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Research Article

Turk J Zool
2011; 35(6) 851-857
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doi:10.3906/zoo-0911-97

Road mortality of amphibians and reptiles in the Anatolian part of Turkey

Cemal Varol TOK[1], Dinçer AYAZ[2], Kerim ÇİÇEK[2,*]

[1]Çanakkale Onsekiz Mart University, Faculty of Science and Literature, Department of Biology, 17100 Çanakkale - TURKEY

[2]Ege University, Faculty of Science, Department of Biology, Zoology Section, 35100 İzmir - TURKEY

Received: 11.11.2009

Abstract: The amphibian and reptile specimens, crushed due to vehicle traffic, were recorded during herpetological trips to various regions of Anatolia between 2005 and 2009. In total, 183 individuals were detected, representing 28 species from 4 amphibian [Salamandridae (1), Ranidae (3), Bufonidae (2), and Hylidae (2)], 3 turtle [Testudinidae (1), Emydidae (1), and Geoemydidae (2)], 3 lizard [Agamidae (1), Anguidae (2), and Lacertidae (5)] and 2 snake [Colubridae (6) and Viperidae (2)] families. The measures required for decreasing herpetofaunal mortalities due to traffic are emphasized.

Key words: Road mortality, amphibians, reptiles, Turkey

Türkiye'nin Anadolu kısmındaki kurbağa ve sürüngenlerde yol ölümleri

Özet: 2005 ila 2009 yılları arasında Anadolu'nun çeşitli bölgelerine yapılan herpetolojik geziler esnasında araç trafiği nedeniyle ezilmiş kurbağa ve sürüngen örnekleri kaydedilmiştir. Toplamda 4 amfibi [Salamandridae (1), Ranidae (3), Bufonidae (2), and Hylidae (2)], 3 kaplumbağa [Testudinidae (1), Emydidae (1), and Geoemydidae (2)], 3 kertenkele [Agamidae (1), Anguidae (2), and Lacertidae (5)] ve 2 yılan [Colubridae (6) and Viperidae (2)] familyasından 28 türe ait 183 birey tespit edilmiştir. Trafik nedeniyle meydana gelen herpetofaunal ölümlerin azaltılması için önlemler alınmasının gerekliliği vurgulanmıştır.

Anahtar sözcükler: Yol ölümleri, kurbağalar, sürüngenler, Türkiye

Introduction

The negative effect of roads on natural life has been observed to be worrisome for many animal groups (Forman and Alexander, 1998; Trombulak and Frissell, 2000; Coffin, 2007). Researchers and environmental planners are worried that roads and traffic will decrease or eliminate natural wildlife populations (Trombulak and Frissell, 2000; Forman et al., 2003). Roads and road use have 7 primary effects on terrestrial and aquatic ecosystems. They are (1) mortalities during road construction; (2) mortalities as a result of being hit by vehicles; (3) modifications in the behavior of animals; (4) changes in the physical environment; (5) changes in the

* E-mail: kerim.cicek@ege.edu.tr

chemical environment; (6) the dispersion of exotic species; and (7) an increase in the quantity of lands being used by people, which corresponds to the construction of roads (Trombulak and Frissell, 2000).

Road mortalities have been reported in many vertebrate and invertebrate groups, primarily mammals (Palomares and Delibes, 1992; Rytwinski and Fahrig, 2007; Roedenbeck and Voser, 2008), birds (Newton et al., 1991; Varland et al., 1993; Bard et al., 2001; Rheindt, 2003), reptiles (Rodda, 1990; Rosen and Lowe, 1994; Lebboroni and Corti, 2006), amphibians (van Gelder, 1973; Cooke, 1995; Vos and Chardon, 1998; Hels and Buchwald, 2001; Vijayakumar et al., 2001; Semlitsch et al., 2007), and insects (Seibert and Conover, 1991).

The aim of the present study was to give preliminary information on the amphibian and reptile species that we found crushed on the road during our herpetological trips to various regions of Anatolia between 2005 and 2009. Furthermore, it is our hope that we will be able to direct attention to the measures that can be taken in order to prevent these types of road mortalities in the future.

Materials and methods

Fieldwork was conducted in various parts of Anatolia during May and June between 2005 and 2009. The most frequently used routes were between İzmir and Kayseri (1) (travelled 4 times – 3460 km), between İzmir and Hatay (2) (travelled 6 times – 6528 km), the whole Mediterranean coast starting from İzmir (3) (travelled 4 times – 5220 km) and the whole Black Sea coast starting from İzmir (4) (travelled 3 times – 4800 km). Approximately 20,000 km were traveled during the course of this study (Figure 1).

In order to obtain data, 2 observers were in the vehicle, which traveled at a speed of 50 to 90 km, trying to determine whether there were any animals that had been crushed on the road. At points in which a crushed individual was observed, the surrounding roadside areas were further examined within a diameter of 50 m. This was done in order to determine whether there were any other crushed individuals within immediate proximity of the road. The species of the determined crushed individual was recorded, as was its sex, wherever possible.

Results

During the study, it was determined that a total of 183 individuals (82 amphibians and 101 reptiles) had been crushed due to vehicle traffic. These individuals belonged to 28 species of 4 amphibian families [Salamandridae (1), Ranidae (3), Bufonidae (2), and Hylidae (2)], 3 turtle families [Testudinidae (1), Emydidae (1), and Geoemydidae (2)], 3 lizard families [Agamidae (1), Anguidae (2), and Lacertidae (5)], and 2 snake families [Colubridae (6) and Viperidae (2)] (Table, Figures 2 and 3). Although the study period (2005-2009) and travel distance (approx. 20,000 km) were very long, relatively few individuals were recorded. The reason for this lies in the relatively high rate of speed (50-90 km)

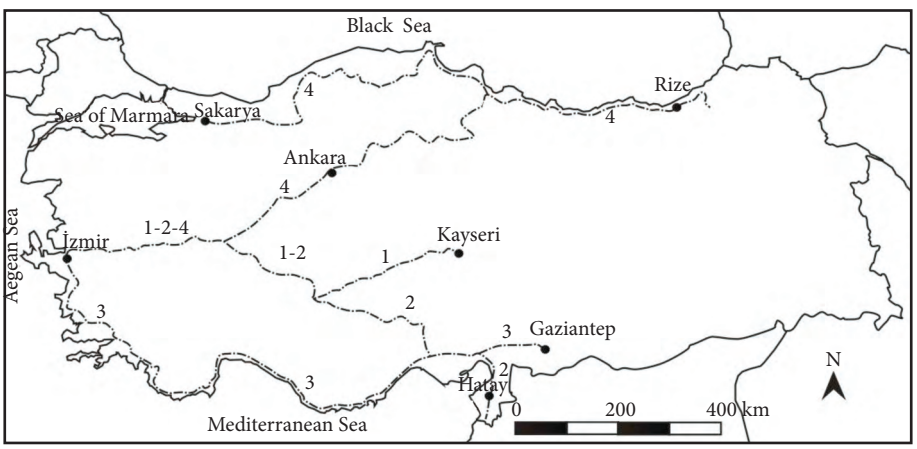

Figure 1. Map showing the traveled (discrete lines) routes (1-4).

Table. Amphibians and reptiles crushed on the road, by region.

Species	Aegean	Mediterranean	Marmara	C Anatolia	Black Sea	SE Anatolia	Total
Triturus karelinii			1				**1**
Bufo bufo	3		2		5	0	**10**
Pseudepidalea variabilis	8	4	3	2		1	**18**
Hyla savignyi		1				3	**4**
Hyla arborea	4	2		1			**7**
Pelophylax bedriage	11	7		4		8	**30**
Pelophylax ridibundus			4		5		**9**
Rana macrocnemis			3				**3**
Testudo graeca	8	5	3	4		6	**26**
Emys orbicularis	3		1	2	1		**7**
Mauremys caspica				1		2	**3**
Mauremys rivulata	5	4				-	**9**
Laudakia stellio	3	1		2		3	**9**
Pseudopus apodus	2	1					**3**
Anguis fragilis					1		**1**
Lacerta viridis			2				**2**
Lacerta trilineata	1		3				**4**
Anatololacerta danfordi	4						**4**
Phoenicolacerta laevis		2					**2**
Podarcis muralis			1				**1**
Dolichophis caspius	5	3	4				**12**
Dolichophis jugularis		2					**2**
Natrix natrix	1	1		2	1		**5**
Coronella austriaca			1		1		**2**
Telescopus fallax	2		1				**3**
Malpolon monspessulanus			1				**1**
Montivipera xanthina		1					**1**
Macrovipera lebetina						4	**4**
Total	**60**	**34**	**29**	**18**	**14**	**27**	**183**

(Scientific names updated to IUCN standard.)

maintained while traveling (because this was not the primary aspect of the study at that time). The highest road mortality was encountered in amphibians; 45% of the cases identified are included in this group. The other groups were populated by turtles (25%), snakes (16%), and lizards (14%), respectively. The highest numbers of crushed individuals in the amphibian family were observed in *Pelophylax bedriage* (30

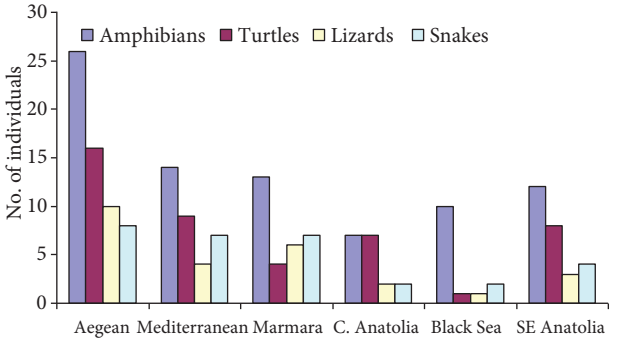

Figure 2. Distribution of amphibians and reptiles crushed on the road, by region.

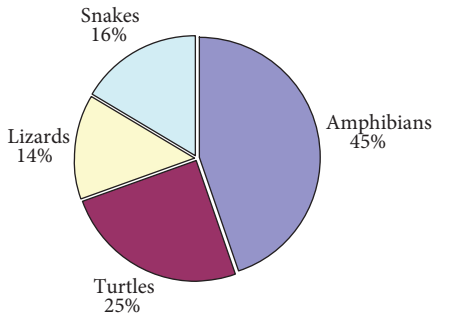

Figure 3. Distribution of amphibians and reptiles crushed on the road, by group.

individuals), *Pelophylax ridibundus* (9 individuals), *Pseudepidalea variabilis* (18 individuals), and *Bufo bufo* (10 individuals). Ranidae (23%) and Bufonidae (15%) were the families with the highest losses of individuals.

The highest mortalities in turtles were observed in *Testudo graeca* (26 individuals) and, therefore, in the family Testudinidae (14%). Among snakes, *Dolichophis caspius* was found to be the most crushed species, with a total of 12 individuals; among lizards, this was *Laudakia stellio* (9 individuals). In descending order, the rates of mortality due to being crushed on the road were determined to be 7% in Lacertidae, 5% in Agamidae, and 2% in Anguidae. The highest rate of mortality in snakes was observed in Colubridae (14%). When compared by region, amphibians constituted the group which was most exposed to traffic accidents most in all of the studied regions except central Anatolia (Figure 1). In general, the lowest loss of individuals was observed in lizards.

Losses in amphibians were generally observed on roads located in the vicinity of wetlands and particularly around lakes and irrigation canals. Losses in terrestrial species (e.g., *Bufo* or *Pseudepidalea*) tend to occur while they are crossing the road during their migration. Amphibians are slow-moving groups that migrate between aquatic and terrestrial habitats. Turtles are also generally considered slow-moving species, particularly *Testudo*. Thus, the highest mortality in reptiles was observed in this group. The losses in snakes may occur while they are crossing the road with the purpose of hunting or migrating or while nocturnal species (*Telescopus*, *Macrovipera*, *Montivipera*) are resting on asphalt, which is hotter than soil, in order to balance their body temperature. Lizards move faster than turtles and snakes, and fewer losses were therefore observed in this group. *Laudakia stellio* is a species that lives in rocky biotopes and as a result is observed frequently on the roadsides, thereby increasing the likelihood of its being crushed by vehicles.

During our observations, some mammals were also detected having been crushed by vehicles. These included *Vulpes vulpes*, *Citellus citellus*, *Erinaceus europaeus*, *Meles meles*, and *Martes foina* as well as many domestic cats and dogs. It was determined that *Pica pica*, *Corvus corone*, and *Buteo* sp. of birds and numerous species of Sylviidae were also crushed as a result of hitting the vehicle glass during feeding or low altitude flights.

Discussion

The declining amphibian and reptile populations worldwide have been noted by many researchers (Blaustein and Wake, 1990; Alfold and Richards, 1999; Gibbons et al., 2000; Houlahan et al., 2000). In addition to the many other causes of declining populations (Alfold and Richards, 1999), a further potential factor is mortality on roads (Fahrig et al., 1995).

According to the results we obtained, roads and vehicular road use had a negative effect on herpetofauna in general and on frogs and toads specifically. This effect can be classified as the loss of individuals due to being crushed by vehicles as

well as the habitat fragmentation and decline in habitat quality that accompanies road development. According to Jager et al. (2005), roads have 3 basic effects on wild life, namely: direct mortalities as a result of being crushed by vehicles, habitat fragmentation and the inability to access resources due to the presence of barriers in the areas where the road passes, and a decline in populations due to loss of habitats. The negative effects of roads on amphibians and reptiles have been reported by many researchers (Fahrig et al., 1995; Rudolph et al., 1999; Gibbs and Shriver, 2002; Houlahan and Findlay, 2003; Porej et al., 2004; Loehle et al., 2005; Row et al., 2007; Elzanowski et al., 2009).

Among vertebrate groups, amphibians are the most defenseless against road mortalities (Trombulak and Frissell, 2000). The reasons for this can include the migrations between aquatic and terrestrial habitats required by their life cycles, the difficulty for drivers in seeing these individuals, and the slow movement of some species. Joly and Morand (1997) reported that roads present a demographic barrier causing habitat and population fragmentation in amphibian populations. The survival rate of amphibians while crossing the road is rather low (Hels and Buchwald, 2001) and generally depends upon traffic volume (Fahrig et al., 1995; Mazerolle, 2004). On roads with a traffic volume of 24 to 40 vehicles per hour, the mortality rate of *Bufo bufo* during migration was reported to be 50% (Kuhn, 1987) whereas the mortality rate was reported to be 90% (Percsy, 1994) on roads with a traffic volume of 60 vehicles per hour. Vijayakumar et al. (2001) recorded the rate of being crushed on the road as being 23% in Ranidae, 11% in Rhacophoridae, and 4% in Icthyophidae and Uraeotyphlidae. Shwiff et al. (2007) reported that, on average, 64 individuals from amphibian and reptile families died annually in Jonathan State Park in Florida. Hardel et al. (2009) reported 2270 crushed individuals (1437 *Rana dalmatina* and 833 *Bufo bufo*) on the basin of the Târnava Mare in Transylvania, Romania between February 15 and May 3, 2007. These researchers noted that the road in question was located on the migration route of these species and that the mortalities reported were associated with this. In this study as well, the highest road mortality was observed in amphibians and the highest number of loss of individuals in this group was observed in *Pelophylax bedriage*, *P. ridibundus*, *Pseudepidalea variabilis*, and *Bufo bufo*.

Steen and Smith (2006) reported that road mortalities in turtles were observed more in large adult females. Researchers stated that females in particular went away from the water in order to lay eggs and were therefore more likely to be crushed by vehicles while crossing the road. Furthermore, they stated that the rate of being crushed could also provide information on the size of the population in the vicinity of the road. In contrast to the female bias noted by these researchers, Aresco (2005) observed a male-biased sex ratio in the road mortalities of freshwater turtles. Among the crushed species we detected in this study, a male-biased sex ratio was observed in *Testudo graeca* (16 males, 10 females), *Emys orbicularis* (4 males, 3 females), and *Mauremys rivulata* (6 males, 3 females) whereas a female-biased sex ratio was observed in *Mauremys caspica* (1 male, 2 females). The sex ratio varies within the year depending on the activities of individuals.

Among reptiles, the road mortality rates of snakes in particular are higher in the South Western Ghats in India. These rates were reported to be 30% in Colubridae, 19% in Uropeltidae, 12% in Viperidae, and 4% in Elapidae (Vijayakumar et al., 2001). Researchers detected that the highest mortality rate in lizards was in Agamidae. Lebboroni and Corti (2006) examined road mortalities in *Lacerta bilineata* (mortality rate: 63%), *Podarcis sicula* (31%), and *Podarcis muralis* (6%) and recorded that there was an increase in mortality rate depending on traffic density. Those researchers also stated that *Lacerta bilineata* was more affected by the presence of roads since it was a larger species. In this study as well, the highest road mortality was determined to be in the family Lacertidae. This association is probably related to the abundance of individuals.

The road mortality rate was determined to be 14%-21% in *Nerodia erythrogaster neglecta* but 3%-5% in *Nerodia sipedon* (Roe et al., 2006). Row et al. (2007) detected that a yearly average of 9 individuals of *Elaphe obsoleta* were crushed by vehicles in Ontario, Canada. One of the reasons why snakes are crushed is that they use the heat trapped in roads to help balance their body temperature (thermoregulation) (Sullivan, 1981). Shepard et al. (2008) detected 321

individuals crushed on the road between 2000 and 2002, and they determined that, of these individuals, 84 belong to 6 turtle species and 237 belong to 9 snake species. Researchers observed that variations by month were present in mortality rates. In our study, *Dolicophis caspius* was the species which was exposed to the highest road mortality, with 12 individuals observed. As in other groups, the rate of being crushed in snakes is higher in species with a high density.

In conclusion, roads have a negative effect on fauna and flora. Although the complete elimination of this effect is not possible, some measures can be taken by authorities in order to partially reduce this negative effect. There are very few existing studies on the negative effects of roads on amphibians (Joly and Morand, 1997; Lesbarrères et al., 2004) and reptiles (Lebboroni and Corti, 2006) in Mediterranean ecosystems. Further research is needed to quantify the population-level effects of major roads in Turkey.

Acknowledgements

This study constitutes part of a project [Project No: TBAG-2402 (103T189) and 108T559] supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK). We are indebted to TÜBİTAK for the financial support it has provided.

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