) found that the distribution and abundance of the Daurian pika (*Ochotona daurica*) were negatively affected by domestic livestock grazing in eastern Mongolia. Yet the situation of the plateau pika on the Tibetan plateau is different (Wangdwei 2012, Wangdwei 2019). Thus, findings by Arthur *et al.* (2009), Wangdwei and Hong-Mei (2013), Wangdwei *et al.* (2013), Wangdwei (2019) show that livestock grazing positively affect wildlife, especially yak grazing and management (Wangdwei *et al.* 2013, Wangdwei 2019).

The plateau pika occupancy in habitats dominated by the sedge *Kobresia* on the QTP was evidently affected by pastoralists' land-use and livestock management. As both occupancy and detection probabilities of pikas decrease with distance to the nearest yak-bedding areas (Fig. 2), and the interaction between yak bedding area and dung management affect the occupancy by the plateau pika, we found that nomads primarily build a fundamental niche to the plateau pika (Fig. 4) (Fig. 5). Thus, according to the concept of niche construction (Oldling-Smee *et al.* 2003), local nomads are fit to be the niche constructor at the treeless alpine area on the QTP. Evidence showed that local nomads are a potent evolutionary agent to the entire ecosystem of the QTP, especially with regard to dung management. Even though the plateau pika ecologically is the key engineering species (Smith and Foggin 1999, Hogon 2010, Wilson and Smith 2015) to the endemic fauna and flora of the QTP, the endemic livestock/yak grazing and dung management have triggered the expanding habitat of the plateau pika (Fig. 5).

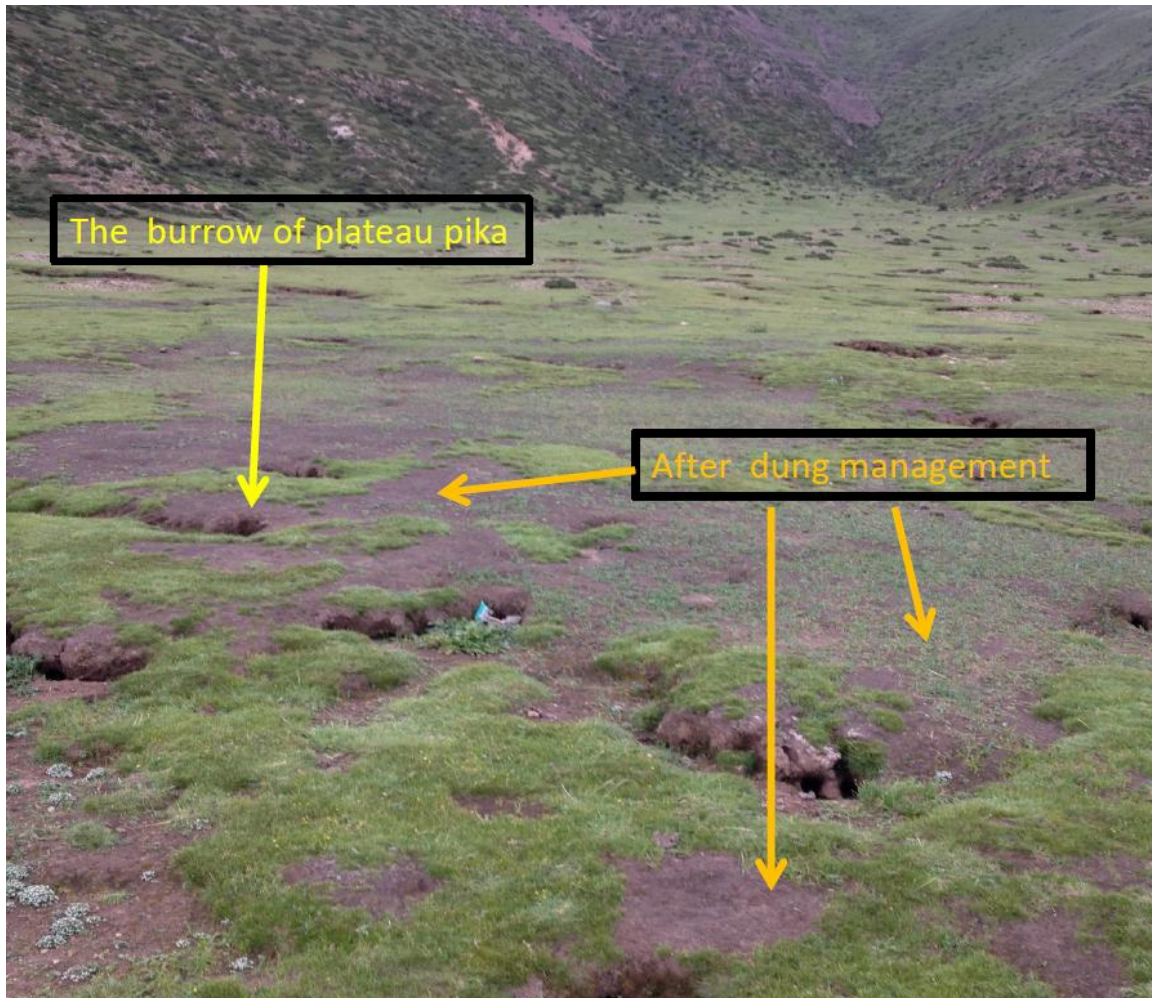


Fig 5 The sedge species *Kobresia* was altered by the drying of dung by nomads

This adaptation of the plateau pika to the QTP does not fit the niche conservatism (Wiens *et al.*, 2010), but it is associated to the unrelated phylogenetic niche constructors of nomads.

In the recent grazing years, the bedding areas have increased and nomads' constant drying of dung on the *Kobresia* sedge species have triggered extending habitats and occupancy

of the plateau pika. This affects the grazing behavior of the plateau pika and may result in a butterfly effect on species depending on the plateau pika. If these findings are

corroborated, pika control programs may result in the decline of local species diversity

and ecosystem function. The programs also trigger an increase in the plateau pika

population based on predator–prey dynamic modeling. Pech *et al.* (2007) reported that current pika control programs have a limited effect, and there is no evidence that control programs will improve the livelihoods of herders. Therefore, this study suggests the implementation of a better method for dung management by local nomads to control the expanding habitat of the plateau pika on the QTP.

ACKNOWLEDGEMENTS

The project was founded by grants from the Major project of science and tech-knowledge of Xizang Autonomous Region (XZ201801-GA-10) to M.W. and by the Network for Cooperation Tibet-Norway to M.W. We appreciate Norbu, Penba Tsering, Lhagpa Wangdwei for assistance in data collecting and local pastoralists for logistic help. We also thank R. Schea, Joshua Weber for linguistic assistance. We appreciate Torbjørn Ergon for assistance with analyzing data.

REFERENCES

- Arthur, A.D., R.P. Pech, C. Davey, Jeibu, Y.M. Zhang, and L. Hui. 2008. Livestock grazing, plateau pikas and the conservation of avian biodiversity on the Tibetan plateau. *Biological Conservation* 141:1972-1981.
- Bagchi, S., T. Namgail, and M.E. Ritchie. 2006. Small mammalian herbivores as mediators of plant community dynamics in the high-altitude arid rangelands of Trans-Himalaya. *Biological Conservation* 127:438–442.

293 Bierman, S.M., J.P. Fairbairn, S.J. Petty, D.A. Elston, Tidhar and D. X Lambin.2006.
 294 Changes over time in the spatiotemporal dynamics of cyclic populations of field voles
 295 (*Microtus agrestis* L.). *American Naturalist*, 167: 583–590.

296 Delibes-Mateos, M., A.T. Smith, C.N. Slobodchikoff, and J.E. Swenson. 2011. The
 297 paradox of keystone species persecuted as pests: A call for the conservation of abundant
 298 small mammals in their native range. *Biological Conservation* 44:1335-46.

299 Elston, D.A. and M.F. Proe. 1995. Smoothing regression coefficients in an
 300 overspecified regression model with interrelated explanatory variables. *Appl. Statist*
 301 44:395-406.

302 Foggin, J. M. 2008. Depopulating the Tibetan grasslands: national Policies and
 303 Persepectives for the future of Tibetan herders in Qinghai Province, China.

304 *Mountain Research and Development* 28 (1), 26–31.

305 Fox, J.L., P. Mathiesen, D.Yangzom, M. Næss , and B.Xu. 2004. Modern wildlife
 306 conservation initiatives and the pastoralist/hunter nomads of northwestern Tibet.
 307 *Rangifer* 15:17-27.

308 Goldstein, M.C., C.M. Beall and R.P. Cincotta. 1990. Traditional nomadic
 309 pastoralism and ecological conservation on Tibet’s northern plateau. *National*
 310 *Geographic Research* 6:139-156.

311 Harris, R. B. 2008. *Wildlife Conservation in China: Preserving the Habitat of*
 312 *China’s Wild West*. M.E. Sharpe, Inc., Armonk, N.Y.

313 Harris, R. B. 2010. Rangeland degradation on the Qinghai-Tibetan plateau: A
 314 review of the evidence of its magnitude and causes. *Journal of Arid*
 315 *Environments* 74:1-12.

316 Hogan, B. W. 2010. The Plateau Pika: A Keystone Engineer on the Tibetan Plateau. PhD
 317 Dissertation. Arizona State University.

318 Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments.
 319 *Ecological Monographs* 54:187-211.

320 Jiang, Z. and W. Xia. 1985. Utilization of food resources by plateau pikas. *Acta*
 321 *Theriologica Sinica* 5:251–262. (In Chinese with English abstract.)

322 Jiang, Z. and W. Xia. 1987. The niches of yaks, Tibetan sheep and plateau pikas in the
 323 alpine meadow ecosystem. *Acta Biologica Plateau Sinica* 6:115–143.

324 Lai, C.H. and A.T. Smith. 2003. Keystone status of plateau pikas (*Ochotona curzoniae*):
 325 effect of control on biodiversity of native birds. *Biodiversity and Conservation* 12: 1901-
 326 1912.

327 Komonen, M., A. Komonen and A. Otgonsuren. 2003. Daurian pikas (*Ochotona*
 328 *daurica*) and grassland condition in eastern Mongolia. *Journal of Zoology* 259:281-
 329 288.

330 Lu, X., D.H. Ke, X.H. Zeng and T. L. Yu. 2009. Reproductive ecology of two
 331 sympatric Tibetan snowfinch species at the edge of their altitudinal range: Response to
 332 more stressful environments. *Journal of Arid Environments* 73:1103–1108.

333 Lunn, D., D. Spiegelhalter, A. Thomas and N. Best. 2009. The BUGS project: Evolution,
 334 critique and future directions (with discussion), *Statistics in Medicine* 28: 3049-3082.

335 MacKenzie, D.I., J.D. Nichols, J.E.Hines, M.G. Knutson and A.B.Franklin.2003.
 336 Estimating site occupancy, colonization, and local extinction when a species is
 337 detected imperfectly. *Ecology* 84:2200-2207.

338 MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L.Bailey and J.E. Hines.
 339 2006. *Occupancy Estimation and Modeling*. Elsevier.

340 Miehe, G., S. Miehe, K.Kaiser, C. Reudenbach, L.Behrendes, LaDuo and F.Schuts.
 341 2009. How old is pastoralism in Tibet? An ecological approach to the making of a
 342 Tibetan landscape. *Palaeogeography, Palaeoclimatology, Palaeoecology* 276:130-147.

343 Milchunas, D.G., W.K. Lauenroth and I.C. Burke. 1998. Livestock grazing: animal and
 344 plant biodiversity of short grass steppe and the relationship to ecosystem function. *Oikos*
 345 83, 65–74.

346 Miller, D.J. 1999. Nomads of the Tibetan Plateau rangelands in Western China, part
 347 two: pastoral production systems. *Rangelands* 21:16–19.

348 Oldling-Smee, J.F., K.N. Laland and M.W. Feldman. 2003. *Niche construction: The*
 349 *neglected process in evolution*. Princeton University.

350 Pech, R.P., Jiebo, A.D.Arthur, Y. Zhang and H.Lin. 2007. Population dynamics and
 351 response to management of plateau pikas. *Journal of Applied Ecology* 44:615-624.

352 Royle, J.A. and J.D. Nichols. 2003. Estimating abundance from repeated presence-
 353 absence data or point counts. *Ecology* 84:777–790.

354 Royle, J.A. and R. M. Dorazio.2008. *Hierarchical Modeling and Inference in*
 355 *Ecology: The Analysis of Data from Populations, Metapopulations, and Communities*.
 356 Academic Press, San Diego, CA.

357 Smith, A.T. and X. G.Wang. 1991. Social relationships of adult black-lipped plateau
358 pikas (*Ochotona curzoniae*). Journal of Mammalogy 72 (2) :231-247.

359 Smith, A.T., N.A.Formozov, R.S.Hoffmann, C.L. Zheng and M.A.Erbajeva. 1990.
360 Lagomorph classification.In: *Rabbits, hares and pikas: Status survey and conservation*
361 *action plan*. (eds. Chapman , J. A. and Flux , J. E. C.) IUCN/WWF, 0070, pp. 7-13.

362 Smith, A. T. and J. M.Foggin. 1999. The plateau pika (*Ochotona curzoniae*) is a
363 keystone species for biodiversity on the Tibetan plateau. Animal Conservation
364 2:235–240.

365 Shi, Y. Z. 1983. On the influence of rangeland vegetation to the density of plateau
366 pika (*Ochotona curzoniae*). Acta Theriologica Sinica 3 :181-187 (In Chinese).

367 Schaller, G. B. 1998. Wildlife of the Tibetan steppe. University of Chicago Press.
368 Chicago.

369 Wesche, K.W., K. Nardrowski, and V.Retzer. 2007. Habitat engineering under dry
370 conditions: The impact of pikas (*Ochotona pallasi*) on vegetation and site condition in
371 southern Mongolian steppes. Journal of vegetation science. 18: 665-674.

372 Wangdwei, M. and S. Tsomo. 2009. Yaks and their herders in the Nyan valley of
373 Medrogonkar County County, Lhasa Prefecture of the central Tibetan Plateau. Journal
374 of Tibet University 3:92-94. (In Tibetan)

375 Wangdwei, M ., N.Namghel and T.Dorjee. 2008. A primary study on the correlation
376 between plateau pika (*Ochotona curzoniae*) and snow finch species. Jounal of Tibet
377 University 1, 1-2. (In Chinese).

378 Wangdwei, M. (2012). Demography, distribution, and behaviour of plateau

379 pika(*Ochotona curzoniae*) in relation to land-use type and yak (*Bos grunniens*)
 380 grazing on the Qinghai-Tibetan Plateau, China. Dissertation for the degree of
 381 philosophiae doctor (PhD) University of Bergen.

382 Wangdwei, M., Brian, S.and R.B. Harries. 2013. Demographic responses of plateau pikas
 383 to vegetation cover and land use in the Tibet Autonomous Region, China. Journal of
 384 Mammalogy 94(5):1077–1086.

385 Wangdwei, M. 2019. Effects of vegetation cover and pastoral land-use types on the
 386 foraging and vigilance behaviors of the plateau pika. Acta Theriologica Sinica 39
 387 (1) :69-76.

388 Wesche, K. W., I.K. Nardrowski and V.Retzer. 2007. Habitat engineering under dry
 389 conditions: the impact of pikas (*Ochotona pallasii*) on vegetation and site condition in
 390 southern Mongolian steppes. Journal of Vegetation Science 18:665–674.

391 Wiens, J.J., D.D. Ackerly, A.P. Allen, B.L. Anacker, L.B.Buckley, H.V.
 392 Cornell,E.I.Damschen, T.J.Davies, J-A.Grytnes, S.P. Harrison, B.A. Hawkins, R.D. Holt,
 393 C.M.McCain and P.R.Stephens. 2010. Niche conservatism as an emerging principle in
 394 ecology and conservation biology. Ecology letters 13:1310-1324.

395 Xia, W.P. 1984. Progress in mammalian ecology in China. Acta Theriologica Sinica
 396 4 :223-238.

397 Xia, W. P. 1976. A bird's eye view on the progress of rodent control and rodent biology
 398 during the past ten years in China. Acta Zoologica Sinica 22 (3):250-256.

399 Zhu, G.F., L.M. Gao and D.Z. Li. 2018. Protect third pole's fragile ecosystem. Science
 400 362 : (6421), 1368.

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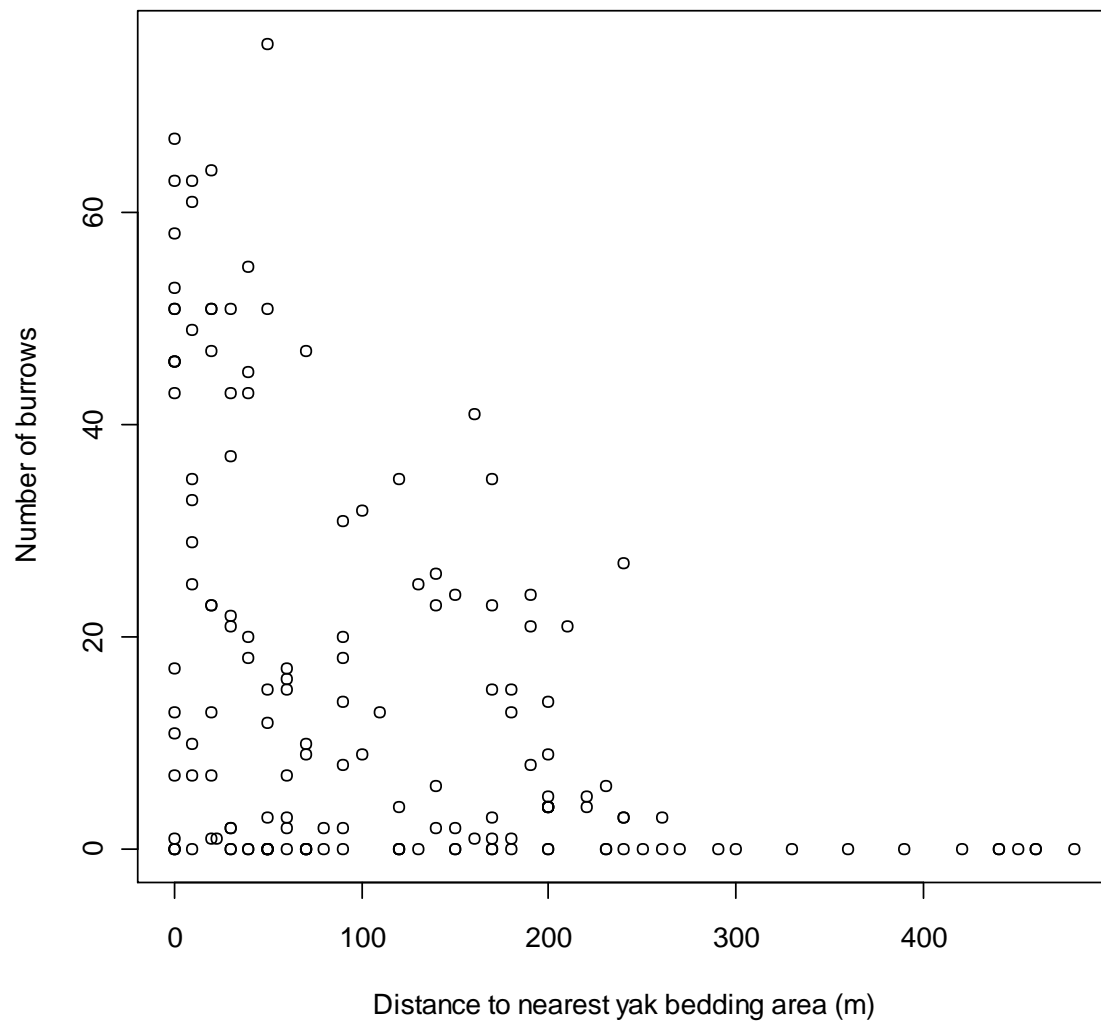
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405 Table 1 Number of sites, general habitat types, total length of survey walked at each, and
 406 elevation range of each of the three sites used for analyses of the plateau pika occupancy
 407 in Nyian Valley, Medrogong County, Tibetan Autonomous Region, China, 2009.

Sampling site	Number of sites	General habitat types	Length of surveys (km)	Elevation (m)
Site 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 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

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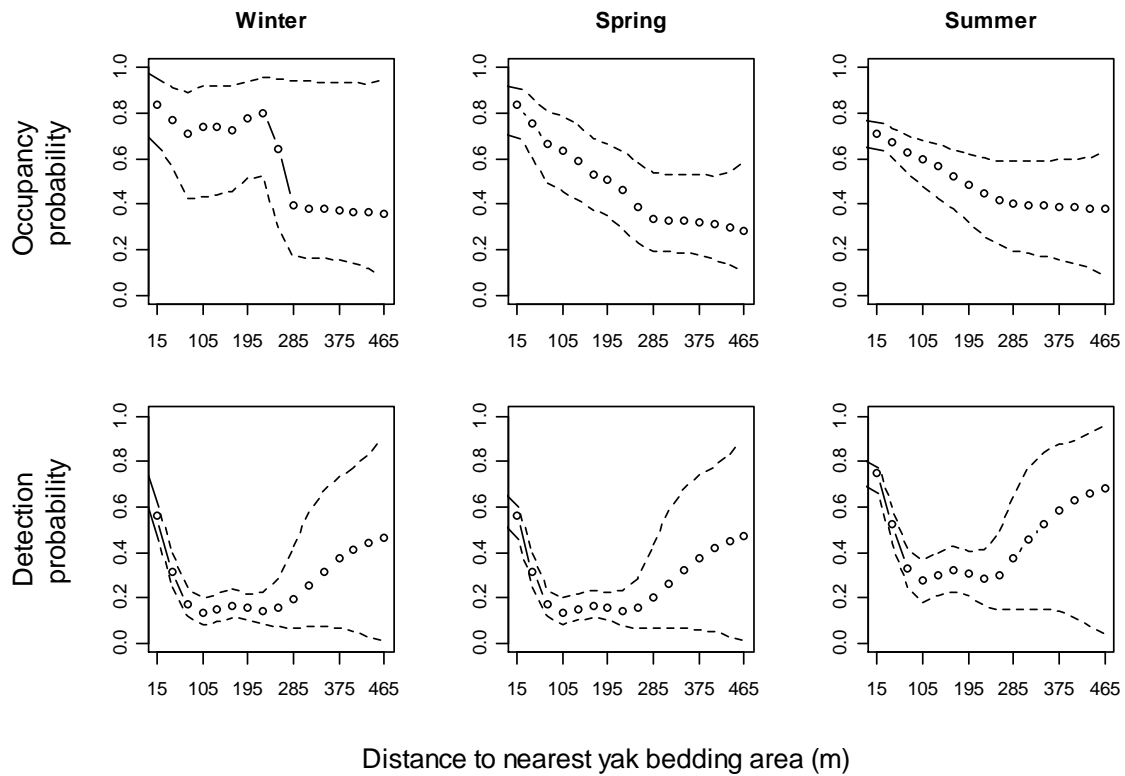
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411 Figure1 Number of burrows at each sampling unit (transect segment) plotted against
 412 distance to the nearest yak bedding area.

413



414 Distance to nearest yak bedding area (m)

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

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

417 nearest yak bedding area (DIST) for winter (left), spring (middle) and summer (right).

418 Plotted circles show the median of the distributions for each distance class, and the

419 stippled lines show the 2.5% and 97.5% quantiles. The plots apply to sampling site 2 (the

420 site with the highest number of sites); the odds ratio for site 1 vs. site 2 was about 0.57

421 (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.:

422 0.10 to 0.82). The odds of occupancy was about 10.2 (95% c.i.: 3.3 to 32.9) times higher

423 when one of the neighbouring sites was occupied than if unoccupied (occupancy

424 probabilities unconditional on the occupancy state of the neighbouring site are plotted).

425 The plotted detection probabilities are not conditional on a given number of burrows, but

426 are instead calculated based on the observed mean number of burrows for each distance

class, and hence represent the effect of DIST when not controlling for the effect of number of burrows.

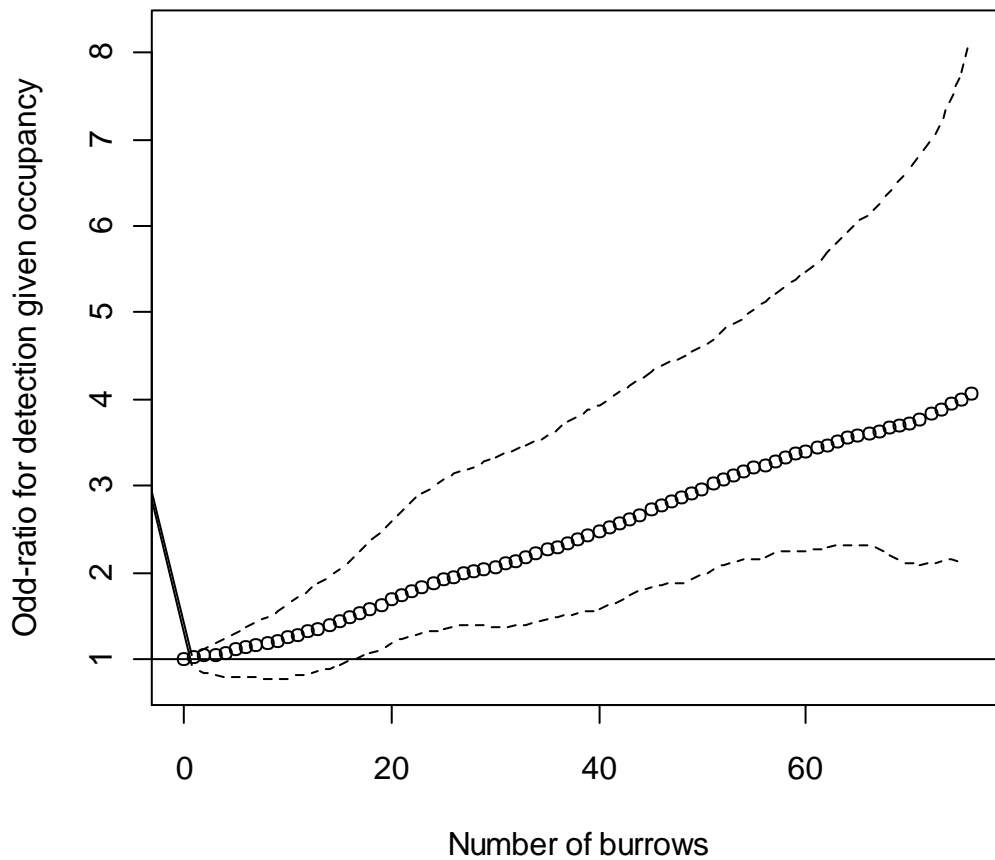
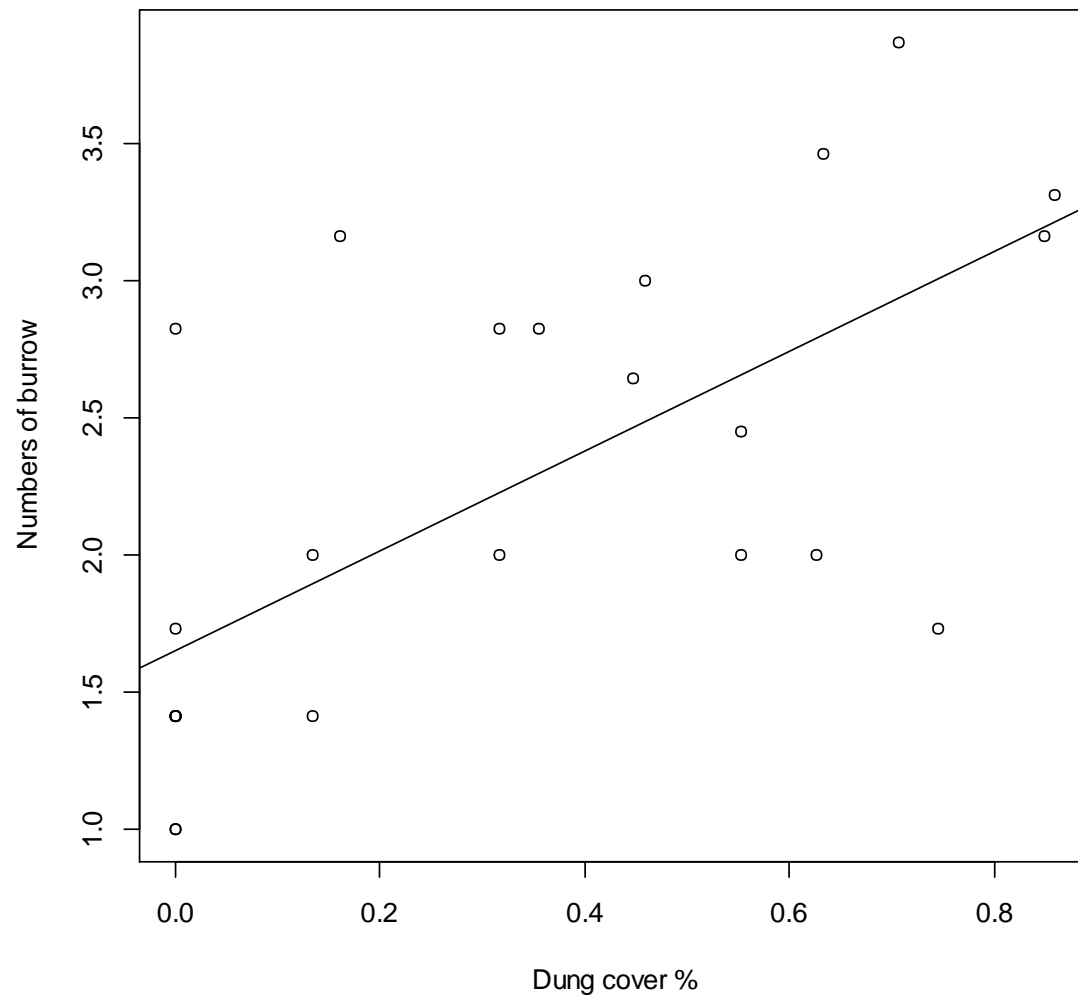


Figure 3 Odds-ratios for the effect of number of burrows on detection given occupancy compared to detection at sampling units with zero burrows.). Plotted circles show the median of the posterior distribution and the stippled lines show the posterior 2.5% and 97.5% quantiles.



437

438 Figure 4 correlation between numbers of burrows and dung cover % (coverage includes
439 both drying dung and old traces)

440