

Predation of Radio-Marked Mallard (*Anas platyrhynchos*) Ducklings by Eastern Snapping Turtles (*Chelydra serpentina serpentina*) and Western Fox Snakes (*Pantherophis vulpinus*) on the Upper Mississippi River

KEVIN P. KENOW,¹ JOSHUA M. KAPFER,^{2,3} AND CARL E. KORSCHGEN^{1,4}

¹United States Geological Survey, Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, Wisconsin 54603 USA

²Natural Resources Consulting, 209 Commerce Parkway, PO Box 128, Cottage Grove, Wisconsin 53527 USA; E-mail: jnkapfer@hotmail.com

ABSTRACT.—Information on the predation rate of Eastern Snapping Turtles (*Chelydra serpentina serpentina*) and Western Fox Snakes (*Pantherophis vulpinus*) on waterfowl, particularly ducklings, is minimal. Most information that exists focuses on the percent of waterfowl found in the diet of sampled turtles or snakes. Although this information is useful, it does not elucidate the potential effect of reptile predation on waterfowl populations by measuring predation rate (i.e., the number of sampled ducklings consumed by reptile predators). We attempted to determine this by tracking the fate of 448 day-old Mallard (*Anas platyrhynchos*) ducklings from 1991–1994 on the Upper Mississippi River. A total of 120 ducklings were preyed upon during the study (26.7% predation rate). Of these, 13 were consumed by Eastern Snapping Turtles (2.9% predation rate) and four by Western Fox Snakes (0.8% predation rate). Predation rate by reptiles was lower than mammals and similar to that of fish and birds, but several depredations with undetermined sources could have been caused by Eastern Snapping Turtles. For a proper perspective on predation impacts on duckling populations, one must also consider the influence of habitat quality as it relates to the interactions of predation, food resources, and cover.

Reptiles have been implicated as substantial predators of upland nesting bird eggs and hatchlings (Messmer et al., 1997). The Eastern Snapping Turtle (formerly the Common Snapping Turtle, *Chelydra serpentina serpentina*) is often listed as such a predator (Thorp, 1994; Drilling et al., 2002), with the implication that this turtle may significantly affect populations of certain upland nesting bird species. Aspects of the feeding biology of the Eastern Snapping Turtle have previously been studied (reviewed by Spotila and Bell, 2008), and it is known that numerous bird species, including waterfowl, are consumed by this turtle (e.g., Mahmoud and Klicka, 1979). However, in a number of past reports from a variety of geographic locations, the proportion of sampled turtles that contained waterfowl remnants in their guts was relatively low. For example, with somewhat small sample sizes, previous studies have found that anywhere from 5.5–27% of the snapping turtles analyzed contained bird remains in their stomachs (e.g., Pell, 1940; Lagler, 1943; Coulter, 1957; Hammer, 1969). With a larger sample size, Alexander (1943) found birds, including the Wood Duck (*Aix sponsa*), only sparsely represented in the guts of snapping turtles. Coulter (1957) found that predation by Eastern Snapping Turtles resulted in an estimated loss of 10–13% of duckling production in Maine. Yet, these studies only revealed the frequency of occurrence and volume of waterfowl found in the gut contents of sampled turtles, rather than the proportion of available waterfowl hatchlings preyed upon by turtles (or predation rate).

With the advent of miniaturized radio transmitters, a handful of studies have tracked the fate of individual ducklings. Kremontz and Pendleton (1991) documented a 6% depredation rate of radio-marked Black Ducks (*Anas rubripes*) and a 1% predation rate of radiomarked Mallard (*Anas platyrhynchos*) ducklings by reptiles on the Chesapeake Bay (these reptilian predators they identified as Eastern Snapping Turtles and Gray Ratsnakes, *Pantherophis spiloides*, but did not report species-specific predation rates). Korschgen et al. (1996a) reported one of 217 (0.5%) radiomarked Canvasback (*Aythya valisineria*) ducklings was taken by an Eastern Snapping Turtle in northwestern Minnesota. Published information on Eastern Snapping Turtle predation of waterfowl on the Upper Mississippi River (UMR) does not exist, despite the common status of this turtle in the region (Vogt, 1981; Oldfield and Moriarty, 1994).

A number of snake species are also known to prey upon the eggs and hatchlings of numerous upland nesting birds, including waterfowl. Glup and McDaniel (1987) found that Bullsnares (*Pituophis catenifer sayi*) were significant predators of the eggs and hatchlings of several duck species when potential mammalian predators were removed. Imler (1945) found that Bullsnares destroyed 45% of duck nests under observation in a Nebraska wildlife refuge. Ratsnakes have been reported as substantial predators of cavity-nesting waterfowl, particularly Wood Ducks (Strange et al., 1971; Muncy and Burbank, 1975; Hansen and Fredrickson, 1990) and are known to consume the eggs of the Giant Canada Goose (*Branta canadensis*; Aldrich and Endicott, 1984). Western Fox Snakes (*Pantherophis vulpinus*) have also been reported as significant predators of duck eggs (Wheeler, 1984). Along the UMR, Bullsnares are often, although not exclusively, found associated with bluff habitats, such

³Corresponding Author.

⁴Present address: United States Geological Survey, Columbia Environmental Research Center, 4200 New Haven Road, Columbia, Missouri 65201 USA

as goat prairies, rather than water (Vogt, 1981; Oldfield and Moriarty, 1994; Kapfer et al., 2008). Because waterfowl tend to nest in upland habitats in close association with water, it is less likely that Bullsnares are a substantial predator of their eggs or hatchlings in this region. However, Western Fox Snakes are often found in association with aquatic habitats in this region and are more likely to have opportunities to take waterfowl eggs or hatchlings as prey on the UMR (Vogt, 1981; Oldfield and Moriarty, 1994; Harding, 1997). As with Eastern Snapping Turtles, specific predation rates (number of available ducklings taken by snakes) have not previously been determined for snakes on the UMR.

The Mallard is a waterfowl species that commonly breeds on the UMR (Cutright et al., 2006), yet limited information exists on early posthatch duckling survival. Few previous studies have endeavored to determine reptile predation rates from a large sample of marked Mallard ducklings, although this has been determined in other waterfowl species (Korschgen et al., 1996a). Therefore, we attempted to determine the significance of reptile predation on Mallard ducklings on the UMR. We hypothesized that although often referred to as substantial predators of ducklings, the reptiles would consume young waterfowl less frequently than other predators.

MATERIALS AND METHODS

Data collection occurred in Navigation Pools 7 and 8 of the UMR. Water levels and flow on the UMR are controlled by a series of locks and dams that was mostly constructed by the late 1930s to facilitate commercial navigation. Pool 8 of the UMR denotes the region that is impounded by Lock and Dam 8, located near Genoa, Wisconsin, upstream to Lock and Dam 7 located near Dresbach, Minnesota. This is a 37.5-km stretch of the river, representing an impounded area of 10,117 ha. Pool 7 extends from Lock and Dam 7 upstream to Lock and Dam 6, located near Trempealeau, Wisconsin. This represents 19.0 km of the river, encompassing an area 5,800 ha in size. Lake Onalaska (2,025 ha) comprises the lower third of this pool and consists mostly of shallow open water (average ≤ 1.5 m in depth), channels, and islands. In general, both pools include a wide range of aquatic habitat types well suited for numerous waterfowl and reptile species. These habitats include flowing open water habitats, associated backwater sloughs and wetlands, and riparian areas possessing various types of structure and cover.

From 1991–1994, we conducted a radio telemetry study to determine cause-specific mortality in Mallard ducklings from hatching to 45 days of age on Pools 7 and 8 of the UMR. To accomplish this, we implanted Mallard ducklings with crystal-controlled, two-stage pulse radio transmitters (model BD-2GTI; Holohil Systems, Ltd, Carp, Ontario, Canada) that weighed 1.4 g and with a life expectancy of approximately 45 days. We obtained Mallard ducklings by systematically searching islands within Pools 7 and 8 during May through July each year. For each nest found, nest status and stage of incubation were determined. We then collected eggs from the nests after allowing the female to resume incubation for at least 20 days (normal incubation period is 24 days). Eggs were then

TABLE 1. Number of Mallard ducklings radiomarked in Pools 7 and 8 of the Upper Mississippi River from 1991–1994.

	Pool 7	Pool 8
1991	0	138
1992	0	51
1993	95	55
1994	109	0
Total	204	244

collected and artificially incubated until hatch via procedures described in Korschgen et al. (1996a). Our experimental brood consisted of a clutch (set of eggs from the same nest) of 4–10 eggs that all hatched within 12 h of each other. When a clutch hatched, we determined body mass and sex for each duckling and randomly assigned them to be radiomarked. We attempted to radiomark approximately 75% of ducklings in each brood. We used accepted methods to implant transmitters subcutaneously between the scapulars of ducklings (Korschgen et al., 1996b). Radios were implanted within a few hours of hatch. Radiomarked Mallard ducklings were then released at their natal nest to the adult female and subsequently located daily from boat or aircraft. Radio tracking of ducklings was conducted on Pool 7 during two consecutive summers (1993 and 1994) and on Pool 8 for three years (1991, 1992, and 1993).

When mortality was observed in radiomarked ducklings, the source of this mortality was determined. Often, this involved tracking transmitter signals to a suspected predator or to scat passed by the predator. In cases where reptiles were believed to be responsible for the mortality of ducklings, the suspected predator was humanely euthanized (in one instance) or captured and returned to the laboratory. In most instances, Eastern Snapping Turtles containing transmitters were held in captivity until transmitters were passed in the feces, and the animal was then released.

RESULTS

During the four-year study, the fates of 84 Mallard broods totaling 448 day-old radio tagged ducklings were determined in Pools 7 and 8. The number of ducklings tracked varied with year (Table 1). A total of 120 ducklings were preyed upon during the study period (Table 2), yielding a predation rate (number of predated ducklings / total number of ducklings with transmitters) of 26.7%. Of these, 13 were taken by Eastern Snapping Turtles from 1991–1994 in both Pools. There were an additional 26 mortalities attributed to unknown “aquatic predators” (unable to identify because of limited visibility in the water, but signal behavior indicated likely movement of the transmitter by fish or turtle) in both pools during this time. Four mortalities in Pool 8 were attributed to a single Western Fox Snake in 1993 only (predation rate = 0.8% for all years pooled). The pooled predation rate of Eastern Snapping Turtles across all years was 2.9% (Table 2). Among all ducklings taken by predators the percentage of depredations attributed to reptiles in both pools throughout the study was 14.2%.

TABLE 2. Annual number of radiomarked Mallard ducklings taken by predators, and attributable percent of overall predation, in Pools 7 and 8 of the Upper Mississippi River from 1991–1994.

	Pool 7		Pool 8			Overall (Pred. rate / % total pred.)
	1993	1994	1991	1992	1993	
Eastern Snapping Turtle	0	6	3	0	4	13 (2.9% / 10.8%)
Western Fox Snake	0	0	0	0	4	4 (0.8% / 3.3%)
Fish	1	0	6	4	0	11 (2.4% / 9.2%)
Unkn. aquatic predator	8	8	2	4	4	26 (5.8% / 21.7%)
Avian	3	2	5	2	2	14 (2.9% / 11.7%)
Mammal	20	0	4	0	14	38 (8.4% / 31.7%)
Unkn. predator	3	0	13	1	1	18 (4.0% / 15%)
Total	35	16	33	11	25	120 (26.7% / 100%)

Of the non-reptile predators observed to consume ducklings, mammals, particularly Mink (*Mustela vison*), were by far the most substantial (31.7% of total predation observed).

The average age of ducklings last recorded alive that were taken by Eastern Snapping Turtles was 3.4 ± 4.0 (SD) days (median = 2 days, range of 0–14 days). The four ducklings taken by a Western Fox Snake were all from the same brood and were consumed within one day of hatch and deployment to the nest. The ducklings consumed by all other predators were an average age of 5.4 ± 6.5 days (Table 3).

DISCUSSION

We documented that 10.8% of all observed Mallard duckling depredations, resulting in a 2.9% predation rate on the UMR were attributable to Eastern Snapping Turtles. We also documented that the Western Fox Snake was responsible for 3.3% of duckling depredations observed, and a predation rate of only 0.8%. Predation by Eastern Snapping Turtles appeared to be quite variable both spatially and temporally (Table 2) and the Western Fox Snake predation we documented was attributable to a single incident. This variation suggests that reptiles only opportunistically feed on hatchling waterfowl. However, if we consider a worst-case scenario in which snapping turtles are also responsible for the mortality credited to unknown aquatic predators, predation by these reptiles would have been less variable.

Of known sources of predation, the proportion of ducklings taken by Eastern Snapping Turtles was roughly equivalent to the proportion taken by fish (9.2%) and avian (11.7%) predators. Mammals were responsible for a larger proportion of total depredations (31.7%) than reptiles (14.1%; Table 2). Past studies have also reported the significance of mam-

malian predators, such as Red Fox (*Vulpes vulpes*) and Mink, of dabbling ducks during the breeding season (Sargeant et al., 1984; Drilling et al., 2002). If the worst-case scenario of snapping turtle predation is assumed, and predation due to unknown aquatic predators is added to known Eastern Snapping Turtle depredations, the observed predation rate for radiomarked ducklings would be 8.7% in both pools over all years (32.5% of observed predations). Under this assumption, predation by Eastern Snapping Turtles rivals that of mammals in this study. Although past observers have reported a small percent of snapping turtles sampled to contain duckling remains in their guts, this does not necessarily reveal how this turtle directly affects waterfowl populations. Our results allow the actual rate of loss among sampled ducklings due to Eastern Snapping Turtles, and other reptiles, to be estimated.

Most Mallard duckling mortality on the UMR was found to occur within two weeks of hatching, which has been observed in other duckling survival studies (Dzubin and Gallop, 1972; Ball et al., 1975; Orthmeyer and Ball, 1990; Mauser et al., 1994; Korschgen et al., 1996a). Ducklings taken by reptile predators, as well as the majority taken by other predators, were within this time frame (Table 3).

These results support our initial hypothesis that reptile predators do not consume ducklings as frequently as other predators, specifically mammals. Our results, in conjunction with past research on Eastern Snapping Turtle and Western Fox Snake diets, also indicate that these reptiles only opportunistically feed on ducklings. In fact, many previous publications have alluded to the general opportunistic feeding tendencies of snapping turtles, and report diets that consist of various invertebrates, birds, amphibians, reptiles, fishes, and vegetation (reviewed by Spotila

TABLE 3. Age of radiomarked Mallard ducklings at the approximate time of predation (age last recorded alive) in Pools 7 and 8 of the Upper Mississippi River, 1991–1994.

Predator	N	Average age (days) \pm SD	Median age (days)	Range (days)
Eastern Snapping Turtle	13	3.4 ± 4.0	2	0–14
Western Fox Snake	4	0.5	0.5	0.5
Fish	11	3.2 ± 4.8	2	0–17
Unkn. aquatic predator	26	6.0 ± 8.3	2	0–33
Avian	14	5.1 ± 6.2	2.5	0–18
Mammal	38	5.8 ± 5.7	5	0–18

and Bell, 2008). Coulter (1957) suggests that higher predation rates of ducklings by snapping turtles may occur in smaller aquatic systems where turtles and waterfowl co-exist in high concentrations (such as an isolated marsh). Although they will consume numerous types of vertebrates, the Western Fox Snake is well documented as primarily rodent predators (Ernst and Ernst, 2003).

Aside from predation, Mallard ducklings face numerous other substantial sources of mortality that impact recruitment, including exposure and disease (Krementz and Pendleton, 1991; Drilling et al., 2002). For a proper perspective on predation impacts on duckling populations, one must also consider the influence of habitat quality as it relates to the interactions of depredation, food resources, and cover.

Acknowledgments.—We thank A. W. Bennett, A. F. Boysen, C. A. Eleronta, W. L. Green, C. O. Kochanny, M. S. Meier, C. A. Nicoli, M. Phillips, H. S. Sampson, G. R. Schultz, K. Unlin, and M. L. Vollemer for assistance in the field. We are grateful to the staff of the Upper Mississippi River National Fish and Wildlife Refuge, especially J. N. Nissen, W. Thrune, and L. Wolsinski, who supported our study. We are also grateful to J. Nelson and J. Wetzel of the Wisconsin Department of Natural Resources for their assistance. We appreciate the critical review of earlier drafts of this manuscript from M. Roth and an anonymous reviewer. All test subjects were treated humanely based on guidelines outlined by the Society for the Study of Amphibians and Reptiles. Handling and care of ducklings and surgical techniques were approved by the Animal Care and Use Committee of the Northern Prairie Wildlife Research Center, and complied with the Animal Welfare Act (Public Law 99-198 and 9 CFR Parts 1, 2, and 3).

LITERATURE CITED

- ALDRICH, J. W., AND C. G. ENDICOTT. 1984. Black Rat Snake predation on giant Canada goose eggs. *Wildlife Society Bulletin* 12:243-264.
- ALEXANDER, M. M. 1943. Food habits of the snapping turtle in Connecticut. *Journal of Wildlife Management* 7:278-282.
- BALL, I. J., D. S. GILMER, L. M. COWARDIN, AND J. H. RECHMANN. 1975. Survival of wood duck and mallard broods in north-central Minnesota. *Journal of Wildlife Management* 39:776-780.
- COULTER, M. W. 1957. Predation by snapping turtles upon aquatic birds in Maine marshes. *Journal of Wildlife Management* 21:17-21.
- CUTRIGHT, N. J., B. R. HARRIMAN, AND R. W. HOWE. 2006. Atlas of the Breeding Birds of Wisconsin. Wisconsin Society for Ornithology, Waukesha.
- DRILLING, N., R. TRITMAN, AND F. MCKINNEY. 2002. Mallard (*Anas platyrhynchos*). In A. Poole and F. Gill (eds.), *The Birds of North America*, No. 658. The Birds of North America, Inc., Philadelphia, PA.
- DZUBIN, A., AND J. B. GALLOP. 1972. Aspects of mallard breeding ecology in Canadian parkland and grassland. In *Population Ecology of Migratory Birds*, pp. 113-152. U.S. Fish and Wildlife Service Research Report no. 2.
- ERNST, C. H., AND E. M. ERNST. 2003. Snakes of the United States and Canada. Smithsonian Books, Washington, DC.
- GLUP, S. S., AND L. L. MCDANIEL. 1987. Bullsnake predation on waterfowl nests on Valentine National Wildlife Refuge, Nebraska. Great Plains Wildlife Damage Control Workshop Proceedings, University of Nebraska, Lincoln.
- HAMMER, D. A. 1969. Parameters of a marsh snapping turtle population LaCreek refuge, South Dakota. *Journal of Wildlife Management* 33:995-1005.
- HANSEN, J. L., AND L. H. FREDRICKSON. 1990. Black Rat Snake predation on box nesting wood ducks. In L. H. Fredrickson, G. V. Burger, S. P. Havera, D. A. Graber, R. E. Kirby, and T. S. Taylor (eds.), *Proceedings of the 1988 North American Wood Duck Symposium*, pp. 251-254. St. Louis, MO.
- HARDING, J. H. 1997. Amphibians and Reptiles of the Great Lakes Region. University of Michigan Press, Ann Arbor.
- IMLER, R. H. 1945. Bullsnares and their control on a Nebraska wildlife refuge. *Journal of Wildlife Management* 9:265-273.
- KAPFER, J. M., J. R. COGGINS, AND R. HAY. 2008. Spatial ecology and habitat selection of Bullsnares (*Pituophis catenifer sayi*) at the northern periphery of their geographic range. *Copeia* 2008:815-826.
- KORSCHGEN, C. E., K. P. KENOW, W. L. GREEN, D. H. JOHNSON, M. D. SAMUEL, AND L. SILEO. 1996a. Survival of radiomarked canvasback ducklings in northwestern Minnesota. *Journal of Wildlife Management* 60:120-132.
- KORSCHGEN, C. E., K. P. KENOW, W. L. GREEN, M. D. SAMUEL, AND L. SILEO. 1996b. Technique for implanting radio transmitters subcutaneously in day-old ducklings. *Journal of Field Ornithology* 67:120-132.
- KREMENTZ, D. G., AND G. W. PENDLETON. 1991. Movements and survival of American black duck and mallard broods on Chesapeake Bay. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 45:488-491.
- LAGLER, K. F. 1943. Food habits and economic relations of the turtles of Michigan with special reference to fish management. *American Midland Naturalist* 29:257-312.
- MAHMOUD, I. Y., AND J. KLICKA. 1979. Feeding, drinking, and excretion. In M. Harless and H. Morlock (eds.), *Turtles: Perspectives and Research*, pp. 229-243. John Wiley and Sons, New York.
- MAUSER, D. M., R. L. JARVIS, AND D. S. GILMER. 1994. Survival of radio-marked mallard ducklings in northeastern California. *Journal of Wildlife Management* 58:82-87.
- MESSMER, T. A., M. R. CONOVER, R. D. DUESER, P. W. KLIMACK, AND C. E. DIXON. 1997. A landowner's guide to common North American predators of upland-nesting birds. Berryman Institute Publication No. 13, Utah State University, Logan.
- MUNCY, J. A., AND J. H. BURBANK. 1975. Comparative use of three types of wood duck nest boxes. *Proceedings Annual Conference of the Association of Game and Fish Commission* 29:493-500.
- OLDFIELD, B., AND J. J. MORIARTY. 1994. Amphibians and Reptiles Native to Minnesota. University of Minnesota Press, Minneapolis.

- ORTHMEYER, D. L., AND I. J. BALL. 1990. Survival of mallard broods on Benton Lake National Wildlife Refuge in northcentral Montana. *Journal of Wildlife Management* 54:62–66.
- PELL, S. M. 1940. Notes on the food habits of the common snapping turtle. *Copeia* 1940:131.
- SARGEANT, A. B., S. H. ALLEN, AND R. T. EBERHARDT. 1984. Red fox predation on breeding ducks in mid-continent North America [Internet]. *Wildlife Monographs* 89:1–41. Jamestown (ND): Northern Prairie Wildlife Research Center [Accessed on 2007 July 27] Available from: <http://www.npwrc.usgs.gov/resources/mammals/redfox/index.htm> (version 02JUN99).
- SPOTILA, J. R., AND B. A. BELL. 2008. Thermal ecology and feeding of the Snapping Turtle, *Chelydra serpentina*. In A. C. Steyermark, M. S. Finkler, and R. J. Brooks (eds.), *Biology of the Snapping Turtle (Chelydra serpentina)*, pp. 71–79. Johns Hopkins Press, Baltimore.
- STRANGE, T. H., E. R. CUNNINGHAM, AND J. W. GOERTZ. 1971. Use of nest boxes by wood ducks in Mississippi. *Journal of Wildlife Management* 35:786–793.
- THORP, T. J. 1994. Common snapping turtle eats duck eggs. *Wilson Bulletin* 106:416.
- VOGT, R. C. 1981. *Natural History of Amphibians and Reptiles in Wisconsin*. Milwaukee Public Museum Press, Milwaukee, WI.
- WHEELER, W. E. 1984. Duck egg predation by fox snakes in Wisconsin. *Wildlife Society Bulletin* 12:77–78.

Accepted: 29 May 2008.