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SEASONAL ACTIVITY-PATTERNS OD BADGERS *(MELES MELES)* RELATED TO FOOD AVAILABILITY AND REQUIREMENTS

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Summary

ZABALA, J., ZUBEROGOITIA, I., GARIN, I. & AIHARTZA, J.R. (2002). Seasonal Activity-patterns od badgers (*Meles meles*) Related to food availability and requirements. *Est. Mus. Cienc. Nat. de Álava.* **17**: 201-207.

We studied the activity and habitat selection of a badger clan at the Urdaibai Biosphere Reserve. The activity was strictly nocturnal, probably as a consequence of the human activities at the area. During summer, duration of the activity period was maximum, and it was interrupted by short resting periods. On the other hand, during winter activity was minimum and resting period lasted for more than an hour. The spring activity pattern was similar to the summer one, and autumn activity pattern was similar to the winter one. Summer and spring activity patterns are explained as a compromise between nocturnity and the need to accumulate fat for the unfavourable autumn-winter period. On the other hand the pattern observed during autumn and winter is understood as a result of the long nights and the severe conditions.

Key Words: Badger, Meles meles, Activity, Movements, Human presence, Food requirements

Resumen

ZABALA, J., ZUBEROGOITIA, I., GARIN, I. & AIHARTZA, J.R. (2002). Patrones estacionales de actividad del tejón *(Meles meles)* en relación a disponibilidad y necesidades tróficas. *Est. Mus. Cienc. Nat. de Álava.* **17**: 201-207.

Se ha estudiado la actividad y desplazamientos de un grupo de tejones en la Reserva de la Biosfera de Urdaibai. La actividad fue eminentemente nocturna, probablemente como consecuencia de la actividad humana en la zona. Durante el verano, la duración del periodo de actividad fue máxima, estando este interrumpido por breves periodos de descanso en las tejoneras. Durante el invierno, por el contrario, la actividad fue mínima estando interrumpida por largos periodos de descanso. En primavera el patrón fue parecido al de verano, mientras que durante el otoño el patrón fue parecido al de invierno. El patrón de actividad durante la primavera y el verano se explica como un compromiso entre la necesidad de acumular grasas y la protección de la oscuridad. Por otra parte, durante el otoño y el invierno, el patrón de actividad es consecuencia de la larga duración de la noche y las condiciones ambientales desfavorables

Palabras Clave: Tejón, Meles meles, Actividad, movimientos, Presencia humana, Necesidades tróficas

Laburpena

ZABALA, J., ZUBEROGOITIA, I., GARIN, I. & AIHARTZA, J.R. (2002). Azkonarren *(Meles meles)* sasoikako aktibitate-patroiak; eskuragarritasun eta beharrizan trofikoen arabera. *Cienc. Nat. de Álava.* **17**: 201-207.

Akonar-talde baten aktibitatea eta mugimenduak ikertu dira Urdaibaiko Biosfera Erreserban. Aktibitatea hertsiki gautarra izan zen, ziur asko eremuko giza-jardueren ondorioz. Udan, aktibitate-jardunaldiak iraupen maximoa izan zuen, honetan azkonar-zuloetan egindako atsedenaldi laburrak tartekatu zirelarik. Neguan, aldiz, aktibitate-aldiak iraupen minimoa izan zuen, eta honetan atsedenaldi luzeak tartekatu ziren. Udaberriko eredua udakoaren antzerakoa izan zen bitartean, udazkenekoak negukoaren antza izan zuen.. Udaberri eta udako aktibitate-patroiak gantzak metazeko eta gauez ekiteko beharren arteko konpromezu bezala azal daitezke. Udazken eta negukoa, bestalde, gauaren iraupen luzearen eta kanpo baldintzen ondorioa.

Gako-hitzak: Azkonarra, Meles meles, Aktibitatea, Mugimenduak, Giza-jarduerak, Beharrizan trofikoak.

INTRODUCTION

Badgers are widespread mustelids in Europe. They are present in most countries, from the Iberian Peninsula to Russia and from Norway to some Mediterranean islands. But while in some countries such as Great Britain there is a great deal of knowledge on their ecology, in Southern Europe the most basic information is lacking, with very little information available for the Mediterranean peninsulas (Griffiths & Thomas 1993). Neither status nor trends are known for these populations (Griffiths & Thomas 1993), being Doñana, in the southernmost region, the only exception, where some studies have been conducted (Rodríguez *et al.* 1996, Revilla 1998, Revilla *et al.* 1999).

Badgers have a peculiar social and spatial organisation, and some studies have been conducted in order to explain it (Kruuk 1989, Revilla 1998). After the Resource Dispersion Hypothesis (RDH)(Macdonald 1983, Kruuk 1989), food resources appear concentrated in patches. These patches change their position in space and time. Therefore, badgers must have a territory big enough to ensure always the presence of at least one patch within it (Macdonald 1983, Kruuk 1989). In areas favourable for badgers, food patches are abundant and near from each-other, so, badgers have very small territories. On the other hand, in unfavourable areas, patches appear dispersed and far from each other and badgers have enormous home ranges (Kruuk 1978, Kruuk 1989, Revilla 1998). Besides, food patches are plenty of feeding resources and can maintain more than one badger (Kruuk 1989). Therefore, badgers typically live in groups, called clans that share a territory that they actively defend against badgers from other clans (Kruuk 1989). Within a territory, badgers from the same clan share the resources and have home ranges that overlap largely (Kruuk 1989).

Seasonal and daily patterns of activity represent behavioural adaptations to variation of environmental or socio-ecological factors, such as foraging efficiency and resource availability and quality (Lodè 1995, Larivière *et al.* 1994). In this paper we study the seasonal activity patterns and movements of a badger clan, and discuss them under the predictions of the RDH and the characteristics of the study area.

STUDY AREA

The present study was conducted in the Urdaibai Biosphere Reserve (43°29'N, 2°40'W), Biscay (Basque country), North Iberian Peninsula. The Urdaibai Biosphere Reserve (UBR) spreads over a whole basin with an area of 270 Km^2. Altitude ranges from 0 to 900 m. Climate is oceanic, average rainfall ranges between 1200 and 1600 mm, and January and July average temperatures are 6°c and 18°c respectively. Winters are mild and there is not effective snow cover.

The landscape is hilly, rugged and patchy. 70% of the land is forested, mainly *Pinus radiata* and *Eucalyptus globulus* plantations, deciduous woods are scarce and fragmented. Native holm oak (*Quercus ilex*) forests are also common in rocky areas. Meadows, pastures and estuarine habitat occupy 25% of the area; the remaining 5% is urban area with circa 45,000 inhabitants. Traditional hamlets with small orchards and garden fruit are frequent and widespread. Also are small vine (*Vitis vinifera*) and maize (*Zea mays*) plantations together with pastures grazed by dairy cattle and sheep.

This study was carried out in the centre of the UBR, in an area combining agricultural and forestall practices. The area was surrounded by roads with different traffic densities, and contained several houses. Therefore, there was a moderate level of human activity, mainly at daytime but also during the first hours of the night and the dawn.

MATERIALS AND METHODS

Between February 13th of 1999 and March 3rd 1999, three badgers, two males and a female, were captured with snares. After capture, badgers were immobilised with a subcutaneous injection of zooletil (virbac. Carros, France), and fitted with radio collars (Biotrack, England). From April 1999 to March 2000 badgers were radio-tracked using a three-element yagi antenna. Radio-tracking period began one month after the last capture to avoid possible bias associated with post-capture behaviour. Due to difficulty inherent to detect underground activity, we classified badgers as active when they were out of setts or any other known resting-place, otherwise they were classified as inactive. We radio-tracked badgers on a weekly basis using a three-element yagi antenna. We took Locations following the multiple triangulation procedure as described by Mech (1986) at regular time intervals of two hours so as to avoid serial correlation problems (Aebischer *et al.* 1993). We also recorded activity each 15 minutes, starting at least one hour before dusk and ending well after dawn when all animals were inactive. In addition, we made random activity records,

mainly during daytime. Using these records we studied the duration and characteristics of the activity period of the badgers.

Data were computed for the whole year and for the following seasons: Spring (April, May and June), Summer (July, August and September), Autumn (October, November and December) and Winter (January, February and March). General comparisons between season were performed using the Kruskal-Wallis test. Comparisons between pairs of seasons were performed using the Nemenyi test (Zar 1999).

RESULTS

We gathered 4520 activity records during 88 full tracking periods and six incomplete tracking periods (13 in spring, 20 in summer, 26 in autumn and 33 in winter). In addition, we gathered 985 random activity records. In total we made 5505 records, 2985 of them corresponding to active animals. We gathered as well 520 locations, 441 during activity period.

Using the activity/inactivity locations we described annual and seasonal activity patterns of badgers at the study area (figure1). Badgers were nocturnal at the UBR (X^2=621.726, p<0.001, df=1), 99.45% of the activity was recorded at night and only 0.55% at daytime.

There were no statisticaly significant differences between the activity periods of the studied animals (Kruskal-Wallis test, H=0.265, p<0.8837, df=2). On the other hand, there were statistical differences in the duration of the activity period in the different seasons (Kruskal-Wallis test H=18.238, p<0.0001, df=3).

Badgers were most active during summer and less during winter (table I). Comparing the seasons in pairs, only the difference between summer and winter reached statistical significance (Nemenyi test Q=4.090, p<0.01). In 7.7% of the autumn tracking nights and in 6.1% of the winter tracking nights no activity was recorded at all.

The activity period was either continuous or was subdivided in two or more subperiods of activity by resting periods in setts or couches. There were minimum differences in the number of resting periods between seasons (table II), but the differences in the duration were statistically significant (Kruskal-Wallis test H=13.827, p<0.0034, df=3). However, when comparing the seasons in pairs there was no statistical significance.

Time elapsed between dusk and activity onset and activity offset an dawn was as quoted in table III. In general badgers started their activity early and ended late in summer an spring, whilst during autumn and, specially, winter started late and ended early. Differences in the duration of the period between dusk and activity onset were statistically significant in general (Kruskal-Wallis test H=15.462, p<0.0015, df=3), and, when comparing pairs of seasons, diffe-

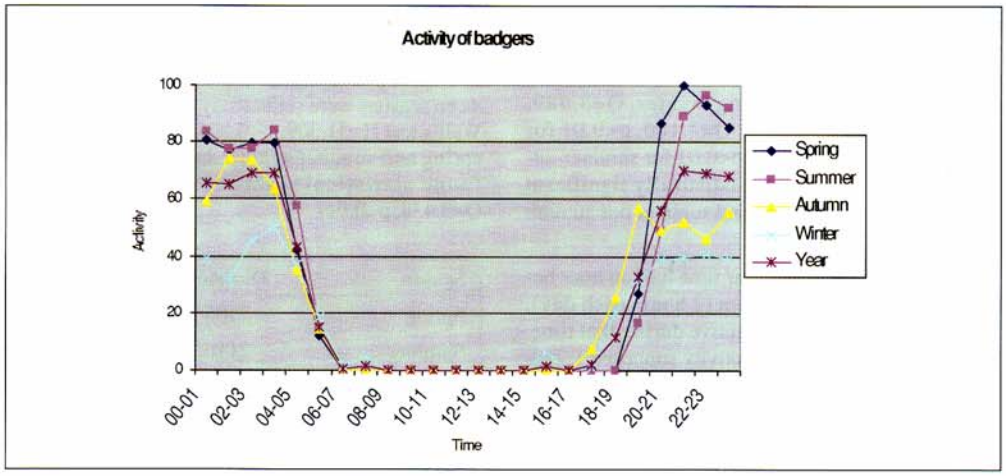

Figure I. Seasonal activity patterns of badgers at the study area. Activity is expressed as a percent, based on the relation between active and inactive locations. Time is G.M.T.

	Year	Spring	Summer	Autumn	Winter
Time	342 (118)	405 (92)	472 (43)	349 (177)	141 (159)

Table I. Duration of the activity period in different seasons. Time is expressed in minutes with standard deviation in brackets.

	Spring	Summer	Autumn	Winter
Subperiods	1.79 (1-4)	1.93 (1-4)	1.79 (1-3)	1.70 (1-3)
Duration of rest	74 (59)	41 (17)	120 (125)	140 (113)
Sample size	14	15	26	33

Table II. number of subperiods of activity, range in brackets, and duration of the resting periods expressed in minutes with standard deviation in brackets.

Season	Dusk	DE	Dawn	DE
Spring	67	41	59	44
Summer	28	23	62	73
Autumn	166	170	197	103
Winter	197	184	214	155

Table III. Time elapsed between dusk and activity onset (Dusk) and activity offset and dawn (Dawn). Time is expressed in minutes with standard deviation in (DE).

rences between summer and autumn and winter reached statistical significance (Nemenyi test $Q=3.305$, $p<0.05$ autumn, and $Q=3.539$, $p<0.05$ winter). Differences in the duration of the period between the activity offset and dawn were also statistically significant in the year-round test (Kruskal-Wallis test $H=33.377$, $p<0.0001$, $df=3$). Compared in pairs of seasons, the period was shorter in spring and summer than in autumn and winter (Nemenyi test $Q=4.133$, $p<0.01$ for spring-winter, $Q=3.989$, $p<0.01$ for spring-autumn, $Q=4.180$, $p<0.01$ for summer-winter y $Q=4.039$, $p<0.01$ for summer-autumn). There were neither statistically significant differences between spring and summer nor autumn and winter.

Considering as crepuscular time half an hour before and after dusk and down (2 hours each day), 7.17% of the records were active during that time. Therefore, the crepuscular activity supposed 1.77% of the total activity recorded. Throughout the year, there were no differences in the degree of crepuscular activity between dusk and dawn ($X^2yates=2.942$, $p<0.1$, $df=1$). After performing the analysis season by season only in summer there were statistically significant differences ($X^2yates=4.535$, $p<0.05$, $df=1$), with a higher degree of activity during dusk than during dawn.

With the fixes obtained in the 88 full-night tracking periods we made an approximation to the displacements of badgers. Distances were maximum in summer and spring and minimum in autumn and winter (table IV). Differences between animals were not statistically significant (Kruskal-Wallis test $H=3.030$, $p<0.2199$, $df=2$), whilst differences between seasons were statistically significant (Kruskal-Wallis test $H=31.309$, $p<0.0001$, $df=3$). Comparing spring and summer against autumn and winter we found statistical significance (Nemenyi test $Q=3.438$, $p<0.01$).

Season	Distance	DE
Spring	2106	654
Summer	2110	684
Autumn	985	737
Winter	991	887

Table IV. Distances travelled by badgers in different seasons. Distances are expressed in metres with standard deviation in brackets (DE).

DISCUSSION

Whilst badgers at the study area were strictly nocturnal, studies from other areas report brief periods of diurnal activity (Harris 1982, Kruuk 1989, Neal & Cheeseman 1996, Rodríguez *et al.* 1996, Revilla 1998). Anyway, diurnal activity reported on literature took place typically in summer and was more frequent in rural areas with low perturbation levels and scarce human activity (Harris 1982, Kruuk 1989, Neal & Cheeseman 1996). The lack of diurnal activity recorded in this study is a probable consequence of human activities in the area. Indeed, setts and foraging areas are close to human settlements. Harris (1982) also reports null diurnal activity in a badger clan from the Bristol suburbs, and, for some species, it has been proved that the activity becomes nocturnal in the presence of humans or human activity (Larivière *et al.* 1994).

Duration of the activity period was maximum in summer and minimum in winter, whilst spring and autumn had halfway values. During summer, when badgers were most active, the nights are shortest, therefore, badgers were constrained by night duration and started their activity just after dusk and finished just before dawn. Besides, during summer, resting periods were shortest. A similar pattern was observed in spring. On the other hand, during winter, badger activity was minimum, with long resting periods, and night duration longest. In autumn the pattern was similar to that of winter.

The general pattern is similar to that reported in other works (Harris 1982, Rodríguez *et al.* 1996, Neal & Cheeseman 1996). On the other hand, Bonnin-Laffargue & Canivec (1961) reported unchanging duration in a badger sow tracked from November to June. Anyway, this difference could be a consequence of their tracking methodology. Although the general pattern, maximum duration in summer and minimum in winter was concordant with other works, duration of the activity period was different to that referred in existing literature (Harris 1982, Rodríguez *et al.* 1996). Indeed, badgers in the study area were active, as a media, 3 hours more than badgers from Wales (Harris 1982). On the other hand, in Doñana (Southern Spain) the duration of the activity period was, as a media, 2.5 hours longer than the reported in this study (Rodríguez *et al.* 1996).

Even interruptions of the activity period are a known phenomenon (Bonnin-Laffargue & Canivec 1961, Harris 1982, Rodríguez *et al.* 1996), so far, only Harris (1982) studied them. His findings were concordant with the pattern observed in the present study, being duration of the resting periods minimum in summer and maximum in winter.

Researches on the onset/offset time of badgers are really scarce. Data available are similar to the findings of this study: activity starts after sunset and ends before sunrise (Bonnin-Laffargue & Canivec 1961, Harris 1982, Neal & Cheeseman 1996). Time elapsed between dusk and activity onset and between activity offset and dawn is minimum in summer, and activity onset/offset is closely related to dusk and dawn whilst onset/offset times are very irregular in other seasons, specially in winter (Harris 1982, Neal & Cheeseman 1996). Onset/offset times recorded by Harris (1982) in a Bristol suburb were especially irregular, mainly in winter.

The weight changes of badgers throughout the year are well known. Weight of badgers is minimum in early summer, then they start to put on weight until late autumn when they start losing weight as they relay on their fat reserves during the unfavourable winter conditions (Kruuk 1989, Page *et al.* 1994, Neal & Cheeseman 1996). This tendency to lose weight continues during the early spring but very attenuated (Neal & Cheeseman 1996). Therefore, the needs to stop the weight loss and accumulate enough fat reserves for the winter seem to be the reason for the long duration of the activity in spring and summer. Besides, the fact that summer nights are shortest, when the feeding requirements are maximum, explains why duration of resting periods is minimum and the activity onset and offset are closely related with dusk and dawn respectively. Like this, badgers make the most of the night hours. From this point of view, we can also understand the diurnal activity, typically in summer, observed in some works (Kruuk 1989, Neal & Cheeseman 1996), as a compromise between the nocturnal way of life of badgers and the need to accumulate fat and reserves. On the other hand, winter is the season with the most severe weather conditions and food is scarce (Zabala *et al.* 2001, Zuberogoitia *et al.* 2001). Therefore, during winter, badgers relay on their fat and only leave the sett for short periods interrupted by long resting periods. Sometimes, as we observed in the study area, they remain inactive all the night in order to reduce their metabolic expenses (Fowler & Racey 1988, Bevanger & Broseth 1998). During spring and autumn, conditions are similar to those in summer and winter respectively, but no so extreme. Therefore, badgers are active for considerable periods of time but with no severe constraints by the night duration, and can rest for some hours.

Works dealing with movements of badgers are also scarce. Harris (1982) found minimum distances in January, with a media of 1140 m, and maximum

in June, with a media of 3950 m. On the other hand, Cresswell & Harris (1988) recorded a media of 500 m in winter and 1650 in summer. Besides, they found statistically significant differences in the distances travelled by different age groups of animals (Cresswell & Harris 1988).

Hawkins & Macdonald (1992), in a pilot study, recorded precisely the movements of 6 badgers for few days. During autumn, badgers travelled a media of 1169 m (Hawkins & Macdonald 1992). Although travelled distances vary between studies, there is a common pattern in the tendencies observed with maximum distances in summer and minimum in winter. In our case, distances travelled were related to seasons, with spring and summer opposed to autumn and winter.

Distances travelled and duration of the activity period are related with the dispersion of food patches. In areas were patches are abundant badgers cover short distances when moving from one to another. And, in areas were patches are rich in food resources, badgers spend less time active due to a better foraging efficiency. Therefore, when we compare our data with data from other areas, we find that conditions in the study area are intermediate for badgers. Indeed, conditions are not so favourable for badgers as in England or Scotland, but better than in Doñana. The findings of Zabala et al. (In prep.) with the size of the home ranges of badgers at the study area also bear out this hypothesis.

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