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Artificial Hibernation of Some Temperate North American Snakes

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Introduction

In the temperate zone of North America snakes must hibernate during the winter — some for six months or more in parts of Canada (Gregory, 1984). In nature, this period serves several purposes. First, it protects the reptiles from freezing temperatures that would kill them. Second, in species which form aggregations at hibernacula, hibernation may increase reproductive success by bringing males and females together (Gregory, 1984). Lastly, in some species, hibernation may be necessary for the production of the hormones that permit fertility (Mara, 1994). Herpetoculturists and herpetologists have tried to imitate this inactive period by placing their snakes in a room or refrigerator that remains around 10°C (Trutnau, 1986; Frye, 1991). Zappalorti and Reinert (1994) described methods for creating artificial hibernacula for free-ranging snakes in New Jersey. The current paper deals with the former methods (using a refrigerator as a hibernaculum).

Hibernating captive snakes can serve several purposes: it simulates natural conditions, increases reproductive behavior, increases reproductive success, and reduces the cost of maintaining captives (Murphy and Campbell, 1987; Holtzman et al., 1989). In addition, it may be necessary to artificially hibernate a snake if its prey becomes difficult to obtain. For example, I chose to hibernate a male *Diadophis punctatus edwardsii*, not because it voluntarily stopped feeding, but because it was nearly impossible to obtain its prefered food of plethodontid salamanders during the winter. This individual refused to eat earthworms or previously frozen salamanders.

It may be necessary to hibernate some captive snakes because they stop feeding in the fall, as they would in the wild. These individuals may starve despite ideal temperatures and being offered appropriate food items. While it is generally a bad idea to hibernate unhealthy snakes, it could benefit anorexic individuals (DeNardo, 1996), such as those that stop feeding in the autumn.

This paper relates my experiences hibernating some temperate zone snakes.

Materials and methods

During the winter seasons of 1996–2000, 21 individuals of five snake species (*Diadophis punctatus edwardsii* (n = 1), *Storeria dekayi dekayi* (n = 3), *S. occipitomaculata occipitomaculata* (n = 3), *Thamnophis sirtalis sirtalis* (n = 11) and *Virginia pulchra* (n = 3) were artificially hibernated in a General Electric refrigerator (model GE SC455). Some individuals were hibernated during more than one season, resulting in 28 individual hibernation events. Feeding was discontinued ten days prior to being placed into the hibernaculum. No acclimation period was provided. All snakes were placed in Tamor Store-N-View plastic shoeboxes, with several layers of newspaper used as a substrate. A water bowl was provided and water changed as needed; usually every 7–10 days, but longer if a snake was in the bowl. Air holes were drilled in the lid and upper sides of the shoeboxes. The temperature inside the refrigerator was taken twice a week (on the third and seventh day) with a digital thermometer accurate to the nearest 0.1°C. Each snake was weighed to the nearest gram immediately before entering and after being removed from hibernation, using an Ohaus electric scale.

Results and discussion

1996–1997. Three eastern garter snakes (*T. s. sirtalis* nos. 1–3; 1 male and 2 females), one female northern redbelly snake (*S. o. occipitomaculata* no. 1), and one male northern ringneck snake (*D. p. edwardsii* no. 1) were artificially hibernated. All snakes, except female *T. s. sirtalis* no. 3 were placed into a shoebox, and entered hibernation on 4 December 1996. *Thamnophis s. sirtalis* no. 3 was placed into a separate shoebox and was entered into the hibernaculum on 19 January 1997. This group of snakes was hibernated for 55–88 days. Most specimens lost from 1.5 to 16.7% of their prehibernation mass; the *D. p. edwardsii* maintained the same weight throughout the hibernation period (Table 1). Temperature within the hibernaculum ranged 4.4–6.6°C ($\bar{x}$ = 5.5, sd = 0.4, n = 30). Upon being removed from hibernation, the largest female garter snake (*T. s. sirtalis* #3) was sluggish and lethargic, and died

Table 1. Artificial hibernation of snakes during 1996–1997. The number following the species name is the individual specimen number. † denotes specimens that died during or immediately after hibernation.

Species	Sex	Date entered	Mass (g)	Date removed	Mass (g)	Mass gain / loss
Diadophis punctatus #1	♂	4 Dec. 1996	7	2 Mar. 1997 (88 d)	7	0.0
Storeria occipitomaculata #1	♀	4 Dec. 1996	6	20 Feb. 1997 (78 d)	6	−16.7%
Thamnophis sirtalis #1	♂	4 Dec. 1996	46	6 Feb. 1997 (64 d)	45	−2.2%
Thamnophis sirtalis #2	♀	4 Dec. 1996	68	6 Feb. 1997 (64 d)	67	−1.5%
Thamnophis sirtalis #3†	♀	19 Jan. 1997	92	15 Mar. 1997 (55 d)	85	−7.6%

Table 2. Artificial hibernation of snakes during 1997–1998. The number following the species name is the individual specimen number. † denotes specimens that died during or immediately after hibernation.

Species	Sex	Date entered	Mass (g)	Date removed	Mass (g)	Mass gain / loss
Diadophis punctatus #1	♂	7 Dec. 1997	10	24 Feb. 1998 (79 d)	9	–10.0%
Storeria dekayi #1	♀	4 Dec. 1997	10	24 Feb. 1998 (82 d)	10	0.0
Storeria dekayi #2	♀	4 Dec. 1997	5	24 Feb. 1998 (82 d)	5	0.0
Storeria dekayi #3	♂	4 Dec. 1997	4	24 Feb. 1998 (82 d)	4	0.0
Storeria occipitomaculata #2	♀	4 Dec. 1997	9	24 Feb. 1998 (82 d)	9	0.0
Storeria occipitomaculata #3	♀	4 Dec. 1997	< 1	24 Feb. 1998 (82 d)	< 1	0.0
Thamnophis sirtalis #1	♂	5 Dec. 1997	44	24 Feb. 1998 (81 d)	41	–6.8%
Thamnophis sirtalis #4	♀	5 Dec. 1997	99	26 Feb. 1998 (83 d)	97	–2.2%
Thamnophis sirtalis #5†	♀	5 Dec. 1997	78	26 Feb. 1998 (83 d)	73	–6.4%
Virginia pulchra #1	♀	4 Dec. 1997	6	24 Feb. 1998 (82 d)	5	–16.7%
Virginia puchra #2†	♀	4 Dec. 1997	< 1	24 Feb. 1998 (died during hibernation)		

three days posthibernation. This specimen appeared healthy prior to entering hibernation. A necropsy was performed and it was determined that the most likely cause of death was complications resulting from visceral gout. Mortality during this period was 20%.

1997–1998. During this period, eleven individuals of five species were hibernated: a male northern ringneck snake (*D. p. edwardsii* #1), three northern brown snakes (*S. d. dekayi* #1–3; one male and two females), two female northern redbelly snakes (*S. o. occipitomaculata* #2 and 3; a juvenile and an adult), three Eastern garter snakes (*T. s. sirtalis* nos. 1, 4 and 5; one male and two females), and two female mountain earth snakes (*V. pulchra* nos. 1 and 2; one adult and one juvenile). All *Storeria* and *Virginia* were placed into hibernation on 4 December 1997. All *Thamnophis* were entered on 5 December 1997; the northern ringneck snake was entered on 7 December 1997. Snakes were hibernated for 79–83 days. Among the garter snakes, weight loss during hibernation ranged 2.0 to 6.8% of prehibernation weight. The *D. p. edwardsii* and adult *V. pulchra* lost 10 and 16.7% of prehibernation weight respectively. All other snakes maintained the same weight during the hibernation period (Table 2). Temperature within the hibernaculum ranged 3.8–6.6°C ($\bar{x}$ = 5.3, sd = 0.9, n = 25). The *V. pulchra* neonate died seven days into hibernation, and was the only mortality (9.1%) during this period. Fitch (1999) noted that young snakes are more vulnerable to mortality during hibernation than adults. Parker and Plummer (1987) state that in wild colubrid snakes, 45–85.5% may not survive their first hibernation.

1998–1999. The same male *D. p. edwardsii* that had been hibernated during the previous two seasons was placed into hibernation for a third time on 17 November 1998. Three garter snakes (*T. s. sirtalis* nos. 1, 4 and 6; one male and two females) were also hibernated, and were placed in the shoebox with the northern ringneck snake on 1 December 1998. The male garter snake (*T. s. sirtalis* no. 1) had been hibernated during the previous two seasons. Snakes were hibernated for 83–105 days, at temperatures ranging from 3.0 to 6.5°C ($\bar{x}$ = 4.2, sd = 0.9, n = 31). The northern ringneck snake lost no weight during the 105 days it was hibernated. Among the three *T. s. sirtalis*, no. 1 lost 6.2% of prehibernation weight, no. 4 showed no change, and no. 6 gained 3.8% (Table 3). All snakes spent some time in the water bowl, however *T. s. sirtalis* no.4 spent 54% of its time (46 out of 85 days) in the water bowl; while *T. s. sirtalis* no.6 spent 39% of its time (33 of 85 days) in the water (Figure 1). There was no mortality during this period.

1999–2000. Seven eastern garter snakes (*T. s. sirtalis* nos.

Table 3. Artificial hibernation of snakes during 1998–1999. The number following the species name is the individual specimen number.

Species	Sex	Date entered	Mass (g)	Date removed	Mass (g)	Mass gain / loss
Diadophis punctatus #1	♂	17 Nov. 1998	10	2 Mar. 1999 (105 d)	10	0.0
Thamnophis sirtalis #1	♂	1 Dec. 1998	48	22 Feb. 1999 (83 d)	45	–6.2%
Thamnophis sirtalis #4	♀	1 Dec. 1998	120	24 Feb. 1999 (85 d)	120	0.0
Thamnophis sirtalis #6	♀	1 Dec. 1998	52	24 Feb. 1999 (85 d)	54	+ 3.8%

Table 4. Artificial hibernation of snakes during 1999–2000. The number following the species name is the individual specimen number.

Species	Sex	Date entered	Mass (g)	Date removed	Mass (g)	Mass gain / loss
Thamnophis sirtalis #1	♂	7 Dec. 1999	52	27 Feb. 2000 (82 d)	48	–7.7%
Thamnophis sirtalis #4	♀	7 Dec. 1999	153	27 Feb. 2000 (82 d)	152	–0.6%
Thamnophis sirtalis #7	♂	14 Dec. 1999	20	21 Feb. 2000 (68 d)	34	+ 70.0%
Thamnophis sirtalis #8	♂	14 Dec. 1999	6	21 Feb. 2000 (68 d)	20	+ 233.0%
Thamnophis sirtalis #9	♂	14 Dec. 1999	14	21 Feb. 2000 (68 d)	27	+ 92.8%
Thamnophis sirtalis #10	♀	14 Dec. 1999	43	21 Feb. 2000 (68 d)	57	+ 32.5%
Thamnophis sirtalis #11	♂	18 Dec. 1999	28	21 Feb. 2000 (64 d)	31	+ 10.7%
Virginia pulchra #3	♂	7 Dec. 1999	6	27 Feb. 2000 (82 d)	6	0.0

1, 4 and 7–11; five males and two females) and a male mountain earth snake (*V. pulchra* no. 3) were hibernated during the winter of 1999–2000. Two shoeboxes were used, with the first containing two *T. s. sirtalis* (nos. 1 and 4) and *V. pulchra* no. 3. The second shoebox held the remaining five garter snakes (nos. 7–11). Two snakes, *T. s. sirtalis* nos. 1 and 4, had been hibernated during the previous season. The snakes were artificially hibernated for 64–82 days (Table 4). The two largest garter snakes lost 0.6– 7.7 % of their prehibernation mass. In the juvenile garter snakes weight was gained by all individuals and ranged from 10.7 to 233.0% of prehibernation weight (Table 4). During the 64– 68 days that juveniles were hibernated, all spent considerable time (up to 7 consecutive days) in the water bowl. In laboratory settings, *T. sirtalis* prefers to hibernate in water, and in this way remains hydrated (Costanz o, 1988). In my garter snakes, the dramatic increase in weight due to the intake of water was primarily observed in smaller individuals (initial mass 6–43 g). Seven snakes that showed no change in mass during hibernation were 10 g or under. Smaller snakes appear to be better at taking in a relatively large volume of water to hydrate themselves, and are also less likely than larger individuals to lose weight. This obviously helps prevent dehydration during hibernation; perhaps the resulting increase in mass also buffers the now "larger" snake from slight temperature changes. There was no difference between prehibernation and posthibernation weight in *V. pulchra*. Temperature within the hibernaculum ranged from 1 to 3.5° C ($\bar{x}$ = 2.5, sd = 0.6, n = 24). No mortality occurred during this period.

Figure 1. Three eastern garter snakes (*Thamnophis sirtalis sirtalis*) and a northern ringneck snake (*Diadophis punctatus edwardsii*) artificially hibernated during 1998–1999. *Thamnophis s. sirtalis* no. 4 is in the water bowl, and spent 46 of 85 days in the water bowl.

Several authors (Murphy and Campbell, 1987; Mara, 1994; Perlowin, 1994; Funk, 1996) recommend that snakes from temperate regions be hibernated at temperatures between 10 and 16°C for at least two months; however, Coborn (1991) and Rossman et al. (1996) suggest lower temperatures (4–10°C) for a similar length of time. The species artificially hibernated by me have been found in nature to hibernate at temperatures in the lower range (Table 5).

DeNardo (1996) noted that loss in body weight during hibernation is usually less than ten percent. Weight loss in my artificially hibernated snakes averaged 7.1% of prehibernation mass (range 0.6–16.7 %). (The calculation of this mean ex-

Table 5. Comparison of body temperatures between wild and captive snakes during hibernation. For wild snakes, the temperature range is given in degrees Centigrade, followed by the region where observed, and the literature source. The temperature range (°C) for individuals artificially hibernated in the present study is given under the heading "Artificially hibernated."

Species	Artificially hibernated	Wild
Diadophis punctatus	3.0–6.6°	0–10° Kansas (Fitch, 1975)
Storeria dekayi	3.8–6.6°	3–7° Pennsylvania (Ernst and Ernst, 2003)
S. occipitomaculata	3.8–6.6°	N/A
Thamnophis sirtalis	1.0–6.6°	3.4–7.0° Michigan (Carpenter, 1953) 2–7° British Columbia (MacArtney et al., 1989)
Virginia pulchra	1.0–6.6°	N/A

cluded individuals that gained weight or remained the same.). A third of the snakes (seven individuals) showed no loss or gain in body weight; whereas six garter snakes gained between 3.8 and 233.0% of their prehibernation body weight as a result of water intake (see above).

While artificially hibernating snakes may have several benefits, such as improving reproductive success and or decreasing maintenance costs, there are also risks. The most significant of these would be the possibility of mortality. Total mortality (# deaths / # individuals hibernated) during the four hibernation periods in this paper was 7.1% (2 of 28). This risk may be reduced by not hibernating unhealthy or very young individuals (Rossi, 1992).

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