Title

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BEHAVIORAL RESPONSES OF SNAKES TO ROAD ENCOUNTERS: CAN WE GENERALIZE IMPACTS ACROSS SPECIES? (A PRELIMINARY OVERVIEW)

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Abstract: Habitat fragmentation from roads is widely recognized as an issue of environmental concern. On-road mortality is frequently noted in studies of snakes. The assumption that road mortality is the only, or even the major, detriment to wild snake populations, could be misleading. Some species could perceive threats posed by the road in a manner that lead them to avoid the road rather than crossing it. In these instances, the larger disruption is the creation of the barrier effect. Research on behavioral responses of snakes in road encounters could uncover patterns of species-specific vulnerabilities for snakes. These behavioral trials test the responses of snake species to primary threats posed by the road-zone, such as road openness and the vehicle. These databased on 846 behavioral tests with 27 species of southeastern snakes, will yield evidence for both mortality and fragmentation impacts on snake species.

Background

Most animals move. Humans move by roads. Non-human animals use dispersal paths we are only beginning to understand. A lack of information currently exists regarding the true impact of road development on wildlife. In understanding how different species respond to roads, we can identify not only the variety of impacts associated for an animal group, but the scope of the problem. Additionally, data that explain how different animals are affected by roads can aid in the design of transportation systems conducive for all styles of movement.

Impact. Roads comprise approximately 1 percent of the land area in the continental United States. The overall ecological impact of roads is even greater than the paved surface itself and has been estimated to extend to 15-20 percent of the United States (Forman and Alexander 1998). Observations of road mortality provide definitive information on which species use the road. However, does a higher rate of mortality denote higher numbers of that species present in the surrounding area, or is there differential mortality on roadways? Not only may there be differential mortality, some animals, or species, may not cross the road although present in the immediate vicinity. While some groups of animals may suffer greater impacts in terms of road mortality, other animals may demonstrate a tendency to avoid the road (Seigel and Pilgrim 2002). In this instance, the barrier effect of the road could be of more significance to population stability than road mortality.

Crossing probability. An extensive number of variables in both animal behavior and physiology, in addition to physical characteristics of the road, may influence an animal's use or non-use of the road and its probability of crossing successfully (table 1). In determining the importance of each variable to whether, or in what manner, an animal crosses the road, we would expect to see consistencies among organisms with similar instincts, as in defense strategies, or having comparable physical constraints, such as the ease with which the organism moves across a particular road substrate.

Table 1
Intrinsic and extrinsic factors of potential influence on whether a snake will attempt to and/or successfully cross the road

Intrinsic (snakes)	*Extrinsic (roads and environment)*
Species	Geographic location/Bordering habitat
Body size or age	Weather
Sex	Road substrate
Reproductive condition	Age of the road
Activity periods	Width
Dispersal tendencies	Median presence and type
(foraging, hibernating, mating)	Traffic patterns
Defense mechanism	Vehicular density
Speed of movement	Driver behavior

Snakes are frequent victims of road mortality (e.g., Klauber 1939, Bernardino and Dalrymple 1996). Road mortality of snakes and its relative impact on local populations has been investigated (e.g., Rosen and Lowe 1994), but how snakes inhabiting the areas directly surrounding roads are affected is largely unknown.

Research Objective

The purpose in design is to conduct trials that generate a direct response from the snake to a stimulus (i.e., road, vehicle). The objectives of the two-part study are detailed:

1. To investigate interspecific variation in how snake species respond in encounters with the road, and for those that do cross, the speed with which they cross.
2. To determine whether a passing vehicle evokes reaction from the snake and whether consistencies of this reaction exist among species.

Hypotheses

1. Some species of snakes are more likely to enter or avoid a road due to particular activity patterns, physical factors, or immediate ecological needs. Among the species that cross the road, there will be variation in crossing speed.
2. Many species of snakes will immobilize in response to an approaching car, thus increasing time spent on the road and their probability of being killed.

Methodology

Study Site. The study is conducted on the Savannah River Site, Aiken, SC, USA on a closed highway. The closed road provides an opportunity to observe snake behavior in a road area without threatening the safety of the animal.

Road Tests. The snake is placed under a bucket along the asphalt-grass boundary to guarantee the sampling of both substrates before the trial. The researcher lifts the bucket from behind a camouflage blind along the wood line. The trials involve direct observation of the snake's behavior (i.e., tongue flicking, head elevation), including times of movement, entering and exiting the road and movement trajectory angles and lengths. Road, ground, and air temperatures are recorded along with other environmental variables. Individuals are tested twice, once on each side of the road to test for any directional bias. The species tested (Table 2) include terrestrial and aquatic, venomous and non-venomous, and diurnal and nocturnal representatives.

Table 2
Snake species included in current analysis of road tests.

Banded watersnake (*Nerodia fasciata*)
Black racer (*Coluber constrictor*)
Canebrake rattlesnake (*Crotalus horridus*)
Cottonmouth (*Agkistrodon piscivorus*)
Eastern hognose (*Heterodon platirhinos*)
Rat snake (*Elaphe obsoleta*)
Red-bellied watersnake (*Nerodia erythrogaster*)
Ringneck snake (*Diadophis punctatus*)
Southern hognose (*Heterodon simus*)
Southeastern crowned snake (*Tantilla coronata*)

Vehicle Tests. A vehicle is driven (35mph) past snakes released in the same manner as the open road tests. The trial is initiated when the snake begins to move. Data collection includes whether the snake immobilizes or flees, the timing of the reaction in relation to the vehicle passing, and the distance between the snake and the vehicle at passing. Walky talkies are used for communication between the observer and the driver to ensure safety of the test animals. Three species are tested: Rat snakes (*Elaphe obsoleta*), Canebrake rattlesnakes (*Crotalus horridus*), and Black racers (*Coluber constrictor*).

Preliminary Findings and Discussion

Snake species differ in the probability of crossing roads because the ecology is unique to each particular species. Their ecology, including defenses toward predators, hence reactions to threats and unknowns such as open spaces and vehicles, is highly determinant on decisions the animal makes when encountering such situations. For example, how snake species behave around a road is likely to be influenced by whether or not they have avian predators and how they respond to them (i.e., flight, fight, camouflage). While some species (e.g., *Coluber constrictor)* cross the majority of time, others (e.g., *Diadophis punctatus*) frequently attempt but rarely cross. Even if the snake enters the road, but decides to retreat, the animal suffers not only the increased risk of mortality from vehicles, but contributes to genetic isolation if it does not successfully cross. The threat is complicated as differential mortality occurs with animals that cross more slowly and then with snakes that immobilize, or freeze, in response to a passing vehicle. An increased amount of time spent in the road lends to an increased likelihood of being killed by a car.

Timeline. As indicated above, the research is currently in progress; data analysis will be completed in late 2003 and manuscripts submitted for publication in 2004. The data collected to date is based on a pilot study performed in summer and fall 2002 (n= 225 tests; 26 species) and the core study being conducted spring through fall 2003 (n= 621 tests; 14 species).

Conclusions

1. There is a species-specific variation in crossing rates and speeds that significantly affects the probability of road mortality or the degree of the barrier effect from the road.
2. The likelihood that a species will cross the road, and the behavior of the animals in the road area reflect ecological traits of defensive and search behaviors. Therefore, road impacts across species cannot be generalized when determining mitigation solutions and developing future infrastructure designs.
3. Additional studies are being planned to determine the degree of road usage that will elucidate how the road impacts of habitat fragmentation and mortality could be affecting local population stability.

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Biographical sketch: Kimberly Andrews received her B.S. in ecology at the University of Georgia in 1999 and will complete her master's in the conservation ecology and sustainable development program at UGA in spring 2004. Her Master's research has focused on a study of differential behaviors of snakes to habitat fragmentation by roads and in their responses to vehicles. Peripheral work has investigated factors affecting observer bias in road surveys. Her professional goals are to contribute to the conservation of reptile and amphibian species through ecological research on dispersal patterns of herpetofauna in relation to habitat fragmentation, including road impacts.

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