Oecologia (Berl.) 44, 390–395 (1980)

Oecologia

Environmental Harshness, Heat Stress, and *Marmota flaviventris*

D.R. Webb*
Department of Zoology, Oregon State University, Corvallis, OR 97331, USA

Summary. Yellow-bellied marmots (*Marmota flaviventris*) were studied at three sites in central Oregon. Juveniles substantially reduced their foraging activity when equivalent black-body temperatures exceeded their upper critical temperature. Inclusion of heat stress into estimates of environmental harshness drastically reduced the differences in available foraging time between high elevation and low elevation sites.

Introduction

Populations and individuals exhibit a variety of responses to the abiotic environment. While the adaptiveness of social organization is often considered in reference to biotic interactions such as predator detection, predator defense, and prey capture, social organization may also be influenced by direct responses to the abiotic environment. An understanding of the abiotic factors acting on individuals in the population is then necessary to evaluate the effects of the abiotic environment on social organization. In this paper, I consider the effects of heat stress on juvenile foraging time and show that inclusion of this factor into estimates of environmental harshness significantly reduces the range of environmental harshness to which marmot populations are exposed. For the purposes of this paper, environmental harshness is defined as abiotic variables which affect foraging within a colony site. It is therefore unlikely that the diverse social behavior found in yellow-bellied marmot colonies is due to differing regimes of environmental harshness as was postulated by Barash (1973b, 1974). The response of social behavior to abiotic factors acting during transit from one colony site to another, was previously analyzed (Webb, MS).

Barash (1974) hypothesized that social behavior in the genus *Marmota* (family: Sciuridae) is determined by the "environmental harshness" of the colony location. He used the length of the growing season of forage plants as an index of environmental harshness, and suggested that this served as the driving factor for the balance of amicable and agonistic behavior in marmot societies. Barash noted that species in this genus which experienced short plant growing seasons evinced amicable social behavior; while populations in lowland areas, which experienced longer growing seasons were characterized by agonistic behavior. He hypothesized that longer growing seasons allowed longer foraging time, and hence enabled juveniles to gain sufficient weight during the year of birth to permit dispersal. At higher elevation areas, which had shorter growing seasons, the time available for foraging was reduced, and increased amicable and decreased agonistic behavior served to retard the dispersal of young from the colony until their second year (yearlings), when prospects for successful dispersal were presumably enhanced. Barash based his hypothesis on an intensive study of *Marmota olympus* (1973a) and extensive, but short term studies of other species (1973b, 1975) plus published accounts on *Marmota flaviventris* (see Armitage, 1975; Anderson et al., 1976). Barash's studies of *M. flaviventris* (1973b) suggested that his hypothesis was also valid in an intraspecific context.

The exact nature of environmental harshness is of critical importance in testing this hypothesis and in understanding social behavior in this genus. Barash's (1973b) identification of environmental harshness as the length of the plant growing season was contested by Anderson, et al. (1976) who used the period of weight gain. In this paper, I refine and quantify the notion of environmental harshness based on studies of *Marmota flaviventris* conducted at a wide range of colony sites in central Oregon. I consider here only abiotic factors which operate within the area of a single colony: heat stress and day length. Except for the use of activity budget data to evaluate the effects of heat stress on available foraging time, I consider only environmental harshness itself; the animals responses to environmental harshness were discussed previously (Webb, MS).

Methods

I studied populations of *Marmota flaviventris* from April to October, 1976 and from March to October, 1977. The study sites represented a diverse range of habitat types and elevations (Table 1). High elevation study sites with animals dispersing as yearlings were designated as mountain sites; those at low elevations, with juvenile dispersal, as lowland sites. Most observations were carried out at the three major sites: Smith Rocks, Devils Garden, and Fall Creek (Fig. 1). The vegetative growing season at Fall Creek was extremely short for *Marmota flaviventris,* approaching that reported for *Marmota olympus* (Barash 1973a, 1974). Smith Rocks had a long growing season, while that at Devils Garden was intermediate. Other minor study sites were used to insure that the major sites chosen were representative of growing season lengths and temperature regimes. I determined growing season lengths, dates of emergence from and entry into hibernation, and

* Present address: Department of Zoology, Washington State University, Pullman, WA 99164, USA

0029-8549/80/0044/0390/$01.20