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Notes on Road-Killed Snakes and Their Implications on Habitat Modification Due to Summer Flooding on the Mississippi River in West Central Illinois

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ABSTRACT

Beginning 6 October 1993 an increase in the number of road-killed (DOR) snakes was noted along Illinois Route 100 in Jersey and Madison counties, Illinois. A total of 113 snakes representing 12 species including *Nerodia sipedon* (n = 29), *Thamnophis sirtalis* (n = 22), *Elaphe obsoleta* (n = 13), *Nerodia erythrogaster* (n = 13), *Regina grahamii* (n = 13), *Nerodia rhombifer* (n = 10), *Elaphe vulpina* (n = 6), *Lampropeltis calligaster* (n = 3), *Lampropeltis getula* (n = 1), *Pituophis melanoleucus* (n = 1), *Storeria dekayi wrightorum* (n = 1), and *Thamnophis proximus* (n = 1) were collected over the 3,402 km of road searched (0.033 snakes/km or 30.1 km/snake). Eighty-six (76%) snakes were collected on five of the 21 dates. Snake counts for these five dates ranged between 12 and 25 snakes per date (17.2 snakes/date or 0.106 snakes/km). The number of snakes collected on the other 16 dates ranged between 0 and 6 snakes per date (1.7 snakes/day or 0.010 snakes/km). Date of collection, daily high and low temperatures, river stage at Grafton and Alton, and precipitation were not correlated with total snake numbers, number of terrestrial species, or number of aquatic species. Correlations between one or more of the abiotic factors and numbers of individual species were found with daily high and low temperatures and river stages being the most frequently associated variables. Principal component analysis indicated that measures of temperature are the best overall predictor of snake movements as measured by the number of DOR snakes in this particular instance. The unusual snake movements observed are thought to be due to the large flood event during the summer of 1993. The flood altered the nature of the rip rap along the road by depositing silt in the interspaces between the individual rocks that make up the rip rap. These snakes may have hibernated within the rip rap and their fall movements to hibernacula went unobserved because they did not cross the road to reach suitable over-wintering sites. When flooding made these hibernacula unsuitable, the snakes were forced to cross the road to find other sites for hibernation.

INTRODUCTION

Illinois Route 100 is a busy, 4-lane divided highway locally known as the Great River Road. For 21 km between Grafton (population 1,000, Jersey County) and Alton (population 36,000, Madison County), Illinois, the road lies between the Mississippi

River and limestone/dolomite bluffs. Except where it crosses Piasa Creek 9 km NW of Alton, the road is bordered by the Mississippi River on one side and the bluffs on the other. Between Grafton and Alton, the road trends NW-SE or W-E due to the river bend. North of Grafton, the road trends N-S and follows the course of the Illinois River. At this point it is not immediately adjacent to that river except at scattered locations.

For almost two years, I have traveled between Elsah and Alton, Illinois, on a daily basis to and from the Illinois Natural History Survey field station south of Alton. During this time I occasionally have noted road-killed (hereafter called DOR) snakes along this route. Beginning 6 October 1993, I noted an increase in the number of DOR snakes. A high level of snake activity along this road is unusual in my experience and in the opinion of other herpetologists (R. Axtell, C. Phillips, O. Sexton pers. comm.) with more experience traveling this road. Geographic distribution records for selected specimens were previously reported by Tucker (1994). The present paper summarizes data on those and the other snakes collected.

MATERIALS AND METHODS

Except for October 26, I traveled the road (Fig. 1) daily between October 7 and October 28 from Alton to Deer Plain Ferry (locally known as the Brussels Ferry) and then back again (= one trip). Each trip covered a road distance of 54 km. I made three trips each day with the first beginning between 1330 and 1630 h., the second between 2000 and 2200 h., and the third between 0200 and 0400 h., Central Standard Time. Speed varied between 24 and 56 km/hour. I recorded the distance from each DOR snake to the Alton water treatment plant at the western edge of Alton. All specimens for which snout to vent length (SVL) could be measured were preserved and are deposited in the collections of the Illinois Natural History Survey (INHS 10999-11109). I identified each specimen to species (Smith, 1961), determined sex by eversion of hemipenes during preservation, and measured SVL to the nearest mm after fixation and preservation. L. E. Brown, Department of Biological Sciences, Illinois State University and C. Phillips, Illinois Natural History Survey confirmed identifications for selected specimens of each species. I recorded the high and low temperatures and precipitation at Alton, and the river stages at both Alton and Grafton from daily summaries compiled by the National Weather Service and published in the Alton Telegraph. Statistical tests were performed with the SAS System computer programs (SAS Institute, 1988). Because some abiotic variables did not meet all assumptions of normality, nonparametric Spearman rank correlation was used for correlation analysis. For comparisons of male and female SVL within species, I used a one-way analysis of variance (ANOVA) with Tukey's *t*-test.

RESULTS

I collected 113 snakes representing 12 species (Table 1) over the 3,402 km of road searched (0.033 snakes/km or 30.1 km/snake). The number of snakes found per km of road between the start point and end point of each trip was 0.066 snakes/km or 0.198 snakes/km/day. The direction of snake movement appeared to be from the river towards the bluffs since most DORs were on the river side of the highway. All five specimens found alive were crawling away from the river and towards the bluffs.

More females were found DOR in two of the four most commonly collected genera. Sex ratios (male:female, chi square value, *p*) for the four most commonly collected genera were 5:14, 4.3, $p < 0.05$ for *Elaphe*; 27:25, 0.08, $p > 0.05$ for *Nerodia*, 4:9, 1.92, $p > 0.05$ for *Regina*, and 6:17, 5.26, $p < 0.05$ for *Thamnophis*.

For the six most commonly collected species mean SVL for males was not statistically different ($p > 0.05$) from females. Mean SVL by sex in mm (males : females) for these six species were *E. obsoleta* (851.7 : 879.6), *N. erythrogaster* (580.8 : 737.1), *N. rhombifer* (510.8 : 628.5), *N. sipedon* (462.8 : 515.1), *R. grahamii* (516.5 : 575.6), and *T. sirtalis* (430.2 : 523.9). However, in each species, females found DOR were larger than males which seems unlikely to be due to chance alone. No data were available on populations of these species from the study area so it cannot be determined if the snakes observed DOR were an unbiased sample of the populations bordering the road.

Distribution of DORs was not uniform over the 27 km of roadway surveyed (Fig. 1). The number of snakes collected formed peaks at km 1, 6, 9, 15, and 26. The peak near km 15 was due to a large number of *T. sirtalis* specimens collected in that area. The drop off at km 21 occurred at Grafton and could be associated with increased human disturbance along with the fact that the road is not as close to the Mississippi River once the confluence with the Illinois River at Grafton is reached. The road does not closely border the Illinois River until it reaches the ferry near km 27. At this point, the number of DORs rebounded. The largest number of specimens of any species at any particular km was eight (*T. sirtalis*) at km 15.

Snake movement as reflected by DOR counts per date was not uniform (Fig. 2). Eighty-six (76%) snakes were collected on five of 21 days. Snake counts for these five days ranged between 12 and 25 snakes per day (mean = 17.2 snakes/day) or 0.106 snakes/km for the trips made on those days. For all days of the study, the mean was 5.38 snakes/day (SD = 7.54). Days with 12 or more snakes departed significantly ($p < 0.01$) from a Poisson distribution. The number of snakes collected on the other 16 days ranged between 0 and 6 snakes per date (mean = 1.7 snakes/day) or 0.010 snakes/km for the trips made on those days. The distribution for total snake numbers per day also departed significantly from a normal distribution (Shapiro-Wilk test, $p < 0.0001$) because it was skewed (skewness measure = 1.78) with positive kurtosis (kurtosis measure = 2.37) by the five days with high numbers of snakes collected.

The first and last date of collection of the six most commonly encountered species during the study period were as follows: *E. obsoleta* 10 to 25 October; *N. erythrogaster* and *N. rhombifer* 7 to 17 October; *N. sipedon* 7 to 27 October; *R. grahamii* 7 to 21 October; and *T. sirtalis* 7 to 28 October.

Because snake numbers were not uniformly distributed over the days spent collecting, I performed Spearman rank correlation analysis using date, total number of snakes per date, the daily high and daily low temperatures for each date, precipitation for each date, and the river stages at Grafton and Alton for each date as independent variables to determine if any of these abiotic factors could explain the variance in snake numbers collected per day. I found no correlations between total snake numbers and any of the abiotic variables.

Because a number of species with diverse habitat requirements were included in the number for total snakes collected and because all species were not represented equally in the sample, I divided the number for total snakes into primarily terrestrial species (*Elaphe obsoleta*, *E. vulpina*, *Lampropeltis calligaster*, *L. getula*, *Pituophis melanoleucus*, *Storeria dekayi wrightorum*, *Thamnophis sirtalis*, and *T. proximus*) and primarily aquatic species (*Nerodia sipedon*, *N. erythrogaster*, *N. rhombifer*, and *Regina grahamii*) based on habitat descriptions in Smith (1961) and repeated the correlation analysis for both groups.

When grouped in this manner, no abiotic factor was significantly correlated with either the number of terrestrial snakes collected per day or with the number of aquatic snakes collected per day. The conditions during the relatively short study period (21 days) may not have varied sufficiently for effects of the abiotic factors on numbers of snakes to be apparent. Another possibility is that the species classified as primarily terrestrial or primarily aquatic differ in their responses to the abiotic variables. Consequently, I performed separate correlation analyses for the three most commonly collected species classified as primarily terrestrial (*Thamnophis sirtalis, Elaphe obsoleta*, and *E. vulpina*) and the four species classified as primarily aquatic.

No abiotic factors correlated with the numbers of *E. obsoleta* and *T. sirtalis*. However, both daily high temperature (*rho* = 0.56, $p = 0.0084$) and river stage at Grafton (*rho* = 0.46, $p = 0.0370$) correlated with number of *E. vulpina* collected each day. These correlations must be suspect considering that I collected only six specimens of the species.

In contrast to the primarily terrestrial species, the numbers collected of two of the aquatic species were correlated with one or more of the abiotic variable. The number of *N. erythrogaster* collected was correlated with daily high (*rho* = 0.44, $p = 0.0457$) and daily low (*rho* = 0.56, $p = 0.0078$) temperatures. For this species, correlation with river stage at Grafton (*rho* = 0.42, $p = 0.0602$) and Alton (*rho* = 0.42, $p = 0.0557$) was nearly significant. The number of *R. grahamii* collected was correlated with daily low temperatures (*rho* = 0.48, $p = 0.0272$). Both *N. sipedon* and *R. grahamii* numbers were slightly though not significantly correlated with river stage at Grafton (*rho* = 0.43, $p = 0.0537$ and *rho* = 0.40, $p = 0.0710$, respectively) and for the latter species with river stage at Alton (*rho* = 0.43, $p = 0.0507$).

Clearly these are preliminary results due to the short duration of the snake movement and the small sample sizes collected for each species on any one day of the study. However, the correlation between temperatures and snake activity is not unusual (see Larsen, 1989, for instance). Possible correlation of snake activity with river stage has not been reported previously. The slight correlation between aquatic snake activity and river stage could be due to actual effects on movement patterns attributable to changes in river stage. The association between snake numbers and river stage could also be due to autocorrelation because daily high temperature was correlated with daily low temperature (*rho* = 0.58, $p = 0.0060$). Furthermore, daily low temperature was correlated with Alton river stage (*rho* = 0.66, $p = 0.0011$) and with Grafton river stage (*rho* = 0.49, $p = 0.0241$), indicating that these abiotic variables cannot be considered independent of each other.

In order to further explore the possible relationships between the numbers of aquatic snakes and terrestrial snakes collected and daily high and low temperatures and river stage at Grafton and Alton, I performed principal component analysis (Fig. 3). The first principal component accounted for 82.08% of the variance, the second accounted for 11.32%, the third for 4.3%, and the fourth for 2.29%. Daily high and low temperatures were responsible for most of the loading of the first and second principal components with eigenvectors of 0.653455 and -0.743643 for daily high and 0.707542 and 0.644512 for daily low temperatures, respectively. Eigenvectors for river stage were uniformly low for the first two principal components being 0.233985 and 0.028268 for river stage at Grafton and 0.132783 and 0.175501 for river stage at Alton, respectively. The number of terrestrial species collected per day showed no obvious pattern. However, the clustering of the days that the largest numbers of aquatic species were collected at the positive extreme of the first principal component is consistent with the hypothesis that the aquatic snakes were more likely to be found when daily high and low temperatures were relatively high.

DISCUSSION

The number of DOR snakes/km (0.033) that I observed fell within the range of 0.0066 to 0.1754 DORs/km listed by Dodd et al. (1989, Table 1) in their summary of other studies reporting data on DOR snakes. However, such large numbers of DOR snakes is unusual for the area and may be a result of habitat changes produced by flooding.

The summer flood of 1993 (Fig. 4) covered the study area, and altered the nature of the rip rap along the road by depositing silt in the interspaces between the individual rocks that make up the rip rap. These snakes may have formerly hibernated within the rip rap and their fall movements to hibernacula went unobserved because they did not cross the road to reach suitable over- wintering sites. When flooding made these hibernacula unsuitable, the snakes crossed the road to find alternative sites.

Of the seven most commonly collected species, *N. erythrogaster, N. rhombifer, N. sipedon, R. grahamii,* and *T. sirtalis* occupy either aquatic habitats or habitats bordering water (Smith, 1961). Except for *T. sirtalis* (Fitch, 1965; Larsen, 1987), these species have not been reported to use large communal hibernacula. If these snakes were searching for hibernacula, then the observation that all but *T. sirtalis* were more or less evenly distributed along the road where it borders the river is explained. The concentration of *T. sirtalis* near km 15 may indicate a communal hibernaculum in that area. It is well known that *T. sirtalis* sometimes makes long distance (up to 17.7 km) migrations to hibernacula (Gregory and Stewart, 1975).

The assumption inherent in this scenario is that the species were resident in this area at the time of the flooding and were not displaced by the flood event. This assumption may hold for aquatic species, such as the three species of *Nerodia*. However, some species, such as *E. obsoleta, E. vulpina, P. melanoleucus*, and possibly *R. grahamii*, seem out of place in a habitat consisting of a rip rapped bank side of a large river. Smith (1961) lists primary habitat as wooded bluffs for *E. obsoleta*, black-soil prairies, pastures and fencerows for *E. vulpina*, sand prairies for *P. melanoleucus*, and lakes, river-bottom sloughs, and prairie marshes for *R. grahamii*. These species may have been dislocated from their more usual habitats by the flooding. Unfortunately, no studies of snakes normally found in rip rapped bank sides have been published.

Few studies (Dowling, 1987; Trauth, 1990; Tucker et al., in press) describe effects of flooding on snakes. These reports seem to differ from the instance reported here. In each of the previously reported cases, unusual movements or numbers of snakes appeared while the flood event was ongoing. In the event reported here, unusual movements occurred well after the flood event itself had passed (Fig. 4). This may indicate that flooding can have long lasting effects through subtle alterations in habitat and immediate effects such as the displacement previously reported.

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Table 1. Snakes listed in order of decreasing abundance collected on Illinois Route 100, Jersey and Madison counties, Illinois between October 7 and 28, 1993.

Species number and % of total snakes collected	Mean SVL mm	Range mm	SD mm	Number of males:females
Nerodia sipedon n = 29, 25.7%	488.1	167 - 974	189.96	15 : 14
Thamnophis sirtalis n = 22, 19.5%	498.3	311 - 680	109.16	6 : 16
Elaphe obsoleta n = 13, 11.5%	873.2	497 - 1070	166.19	3 : 10
Nerodia erythrogaster n = 13, 11.5%	665.0	370 - 905	164.6	6 : 7
Regina grahamii n = 13, 11.5%	557.4	387 - 760	97.6	4 : 9
N. rhombifer n = 10, 8.8%	557.9	445 - 840	117.31	6 : 4
E. vulpina n = 6, 5.3%	822.2	555 - 1010	187.6	2 : 4
Lampropeltis calligaster n = 3, 2.7%	768.3	642 - 863	113.85	1 : 2
L. getula n = 1, 0.9%	795	------	------	1 : 0
Pituophis melanoleucus n = 1, 0.9%	1030	------	------	0 : 1
Storeria dekayi wrightorum n = 1, 0.9%	275	------	------	1 : 0
T. proximus n = 1, 0.9%	520	------	------	0 : 1

Abbreviations: n = number of specimens; SVL = snout to vent length; SD = standard deviation.

Figure 1. Location of Illinois Route 100 and place names mentioned in text with the number of snakes collected per km superimposed.

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Figure 2. The number of snakes found each day between October 7 and 28 compared to daily high and low temperature (°C) and river stage (feet) at Grafton. No collections were made for October 26.

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Figure 3. Results of principal component analysis including independent variables daily high and low temperature and river stage at Grafton and Alton for terrestrial and aquatic species. The numbers represent the numbers of each kind of snake collected on each day of the study.

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Figure 4. Hydrograph showing extent and duration of river flooding along Illinois Route 100 utilizing 432 MSL as the average elevation of the road. Period during which snakes were found on the road is shown.

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