THE EFFECTS OF HIGHWAY MORTALITY ON FOUR SPECIES OF AMPHIBIANS AT A SMALL, TEMPORARY POND IN NORTHERN FLORIDA

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Astract

Migrations into and out of a small, temporary pond by 26 species of amphibians (4 salamanders, 14 frogs) and reptiles (5 turtles, 3 snakes) was studied over a three-year period from September, 1995 - September, 1998. This paper reports the attempt to assess the effects of highway mortality on four species, the striped newt (*Notophthalmus perstriatus*), common newt (*N. viridescens*), mole salamander (*Ambystoma talpoideum*), and gopher frog (*Rana capito*). Both the striped newt and gopher frog are under consideration for federal listing as threatened species.

Introduction

Ephemeral, or temporary, ponds are found on every continent and have been a persistent feature of the landscape probably since rainfall and water appeared on the globe (Williams 1964). These are water bodies of varying size, often on the order of 0.1 ha in surface area, but sometimes ranging up to 10-100 ha, as in some playas and salt pans. They occur wherever precipitation, topography, and impervious substrates combine to create standing water for varying periods of time, usually less than a year, but sometimes with hydroperiods of 1-10 years long, or alternatively, of only a few months in 1-10 years or more.

In the southeastern U. S., temporary ponds are very important to vertebrates (Moler and Franz 1987, Wolfe, et al. 1988, Means 1990, Dodd 1992, Means 1996), but studies have been few and even simple surveys for invertebrates are relatively nonexistent (King et al. 1999). This paper reports the results of one component of a larger study designed to examine the use by vertebrates of all the different types of lentic habitats (n = 245; Means and Means 1998) in the Munson Sand Hills of north Florida, an active karst region of the Florida panhandle (Means et al. 1994a,b; Means and Printiss a,b; Means and Means 199`7, 1998).

In order to understand how and why individual species of vertebrates utilize the different lentic habitats of the Munson Sand Hills, several sub-projects are being conducted (Means 1996). Project 1 is a study of the life history phenology of all the species that utilize Study Pond #1, especially the striped newt and gopher frog. Project #2 is a study of the dispersal through the terrestrial environment surrounding the ponds of the species using Study Pond #1; this will generate information about gene flow among the ponds and the metapopulational relationships of each species. Project #3 is a study of the range of different hydroperiods and other physical factors among all the ponds. Twenty-six ponds representing all the different types of ponds each have a rain gage and water depth gage and are being checked weekly. Project #4 is an experiment to determine whether special vertebrates such as the striped newt and gopher will naturally colonize artificially created wetlands (borrow pits and stormwater retention ponds). And Project #5 is a survey of which vertebrates inhabit 245 different ponds in the Munson Sand Hills.

Besides the ecological information to be gained from the overall study, the results of the sub-projects will provide vital information that will assist planners in designing state and federal highway construction projects through the Munson Sand Hills. This paper examines the effects of mortality caused by automobile traffic using a major federal highway on four species of amphibians (striped newt, *Notophthalmus perstriatus*; common newt, *N. viridescens*; mole salamander, *Ambystoma talpoideum*; gopher frog, *Rana capito*) that obilgately utilize Study Pond #1 for breeding and to complete their larval life cycles.

Study Area

The study area is the Munson Sand Hills of the Woodville Karst Plain in the Coastal Lowlands of Wakulla and Leon counties (Puri and Vernon 1964, Wolfe, et al. 1988). It includes all the lentic habitats found in the region, ranging from relative large (-20 ha) permanent lakes to small (0.1-0.5 ha) temporary ponds, and including small sinkholes whose hydrology is driven by perched, temporary, surficial aquifer waters as well as sinkholes fed by the permanent waters of the Floridan Acquifer. Study Pond #1 is a shallow limesink depression located on the west side of U. S. Highway 319 about 0.3 km south of its junction with Florida Road 61 in the NW1/4 of the Sw1/4 of Section 35, T1S, R1W on the Apalachicola National Forest, and about 3.5 km S of the City of Tallahassee, Florida (see Means et al. 1994a).

Methods

In September 1995, an approximately 300-m long drift fence was buried on edge about 10 cm in the ground encircling Study Pond #1. The fencing was the standard black plastic silt-fence used to prevent sedimentation in wetlands during road construction, about 90 cm high and supported by 2.5 cm X 2.5 cm upright wooden rods to which it is tacked. Thirty-three pairs of twenty-liter plastic buckets were buried flush with the ground surface on each side of the fence about every 10 m. A unique number was spray painted on the fence next to each bucket such that immigrating individuals dropped into odd-numbered buckets outside the fence and emigrating individuals dropped into even-numbered buckets inside the fence.

Drift fence buckets were checked for animals three days a week, usually Monday, Wednesday, and Friday, except that if heavy rains fell the fence was checked daily. All animals (especially the amphibians and reptiles) were removed from each bucket and released on the opposite side of the fence, under the assumption that an animal had been moving in that direction when intercepted by the bucket into which it fell. We maintained 10-15 cm of water in the buckets to aid the amphibians and reptiles in resisting desiccation.

Weather data were monitored with a minimum/maximum thermometer and rain gage placed within 7 m of the fence. Water depth in the largest and deepest part of the limesink depression was monitored by driving a white 2.5 cm-diameter PVC pipe into the deepest part of the pond. The PVC pipe was graduated with bold black centimeter marks for viewing from a distance.

Pond #1 was chosen for study because it is a known breeding pond of the gopher frog and striped newt, and because it is adjacent to a major federal highway, U. S. 319. The limesink depression is somewhat heart-shaped, with the truncated apex facing northeast (fig. 1). The northeast, north, northwest, and southwest sides of the drift fence faced a zone of 20-50 m of gently rising terrain with a mesic forest of longleaf pines and a dense shrubby growth of *Vaccinium arboreum* and *V. darrowi*. Beyond, the land rises more steeply into a second-growth longleaf pine/wiregrass/turkey oak sandhill habitat, the pines having been clear cut in the 1930s. The southeast side of the drift fence lies adjacent to a major two-lane federal highway. A narrow forested zone about 7 m wide separates the limesink depression from the grassy road shoulder. The road shoulder is about 7 m wide, giving way to an asphalt surfaced road 20 m wide.

The drift fence is positioned in such a manner that 10 pairs of the total of 33 pairs of buckets are positioned along US Highway 319. These

10 pairs of pit-fall buckets sample animals that are going into and of Study Pond #1 in the direction of the highway. All else being equal, migrating animals going in and out of Study Pond #1 should have the same chance of falling into any one either set of the 33 buckets while either entering or exiting the pond. Under this assumption, that is, the null hypothesis that nothing affects immigration, I compare the percentage of immigrating individuals of each species fall into the highway-adjacent buckets with the percentage falling into the remaining 23 buckets, doing so for each of three different years. I also compare the percentages of emigrating individuals for each species among the three years to test the null hypothesis for out-migration. For both immigration and emigration, therefore, under the null hypothesis, I should expect 30% (10 of 33 buckets) of the migrating individuals to fall into the highway-adjacent buckets.

Results

Figure 1 displays the percentages of migrating individuals falling into the two sets of pit-fall buckets. Note that for the striped newt in years 1 and 2, the percentage of the total immigrating and emigrating newts was substantially lower than the expected 30%. On the other hands, in year 3, the percentages were about as expected for both immigration and emigration. Percentages of the common newt going in and out of the pond were all lower than 30% in all three years. Immigration by the mole salamander was lower than expected but emigration was consistently higher for all three years. More gopher frogs entered the pond from the direction of U. S. Highway 319 than expected in all three years, but out-migration of combined adults and metamorphs was lower than expected in years 1 and 3 and higher in year 2. Table 1 displays the actual numbers of amphibians that migrated in and out of Study Pond 1 for three years.

Table 1. Total numbers of migrating amphibians at Study Pond #1 for each of three years. In = immigrating amphibians; out = emigrating amphibians.

	Striped Newt		Common Newt		Mole Salamander		Gopher Frog	
	In	Out	In	Out	In	Out	In	Out
Year 1 1995-96	65	158	69	500	139	6,282	8	7
Year 2 1996-97	88	91	147	26	725	563	30	56
Year 3 1997-98	53	295	49	465	524	482	39	76

Discussion

The overall trend for all four species is that a much larger number of metamorphs were involved in emigrations than the adults that compromised the immigrations (Table 1), as one expect. There are some significant departures from this trend, however. For instance, in year 2, more common newts immigrated than emigrated. And in years 2 and 3, more adult mole salamanders went into the pond to breed than combined post-breeding adults and dispersing metamorphs went out of the pond. The reasons for these disparities are unknown mortality factors that affected either breeding success, egg and larval survival, or a combination of different types of mortality.

U. S. Highway 319 does, in fact, have a negative impact on migrating individuals of all four species of this report, and probably of all the remaining 22 species that utilize Study Pond #1, because over the past five years of the overall study, on numerous occasions I and my assistants have recorded dead and squashed carcasses of most of the species. What we would like to know, however, is the severity of highway mortality in the population biology of each species.

Except for the gopher frog, in all three years the numbers of striped newts, common newts, and mole salamanders coming into the pond from the direction of U. S. Highway 319 were fewer proportionately than expected (Figure 1). This result is consistent with the additional mortality inflicted on these species by road traffic. It is worth noting, though, that the proportional representation of out-migrating individuals in all cases but one (striped newt in year 3) was lower also, and for these species one could argue that this is the cause of the reduced proportional representation of immigrants from U. S. Highway 319. The same does not hold true for the mole salamander, however. In all three years, the proportion of immigrating breeding adults was lower than expected, whereas over the same time period, proportionally more metamorphs and post-breeding adults emigrated in the direction of U. S. Highway 319 (Figure 1).

In the case of the gopher frog, in all three years a higher proportion of the total immigrating individuals came into the pond from the direction of U.S. Highway 319 than would be expected if the chance of immigration was equal for any direction (Figure 1). For some unexplained reason, more gopher frogs come into the pond from the direction of this busy federal highway than from the adjacent native sandhill vegetation surrounding the rest of the pond. For year three, this might be explained by the fact that in the pervious breeding season (year 2) more than 50% of the emigrating metamorphs went out of the pond in the direction of the highway. In year 1 eight adults went into the pond, 7 came out, and no breeding took place. Then in year 2, 30 adults came into the pond from U. S. Highway 319, 16% more than was expected. It will be interesting to see the proportion of immigrating adults in year 4 (data as yet unavailable) because there were fewer emigrating metamorphs than expected in year 3, in which the most successful breeding episode in three years took place.

What do these data tell us about levels of highway mortality inflicted on these four species by U. S. Highway 319? There are trends in the proportions of migrating individuals that are consistent with the hypothesis that mortality from automobile traffic is significant, and yet there are trends that do not support the hypothesis. The most convincing trend is with the mole salamander, in which for every year, more salamanders emigrate in the direction of U. S. 319 and fewer immigrate than expected. Why the mole salamander shows a consistent trend— and ultimately why the rest of the data are unclear— may be related to sample size. The numbers of migrating mole salamanders were sometimes tenfold greater than the other species (Table 1), so that the mole salamander data set may be the only one that is statistically significant. Comparing proportions of migrating animals among 33 different buckets, when from only 7 to 500 individuals are scored each year, may not be based upon a large enough sample size to override the inherent variation of the system. Rather than proportions, what probably should be compared are means and variances generated from the numbers of individuals per bucket of the two different sets of drop-buckets.

Every population experiences mortality, but mortality is not always harmful in a population sense. For every population, however, there is a threshold limit of mortality below which the population is inevitably driven to extinction. That the striped newt, common newt, mole salamander, and gopher frog still breed in Study Pond #1 is evidence that the extra mortality inflicted by U. S. Highway 319 has not been sufficient in the recent past to have driven any of these populations to extinction. On the other hand, there are data from this study that suggest that the populations of the striped newt, common newt, and gopher frog that depend upon Study Pond #1 may be in trouble.

Franklin (1980) suggested that 50 reproductive individuals might be the minimum number necessary to maintain genetic variability and avoid inbreeding depression. He also posited that in an isolated population, 500 individuals might be necessary in order to balance the variation being lost to small populations size on the one hand, with the rate of mutation on the other hand. Lande (1995), arguing that mutation rates are lower than those suggested by Franklin (1980), believes that at least 5,000 individuals are required to protect and maintain the genetic variability and long-term survival of a population.

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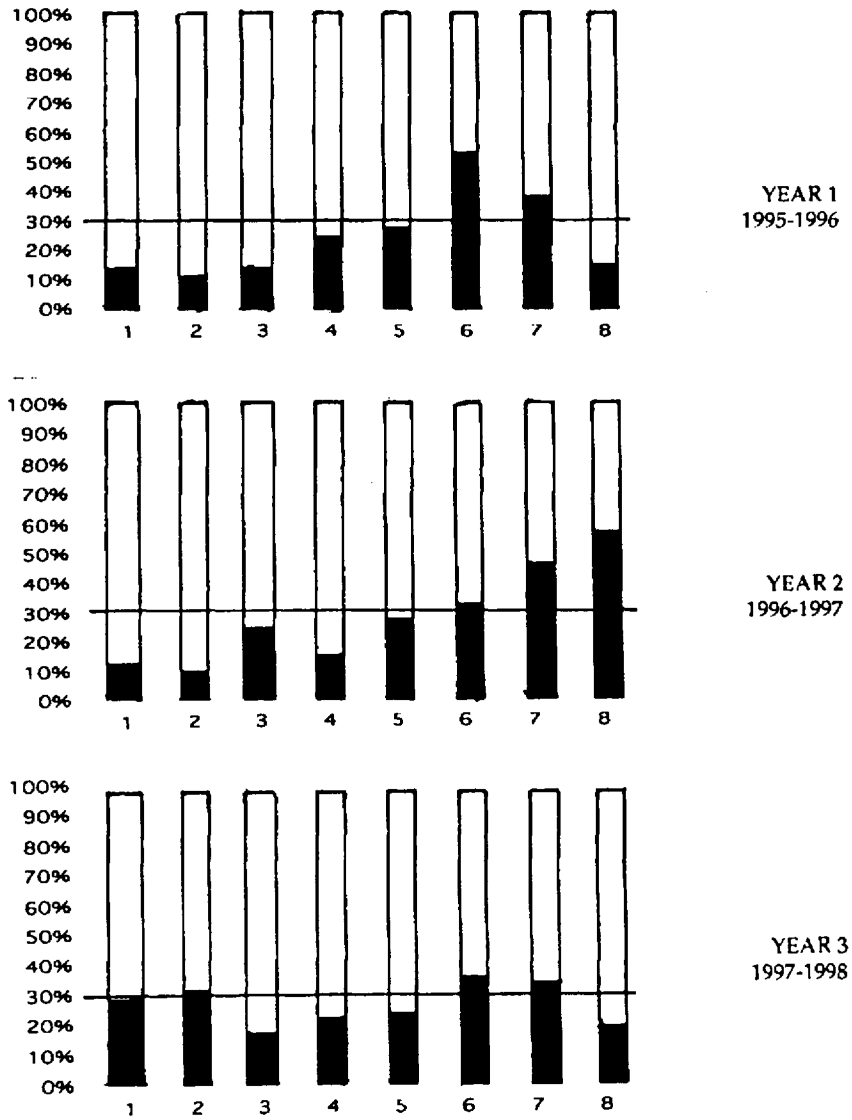

Figure 1. Percentages of migrating individuals of four species of amphibians using Study Pond #1. Black portion of each column = percentage of individuals trapped by pitfall buckets facing U. S. Highway 319; white portion = percentage of individuals trapped by buckets facing longleaf pine/wiregrass sandhill community adjacent to the drift fence. Columns 1 & 2 = striped newt, *Notophthalmus perstriatus*; 3 & 4 = common newt, *N. viridescens*; 5 & 6 = mole salamander, *Ambystoma talpoideum*; 7 & 8 = gopher frog, *Rana capito*. Odd columns = immigration; even columns = emigration.