

SEASONAL BODY TEMPERATURE FLUCTUATIONS AND ENERGETIC STRATEGIES IN FREE-RANGING EASTERN WOODCHUCKS (*MARMOTA MONAX*)

STAM. M. ZERVANOS* AND CARMEN M. SALSURY

Department of Biology, Pennsylvania State University, P.O. Box 7009, Reading,
PA 19610-6009, USA (SMZ)

Department of Biology, Albright College, P.O. Box 15234, Reading, PA 19612, USA (CMS)

Present address of CMS: Department of Biology, Butler University, 4600 Sunset Avenue,
Indianapolis, IN 46208, USA

During a 2-year period, radiotelemetry was used to continuously monitor body temperature (T_b) of free-ranging woodchucks (*Marmota monax*) in southeastern Pennsylvania. Hibernation was preceded by daily T_b fluctuations ("test drops") of 2–4°C. During hibernation, woodchucks exhibited the characteristic pattern of torpor bouts. Time of arousals occurred randomly, but onset of torpor occurred predominantly between 1800 and 0000 h. Males had shorter hibernation periods (mean of 104.8 days) than did females (121.8 days). Males had shorter torpor bouts, but euthermic bouts were the same length as in females. Males also maintained higher T_b during torpor. Overall, the cost of hibernation was greater for males than for females: males spent 38% more energy than did females. The primary energetic expense for both sexes was the periodic maintenance of euthermia throughout hibernation, which accounted for 75.2% of the energy budget for males and 66.8% for females. Compared with the 1999–2000 hibernation seasons, woodchucks during the 1998–1999 season had longer euthermic bouts, fewer torpor bouts (11.8 compared with 13.1), and spent less time in torpor (68% compared with 75%). These differences conserved more energy during the 1999–2000 hibernation season and may have been the result of severe drought conditions during summer 1999. After emergence from hibernation, woodchucks generally maintained a constant state of euthermia throughout the active season, with T_b fluctuating daily by 1–2°C. However, during the summer drought of 1999, daily T_b fluctuated 8–17°C in 5 of 8 woodchucks, presumably to conserve energy and water.

Key words: body temperature, energetics, estivation, hibernation, *Marmota monax*, torpor, woodchucks

Hibernation is prominent among ground-dwelling squirrels of the family Sciuridae and is characterized by an extreme reduction in metabolic function and body temperature (T_b) that may extend over repeated bouts, each lasting several days (Lyman et al. 1982). Because of substantial energy savings from depressed metabolic function, hibernation is widely used as a mechanism to survive harsh conditions such as low ambient temperatures (T_a) and food scarcity.

The hibernation patterns of ground-dwelling squirrels have been studied extensively in the laboratory (French 1982; Geiser and Kenagy 1988; Harlow and Menkens 1986; Pivorun 1976). Fluctuations in T_b and arousal state have been documented for many species in captivity including species of *Marmota* (Armitage et al. 2000; French 1990; Heldmaier et al. 1993; Lyman 1958). Depletion of fat stores and changes in body mass throughout hibernation have also been examined (Armitage et al. 2000; Davis

* Correspondent: smzl@psu.edu