Habitat selection in a low-density badgers (*Meles meles*) population: a comparison of radiotracking and latrine surveys

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Abstract

Indirect methods, such as faecal counts, have been widely used for assessing the abundance and habitat preferences of many mammal species, although their reliability has been long debated. We tested the validity of this method for the Eurasian badger *Meles meles* in a low density population of northern Italy, comparing the results obtained by both radiotracking and latrine distribution. The pattern of habitat use was sharply similar with both methods. Badgers selected patches of woodland, whilst agricultural and urban areas were avoided. Latrines were mainly sited in the centre of activity of all individuals, along man-made linear features. Although our data need to be validated across a wider range of social groups, evidence suggests that latrines might be used to broadly infer habitat preferences of badgers at the landscape level in low-density areas.

1. Introduction

Landscapes consist of a dynamic (both in space and time) mosaic of heterogeneous elements named "patches" (Wiens 1976) which, offering different resources, can be of different value for animals in terms of the use that can be made of them.

The understanding of how animals interact with landscapes is a main tool for wildlife management and conservation in fragmented habitats (Noss & Csuti 1997), but it is hindered by the difficulty of quantifying all the biotic and abiotic parameters that can affect habitat selection by different species or even individuals of a same species

(Gough & Rushton 2000) and of interpreting how they perceive the surrounding environment (i.e. adopting an "organism-centred" point of view; Wiens 1989).

Dealing with nocturnal and elusive species such as carnivores, two main methods have been adopted to investigate their pattern of use of landscapes, namely radiotracking and faecal counts. With the first method, the observed number of radio-locations occurring in each habitat type is compared with habitat availability. The relative amount of time spent by an animal in the available habitat types is believed to state its preference for each particular habitat or, which is the same, to reflect the relative value of each habitat for the animal. Radiotracking is time expensive, but represents a powerful method to obtain sound information about the natural behaviour of wildlife (White & Garrott 1990).

Faecal counts are based on the same assumption as radiotracking: the intensity of marking activity, i.e. the proportion of faeces deposited by animals in the available habitats, is considered to be an index of their relative preference for each habitat type. This indirect sampling method has been widely used for assessing the abundance and habitat preferences of many mammal species (Putnam 1984, Kohn & Wayne 1997, Gese 2001), although its reliability has been the object of a long-term debate, particularly with the otter *Lutra lutra* (Kruuk et al. 1986, Mason & Macdonald 1987, Kruuk & Conroy 1987, Conroy & French 1987). The main opponents' objection is that faeces have a communication function and the site of deposition may depend on the presence of vegetation, prominent points or specific landmarks rather than reflect the pattern of habitat use (Kruuk et al. 1986). On the other hand, for many carnivores scat counts often represent the only effective, non-invasive and low cost method for deriving an index of their relative abundance in different times or habitat (Davison et al. 2002, Sadlier et al. 2004).

Eurasian badgers (*Meles meles*) are social mustelids which form spatial groups of up to 27 individuals (Rogers et al. 1997) sharing a communal home range. Badgers deposit their faeces, as well as urine and anal and sub-caudal gland secretions, into a number of shallow pits or “latrines” (Kruuk 1978, Kruuk et al. 1984, Roper et al. 1993).

The use by badgers of restricted sites for defecation (Böhm et al. 2008), rather than simply defecating randomly while foraging, and their well-documented role in intra- and inter-group communication (e.g. Gorman et al. 1984, Palphramand & White 2007) could suggest a lack of correlation between marking activity and habitat selection. According to the hypothesis of Kruuk et al. (1986), specific sites of deposition, such as linear features (e.g. ditches and fences; Roper et al. 1986, Stewart et al. 2002) and the cover of the canopy of close-standing trees, particularly conifers (Kruuk 1978, Stewart et al. 2002), have been reported to be strongly associated with latrines.

However, research on high-density badger populations has shown that woodland seems to be selected for positioning latrines, whilst arable land is generally avoided (Brown 1993, Hutchings et al. 2001).

As reported for other areas of Mediterranean Europe (Revilla & Palomares 2002, Rosalino et al. 2004, Loureiro et al. 2007), in the River Po plain (northern Italy) badgers form social groups composed of a few individuals (one male and 1-3 females), which share the same main sett (Remonti et al. 2006a). Mean sett density (0.21 setts/km^2; Remonti et al. 2006b) falls in the range of available data for continental Europe (0.04-0.65 setts/km^2), being distinctly lower than in Great Britain (0.11-4.55 setts/km^2; Kowalczyk et al. 2000).

In this paper we compare badgers' use of space as assessed by radiotracking with the pattern of use emerging from the analysis of latrine distribution in a plain, riverside protected area, where research on badger ecology has been carried out almost continuously since 2000.

Our aim was to check if, in low density populations, latrine distribution reflects the pattern of use of their home range by badgers, i.e. if marking activity can be used as a broad index of habitat preference.

2. Materials and methods

2.1. Study area

The study area includes a Natural Reserve ("Garzaia di Valenza", SE Piedmont region, NW Italy) and its surroundings, covering 12.3 km^2 on the left bank of the River Po. The whole territory is flat, extensively covered by maize crops (22.0%), rice fields (38.0%), and poplar *(Populus* sp.) plantations (16.0%). Woods (6.8%) consist of willows (*Salix cinerea*, *S. alba*), oaks (*Quercus robur*), poplars (*Populus alba* and various hybrids) and alder (*Alnus glutinosa*), bordering an abandoned river meander and three naturalized artificial lakes (3,5%). Black locusts (*Robinia pseudoacacia*) are widespread along roads and man-made embankments. Gravel soils are covered with high herbaceous vegetation mainly formed by drought-resistant Graminaceae associated with black locust shrubs (1.6%). Flood-drifts are spread near the river-bed (3.2%). Two villages and a few rural farms are scattered throughout the area (8.9%).

The climate is sub-continental temperate, with an average yearly temperature of 12.4°C and an average yearly precipitation of about 1000 mm.

In the study period, one male and 2-3 female adult badgers shared 5 setts, dug in narrow wooded strips bordering marshlands or along embankments, inside the protected area. The average home range size was 3.8 km^2 (100% MCP; Remonti et al. 2006a).

2.2. Habitat use by radiolocations

Between June 2000 and December 2003, the locations of one male and two female adult badgers belonging to a same social group were estimated by triangulation from a vehicle-mounted receiving system, usually standing less than 500 m from the animals (see Remonti et al. 2006a for details). Once per week, nocturnal locations were estimated every two hours between sunset and sunrise. The radiotracking period varied from eight (♂) to twelve months ($♀_1$, $♀_2$). A total of 358 radio-locations was collected (respectively: ♂ = 100, $♀_1$ = 124, $♀_2$ = 133; Remonti et al. 2006a).

Fixes were transferred on top of a land-cover 1:10.000 digitalized map by a Geographic Information System (Arcview 3.1). The land-cover map was produced based on ground surveys. Six land-cover types were defined: woodland (woods and high shrubs, WO), poplar plantations (PP), maize fields (MF), rice fields (RF), urban areas (villages and farms, UA) and “others” (OT), which grouped some habitats scarcely represented in the study area such as pastures, wheat-fields or gravely riverbanks.

Home ranges were drawn by the Fixed Kernel (FK) estimator (Worton 1989, Seaman & Powell 1996), using Ranges 6.0 and range boundaries were overlaid on the land-cover map.

Selectivity in habitat use during the nocturnal activity was assessed by two methods.

1) Compositional analysis (Aebischer et al. 1993): habitat preferences of individual badgers were analysed as the ratio of proportional use (the number of active radio locations within a habitat) against the proportional availability of each habitat type inside each home range (FK 95%). A $n \times n$ matrix of habitat types, where n is the number of habitat types (n = 6), was calculated for both habitat use and habitat availability,. Zero proportions were replaced with 0.0001 (Aebischer and Robertson 1992). Habitat types were ranked in the order of preference according to the value of the difference between the log-ratios of use and availability of each habitat type. We also obtained habitat preference at the group level, calculating, at each position in the matrix, the mean and standard error (SE) of all elements across the three badgers (Aebischer et al. 1993). For each element, statistical significance was determined by comparing the ratio mean / SE with t distribution with n-1 degrees of freedom, where n is the number of individuals used in the analysis.

2) We assumed that within the overall home range of the badger group the percent cover of a selected habitat type would increase in the areas of concentrated use, which were drawn by FK using different contours (from 10% to 90% in 10% intervals and 95%). The variation of the percent cover of each habitat type was tested by mean of a stepwise linear multiple regression, using Fisher's F test to check the level of significance of the model and to enter or remove the variables (SPSS 12.0.1, SPSS Inc., Chicago, USA). Before the analysis, all variables were tested for normality by Lilliefors' test. When necessary, data were transformed to achieve normality and homoschedasticity.

To obtain an absolute preference value for each habitat, we used Jacobs' preference index (Jacobs 1974), calculated as:

$$J = (r - p) / [(r + p) - 2rp],$$

where *r* is the used proportion and *p* the available proportion. *J* ranges between +1 for maximum preference and -1 for maximum avoidance.

Student's *t* test with *n-1* degrees of freedom (being *n* the number of available home ranges) was used to compare the mean value of *J* with the null hypothesis corresponding to $J = 0$ (habitat used as available).

2.3. Habitat use by latrines distribution

Latrines were searched for throughout the whole study period, following badger paths and examining linear features such as field outlines and man-made embankments. Radiotracking helped to focus on areas used by badgers. Latrines were georeferenced and overlaid on the land-cover map. Those included in a 5 m wide strip on each side of the border between two different habitat types were assigned to both habitats with a 0.5 score. The chi-square (χ^2) test with Yates' correction for small samples (Yates 1934) and Bonferroni's confidence intervals for the proportion of use were used to compare the observed and expected frequencies. Jacobs' index was also applied, as done for radiolocations.

3. Results

Applying compositional analysis, habitat use by each badger differed significantly from random (♂: WO > PP > MF > UA > OT > RF, $-N\ln\lambda = 19.7$, $P = 0.0014$, 5 d.f.; $♀_1$: WO

> OT > PP > RF > MF > UA, $-N\ln\lambda = 21.0$, $P < 0.001$, 5 d.f.; ♀$_2$: WO > PP > OT > RF > MF > UA, $-N\ln\lambda = 16.8$, $P = 0.0047$, 5 d.f.). The mean / SE matrix ranked badger habitats as follows: WO > PP > OT > MF > RF > UA; wood showed significantly greater use than the remaining habitat types ($P < 0.01$).

A similar pattern emerged with the second method: moving from the range boundaries towards the areas of concentrated use, the per cent cover of woods significantly increased ($R^2 = 0.91$, $F = 74.8$, $P < 0.0001$), whilst those of both maize and rice fields fell (respectively: $R^2 = 0.74$, $F = 19.9$, $P = 0.0029$ and $R^2 = 0.73$, $F = 19.4$, $P = 0.0031$).

Using Jacob's preference index woods were the only selected habitat ($J_{WO} = 0.94$, $t = 145.3$, $P < 0.0001$), whilst maize ($J_{MF} = -0.73$, $t = 6.8$, $P = 0.021$) and rice fields ($J_{RF} = -0.74$, $t = 6.08$, $P = 0.026$) were avoided.

A total of 14 latrines was found, with a mean of 5.3 pits each (Standard Deviation = 4.9, min-max = 1-17). Latrines were not distributed according to habitat availability ($\chi^2 = 166.4$, $P < 0.0001$, 4 d.f.): they were mainly sited inside woods or at their margins, whilst fields were avoided (Fig. 1).

Jacobs' index showed a similar pattern, but including urban areas among avoided habitats ($J_{WO} = 0.97$, $J_{OT} = 0.56$, $J_{PP} = -0.19$, $J_{MF} = -0.97$, $J_{RF} = -1$, $J_{UA} = -1$).

Most latrines were placed under tree cover (85.7%) and close to linear features (71.4%).

Eleven latrines (79%) were situated inside the 60% isopleth (Fig. 2), which broadly corresponded to the area of overlap of the three home ranges.

4. Discussion

The pattern of habitat use drawn by latrine distribution was essentially identical to that obtained by radiotelemetry. In the agricultural landscape which formed the badgers' environment, the small available wooded areas were sharply selected by badgers both for their nocturnal activity and for marking.

The preference of badgers for woods might ensue from their selection of suitable sett-sites: setts require slope, cover and seclusion, and woods often represent an optimal solution in rural areas (Thornton 1988, Revilla et al. 2001, Jepsen et al. 2005) such as the River Po plain (Balestrieri & Remonti 2000, Balestrieri et al., 2006, Remonti et al. 2006b).

Nonetheless, in the interval between two consecutive fixes (2 hrs.) badgers proved to be able to cover a distance equal to their range maximum width (Remonti et al. 2006a) suggesting that the large amount of time spent by them in the wooded surroundings of their main sett was not only a consequence of its location.

Trophic resources availability and distribution have been most frequently quoted among the several parameters and ecological constrains which can influence animals selection of a particular habitat (Krebs 1994). Wherever available, earthworms are the staple food for badgers, their abundance and distribution determining the badgers' home range size and numbers (review in Johnson et al. 2000). In our study area, woods were likely to be related to foraging activities, the availability of earthworms, which form with maize the bulk of badger diet, being the highest under the tree canopy and the lowest in cultivated lands (Balestrieri et al. 2004). Accordingly, in the middle boreal region, where coniferous forests are widespread, Brøseth et al. (1997) reported the selection by badgers for the small patches of deciduous forest offering the highest earthworm biomass.

Finally, in heavily managed areas the need of badgers for seclusion cannot be excluded as a factor determining the selection for woods, even if their nocturnal habits limit the chance of human interference.

Latrine distribution agreed with the selection for linear elements of the landscape and cover highlighted by previous studies (Kruuk 1978, Roper et al. 1986, Feore & Montgomery 1999, Delahay et al. 2007). The chance of faeces being discovered by conspecifics is enhanced by the siting of latrines next to linear features, which are likely to channel badger movements (Stewart et al. 2002). Man-made linear features are widespread in rural areas, as low banks criss-cross the fields (particularly rice-fields). Tracks showed that these banks were often used by badgers as travelling routes but, nonetheless, avoided for marking. As suggested by Stewart et al. (2002), the lack of vegetation characterizing field banks could explain the preference of badgers for marking sites inside wooded areas, the canopy of trees reducing the washing away of faeces by rain. Both Stewart et al. (2002) and Kruuk (1978) found a positive association with conifers, whose dense canopy is likely to protect faeces from rain during all seasons, whilst deciduous trees are likely to offer a less effective protection, particularly in winter. Incidentally, in our study area the two largest and most enduring latrines were dug under shrubs or scattered oak woods and, moreover, in clayey, moist soils which retain water from heavy rain for days, suggesting that the protection of scent marks was not the factor inducing badgers to mark in those particular spots.

Marking activity took place in the centre of activity of all individuals, confirming that the sharp correspondence between the data from radiotracking and surveys for latrines was not a casual by-product of badger choice for the most effective sites for scent marks deposition.

Questioning the validity of faeces counts to assess habitat selection by otters, Kruuk and Conroy (1987) asserted that faeces do not indicate importance of sites for activities other than marking, quoting bridges for otters and lamp-posts for domestic dogs. These examples may lead to some misunderstanding, confusing the selection for habitats with that for marking sites. Our results suggest that these two levels of selection must be clearly distinguished: among available marking sites - linear elements - badgers selected those crossing the habitat – woods - where all the members of the group were most active and scent-messages had the highest probability of being shared.

The small sample size of our study does not allow to infer general conclusions about the validity of surveys for latrines to assess habitat selection of badgers. Nonetheless, a similar pattern seemed to emerge in a hilly area of northern Italy, where, however, surveys were not careful enough to allow sound comparison with radiotracking data (Balestrieri et al., 2006). Moreover, in southern Portugal, surveys for badger signs have outlined a pattern of habitat selection consistent with that drawn through radiotelemetry (Rosalino et al. 2008).

Although radiotracking allows the best insight into carnivore territorial behaviour at a small scale level, available evidence suggests that latrine distribution might be used to broadly determine the habitat selection of badgers at the landscape level in low-density populations.

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References

Aebischer, N.J. & Robertson, P.A. 1992: Practical aspects of compositional analysis as applied to pheasant habitat utilization. - In: Priede, I.G. & Swift, S.M. (Eds.); Telemetry: Remote Monitoring and Tracking of Animals.Wildlife Ellis Horwood, Chichester, pp. 285-293.

Aebischer, N.J., Robertson, P.A. & Kenward, R.E. 1993: Compositional analysis of habitat use from animal radio-tracking data. - Ecology 74: 1313-1325.

Balestrieri, A. & Remonti, L. 2000: Reduction of badger (Meles meles) setts damage on artificial elements of the territory. - Hystrix It. J. Mamm. (n.s.) 11 (2): 3–6.

Balestrieri, A., Remonti, L. & Prigioni, C. 2004: Diet of the Eurasian badger (Meles meles) in an agricultural riverine habitat (NW Italy). - Hystrix The Italian Journal of Mammalogy 15 (2): 3-12.

Balestrieri, A., Remonti, L. & Prigioni, C. 2006: Reintroduction of the Eurasian badger (Meles meles) in a protected area of northern Italy. - Italian Journal of Zoology 73 (3): 227-235.

Böhm, M., Palphramand, K.L., Newton-Cross, G., Hutchings, M.R. & White, P.C.L. 2008: The spatial distribution of badgers, setts and latrines: the risk for intra-specific and badger-livestock disease transmission. Ecography doi: 10.1111/j.2008.0906-7590.05314.x.

Brøseth, H., Knutsen, B. & Bevanger, K. 1997: Spatial organization and habitat utilization of badgers Meles meles: effects of food patch dispersion in the boreal forest of central Norway. - Zeitschrift für Säugetierkunde 62: 12–22.

Brown, J.A. 1993: Transmission of bovine tuberculosis (Mycobacterium bovis) from badgers (Meles meles) to cattle. - PhD thesis, University of Bristol.

Conroy, J.W.H. & French, D.D. 1987: The use of spraints to monitor populations of otters (Lutra lutra L.). – Symposia of the Zoological Society of London 58: 247-262.

Davison, A., Birks, J.D.S., Brookes, R.C., Braithwaite, T.C. & Messenger, J.E. 2002: On the origin of faeces: morphological versus molecular methods for surveying rare carnivores from their scats. - Journal of Zoology of London 257: 141–143.

Delahay, R.J., Ward, A.I., Walker, N., Long, B. & Cheeseman, C.L. 2007: Distribution of badger latrines in a high-density population: habitat selection and implications for the transmission of bovine tuberculosis to cattle. - Journal of Zoology 272: 311–320.

Feore, S. & Montgomery, W.I. 1999: Habitat effects on the spatial ecology of the European badger (Meles meles). Journal of Zoology of London 247: 537–549.

Gese, E.M. 2001: Monitoring of terrestrial carnivore populations. - In: Gittleman, J.L., Funk, S.M., Macdonald, D.W. & Wayne, R.K. (Eds.); Carnivore conservation. Ithaca, New York, USA, Cambridge University Press 372-396.

Gorman, M.L., Kruuk, H. & Leitch, A. 1984: Social functions of the sub-caudal scent gland secretion of the European badger Meles meles (Carnivora: Mustelidae). - Journal of Zoology of London 204: 549–559.

Gough, M.C. & Rushton, S. 2000: The application of GIS modelling to mustelid landscape ecology. - Mammal Review 30 (3 & 4): 197-216.

Hutchings, M.R., Service, K.M. & Harris, S. 2001: Defecation and urination patterns of badgers (Meles meles) at low density in south west England. - Acta Theriologica 46: 87–96.

Jacobs, J. 1974: Quantitative measurements of food selection. A modification of the forage ratio and Ivlev's electivity index. - Oecologia (Berl.) 14: 413-417.

Jepsen, J.U., Madsen, A.B., Kalsson, M. & Groth, D. 2005: Predicting distribution and density of European badger (Meles meles) setts in Denmark. - Biodiversity and Conservation 14: 3235-3253.

Johnson, D.D.P., Macdonald, D.W. & Dickman, A.J. 2000: An analysis and review of models of the sociobiology of the Mustelidae. - Mammal Review 30 (3): 171-196.

Kohn, M.H. & Wayne, R.K. 1997: Facts from feces revisited. - Trends in Ecology and Evolution 12: 223–227.

Kowalczyk, R., Bunevich, A.N. & Jédrzejewska, B. 2000: Badger density and distribution of setts in Bialowieza Primeval Forest (Poland and Belarus) compared to other Eurasian populations. - Acta Theriologica 45: 395–408.

Krebs, C.J. 1994: Ecology: The Experimental Analysis of Distribution and Abundance. - 4th Edition, Harper Collins College Publishers, New York.

Kruuk, H. 1978: Spatial organization and territorial behaviour of the European badger Meles meles. – Journal of Zoology of London 184: 1–19.

Kruuk, H. & Conroy, J.W.H. 1987: Surveying otter Lutra lutra populations: a discussion of problems with spraints. - Biological Conservation 41: 179-183.

Kruuk, H., Gorman, M.L. & Leitch, A. 1984: Scent marking with the sub-caudal gland by the European badger (Meles meles). - Animal Behaviour 32: 899–907.

Kruuk, H., Conroy, J.W.H., Glimmerveen, U. & Ouwerkerk, E.J. 1986: The use of spraints to survey populations of otters Lutra lutra. - Biological Conservation 35: 187-194.

Loureiro, F., Rosalino, L.M., Macdonald, D.W. & Santos-Reis, M. 2007: Use of multiple den sites by Eurasian badgers, Meles meles, in a Mediterranean habitat. – Zoological Science 24: 978-985.

Mason, C.F. & Macdonald, S.M. 1987: The use of spraints for surveying otter (Lutra lutra) populations: an evaluation. - Biological Conservation 41: 167-177.

Noss, R.F. & Csuti, B. 1997: Habitat fragmentation. - In: Meffe, G.K. & Carroll, C.R. (Eds.); Principles of Conservation Biology, 2nd Editon. Sinauer Associates, Inc, Sunderland 269-304.

Palphramand, K.L. & White, P.C.L. 2007: Badgers, Meles meles, discriminate between neighbour, alien and self scent. Animal Behaviour 74: 429-436.

Putman, R.J. 1984: Facts from faeces. - Mammal Review 14: 79–97.

Remonti, L., Balestrieri, A. & Prigioni, C. 2006a: Range of the Eurasian badger (Meles meles) in an agricultural area of northern Italy. - Ethology Ecology & Evolution 18 (1): 61-67.

Remonti, L., Balestrieri, A. & Prigioni, C. 2006b: Factors determining badger Meles meles sett location in agricultural ecosystems of NW Italy. - Folia Zoologica 55 (1): 19-27.

Revilla, E. & Palomares, F. 2002: Spatial organization, group living and ecological correlates in low-density populations of Eurasian badgers, Meles meles. - Journal of Animal Ecology 71: 497–512.

Revilla, E., Palomares, F. & Fernandez, N. 2001: Characteristics, location and selection of diurnal resting dens by Eurasian badgers (Meles meles) in a low density area. - Journal of Zoology of London 255: 291–299.

Rogers, L.M., Cheeseman, C.L., Mallinson, P.J. & Clifton-Hadley, R. 1997: The demography of a high density badger (Meles meles) population in the west of England. - Journal of Zoology of London 242: 705–728.

Roper, T.J., Conradt, L., Butler, J., Christian, S.E., Ostler, J. & Schmid, T.K. 1993: Territorial marking with faeces in badgers (Meles meles): a comparison of boundary and hinterland latrine use. - Behaviour 127: 289–307.

Roper, T.J., Shepherdson, D.J. & Davies, J.M. 1986: Scent marking with faeces and anal secretion in the European badger (Meles meles): seasonal and spatial characteristics of latrine use in relation to territoriality. - Behaviour 97: 94–117.

Rosalino, L.M., Macdonald, D.W. & Santos-Reis, M. 2004: Spatial structure and land-cover use in a low density Mediterranean population of Eurasian badgers. – Canadian Journal of Zoology 82: 1493-1502.

Rosalino, L.M., Santos, M.J., Beier, P. & Santos-Reis, M. 2008: Eurasian badger habitat selection in Mediterranean environments: does scale really matter? – Mammalian biology 73: 189-198.

Sadlier, L.M.J., Webbon, C.C., Baker, P.J. & Harris, S. 2004: Methods of monitoring red foxes Vulpes vulpes and badgers Meles meles: are field signs the answer? - Mammal Review 34 (1): 75–98.

Seaman, D.E. & Powell, R.A. 1996: An evaluation of the accuracy of Kernel density estimators for home range analysis. - Ecology 77 (7): 2075-2085.

Stewart, P.D., Macdonald, D.W., Newman, C. & Tattersall, F.H. 2002: Behavioural mechanisms of information transmission and reception by badgers, Meles meles, at latrines. - Animal Behaviour 63: 999–1007.

Thornton, P.S. 1988: Density and distribution of badgers in south-west England - a predictive model. - Mammal Review 18: 11-23.

Wiens, J.A. 1976: Population responses to patchy environments. - Annual Review of Ecological Systems 7: 81-120.

Wiens, J.A. 1989: Spatial scaling in ecology. - Functional Ecology 3: 385-397.

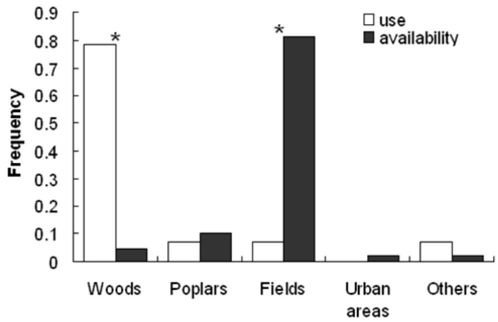
White, G.C. & Garrott, R.A. 1990: Analysis of wildlife radio-tracking data. - Academic Press, San Diego, California, USA, 386 pp.

Worton, B.J. 1989: Kernel methods for estimating the utilization distribution in home range studies. - Ecology 70 (1): 164-168.

Yates, F. 1934: Contingency tables involving small numbers and the test χ^2. - Journal of the Royal Statistical Society 1: 217-235.

Figure 1. Habitat selection as assessed by badger latrines distribution (*$p<0.001$).

Figure 2. Home range (95% and 60%, Fixed Kernel estimator), setts and latrines of the badger group.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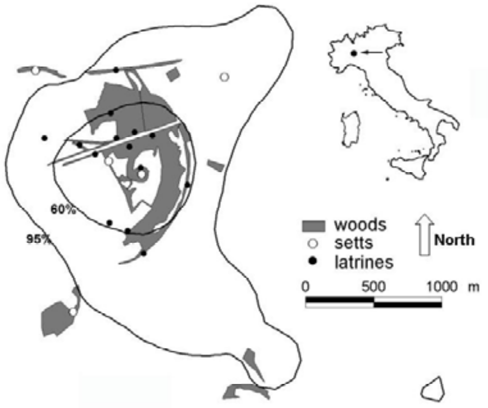
Fields
Urban areas
Others



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