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BARKING IN ROE DEER (*CAPREOLUS* ***CAPREOLUS):*** SEASONAL TRENDS AND POSSIBLE FUNCTIONS

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ABSTRACT - We studied barking behaviour of roe deer, *Capreolus capreolus,* in an area when wolves actively prey on this species, to determine the possible functions of this signal. Our data showed that males barked more frequently than females and that males barked more often during the territorial period than outside it. Undisturbed deer that barked spontaneously, before the arrival of the observer, were significantly more likely to be male than female, while both males and females showed the same likelihood to bark in response to the presence of a human observer. When barking occurs as a result of disturbance, it may act as a "pursuit-deterrent signal" rather than to warn conspecifics of potential danger. We suggest that counterbarking also acts as a pursuit-deterrent call, since audibility is reinforced by duetting, and signals to the predator that it has been detected by the pair.

Key words: barking, roe deer, alarm signal, pursuit - deterrent signal, territoriality

INTRODUCTION

Among artiodactyls, the use of alarm signals in response to predators is widespread (Guthrie, 1971). Alarm signals usually involve the use of a white rump patch or tail, some form of a bounding gait and sometimes an auditory signal such as snorting, stamping or barking. Such antipredator behaviour may be considered a warning signal to conspecifics about the presence of a predator, as in Spanish ibex *(Capra pyrenaica)* that give alarm calls to alert group members which then flee together (Alados and Escos, 1988). Antipredator behaviour may also signal information to the predator and thus act as a "pursuit-deterrent'' signal, by which the predator is informed that it has been detected and that further stalking is unlikely to lead to capture. This latter hypothesis was proposed by Woodland *et al.* (1980) for tail flicking in swamphen (*Porphyrio porphyrio).* Other authors have proposed a similar function for ungulate alarm signals: Yahner (1980) for barking in muntjacs *(Muntiacus reevesi*), Tilson and Norton (1981) for alarm duetting in klipspringer (*Oreotragus oreotragus*), LaGory (1987) for snorting in white-tailed deer *(Odocoileus virginianus*) and Caro (1994) for snorting in African bovid.

Vocal communication may be particularly important for species in closed, forested habitats where dense vegetation reduces the effectiveness of visual signals.

The roe deer *(Capreolus capreolus)* is a small cervid that inhabits many different environments, predominantly wooded habitats, in Europe.

Barking is the most typical and intensive call of roe deer. Typically, roe deer bark in response to some form of disturbance and barking is then associated with postures that are characteristic of a state of alarm in cervidae: flared target (erect caudal hair), jumps, stilted gait, and brusque vertical head movements (Hewison *et al.,* 1998). Roe deer, however, can also bark spontaneously during agonistic interactions or while marking a territory. Thus, barking could play an important role in the territorial system of this species (Danilkin, 1996; Reby '*et al.*, 1999a,b). Males seem to bark more than females and barking increases during the territorial period (Danilkin, 1996; Reby ***et al.***, 1998). While visual communication is inefficient in closed habitats and scent marking advertises the long-term presence of territorial individuals, barking signals the immediate location of the emitter and plays an important role in territory maintenance (Reby ***et al.***, 1999 a and b). Few roe deer studies on barking behaviour were present in literature and our study in an a mountainous habitat is the first in Italy. Every month we collected data along fixed transects and vantage points to investigate in which time period barking occurs more frequently. We observed deer barking to determine the difference between sexes in the barking frequency and in the response to disturbance by humans throughout the year. We also investigated if solitary individuals were more likely to bark than individuals in a group.

METHODS

Study Area

We carried out the study in the Casentinesi Forest National Park, in the northern Apennines, in the Arezzo province, between Tuscany and Romagna, Italy. The area is delimited by the Monte Falterona (NW) and the Passo dei Mandrioli (SE). Our study area consisted of 5,000 ha on the Tuscany side of the Casentinesi Forest (43°48'N, 11°49'E). This area ranges in elevation from 400 to 1,520 m, with a mean annual temperature of 8" C and a mean annual snow cover of 94 days at 1,100 m. The region is mountainous and only small parts (4%) of the study area are flat. Most of the area is wooded (97%) and above 1,000 m elevation, forests are dominated by *Fagus* and ***Abies*** and, under 1,000 m elevation, by ***Quercus***, ***Tilia*** and ***Acer***. The roe deer population in the Casentinesi Forest has not been hunted since World War II, but is preyed upon by the wolf. Roe deer in this area live are sympatric with red deer (***Cervus elaphus***), fallow deer (*Dama* ***dama***) and wild boar (*Sus* ***scrofa***). Density of roe deer was estimated to be about 10 deer/100 ha in 1998 by drive counts (Arezzo Province, unpublished) and the population structure was 33.5% adult males, 6.2% young males, 49% adult females and 12.3% fawns (Laficara **S.** ***et al.***, unpublished).

Methods

From May 1998 to April 1999, we collected data on foot along eight fixed transects of an overall length of about 40 Km, and from two fixed vantage points far away from the transects, within the study area. Each transect and vantage point were regularly walked and visited once a month at dawn or dusk. The average time spent by observers along transects and at vantage points each month was 30 hours. We always recorded all direct (visual) observations of roe deer that barked, determining whenever possible the sex, age class and behaviour of the emitter (the distance to the observer was lesser than 50m). We considered the following age classes for the two sexes: fawn (0-1 year old), young (1-2 years old), adult (>2 years old) for males; fawn (0-1 year old), adult (>1 year old) for females. We also noted whether observed animal(s) barked and if other deer in the vicinity responded by counterbarking. In addition, we recorded indirect (auditive) evidence of all other barks heard, without seeing roe deer that barked. The total number of barks recorded was 96, of which 74 were direct observations of deer barking and 22 were only acoustic contacts.

Statistical Analyses

We used chi-square tests to look for variation in barking frequency (a binary variable: bark/no-bark) between two periods (territorial: from March to August, and non-territor-

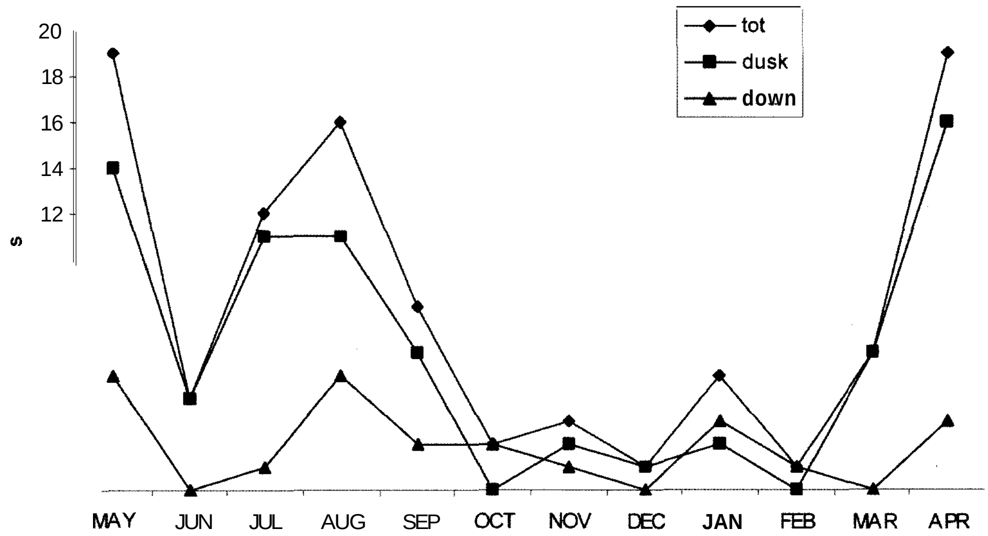

Figure 1 - Number of barks recorded while walking fixed transects and from fixed vantage points **for** roe deer in the Casentinesi Forest from May 1998 to **April** 1999.

ial: from September to February), and sexes. We also looked for variation in barking frequency between the sexes and two individual situations ("disturbed" and "undisturbed"). All roe deer that were observed barking were divided into two groups on the basis of their behaviour: "disturbed" deer barked in response to the presence of a human observer (the observer saw the deer, then saw it barking and going away), while the "undisturbed" deer barked spontaneously, before the arrival of the observer (the observer herd barking before to see the deer, then saw it barking and staying where it was).

RESULTS

During the study year, the number of recorded barks increased across the territorial period, reaching a peak in April and May, and diminished from October through March (Fig. 1). The higher values were data collected at dusk (Fig. 1). Although both sexes of roe deer can bark, significantly more males barked than females (included both disturbed and undisturbed deer) during the territorial period (χ^2= 28.521, df= **1,** p< 0.001), but not during the non-territorial period (Fig. 2).

The percentages of barking males in comparison to all males observed during the transects, reached a peak in April and May (Fig. 3). In contrast, the percentages of barking females in comparison to all transect females were essentially constant over the year. The analysis of barking roe deer showed that the 9% of all observed roe deer barked and the 53% of barking deer were disturbed Among the percentages of barking roe deer in comparison to all observed roe deer, disturbance by humans generated a different response between females but not males (χ^2= 6.376, df= 1, p< 0.02).

Although we never find cases of several animals barking inside the same group, in some cases (28%), barking provoked counterbarking in neighbouring animals. Such reciprocal barking sessions included up to

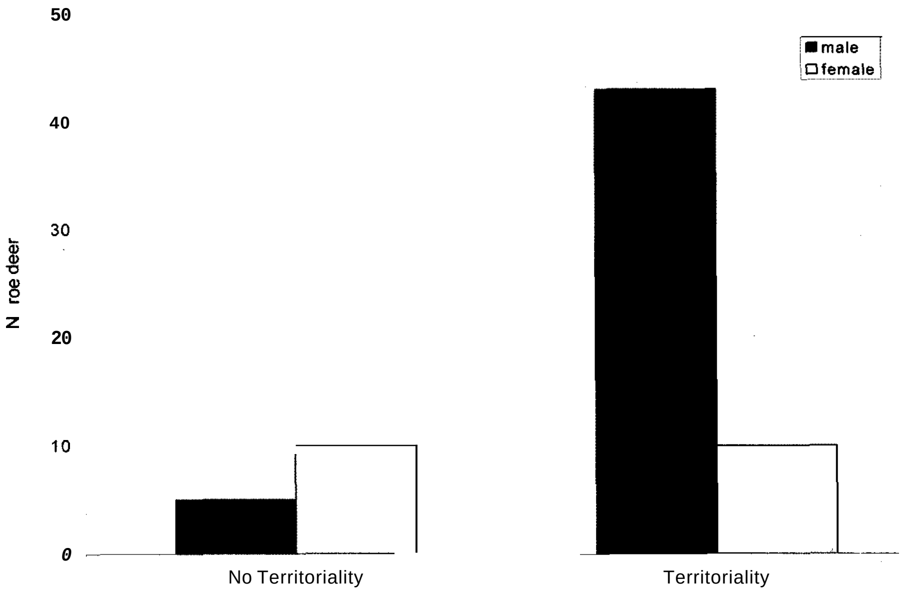

Figure 2 - Number of male and female roe deer that barked during the territorial and no- territorial period in the Casentinesi Forest from May 1998 to April 1999.

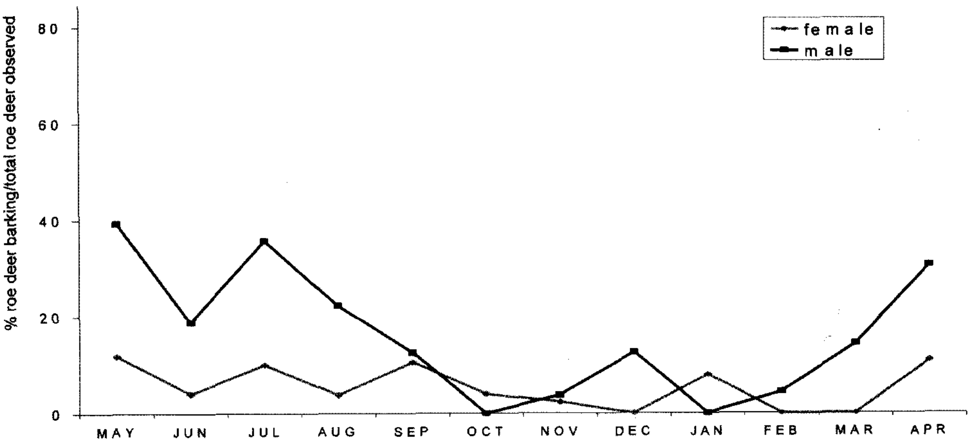

Figure 3 - Percentages of barking male and female roe deer in comparison to all observed deer in the Casentinesi Forest from May 1998 to April 1999.

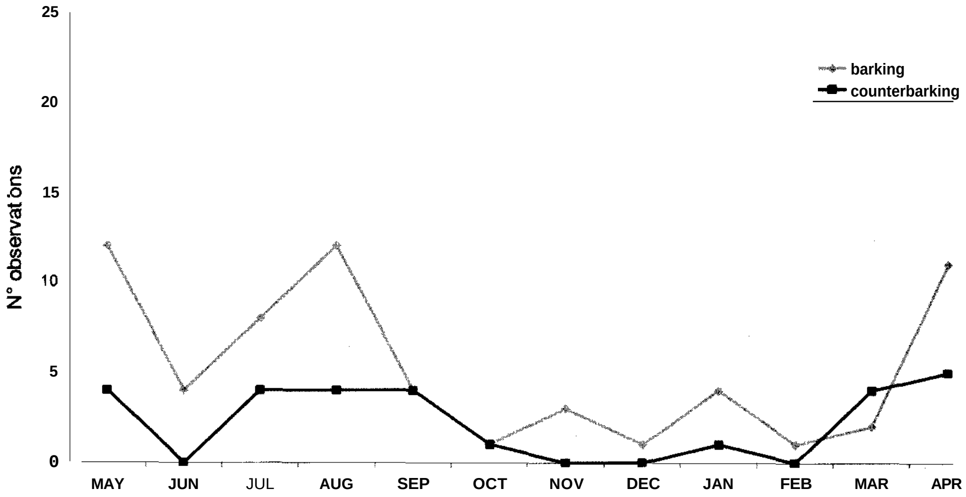

Figure 4 - Number of individual barks and counterbarks recorded for roe deer in the Casentinesi Forest from May 1998 to April 1999.

three deer from distinct locations. The frequency of counterbarking did not vary across the year, unlike barking which increased during the territorial period (Fisher test, p=0.048; Fig. 4).

DISCUSSION

We found that the rate of barking increased across the territorial period and reached a peak in April and May, coincident with increasing intolerance between males and intensive marking activity (Johansson and Liberg, 1996). This result confirms that barking can have also a territorial function among roe deer (Danilkin, 1996; Reby *et al.*, 1999a,b). Although both sexes of roe deer can bark, significantly more males barked than females, during the territorial period (from March to August) and the number of observed bucks barking was very high in April and May. Thus, barking may act as a mode of communication with conspecifics (Hewison *et al.*, 1998) signalling the presence, spatial position and identity of the emitter. Also the behavioural analysis of observed roe deer barking showed a territorial function of this call. More undisturbed males barked spontaneously before the observer arrived than did undisturbed females and, in this case, barking was not a response to the presence of the observer. However, males and females were equally likely to bark in response to the presence of a human observer. When barking occurs as a result of disturbance, it could be an alarm call designed to warn conspecifics of imminent danger. As Tilson and Norton pointed out (1981) for alarm duetting in klipspringer, barking in roe deer is louder than necessary to warn immediate group members and conveys information on the location of the barker. These qualities of calls could be properties to facilitate communication of the caller's alertness to potential predators and act as pursuit-deterrent signals, as Woodland *et al.* proposed (1980) for tail flicks of the swamphen. In fact, while roe deer that were surprised at close quarters fled immediately without barking (Hewison *et al.*, 1998), deer standing at a distance from the observer barked repeatedly as if to inform a potential predator that the deer was aware of its presence (Reby *et al.*, 1999a). Similarly, counterbarking may also act as a pursuit-deterrent call (Reby *et al.*, 1999a). Indeed, the frequency of counterbarking did not vary across our study, unlike barking that reached a peak during the territorial period. As Tilson and Norton proposed (1981) for alarm duetting in klipspringer, the audibility of the alarm signal is reinforced by duetting, which is a signal to the predator that the pair has detected it.

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