Sex Ratios in Samples from Eight Snake Populations in Sand Prairies in South-Central Kansas

Dwight R. Platt

Professor Emeritus of Biology
Bethel College, North Newton, Kansas

Photographs by the author.

Sex ratios are important parameters of population structure, and may also provide information on differential behavior, activity, or habitat selection by the sexes. Sample sex ratios may be affected by many factors, including the method of capturing the animals, seasons, weather patterns, foraging behavior, and reproductive status (Parker and Plummer 1987). This report discusses sex ratios in samples collected in a study of natural snake populations, using live traps and mark-recapture methods to investigate population parameters.

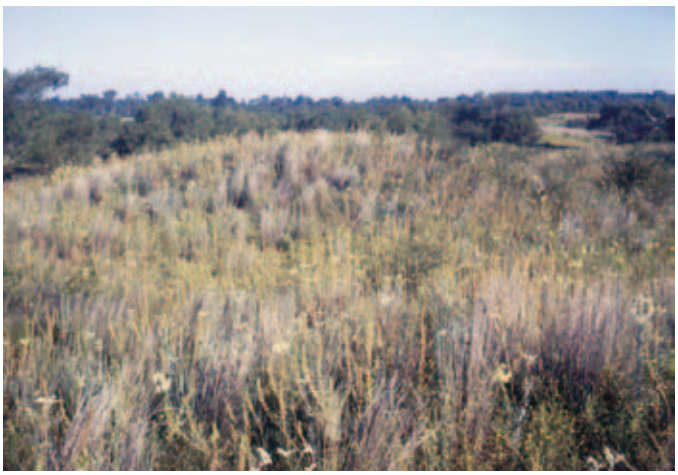
Methods

Three study sites in western Harvey County, south-central Kansas, were used in this study. In 1959–1963, trapping was conducted on a 50-acre study site in the southwestern part of Harvey County West Park. In 1960–1963, a second 50-acre study site was used in the northeastern part of the Graber Pasture that was less than one mile northwest of the initial study site. In 1966–1974, the 80-acre Sand Prairie Natural History Reservation, which adjoins Graber Pasture to the north, was used. These are all hum-

One end of a trapping station with funnel trap fitted under end of the metal drift fence.

Large wetland on Sand Prairie Natural History Reservation, Harvey County, Kansas. In some years it is completely dry.

Low grassland on Sand Prairie Natural History Reservation, Harvey County, Kansas.



Upland on Sand Prairie Natural History Reservation, Harvey County, Kansas.

Table 1. Primary sex ratios in populations of five species of snakes in Harvey County, Kansas. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level.

Species	N	♂ per 100 ♀	χ^2
A. Neonates trapped in Fall			
Yellowbelly Racer	85	81	0.753
Bullsnake	247	104	0.065
Eastern Hognose Snake	73	128	0.877
B. Neonates in litters born in captivity			
Red-sided Garter Snake	538	126	6.916**
Plains Garter Snake	870	98	0.093

Table 2. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in the period May through October in the 14 years 1959–63 and 1966–74. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level and three asterisks (***) at 0.1% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	2288	120	18.368***
Plains Garter Snake	2209	133	43.504***
Yellowbelly Racer	1086	143	33.592***
Bullsnake	721	125	8.876**
Plains Hognose Snake	520	127	7.156**
Eastern Hognose Snake	228	165	13.268***
Kansas Glossy Snake	81	212	9.679**
Prairie Kingsnake	100	127	1.210

Table 3. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in May and June in the 14 years 1959–63 and 1966–74. Two asterisks (**) after the chi-square value indicate a significant difference at the 1% level and three asterisks (***) at 0.1% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	753	137	17.870***
Plains Garter Snake	841	211	107.015***
Yellowbelly Racer	455	242	77.679***
Bullsnake	255	186	22.651***
Plains Hognose Snake	256	158	12.691***
Eastern Hognose Snake	81	200	8.346**
Kansas Glossy Snake	48	500	20.021***
Prairie Kingsnake	44	175	2.750

Table 4. Sex ratios in samples trapped from snake populations in Harvey County, Kansas, in July and August in the 14 years 1959–63 and 1966–74. None of the differences were significant at the 5% level.

Species	N	♂ per 100 ♀	χ^2
Red-sided Garter Snake	612	106	0.472
Plains Garter Snake	891	104	0.287
Yellowbelly Racer	273	95	0.132
Bullsnake	135	85	0.741
Plains Hognose Snake	179	86	0.944
Eastern Hognose Snake	54	100	0.000
Kansas Glossy Snake	22	100	0.000
Prairie Kingsnake	39	77	0.410

Table 5. Sex ratios in samples of snakes at least one year old trapped from populations in Harvey County, Kansas, in September and October in the 14 years 1959–63 and 1966–74. One asterisk (*) after the chi-square value indicates a significant difference at the 5% level and two asterisks (**) at the 1% level.

Species	N	♂per100♀	χ^2
Red-sided Garter Snake	923	117	5.309*
Plains Garter Snake	477	97	0.075
Yellowbelly Racer	264	111	0.640
Bullsnake	48	118	0.188
Plains Hognose Snake	72	188	6.125*
Eastern Hognose Snake	35	289	7.314**
Kansas Glossy Snake	11	57	0.364
Prairie Kingsnake	16	220	1.562

Table 6. Sex ratios in samples of Garter Snakes trapped in May and June in A. years of high frog populations following at least one year of low frog populations (1961, 1969, 1973), B. years of high frog populations following a year of high frog populations (1962, 1974), and C. years of low to moderate frog populations (1959–1960, 1963, 1966–1968, 1970–1972). One asterisk (*) after the chi-square value indicates a significant difference at the 5% level and three asterisks (***) at the 0.1% level.

Year	N	♂per100♀	χ^2
Plains Garter Snake			
A. 61,69,73	280	344	83.604***
B. 62,74	206	199	21.791***
C. 59–60,63,66–68,70–72	355	155	16.270***
Red-sided Garter Snake			
A. 61,69,73	241	177	18.075***
B. 62,74	174	142	4.833*
C. 59–60,63,66–68,70–72	338	112	1.183

mocky shrubby grasslands on fine sand. Because surface drainage is poorly developed and the subsoil is relatively impervious, small temporary or semi-permanent ponds and marshes are present in many of the swales between dunes for short periods or whole seasons.

Each year, live-trapping of snakes was conducted using traps with funnel entrances (modified from those described in Fitch 1951) fitted on each end of low drift fences. Samples of eight species of snakes were large enough to provide information on sex ratios: Plains Garter Snake (*Thamnophis radix*), Red-sided Garter Snake (*T. sirtalis parietalis*), Yellowbelly Racer (*Coluber constrictor flaviventris*), Bullsnake (*Pituophis catenifer sayi*), Plains Hognose Snake (*Heterodon n. nasicus*), Eastern Hognose Snake (*H. plati-*

Sex ratios of Eastern Hognose Snakes (*Heterodon platirhinos*) captured in July/August did not differ significantly from a 1:1 ratio, but those taken in May/June and September/October were male-biased.

The male-biased sex ratios in fall samples for Plains Hognose Snakes (*Heterodon n. nasicus*) suggest a resurgence of mating activity in the autumn.

rhinos), Kansas Glossy Snake (*Arizona e. elegans*), and Prairie Kingsnake (*Lampropeltis c. calligaster*). The sex of snakes was determined by probing for the hemipenial sacs and later confirmed by the tail length as a percentage of snout-vent length (SVL). In tabulating the sex of captured snakes, only the first capture of an individual in a year was included. The null hypothesis of an equal sex ratio was tested by chi-square tests with Yates correction. For all results, one asterisk after the chi-square value indicates a significant difference at the 5% level, two asterisks at the 1% level, and three asterisks at 0.1% level.

Female Garter Snakes that were obviously gravid when captured were kept in cages until the litters were born. In this way, 32 litters of Red-sided Garter Snakes and 59 litters of Plains Garter Snakes were obtained and the neonates were sexed by probing for hemipenial sacs with a small probe. Relative tail length varies little between the two sexes at this age. The term neonate is used in this paper for young snakes in autumn from birth or hatching to first dormancy. For additional information on the methods used in this study, see Platt (1969, 1984).

Results

Primary Sex Ratios.—Samples of neonate Yellowbelly Racers, Bullsnakes, and Eastern Hognose Snakes trapped in the fall had sex ratios that did not differ significantly from 1:1 (Table 1). Although the sample of Racers was moderately female-biased and of Eastern Hognose Snakes was moderately male-biased, the samples were too small to detect a statistically significant imbalance. Few neonate Glossy Snakes or Kingsnakes were caught and neonate Garter Snakes and Plains Hognose Snakes were too small to be caught in the funnel traps. However, 538 neonate Red-sided Garter Snakes and 870 neonate Plains Garter Snakes born in captivity provided information on the primary sex ratios in these two species (Table 1). The sample of Red-sided Garter Snakes had a moderately but significantly male-biased sex ratio. Eight Red-sided Garter Snake litters consisted of 67–82% males, whereas only two litters were female-biased to that degree. If those 10 litters are omitted, the sex ratio in the remaining litters is 107 males per 100 females. The sex ratio of Plains Garter Snakes did not significantly differ from equality.

Secondary Sex Ratios.— The total samples (excluding neonates) of each of the eight species of snakes trapped on the study sites from May–October in the 14 years were moderately to strongly male-biased (Table 2). The deviations from an equal sex ratio were significant, except for the Prairie Kingsnakes, in which the sample was small and only moderately male-biased.

The sex ratios varied in samples taken at different seasons. The samples from May and June were more strongly male-biased than the total sample (Table 3). In each species, the sample from May was more strongly male-biased than the sample from June, except for the Eastern Hognose Snake, in which the sex ratio of the sample from May was 1.81:1 and from June was 2.27:1. The sex ratios of the May/June samples were significantly different from equality in all species except the Prairie Kingsnake, for which, however, the May sample did differ significantly from equality. The sex ratios in samples taken from all eight species in July and August did not differ significantly from equality (Table 4). The sex ratios in samples of Yellowbelly Racers, Bullsnakes, Plains Hognose Snakes, and Prairie Kingsnakes were slightly to moderately female-biased, but the differences were not significant.

The sex ratios in samples of Red-sided Garter Snakes, Plains Hognose Snakes, and Eastern Hognose Snakes that were at least one year old when captured in September and October were significantly male-biased. However, the sex ratios in similar samples of Plains Garter Snakes, Yellowbellied Racers, Bullsnakes, Kansas Glossy Snakes, and Prairie Kingsnakes did not differ significantly from equality (Table 5). The sex ratios of Racers were slightly male-biased and those of Plains Garter Snakes were slightly female-biased.

Yearly samples of Garter Snakes were large enough to detect significant differences in sex ratios. These differences may be related to the abundance of the snake's primary prey item, the Plains Leopard Frog (*Lithobates blairi*). Frog populations varied greatly, being almost nonexistent in those years when the wetlands were dry for most of the season and very large in

Samples of neonate Yellowbelly Racers (*Coluber constrictor flaviventris*) trapped in the fall had a sex ratio that was moderately female-biased, but did not differ significantly from 1:1.

Primary sex ratios in samples of Bullsnakes (*Pituophis catenifer sayi*) from Harvey County, Kansas, did not differ significantly from 1:1.

years when they were flooded all season. Table 6 shows pooled samples of Garter Snakes from May and June in years with similar frog abundance. All three pooled samples of the Plains Garter Snake were significantly male-biased, but the excess of males was greatest in those years with good flooding following one or more years with very low frog populations. The sex ratio in the pooled sample from those years was significantly different from the other two pooled samples (chi-squares: A to B, 14.169***; A to C, 32.376***; B to C, 2.691). The Red-sided Garter Snake had a similar pattern but less extreme, and only the two pooled samples from years with high frog populations have a significantly male-biased sex ratio. The sex ratio in the pooled sample from those years with good flooding following one or more years with very low frog populations was significantly different from years with low to moderate frog populations (chi-squares: A to B, 1.798; A to C, 10.834***; B to C, 2.082).

Discussion

Most published primary sex ratios from snake populations do not differ significantly from 1:1 (Parker and Plummer 1987). Primary sex ratios in samples of Plains Garter Snakes, Bullsnakes, Yellowbelly Racers, and Eastern Hognose Snakes from Harvey County, Kansas, did not differ significantly from 1:1. A sample of 96 hatchling Bullsnakes from eight clutches of eggs laid by females from Nebraska had a male-biased sex ratio of 2:1 (Gutzke et al. 1985), but Iverson (1990) reported a primary sex ratio that did not differ from equality for Bullsnakes from the same study area.

The primary sex ratio of Red-sided Garter Snakes in our study was 1.26:1 and differed significantly from 1:1. In a sample of 514 neonates of the Red-sided Garter Snake born in captivity to females from a population in northeastern Kansas, the sex ratio was even more skewed at 1.66:1 (Fitch 1999). Carpenter (1952) reported a primary sex ratio of 1.06:1 for another subspecies of this Garter Snake in Michigan. In my study, the male-biased sex ratio was primarily due to eight litters that consisted of two-thirds or more males. Dunlap and Lang (1990) reported from a study of another subspecies in Minnesota that male-biased litters were produced by larger females, but this was not true in my study. The eight extremely male-biased litters in this study came from females averaging 645 mm SVL and the other 24 females contributing litters averaged 676 mm SVL.

Secondary sex ratios in the samples of older snakes caught in the funnel traps were moderately to greatly male-biased. Males can invest more resources in activity than females, because females invest more in the production and development of eggs. If males are more active, this can result in male-biased sex ratios in samples from funnel traps on drift fences. These traps intercept moving snakes, and individuals that are more active and move around more have a greater probability of being caught. The seasonal changes in sex ratio in samples from the three study sites in this study are consistent with increased male activity during the mating season in spring and early summer and essentially equal activity later in the summer; this has been reported by many authors (e.g., Parker and Plummer 1987, Iverson 1990). The male-biased sex ratios in autumn samples for the Red-sided Garter Snake and the two Hognose Snake species suggest a resurgence of mating activity for these species in the autumn. Fitch (1965) reported evidence of autumn mating of Red-sided Garter Snakes and Platt (1969) reported similar evidence for the Eastern Hognose Snake. The sex ratio for the sample of Racers from autumn was not significantly different from 1:1, and Fitch (1963) concluded that Racers probably did not copulate during that season.

Most Garter Snakes leave the study sites in Harvey County during seasons when the wetlands are dry, but come back in large numbers in years when the wetlands are flooded and the frog populations surge. The extreme male bias of May/June samples of Plains Garter Snakes in wet years that follow dry years, and to a lesser degree in samples of Red-sided Garter Snakes (see Table 6), is consistent with greater movement by males that results in their return to this favorable habitat before most females and even before the great increase in frog populations that occurs in July with the metamorphosis of young.

The sex ratios of the May/June samples were significantly different from equality in all species except the Prairie Kingsnake (*Lampropeltis c. calligaster*), for which, however, the May sample did differ significantly from equality.

Although rarely encountered in nature, an albino Kansas Glossy Snake (*Arizona e. elegans*) was collected during sampling in Harvey County, Kansas. Note the sharp contrast when compared with a normally pigmented individual.

Yearly samples of Red-sided Garter Snakes (*Thamnophis sirtalis parietalis*) were large enough to detect significant differences in sex ratios. These differences may be related to the abundance of the snake's primary prey, the Plains Leopard Frog (*Lithobates blairi*).

Secondary sex ratios in samples of snakes must be interpreted with caution because they can be influenced by many factors that differentially affect the two sexes, and changes in actual population structure may be a minor factor. Sex ratios in samples have been shown to change rapidly when differential sexual behavior is affected. Shine et al. (2006) found significant daily variation in sex ratios of samples of Garter Snakes as they emerged from hibernation. These variations were related to time in season and daily maximum and minimum temperatures. In my study, greater activity by males in the spring and, in some species, in the autumn searching for mates and/or favorable habitat are probably the most important factors in the male-biased secondary sex ratios of these eight species of snakes.

Acknowledgments

I am grateful to the late Henry Fitch who hired me to manage snake studies in Harvey County from 1959 to 1963. This was my initiation into a herpetological career. Financial support for the study from 1966 to 1974 came from the National Science Foundation (Grants GB-7830 and GB-35441), The Nature Conservancy, and Bethel College. A number of students assisted with the field study: Victor Claassen, Steven G. Hetzke, Marilyn Johnson, Mark Matthies, Scott Matthies, Kamala Platt, Stanley Senner, Patricia Senner, Robert C. Waltner, and James Wedel.

Literature Cited

Carpenter, C.C. 1952. Comparative ecology of the Common Garter Snake (*Thamnophis s. sirtalis),* the Ribbon Snake (*Thamnophis s. sauritus*), and Butler's Garter Snake (*Thamnophis butleri*) in mixed populations. *Ecological Monographs* 22:235–258.

Dunlap, K.D. and J.W. Lang. 1990. Offspring sex ratio varies with maternal size in the Common Garter Snake, *Thamnophis sirtalis. Copeia* 1990:568–570.

Fitch, H.S. 1951. A simplified type of funnel trap for reptiles. *Herpetologica* 7:77–80.

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

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

Fitch, H.S. 1999. *A Kansas Snake Community: Composition and Changes Over 50 Years.* Krieger Publishing Company, Malabar, Florida.

Gutzke, W.H.N., G.L. Paukstis, and L.L McDaniel. 1985. Skewed sex ratios for adult and hatchling Bullsnakes, *Pituophis melanoleucus,* in Nebraska. *Copeia* 1985:649–652.

Iverson, J.B. 1990. Sex ratios in snakes: A cautionary note. *Copeia* 1990:571–573.

Parker, W.S. and M.V. Plummer. 1987. Population ecology, pp. 253–301. In: R.A. Seigel, J.T. Collins, and S.S. Novak (eds.), *Snakes: Ecology and Evolutionary Biology.* Macmillan Publishing Company, New York.

Platt, D.R. 1969. Natural history of the hognose snakes *Heterodon platyrhinos* and *Heterodon nasicus. University of Kansas Publications Museum of Natural History* 18:253–420.

Platt, D.R. 1984. Growth of Bullsnakes (*Pituophis melanoleucus sayi*) on a sand prairie in south central Kansas, pp. 41–55. In: R.A. Seigel, L.E. Hunt, J.L. Knight, L. Malaret, and N.L. Zuschlag (eds.), *Vertebrate Ecology and Systematics, A Tribute to Henry S. Fitch.* University of Kansas Museum of Natural History Special Publication No. 10. Lawrence, Kansas.

Shine, R., T. Langkilde, M. Wall, and R.T. Mason. 2006. Temporal dynamics of emergence and dispersal of garter snakes from a communal den in Manitoba. *Wildlife Research* 33:103–111.

Salamander Sci-Art

Peter R. Warny[1], Stanley K. Sessions[2], and Brandon Ballengée[3]

[1]Biological Research Division, New York State Museum, Albany, New York 12230
[2]Biology Department, Hartwick College, Oneonta, New York 13820
[3]Redpath Museum, McGill University, Montréal, Quebec

All scanned images by the authors.

"Salamander" is the common name for amphibians with tails, and (with the exception of the Sirenidae) four legs of about equal size. They include all the members of the order Caudata, comprising nine families and over 500 species. The name "salamander" is derived from an old Arab/Persian word meaning "lives in fire," stemming from the belief that the salamander was born in fire or could walk through fire without being harmed (Khanna and Yadav 1998). This myth might have originated from the bright skin colors that resemble flames in some salamanders, perhaps from the burning taste one might feel while trying to eat such a creature, or observations of salamanders emerging from logs thrown onto a fire.

Salamanders of the northeastern United States and southeastern Canada are an ecologically interesting group. Their habitats include eastern mesophytic forests and periglacial features, such as woodland pool depressions, rocky wooded hillsides, outcrops, talus, and ravines (Petranka 1998). Included among northeastern species are enigmatic permanently aquatic forms that include Hellbenders (*Cryptobranchus alleganiensis*) and the mys-