

Effect of Traffic on Mortality of Amphibians, Reptiles, Birds and Mammals on Two Types of Roads Between Pazardzhik and Plovdiv Region (Bulgaria) – Preliminary Results

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Abstract: The study explores the mortality of birds, amphibians, reptiles and mammals caused by traffic on Trakia highway (the section is 68 km long) and one control road section: first-class road (the section is 58 km long) between Pazardzhik and Plovdiv. To observe the number of killed amphibians, reptiles, birds and mammals on the highway 11 one-kilometer transects were chosen and on the control section – 10 transects. They were visited for overall 20 days in seven months. During the visiting of transects was registered every animal, the species, sex and age (if possible) and also the exact distance from the end of the road at which the individual was found. In total, 756 corpses of amphibians, reptiles, birds and mammals were found. The results from this one-year study show that the amphibians are most affected from the traffic on the two types of roads between Pazardzhik and Plovdiv, but if we exclude the migration of Marsh Frog, the most affected groups are birds and mammals. From all killed animals, 67.2% were amphibians, 15.7% birds, 9.2% mammals and 7.8% reptiles. Difference of animal mortality between Trakia highway and the first-class road between Pazardzhik and Plovdiv was found. On the highway the most abundant group of killed animals are birds and on first-class road are amphibians and reptiles. The highest casualties occurred in September – 92 individuals and the numerous killed individuals are adults (without the masking effect of migration of Marsh Frog). Overall 36 killed animals per 1 km were found. The largest number of killed animals was found on the roadway (44%).

Key words: Traffic, mortality, vertebrate animals, Trakia highway.

Introduction

Roads represent one of the most widespread forms of modification of the landscape that occurred during the past century (TROMBULAK, FRISSELL 2000; SMITH 1990). Road developments affect and modify the habitat conditions, which in turn influence the abundance and distribution of plant and animal species, i.e. biodiversity of the impacted areas.

Among the most conspicuous environmental effects of roads are vehicle-related mortalities of wildlife and factors that are contributing to wildlife-vehicle collisions are vehicle speed, traffic volume, road width, animal abundance, roadside vegetation, time of day/year, and habitat diversity along the road (LITVAITIS, TASH 2008). Reptiles and amphibians are among the

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fauna most negatively affected by poor transportation planning associated with wetlands alteration and their mortality can be significant (ASHLEY, ROBINSON 1996; CLEVENGER *et al.* 2001; SMITH, DODD 2003). Although the number of bird road victims can be rather large, it was assumed that they are, in general, not sufficient to cause a significant increase of the total mortality of species (REIJNEN *et al.* 1995). But for some species, in particular barn owl (*Tyto alba*), road mortality might influence population size significantly (ILLNER 1992).

In Bulgaria research works concerning the impacts of motorways on the ornithofauna were done by NANKINOV, TODOROV (1983) and NANKINOV (1999). The first paper explored the influence of motorway transport on birds in a 3.5 km-long road section between the villages of Dragichevo and Rudartsi (Pernik District) and the second paper (NANKINOV, 1999) studied the effect of transport corridor N 8 crossing the Balkan Peninsula from East to West (995 km).

The aim of the paper is to represent the preliminary results of one-year study which explores the impacts of traffic on one section of Trakia highway and one section of a first-class road between Pazardzhik and Plovdiv on birds, amphibians, reptiles and small mammals.

Materials and Methods

The studied area is one road section from Trakia highway (AM) and the controlled road section (first-class road – Vt) is between the town of Belovo and Plovdiv. The length of the studied road sections is as follows: 1) the Trakia highway – road fork for the village of Kalugerovo – village of Manolsko Konare (68 km); 2) the controlled road section – the first-class road between the town of Belovo and Plovdiv – 58 km.

The area around the studied road sections is cultivated agricultural landscape. The main crops are wheat, maize, sunflower, barley, rice-fields and also pastures and uncultivated lands.

To observe the number of killed amphibians, reptiles, birds and mammals on the highway, 11 one-kilometer transects were chosen on the highway and 10 transects on the controlled section (overall – 21 km) (Fig. 1). The choice of the transects was accomplished according to casual principle on the computer program ArcGIS. They were visited during seven months for overall 20 days: 4 days in April, 2 days in May, 3 days in June, 4 days in July, 3 days

in September, 1 day in October and 3 days in March. During the visiting of transects every animal, the species, sex and age (if possible) were registered and also the exact distance from the end of the road at which the individual was found. When the killed animals were registered they were removed from the transects. The transects were observed on foot. The method probably provides an underestimated mortality as predators could, in fact, have removed numerous small dead animals.

The differences in the number of killed vertebrate animals on two types of roads according to t-test (Programs STATISTICA and PAST) were examined. The Pearson correlation was used to find any dependence between number of killed animals and average 24-hour traffic intensity (number of vehicles) by month.

Results

Species composition of killed animals

Totally, 756 corpses of amphibians, reptiles, birds and mammals were found. From them 67.2% were amphibians (508 individuals), 15.7% birds (119 individuals), 9.2% mammals (70 individuals) and 7.8% reptiles (59 individuals). Table 1 shows the 3 taxa of amphibians that were found. The Marsh frog (*Pelophylax ridibundus*) accounted for 93.1% of the killed amphibians, followed by the Green toad (*Pseudepidalea viridis*, 3.1%) and the Common toad (*Bufo bufo*, 2.9%). The 87% (442 individuals) of killed Marsh frog were found in two days (26. 09. 2009 and 28. 09. 2009) on two transects of the first-class road between Pazardzhik and Plovdiv. This is maybe an autumn migration of Marsh frog between rice-fields and Maritsa River. The weather on 26. 09. 2009 and 28. 09. 2009 was sunny, without rain and the minimum temperature was 11 °C and the maximum – 22 °C. If we exclude the masking effect of Marsh frog overall the corpses of died animals will be 314 individuals.

Birds were represented by 20 taxa and 119 individuals (Table 1). We were not capable to identify many of the small birds from order Passeriformes (33.6%) as they were mostly run over flat. After these individuals the most abundant victim among the birds is Common buzzard (*Buteo buteo*, 11.8%), followed by Tree sparrow (*Passer montanus*, 8.4%), *Passer* sp. (6.7%), Long-eared owl (*Asio otus*, 5.9%), Falconiformes

Table 1. Number of road-killed amphibians, reptiles, birds and mammals on the two types of monitored roads between Pazardzhik and Plovdiv (21 km) in 2009.

Animal species	Found cadavers					Number/1 km	
	Number of individuals	Proportion %		Number on Trakia highway	Number on first-class road	On Trakia highway	On first-class road
		% for animal class	% total				
1	2	3	4	5	6	7	8
<i>Pelophylax ridibundus</i>	473	93.1	62.6	15	458/16	0.7	21.8/0.8
<i>Epidalea viridis</i>	16	3.1	2.1	7	9	0.3	0.4
<i>Bufo bufo</i>	15	2.9	2	7	8	0.3	0.4
<i>Anura</i> spp.	4	0.8	0.5	3	1	0.1	0.05
Amphibians total	508/66	100	67.2	32	476/34	1.5	22.7/1.6
<i>Accipiter nisus</i>	1	0.8	0.1	1	0	0.05	0
<i>Acrocephalus arundinaceus</i>	1	0.8	0.1	0	1	0	0.05
<i>Alcedo atthis</i>	2	1.7	0.3	2	0	0.09	0
<i>Asio otus</i>	7	5.9	0.9	6	1	0.3	0.05
<i>Athene noctua</i>	1	0.8	0.1	1	0	0.05	0
<i>Buteo buteo</i>	14	11.8	1.8	13	1	0.6	0.05
<i>Columba livia</i> forma <i>domestica</i>	1	0.8	0.1	1	0	0.05	0
<i>Emberiza citrinella</i>	1	0.8	0.1	1	0	0.05	0
<i>Emberiza melanocephala</i>	1	0.8	0.1	1	0	0.05	0
<i>Falco tinnunculus</i>	1	0.8	0.1	1	0	0.05	0
<i>Falconiformes</i>	7	5.9	0.9	6	1	0.3	0.05
<i>Hirundo rustica</i>	3	2.5	0.4	2	1	0.09	0.05
<i>Motacilla flava</i>	1	0.8	0.1	0	1	0	0.05
<i>Passer domesticus</i>	4	3.4	0.5	2	2	0.09	0.09
<i>Passer montanus</i>	10	8.4	1.3	7	3	0.3	0.1
<i>Passer</i> sp.	8	6.7	1	2	6	0.09	0.3
<i>Passeriformes</i>	40	33.6	5.3	30	10	1.4	0.5
<i>Phylloscopus collybita</i>	1	0.8	0.1	0	1	0	0.05
<i>Pica pica</i>	1	0.8	0.1	1	0	0.05	0
<i>Saxicola rubetra</i>	1	0.8	0.1	1	0	0.05	0
<i>Sturnus vulgaris</i>	7	5.9	0.9	6	1	0.3	0.05
<i>Turdus merula</i>	1	0.8	0.1	0	1	0	0.05
<i>Tyto alba</i>	5	4.2	0.7	5	0	0.2	0
Birds total	119	100	15.7	89	30	4.2	1.4
<i>Arvicola terrestris</i>	1	1.4	0.1	0	1	0	0.05
<i>Canis aureus</i>	3	4.3	0.4	1	2	0.05	0.09
<i>Canis lupus familiaris</i>	13	18.6	1.7	10	3	0.5	0.1
<i>Carnivora</i>	1	1.4	0.1	1	0	0.05	0
<i>Erinaceus concolor</i>	9	12.8	1.2	5	4	0.2	0.2
<i>Felis silvestris catus</i>	10	14.3	1.3	5	5	0.2	0.2
<i>Lepus europaeus</i>	2	2.8	0.3	2	0	0.09	0
<i>Mammalia</i>	1	1.4	0.1	1	0	0.05	0
<i>Micromamalia</i>	1	1.4	0.1	1	0	0.05	0
<i>Microtus</i> sp.	3	4.3	0.4	3	0	0.1	0

Table 1. Continued.

1	2	3	4	5	6	7	8
<i>Muridae</i>	1	1.4	0.1	0	1	0	0.05
<i>Mustela nivalis</i>	2	2.8	0.3	1	1	0.05	0.05
<i>Mustela putorius</i>	1	1.4	0.1	1	0	0.05	0
<i>Mustelidae</i>	3	4.3	0.4	2	1	0.09	0.05
<i>Rodentia</i>	10	14.3	1.3	9	1	0.4	0.05
<i>Soricidae</i>	1	1.4	0.1	0	1	0	0.05
<i>Spermophilus citellus</i>	1	1.4	0.1	1	0	0.05	0
<i>Talpa</i> sp.	1	1.4	0.1	1	0	0.05	0
<i>Vormela peregusna</i>	1	1.4	0.1	1	0	0.05	0
<i>Vulpes vulpes</i>	5	7.1	0.7	2	3	0.09	0.1
Mammals total	70	100	9.2	47	23	2.2	1.1
<i>Dolichophis caspius</i>	8	13.5	1	3	5	0.1	0.2
<i>Emys orbicularis</i>	5	8.5	0.7	4	1	0.2	0.05
<i>Lacerta trilineata</i>	1	1.7	0.1	0	1	0	0.05
<i>Lacerta viridis</i>	1	1.7	0.1	1	0	0.05	0
<i>Natrix natrix</i>	10	16.9	1.3	7	3	0.3	0.1
<i>Natrix tessellata</i>	11	18.6	1.4	1	10	0.05	0.5
<i>Natrix</i> sp.	10	16.9	1.3	4	6	0.2	0.3
<i>Podarcis taurica</i>	13	22	1.7	4	9	0.2	0.4
Reptiles total	59	100	7.8	24	35	1.1	1.7

(5.9%), Starling (*Sturnus vulgaris*, 5.9%), Barn owl (*Tyto alba*, 4.2%) and other species (less than 4%).

Mammals were represented by 16 taxa (Table 1), among them there are two domestic species (dogs and cats). The most abundant victim among the mammals is Domestic dog (*Canis lupus familiaris*, 18.6%), followed by Domestic cat (*Felis silvestris catus*, 14.3%), order Rodentia (unidentified mice and voles) – 14.3%, White-breasted hedgehog (*Erinaceus concolor*, 12.8%), Red fox (*Vulpes vulpes*, 7.1%), Jackal (*Canis aureus*, 4.3%), Voles (genus *Microtus* sp., 4.3%), Weasel family (Mustelidae, 4.3%) and other species (less than 4%).

Reptiles were represented by 7 taxa. The most abundant victim among them was Balkan wall lizard (*Podarcis taurica*, 22%), followed by Dice snake (*Natrix tessellate*, 18.6%), Grass snake (*Natrix natrix*, 16.9%), Caspian whip snake (*Dolichophis caspius*, 13.5%), European pond turtle (*Emys orbicularis*, 8.5%) and other species (less than 2%).

Distribution of killed animals on the two types of roads

On Trakia highway totally 192 killed animals were found and on the first-class road between Pazardzhik

and Plovdiv – 564. This result shows that on the first-class road the animal loss is higher than on the highway where the traffic is much more intensive. But if we exclude the autumn migration of Marsh frog (442 individuals) the mortality on the first-class road will be 122 killed animals. The next results are calculated without masking effect of migrating Marsh frog (442 individuals on first-class road – Vt). On Trakia highway the mortality is higher (192 killed animals) than on the first-class road – 122 killed animals. This difference is statistically significant ($t=1.99$, $N= 59$, $df = 58$, $p= 0.05$). For the analyses were used the two columns from Table 1: ‘number of cadavers on Trakia highway’ and ‘number of cadavers on first-class road’. This means that the highway is more dangerous than first-class road.

The difference of killed vertebrate animals by groups in two types of roads was examined. For the analyses were also used the two columns from Table 1: ‘number of cadavers on Trakia highway’ and ‘number of cadavers on first-class road’ but for different animal groups. The results are given in Table 2.

On the highway (overall 192 individuals) the most abundant group of killed animals are birds – 46.3% (Fig. 2). On the highway the most abundant

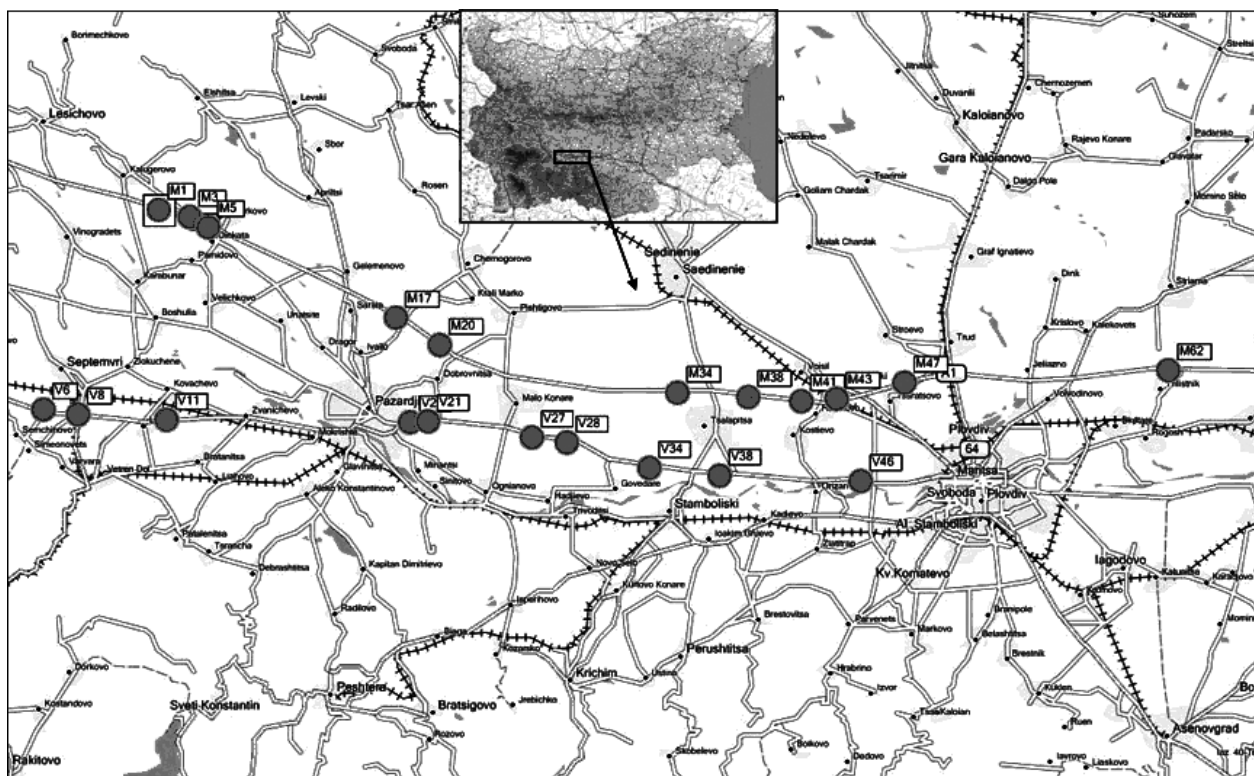


Fig. 1. The location of 21 one-kilometer transects along the Trakia highway and first-class road between Pazardzhik and Plovdiv.

Table 2. Results from T-test for difference of killed vertebrate animal groups in two type of roads in 2009

T-test for Dependent Samples (new.sta)								
Marked differences are significant at $p < .05000$								
Birds	Std.Dv.							
	Mean	Std.Dv.	N	Diff.	Diff.	t	df	p
AM	3.8695	6.5038						
VT	1.3043	2.32447	23	2.56	4.96	2.48	22	0.02
Amphibians								
AM	8	5.0332						
VT	8.5	6.1373	4	-0.5	1.73	-0.58	3	0.60
Mammals								
AM	2.35	2.8149						
VT	1.15	1.4964	20	1.2	2.42	2.22	19	0.04
Reptiles								
AM	3	2.2677						
VT	4.375	3.7772	8	-1.375	4.24	-0.91	7	0.39

victim from birds is the unidentified species from order Passeriformes (33.6%) followed by Common buzzard (14.6%) and other species. From the mammals the most affected are Domestic dog (21.3%) and order Rodentia (unidentified mice and voles) – 19.1%, from the amphibians – Marsh frog (46.8%) and from the reptiles – Grass snake (29.2%) (Table 1).

On the first-class road (overall 122 individuals) the most abundant group of killed animals are reptiles – 35 individuals (29%) and the most affected species is Dice snake (8%). After that the next abundant group of victims on first-class road is amphibians (28%) (this is amphibians and separate individuals of Marsh frog which are not in the large group

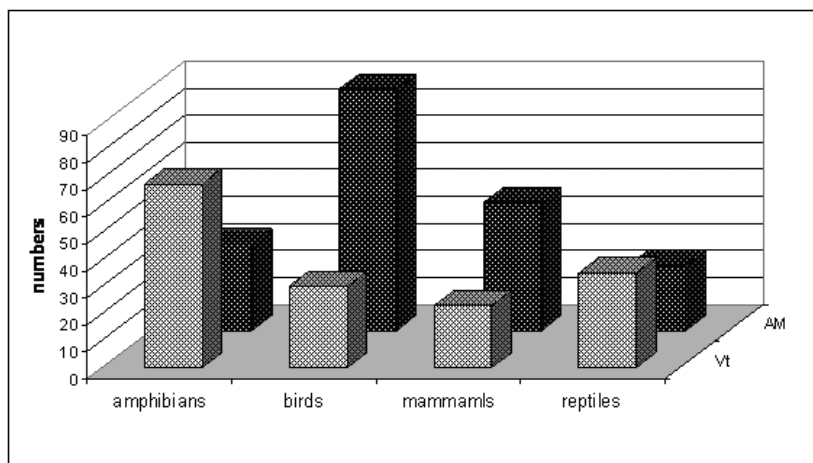


Fig. 2. Number of road-killed amphibians, reptiles, birds and mammals (excluding the migration of Marsh frog) on Trakia highway (AM) and first-class road (Vt) between Pazardzhik and Plovdiv in 2009.

of migrating individuals). After that come the birds and the most affected species among them is unidentified species from order Passeriformes (8%). From mammals the mortality was highest for Domestic cat (4%) and for Hedgehog (3.3%). The largest number of killed animals was found on transects Vt28 (336 individuals) and Vt46 (113 individuals). On these two transects was found the accidents of Marsh frog.

Table 3. The prognoses average number of vehicles for 24-hour in 2010 on Trakia highway and first-class road.

	First-class road	Trakia highway
Heavy-freight vehicle	1498	4985
Light-freight vehicle	6599	12836
All vehicles	8097	17820

The average number of vehicles on the two type of roads for 24-hour in 2010 was shown in Table 3. This is prognoses number of vehicles calculated on the basis of the counting of vehicles in 2005. We still do not have data from the vehicles counting in 2010.

There is no correlation between number of road-killed vertebrates on the transects in the two type of roads overall and average 24-hour traffic intensity by month ($r_{\text{Pearson}} = -0.08$).

Mortality variations by months

Overall, there is some variation by days in different months in road killings (Fig. 3). The highest casualties occurred in September – 31 individuals per day (this number is without masking effect of frog migration), the lowest in July – 6 individuals per day. The next number is without masking effect of

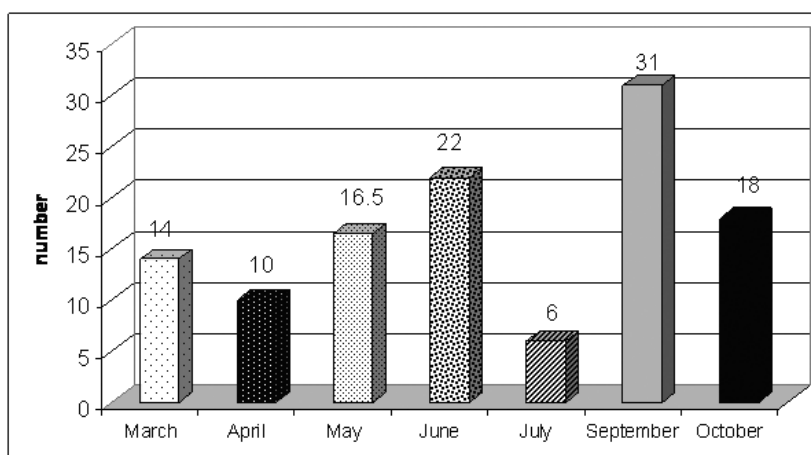


Fig. 3. Monthly dynamics (overall number) of killed vertebrate animals per day (excluding the autumn migration of Marsh frog) on the two types of roads between Pazardzhik and Plovdiv in 2009.

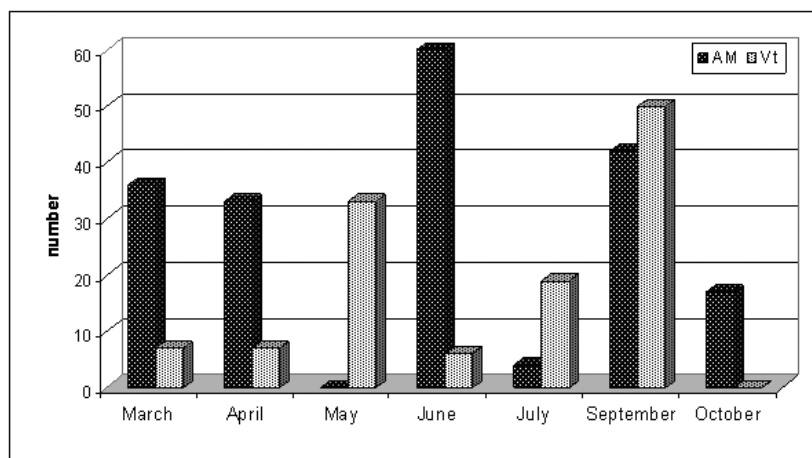


Fig. 4. Monthly dynamics of killed animals (number of individuals) (excluding the autumn migration of Marsh frog) on the two types of roads between Pazardzhik and Plovdiv in 2009.

Table 4. Number of killed vertebrate animals per day distributed by months on the two type of roads between Pazardzhik and Plovdiv in 2009.

	March	April	May	June	July	September	October	Total
Birds	11	4.2	1.5	10	3.2	5	9	43.9
Mammals	1.7	3.7	1.5	5.3	1	7	6	26.2
Amphibians	1	1.2	10.5	4.3	0.5	7	1	25.5
Reptiles	0	0.7	3	2.7	1	12	1	20.4

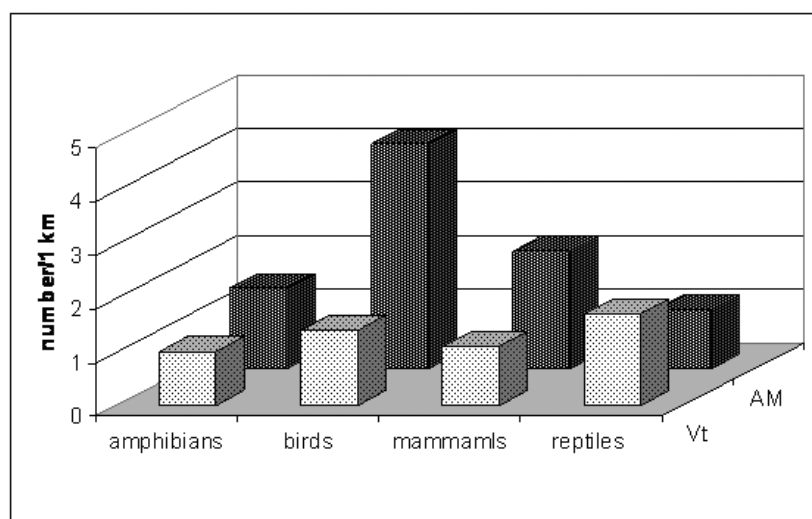


Fig. 5. Mortality per km of amphibians, birds, mammals and reptiles on the two types of roads between Pazardzhik and Plovdiv in 2009.

frog migration. Birds are characterized by the highest number of killed individuals in March (11 ind./day) and in June (10 ind./day). The mammals are at high danger in September (7 ind./day) and October (6 ind./day). Amphibians are characterized with the highest number of killed individuals in May (10.5 ind./day) and in September (7 ind./day). Reptiles are

most affected in September (12 ind./day).

The highest number of killed animals on Trakia highway is observed in June (60 individuals) and the lowest – in May (0 individuals). The highest number of killed animals on the first-class road is observed in September (50 individuals) and the lowest – in October (0 individuals) (Fig. 4).

Table 5. The proportion of road-killed animals found on the motorways on five different parts of the road

Part of the road	Amphibians	Birds	Mammals	Reptiles	Total
roadway	62	6	7	8	44
road shoulder	35	40	53	53	39
1 m from the shoulder	1	17	11	17	5
0,5 m from the shoulder	0	12	7	10	3
others	3	25	24	8	8
n	508	119	70	59	756

Mortality per kilometer

The number of animals found dead per kilometer of road is given in Table 1. Overall 36 killed animals per km were found, if we exclude the autumn migration of Marsh frog the value is 13.4 killed animals/km. We found 1.67 killed amphibians per km of the studied roads (24.1 killed amphibians per km with migration of Marsh frog), 5.6 killed birds/km, 3.3 killed mammals/km and 2.8 killed reptiles/km (Fig. 5).

On Trakia highway 9 killed animals/km were found and 6.1 killed animals/km on the first-class road (without the autumn migration of Marsh frog). From 192 animals on Trakia highway, the most common were the small birds from Passeriformes (1.4 killed birds/km), followed by Marsh frog (0.7 corpses/km), Common buzzard (0.6 corpses/km), Domestic dog (0.5 corpses/km), Rodentia (0.4 corpses/km) and other animals – under 0.4 corpses/km.

From 564 animals on the first-class road, the most common were Marsh frog (21.8 killed amphibians/km). If we exclude the autumn migration of Marsh frog the value is 1.0 killed amphibian/km. After that followed the unidentified small birds from Passeriformes, Dice snake (0.5 killed animals/km), Green toad, the common toad and the Balkan wall lizard (0.4 killed animals/km), *Passer* sp. and *Natrix* sp. (0.3 killed animals/km) and other animals 0- under 0.3 corpses/km.

Placement of killed animals

The largest number of killed animals was found on the roadway (44%). From this 94% are the corpses of migrating Marsh frog. This means that the numerous dead animals were observed on the road shoulder (39%). In Table 5 are given the proportions of road-killed animals found on the motorway on five different parts of the road.

On the highway 56.7% of killed animals are found on the road shoulder and the rest in other parts of the road. On the first-class road 57.3% of killed an-

imals are found on the roadway and from them 96.3% are the corpses of migrating Marsh frog. 32.6% of dead animals are found on the road shoulder.

The age of the killed animals

Fifty-nine per cent of the killed animals are juvenile and from them Marsh frog accounts for 98.4%. If the migrating juvenile individuals of Marsh frog are excluded, the numerous killed individuals are adults. Twenty per cent of the killed animals are adults but 17% are of unidentified age. From adult dead animals 28.8% are birds, 26.2% – amphibians, 23.5% – mammals and 21.5% – reptiles. From adult animals 54.4% are found on Trakia highway and the others are found on the first-class road. From juvenile birds 98.4% are found on the first-class road.

Discussion

Species composition of killed animals

The results from this one-year study show that the amphibians and birds are more affected from the traffic on the two types of roads between Pazardzhik and Plovdiv. If the migration of Marsh frog is excluded, the birds and mammals will be the most affected creatures from the traffic on the two types of roads.

The most affected animal from the traffic is Marsh frog. Most of killed individuals (92.2%) are found in two days on two transects of the first-class road (Vt27 and Vt28). The high mortality of this species on these two transects can be explained by three factors: 1) characteristics of the surrounding habitats which provide suitable breeding sites – in the close vicinity (600 m) of Vt28 there is a large irrigating channel and along the VT46 there is rice filled and Maritsa River is on the 300 m distance; 2) migration pattern of the amphibians demanding regular crossing of the road, and 3) the fact that individuals are slow-moving and inconspicuous and also the abundance of local population. ORLOVSKI (2007) ob-

tained a positive correlation between the number of road killed toads and the overall area of water bodies around the roads. Not only our study but many others demonstrate that the amphibians are the most affected from the road traffic (GRYZ, KRAUZE 2008; GLISTA *et al.* 2008; SMITH, DODD 2003; LODÉ 2000; FAHRIG *et al.* 1995; GIBBS 1998). For example, SMITH, DODD (2003) found that the frogs represented 45.7% from the road killing. But CLEVINGER *et al.* (2003) found that the amphibians represented only 7.2% of total dead animals.

If the migration of Marsh frog (442 individuals) is excluded, the birds are most affected from the traffic on the two type of roads (119 bird individuals and 66 amphibian individuals).

Birds are on the second place by number of accidents. Among them the species from genus *Passer* dominate the road kills (18.5% of 119 bird carcasses). This fact could be explained with the surrounding habitats which are mainly cultivated agricultural landscape (crops of wheat, maize, sunflower, barley, pastures and uncultivated lands). The common bird species in these habitat types are Skylark (*Alauda arvensis*), Yellow wagtail (*Motacilla flava*), Black-headed bunting (*Emberiza melanocephala*). Birds killed by traffic also varied in different studies (GRYZ, KRAUZE 2008; HELL *et al.* 2005; SMITH, DODD 2003; LODÉ 2000).

The predomination of Domestic dogs and cats among killed mammals are explainable with the fact that the study region is well populated (the villages are large and in close vicinity to towns Pazardzhik and Plovdiv), and the local people work hard to cultivate their lands. The relative large percent of killed Rodentia is explainable with the surrounding habitats which are agriculture lands. The mammals are differently affected from the traffic in different papers and the cause for this maybe is the surrounding habitats (LODÉ 2000; CLEVINGER *et al.* 2003; GRYZ, KRAUZE, 2008).

In spite of that reptiles are on the last place among the killed animals – in our study this group of species is vulnerable from the traffic intensity. The Balkan wall lizard is the most affected in this study and this is because in the region the species found suitable habitats. The road mortality of reptiles also varied in different studies and this is because the explorations were made in different landscapes (SMITH, DODD, 2003; GRYZ, KRAUZE, 2008).

Distribution of killed animals on the two types of roads

In our study was found significant difference of animal mortality between Trakia highway and the first-class road between Pazardzhik and Plovdiv which means that the highway is more dangerous than first-class road.

On the highway the accidents are 192 killed animals and on the first-class road it – 122 killed animals (without masking effect of migration of Marsh frog). The highest number of victims on highway is of passerine birds because the surrounding habitats are mainly cultivated agricultural landscape. On the highway the largest number of killed animals was found on transects M62 – 39 individuals and on M41 – 31 individuals. Along the half of the transect M62 there is a small isolated forest and in the other half of the transect the forest is on the 500 m distance from the highway. This result is in concordance with the results of CLEVINGER *et al.* (2003) who showed that the birds were more vulnerable to collisions than mammals on the Trans-Canada highway.

On the first-class road the amphibians and reptiles characterized the largest number of accidents. This could be explained with the close vicinity to this road of a number of rice-fields, large irrigating channels, and Maritsa River is at 300-1000 m distance.

Some authors find different mortality rate on different types of roads. KOBYLARZ (2003) found that on the two-lane paved highway was the greatest percentage of dead amphibians in comparison with gravel road. GOŁAWSKI, GOŁAWSKA (2002) and GLISTA *et al.* (2008) found that on high traffic loaded road was the highest occurrence of road-kills. In the Netherlands on the data of deaths of Badgers (*Meles meles*) VAN LANGEVELDE *et al.* (2009) illustrated that the traffic mortality was higher on minor roads.

We did not found correlation between number of road-killed vertebrates on the transects and average 24-hour traffic intensity by month. But LODÉ (2000) found correlation between number of road-killed vertebrates on the motorway and traffic intensity (vehicles per km).

Monthly dynamics of animal mortality

In this study the mortality was highest in September (31 ind./day) and during this month the accidents of amphibians was the highest. This is relevant to the movement of amphibian individuals towards their

winter resting sites. This result is in concordance with the findings of WOJDAN (2010), GLISTA *et al.* (2008) and GRYZ, KRAUZE (2008). But in the southern states of the USA where the climate does not have seasonal variation, the amphibians have the highest mortality rate in summer (SMITH, DODD 2003). If the movements of Marsh frog are excluded, the amphibians are the most affected from the traffic in May (10.5 ind./day). The breeding period of Marsh frog is in April and May.

The larger killed reptiles in September (12 ind./day) in comparison with other months is maybe relevant to the processes of dispersal of young individuals.

Most of the killed birds are found in March (11 ind./day). In this study the Common buzzard is represented by 11.8% of all bird carcasses and 50% of them are found in March. We census that this species looking for food in road verges. This is in concordance with the study of MEUNIER *et al.* (2000). They found that Buzzards and Kestrels used motorway verges as hunting area, predominantly in winter. The supply of perching sites, allowing a less energy-demanding hunting behaviour than flight-hunting, and the width of the verges, appeared to be important factors in attractiveness of roadside for these species.

Birds are the most affected from traffic collisions also in June (10 ind./day) – probably in association with the dispersal of young individuals. Corresponding observations were made by CLEVINGER *et al.* (2003), GRYZ, KRAUZE (2008), HELL *et al.* (2005).

In our study the mortality of mammals is the highest in September (7 ind./day). But CLEVINGER *et al.* (2003) found that road killings were most prevalent among mammals in April. According to GRYZ, KRAUZE (2008) the mortality among mammals varied between months (May-October).

Mortality per one kilometer

We found 36 killed animals per km but if the autumn migration of Marsh frog is excluded, the value was 13.4 killed animals/km. Different authors found different number of killed animals per km (GLISTA 2008; SMITH, DODD 2003; CALETTRIO *et al.* 1996). In our study the birds are most affected per km – 5.6 ind./km (if migration of Marsh frog is excluded). GOLAWSKI, GOLAWSKA (2002) obtain 0.7-0.36 killed birds/km. But HELL *et al.* (2005) found very high values of road mortality for birds – 51.3 cadavers/

km and mammals – 42.7 cadavers/km (average = 3.6 carcasses per km). Significant difference in casualty number per km of road could be found due to the season, traffic density and methods used (ERRITZOE *et al.*, 2003).

Placement of killed animals

Our results show that largest number of killed animals was found on the roadway (44%). From this 94% are corpses of migrating Marsh frog. This means that the numerous dead animals were observed on the road shoulder (39%). Similar observations were made by SMITH, DODD (2003), they also found numerous carcasses on road shoulders.

The age of the killed animals

In our study most of the killed animals were juveniles (59%), but if the migrating juvenile individuals of Marsh frog are excluded, the numerous killed individuals are adults. In the study of GRYZ, KRAUZE (2008) also the most of amphibians found dead were juveniles. In our study we are not capable to identify the age of 60% of the killed birds but were found only 5 juvenile dead birds. According to the review paper of ERRITZOE *et al.* (2003), in many studies the most road casualties are adult birds and only a few show different results. But according to the same author, several papers reported a significantly different proportion of adult vs. juvenile road-killed birds. The most important factor affecting these results seems to be the time when data were collected and the way they were analyzed.

Conclusions

The results from this one-year study show that highway is more dangerous than first-class road. They also show that the amphibians are most affected from the traffic on the two types of roads between Pazardzhik and Plovdiv, but if the migration of Marsh frog is excluded, the most affected groups are birds and mammals. On Trakia highway the mortality is higher (192 killed animals) than on the first-class road (122 killed animals). On the highway the most abundant group of killed animals were birds and on first-class road – amphibians and reptiles. The birds are most affected per km – 5.6 ind./km. A realistic and relevant overview of road losses for amphibians, birds, mammals and reptiles could be obtained only if a particular route is monitored in a systematic way

and at regular intervals for at least a year. The construction of new motorways requires clear studies on migrations and population exchanges to preserve local populations and to minimize the impact on the ecosystem.

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