

**Consistency in Individual Differences
of Foraging and Vigilance Patterns
in Yellow-Bellied Marmots,
*Marmota flaviventris***

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Abstract

Animals frequently exhibit variation in their behavior. In the past this variation has been treated as statistical error, but research has identified correlated behaviors across contexts, referred to as behavioral syndromes. We focused on yellow-bellied marmots (*Marmota flaviventris*) and examined vigilance and foraging patterns while in five different contexts: food alone, food in the presence of a mirror, food in the presence of a plastic Canada goose decoy, foraging on natural vegetation, and behavior while in a trap. We found correlations in how animals foraged across some of these different contexts. Thus, we discovered that a ‘vigilance while foraging’ syndrome exists in a natural population of marmots. We found that there are contextually linked groups of behavior that explain variation in behavior within a population of animals, and further research needs to be done to analyze the fitness consequences of this syndrome.

INTRODUCTION

Animals are variable in their behavior but some behavior varies systematically across different contexts (Gosling & John 1999; Hedrick 2000; Gosling 2001; Sih et al. 2004; Bell 2005). In the past these variations within a species were discounted as error. On the other hand, we all know that it is very easy to discern one individual from another on the basis of their personality. Recent research in various species of animals has focused on “personality” traits in animals and the ecological and evolutionary effects of these “personality traits” on a species (Gosling 2001; Sih et al. 2004).

Correlations in behaviors where rank order is maintained through various contexts have been termed behavioral syndromes (Sih et al. 2004). For example, if an animal is

very bold in the presence of a predator, it must also be very bold in a competitive situation. In comparing the two situations the animal may be less bold in the presence of the predator, but in relation to other conspecifics the individual is the boldest through out both of the situations. The term behavioral syndrome originated because correlated traits in evolutionary ecology are called syndromes (Sih et al. 2004). Behavioral syndromes have been very important in explaining traits that are non-adaptive, and correlations between these behaviors often elicit different ecological and evolutionary outcomes depending on the context of the situation (Bell & Stamps 2004). For example, if an animal has a bold-aggression syndrome that is present across various contexts, through aggression it will benefit in a competitive situation with a conspecific, but in the presence of a predator a bold display will increase the risk of attack. A recent reintroduction study of captive bred swift fox (*Vulpes velox*) showed that bolder foxes had a higher mortality rate when reintroduced into the wild (Bremner-Harrison et al. 2004). It has also been found that a bold-aggressive personality has a link to dominance, and in mating situations bold individuals will breed more (Dingemanse et al. 2004). There are various ways to identify personalities in animals, but the methods I used involved the use of novel stimuli.

Many experiments in the past have utilized novel stimuli in a subject's environment to see how they respond to a stimulus which is unfamiliar (Wilson et al. 1993; Verbeek et al. 1994; Bremner 2002). While the majority of these studies have been conducted in lab conditions, there is a need for this type of work to be done in the field to identify patterns and stability of behavioral syndromes across various contexts. I studied how behavior in yellow-bellied marmots (*Marmota flaviventris*) was correlated with time spent foraging in their natural environment when exposed to ecologically relevant novel stimuli.

The experiment consisted of exposing yellow-bellied marmots in their natural environment to three different novel stimuli which varied the context of the situation. The three treatments were a mirror in the presence of food, a plastic goose decoy in the presence of food, and food alone. The exposure of animals to their own image through a mirror, mirror image stimulus test (MIS test), has been utilized to study behavior in an assortment of species (Gallup 1968; Svendsen and Armitage 1973; Armitage and Van Vuren 2003). In recent research on social behavior in yellow-bellied marmots a MIS test in a closed environment was used to gauge shy and bold behavior through observed behavioral interactions that the subject had with the mirror (Armitage and Van Vuren 2003). This test is relevant because it introduces the subject to a conspecific it has obviously never seen before that is foraging on the same food that the marmot is foraging on. I then exposed the subject to a potentially threatening situation by placing a plastic Canada goose decoy with food near a marmot burrow and observing how the behavior of the marmot was affected. Although geese fly over the study areas they can still be considered novel because they have never been seen sitting next to a marmot burrow. In a similar experiment with fish a red-tipped stick was placed in the aquarium to expose the fish to a novel object which was potentially threatening (Coleman and Wilson 1998). The methods are the same between both experiments, but I believe a novel stimulus such as a goose decoy in the subject's natural environment to be much more ecologically relevant. The third treatment consisted of food alone. This situation is very beneficial to the marmot and is accompanied with less perceived risk when compared with the previous two treatments. By conducting the experiment in the field there was relatively little interference when compared to studies done in the lab. Animals in a closed environment

must be handled numerous times, as in previous marmot research involving MIS tests (Armitage and Van Vuren 2003). The only interference the marmots encountered in the field was when the observers set up the different treatments near their burrows. The main novelty of this research is that by exploring particular behaviors in the field many correlations with certain behaviors can be explored in their natural environment instead of lab conditions.

The main question I seek to answer is whether or not there is a foraging syndrome in yellow-bellied marmots. By analyzing the total time spent foraging and vigilant I was able to see if there were strong correlations across the various contexts through out the subjects being studied, or if total time allocated to foraging was context specific. By conducting this research in the field I was also able to explore behavior in an ecologically relevant environment, and perpetuate the study of behavior by integrating past techniques into a natural environment. This type of behavioral research in the field has rarely been done in the past, and must be done to identify if indeed larger behavioral patterns do exist in a natural environment.

METHODS

Yellow-bellied marmots are large, diurnal, ground dwelling rodents that occupy a range of middle elevation to alpine environments in the mountains of the western United States (Frase and Hoffmann 1980). We study marmots in the upper East River Valley, Gunnison County, Colorado. Each year the marmots are trapped and marked with dye, so they are easily identified from a large distance with the aid of a 15-45X spotting scope. Animals are also affixed with ear tags for permanent identification. Observers sat in locations where their presence does not obviously affect marmot behavior, and

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observations were done during times of peak activity (sunrise to 10:00 h, and 16:00 h to sunset).

My sample size consisted of 45 subjects of various sexes and ages. I exposed each subject to four different treatments. The order of the treatments was varied from colony to colony to control for order effects. The first treatment consisted of the subject in its natural environment foraging on vegetation. In the second treatment the subject was exposed to a large handful of Purina Mills Omalene 100 horse food alone. I chose Omalene because it consists of small non-monopolizable pieces of food. Thus, the animals were unable to take a large piece and run off to forage on it elsewhere, and as a result the animal had to remain in the presence of the stimuli to consume the food.

The third treatment was a 22 cm x 29 cm mirror with a large handful of food 25 cm in front of the mirror where the animal was presented with an image of itself while foraging. The fourth treatment was a plastic decoy of a Canada goose with a large handful of food 25 cm in front of the goose. The decoy was situated such that the head of the decoy was directed towards the food. The experimental treatments varied the context of the environmental situation by exposing subjects to three different types of stimuli. I collected the following data for each experimental presentation: the date, identification of the subject, area under observation, burrow location of the subject, time the observer first saw the subject, the number and identity of conspecifics within 10 meters when the subject was first seen, time the subject first oriented itself towards the stimulus, number and identity of conspecifics within 10 meters when the subject first oriented itself to the stimulus, time subject first contacted stimulus, number of contacts with stimulus, type of

contact with stimulus, number of alarm calls, start and stop time of alarm calling, time subject contacted food, subject exposure number for the specific stimuli, subject exposure number for all stimuli, angle of incline of the area in which the subject foraged, and substrate (stones, talus, dirt, short vegetation, and tall vegetation).

When the subject began to forage, I conducted a two-minute focal animal sample in which behavioral transitions were recorded. My ethogram of behaviors consisted of quadrupedal foraging, bipedal foraging (later combined into a total foraging variable), quadrupedal looking, bipedal looking (later combined into a total looking variable), locomotion, and periods of time when the animal was out of sight. I dictated observations into a micro-cassette recorder and later scored the behaviors utilizing JWatcher 0.9 (Blumstein et al. 2000). By utilizing this technique in which observers were trained to observe behavior and use JWatcher software with 100% accuracy, intra-observer reliability across all four treatments was very high, and each observer was trained to conduct focals until their intra-observer reliability was 100%. Focals were not conducted in inclement weather such as snow, rain, or excessive winds. This was to control for environmental factors that may affect marmot behavior. I also eliminated all focals in which an individual did not forage for more than 20 s because I wished to collect data on animals that were foraging. In these instances we obtained a second focal for the animal and noted that this was their second exposure to the treatment.

I collected data on the time in which the subject was first seen, first oriented itself towards stimulus, and began foraging, and I was able to see if latency to forage correlated across all four treatments. Of course, the time in which the animal orients itself towards the stimulus was not utilized in the treatments with food alone and no food because there

was no stimulus present. The number of conspecifics present within 10 meters when the animal first appeared, saw the stimuli, and began foraging was important because it has been shown that as group size increases vigilance decreases (Blumstein et al. 2004) and time spent foraging is also affected either through increased foraging competition (Clark and Mangel 1986; Elgar 1989) or by reduced predation risk through the idea of “safety in numbers” (Vine 1971; Pulliam 1973). The identification of the conspecifics was noted because nearly all males and fifty percent of all females disperse as yearlings (Armitage 1986). Because dispersal is usually the result of aggression from the resident male (Armitage 1975), yearlings in the dispersal process are likely to be more wary in the presence of a dominant conspecific (Blumstein et al. 2004). Observers were trained to judge the angle of incline with a clinometer because in a recent study it was shown that marmots allocated most of their time to foraging while on slopes $< 30^\circ$ and less of their time foraging on slopes $> 10^\circ$ (Blumstein et al. 2004). Substrate was noted because time allocated to foraging may vary as the vegetation changes throughout the growing season.

I also had a master list of all exposures an animal encounters and the dates in which the focals were taken for each treatment. It was important to note if an animal had previous exposure to a stimuli because a subject’s wariness to forage is likely to be reduced as a result of familiarity with the stimuli, thus eliminating its novelty.

Trap data was also utilized in the analysis of the subjects being studied. When trapped it was recorded whether or not the marmot defecated, tooth chattered, called, struggled in trap, tried to bite through the cage, and if the marmot immediately walked into the bag. This data was useful in analyzing the disposition of the marmot while in the trap. The trap data that was most proximal to the treatments was used in the data set.

Analysis was conducted utilizing JWatcher and focused on the total time allocated to vigilance and foraging behaviors throughout the two minute focal. Behavior was grouped into three categories: foraging behavior (stand forage and rear forage), vigilance behavior (stand look and rear look), and vigilance with locomotion behavior (stand look, rear look, walk, and run). The locomotion behavior can be grouped with the vigilance behavior because it is a flight response that can be associated with heightened vigilance. A principal component analysis was used to derive two components from the trap data which has been collected since the onset of trapping this year. I calculated parametric correlation coefficients to see if strong correlations existed between the treatments. I also fitted repeated measures general linear models to see if there were any specific effects of colony site. Models were fitted to study how variation in time allocated to foraging was influenced by latency to forage, foraging group size, sex, and age. I collected data at a total of six colony sites. One of those colony sites (Picnic) was not used in the final analysis because out of nine subjects fewer than two of the cases involving the mirror could be utilized for data analysis.

RESULTS

My final data set consisted of 144 observations on 12 female yearlings, ten female adults, ten male yearlings, and four male adults. On average, the interval between the food, goose, and the mirror stimuli was 61 hours from the next treatment with a standard deviation of ± 57.81 and a range of 7.45 – 136.07. The ‘natural’ observation of foraging (i.e., my blank treatment) on average was conducted within 93 hours from the other three treatments with a standard deviation of ± 87.17 and a range of 16.47 –

215.76. A principal component analysis was run on the trap data and the two components that were extracted were struggling in the trap and defecating in the trap. We used a general linear model with repeated measures to analyze the effects of colony sites on the data set. Excluding the Picnic area we found no significant effects, P-values for the three behavioral groups and colony effects were: vigilance plus locomotion behavior 0.899, vigilance behavior 0.821, foraging behavior 0.873. We also ran a parametric correlation that analyzed latency to forage and age and sex affects. These two factors were correlated against all of the treatments and trap data and no correlations with a P value less than 0.5 were found.

Table 1. Correlation coefficients for the total time allocated to vigilance plus locomotion for the relationships between the 4 treatments plus the two factor scores for the trap data. Significant correlations ($p < 0.05$) are in bold; non-significant tendencies ($0.05 < p < 0.1$) are italicized. N = 36.

	FOOD TREATMENT	GOOSE TREATMENT	MIRROR TREATMENT	DEFECATE IN TRAP	STRUGGLE IN TRAP
BLANK FOCAL	-0.075	0.396	<i>0.195</i>	-0.1	0.029
FOOD TREATMENT	/	0.391	-0.04	<i>-0.195</i>	0.053
GOOSE TREATMENT		/	0.106	-0.346	-0.003
MIRROR TREATMENT			/	<i>-0.127</i>	0.046

As you can see in Table 1 there are strong correlations between the goose treatment and the blank focal and food treatment, but there is no correlation between the blank focal and food treatment. There is a slight correlation between the blank focal and mirror treatment. The trap data also slightly correlates negatively with the food and mirror treatment and strongly correlates negatively with the goose treatment. There is no

correlation with struggling in the trap and any of the treatments. Data across all of the three treatments makes almost all of the same correlations as would be expected because these behaviors are traded-off, the results are similar for the other measures (Tables 2 and 3).

Table 2. Correlation coefficients for the total time allocated to vigilance for the relationships between the 4 treatments plus the two factor scores for the trap data.

Significant correlations ($p < 0.05$) are in bold; non-significant tendencies ($0.05 < p < 0.1$) are italicized. $N = 36$.

	FOOD TREATMENT	GOOSE TREATMENT	MIRROR TREATMENT	DEFECATE IN TRAP	STRUGGLE IN TRAP
BLANK FOCAL	-0.019	0.442	<i>0.149</i>	-0.074	0.713
FOOD TREATMENT	/	0.343	-0.046	<i>-0.204</i>	0.821
GOOSE TREATMENT		/	0.096	<i>-0.313</i>	0.846
MIRROR TREATMENT			/	-0.109	0.965

Table 3. Correlation coefficients for the total time allocated to foraging for the relationships between the 4 treatments plus the two factor scores for the trap data.

Significant correlations ($p < 0.05$) are in bold; non-significant tendencies ($0.05 < p < 0.1$) are italicized. $N = 36$.

	FOOD TREATMENT	GOOSE TREATMENT	MIRROR TREATMENT	DEFECATION IN TRAP	STRUGGLE IN TRAP
BLANK FOCAL	-0.006	0.418	<i>0.133</i>	0.053	-0.026
FOOD TREATMENT	/	0.403	-0.056	<i>0.193</i>	-0.041
GOOSE TREATMENT		/	0.091	0.341	0.01
MIRROR TREATMENT			/	<i>0.131</i>	-0.058

DISCUSSION

Investigating the relationship of total time allocated to different behaviors across different contexts demonstrated that it is possible to establish a ‘vigilance while foraging syndrome’ in a natural population of yellow-bellied marmots, and it is possible to conduct research on ‘foraging and vigilance’ syndromes on a natural population in the wild. We found that total time allocated to foraging was strongly correlated across several contexts. As you can see in all three of the tables there were very strong correlations with the goose treatment and the blank and food treatments. Foraging behavior in the goose treatment can be used as a good predictor of foraging behavior in the blank focal and food treatment. For example, if a marmot allocates the majority of its time towards vigilance behavior in the presence of the goose, it will also allocate a large percentage of its time to vigilance behavior while foraging on food alone. This same marmot will also allocate a large percentage of its time towards vigilance behavior while foraging on vegetation in its natural environment. It is easy to assume that since the blank and the food correlated with the goose there should be a correlation with the blank focal and the food treatment, but as you can see in the tables this is not the case.

There is a lot of variance in the data, and this variance may be why the food treatment and blank focal do not correlate. While foraging in natural conditions the marmots are naturally wary as a result of many factors. One example is that marmots typically forage a substantial distance from their burrow in an environment where they are typically preyed upon, and their wariness is heightened in this type of situation. The same could be said for a marmot foraging in the presence of novel stimuli such as the goose. The

marmot's wariness would be high in the presence of the stimuli, because it poses a more realistic situation in that the marmot is fearful of the novel stimuli. In contrast the marmot's vigilance would be significantly lower in the presence of food alone, because the situation is relatively beneficial with low risk. The food is very close to the burrow and the food is an excellent source of protein with a low energy investment. Marmots in the presence of the goose are warier than when they are in the presence of food alone, and because of this variation in foraging behavior the food treatment and blank focal are not strongly correlated even though they are each individually correlated with the goose treatment. Another interesting result was that the mirror was not significantly correlated with any of the other treatments.

In the past the mirror stimulus test has been used to gauge social behavior (Gallup 1968; Svendsen & Armitage 1973) in various species of animals. Because of this the mirror created a situation that was more social than threatening and the percent time foraging was not consistent when compared to the other three treatments. The marmot was in a situation where not only was it foraging in the presence of a conspecific, but the conspecific was also foraging at the same time that it was. The marmot was also never able to forage alone and to some extent the mirror doubled the group size of foraging marmots as a result of the image reflection. Several previous studies have demonstrated that group size influences foraging behavior (Carey & Moore 1986; Blumstein et al. 2004). As a result these two factors may be why there was not a strong correlation between the mirror treatment and the other treatments. There was a slight correlation between the mirror treatment and blank focal data. A marmot that was vigilant throughout the blank focal tended to be vigilant in the presence of the mirror.

We also found that there were strong correlations between defecation in traps and goose treatments as seen in Table 1 (vigilance plus locomotion correlations) and Table 3 (foraging correlations). A marmot that forages a lot in the presence of the goose is more likely to defecate while in a trap. Defecation in a trap is a behavior that can be interpreted as a relaxed state. This finding makes sense because a marmot that is less wary in the presence of novel stimuli is also less wary and relaxed in a trap. As seen in Table 1 (vigilance plus locomotion correlations) and Table 3 (foraging correlations) there were also slight correlations between the trap data and the mirror and food treatments, and in Table 2 (vigilance correlations) there were also slight correlations between the trap data and the goose and food treatments. This data suggests that there is a weak relationship between foraging and vigilance behavior in these treatments and being relaxed in a trap. For instance, animals that were more vigilant in the food treatment tended to not defecate in the trap. Although defecating in the trap was correlated with other treatments, struggling in the trap was not correlated with any of the treatments (Tables 1, 2, and 3). This may be because the behaviors are contextually different in that struggling in the trap may be representative of personality types like boldness or aggressiveness, but our experiment is not designed to gauge this type of personality. This may also explain why there are no correlations between the treatments and struggling in the trap. Defecating in the trap may be more indicative of wariness, and was correlated because wariness is directly related to foraging behavior.

Armitage et al. (1996) previously found that there are meaningful age and sex effects on time allocation in foraging and vigilance behavior. Age and sex was known for each subject and through analysis with a general linear model that utilized repeated measures

we found that there were no significant effects on the data as a result of age and sex of the subjects. We also used this same general linear model with repeated measures to analyze whether there were any colony effects on the three groups of data collected (vigilance, vigilance plus locomotion, and foraging behavior). After removing the Picnic site, we found that colony sites had no significant effects on any of the data and thus there were no site specific effects distorting the data. Again utilizing the same statistical model we analyzed whether or not latency to forage was correlated across the treatments, and we found that there were no significant differences of the latency to forage across the different treatments.

In conclusion, through our research we have been able to identify a ‘vigilance while foraging’ syndrome in a natural population of marmots. We have found that foraging behavior in one context has predictive power in another. Future research will be necessary to evaluate the fitness consequences of this syndrome, and continuance of this research will generate more data so questions about how foraging behavior affects dispersal of female yearlings can be answered.

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