

The effect of body condition of yellow-bellied marmots on time allocation to vigilance and food acquisition while foraging

Abstract

Condition can influence many traits. I looked at how condition affects time allocation while foraging for yellow-bellied marmots (*Marmota flaviventris*) by taking two minute focal samples of adults and yearlings and recording their behavior. Each focal was paired with measurements of condition collected from the nearest trapping date. Overall, condition did not affect time allocation for foraging. When the individuals were separated into age-sex cohorts, condition was not significantly correlated with time allocation for females. The sample size of adult males was too small to form any conclusions, but as condition improved time allocation to both foraging and looking increased. Yearling males had a moderately significant tendency to trade-off looking for foraging if they were in poorer condition. Yearling males may be the only group to respond because they are the only cohort that must disperse and condition may be essential for the survival of dispersing individuals.

Introduction

While foraging, animals face many decisions. They must decide where to forage, when to forage, who to forage with, and how intently they look while foraging as well as how far they should move from refugia. Armitage (1996) found that yellow-bellied marmots (*Marmota flaviventris*), herbivores with aerial and ground predators (Van Vuren 2001), spend 12-23% of their overall time foraging. However, while foraging they must trade-off antipredator vigilance with food ingestion. I studied factors that influence wariness while foraging.

Body condition affects many areas of decision-making in animals. A predator with nutrient deficiency may decide to eat a weakly toxic prey that it would otherwise ignore (Sherrat et al. 2004). Scorpions with a lower mass-to-size ratio forage more often in the moonlight than those with a normal mass-to-size ratio, although the light makes them more susceptible to predators. Juvenile scorpions also forage in the moonlight than

adults (Scatelsky 1996). Belding's ground squirrels (*Spermophilus beldingi*) were found to decrease vigilance while foraging if they had a lower body mass relative to their peers (Bachman 1993). Marmots are energy conservers and only have a few months to gain enough mass to prepare for hibernation (Armitage 1976). The condition of a marmot, which can be measured by comparing the length of their foot to their mass, may affect time allocation while foraging. This may be separated into age-sex cohorts, because of different metabolic rates which influences the total amount of time spent foraging (Armitage 1991).

Age can also affect time allocation to anti predator behavior and food gathering because younger animals face the conflict of higher predation and more pressure to consume enough nutrition to grow. Young marmots were found to spend more time looking while foraging than adults (Carey & Moore 1986). They also can forage more during the afternoon because they are not as adversely affected by heat as are adults (Armitage 1991). Younger California ground squirrels spend more time in bipedal postures than adults, probably because they are shorter and it will allow greater visibility and hearing of conspecifics. Ground squirrel pups allocate more time to movement and social activities and less time to foraging than adults (Hanson & Coss 2001). Younger animals may spend more time vigilant because they may also need to learn about their surroundings (Mateo 1996).

Females may have different time allocation patterns than males while foraging because they may have conflicts with other females, they have to gain mass to reproduce, and because they may have to allocate time to guarding their pups. Females form matrilineal groups that consist of a female, possibly sisters, and daughters that may or may not be

reproductively suppressed (Armitage 1991). The groups of females may be distinct or blurred; they can stay in different areas or they may mix litters. Conflict between female marmots in different social groups increases vigilance (Armitage 1996). Females of a variety of species that are breeding increase foraging and decrease vigilance (Fennica 1993; Moreno 1992; Vila et al. 1994) and female ground squirrels that have given birth on at least one occasion spend more time overall foraging and less time vigilant, but do not increase time allocation to vigilance while foraging (Macwhirter 1991).

Males are polygamous and have larger home ranges than non dispersing females. Territorial defense may influence time allocation to wariness. Territorial male vicunas decrease foraging and increase vigilance (Vila et al. 1994) relative to females. Male marmot pups are allowed to stay in the territory, as well as some yearling males, although they may be chased or by themselves set out to disperse, but adult males do not generally stay within the same vicinity. Conflict between yearling males and dominant males increases vigilance (Armitage 1996).

Previous studies on time allocation found that a steeper incline and more conspecifics within 10 m increases time allocated to vigilance, while Julian date, and substrate did not strongly affect vigilance (Blumstein et al. 2004). This study also found some evidence of ‘cohort’ effects: the only age-sex category found to significantly explain variation in time in sight allocated to foraging and looking was the adult male category. My goal is to find if condition influences time allocation to foraging and looking specifically while foraging. Previous studies on time allocation while foraging in marmots have not included condition as a factor. I will also separate the marmots into groups of adult females, adult males, yearling females, and yearling males, to examine

any differences between cohorts. To control for other factors that affect foraging, the number of conspecifics within 10 m and incline will be included in the analysis.

Methods

The study was conducted in Gothic, Colorado, at 3 main elevation sites: 2852 m (River, Bench, and Town), 2938 m (Marmot Meadow), and 3048 m (Picnic), from 10 May to 31 July 2004. These are the main colony sites of marmots that are under regular observation. By having multiple sites I was able to increase my sample size of unique individuals. Foraging observations took place during morning and evening, when marmots are most active. Adults and yearlings were observed foraging for 2 minutes at a time. The date, time, and number of marmots within 10 m were recorded on a data sheet. Observers spoke into a microcassette to record the behaviors the marmot was engaged in: foraging, rear foraging, looking, rear looking, running, other, and out of sight. The observations were later played back and scored using the computer program JWatcher (Blumstein et al. 2000), which then calculated the percentage of time an animal allocated to foraging and looking.

To determine condition, we tried to trap all marmots every other week. Some marmots went into traps more often than others. They were marked with fur dye, which lasts until molting, and permanent ear tags. The fur dye allowed for identification of the marmot from a distance. They were weighed and their left hind foot, representative of structural body size, was measured. Their sex was determined by measuring their anogenital (A-G) distances; males have longer A-G distances than females. Their reproductive status was noted by the size of their nipples or testes.

I estimated the condition of each marmot in each age-sex cohort by using the residuals of a general linear model that explained variation in body mass as a function of the left hind foot measurement and the date of trapping. For animals with multiple focal observations, the focal date that most closely matched the trap date of the individual was used for the analysis. Separate residuals were calculated to study time allocation for each age-sex cohort. In this case, I used the time-in-sight foraging and time-in-sight looking as dependent variables, and the number of conspecifics w/in 10 m as a covariate and angle category (0-10°, 10-30°, >30°) as a factor in the general linear models.

To determine whether there was a relationship between condition and time allocation, I regressed the condition residual of a given cohort against the residuals of time allocation. The residuals and regression analysis were calculated using SPSS. I interpreted $p < 0.05$ as significant and $0.1 > p > 0.05$ as moderately significant.

Results

Overall, there was no relationship between body condition and time allocation to foraging and looking. However, when age-sex cohorts were examined independently some significant patterns emerged. There was no significant relationship between female adult condition and time allocated to foraging (Adj. $R^2 = -0.038$, $p = 0.695$, $N = 25$, fig 1a) or vigilance (Adj. $R^2 = 0.017$, $p = 0.248$, fig 1b). There was no significance in the regression analysis of yearling female condition and foraging (Adj. $R^2 = -0.82$, $p = 1.0$, $N=13$, fig 1c) or vigilance (Adj. $R^2 = -0.083$, $p = 0.786$, fig 1d). There was no significance in the regression analysis of adult male condition and foraging (Adj. $R^2 = 0.305$, $p = 0.196$, $N=5$, fig 2a) or vigilance (Adj. $R^2 = 0.550$, $p = 0.151$, fig 2b).

However, the regression line sloped upwards in both cases. There were moderately significant effects of yearling male condition on vigilance (Adj. $R^2 = 0.080$, $p = 0.083$, $N=27$, fig 2c), and foraging (Adj. $R^2 = 0.109$, $p = 0.052$, fig 2d). There was a tendency for time allocation to foraging to decrease as condition improved.

Discussion

Optimal foraging theory predicts a variety of factors will influence foraging including the cost of predation, and the rate of change in expected fitness that foraging will provide. Animals in poorer condition have reduced expected fitness and should forage more (Olsson et al. 2002). My results were not entirely consistent with these expectations. Specifically, I found that overall there is no effect of condition on time allocation while foraging. When the residuals were separated into age-sex cohorts, there was no effect of condition on time foraging for females but some effects for males. Yearling males conformed to predictions and traded-off looking for foraging if they were in worse condition. Adult males formed too small of a sample size to base predictions off of, but they both foraged and looked more if they were in better condition.

Adult females exhibited no relationship between time allocation to foraging and condition. The condition residual did not include any elements to correct for weight gained because of gestation and lactation and the adult females were not separated into reproducing and non reproducing females, although most of them had litters. Body mass of reproductive females were found to increase 9% from gestation to lactation and then remain stable from lactation to post lactation (Armitage 1992). Weight that had been gained would not have indicated additional reserves for themselves during hibernation,

but energy expenditure for offspring. Females that have had pups do not start gaining mass needed for hibernation until after the young are weaned (Armitage 1976), and all of the focals were taken before the pups emerged.

The focals were taken any time a marmot was seen foraging, but it may have occurred when the marmot was traveling or watching and was not focused on obtaining food. Some of the focal foraging bouts ended with marmots sitting on a rock, or interacting with a conspecific. Weather was not included as a factor, but may have influenced their vigilance. If a marmot had been scared by a predator or heard an alarm call prior to the focal, it may make them more vigilant than otherwise. The experience of a marmot prior to the focal was not monitored.

Although it was not significant, adult males in better condition showed a slight trend to forage and look more. I do not know why there is no trade-off in foraging and looking, only less walking, for adult males in better condition. There was a small sample of adult males, five compared to 26 yearlings, because there is usually only one adult male per colony.

Yearling males conformed to predictions and took the risk of allocating less time to looking and more time to foraging if they were in worse condition relative to their peers. They may respond this way although the other cohorts do not because they are more concentrated on food acquisition than the other cohorts. Yearling males usually disperse by the time they are two years old (Armitage 1974). They are not part of the matriline like some yearling females, they do not have to worry about offspring like adult females, and they do not have to patrol territory like adult males. All they need to worry about is their own survival. They often engage in social interactions with yearling

females, but avoid the adult male (Armitage 1973). Some yearling females, like yearling males, do not join the matriline but instead disperse. Future studies on time allocation while foraging could look at dispersing yearling females to see if they show the same trend as yearling males and if dispersal makes condition more of a factor.

References

- Armitage, K.B., et al. 1996: Population time budget for the yellow-bellied marmot. *Ethology & Evolution* **8**, 67-95.
- Armitage, K.B. 1991: Social and population dynamics of yellow-bellied marmots: results from long-term research. *Annual Review of Ecology and Systematics* **22**, 379.
- Armitage, Kenneth B. 1974: Male Behavior and territoriality in the yellow-bellied marmot. *J. Zool.* **172**, 233-265.
- Armitage, K.B., Downhower, Jerry F., & Svendsen, Gerald E. 1976: Seasonal changes in weights of marmots. *The American Midland Naturalist* **96**(1), 36-51.
- Armitage, K.B., & Salsbury, Carmen M. 1992: Factors affecting oxygen consumption in wild-caught yellow-bellied marmots (*Marmota Flaviventris*). *Comparative Biochem. Physiology*, **103A** (4), 729-737.
- Bachman, Gwendolyn C. 1993: The effect of body condition on the trade-off between vigilance and foraging in Belding's ground squirrels. *Animal Behaviour* **46**, 233-244.
- Blumstein, D. T., et al. 2004: Locomotor ability and wariness in yellow-bellied marmots. *Ethology* **110**, 615-634.
- Carey, H. V. & More, P. 1986: Foraging and predation risk in yellow-bellied marmots. *Am. Midl. Nat.* **116**, 267-275.
- Fennica, Ornis. 1993: Time allocation in Canada Geese during the breeding season. *Astroni* **70**(2), 89.
- Hanson, MT., & Goss, RG. 2001: Age differences in arousal and vigilance in California ground squirrels (*spermophilus beecheyi*). *Dev. Psycobiol* **39**(3), 199-206.

- Mateo, JM. 1996: The development of alarm-call response behavior in free-living juvenile Belding's ground squirrels. *Animal Behavior* **52**, 489-505.
- Moreno J, & Hillstron, L. 1992: Variation in time and energy budgets of breeding wheatears. *Behavior* **120**, 11-39.
- Macwhirter, RB. 1991: Effects of reproduction on activity and foraging behavior of adult female Columbian ground squirrels. *Canadian Journal of Zoology*, **69**(8), 2209-2216.
- Olsson, Ola, Brown, Joel S., & Smith, Henrick G. 2001. Long and short-term state-dependent foraging under predation risk: an indication of habitat quality. *Animal Behavior* **63**, 981-989.
- Scatelsky, O. 1996. Predation risk and state-dependent foraging in scorpions: Effects of moonlight on foraging in the scorpion *Bathus occitanus*. *Animal Behavior* **52**, 49-57.
- Sherratt, Thomas N., Speed, Michael P., & Ruxton, Graeme D. 2004. Natural selection on unpalatable species imposed by state-dependent foraging behavior. *Journal of Theoretical Biology*, **228**(2), 217-226.
- Van Vuren, D. 2001: Predation on yellow-bellied marmots (*Marmota flaviventris*). *Am. Midl. Nat.* **145**, 94-100.
- Vila, BL., Cassini, MH. 1994: Time allocation during the reproductive season in vicunas. *Ethology* **97**(3), 226-235.

Figure Legend

Fig. 1: Graphs illustrating a regression analysis for adult females of time allocated to foraging in (a) and time allocated to looking in (b) vs. condition. Graphs (c) and (d) show time allocated to foraging and looking vs. condition for yearling females.

Fig. 2: Graphs illustrating a regression analysis for adult males of time allocated to foraging in (a) and time allocated to looking in (b) vs. condition. Graphs (c) and (d) show time allocated to foraging and looking vs. condition for yearling males.