Herpetological Conservation and Biology 4(1):80-84
Submitted: 29 August 2008; Accepted: 4 February 2009

COVER OBJECT USAGE AMONG AN ASSEMBLAGE OF IOWA SNAKES

CHRISTIAN L. COX[1,2], EUGENIA S. FARRAR[1], JANE D. HEY[3], AND MATTHEW C. MORRILL[1]

[1]*Department of Ecology and Organismal Biology, Iowa State University, Ames, Iowa 50010, USA.*
[2]*Present Address: Department of Biology, University of Texas at Arlington, Arlington, Texas 76019, USA, e-mail: clcox@uta.edu*
[3]*Department of Biology, Morningside College, Sioux City, Iowa 51106, USA.*

***Abstract.*—We assessed cover object usage among four species of snakes in western Iowa to evaluate the different characteristics of surface cover objects used by each species. Snake species differed significantly in both size and type of cover object utilized, with the Smooth Green Snake (*Opheodrys vernalis*) using smaller and non-metal cover more frequently than other species at the study site. Snakes did not differ in the size or type of cover object used based on sex, body size, or state of ecdysis. The difference in cover object usage may be attributed to intrinsic requirements of the snake species or competition among individuals. Moreover, this differential use of cover objects might have implications for the management and sampling of snake communities.**

Key Words. —Opheodrys vernalis; *Thamnophis radix*; *Thamnophis sirtalis*; *Pantherophis vulpina*; cover object selection.

INTRODUCTION

The characteristics of microhabitats within a landscape influence the presence of a species within that landscape (Reinert 1984). For snakes, cover objects (any surface object that may be used as refugium) are important features of these microhabitats (Hirth et al. 1969; Elick and Sealander 1972; Huey et al. 1989). Many species of snake use cover objects as a refuge from predation, to prevent water loss, for thermoregulation, and during reproduction (Hirth et al. 1969; Elick and Sealander 1972; Huey et al. 1989; Ford and Burghardt 1993). Although use of surface cover objects is common among snakes, species may prefer different sizes or types of cover due to physiological or ecological constraints (Fouquette 1954; Huey 1991). Similarly, individual variation in how they select cover objects may reflect body size, sex, or other life history traits (Shine 1987; Lind and Welsh 1994). The goal of this study was to determine the characteristics of surface cover objects and the snakes that utilize them.

Characterizing the use of cover objects is not only important for understanding the ecology of a species, but may also have important implications for the monitoring and management of vulnerable species. To make informed conservation and management decisions, the abundance and distributions of the vulnerable species must be assessed (Yoccoz et al. 2001; Guisan et al. 2006). However, standard surveying techniques may be inadequate to detect the presence of rare species (Rushton et al. 2004). Knowledge of habitat preferences can aid in the management of at-risk species by facilitating accurate assessment of habitat degradation and increasing the effectiveness of habitat augmentation (Shine et al. 1998; Webb and Shine 1998).

This study took place in a western Iowa wetland containing a high density of snakes and cover objects. In order to determine the relative roles of body size and species in cover object usage, we recorded the size and type of each cover object, identified the species using it, and recorded the snake's length, sex, and state of ecdysis.

MATERIALS AND METHODS

***Study Site.*—**We conducted the study at the Owego abandoned town site (3.5 ha), part of the Owego Wetland Complex (525 ha) in northwestern Iowa, USA. The wetland complex adjacent to the town site is a network of water-filled basins and wet prairies dominated by Little Bluestem (*Schyzachrium scoparium*) and Big Bluestem (*Andropogon gerardii)*. The town site contains cover objects including tin roofing and siding, wooden planks, metal barrels, wooden siding, and a myriad of refuse (e.g., clothes, planters, old cars, couches, etc.) ranging in surface area from 0.04 m^2 (e.g., a baseball cap) to 18 m^2 (e.g., the fallen wall of a building). Four species of snakes occur in the town site: Plains Garter Snake (*Thamnophis radix),* Red-sided Garter Snake (*Thamnophis sirtalis parietalis*)*,* Western Fox Snake (*Pantherophis vulpina vulpina*)*,* and the Smooth Green Snake (*Opheodrys vernalis*). Smooth Green Snakes are a species of special concern in Iowa (Christiansen and Bailey 1993).

***Survey methods.*—**We surveyed the town site three times during May (16^{th}, 17^{th}, and 18^{th}) and twice during June (9^{th} and 19^{th}) 2004, during the active season for snakes in Iowa, but past the breeding season (Christiansen and Bailey 1993). To survey, we walked

TABLE 1. The number, gender ratio, and state of ecdysis of snakes captured at the Owego town site in northwestern Iowa.

Variable	*Thamnophis radix*	*Thamnophis sirtalis*	*Opheodrys vernalis*	*Pantherophis vulpina*
n	81	71	17	11
SVL (cm)	34 ± 0.6	37 ± 0.8	30 ± 1.2	48 ± 6.0
Males/females	45/36	24/47	5/12	6/5
In shed (# of snakes)	37	36	5	3

a decreasing concentric route through the town site and checked all cover objects for snakes (Fellers and Drost 1994). If a snake occurred under a cover object, we attached a unique numerical identifier to the piece of cover, and recorded the length (cm), width (cm), and type (metal or non-metal) of the cover object. We estimated the surface area of each quadrilateral piece of cover as $length \times width \approx area$. For circular cover objects, the radius was taken to compute the surface area as $\pi \times radius^2 = area$. We measured snout-vent length (SVL) to the nearest centimeter by stretching the snake alongside a measuring stick and determined sex by hemipenal palpation and extrusion. We determined the state of ecdysis by the presence of shedding skin or glazed eyes on the snake.

Statistical Methods.—We transformed data when necessary to correct for any violations of test assumptions. We used a one-way analysis of covariance (ANCOVA) to analyze potential relationships among: (1) interspecific variation in the surface area of utilized cover objects; (2) gender; and (3) state of ecdysis, and body size (SVL). If the results of the ANCOVA were significant ($P < 0.05$), we used the Tukey Kramer procedure (Sokal and Rohlf 1995) for post-hoc linear pairwise mean comparisons among species. We used linear regression to describe the relationship between SVL and cover object surface area. Contingency analysis was used to determine if species, gender or state of ecdysis (yes or no) affected the type of utilized cover object (metal or non-metal). We used $\alpha = 0.05$ for significance. Data appear as mean ± S.E. We used JMP 5.1 statistical software (SAS Institute, Cary, North Carolina, USA) to perform all statistical analyses.

RESULTS

We found 180 snakes using cover objects (metal, wood, clothing items, and plastic; Table 1). Among the four species, log-transformed surface area of the cover object varied significantly ($F = 18.499$, df = 180, $P < 0.0001$) with *O. vernalis* using significantly (Tukey Kramer Test, $P < 0.0001$) smaller cover objects (Fig. 1), 26.15% of the surface area of cover objects used by either *Thamnophis* sp. or *P. vulpina*. *Opheodrys vernalis* also used a smaller range of surface areas than did the other species at the town site (Table 2). Use based on surface area was not significantly affected by the stage of ecdysis ($F = 2.617$, df = 3, 176, $P = 0.108$) or the sex ($F = 0.647$, df = 3, 176, $P = 0.432$) of snakes. Similarly, no significant relationship existed between SVL and cover object size for *T. sirtalis* ($F = 2.26$, df = 1, 70, $P = 0.137$), *T. radix* ($F = 2.51$, df =1, 80, $P = 0.116$) or *O. vernalis* ($F = 0.019$, df = 1, 16, $P = 0.893$). Whereas, *O. vernalis* demonstrated preferences for non-metal cover objects, *T. sirtalis, T. radix* and *P. vulpina* preferred metal cover objects ($\chi^2 = 11.19$, df = 3, $P = 0.011$). We found 93.9% (76/81) of *T. radix,* 88.7% (63/71) of *T. sirtalis,* and 100% of *P. vulpina* (11/11) under metal cover objects, but only 58.81% (11/17) of *O. vernalis* under metal. Neither sex ($\chi^2 = 0.689$, df = 1, $P = 0.409$), nor ecdysis ($\chi^2 = 1.29$, df = 1, $P = 0.256$) significantly influenced preference for metal and non-metal cover objects.

DISCUSSION

Our results suggest that sex, body size, or state of ecdysis are not factors influencing cover object usage by snakes. Interspecific variation in cover object preference was present for both size and material. Snakes probably do not directly select cover objects based on size, but indirectly due to the microclimate characteristics that result (e.g., humidity, temperature, etc.) indirectly from the size of the object. Previous studies demonstrated that Ringneck Snakes (*Diadophis punctatus*) use cover objects to control water loss (Elick and Sealander 1972),

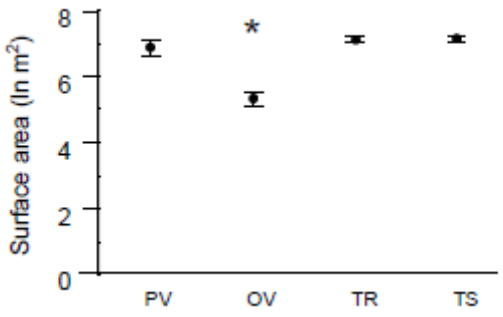

FIGURE 1. Mean area (natural log) of cover objects utilized by snake species at the Owego town site, Iowa, USA. Values are mean ± standard error. Abbreviations are as follows: PV = *Pantherophis vulpina*, OV = *Opheodrys vernalis*, TR = *Thamnophis radix*, TS = *Thamnophis sirtalis*, means as determined by Tukey-Kramer procedure. Note that *Opheodrys vernalis* is found under cover objects with significantly smaller surface areas. Asterisk designates significant difference.

TABLE 2. Total number of snakes found (n), average surface area (cm) of cover objects that each snake species were found under, and numbers of individuals of each species under each cover object material at the Owego town site, Iowa, USA.

Variable	*Thamnophis radix*	*Thamnophis sirtalis*	*Opheodrys vernalis*	*Pantherophis vulpina*
n	81	71	17	11
Average surface area (cm^2)	1548.3	1477.6	390.2	1242.8
(range)	(225–3240)	(60–3240)	(80–2400)	(225–3090)
Metal	76	63	10	11
Wood	5	4	2	0
Cloth	0	0	1	0
Plastic	0	4	4	0

while Western Garter Snakes (*Thamnophis elegans*) use rocks to thermoregulate (Huey et al. 1989), and Coachwhips (*Masticophis flagellum*) use rocky retreats to assist in ecdysis (Hirth et al. 1969). Snakes also forage (Webb and Shine 1998), and lay eggs or give birth (Ford and Burghardt 1993) under cover objects. Indeed, we found that 45% (81/180) of the snakes using cover objects were at some stage of ecdysis, and 26% (26/100) of all females found under cover objects were gravid. Given the many roles of cover objects, interspecific differences in size and type preference might stem from the different ecological or physiological requirements of each species.

Conversely, competition could exclude competitively inferior species (Gause 1934) from higher quality cover objects (i.e., different types or sizes of cover). However, many of the cover objects we examined housed multi-species assemblages. Future experiments could focus on the thermal and moisture characteristics of surface cover objects, and test for the relationship between species presence and absence. This will allow assessment of how competition and intrinsic requirements might influence cover object selection.

Snakes were only found under unnatural (e.g., metal, cloth, boards, etc.) cover at the town site. Obviously, prior to the abandoned town site, snakes persisted in this wetland in natural retreats such as under bark, logs, rocks, and in crayfish burrows (McCallum 2001; Ernst and Ernst 2003), which are still occasionally used in the wetlands outside of the town site (C. Cox and M. Morrill, pers. obs.). Snakes are abundant at the town site, with some sampling trips yielding > 100 snakes from a few hours sampling effort (C. Cox and M. Morrill, pers. obs.). We speculate that abundant artificial cover at Owego may support the large snake populations at the town site.

This data has important applications for the conservation of imperiled species. *Opheodrys vernalis* is extirpated from much of its historic range and it is a species of special concern in Iowa (Christiansen and Bailey 1993), with estimates suggesting that fewer than 10 reproductive populations remain in Iowa (Christiansen and Bailey 1993; Cox et al. 2005). Our data suggests that *O. vernalis* uses smaller cover objects than does either *Thamnophis* sp. or *P. vulpina.* This may allow targeted use of cover boards that comply with its preferences when monitoring populations of *O. vernalis*. Additionally, land managers could use these findings to augment natural cover objects in habitat restoration activities for *O. vernalis*. Our study highlights the importance of characterizing habitat preferences for these beleaguered snakes, and the importance of surface cover in areas where *O. vernalis* still persists.

Acknowledgments.—We thank Aubrey Heupel and Jill Hunt for assistance in the field. We appreciate the thoughtful comments of Scott Boback, Robert Makowsky, Brian Ott, and Robert Jadin on earlier versions of this manuscript. The Undergraduate Mentoring in Environmental Biology NSF program provided funding for this work.

LITERATURE CITED

Christiansen, J.L., and R.M. Bailey. 1993 Snakes of Iowa. Iowa Department of Natural Resources. Nongame Technical Series No. 1. 16 p.

Cox, C.L., E.S. Farrar, and J. Hey. 2005. Geographical distribution: *Opheodrys vernalis*. Herpetological Review 36:339.

Elick, G.E., and J.A Sealander. 1972. Comparative water loss in relation to habitat selection in small colubrid snakes. American Midland Naturalist 88:429–439.

Ernst C.H., and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, D.C., USA.

Fellers, G.M., and C.A. Drost. 1994. Sampling with artificial cover. Pp. 146 *In* Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster (Eds.). Smithsonian Institution Press, Washington, D.C., USA.

Ford, N.B., and G.M. Burghardt. 1993. Perceptual mechanisms and the behavioural ecology of snakes. Pp. 117–164 *In* Snakes: Ecology and Behavior. Seigel, R.A., and J.T. Collins (Eds.). McGraw-Hill, New York, New York, USA.

Fouquette, M.J. 1954. Food competition among four sympatric species of Garter Snakes, genus *Thamnophis*. Texas Journal of Science 6:172–188.

Gause, G.F. 1934. The Struggle for Existence. Williams and Wilkins, Baltimore, Maryland, USA.

Guisan, A., O. Broennimann, R. Engler, M. Vust, N.G. Yoccoz, A. Lehmann, and N.E. Zimmermann. 2006. Using niche based models to improve the sampling of rare species. Conservation Biology 20:501–511.

Hirth, F.F., R.C. Pendleton, A.C. King, and T.R. Downard. 1969. Dispersal of snakes from a hibernaculum in northwestern Utah. Ecology 50:332–339.

Huey, R.B. 1991. Physiological consequences of habitat selection. American Naturalist 137:S91–S115.

Huey, R.B., C.R. Peterson, S.J. Arnold, and W.P. Porter. 1989. Hot rocks and not-so-hot rocks: Retreat site selection by garter snakes and its thermal consequences. Ecology 70: 931–944.

Lind, A.J., and H.H. Welsh. 1994. Ontogenetic changes in foraging behaviour and habitat use by the Oregon Garter Snake, *Thamnophis atratus hydrophilus*. Animal Behavior 48:1261–1273.

McCallum, M.L. 2001. *Opheodrys aestivus* (Rough Green Snake). Hibernaculum. Herpetological Review 32:50

Reinert, H.K. 1984. Habitat separation between sympatric snake populations. Ecology 65:478–486.

Rushton, S.P., S.J. Ormerod, and G. Kerby. 2004. New paradigms for modeling species distributions? Journal of Applied Ecology 41:193–200.

Shine, R. 1987. Intraspecific variation in thermoregulation, movements, and habitat use by Australian Blacksnakes, *Pseudechis porphyriacus* (Elapidae). Journal of Herpetology 21:165–177.

Shine, R., J.K. Webb, M. Fitzgerald, and J. Sumner. 1998. The impact of bush-rock removal on an endangered snake species, *Hoplocephalus bungaroides* (Serpentes:Elapidae). Wildlife Research 25:285–295.

Sokal, R.R., and F.J. Rohlf. 1995. Biometry: The Principles and Practices of Statistics in Biological Research. 3rd Edition. W.H. Freeman and Company, New York, New York, USA.

Webb, J.K., and R. Shine. 1998. Using thermal ecology to predict retreat site selection by an endangered snake species. Biological Conservation 86:233–242.

Yoccoz, N.G., J.D. Nichols, and T. Boulinier. 2001. Monitoring of biological diversity in space and time. Trends in Ecology and Evolution 16:446–453.

CHRISTIAN COX is a graduate student at the University of Texas at Arlington. He received his B.S. in Zoology from Iowa State University (2005), and M.S. in Biological Sciences from The University of Alabama (2007). Christian was an undergraduate in the Department of Zoology and Genetics at Iowa State University when we conducted this study. His current research includes the ecology and evolutionary biology of reptiles and amphibians. (Photographed by anonymous).

EUGENIA FARRAR is a Professor Emeritus from Iowa State University. Her body of research includes diverse work on the endocrinology and ecology of reptiles and amphibians. As a faculty member, Dr. Farrar has mentored many undergraduates at Iowa State University, supervising student projects ranging from ecology of snakes to digestive physiology of larval amphibians. She currently continues research involving ecology and conservation biology of amphibian in Iowa. (Photographed by anonymous).

JANE HEY is a retired Professor of Biology at Morningside College in Sioux City, Iowa. During her nearly 30 year career at Morningside, she served as chair of the Biology and Chemistry department, and conducted research in aquatic biology in western Iowa. Dr. Hey also mentored many undergraduates during her tenure at Morningside College, including them in her ecology research of the Missouri River floodplain. (Photographed by anonymous).

MATTHEW MORRILL is a senior in Zoology at Iowa State University. His current research involves life-history evolution of snakes. Matthew graduated in 2008, and commence graduate research in the evolutionary biology and ecology of reptiles and amphibians. (Photographed by anonymous).