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Footprint tunnels are effective for detecting dormouse species

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ABSTRACT

Glirids are a group of arboreal rodents difficult to monitor for their nocturnal activity and their relatively low density. In this study we tested footprint tunnels in comparison with other two traditional methods (i.e. nest boxes and nest tubes) for three dormouse species in an occupancy framework. Footprint tunnels performed better than the other two techniques for *Muscardinus avellanarius* and *Glis glis* and was the only method which detected *Eliomys quercinus*. Our findings provide evidence to support the effectiveness of footprint tunnels in monitoring occurrence of dormouse species in respect to other traditionally techniques.

Keywords Cost-effectiveness, edible dormouse, garden dormouse, hazel dormouse, monitoring, occupancy

Running head: Footprint tunnels for detecting dormouse species

INTRODUCTION

Knowledge on species distribution represents the basic information necessary to establish any conservation or management strategy. In particular, the detection of rare or cryptic organisms often requires specific sampling methods and the wide variety of traditional field techniques currently employed to establish species presence-absence vary in efficacy, accuracy, effort and costs (Ryan 2018).

Glirids are a group of arboreal species difficult to monitor for their nocturnal activity and their relatively low density. Within this group, most of the species could be investigated with the use of nest boxes (e.g. Bright et al. 2006). This technique enables the collection of information not only on species presence, but also on individual behaviour, morphology and on demography. The method, however, is costly and requires a high sampling effort. Nesting tubes and hair-tubes are used to detect species presence, but their effectiveness is generally low (Bright et al. 2006; Mortelliti et al. 2010). Other monitoring techniques are species-specific. For example, nest of hazel dormice *Muscardinus avellanarius* could be spot in autumn after leaves fall and hazelnut shells are opened by these animals in a characteristic way (Bertolino et al. 2016). Moreover, edible dormice *Glis glis* have a characteristic call, used to confirm the presence of the species (Adamík et al. 2019).

Detecting footprints left by the animals is a widely used technique to monitor many mammalian species (e.g. Yarnell et al. 2014). This method was recently proposed for monitoring dormice (Haag & Tester 2016), but its usefulness has been partly evaluated only for the hazel dormouse (Bullion et al. 2018). Mills et al. (2016) proposed an application with tracking cages.

In this study, we tested cost and effectiveness of using footprint tunnels for monitoring three dormouse species, within the framework of occupancy models in order to take into account imperfect detection (MacKenzie et al. 2002). We compared this technique with two traditional methods routinely used to monitor dormice: nest boxes and nest tubes.

METHODS

The research was conducted in five valleys of the Gran Paradiso National Park, in the Western Italian Alps. In each valley, 5 transects were established along an altitudinal gradient from 800 m to 2000 m a.s.l., for a total of 25 transects (Appendix S1). Each transect was composed of 10 sampling sites, spaced 50 m one from the other, where one nest box (NB), one nesting tube (NT) and one footprint tunnel (FT) were deployed at 1.5m above the ground on the same or on the closest tree/shrub (Figure 1; see Appendix S2 for details on FT). Transects were monitored every 10 days from June to September 2018, for a total of 8 sampling sessions. During every check the presence and absence of each species for each technique was recorded at the transect level.

The effectiveness of the three monitoring techniques for three species (hazel dormouse, edible dormouse, and garden dormouse *Eliomys quercinus*) was evaluated running single-season occupancy models with the software PRESENCE 12.25 (Hines 2006). Analyses were conducted starting with the more general model, $\psi(.)p(.)$, which assume that species presence (occupancy) and detection probabilities (probability to find a species when present) were constant across time and sites and then considering a change in detectability through time $\psi(.)p(t)$. While these basic models are not the best representation of the data, using parameter estimates from different models including covariates may introduce confounding and unknown biases. Analyses using best models with covariates are reported in Appendix S3 for comparison.

Subsequently, as an example of the usefulness of this approach, we evaluated the influence of four covariates on the species presence probability using data obtained by a more efficient technique: habitat type (mixed, coniferous or deciduous forest), shrub abundance (which represents shelter for animals), diversity (i.e. food availability), and elevation (a proxy of temperature). Continuous variables were checked for correlation and standardized to z-values. After selecting the relatively best detection probability model with $p(.)$ or $p(t)$, the covariates with the occupancy probability were modelled, allowing ψ to vary with all additive combinations of variables and to find the best set of variables explaining site occupancy adjusted for imperfect detection. The minimum number of visits necessary to be confident of the species' absence from an area, was evaluated for the most effective technique using the formula $N = \ln(\alpha\text{level})/\ln(1\text{-}p)$ (Reed 1996), where α represents the probability of type I error (fixed at 0.05) and p the detection probability.

Best models were selected with the Akaike Information Theoretic approach (Burnham & Anderson, 2002) using AICc for small sample sizes. The goodness of fit of the global models were assessed by estimating the mean dispersion parameter $\hat{c}$ using 2,000 parametric bootstraps to see if at least one model fit the data, correcting the overdispersion parameter when necessary.

Model-averaging was used to obtain parameter estimates and associated standard errors for covariates present in two or more selected models (Burnham & Anderson, 2002). Akaike weights of the models were normalized to sum to one prior to model averaging.

RESULTS

Detectability was similar with the three methods for hazel dormouse (NBp = 0.52±0.07, NTp = 0.60±0.06, FTp = 0.55±0.04), much higher in FT for edible dormouse (NBp = 0.21±0.11, NTp = 0.29±0.12, FTp = 0.48±0.04), while garden dormouse was detected only by FT (FTp = 0.46±0.04) (Appendix S3).

Occupancy naïve estimation, calculated as the ratio between the number of sites where the species was detected during the surveys and the total number of sampled sites, for nest box and nest tubes, was low and similar for hazel dormouse (NB = 0.20, NT = 0.28) and low and equal for edible dormouse (NB = NT = 0.08), whereas the garden dormouse was not detected with these techniques. Through footprint tunnels, however, species were detected more frequently: hazel dormouse (FT= 0.68), edible dormouse (FT= 0.52), and garden dormouse (FT= 0.80). With this last method, species were detected since the first sampling sessions (Appendix S3).

Models with a constant detection probability received more support than models including a time-dependent detection, indicating that the detection can be considered as constant over the entire period (Appendix S3). The occupancy probabilities (Figure 2) were higher using FT for hazel dormouse and edible dormouse and unique for garden dormouse: hazel dormouse $\psi_{(FT)}$=0.68±0.09, edible dormouse $\psi_{(FT)}$=0.52±0.10, garden dormouse $\psi_{(FT)}$=0.80±0.08.

The proportion of sites where a species was detected with at least one of the three methods ψ(min) overlapped with occupancy estimations obtained with FT [ψ(.) ± 1SE] for the three species, but it was always outside the occupancy range obtained with NB and NT for all species (Table 1).

The minimum number of visits per transect necessary to establish the absence of dormice from an area with FT was between 3-5 replicates: hazel dormouse (mean, 95% confidence interval: 3.67, 2.94-4.68), garden dormouse (4.78, 3.81-6.10), edible dormouse (4.47, 3.41-6.02).

Models with FT including covariates outperformed the reference constant models (Appendix S3). Model averaging indicate an effect of altitude and habitat on species occupancy; however, effect sizes were generally low, probably due to the low number of transects that inflated the standard error. Occupancy with covariates did not differ from general models (Appendix S3).

The cost for installing one transect (consumables excluded, see Appendix S2 for FT) with ten sampling sites was 8.15 € for FT, 17.17€ for NT (2.1 more than FT) and 156.91 € for NB (19.2 more). Time to build or control a transect was: 1:30 h for FT, 0:45 h for NT, and 1:30-2:00 h for NB.

DISCUSSION

Our study emphasises the cost-effectiveness of footprint tunnels in detecting presence/absence of dormouse species compared to other traditionally used techniques (i.e. nest boxes and nest tubes). Footprint tunnels outperformed NB and NT, returning an occupancy rate nearly 5 times higher for hazel and edible dormice, while the garden dormouse was recorded only with FT. The absence of the latter species in NB and NT is probably related to its behaviour in alpine habitats, where nesting sites are located preferably in cavities between rocks inside the forest; furthermore, the species is not very arboreal spending most of the time on the ground (Bertolino et al. 2007).

Footprint tunnels have the potential to determine dormice presence much more rapidly than current dormice survey techniques and can be employed at any time throughout the active season. Our results show that dormice may visit the tunnels and hence be detected as soon as 10 days after installation with a high percentage of sites visited in this short period. Between 3 to 5 replicates were enough to establish the absence of the three dormouse species from an area. The cost for a transect with 10 FT was about € 10 including consumables.

As suggested by Bullion et al. (2018), we produced the ‘ink’ solution using charcoal designed for human consumption mixed with olive oil. Due to ink drying and the overlapping tracks that make footprint identification difficult, FT require more regular visits than the recommended monthly nest box/tube checks (Bright et al. 2006). We established a period of 10 days for checking tunnels after several tests to find the right period to avoid having too much footprints on the cardboards and maintain a wet ink pad. Additionally, this method does not require the presence of any specific tree or shrub species (e.g. hazel trees for gnawed hazel shells or hedges and bushes for searching hazel dormouse nests) and should not being affected by the availability of nesting sites.

Models with habitat variables seem to indicate an effect of altitude and habitat on the probability of presence for the three dormice species. However, effects size was low probably due to the limited number of transects. In any case, footprint tunnels could be used to effectively detect the three species and evaluate the influence of covariates on detectability and occupancy.

The three dormouse species here considered are distributed in many European countries and two of them are considered a priority for conservation. In particular, the hazel dormouse is listed in the habitat Directive 92/43/EEC and there is an obligation to monitor its distribution and report its status regularly. The garden dormouse has been lost from most of its range of distribution in central and eastern Europe. Nowadays populations are patchy and isolated in many countries and there is a need of widespread monitoring programs (Bertolino 2017). In this context, considering the lack of information and the relevant ecological role of these species, widespread monitoring programs are necessary.

Presence/absence survey techniques need to be cost-effective, allowing to detect the target species effectively, with limited human effort and inexpensive materials. The field test of alternative techniques increases the range of potential survey methods, providing ecologists with greater flexibility to choose a technique most suitable for their needs. While acoustic survey still remains cost-effective for edible dormice (Adamík et al. 2019), footprint tunnels allow to monitor multiple species simultaneously.

Footprint tunnels showed to be effective and cheaper than other two well-established techniques for detecting dormouse species. Therefore, we believe that future studies should consider footprint tunnels as a standard method for monitoring these species.

REFERENCES

Adamík P, Poledník L, Poledníková K, Romportl D (2019) Mapping an elusive arboreal rodent: Combining nocturnal acoustic surveys and citizen science data extends the known distribution of the edible dormouse (*Glis glis*) in the Czech Republic. *Mammalian Biology* 99(1): 12–18.

Bertolino S, Cordero di Montezemolo N (2007) Garden dormouse (*Eliomys quercinus*) nest site selection in an alpine habitat. *Ethology Ecology & Evolution* 19: 51–60.

Bertolino S, Büchner F, Mori E, Büchner S (2016) Presence of the hazel dormouse *Muscardinus avellanarius* at the limit of its altitudinal range. *Hystrix, the Italian Journal of Mammalogy* 2016, 27(2).

Bertolino S, (2017) Distribution and status of the declining garden dormouse *Eliomys quercinus*. *Mammal Review* 47: 133–147.

Bright P, Morris P, Mitchell-Jones T (2006) The dormouse conservation handbook. *Second edition. English Nature, Peterborough, UK.*

Bullion S, Looser A, Langton S, (2018) An evaluation of the effectiveness of footprint tracking tunnels for detecting hazel dormice. *In Practice. Bulletin of the Chartered Institute of Ecology and Environmental Management* 101: 36–41.

Burnham KP, Anderson DR (2002) Model selection and multimodel inference – a practical information-theoretic approach. Second edition, Springer, New York.

Haag L, Tester R (2016) Tracking tubes to detect dormice – a case study from Switzerland. *The Dormouse Monitor, Summer* 2016*:* 6–9.

Hines, JE (2006). PRESENCE2. Software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.usgs.gov/software/presence.html

MacKenzie DI, Nichols JD, Lachman GB, Droege S, Royle JA, Langtimm JA (2002) Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83: 2248–2255.

Mills CA, Godley BJ, Hodgson DJ (2016) Take only photographs, leave only footprints: novel applications of non-invasive survey methods for rapid detection of small, arboreal animals. *PloS one* 11(1): e0146142.

Mortelliti A, Cervone C, Amori G, Boitani L (2010) The effect of non-target species in presence-absence distribution surveys: A case study with hair-tubes. *Italian Journal of Zoology* 77: 211–215

Reed JM (1996) Using statistical probability to increase confidence of inferring species extinction. *Conservation Biology* 10: 1283–1285.

Ryan JM (2018) *Mammalogy Techniques Lab Manual*. Johns Hopkins University Press.

Yarnell RW, Pacheco M, Williams B, Neumann JL, Rymer DJ, Baker PJ (2014) Using occupancy analysis to validate the use of footprint tunnels as a method for monitoring the hedgehog *Erinaceus europaeus*. *Mammal Review* 44: 234–238.

Table 1. Parameter estimates using the general model $\psi(.)p(.)$. $\psi(min)$ is the proportion of sites where a species was detected with at least one of the three methods; $\psi(obs)$ is the proportion of sites where a species was detected with the given method, and $\psi(.)[SE]$ and $p(.)[SE]$ respectively the occupancy and detectability with related standard errors for the given technique and species. In bold cases where $\psi(min)$ fall within $\psi(.) \pm 1SE$.

		NB			NT			TT		
Species	psi(min)	psi(obs)	psi(.)[SE]	p(.)[SE]	psi(obs)	psi(.)[SE]	p(.)[SE]	psi(obs)	psi(.)[SE]	p(.)[SE]
M.avellanarius	0.68	**0.20**	**0.20[0.08]**	0.52[0.08]	**0.28**	**0.28[0.09]**	0.60[0.07]	0.68	0.68[0.09]	0.60[0.04]
G.glis	0.52	**0.08**	**0.09[0.07]**	0.21[0.11]	**0.08**	**0.08[0.06]**	0.30[0.12]	0.52	0.52[0.10]	0.49[0.05]
E.quercinus	0.80							0.80	0.8[0.08]	0.47[0.04]

Fig. 1. A footprint tunnel placed on a branch.

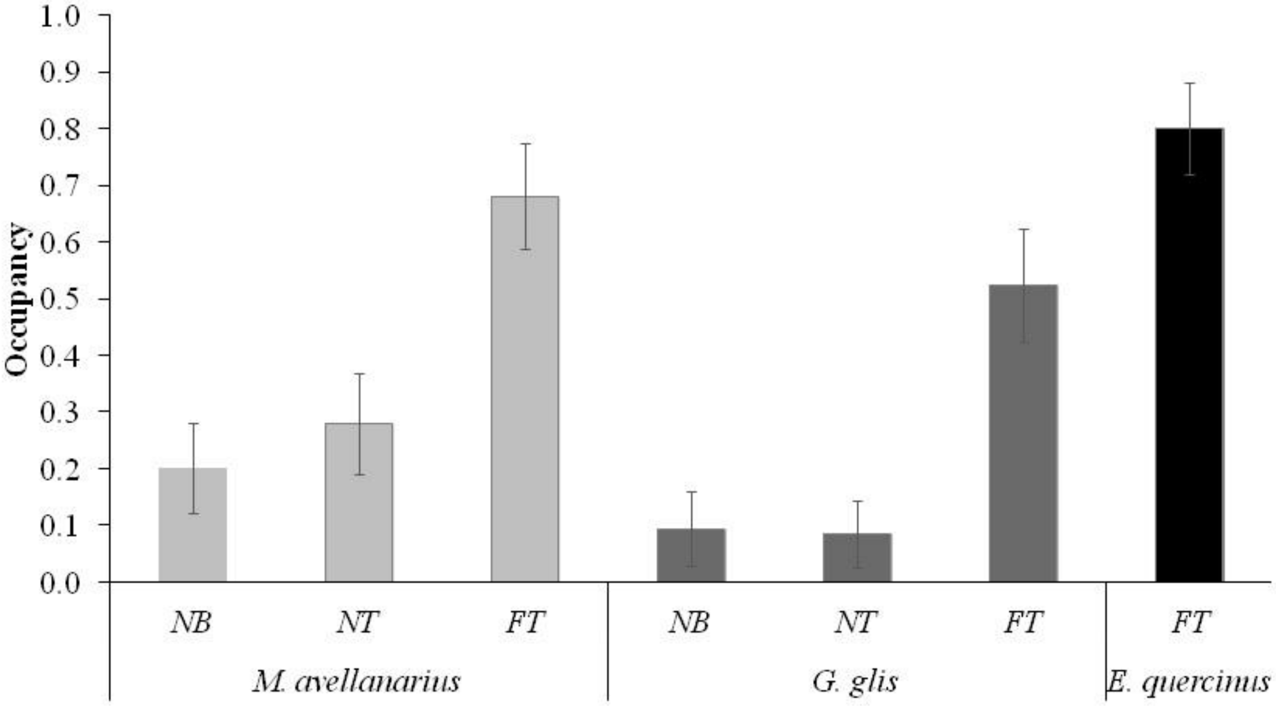

Fig. 2. Psi value (ψ±SE) for the three tested methods per each species, calculated from the base model with *psi* and *p* constant. NB: nest box; NT: nest tubes; FT: footprint tunnel.

Appendix S1. Study area and list of the 25 transects with relative coordinates

Appendix S2. How to build footprint tunnels and recognize dormouse footprints

Appendix S3. Raw data of the species presence/absence for each transect and results of general single-season occupancy models.