

**Variation of Vigilance Due to Predator Pressure
in Yellow-bellied Marmots
(*Marmota flaviventris*)**

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Abstract

Vigilance is an anti-predator behavior responsible for ensuring the survival of an individual. This behavior directly benefits the individual, as well as conspecifics by scanning for potential threats. The amount of time devoted to vigilance in yellow-bellied marmots varies based on many factors including age, sex, group size, presence of other marmots, and predator pressure. The goal of this study is to explain variation in vigilance by incorporating predator pressure into a statistical model. By using focal observations time allocations for vigilant behaviors were obtained. A general linear model was fit in order to explain the variation in vigilance for eight known colonies at the Rocky Mountain Biological Laboratory. Several factors such as age, sex, and slope were not statistically significant whereas the category of animals within 10m was marginally statistically significant. The covariate of total predators per observation time provided statistically significant results.

Introduction

Vigilance is a common anti-predator behavior necessary for survival in bird and mammal prey species (Blumstein 1996; Blumstein 2006; Beauchamp 2008). Being vigilant involves rising of the head a certain distance from the ground in order to look for potential threats. In Thomson's gazelle the more vigilant an individual is, or the higher rate of scanning for predators, the greater chance of escape. Inversely, lower vigilance resulted in a slower reaction to a potential predator or an attack (FitzGibbon 1989). This is a costly behavior because it conflicts with other beneficial behaviors, such as feeding or mate searching, so differences among individuals are found. Not all vigilance is anti-predator related since individuals are also observing conspecifics that are in direct competition for resources (Monclús et al. 2008). In general, social species require individuals to be vigilant in order to ensure the survival of conspecifics with an added benefit of increasing the odds

that the individual is not preyed upon (Caro 2005). In field studies it has been shown that predators will prey upon the least vigilant individual in a group as well as any individuals that are tending more to their foraging needs as they are usually considered the weakest (FitzGibbon 1989; Krause & Godin 1996). In other cases juveniles are known to feed more often than adults to maintain their bodily growth needs which is a trade off in vigilance behavior (Carey & Moore 1986).

In yellow-bellied marmots (*Marmota flaviventris*), many factors affect the amount of time and energy that can be allocated to scanning for predators. This includes group size, age of the individual, vegetation, food type as well as terrain they live in (Blumstein 2004a). Being a social species, marmots benefit from having conspecifics look out for predators as it affords the individual more time to forage (Carey & Moore 1986). One example of how terrain affects predation risk comes from a study focused on locomotor ability which showed that marmots move faster through low vegetation and dirt compared to stone and talus environments (Blumstein et al. 2004a). The sex of animal can have an effect on the scan duration of an individual. For example, mother Przewalski's gazelle's had higher scanning rates than single males (Li 2009).

Yellow-bellied marmots create elaborate burrows in order to find refuge from predation (Armitage 1975) and thus must be aware of how far they stray from a burrow in order to forage, socialize and engage in other life activities. Elk vigilance increases with distance from refuge (Wolff & Van Horn 2003) as would be expected in other prey species. In golden marmots (*Marmota caudata aurea*) vigilance decreases with group size due to the "Group Size Effect" (Blumstein 1996) and increases along with the steepness of a slope (Blumstein et al. 1994).

Variation in vigilance depends on the location where predator pressure is high or low. It is known that animals are able to assess their actual risk of predation and should respond accordingly (threat-sensitive predator avoidance hypothesis) (Helfman 1989). In this study we used various

methods of determining predator existence at known marmot colonies within the Upper East River valley that have been studied continually for the past 47 years. Certain colonies may face higher mortality that lead to population sinks (Van Vuren 2001) thus vigilance plays a crucial role in the survival of an individual. The goal of this study is to explain variation in vigilance by incorporating predator pressure into a model which, up until now, only thirty percent has been explained using group size in golden marmots (Blumstein 1996). My hypothesis is that increased predator pressure will increase vigilance.

Methods

This study was conducted at the Rocky Mountain Biological Laboratory (RMBL) in Gothic, Colorado, USA for 8 weeks during the summer of 2009 at various colonies among the Elk Mountain region. Eight different colonies located up or down valley were used for study sites. Down valley colonies included Bench, River, Horse Mound, and Town which are also at lower elevations (2,986m). Down valley colonies live among various vegetation heights and mild terrain. Up valley colonies include Marmot Meadow, Picnic, North Picnic, and Stonefield which are at higher elevations measuring 3,000m and above. These up valley locations vary in vegetation types and heights as well as incline and substrate. The Picnic site is primarily composted of talus, shrub and grass whereas the other locations have denser vegetation with various amounts of stones dispersed among the site.

Generations of marmots have been tracked using live traps and marking of individuals with Nyanzol ® cattle dye for identification purposes in order to observe them in their natural environment. This dye is inert and allows for easy identification of individuals from a distance. Observations were made with 10 x 45 spotting scopes from distances of 30-300m as to not disrupt natural behaviors. Two minute focal observations were dictated into a microcassette recorder while

observing an individual's foraging bout and one per individual used. These specific behaviors are defined by the ethogram from Blumstein et al. (2004a) which incorporates the following: quadrupedal foraging, bipedal foraging, quadrupedal looking, bipedal looking, locomotion and when the animal was out-of-sight. Foraging consists of food intake whereas the looking behaviors involve peripheral scanning with their head above the shoulders whether they are standing quadrupedal or rearing on their hind legs.

These classifications help us define how marmots utilize their time budget and are a focal point of this study. They also can be used to quantify vigilance as the "rear look" stance has been documented to increase visibility (Monclús et al. 2008; Bednekoff & Blumstein 2009). These behaviors are analyzed using JWatcher 1.0 software (Blumstein & Daniel 2007) in order to calculate time allocation to vigilance. Additional information collected includes number of individuals within 10m from the foraging marmot, distance to burrow, age, sex and slope.

Alarm calling is also a signal of anti-predator behavior where receivers reap the benefits of being alerted to danger. In group-living mammals this is a key survival tactic used in order to reduce predation (le Roux et al. 2009). Studies have shown that individuals have "distinct acoustic characteristics" of their whistle calls (Blumstein & Armitage 1997; Blumstein et al. 2004b). Alarm call rates were incorporated into the analysis of variation in vigilance via observational records.

To measure predator pressure our observations were recorded whenever a potential predator was seen or heard. Predation is observed rarely and possible predators include, but are not limited to, red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), badgers (*Taxidea taxus*), American martens (*Martes americana*), black bears (*Ursus americanus*) and various raptors. Each predator has their own method of hunting which leaves a unique mark when successful. Badgers are known to dig at burrows whereas bears and coyotes leave barely any trace behind (Van Vuren 2001).

Other perceived threats such as domesticated dogs elicit anti-predator behavior in marmots and therefore were incorporated into predators observed.

Data Analysis

Statistically, variables were fit to a general linear model (GLM) in order to explain variation in time allocated to foraging and vigilance as a function of predator visits, predator sign, and alarm calling rates after controlling for variation explained by age, sex, slope, substrate, and date of focal. All the variables were normally distributed and the variances homogeneous. Age was listed as juvenile, yearling or adult. Substrate had four categories consisting of low vegetation, high vegetation, talus, and stone. Slope was measured in degrees ranging from 0-10, 10-30, and >30. Another category included was number of marmots within 10m. An index of predator pressure (low, medium, high) was determined by total number of predators in relation to observation time for the eight different colonies.

Results

Focals (n=100) were analyzed with a general linear model (GLM). The GLM was filled with the following factors: animals within 10m, sex, age, slope, and substrate. The category of total predators sighted (during observations) was used as a covariate. Total predators sighted per observation time yielded a statistically significant level ($F=4.549$, $p=0.036$). This indicates strong evidence to explain variation in vigilance thus supporting the hypothesis that vigilance will increase with higher predator pressure. It was also found that animals within 10m was marginally significant ($F=3.429$, $p=0.067$). Vigilance was lower with more marmots near. Other factors that did not yield significant results were sex, age, slope, and substrate (see Fig. 1).

Figure 1: Tests of Between-Subject Effects

Source	DF	F	Significance	Partial Eta
Animals within 10m	1	3.429	0.067	0.037
Sex	1	1.411	0.238	0.016
Age	2	1.794	0.172	0.039
Total Predators/Observations	1	4.549	0.036	0.049
Slope	2	0.255	0.776	0.006
Substrate	3	0.695	0.556	0.023

Discussion

By using total predators per observations as an explanatory variable in the model 5% of variation in vigilance can be explained. The statistically significant level was only obtained using the covariate representing predator intensity whereas the other variables of sex, age, slope, and substrate were non-significant. It is unclear what effect slope has on vigilance which was also found in Blumstein & Bednekoff (in press). For this study it may be due to a low sample size from each location. Having a low sample size, however, was a limitation of the study itself.

Adults, yearlings, and juveniles were similarly vigilant for potential predators whereas in other cases the young should be more vigilant considering there are more predators able to consume them (Caro 2005). This could be due to adults and young both being wary of aerial and terrestrial predators in the area which were seen as well as heard by several observers. Substrate also failed to explain variation due to most focals being performed before high vegetation occurred whereas a study (Blumstein 2004a) showed that substrate influences the speed of escape which alternatively affects vigilance. Predator pressure can be considered to induce a behavior change in the prey species, due to the predator's existence in the same area, which is considered a "risk

effect” (Creel 2008; Schmitz et al. 1997). Risk effects are also considered trade-offs of time allocations (Schmitz et al. 1997) and result in variation of foraging as well as vigilance behavior.

This has been a novel study regarding predator pressure being incorporated into a linear model and the results are promising as further studies may explain more variation. The findings from this study imply that there may be a component of marmot behavior that contributes to their individuality when it comes to vigilance. Future studies could look at vigilance in marmots from a different perspective in order to explain this variation in vigilance.

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