ELAPHE OBSOLETA (Black Rat Snake). **BEHAVIOR.** Behavior is known to influence thermoregulation in lizards and snakes. For example, snakes can limit their heat loss by coiling themselves, and lizards can increase their heating rate by positioning their back at a right angle to the sun's rays, or minimize their heat absorption by facing the sun (Heatwole and Taylor 1987. Ecology of Reptiles. Surrey Beatty & Sons Pty Limited, Chipping Norton, NSW, Australia. 325 pp.; Lillywhite 1987. *In* Seigel et al. [eds.], Snakes: Ecology and Evolutionary Biology, pp.422–477. Macmillan Publishing Co., New York; Tracy 1982. *In* Gans and Pough [eds.], Biology of the Reptiles, pp. 275–321. Academic Press, New York; Stevenson 1985. Am. Nat.126:362–386). Dorsoventral flattening of the body is another behavioral mechanism for increasing the rate of heating as this allows a greater area to be exposed to the sunlight than might be in a normal posture. This flattening of the body has been observed in lizards when ambient temperatures are cool, but the behavior is little known in snakes (Cogger 1974. Australian J. Zool. 26:653-672; Heatwole and Johnson 1979. Zool. J. Linn. Soc. 65:83-101; Heatwole and Taylor, *op. cit.*).

Dorsoventral flattening was observed in a snake on 15 April 2000, when the herpetology class at Yale University sponsored a field trip to Hurd State Park in East Haddem, Connecticut, USA. Despite several warm and sunny spring days from the end of March into the beginning of April (i.e., afternoons reaching an average of 22°C), the entire week prior to this trip was characterized by cold cloudy days with temperatures ranging from 0°C to 4°C. The morning of the trip was overcast with a temperature of 10°C at 0930 h. Thus, the cold and cloudy conditions reduced the expectation that snakes would be visible on such a day.

At 1330 h on 15 April the temperature at Hurd State Park reached its maximum of 15°C, and the conditions were still overcast with a slight drizzle. Unexpectedly, the class discovered a large *Elaphe obsoleta* in a grassy meadow bordered by higher elevation forest and rock ledges. The activity period for *E. obsoleta* is reported to begin around 20–27 April in southern New England and New York (Klemens 1993. Bulletin 112: State Geol. Nat. Hist. Surv. Connecticut. Hartford, Connecticut. 228 pp.), but Ernst and Barbour (1989. Snakes of Eastern North America. George Mason University Press, Fairfax, Virginia. 282 pp.) report activity as early as late March. Thus, our sighting (15 April) of *E. obsoleta* was in accordance with the start of the snake's activity period in this region.

Upon discovery, the snake remained stiff and motionless in the wet grass as we approached it to within 1 m. Initially it appeared to be a gravid female with lumps of eggs alternating along the length of the body. Closer inspection revealed that the body was flattened and contraction of body muscles caused a zigzag pattern along the entire body. Within a minute of being observed, the lumps disappeared, and the motionless snake began to move. It first started flicking its tongue, and rattling its tail defensively (Schulz 1996. A Monograph of the Colubrid Snakes of the Genus *Elaphe* Fitzinger. Koeltz Scientific Books, Havlickuv Brod, Czech Republic. 439 pp.). The snake was identified as an adult male with a total length of 98 cm. Based on natural history information for lizards we believe that this snake may have used this flattened posture to improve its ability to gain heat.

Laboratory studies of snakes have shown similar flattening behavior. Heatwole and Johnson (*op. cit.*) examined temperature changes along the body of the Australian Red-bellied Blacksnake (*Pseudechis porphyriacus*) in the laboratory with subcutaneous thermocouples. They subjected the snake to various degrees of sunlight during the winter months and reported that as the area of sunlight exposed to the surface of the snake increased from the anterior end to the posterior end, the snake progressively flattened its body. This behavioral change in body shape corresponded to sharp rises in subcutaneous temperature. In addition to the increased heat captured from an increased surface area, heating rates when the body is flattened may also be higher because the complex system of integumentary blood vessels known to exist in snakes come into closer contact with the main arterial system (Bartholomew 1982. *In* Gans and Pough [eds.], Volume 12 [Physiology C], pp. 167–211. Academic Press, New York). This permits more efficient heat exchange between the body core and dorsal surface. Thus, the laboratory experiments of Heatwole and Johnson (*op. cit.*) appear to support our proposition regarding the utility of flattening behavior in increasing heat gain, and helps to explain our field observation of *Elaphe obsoleta*.

Laboratory studies that lack sunlight, however, have not detected behavioral changes in the dorsal surface area of snakes. A study by Lillywhite (1980. Copeia 1980:452–458) which examined behavioral thermoregulation among five species of Australian elapids (one of these species was *P. porphyriacus*, the same species studied by Heatwole and Johnson [*op. cit.*]) reported no dorsoventral change in body shape as the temperature varied between 18°C and 40°C. However, Lillywhite never exposed his snakes to conditions as cold as those in the study by Heatwole and Johnson (*op. cit.*) (e.g., the lowest temperatures reported are 18°C in Lillywhite [*op. cit.*] versus 5°C in Heatwole and Johnson [*op. cit.*]). Another study which examined the physiological responses of *E. obsoleta* and *Pituophis melanoleucus* to low ambient temperatures (ranging from 0–20°C) also fails to mention behavioral body shape changes corresponding to thermoregulation (Landreth 1972. Herpetologica 28:376–380).

These limited data suggest that sunlight may be the critical factor stimulating behavioral changes in body shape, rather than ambient temperature alone. It also helps to explain why we observed this flattening behavior in the field, despite the cool Spring temperature. Solar rays can reach the surface of the earth despite cloud cover, and it is likely that these rays, rather than ambient heat, were primarily being absorbed by the snake's dorsal surface when we encountered *E. obsoleta* on the wet field.

Other herpetologists have also observed this dorsoventral flattening behavior in nature. Herndon G. Dowling (pers. comm.) has observed this behavior in *E. obsoleta* while driving down a road in western Alachua County on a sunny day, ca. 15 March 1957. He stated that the contracted muscles made the snake "as stiff as a stick and he thought when he first picked it up that it was dead and dried out."

Jan Jenner (pers. comm.) has observed adult *Elaphe obsoleta*, *E. guttata*, and *Lampropeltis getula* lying in the contorted, zigzag posture in north-central Alabama (Talladega County). She notes that they are especially easy to spot because they seem to prefer to lie in the middle of a sunny road in early spring. When picked off the road she found that the snakes usually stay stiffly "kinked" for several seconds before reacting to being handled.

Dorsoventral flattening is not typically reported in the literature for snakes. This omission could be due to three reasons. First, most field-based thermoregulation studies on snakes have taken place when the snakes are at their peak activity period and can easily be encountered by the investigator in the field. Second, this behavior is unfavorable because it restricts the snake's ability to move, rendering it more subject to predation. Thus, snakes may restrict this behavior to activity times during cooler temperatures when their choices for thermoregulation are limited. The inability of the snake to move while flattened can be explained by the anatomical and mechanical relationship that the vertebrae and ribs have to the subcutaneous muscles (Gasc 1981. *In* Gans and Parsons [eds.], Biology of the Reptilia: Volume 11 [Morphology F], pp. 355–435. Academic Press, New York). Thus, if the muscles and bones are participating in the flattening of the body, they cannot be used simultaneously for sinusoid mobility. A third reason that explains why this behavior is not typically observed in the field is because this behavior may be limited to a small number of snake species, particularly those in temperate climates that require a thermoregulatory mechanism to protect them during drops in temperature typically experienced during the spring season.

Without field data it is difficult to say whether the *E. obsoleta* we observed on the field was heating or cooling its body. The cool ambient temperature makes it unlikely that this snake would choose to use a mechanism of body cooling that rendered it inactive and more susceptible to predation. Therefore, although heat gained by absorbing solar radiation likely outweighs heat lost by conduction to the substrate on this cold morning, we cannot dismiss the possibility that the body heat that is lost by conduction may decrease the overall benefit (in terms of an increased overall rate of heat gain) of dorsoventral flattening. Quantitative data that can explain the biological relevance of this behavior must be collected for snakes before we can be sure of the explanation for the snake behavior we observed. For this reason, we encourage scientists interested in thermoregulatory studies and dorsoventral flattening to consider studying snakes and comparing their behavioral thermoregulatory mechanisms to those known for lizards.

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