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# Badger *Meles meles* setts in the Swiss Jura Mountains: characteristics and utilization patterns

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**Badger *Meles meles* setts in the Swiss Jura Mountains: characteristics and utilization patterns. -** Sett characteristics and utilization patterns by badgers *Meles meles* were investigated in a central European mountainous area. Two study areas located at the foothill and on the mountain top respectively were compared. Data on diurnal resting sites were provided by locating daily eight radio-collared badgers in the lowland area and three radio-tagged individuals in the mountain area. In both areas, main setts were preferentially located in the forest, and badgers avoided open habitat for their outlier setts. Distance to nearest house was not different for lowland and mountain main and outlier setts. Badgers used a mean of 6 (± 1.7) and 4.1 (± 2.4) different setts in the mountain and in the plain, respectively. Seasonal variation in sett use was observed in both areas. For instance, mountain badgers rested predominantly in outlier setts during summer. The number of consecutive days badgers used a same resting site before moving to another one was lower in summer than in other seasons.

**Keywords**: European badger - *Meles meles* - sett use - mountainous habitat - Switzerland.

## INTRODUCTION

As the centre of most social, breeding and resting activities, dens called 'setts' are an essential element of European badger *Meles meles* ecology. Depending on the size, the complexity, and the frequency of utilization by badgers, setts are generally categorized into two types: main and outlier setts (Neal, 1986). While the former consist of frequently-used large and complex structures of inter-connected tunnels and chambers, the latter are usually smaller and used only sporadically (Kruuk, 1989; Roper, 1992a). Typically, a badger territory holds several setts, and their location is influenced by various parameters such as the type of soil, the slope of the terrain, vegetation cover and human disturbance (Neal, 1986; Neal & Roper, 1991).

Setts are used as diurnal resting sites. In this regard, sett utilization does not follow any routine, since badgers may periodically change resting sites within a sett or between setts (Kruuk, 1978, 1989; Brøseth *et al.*, 1997; Roper *et al.*, 2001; Kowalczyk *et al.*, 2004). Several hypotheses have been put forward to explain why badgers use

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different setts as resting sites within their territories. First, as the animals are often infested by a variety of ectoparasites such as fleas and ticks (Hancox, 1980), Neal and Roper (1991) suggested that periodical movements from one resting site to another may help badgers to avoid a build-up of ectoparasites. Some evidence supporting this ectoparasite avoidance hypothesis was found by Butler & Roper (1996) and more recently by Roper *et al.* (2001). Another explanation relates sett use and social factors. To escape from harassment by dominant conspecifics when sharing the main sett, subordinate badgers would be more inclined to rest in outliers (Kruuk, 1989). Lastly, a third hypothesis suggests that badgers prefer to rest in an outlier close to their feeding grounds instead of returning after their foraging period to a possibly more distant main sett (Kowalczyk *et al.*, 2004).

Although the badger has been extensively studied throughout its range, sett use has only been investigated in a few occasions. In addition, most studies dealing with this aspect have been carried out in Britain where much higher badger densities, larger group size and different ecology could influence sett use (Kruuk, 1989; Roper & Christian, 1992; Roper *et al.*, 2001) in a different way than in Scandinavia (Brøseth *et al.*, 1997), Mediterranean countries (Revilla *et al.*, 2001), or central Europe (Kowalczyk *et al.*, 2004). In a recent paper, Do Linh San (2002a) presented data on sett utilization by badgers in a Swiss agricultural area. However, this study was carried out without telemetry in its early stage and based on the occurrence of badger signs at setts. In these circumstances, individual sett use could not be quantified.

In this paper, we describe badger setts and their location, and we examine and compare the use of individual setts as diurnal resting sites by badgers in a lowland and in a mountainous area of Switzerland.

## STUDY AREA AND METHODS

The plain, or lowland, study area is located at the foothill of the Swiss Jura Mountains (47°02' N, 7°00' E; altitude: 430-630 m a.s.l.). Most of the 26 km$^2$ area is highly influenced by both professional and sporting human activities. Forests are mainly dominated by oak *Quercus* spp. and beech *Fagus silvatica* and represent 46.2% of the study area. Agricultural land occupies more than 40% of the surface and is the second most important feature of the area; it consists of arable land and pastures (39%), vineyards (2.2%), and wooded pastures and edges (0.6%). Villages and roads cover the remaining 12% of the area. The mean annual temperature is 10.4° C and the mean annual precipitation is 962 mm.

Situated at the top of the Swiss Jura Mountains (47°09' N, 6°56' E; altitude: 995-1288 m a.s.l.), the 30 km$^2$ mountainous study area is also influenced by agriculture. Cattle breeding is the main human activity. Consequently, grasslands and wooded pastures come first amongst the different habitats in the area and cover 52% and 25% of it, respectively. Small patches of forest dominated by spruce *Picea abies* also occur in the area (20%). Less numerous than in the lowland study area, human settlements and roads represent only 3% of the surface. The climate is wet (mean annual precipitation: 1460 mm) and cold (mean annual temperature: 6.5° C).

Badger densities were low in both study areas. Density estimates ranged from 2.8 to 3.3 individuals/km$^2$ in the lowland area and from 0.5 to 0.9 individuals/km$^2$ in

the mountainous area (Ferrari, 1997). Eight (5 males, 3 females) and three (2 males, 1 female) badgers were trapped or neck-snared in the plain and mountainous areas, respectively. Traps and snares were regularly checked during the night to avoid injuries to badgers. The lowland individuals came from five different social groups, whereas the mountain badgers belonged to three different social units. Except one male caught before the 31 December of its first year, all individuals were adults (i.e. caught after the 31 December of their first year). Badgers were immobilized by an intramuscular injection of ketamine hydrochloride, weighed, sexed and aged. Captured individuals were then fitted with activity-monitoring transmitters (Wildlife Material Inc., Carbondale, Illinois; models HPLM-2140-LDA and HPLM 2124-LDA) and tracked using a portable receiver (Falcon Five, Wildlife Materials Inc.) and a hand-held three-element Yagi antenna (Wildlife Materials, Inc.). Radio tracking was performed between summer 1993 and spring 1996. Daily locations (1 fix per animal each day; lowland area: N = 1767; mountainous area: N = 338) provided data on the utilization of setts as diurnal resting sites. Setts were classified into two categories: main setts and outliers (Neal, 1986). Main setts are large and occupied permanently by the members of a badger group. Usually, reproduction occurs in main setts. Outliers are smaller and their occupation by badgers is generally sporadic or discontinuous (Kruuk, 1989; Roper, 1992a). The area in a 10 m radius around each diurnal resting site was characterized using various parameters: i) five categories of habitat were distinguished in the lowland area: forest, semi-open (i.e. wooded pasture and edge), open (i.e. pasture and culture), vineyard and building (i.e. house, and garden). Except vineyard which does not occur in the area, the same categories were used for the mountainous region; ii) vegetation cover (shrubs and trees) was assessed according to the method of the sigmatist school (Braun-Blanquet, 1951); iii) the slope and aspect of each sett were evaluated using an air-level and a folding rule, and a compass, respectively; iv) entrances were counted; v) distance to nearest field and distance to nearest house were measured on the local 1:25'000 Swiss national map. Seasons were defined following a meteorological subdivision of the year (spring: March-May; summer: June-August; autumn: September-November; winter: December-February).

Considering sett location, preference or avoidance of habitat was quantified using a Bonferroni $z$ statistic (Neu *et al.*, 1974; Byers *et al.*, 1984). Chi-square test was used to compare seasonal variation in sett occupancy, and Mann-Whitney U test, Exact binomial test and Kruskall-Wallis test to compare the habitat parameters for setts and duration of sett occupancy, respectively.

## RESULTS

### Location and description of setts

Twenty-one diurnal resting sites of badgers were identified in the lowland study area. No badger was found resting above ground during the day. Main setts (N = 5) were exclusively located in the forest, all other habitats being significantly avoided by badgers (Bonferroni confidence intervals, $p = 0.0025$; Table 1). Most outlier setts (N = 16) were also found in the forest. However, except for open habitat that was clearly avoided ($p = 0.0025$), badgers did not show any habitat preference for their outlier setts

(Table 2). Four of them were in man-made structures (i.e. sheds and pipes). Vegetation cover (mean ± SD: 50 ± 30%; range: 10-100%) and slope (20 ± 10°; range: 10-40°) were similar for both categories of setts (Table 3). Main setts had more entrances (12.2 ± 3.8; range: 8-15) than outliers (1.6 ± 0.9; range: 1-4; Mann-Whitney U test, $p < 0.001$). Concerning the aspect, most outliers were facing southeast, while there was no preference in the very small sample of main setts (Exact binomial test, $p < 0.001$; Table 4). Mean distance to nearest field (195.2 ± 161.2 m; range: 30-700 m) and mean distance to nearest house (313 ± 173 m; range: 5-500 m) did not differ between main and outlier setts (Table 3).

Also mountain badgers always spent the day underground. Habitat selection for sett establishment was similar to that in the plain. Main setts (N = 3) were preferentially located in the forest, and badgers avoided open habitat for their outlier setts (N = 15; Bonferroni confidence intervals, $p = 0.0062$; Tables 5 & 6). One of the latter was dug under a railway. Other habitat parameters for setts were not different to those in lowland, except for the following: the slope of outliers was smaller in the mountainous area (10 ± 10°; range: 0-50°; Mann-Whitney U test, $p < 0.05$) and distance to nearest field was greater for mountain outlier setts (474.7 ± 246.2 m; range: 50-1000 m; $p < 0.001$) than for lowland ones (Table 3).

### Utilization of setts

On average, individual badgers used 6 (± 1.7; range: 4-7) different setts in the mountain area, whereas each lowland badger used a mean of 4.1 (± 2.4; range: 1-8) setts (Mann-Whitney U test, $p > 0.05$). The latter chose to a large extent their main setts as diurnal resting sites, and only 25.3% of the total daily radiolocations (N = 1767) were assigned to outlier setts (Table 7). In contrast, mountain badgers were more often located in outliers during the day (45.6%; N = 338; $c^2 = 57.12$, $p < 0.0001$). Seasonal variation in sett use has been observed in both areas ($p < 0.0001$). Utilization of main setts decreased significantly from winter to summer, and then increased again. However, main setts remained the preferred diurnal resting sites for lowland badgers in any season, whereas mountain badgers rested predominantly in outlier setts during summer (Table 7).

Considering the number of consecutive days badgers remained in a particular diurnal resting site before moving to another one, we found individual and seasonal variations (Table 8). Areas were pooled because sample size was too small to compare lowland and mountain badgers. However, in both areas, badgers used the same resting site for a shorter period in summer (2.68 ± 1.06 consecutive days) than in other seasons (Kruskall-Wallis test, $p < 0.05$; Table 8).

## DISCUSSION

### Location and description of setts

Generally, badgers exploit different types of shelter for their diurnal rest (Neal 1986). In addition to natural setts, they also use man-made structures such as drainpipes or cottages (Henry *et al.*, 1988; Brøseth *et al.*, 1997), a behaviour recorded to a lesser extent during our study. Typically, badger clans have one main sett and several outliers in their territory (Kruuk, 1978). As breeding sites, main setts constitute a

resource of primary importance to badgers (Neal & Roper, 1991; Roper, 1992b, 1993; Doncaster & Woodroffe, 1993), and for this reason they can be used for decades or even centuries (Neal, 1986). Consequently their size progressively increases, and eldest main setts count often more than 50 entrances (van Wijngaarden & van de Peppel, 1964; Anrys & Libois, 1983; Neal, 1986; Roper 1993). However, such dimensions are not a general rule: as observed in earlier studies the mean number of entrances is usually comprised between 10 and 14 (Kruuk, 1978; Anrys & Libois, 1983; O'Corry-Crowe *et al.*, 1993). The mean number of main sett entrances recorded in our two study areas (11 and 12.2 entrances, respectively) is close to those values. In contrast, outliers are much smaller and their occupation is usually discontinuous or sporadic (Kruuk, 1989; Roper, 1992a). Moreover, they are rarely used for reproduction, although some females in high-density badger populations could occasionally use them for this purpose (Cresswell *et al.*, 1992). In our study areas, outlier setts have in average 1.6 (lowland) and 2.1 entrances (mountain), confirming former observations (Kruuk, 1978; Neal, 1986; Henry *et al.*, 1988; Roper, 1992b; O'Corry-Crowe *et al.*, 1993).

Diurnal resting sites of badgers can be found in various habitat types (Henry *et al.*, 1988) but three factors influence predominantly the choice of a site favourable to their installation: a soil easy to dig, a slope which facilitates water drainage and evacuation of excavated material, and a dense vegetation cover to ensure protection and concealment (Neal, 1986; Neal & Roper, 1991). The latter factor seems important since badgers make their setts preferentially in wooded areas such as forests and edges, and avoid open habitats (Kruuk, 1978; Neal 1986; O'Corry-Crowe *et al.*, 1993; Brøseth *et al.*, 1997). Our results confirm these general preferencies. In both study areas, diurnal resting sites are located on medium slopes and are surrounded by a dense vegetation cover. Open areas are also clearly avoided.

Disturbance caused by man and his activities may influence the choice of a diurnal resting site, although badgers can get accustomed to human neighbourhood if landscape structure and/or human density require it (Harris, 1982; Skinner *et al.*, 1991). In our study areas, diurnal resting sites are usually located at considerable distance from human settlements and cultivated fields. Besides, unlike elsewhere (Paget, 1980; Harris, 1982; Rodriguez *et al.*, 1996; van Teeffelen *et al.*, 2001; Do Linh San, 2002b; Kowalczyk *et al.*, 2004), our badgers were never found resting above ground during the day.

Aspect is another important factor to consider for sett site selection. In the boreal forest of central Norway, badgers prefer setts facing south to southwest directions likely because of increased sun radiation and earlier melting of snow at these sites (Brøseth *et al.*, 1997). A similar pattern has also been described in earlier studies (van Wijngaarden & van de Peppel, 1964; Anrys & Libois, 1983; Skinner *et al.*, 1991) and was confirmed by our observations. However, if aspect seems to play a significant role in outliers, it has almost no influence as far as main setts are concerned (Table 4). This could be due to the fact that the siting of main setts is determined principally by other factors like vegetation and slope.

### Utilisation of setts

With the exception of a female that was always located in her main sett during the day, badgers from both study areas used, beside main sett, different outlier setts

(range: 1-7). Utilization of setts as diurnal resting site showed similar seasonal variations in both lowland and mountain areas. Main sett occupancy was higher in autumn and winter, whereas outlier setts use increased considerably in spring and summer. This pattern has been described in a number of studies and likely results from ecological and social constraints (Roper & Christian, 1992; Sleeman & Mulcahy, 1993; Roper *et al.*, 2001).

Ambient temperature seems to have a significant effect on the behaviour of badgers during the coldest months. During this period, badgers find better climatic conditions in the main setts where external temperature has a negligible influence. The microclimate prevailing in their deepest parts is constant year-round. Moreover, the chambers of the main setts are usually large enough to be shared by several individuals that limit their losses of heat by sleeping side by side (Roper, 1992a, 1992b). In contrast, external temperature has a strong influence in outliers because of their smaller size and this could deter badgers to choose them during the cold seasons (Bock, 1988; Roper, 1992b). On the other hand, external temperature possibly plays a less important role during other seasons, particularly in summer.

The design of our study and the small number of radiocollared individuals did not allow addressing the hypotheses related to sett use, and, for instance, finding any evidence of an influence of social factors on the use of diurnal resting sites. However, in low density badger populations – like ours – social interactions have probably a secondary role in that process, though higher social tension within badger groups could partly explain the decrease in main sett occupancy in the cub-rearing season. The higher turnover in sett use recorded in summer could be an ectoparasite avoidance strategy, but it could also result from an increasing foraging activity as usually observed during the warm season (Henry *et al.*, 1988; Roper, 1994). Finally, home ranges of badgers are larger in the mountain than in the lowland and individuals are often located several km away from the main sett at the end of the activity period (Ferrari, 1997). Utilization of outliers is also more frequent in the mountain than in the lowland. Under these circumstances and to avoid too high energy expenditure, badgers could probably prefer to spend the day in an outlier sett close to food patches, rather than to undertake a long, and sometimes risky, journey back to the main sett (Henry *et al.*, 1988; Kowalczyk *et al.*, 2004).

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TABLE 1. Location of badger main setts in the lowland study area

| Habitat | Proportion in the study area | Main setts (N = 5) | Proportion of main setts | Confidence interval Low | Confidence interval High | |
|---|---|---|---|---|---|---|
| Forest | 0.462 | 5 | 1.000 | 1.000 | 1.000 | Preference |
| Semi-open | 0.006 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Open | 0.390 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Vineyard | 0.022 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Building | 0.120 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |

TABLE 2. Location of badger outlier setts in the lowland study area. ns: non-significant

| Habitat | Proportion in the study area | Outlier setts (N = 16) | Proportion of setts | Confidence interval Low | Confidence interval High | |
|---|---|---|---|---|---|---|
| Forest | 0.462 | 10 | 0.626 | 0.316 | 0.926 | ns |
| Semi-open | 0.006 | 1 | 0.062 | 0.000 | 0.217 | ns |
| Open | 0.390 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Vineyard | 0.022 | 1 | 0.062 | 0.000 | 0.217 | ns |
| Building | 0.120 | 4 | 0.250 | 0.000 | 0.528 | ns |

TABLE 4. Aspect of badger setts in the Swiss Jura Mountains

| | N | S | E | W | NE | NW | SE | SW |
|---|---|---|---|---|---|---|---|---|
| Main setts - lowland (N = 5) | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| Outlier setts - lowland (N = 16) | 0 | 2 | 1 | 0 | 3 | 1 | 9 | 0 |
| All setts - lowland (N = 21) | 0 | 3 | 2 | 1 | 3 | 2 | 10 | 0 |
| Main setts - mountain (N = 3) | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| Outlier setts - mountain (N = 15) | 2 | 2 | 1 | 1 | 1 | 1 | 6 | 1 |
| All setts - mountain (N = 18) | 2 | 2 | 1 | 1 | 1 | 2 | 8 | 1 |

TABLE 5. Location of badger main setts in the mountainous study area

| Habitat | Proportion in the study area | Main setts (N = 3) | Proportion of main setts | Confidence interval Low | Confidence interval High | |
|---|---|---|---|---|---|---|
| Forest | 0.200 | 3 | 1.000 | 1.000 | 1.000 | Preference |
| Semi-open | 0.250 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Open | 0.520 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |
| Building | 0.030 | 0 | 0.000 | 0.000 | 0.000 | Avoidance |

TABLE 6. Location of badger outlier setts in the mountainous study area. ns: non-significant

| Habitat | Proportion in the study area | Outlier setts (N = 15) | Proportion of setts | Confidence interval Low | High | |
|---|---|---|---|---|---|---|
| Forest | 0.200 | 7 | 0.467 | 0.147 | 0.787 | ns |
| Semi-open | 0.250 | 4 | 0.267 | 0.000 | 0.551 | ns |
| Open | 0.520 | 3 | 0.200 | 0.000 | 0.457 | Avoidance |
| Building | 0.030 | 1 | 0.066 | 0.000 | 0.226 | ns |

TABLE 7. Frequency of main setts occupation by badgers in the Swiss Jura Mountains

| | Lowland | | Mountain | | |
|---|---|---|---|---|---|
| Season | N | Main sett occup. (%) | N | Main sett occup. (%) | P |
| Winter | 368 | 83.7 | 75 | 77.3 | 0.1851 |
| Spring | 448 | 73.4 | 105 | 45.7 | < 0.0001 |
| Summer | 438 | 58.0 | 31 | 29.0 | 0.0017 |
| Autumn | 513 | 83.6 | 127 | 54.3 | < 0.0001 |
| Whole year | 1767 | 74.7 | 338 | 54.4 | < 0.0001 |

TABLE 8. Number of days individual badgers used the same sett before moving to another one. In parentheses: number of changes

| Individual | Spring | Summer | Autumn | Winter |
|---|---|---|---|---|
| M1 | | 1.13 ± 0.35 (15) | 1.79 ± 1.21 (29) | |
| M11 | 2.12 ± 2.71 (33) | 1.75 ± 1.03 (8) | 2.92 ± 5.07 (26) | 15.0 ± 13.02 (5) |
| F9 | 2.0 ± 1.41 (17) | | | |
| M2 | 2.58 ± 4.11 (68) | 1.95 ± 1.81 (81) | 8.8 ± 28.03 (15) | 10.89 ± 25.95 (9) |
| M4 | 1.33 ± 0.78 (12) | 3.17 ± 7.24 (24) | 71 (0) | 19.33 ± 30.89 (3) |
| M5 | 3.0 ± 2.58 (10) | | 4.21 ± 5.86 (14) | 6.18 ± 12.77 (11) |
| M6 | 5.13 ± 8.51 (15) | 3.46 ± 4.62 (24) | 3.57 ± 8.92 (30) | 68 (0) |
| M10 | 2.62 ± 2.26 (8) | 4.0 ± 8.11 (10) | 2.91 ± 2.54 (23) | 7.0 ± 13.28 (7) |
| F6 | | 3.29 ± 3.69 (24) | 5.0 ± 8.25 (15) | 26 (0) |
| F7 | 57 (0) | | | |
| F8 | 40 ± 55.15 (2) | | | |
| Total | 12.86 ± 20.67 | 2.68 ± 1.06 | 12.53 ± 23.72 | 21.77 ± 21.55 |

TABLE 3. Characteristics of badger diurnal resting sites in the Swiss Jura Mountains.

| | N | Mean cover ± SD (%) | Mean number of entrances ± SD | Mean slope ± SD (°) | Mean distance to nearest field ± SD (m) | Mean distance to nearest house ± SD (m) |
|---|---|---|---|---|---|---|
| Main setts-lowland | 5 | 50 ± 30 | 12.2 ± 3.8 | 20 ± 10 | 216.0 ± 193.7 | 276.0 ± 163.9 |
| Outlier setts-lowland | 16 | 50 ± 30 | 1.6 ± 0.9 | 20 ± 10 | 188.7 ± 156.4 | 325.0 ± 177.9 |
| All setts-lowland | 21 | 50 ± 30 | 4.1 ± 5.0 | 20 ± 10 | 195.2 ± 161.2 | 313.0 ± 173.0 |
| *Mann-Whitney U test* | | *$p > 0.05$* | *$p < 0.001$* | *$p > 0.05$* | *$p > 0.05$* | *$p > 0.05$* |
| Main setts-mountain | 3 | 40 ± 10 | 11.0 ± 3.6 | 20 ± 20 | 250.0 ± 180.3 | 163.3 ± 121.0 |
| Outlier setts-mountain | 15 | 30 ± 20 | 2.1 ± 1.4 | 10 ± 10 | 474.7 ± 246.2 | 267.0 ± 113.0 |
| All setts-mountain | 18 | 30 ± 20 | 3.5 ± 3.9 | 10 ± 10 | 437.2 ± 247.3 | 249.7 ± 117.6 |
| *Mann-Whitney U test* | | *$p > 0.05$* | *$p < 0.05$* | *$p > 0.05$* | *$p > 0.05$* | *$p > 0.05$* |

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