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HERPETOFAUNAL MORTALITY ON ROADS IN THE ANAMALAI HILLS, SOUTHERN WESTERN GHATS

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(with two text-figures)

ABSTRACT.– We sampled road-killed amphibians and reptiles from the highway segments passing through rainforest fragments and tea gardens in the Anamalai hills in order to evaluate the effects of vehicular traffic on the herpetofauna. There was greater mortality among amphibians than reptiles due to vehicular movement. A total of 73 reptiles belonging to 24 species, 13 genera and seven families and 311 amphibians belonging to eight genera and five families killed on the highway were recorded. These figures included several endemic species of amphibians and reptiles. Rainfall resulted in increased activity of amphibians and uropeltids, thereby making them vulnerable to road traffic. Amphibian roadkills were associated with coffee and forest habitats while reptiles were found only in forested habitats. Road segments passing through tea plantations had the lowest number of amphibian and reptile roadkills compared with other vegetation categories. Possible explanations for differences in species richness and relative counts in the forest in relation to roadkill are discussed. The long-term effects of mortality due to roads is of conservation importance considering the low abundance of herpetofauna in the rainforests.

KEY WORDS.– Roadkills, herpetofauna, rainforest, Western Ghats, India.

INTRODUCTION

The increase in road networks throughout the world has brought about for a concern for the effects of vehicular traffic on flora and fauna. This concern is evidenced by the increasing amount of literature dealing with the ecological effects of roads and traffic (Spellerberg, 1998. Forman and Alexandra, 1998). Roads are known to cause forest fragmentation (Reed et al., 1996. Forman and Alexandra, 1998. Goosem, 1997), affect the density of amphibians (Fahrig et al., 1995), cause barriers to dispersal of arthropods (Mader et al., 1990), reduce average heterozygosity and genetic polymorphism among frogs (Reh and Seitz, 1990) and affect the physical environment (Spellerberg, 1998). Development in any area generally leads to extensive road networks and subsequent traffic. The effects of such landscape changes can be dramatic on fragile habitats, such as the rainforests of the Western Ghats. The Western Ghats of south India have experienced large-scale changes over the last century because of expansion of plantations and townships (Nair, 1991). The impact of roads on the flora and fauna of this region is poorly documented. At a landscape level, such features may be permeable to vagile forms or filter them out by acting as a barrier to dispersal (Gibbs, 1998). Thus the presence of roads can be of conservation importance since the Western Ghats supports large number of endemic forms among the reptiles and amphibians (Inger and Dutta, 1986). Apart from a single study which reported mortality in snakes due to highway traffic in the dry deciduous forest of Mudumalai Wildlife Sanctuary, Tamil Nadu (Gokula, 1997), there is no information on the effect of road traffic on the fauna of the Western Ghats. This present study provides evidence of the impacts of vehicular traffic on the rainforest herpetofauna of the Western Ghats. We explore

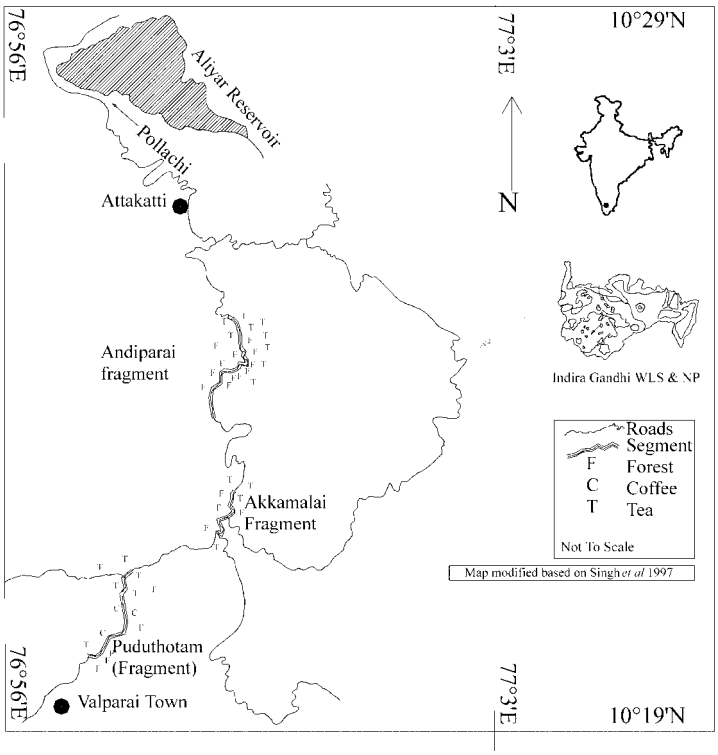

FIGURE 1: Map showing road segments sampled in the Indira Gandhi Wildlife Sanctuary.

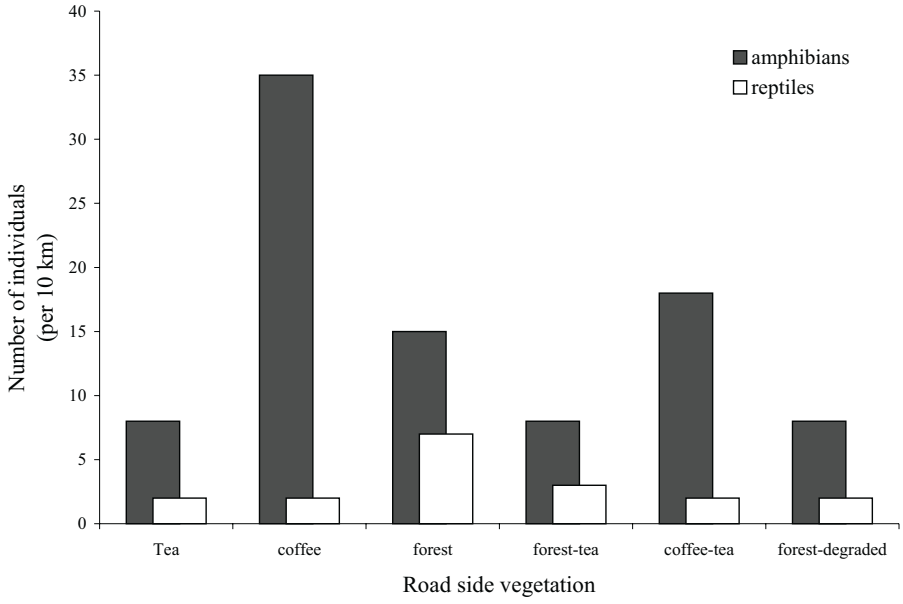

FIGURE 2: Number of amphibian and reptile road kills per 10 km of different roadside vegetation categories in IGWLS during May-June 1998.

the probable causes for such mortality and examine some secondary effects of roads and traffic on the herpetofauna.

STUDY AREA

The study was conducted in and around the town of Valparai situated in the Anamalai hills of the southern Western Ghats. The township is surrounded by forests which are part of the Indira Gandhi Wildlife Sanctuary and National Park (10° 00-30' N to 76° 48'-77° 30' E; Fig. 1). The road segment sampled forms part of the highway connecting the Pollachi and Valparai in the Tamil Nadu with Chalakudi in Kerala across the Western Ghats mountains. The roadside vegetation is regularly cleared and maintained by the Public Works Department. Valparai township forms part of the tourism network of the state. The town is one of the fast expanding commercial areas for cash crops like tea, coffee and cardomom. These factors have led to an increase in the volume of traffic by tourist and commercial vehicles over the years.

METHODS

Roadkills were sampled in four different road segments. The length of the road section sampled, the area of fragment, altitude, and the numbers of days walked are given in Table 1. The natural vegetation of the area has been classified as wet-evergreen forests (Pascal, 1998). Two segments (Andiparai and Akkamalai) traversed through the fragments of rainforest and one segment (Pudhuthottam) went along the edge of the fragment (Fig. 1). The fourth segment was entirely in a tea plantation. One of us (SPV) walked these road segments during early hours in the morning looking for road kills. On sighting a roadkill, the roadside habitat, state of the roadkill, and the location of the roadkill on the road segment were recorded. All road-killed individuals were examined and collected. Voucher specimens are in the museum of the Wildlife Institute of India. Based on the state, highly damaged specimens were not collected, although all of them were removed from the road to avoid multiple counts of the same kill. Wherever possible, individuals crossing roads were caught, identified and released at the same location. Sampling was repeated every day but the order of sampling the road segments was randomized. Individuals collected were preserved in 10% formalin and tagged for later identification. Most road-killed amphibians were damaged, thus sometimes impeding identification to the species level. In such cases, specimens were identified to the family level; a few specimens were identified to genus or species. In the case of road-killed reptiles, specimens were identified to the genus or species. Data on other fauna, such as rodents, birds and insects also were collected. We restrict our discussion in the results to reptiles and amphibians. Data from the four road segments were pooled for the purpose of analysis. We did not attempt to compare road segments, because of their variability in slope, altitude, distance sampled, and vegetation categories along the road. Roadside vegetation was divided into six categories, viz. forest, coffee, tea, forest-tea, coffee-tea and forest-degraded based on the combination that existed on either side of the road. In order to make comparisons of roadkills across these vegetation categories, the frequency of roadkills was expressed as the number of individuals per 10 km. We recorded the occurrence of rainfall during the study period.

We used the non-parametric test for comparison of independent samples (Mann-Whitney U-test) to test the difference between the number of roadkills on rainy and dry days. We used the frequency of kills in different vegetation categories (expressed as the number of individuals per 10 km of vegetation segment) to test for the effect of vegetation. Information on species richness

TABLE 1: Summary of the sampling sites in IGWLS during May-June 1998. Total distance walked – 170.70 km (9.05.1998-19-06.1998).

Fragment	Area (ha)	Altitude (m)	Length of road segment walked (km)	Number of days walked
Pudhuthotam	50	1070-1100	3.00	20
Andiparai	185	1205-1320	2.50	19
Akkamalai	2500	1220-1365	2.90	18
Tea Plantation	–	1370-1405	1.10	10

and relative abundance of the herpetofauna in the three forest fragments was provided by Karthikeyan Vasudevan and N.M. Ishwar through their respective ongoing studies in the region.

RESULTS

A total of 73 individuals of roadkilled reptile (0.43 individuals/km), belonging to 24 species, 13 genera and 7 families and 311 roadkilled amphibians (2 individuals/km) represented by 8 genera and 5 families, were recorded (Appendix Ia).

In the case of amphibians, the family Bufonidae represented almost half (46.6%, N = 144) the total number of individuals recorded, followed by Ranidae (23.3%, N = 73), Rhacophoridae (11.3%, N = 35), Icthyophidae and Uraeotyphlidae (3.7%, N = 27). *Bufo melanostictus* was the only recorded Bufonid. Endemic genera, such as *Indirana* (Family: Ranidae), and several endemic species of the genus *Philautus* were among individuals killed on the road.

For reptiles, more than 80% (N = 49) of the road kills are snakes. Families included Colubridae (30.1%, N = 22), Uropeltidae (19.2%, N=14), Viperidae (12.3%, N = 9) and Elapidae (4.1%, N = 6). The Viperidae was represented by a single species, the large scaled green pitviper *Trimeresurus macrolepis.* The family Elapidae was represented solely by the coral snake, *Calliophis melanurus.* Lizards were represented by the family Agamidae, which had two endemic species *Calotes ellioti* (N = 5) and *Calotes nemoricola* (N = 2). There were fewer roadkills in the family Gekkonidae (N = 1) and Scincidae (N = 3) than among any other reptile taxa. There was a high representation (45%) of forest litter dwelling reptiles such as *Calliophis, Lycodon* and *Amphiesma* among the road kills. The arboreal (e.g., *Boiga* and *Calotes*) and fossorial genera (e.g., *Uropeltidae*) formed 30% and 20% of the roadkills, respectively.

The number of individuals collected as roadkills during rainy and non-rainy days was different for amphibians (Mann Whitney U test. $Z = -1.869$, $n_1 = 6$, $n_2 = 14$, $P = 0.06$). Field observations at night hours during rains, supports the hypothesis of a positive influence on the activity of amphibians on roads. In the case of reptiles, there was no such influence (Mann Whitney U-test. $Z = -0.38$, $n_1 = 6$, $n_2 = 14$, $P = 0.35$).

There was greater mortality of amphibians in coffee plantations compared with other vegetation (Fig. 2, Chi-square test. $^2 = 51.11$, $df = 5$, $P < 0.001$). On the other hand, there was higher number of roadkilled reptiles associated with forests (Fig. 2). However, the number of roadkills was independent of vegetation (Chi-square test. $^2 = 6.65$, $df = 5$, $P > 0.05$). There were high proportions of caecilians 51.9 % (N = 14), agamids 90 % (N = 9), skinks 66.7% (N = 2), colubrids 81.8 % (N = 18), elapids 66.7 % (N = 4) and vipers 55.6 % (N = 5) associated with forest. In coffee, rhacophorids 65.7 % (N = 23), bufonids 44.1 % (N = 64) and uropeltids 42.9 % (N = 6) were the dominant roadkills. Roadkills were relatively low in road sections associated with other vegetation categories. The lowest mortality of amphibians and reptiles was found associated with tea plantation (Fig. 2).

The number of reptile species counted as roadkill formed 50% of the total number of reptile species observed in each fragment (based on independent sampling by NMI). Species such as *Uropeltis macrorhyncha*, *Uropeltis phipsoni*, *Boiga dightoni*, found among the roadkills were not documented during intensive sampling (NMI) in the rainforest fragments.

Apart from the animals killed, we also observed a number of individuals crossing roads during formal sampling. A list of these species is provided in Appendix Ib. These data provides additional information on the species that cross roads to move between habitats, or for activities such as basking which make them vulnerable to traffic.

Among other vertebrates, rodents formed the dominant group, including the endemic spiny dormouse (*Platacanthomys lasiurus*) and a few unidentified rodents. Among birds, a spotted dove (*Streptopelia chinensis)* was the only roadkill. Invertebrates included several individuals of millipedes, lepidoptera (mostly butterflies), and hemipterans (mostly bugs).

DISCUSSION

Rainforest amphibians and reptiles occur in low numbers (for amphibians, Vasudevan et al., 2001; for reptiles, Ishwar et al., 2001) and the mortality due to roadkill could deplete local population. Vehicular traffic causes negative effects on amphibian density (Fahrig et al., 1995) and the traffic-related mortality is highly detrimental, especially for species with small and declining populations (Spellerberg, 1998). Considering the unique herpetofaunal diversity of the rainforests of the Western Ghats (Groombridge, 1990), the long-term effects of such mortality should be cause for conservation planning.

On the forest floor, bufonids were fewer in numbers and ranked third after ranids and rhacophorids in abundance (K. Vasudevan, unpublished data). However, the only species that represented in the roadkills among the bufonids was *Bufo melanostictus*. This species was present in degraded rainforest fragments and in coffee estates (Vasudevan, pers. obs.). A majority of *B. melanostictus* kills were in coffee vegetation, although it occurred in all vegetation types. *Bufo melanostictus* is cosmopolitan in distribution (Dutta, 1997) and is known to occur in a variety of habitats, especially in disturbed areas (Inger et al., 1984). The greater proportion of this species among roadkills probably reflects the disturbed nature of the area sampled.

Because more than 50% of the amphibian kills were ranids, rhacophorids and caecilians, a number of endemic species could constitute the roadkilled amphibians. The family Rhacophoridae was dominated by several species in the genus *Philautus,* and most roadkills were associated with coffee vegetation. The greater representation of *Philautus* in coffee probably reflects on their resistance to habitat alteration. This might be specific to some species, a question, which needs further data. Caecilians not found in the forests were commonly found as roadkills in other vegetation such as coffee. This suggests that subterranean caecilians are probably more vagile and tolerant to habitat alterations than popularly believed.

The high incidence of reptile roadkills in forested areas probably implies greater abundance of reptiles, and the permeability of roads to forest reptiles, compared to road segments associated other vegetation types. Low incidence of roadkills associated with vegetation types such as tea might be due to the unsuitability of these highly modified habitats for rainforest reptiles and amphibians. The substantial representation of snakes and other amphibians such as caecillians, among the roadkills is striking when compared to their rarity in the forest. This results likely demonstrate the inefficiency of conventional sampling methods such as quadrats or transects, in estimating their abundance in the forest.

Snakes might be using roads as substrates for thermoregulation, a likely reason for their vulnerability to vehicular traffic. Scincids and Geckkonids although found in numbers greater than snakes in the forest (Ishwar et al., 2001), were poorly represented as roadkills. However, we have observed *Mabuya* species (Scincidae) crossing the road, they might be escaping the traffic by their swift movement unlike gekkonids. Unlike other reptiles, more uropeltid roadkills were associated with coffee, probably indicating their persistence and abundance in human modified habitats.

Amphibian roadkills occurred more on rainy nights, and caecilians invariably were found on such occasions. Rains probably trigger some kind of movement in these animals, which makes them vulnerable to traffic. Caecilians probably use the roads as conduits or, since the soil under the road is compacted they may emerge to the surface to continue their previously impeded journey. The reptiles did not show any increase in mortality because of to rains. The activity of reptiles, except for uropeltids, was probably not influenced by rains. Uropeltids, like the caecilians, were killed more often on roads when there were rains.

The disparity in the number of species and the proportion of counts of species in the roadkills when compared to the estimates made within the fragments can probably be attributed to the following reasons: (1) The number of individuals of

different taxa that use the roads were in similar proportion to their abundance in the forest floor, but they had different probabilities of being roadkilled. This could be because of their differential ability in crossing roads. (2) The difference in species richness and relative counts between roads and inside forests could be because of the differential permeability (ability to cross) of species to the roads. In such a case the roads acted as a barrier for some taxa. (3) Difference could result because some species use streams or the canopy and hence did not appear as roadkills. (4) Animals that were killed on the roads generally resided on the roads or at the edge of the road, and they occurred in direct proportion to numbers that were killed. This explanation is not supported by our observations and through extensive sampling in these areas. The absence of stream dwelling amphibians such as *Micrixalus* and *Nyctibatrachus* among the roadkills supports our third explanation, and they are probably least influenced by traffic on roads. Species such as *Trimeresurus macrolepis*, is an example for our first explanation. This species was prominent in the roadkills was also found to be abundant in the forest among snakes. However, the fact that *T. macrolepis* moves slowly on the ground predisposes it to mortality due to traffic on roads. Arboreal taxa such as gekkonids probably provide evidence for the second explanation. This taxon despite their high abundance in the forests, was represented by only one individual among the roadkills. The example provided for the second explanation is speculative, and needs further investigation. The fact that our sampling regime was short and covered only a single season poses limitations on our ideas regarding the barrier effect to the herpetofauna. Amphibians and reptiles show stronger avoidance to roads with increasing traffic volume (Goosem, 1997). Hence, species are likely to be isolated over a period of time by roads. An with increase in traffic volume coupled with this innate barrier effect probably has pronounced ecological effects other than the mortality (Forman and Alexandra, 1998).

There is a dearth of information regarding highway-related mortality on amphibians and reptiles from the Western Ghats. It is crucial to quantify the magnitude of the effect due to vehicular traffic on different faunal groups. As an ad hoc measure the park authorities of the Indira Gandhi Wildlife Sanctuary should explore the possibility of closing heavy vehicle traffic at night hours beyond Attakatti check post in order to reduce the road-related mortality on the herpetofauna.

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APPENDIX I

List of fauna represented in the road kill sample in IGWLS during May-June 1998.

	REPTILES	Individuals (N)
	Family Agamidae	
1.	*Calotes ellioti*	5
2.	*Calotes nemoricola*	2
3.	*Calotes* sp.	3
	Family Scincidae	
4.	*Mabuya carinata*	1
5.	*Mabuya* sp.	
	Family Gekkonidae	
6.	*Cnemaspis* sp.	1
	Family uropeltidae	
7.	*Uropeltis macrorhyncha*	2
8.	*Uropeltis ceylanicus*	3
9.	*Melanophidium bilineatum*	1
10.	*Uropeltis phipsonii*	3
11.	*Uropeltis* sp.	1
	Unidentified	4
	Family Colubridae	
12.	*Amphiesma beddomei*	2
13.	*Lycodon* spp 1	4
14.	*Lycodon* spp 2	1
15.	*Xenochrophis piscator*	1
16.	*Boiga ceylonensis*	2
17.	*Boiga dightoni*	1
18.	*Boiga* sp.	1
19.	*Atretium schistosum*	1
20.	*Oligodon brevicaudus*	1
21.	Unidentified sp. 1.	1
22.	Unidentified sp. 2.	1
	Unidentified (others)	6
	Family Elapidae	
23.	*Calliophis melanurus*	6
	Family Viperidae	
24.	*Trimeresurus macrolepis*	9
	Unidentified reptiles	8
	Total	73

AMPHIBIANS		
	Family Bufonidae	145
1.	*Bufo melanostictus*	145
	Family Ranidae	73
	Family Rhacophoridae	35
	Family Ureotyphlidae	19
7.	*Uraeotyphlus* sp.	19
	Family Icthyophidae	8
8.	*Icthyophis* sp.	8
	Unidentified (Ranids & Rhacophorids)	31
	Total	311
	Other faunal groups*	

MAMMALS		
	Platacanthomys lasiurus Spiny dormouse	1

BIRDS		
	Streptopelia chinensis Spotted dove	1

ARTHROPODS		
	Millipede	-
	Lepidopterans	-
	Hemipterans	-

APPENDIX II

List of herpetofaunal species observed crossing roads in IGWLS during May-June 1998.

REPTILES
Atretium schistosum
Calotes ellioti
Trimeresurus malabaricus
Calotes grandisquamis
Oligodon taeniolata
Mabuya carinata

AMPHIBIANS
Rana temporalis
Bufo melanostictus
Uraeotyphlus sp.
Philautus temporalis
Fejervarya cf. limnocharis
Philautus spp.

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