

Maintenance of biological rhythms during hibernation in Eastern woodchucks (*Marmota monax*)

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Abstract We undertook a study to determine presence of circadian rhythms during woodchuck hibernation using continuously monitored body temperatures. Males had shorter torpor and longer euthermic periods than females. Circular statistics revealed a significant mean vector for males entering into torpor (10:21 h), but not for females. No significant mean vector was found for male or female arousal from torpor. A contingency test was applied to the torpor bout durations. All 7 males tested had significant τ 's between 24 and 26 h, while 6 of the 13 females tested had significant τ 's with a range of 22–27 h. These results implicate a free-running circadian clock during torpor bouts. Overall, the data support the existence of biological rhythms during hibernation in woodchucks, especially for males during arousals. Since entries into torpor appear to be synchronized for males, arousal periods may be used to resynchronize their circadian system. The persistence of biological rhythms during hibernation may help to insure successful mating in the spring after emergence.

Keywords Circadian rhythms · Hibernation · *Marmota monax* · Periodicity · Torpor · Woodchuck

Abbreviations

h	Hour
SCN	Suprachiasmatic nuclei
τ	Tau
T_b	Body temperature

Introduction

Although hibernation is adaptive by reducing energy expenditure and in turn increasing probability of survival during harsh conditions, its major disadvantage is that it limits the time available to hibernators for reproduction, growth, and related activities (McNab 2002). Two ways to minimize the effects of limited time on reproductive success is to mate as early after hibernation as possible and to reduce the period of gestation. Woodchucks (*Marmota monax*) follow this strategy. Males and females emerge from their burrows before final arousal from hibernation and engage in pre-mating activity. Mating occurs upon final arousal (Zervanos 2003). This behavior enhances reproductive success as young are born as early as possible in order to be weaned during high food availability and to have sufficient time to gain mass for hibernation in the fall. This strategy requires pre-emergence reproductive development and precise timing for emergence (Concannon et al. 1990; Zervanos 2003). In south central Pennsylvania, male woodchucks emerge in the spring with testis fully developed, and the majority of mating occurs in early March with more than half of young being born within a 6-day period in April (Snyder and Christian 1960; Christian et al. 1972). To further optimize the time available for rearing of young, woodchucks utilize induced ovulation and a short gestation period of 31–32 days (Snyder and Christian 1960; Concannon et al. 1990).

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