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Spotting behaviour and daily activity cycle in the Alpine Marmots (*Marmota marmota* L.): a role for infant guarding

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Abstract. During summer season, and across the day, marmot spp. exhibit a peculiar behaviour defined "spotting" or wary-sitting lying, this aspect of Alpine Marmot behaviour is investigated in the present field study conducted from 1985 until 1993 at the Gran Paradiso National Park, Valle d'Aosta, Italy. Results show that male and female adults considered together allocated more time to spotting than to feeding when infants were present than in the year of settling or when skipping reproduction. They also did more spotting than adults that never reproduced, and their sons and daughters of two years or more. During the month of July infants of the year allocated less time to feeding than to social activities, suggesting that this is a very important behaviour for confirmation of their social role. Conclusions suggest that in the alpine marmots spotting might have more than one function and kin guarding is included.

Key words: *Marmota marmota*, ethology, daily activity cycle, spotting, kin guarding

Introduction

For any living species, time is a not disposable resource (Jeschke *et al.* 2002). As many not disposable resources the time budget undergoes what economists call the cost-opportunity constraint, that is any kind of behaviour allocation hinders the allocation of the same time span in other activities. For this reason behaviours must be allocated along the life time of one individual according a hierarchical order that must guarantee 1) growth and survival and 2) reproduction. Many activities, such as feeding, antipredator behaviour and territorial defence, play and social behaviour, mate guarding, and care of the young, among others, are related to the above mentioned points according to the life history of the species and to ecological constraints, such as growth season, meteorological contingencies, conspecifics and predator density, etc. thus, variation of the time budget is a means of coping with changing environment, especially in hibernators, in particular the marmot genus (Armitage *et al.* 1996, Van Vuren and Armitage 1991, Inouye *et al.* 2000, Lenti Boero 2001, Semenov *et al.* 2000, Schwartz and Armitage 2005). Across the summer day, marmot spp. exhibit a peculiar behaviour defined "staying; spotting" in alpine marmot (Lenti 1983, Lenti Boero 2004), or "sunning" and "wary-sitting lying" in *Marmota flaviventris* (Travis and Armitage 1972, Armitahe and Chiesura Corona 1994, Armitage *et al.* 1996). During this activity, marmots stay at burrow entrance, though seeming quiet, they promptly answer to social and biological stimuli, such as conspecifics intruding in territories, alarm signals for predators flying or walking through the colony (Lenti Boero 1992, Perrin *et. al.* 1993, Lenti Boero 1995, Armitage *et al.* 1996, Lenti Boero 2003a,b). It must be underscored that although performed near burrow entrance, spotting is a risky behaviour, because animals can be caught by undetected predators (Lenti Boero 1999).

Two different hypotheses were proposed for the function of spotting in alpine marmots: A) sun exposition and resting (Zelenka 1965, Perrin *et al.* 1993); B) visual exploration and territorial control (Zelenka 1965, Lenti Boero 1983, Perrin *et al.* 1993). This aspect of alpine marmot behaviour is investigated in the present study, together with the overall pattern of daily activity.

Methods

Species and study area. A typical Alpine Marmot family group includes a dominant reproductive pair and subordinate offspring of different ages, occupying a common space (Zelenka 1965, Arnold 1990a, b), Perrin *et al.* 1993, Lenti Boero 1995, 1999). Generally Alpine Marmots reproduce every two years, and the first year of settlement in a new territory the new couple does not reproduce (Zelenka 1965, Barash 1976, Mann and Janeau 1988, 1990; Lenti Boero and Boero 1989, Arnold 1990a, Lenti Boero 1991; Perrin *et al.* 1993, Sala *et al.* 1996, Lenti Boero 1995, Lenti Boero 1999). The budget of activity is distributed in different parts of the home area according to the behaviour performed and the hour of the day (Zelenka 1965, Lattman 1973, Perrin *et al.* 1993). The study area was included in a colony of 200 ha, facing North, and was located at 2,300 m above timberline in a small valley branching from the main Cogne Valley at the Gran Paradiso National Park, Valle d'Aosta, Italy for further details see Lenti Boero (1999, 2001).

Subjects and data collection

Present data were collected from 1985 until 1993 in field observation performed in July, August and September. A mean of fifteen marmots of all age were observed per year, and 90% were individually recognized by means of trapping. For details on

trapping see Lenti Boero (1999). Observations lasted from early morning (5 a.m.) to late evening (20 p.m.). The observer sat in an inconspicuous place with 10 X 40 binoculars or a 30 X 60 telescope. From 1985 to 1988 71 days were completely devoted to scan sampling (Altman 1974) and provided 827 scans relative to the daily activity cycle. From 1989 to 1993 scan and focal sampling were alternated for a total of 506 scans. Every scan provided 5 minute time budget for each individual animal scanned if it was located in the same activity at the start and the end of scanning. During scanning the name and activity of recognized marmots, and the approximate age (ad(sub)ults/yearlings and infants) and activity of unrecognized marmots were recorded. Scan sampling was suspended for 20 min every time a disturbance such as alarm calls, grazing cattle, tourists or predators altered the normal quiet activity in the colony. Due to vegetation and marking techniques (Lenti Boero 1999), scanning provided a low percentage of individual identification, for this reason, the daily activity cycle was estimated on recognized and not recognized marmots distributed as infants and adults and subadults (including yearlings), but the activity budget according to reproductive status was calculated only on a smaller portion of individually recognised animals.

Behaviours

Marmots exhibit two readily distinguishable behavioural states (sense Lehner 1996): foraging and sitting/lying or spotting (Lenti Boero 2003a, Sala *et al.* 1996), and less frequent behaviours such as marking (Lenti Boero 1995), locomotion, and social activities (Lenti Boero 2003b), most rarely, bringing hay to burrow, alert upright posture, excavating or refurbishing burrows. In the present study the least frequent behaviours were considered as "other activities".

Spotting

The animal is quiescent in a specific place, may have the belly in contact with the substrate (stone, ground or log) in a relaxed posture, or may extend the forelegs. I adopt this term in the present paper, instead of the general term of „wariness" used by Armitage and Chiesura Corona (1994), because I did not consider the vigilance patterns exhibited by foraging or otherwise moving animals, as those authors did. When performing sitting or lying, marmots are undoubtedly wary, because they are ready to move the head in consequence of alarm signals, or move toward intruders (Lenti Boero 1992, 2003b).

Foraging

Two foraging patterns were observed (Lenti Boero 2003a): a) the animal walks in a straight direction and eats the forage from the area that it can reach with the muzzle; b) when walking, the animal clearly displaces itself some meters away from the previous path in order to select a specific flower or plant, which frequently is grasped with one or both forepaws. As in other marmot species, foraging is alternated with alert postures, mainly head raising (Armitage *et al.* 1996). Typically, adults and subadults marmots of both sex forage alone, less frequently at a distance of less than five meters from each other and seldom exhibit social interactions while foraging, each animal following her/his own path.

Data analysis

Daily activity cycle was computed only from 1985 to 1989: hours of the days were divided in three blocks of five hours each: from 5 am to 10 am (morning), from 10 am to 15 pm (noon), from 15 pm to 20 pm (afternoon), according to Armitage *et al.* (1996). Scans of unknown and unrecognized individual marmots were treated as average animal per scan subdivided into the three above mentioned behavioural categories: spotting, feeding, other activities. For each year and for each month (with July further subdivided in two half: without and with infants) all the animals counted were summed and then divided for the total of scans. Thus I obtained a figure of average marmot per scan across the day for the four years. The proportion in each category was multiplied for 10 (adults) and 100 (infants) and G-test according to Sokal and Rohlf (1981) was applied.

Activity budget according to reproductive and family status

Time allocated in July (after the coming out of infants) and August on the three above mentioned behavioural categories by different reproductive class was analysed by means of GLIM (Aitkin *et al.* 1989).

Results

Daily activity cycle

Percent of adults and subadults animals active per scan are shown in Figure 1, the first behaviour in the morning was spotting, subsequently followed by feeding, those behaviours are compacted in the morning time span of five hours, and no statistical difference in time allocation appear (Table 1). At noon, spotting was significantly less than feeding in July, but in August and September no difference was found (Table 1). Fifty per cent of the time allocated to spotting happened before the sun came on the colony (about 11 hrs at the end of July, due to North-West exposition), or when the time was cloudy or foggy, and spotting was even observed in the rain. Other activities were significantly less than feeding throughout the whole summer (Table1).

Percent of infants active per scan are shown in Figure 2, as can be seen the pattern was different from adults and subadults in July, because spotting and feeding, and feeding and other activities were equally distributed in morning and afternoon. During middle of the day spotting was significantly less than feeding and other activities significantly more than feeding, it should be underscored that infants do not mark, nor refurbish burrows, thus social activities generally coincide with play and social behaviour towards adults and exploratory displacement around natal burrow. In August and September this pattern changed and both spotting and other activities were significantly less than feeding throughout the day (Table 2).

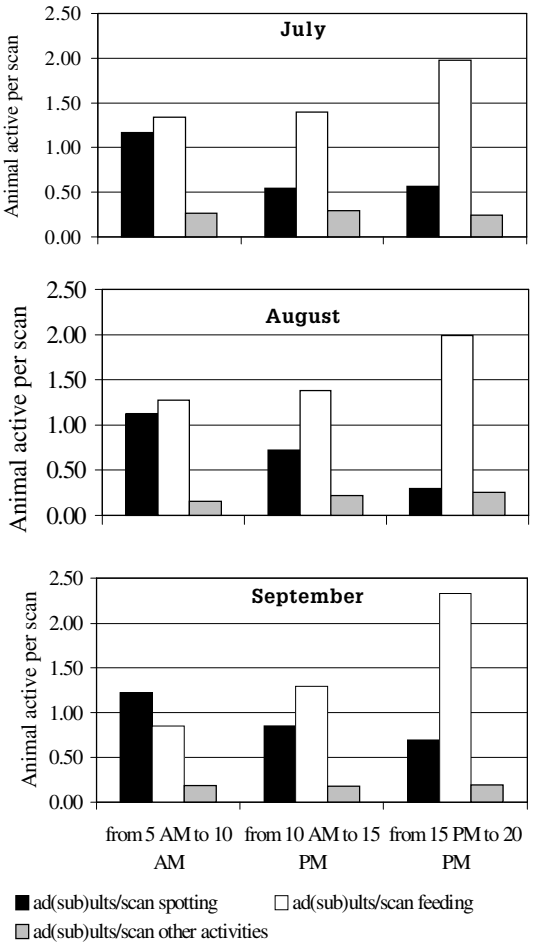

Fig. 1. Percent of adults and subadults active per scan. At noon on July, spotting was significantly less than feeding (see Table 1). Other activities were significantly less than feeding.

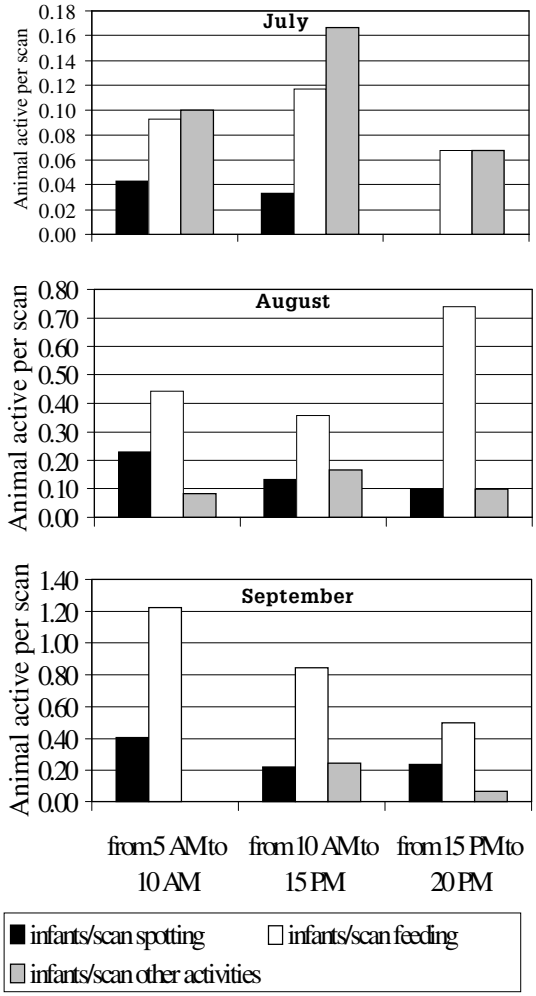

Fig. 2. Percent of infants active per scan. July: The pattern is different from adults and subadults. August - September: Both spotting and other activities are significantly less than feeding throughout the day.

Budget allocation according to parenting and sibling status

Because Alpine Marmots reproduce every two years, and the first year of settlement in a new territory the new couple does not reproduce, it was possible to compare the same individuals in the different condition of new settlers, parents and skipping reproduction. Male and female adults considered together allocated more time to spotting than to feeding when infants were present than in the year of settling (Glim: Chi-square = 14.04, df = 1, P < 0.0005), or when skipping reproduction (Glim: Chi-square = 6.98, df = 1, P < 0.01). They also did more spotting than adults that never reproduced (Glim: Chi-square = 427.5, df =1, P < 0.0001), and their sons and daughters of two years or more (Glim: Chi-square = 429.6, df =1, P < 0.0001). There was no statistical difference as regards the amount of spotting vs feeding when male and female adults were settling for the first time, than when they were skipping reproduction (Glim: Chi-square = 0.09, df

	5 AM to 10 AM		10 AM to 15 PM		15 PM to 20 PM	
			spotting vs feeding			
	G	P	G	P	G	P
July	0.12	ns	3.95	<0.05 *	8.16	<0.005 *
August	0.09	ns	2.04	ns	13.70	<0.0005 *
September	0.66	ns	0.87	ns	9.25	<0.005 *
Legend: spotting less than feeding = *						
			feeding vs other activities			
July	7.98	<0.005 *	7.93	<0.005 *	15.45	<0.0005 *
August	9.92	<0.005 *	9.11	<0.005 *	15.08	<0.0005 *
September	4.53	<0.05 *	9.45	<0.005 *	21.09	<0.0001 *
Legend: other activities less than feeding = *						

Table 1. Daily activity cycle for adult and subadult Alpine Marmots at P.N.G.P., Italy, from 1985 to 1988.

= 1, ns). However, even in the year of settlement next year parents did more spotting than adults that never reproduced (Glim: Chi-square = 214.2, df = 1, P < 0.0001), and even more than infants' two years old siblings (Glim: Chi-square = 131.70, df = 1, P < 0.0001). Also when skipping reproduction last and next year parents performed more spotting vs feeding than adults that never reproduced (Glim: Chi-square = 172.1, df = 1, P < 0.0001), and their two year old sons and daughters (Glim: Chi-square = 94.33, df = 1, P < 0.0001), however, the latter performed more spotting when their infant siblings were present than adults that never reproduced (Glim: Chi-square = 42.5, df = 1, P < 0.0001).

Discussion

Data on daily activity cycle strongly suggest that for adults and subadults marmots the most important behaviours are spotting and feeding, other activities, including social interactions and marking were significantly less performed. In the Alpine Marmot Zelenka (1965) proposed three functions for spotting, according to the time of the day: visual inspection, then sunning, then burrow guarding, and Perrin *et al.* (1993) found that "postures" a behaviour related to "both rest and visual exploration", that could be compared with spotting as defined in the present study, diminished in August, but augmented in September, before hibernation, however, in those studies no attempt was made to relate spotting with parental status. Data collected in present study suggest that spotting in Alpine Marmots might have multiple functions, including infant guarding: the analysis of the daily activity cycle for adults and subadults of all age, sex and parental state indicate that spotting is prevalent in the first part of the day, and decreases during the afternoon, this suggests a role of general control for all age-sex class, while it seems less plausible that spotting might be related to rest, as Perrin *et al.* (1993) suggest: in fact animals should be tired in the late day, and not in the morning. The fact that fifty per cent of the time allocated to spotting happened before the sun came on the colony (about 11 h at the end of July, due to North-West exposition), or when the time was cloudy or foggy, and spotting was even observed in the rain suggests that heating in the sun is not a prominent function for spotting in *Marmota marmota*. In the yellow bellied marmots, earlier studies proposed that spotting at burrow had to be related to sunning (Armitage 1962), but further considerations about the thermal constraints of hibernators (Kilgore and Armitage 1978), suggested a view of multiple function for spotting and related "sitting lying" to the time necessary for process ingested food (Armitage *et al.* 1996) and to maternal control of infants' activity (Travis and Armitage 1972, Armitage and Chiesura Corona 1994). The latter view is confirmed for alpine marmots in present study: the same individual animal differentially allocate time to spotting according to their parental status, and perform more spotting when infants of the year are present than in the year of settlement in a new territory, or when skipping reproduction (Lenti Boero 1999). Analogously as yellow-bellied marmots, alpine marmots seem to adjust behaviour according to contigencies (Armitage *et al.* 1996) and to have enough elasticity in behaviour allocation (Jechke *et al.* 2002). The dominant couple did more spotting than their subordinate daughters and sons aged two years or more, but the latter did more spotting than adults occupying a less favourable territory where only two litters were produced (Lenti Boero 1999, 2001). Because it is known that subordinates help during hibernation their younger siblings of the year (Arnold 1990a, Allainé and Theuriau 2004), it might be possible that a kind of behavioural helping in guarding is present during the active season. Why parental (or siblings) spotting should exist only in the interest of infants? Descendants from a reproductive couple might stay in the natal territory until when two to seven years old (Arnold 1990b, Lenti Boero 1999, Allainé *et al.* 2000), thus time allocation to spotting should appear also in the year of reproductive skipping, but this was not the case in present study. My hypotheses are that infants are more subjected to predation both from predators that generally do not predate on older marmots, such as goshawk (Perrone *et al.* 1992, Lenti Boero 1999) and from conspecifics living in nearby territories (Coulon *et al.* 1995, Blumstein 1997).

As regards as daily activity in infants data show ontogenetic changes during their first Summer, in

	5 AM to 10 AM		10 AM to 15 PM		15 PM to 20 PM	
			spotting vs feeding			
	G	P	G	P	G	P
July	1.97	ns	5.78	<0.025 *	no spotting	
August	6.69	<0.01 *	11.23	<0.001 *	55.12	<0.0001 *
September	42.10	<0.0001 *	38.68	<0.0001 *	9.33	<0.005 *
Legend: spotting less than feeding = *						
			feeding vs other activities			
July	7.36	<0.001 **	0.87	ns	0.00	
August	27.44	<0.0001 *	6.97	<0.01 *	55.12	<0.0001 *
September	none		35.30	<0.0001 *	36.56	<0.0001 *
Legend: other activities less than feeding = *; other activities more than feeding = **						

Table 2. Daily activity cycle for infant Alpine Marmots at P.N.G.P., Italy, from 1985 to 1988.

fact infants' activity pattern was different from adults' and subadults' in July, when other activities (mostly play and social were prominent), suggesting that immediately after emergence activities were as much as vital as feeding itself, this pattern of time allocation might be ascribed to the fact that infants were still nursing, however, I never saw an infant nursing from the mother on surface, oppositely, they were rejected when tried to do this (personal observation). In August and September infants' activity cycle became more similar to adults' and subadults' and both spotting and other activities were significantly less than feeding throughout the day.

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