Population Size and Structure of Four Sympatric Species of Snakes at Amherstburg, Ontario

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Populations of *Thamnophis butleri, T. sirtalis sirtalis, Storeria dekayi dekayi*, and *Elaphe vulpina gloydi* were studied in an abandoned quarry site in extreme southwestern Ontario. Estimates of population size for the 40-ha study area, based on various census techniques, are 900 *T. butleri*, 23 snakes/ha; 150 *T. sirtalis*, 4 snakes/ha; 550 *S. dekayi*, 14 snakes/ha; and 50–120 *E. vulpina*, 1.3–3.2 snakes/ha. *Thamnophis sirtalis* and *S. dekayi* were confined to small subsections of the main study area and within their actual area of occurrence had densities of 20 and 70 snakes/ha respectively. The relatively high density of snakes in the study area is thought to be related to abundant food, cover and denning sites. Sex ratios and size frequency distributions are described for all species, and brood size and percentage of gravid females are given for *T. butleri*. For all species, the proportion of young of the previous year was small, and the size distributions were strongly skewed toward adult size classes.

Key Words: *Thamnophis butleri, Thamnophis sirtalis sirtalis, Storeria dekayi dekayi, Elaphe vulpina gloydi*, population size, sex ratios, size classes, population densities, brood size, Amherstburg, southwestern Ontario.

Although some qualitative assessments have been made concerning changes in status of Canadian snakes (i.e., Logier 1957; Cook 1970; Rivard 1976; Pendlebury 1977; unpublished manuscripts by C. A. Campbell for Ontario Ministry of Natural Resources 1975, University of Western Ontario 1977, and Canadian Wildlife Service 1977), few quantitative estimates of population size or structure now exist. The only published estimates of Canadian snake populations known to the authors of this paper are for certain dense local aggregations of the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) utilizing karst hibernacula in the Interlake district of Manitoba (Gregory 1974, 1977; Aleksiuk 1977). For the 14 taxa of snakes (including 10 species) represented as rare or endangered in Canada by Cook (1970), there are no published estimates of size of local populations. Such quantitative estimates are important to the conservation of animal populations, since before effective management programs or protective measures can be undertaken, geographical distributions, demographic characteristics, and various other aut-and syn-ecological relationships must be described, so that action can be based on sound knowledge of the organisms concerned.

The purpose of the present report is to describe the population sizes and structure of four sympatric species of snakes at a site near Amherstburg, Ontario. Two of these species, the Butler's Garter Snake (*Thamnophis butleri*) and the Eastern Fox Snake (*Elaphe vulpina gloydi*), have been considered as rare or endangered in Canada by Cook (1970). The other two species, the Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) and the Northern Brown Snake (*Storeria dekayi dekayi*), are widespread and common but are also dealt with in this study because little demographic data exist for Canadian populations of these species, and because interactions may occur between them and the two less common species with which they are sympatric. Other aspects of the ecology of sympatric snakes at the Amherstburg site, such as movements and distribution, are under study.

Study Area

Located approximately 2.4 km northeast of Amherstburg, 42°07′N and 83°05′W, in Anderdon Township of Essex County, Ontario, the study area is approximately 40 ha in extent. The substrates are calcareous (pH 7.6–7.8) throughout the area and vary from limestone pavement and coarse limey gravel to fine-textured calcareous clay-loam. The western portion of this area is comprised of an old limestone quarry that is relatively high, rocky, and irregular in topography. The lower eastern portion includes abandoned industrial and agricultural lands.

The quarry has been abandoned for at least 15 years, and the agricultural and industrial sectors for 5 years. Cottonwood (*Populus deltoides*), hawthorn (*Crategus mollis*), dogwood (*Cornus drummondii*), sumacs (*Rhus typhina* and *R. glabra*), and choke cherry (*Prunus virginiana*) have partially colonized the landscape, but extensive open areas exist, dominated in the drier parts by *Poa compressa* and elsewhere by other grasses and forbs (*Poa pratensis, Dactylis glomerata, Phleum pratense, Festuca pratensis, Daucus carota, Solidago nemoralis, Melilotus alba, Fragaria virginiana, Pastinaca sativa,* etc.). Periodically wet areas are dominated by *Puccinellia distans* while some permanently wet areas in the eastern part of the study have dense stands of cattail (*Typha latifolia* and *T. angustifolia*). Extensive rocky barren and semi-barren areas occur throughout the study area, and the cover of non-wooded areas varies from low (20 cm) and sparse to tall (1 m) and dense. Such variation frequently occurs over distances of only a few metres.

The study area is bounded on the west by the settling pools and service roads of Allied Chemicals Ltd., on the north by a railway and agricultural lands, on the east by oak-hickory woods (*Quercus alba, Q. macrocarpa, Q. borealis, Carya ovata*) and swampy lowlands, and on the south by agricultural lands. Since no snakes were found in these peripheral areas (comprising a larger study area of 64 ha), it appears that our 40-ha study area represents a more or less isolated "island" of optimal snake habitat.

Much of the site has been used as an unmanaged garbage dump by local residents, and numerous small fires, started to burn trash, have helped to maintain open grasslands. Litter from derelict buildings is common in the eastern section and piles of debris and rubble are characteristic of at least half of the area. Trails made by all-terrain vehicles and trail bikes are much in evidence in the quarry section.

Methods

All data presented here were gathered during a series of visits to the study area during the spring and summer of 1976. Some additional data relevant to Eastern Fox Snakes, collected in the spring of 1977, are also included. During the initial precensus and on each of the four census dates, sub-sections of the study tract were walked in a pre-determined order and virtually all snakes seen (including many hiding under cover) were captured for examination. Unmarked individuals were marked by clipping scales from the dorsal scale rows according to a numbering scheme that made it possible to distinguish individuals. This technique of marking is quite simple, and requires simpler surgery than the method of Blanchard and Finster (1933), who advocate the removal of complete subcaudal scutes, and yields more easily recognized marks than the method of Spellerburg (1977), who advocates the partial removal of subcaudal scutes. Our technique appeared to cause no discomfort to the snakes, and in captive Eastern Garter Snakes the marks were healed within 2 wk, but were clearly visible at the time of their release 1½ yr later. In addition, for all snakes captured and marked, the sex (determined by post-cloacal hemipenal distention in males), total length, gravidity (based on pronounced pre-cloacal body distention), color variation, characteristic markings, and various ecological data were recorded. Snakes born in 1976 were found only in the late summer censuses and were too small to be marked without possible injury, and are not included in the population size estimates or in the calculations of size distributions or sex ratios.

Population size estimates were made using the Petersen mark-recapture method within the context of multiple censusing. Statistically, the method requires that (1) the population is constant, with no mortality or recruitment during the experiment, (2) no immigration or emigration occurs, and (3) certain statistical assumptions are met concerning the randomness of capture and mixing of marked and unmarked individuals. Although these requirements are rarely fully satisfied in studies of animal populations, the method has nevertheless been effectively utilized in estimating local populations of snakes in the United States (Carpenter 1952; Fitch 1960, 1963, 1964, 1965, 1975). The technique is described in detail in the above references, and by Ricker (1975) and Smith (1974).

For each of the four census dates, a Petersen estimate of the population size was calculated

for three of the four species of snake. In addition, separate population estimates were made using four different multiple census calculations (i.e., the Schumacher, Schnabel, modified Schnabel, and Mean of Petersen Estimates). Ninety-five percent confidence intervals were also calculated for each population estimate. All of these calculations, and their relevant statistical assumptions, are summarized in detail by Ricker (1975).

Unfortunately, there were no recaptures of Eastern Fox Snakes during the 1976 censuses, and only one recapture was observed during the spring of 1977. Assuming that all Eastern Fox Snakes marked on the five 1976 sampling dates comprised a collective precensus, one can calculate a Petersen population estimate based on the single 1977 recapture. But an indirect estimate of the Eastern Fox Snake population can also be calculated, as follows. From Table 1, it may be calculated that a mean of 50 different Butler's Garter Snakes were captured on each of the five census dates, i.e., (61 + 69 + 49 + 48 + 23)/5 = 50. The mean estimate of population size for this species is given in Table 2 as 896. Thus, the probability of capturing a particular snake during any particular one of the census dates may be estimated as 50/896 = 0.0558. This probability is based on the same assumptions stated previously for the mark-recapture method in general. By similar means, the probability of capture for Eastern Garter Snakes is established as 14.4/158 = 0.0911, and for Northern Brown Snakes as 20.4/545 = 0.0374. The mean of these three estimates is (0.0558 + 0.0911 + 0.0374)/3 = 0.0614. Assuming that the probability of capturing a particular Eastern Fox Snake is roughly the same as that for the other species, we can apply the average probability of capture (0.0614) to Eastern Fox Snakes. This is done by multiplying the average number captured by the inverse of this probability in order to calculate a first-order approximation of the population size.

Observations and Discussion

Petersen estimates of the population sizes of three of the four species of snake on each of the four census dates are summarized in Table 1. The large standard errors are mainly due to relatively low recapture percentages.

Table 2 gives the multiple census population estimates for three species of snake. These four population estimates each involve somewhat different statistical assumptions and have different modes of calculation. Each calculation is based on an integration of the data from all four census dates presented in Table 1. Where population estimates at various dates are quite different from each other and the number of censuses in the multiple census is low (both of which are factors in our data), the 95% confidence interval can be quite large. High variation in population estimates of snake populations have also been reported in other snake census studies (i.e, Fitch 1960, 1963, 1975; Gregory 1974, 1977). Fitch (1975) considered this high variability to be an inescapable feature of mark-recapture censuses involving snakes because of low recapture success and the secretive behavior of most

TABLE 1—Population estimates (Petersen calculation) for four species of snakes on four 1976 census dates. H = number handled; R = number recaptured; Est. = population estimate

	Butler's Garter Snake (*Thamnophis butleri*)				Eastern Garter Snake (*Thamnophis sirtalis*)				Northern Brown Snake (*Storeria dekayi*)				Eastern Fox Snake* (*Elaphe vulpina*)			
Date	H	R	Est.	SE	H	R	Est.	SE	H	R	Est.	SE	H	R	Est.	SE
14 May**	61	—	—	—	15	—	—	—	15	—	—	—	3	—	—	—
30 May	69	6	702	±274	14	1	210	±56	25	1	375	±367	6	0	—	—
15 June	49	6	1013	±387	15	4	105	±45	22	3	286	±153	3	0	—	—
10 July	48	5	1603	±679	16	3	208	±108	33	2	957	±656	2	0	—	—
24 July	23	9	537	±140	12	4	156	±64	7	1	623	±577	2	0	—	—
Mean ± SD			964	±470			170	±50			560	±300			—	—

*See text for Petersen estimate based on 1977 recapture.
**Precensus date.

TABLE 2—Multiple census population estimates for three species of snakes. Four methods of calculating population size are summarized, based on four 1976 census dates

Method of population size estimate calculation	Butler's Garter Snake (*Thamnophis butleri*)		Eastern Garter Snake (*Thamnophis sirtalis*)		Northern Brown Snake (*Storeria dekayi*)	
	Population size	95% confidence interval	Population size	95% confidence interval	Population size	95% confidence interval
Schumacher	872	220 to 1922	159	63 to 484	610	96 to 1229
Schnable	890	220 to 2317	157	63 to 327	539	96 to 987
Modified Schnabel	857	593 to 1285	144	85 to 268	471	251 to 943
Petersen mean	964	220 to 1904	170	70 to 270	560	96 to 1160
Mean of four different estimates	896		158		545	

snakes. He nevertheless noted that, although the mark-recapture method does not provide a precise measure of population size, it does provide better information in most cases than direct or relative (i.e., snakes seen or caught per man-hour) counts, and at least indicates the order of magnitude of the population size.

Table 2 shows that the approximate population size of Butler's Garter Snake is 900 (23 snakes/ha), Eastern Garter Snake 150 (4 snakes/ha), and Northern Brown Snake 550 (14 snakes/ha). But both Eastern Garter Snakes and Northern Brown Snakes were localized in the mesic to wet eastern parts of our study area (approximately 7–8 ha), so that the effective population densities of these species within their areas of occurrence are closer to 20 snakes/ha and 70 snakes/ha, respectively.

The Eastern Fox Snake population can only be crudely estimated by the mark-recapture method because there was only one recapture. The Petersen population estimate based on this recapture is 128 snakes (SE = 120, density = 3.2 snakes/ha). The large standard error is largely a result of the single recapture. Rivard (1976) also noted very low recapture success with Eastern Fox Snakes in a study at Point Pelee, Ontario. An indirect first-order approximation of the Eastern Fox Snake population (based on an average probability of capture of the other three species sympatric at this site, and the assumption that the Eastern Fox Snakes exhibit a similar probability) is 52 (1.3 snakes/ha).

Carpenter (1952) calculated densities of 24.2 and 7.2 snakes/ha for Eastern Garter Snakes and Butler's Garter Snakes, respectively, at a site in Michigan where they were sympatric, while Fitch (1965) observed densities of Eastern Garter Snakes that ranged from 2.2 to 10.9 snakes/ha from 1956 to 1963 at a site in Kansas. Gregory (1977) calculated population sizes of Red-sided Garter Snakes at an intensively utilized denning site in Manitoba that ranged from 2056 to 5347 at various times from 1969 to 1973. He did not express any of his populations on a density basis. All of these authors considered their study sites to be areas of locally high snake populations. R. J. Planck (1977, unpublished report to Department of Supply and Services, Ottawa) reported total populations of Butler's Garter Snakes at a site (apparently 16 ha) near the Windsor airport, Ontario which varied from 55 to 1414 (mean = 455, SD = 457), based on five sampling dates in 1976.

The calculated Eastern Fox Snake densities at our site can only be compared to densities of the congeneric Black Rat Snake (*Elaphe obsoleta*) studied in Kansas by Fitch (1964), where densities of 4.2 snakes/ha were calculated during the period of relatively high abundance following the seasonal appearance of young snakes, while densities of 2.1 snakes/ha were noted at other times of the year. Fitch considered his study locale to be an area of high density for this species. We are unaware of any published population estimates to which our data on Northern Brown Snake can be compared.

The relative abundance of snakes at the Amherstburg site is believed due to some combination of (1) good cover provided by the numerous flat boards, pieces of metal, discarded mattresses, and miscellaneous other

scattered items that were found throughout the study area; (2) the apparent abundance of suitable food resources (i.e., an abundance of earthworms, amphibians, and small mammals); and (3) the probable presence of hibernacula in rocky parts of the quarry, in numerous piles of debris, or in foundations of derelict buildings.

Table 3 summarizes data on sex ratios and total length. The ratio of males to females in Butler's Garter Snake and the Eastern Garter Snake approximates 1, while for the Northern Brown Snake we found twice as many females as males, and for the Eastern Fox Snake there were approximately twice as many males as females. Fitch (1965) found the proportion of male snakes to be 0.53 for Eastern Garter Snakes at a site in Kansas, and he noted that this ratio varied seasonally, with relatively more males than females being present in his fall samples relative to his spring-summer samples. Gregory (1977) found the proportion of males in Red-sided Garter Snakes ranged from 0.52 to 0.65 at a site in Manitoba. Planck (*op. cit.*) found the proportion of males of Eastern Garter Snakes and

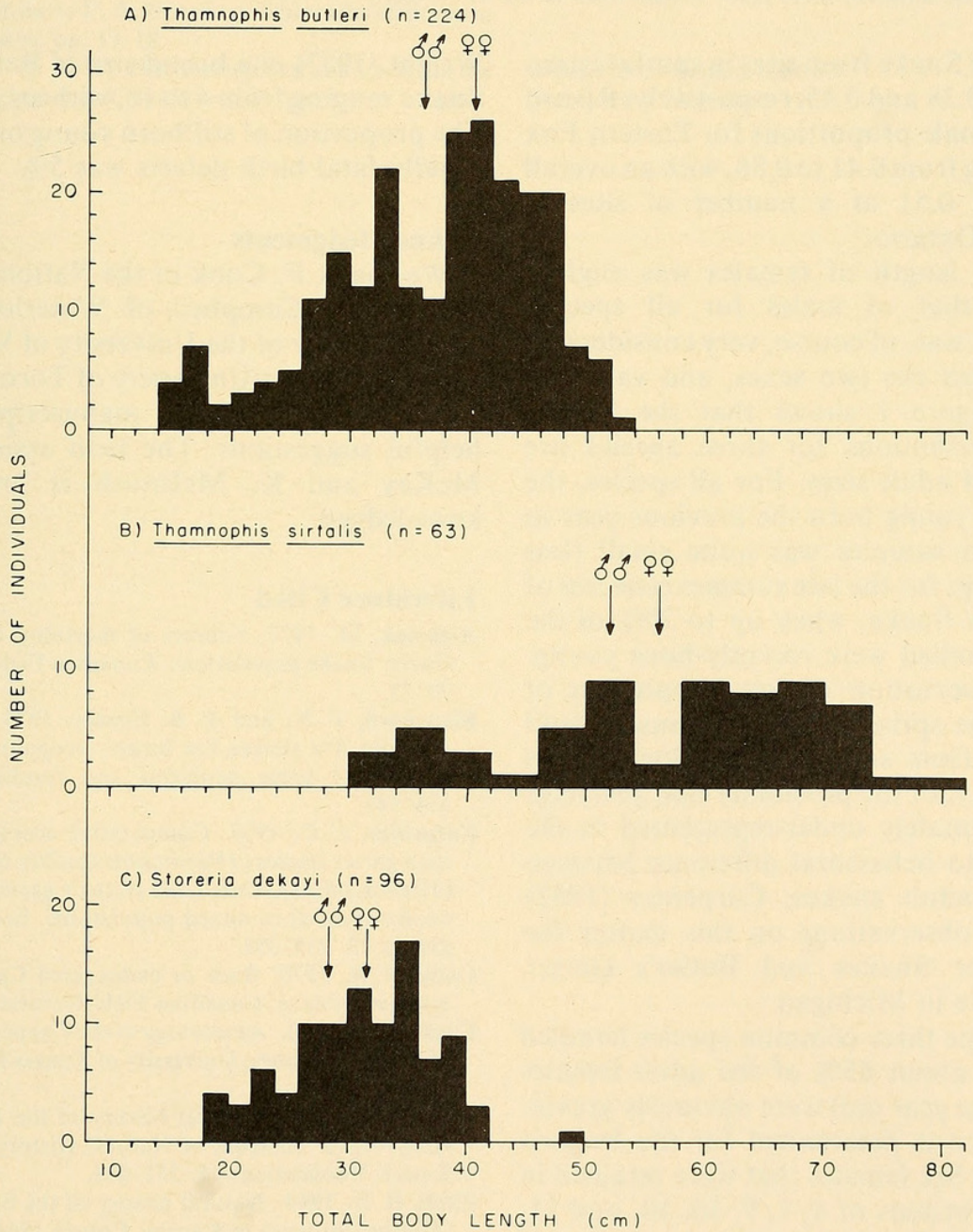

FIGURE 1. Size frequency distributions for three species of snakes from the Amherstburg, Ontario study site. The mean sizes of males and females are indicated. A, Butler's Garter Snake (*Thamnophis butleri*); B, Eastern Garter Snake (*Thamnophis sirtalis sirtalis*); C, Northern Brown Snake (*Storeria dekayi dekayi*).

TABLE 3—Sex ratios and mean total length of four species of snakes at the Amhertsburg study site

Species	No. examined	Proportion of males ± SE	Mean length, male (cm ± SD)	Mean length, female (cm ± SD)
Butler's Garter Snake (*Thamnophis butleri*)	220	*0.555 ± 0.034	36 ± 7	40 ± 7
Eastern Garter Snake (*Thamnophis sirtalis*)	63	*0.495 ± 0.063	52 ± 12	56 ± 13
Northern Brown Snake (*Storeria dekayi*)	96	0.365 ± 0.049	29 ± 4	33 ± 6
Eastern Fox Snake (*Elaphe vulpina*)	28	0.680 ± 0.089	102 ± 20	110 ± 25

* = Not significantly different from male: female ratio of 1.0 ($P < 0.05$).

Butler's Garter Snake from sites in southwestern Ontario to be 0.38 and 0.45, respectively. Rivard (1976) found male proportions for Eastern Fox Snakes ranging from 0.41 to 0.86, with an overall proportion of 0.51 at a number of sites in southwestern Ontario.

Mean total length of females was slightly longer than that of males for all species, although there was, of course, very considerable overlap between the two sexes, and variation was large. Figure 1 shows that the length-frequency distributions for three species are skewed toward adult sizes. For all species, the proportion of young born the previous year in the population samples was quite small (less than 5%), except for the late summer censuses of Butler's Garter Snake, when up to 30% of the individuals handled were recently-born young. The latter observation of low proportion of yearlings in the spring-summer censuses could have resulted from some combination of high infant mortality, or the possibility that yearlings were proportionately under-represented in the census owing to behavioral difference between yearling and adult snakes. Carpenter (1952) made similar observations on this matter for Eastern Garter Snakes and Butler's Garter Snakes at a site in Michigan.

In each of the three common species handled in our study, about 65% of the adult females (more than one year old) were obviously gravid.

Brood size was determined for the Butler's Garter Snake. Six females that were retained in captivity had broods of 4, 7, 9, 10, 10, and 11. The largest broods were from females with total lengths of 54.5 cm (11 young), 54.5 cm (10 young), and 46.0 cm (10 young). Wright and Wright (1957) cite brood size of Butler's Garter Snake ranging from 4 to 16, with an average of 9. The proportion of stillborn young or young with rapidly fatal birth defects was 5%.

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Literature Cited

Aleksiuk, M. 1977. Sources of mortality in concentrated Garter Snake populations. Canadian Field-Naturalist 91: 70–72.

Blanchard, F. N. and **E. B. Finster.** 1933. A method of marking live snakes for future recognition, with a discussion of some problems and results. Ecology 14: 334–347.

Carpenter, C. C. 1952. Comparative ecology of the common garter snakes (*Thamnophis sirtalis*), the ribbon snake (*Thamnophis sauritus*), and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22: 235–258.

Cook, F. R. 1970. Rare or endangered Canadian reptiles and amphibians. Canadian Field-Naturalist 84: 9–16.

Fitch, H. S. 1960. Autecology of the Copperhead. Museum of Natural History, University of Kansas Publications 13: 85–228.

Fitch, H. S. 1963. Natural history of the Racer (*Coluber constrictor*). Museum of Natural History, University of Kansas Publications 15: 351–468.

Fitch, H. S. 1964. Natural history of the Black Rat Snake (*Elaphe obsoleta*) in Kansas. Copeia 1964: 649–659.

Fitch, H. S. 1965. An ecological study of the Garter Snake (*Thamnophis sirtalis*). Museum of Natural History, University of Kansas Publications 15: 493–564.

Fitch, H. S. 1975. A demographic study of the Ringneck Snake (*Diadophis punctatus*) in Kansas. University of Kansas Museum of Natural History, Miscellaneous Publications 62. 53 pp.

Gregory, P. T. 1974. Patterns of spring emergence of the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) in the Interlake region of Manitoba. Canadian Journal of Zoology 52: 1063–1069.

Gregory, P. T. 1977. Life history parameters of the Red-sided Garter Snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake region of Manitoba. National Museums of Canada, Publications in Zoology Number 13. 44 pp.

Logier, E. B. S. 1957. Changes in the amphibian and reptilian fauna of Ontario. *In* Changes in the fauna of Ontario. *Edited by* F. A. Urquhart. University of Toronto Press, Toronto. pp. 13–18.

Pendlebury, G. B. 1977. Distribution and abundance of the Prairie Rattlesnake, *Crotalis viridis viridis*, in Canada. Canadian Field-Naturalist 91: 122–129.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish. Fisheries Research Board of Canada, Bulletin 191. 382 pp.

Rivard, D. H. 1976. The biology and conservation of Eastern Fox Snakes (*Elaphe vulpina gloydi* Conant). M.Sc. thesis, Carleton University, Ottawa. 64 pp.

Smith, R. L. 1974. Ecology and field biology. 2nd edition. Harper and Row, New York. 850 pp.

Spellerberg, C. G. 1977. Marking live snakes for identification of individuals in population studies. Journal of Applied Ecology 14: 137–138.

Wright, A. H. and **A. A. Wright.** 1957. Handbook of snakes. 2 volumes. Comstock Publishers, New York. 1107 pp.

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