

Reactions and adjustment of adult and young alpine marmots *Marmota marmota* to intense hiking activities

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In the region of First near Grindelwald in the Swiss Alps, experiments were carried out on the reaction of alpine marmots *Marmota marmota* when confronted with hikers. Marmots in highly frequented areas showed less reaction to hiking activities than marmots in remote areas. In adult marmots, there was no change in reaction during the season. In young animals the reaction shortly after leaving the burrows in early July, was slight and similar in highly frequented and remote areas. In late summer, the intensity of the reaction of young animals increased significantly in animals in both study groups but to a much larger extent in the remote areas. We conclude that the perception of danger has to be learned or is built up during growth and development. At the same time, young animals in highly frequented areas may adjust to the presence of hikers.

Key words: adjustment, flight distance, *Marmota marmota*, ontogeny, tourism

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In the Alps, areas of wilderness are decreasing partly because of their increasing use for tourism. For example, the transport capacity of the cable railways at Grindelwald - First was doubled between 1960 and 1980 (Messerli 1989). Besides the quantitative increase, there is also a qualitative change in tourist activities. While in the past hiking and mountain climbing were the only summer activities, today, there are more than 20 different forms of leisure

activity (Ott 1988). Animals living in these areas have to adjust rapidly to the increased disturbance or find less disturbed habitats.

Marmots *Marmota marmota* can react to changes in disturbance levels (Mainini, Neuhaus & Ingold 1993). In the Swiss National Park, animals can be observed foraging or playing in the vicinity of hiking paths. The reason for this apparent tolerance might be that hikers are not allowed to leave the trails in the

National Park and that the animals are accustomed to hikers crossing their territory on the same route. Marmots living close to main hiking routes in areas where hikers cross their territories at random were much shyer when approached by hikers both on and off trails. Animals in the vicinity of hiking trails were observed to spend more time in and around their burrows and less time foraging than animals in remote areas (Neuhaus, Mainini & Ingold 1989, 1993, Zimmerli 1993). However, animals can frequently be observed near the trails after hikers have entered into the area (pers. obs.). This is presumably an adaptation or adjustment resulting from a learning process. While this could be initiated in young animals during their first year, it could also take place later. There are two distinct forms of adaptation, genotypic and phenotypic (McFarland 1987). While genotypic adaptation is the genetically fixed result of an evolutionary process, phenotypic adaptation takes place at an individual and non-genetic level via learning. In our research we were specifically interested in the learning type of adaptation. To avoid misunderstandings, we will use the term adjustment. It is only possible to determine whether animals can adjust successfully to disturbance when fitness parameters are examined. Ideally long-term studies measuring the influence on reproductive success would be necessary to obtain such results. However, behavioural parameters, such as decrease in flight distance, decrease in the time the animals stay in the burrows after being disturbed and the time spent foraging (Ingold, Huber, Mainini, Marbacher, Neuhaus, Rawyler, Roth, Schnidrig & Zeller 1992), may correlate with fitness and therefore indicate whether the animals have adjusted successfully to disturbance.

In this study we asked if there are changes in behaviour through experience during the season and if age-classes differed in their responses. Specifically we asked if marmots living close to the hiking path allow hikers to approach more closely, have shorter flight distances, stay in their burrows for a shorter period of time after disturbance than marmots living in remote areas, and whether there is a seasonal difference in their responses to disturbance.

Study area and animals

The observations took place in the region of First, near Grindelwald in the Bernese Oberland, Switzerland, during the summer of 1989. The study area,

which is about 7 km² (approximately 6 km long and 0.5–2 km wide), is part of a reserve where hunting is prohibited. The area can be reached by a chairlift and on nice summer days several thousand people may visit the area. The paths lead through habitat occupied by marmots.

In 1989, about 120 family groups of alpine marmots comprising a total of ca 1,000 individuals (adults, yearlings and juveniles) lived in the area. The averages of 8.1 (1988) and 8.2 (1989) animals per group is comparable to that found in the central Swiss Alps by Wüthrich (1982), but larger than that found in the Berchtesgaden Alps (Germany) (Arnold 1990).

Methods

Each of two observers simulated a hiker and each chose a foraging adult marmot at random. The choice was made at a distance at which the marmots were not detectably influenced by us (300 m). The selected marmot was approached at normal hiking pace until it disappeared into a burrow. The observer then went to the burrow and left immediately afterwards. The observer withdrew to a distance of approximately 300 m and waited to see if one or two members of the marmot group reappeared within 30 minutes. Care was taken that no group was used twice for the experiments.

The same approach protocol was followed with juvenile marmots, but here the choice was not restricted to foraging animals.

The following variables were recorded:

- 1) Distance at first reaction (DR): Distance between the animal and the observer at the moment when the marmot first reacted, i.e. lifting its head and looking in the direction of the observer. The distance was measured after the approach;
- 2) Flight distance (DF): Distance between the animal and the observer at which the stationary or slowly moving animal began to run;
- 3) First time (FT): The time passing between the moment when the observer withdrew from the marmot burrow until any animal of the group emerged;
- 4) Second time (ST): The time passing between the moment when the observer withdrew from the marmot burrow until at least two different marmots of the group had reappeared;

- 5) Alarm calls: Occurrence of a single or a series of alarm calls from any animal of the observed group during the sampling period.

A first series of experiments with adult animals (two years or older) was carried out between 13 June and 24 July and a second series between 30 August and 12 September. The experiments with young of the year took place during 4-27 July and 30 August - 12 September.

We divided the study area into two sections: one in the vicinity of paths (a hiking path touches the marmot territory or leads through it) highly frequented by hikers and one far from paths that were used less frequently. In the remote areas we observed an average of less than 30 hikers, whereas in the vicinity of paths ca 800 hikers were observed on an average day. In total, we found 72 groups in remote areas and 47 groups in areas highly frequented by hikers. There were groups of both types distributed over the whole study area.

Each series consisted of 10 experiments in highly frequented and 10 in less frequented areas. All experiments were made during normal hiking time between 08:30 and 18:00. We observed the animals before the experiment to determine if their behaviour had changed due to recent responses to hikers.

Juvenile marmots leave their natal burrows for the first time in July at the age of about 40 days, and the first set of experiments was made at this time. First

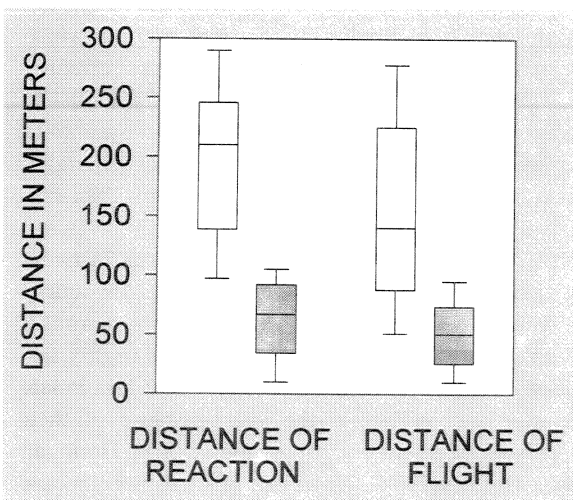


Figure 1. Distances of first reaction and flight distance of adult marmots in highly frequented (■) and less frequented (□) areas. Medians, first and third quartile, minima and maxima are indicated.

Table 1. The number of experiments in which first one and then two animals did or did not reappear within 30 minutes after the observer had left the marmot burrows, for less and highly frequented areas.

Time	Reappearance registered		χ^2	P
	+	÷		
One animal reappeared				
Less frequented areas	5	5	6.667	<0.05
Highly frequented areas	10	0		
Two animals reappeared				
Less frequented areas	2	8	9.899	<0.01
Highly frequented areas	9	1		

reaction and flight happened simultaneously at this time. Therefore, only one variable was recorded. When the experiments were repeated in September, we could differentiate between first reaction and flight distance.

We used non-parametric tests because several data sets were not normally distributed.

Results

Adults

The marmots in highly frequented areas allowed us to approach more closely before they reacted and fled than the animals in less frequented areas (Mann Whitney U-Tests: both Ps < 0.001, N = 20; Fig.1).

In less frequented areas, animals were less likely to reappear at all within 30 minutes than in highly frequented areas (for the first animal: $\chi^2 = 6.667$, df = 1, P < 0.05; for the second animal: $\chi^2 = 9.899$, df = 1, P < 0.01; Table 1).

There were no significant differences in the distances of reaction or flight between early and late summer in either low-use or high-use areas (Mann Whitney U-Tests: both Ps > 0.05, N = 20).

While there were no alarm calls elicited during the June-July experiments the marmots called frequently when approached in September. This difference was

Table 2. The number of experiments in June-July and September during which alarm calls by adult marmots were or were not registered in less frequented and highly frequented areas.

Groups	Alarm call registered		χ^2	P
	+	÷		
Less frequented areas				
June/July	0	10	10.769	<0.01
September	7	3		
Highly frequented areas				
June/July	0	10	3.529	n.s.
September	3	7		

significant in the less frequented areas ($\chi^2 = 10.769$, $P < 0.01$; Table 2).

Juveniles

The reaction/flight distances varied little between areas of different impact by hikers in July (Mann Whitney U-test, $P > 0.05$).

When the experiments were repeated in September, there was a significant increase of flight distance in both highly frequented and low-use areas (Mann Whitney U-Tests, all between mid to late summer $P_s < 0.001$, $N = 20$; Fig.2). In September there was also a difference between the highly and low frequented areas due to a much higher increase in flight distance in low-use areas (Mann Whitney U-Test, $P < 0.001$, $N = 20$). This clearly showed that there was a difference in the rate at which the young animals in highly frequented areas changed their reaction towards hikers, compared to those in the less frequented areas.

In both low-use and high-use areas, the flight distance was much shorter in juveniles than in adults (Mann Whitney U-Test, June-July and September $P_s < 0.001$, $N = 20$).

In the experiments in July the first animal returned within five minutes in all areas. The time until a second animal reappeared was also relatively short and similar in all areas. In late summer, we observed a

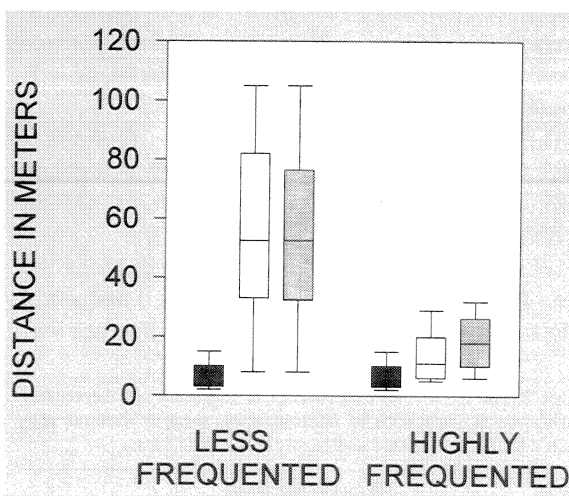


Figure 2. Distances of first reaction and flight distance, of young marmots in less frequented and highly frequented areas in mid and late summer. The distance of first reaction = distance of flight (■) in mid summer; in late summer the distance of first reaction (□) and the distance of flight (■) are given separately. Medians, first and third quartile, minima and maxima are indicated.

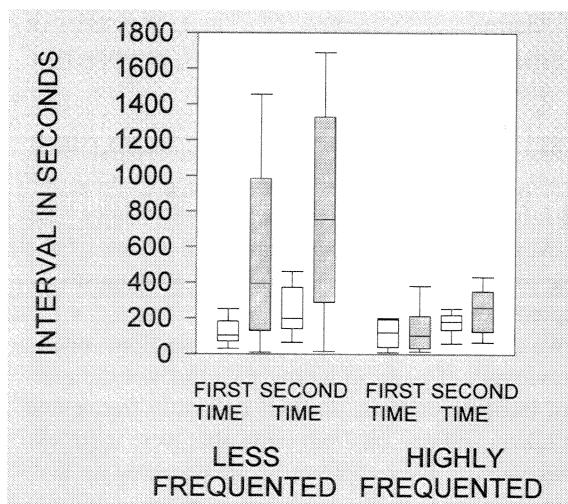


Figure 3. Interval of first and second time appearance of the first and two marmots of the group, respectively, after the observer had left the burrow. Intervals for mid summer (□) and late summer (■) are given for less frequented and highly frequented areas. Medians, first and third quartile, minima and maxima are indicated.

significant increase in time until the animals reappeared in less frequented areas whereas in highly frequented areas the time was still very short and did not differ from that found in July (Mann Whitney U-Tests: highly frequented areas, $P_s > 0.05$; less frequented areas, $P_s < 0.01$, $N = 20$; Fig.3).

Discussion

Adult animals in the highly frequented areas which are subjected to considerable human intrusion ($>1,000$ hikers on peak days), apparently adjust to disturbances and react differently when compared to marmots in less frequented areas. Marmots in highly frequented areas therefore appear less shy than animals in remote areas.

It would be reasonable to assume that adjustment to disturbance would take place during the tourist season, even if it were only of temporary nature. It could also be argued that animals in the highly frequented areas would be expected to react less in late summer than earlier in the year, because of their increasing need for foraging time (Dill & Houtman 1989, Holmes 1984). However, this was not the case indicating that adult marmots do not need to adjust or that their ability to do so is limited. An alternative explanation is that marmots in highly frequented areas learned in previous years that hikers typically

pose no threat and remember this for the rest of their lives. Animals in less frequented areas may already have had sufficient foraging time and can afford to be more cautious. This could be the reason why flight distances are slightly longer and alarm calls more frequent in such areas. Blumstein, Steinmetz, Armitage & Daniel (1997) suggested that alarm calling is a form of parental care. Adults could have called more frequently to warn young, inexperienced animals. In highly frequented areas, where several hundred people pass every day, it would not be feasible to call each time a hiker passes.

Whilst juvenile marmots show very little fear when they leave the burrows in early summer, their sensitivity increases during the first months, but increases much less in the highly frequented areas than in the less frequented areas.

That young animals are still less shy in autumn than adults may well be due to the fact that they have less time to acquire fat reserves than adults (100 days instead of 170, Naef-Daenzer 1984). This could explain their greater readiness to accept potential danger from disturbance in favour of additional foraging time.

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