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Assessing the Influence of the Automobile Traffic on the Amphibians and Reptiles in the Buffer Zone of Biosphere Reserve "Srebarna" (NE Bulgaria)

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Abstract. Currently the problem of the effects of the road network and traffic on the amphibians and reptiles in Bulgaria is poorly studied. During the period March 2002 - March 2004 in the Buffer Zone of Biosphere Reserve "Srebarna" (NE Bulgaria) were built two anti-fire roads from the eastern and western side of the lake in area of grasslands of semi-steppe type, typical for north-eastern Bulgaria. The aim of the constructed roads is to provide access for fire vehicles to areas in and around the reserve. The current study aims to provide data on the impact of road traffic and the newly constructed road network and another previously existing road on the amphibians and reptiles inhabiting the buffer zone of the biosphere reserve "Srebarna". For the entire period of study in the three studied road sections a total of 15 dead specimens of amphibians belonging to 4 species (*Bombina bombina, Hyla arborea, Bufo bufo, Bufo viridis*) and 70 dead specimens of reptiles belonging to 8 species (*Emys orbicularis, Ablepharus kitaibelii, Lacerta viridis, Podarcis tauricus, Podarcis muralis, Natrix natrix, Coronella austriaca* and *Dolichophis caspius*) were recorded. Several "hot spots", where most cadavers were recorded are well described and possible conservation measures are discussed.

Key words: road traffic, road mortality, Amphibia, Reptilia, conservation, Srebarna, Bulgaria

Introduction

Building roads for the needs of automobile transportation greatly affects the environment (HAWBAKER & RADELOFF, 2004), because they serve as barriers or filters to some animal movement. Road width and traffic density are major determinants of the barrier effect, whereas road surface (asphalt or concrete versus gravel or soil) is generally a minor factor (FAHRIG *et al.*, 1995; FORMAN, 1995).

Existing road network with high intensity of traffic is virtually insurmountable barrier for small terrestrial animals, which include amphibians and reptiles. Particularly critical are road sections adjacent to ponds or wetlands crossed by ravines without the necessary equipment to protect small animals (BISERKOV *et al.*, 2005). A growing literature suggests that roads by wetlands and ponds commonly have the highest roadkill rates (FAHRIG *et al.*, 1995; ASHLEY & ROBINSON, 1996; VOS, 1997, CICORT-LUCACIU *et al.*, 2012). Reptiles and amphibians are among the 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).

In Bulgaria, this problem is poorly studied. With the exception of a few fragmentary reports of the road kill specimens of amphibians and reptiles in various parts of the country so far there are only two studies, which provide data on the impact of traffic on amphibians and reptiles in the city of Plovdiv (MOLLOV, 2005) and on a section of "Trakia" highway between Belovo Village and Plovdiv (KAMBOUROVA-IVANOVA *et al.*, 2012). Representative data from road sections located outside populated areas is extremely scarce.

During the period March 2002 - March 2004 in the Buffer Zone of Biosphere Reserve "Srebarna" were built two anti-fire roads from the eastern and western side of the lake in area of grasslands of semi-steppe type, typical for north-eastern Bulgaria. The aim of the constructed roads is to provide access for fire vehicles to areas in and around the reserve.

The purpose of the current study is to provide data on the impact of the road traffic and road network on some amphibians and reptiles inhabiting the buffer zone of the biosphere reserve "Srebarna" (NE Bulgaria).

Material and Methods

*Study area.*The lake of Srebarna is situated in North-Eastern Bulgaria on the right bank of the Danube River (44°05' n.l. and 27°07' e.l.) between the river kilometres 393 and 391. The total territory of the Srebarna Biosphere reserve is 902.1 ha including the shallow holo-polymictic Srebarna Lake with slightly alkaline to neutral waters and the Danubian island Devnya. The watershed basin covers area of 1,070 km^2 and is formed of the basins of the rivulets Srebrenska, Babukska and Kalnezha (MODEV, 1994).

Data collection. For purposes of the current study a series of observations were carried out in the period from March to October 2004-2006, in three road sections within the buffer zone of the biosphere reserve "Srebarna" (Fig. 1):

1. Anti-fire road in the western part of the buffer zone of the reserve (AFRBZ-W);
2. Anti-fire road in the eastern part of the buffer zone of the reserve (AFRBZ-E);
3. Section of the main road Ruse-Silistra (MRRS).

Surveying of road sections was done on foot in order not to miss any specimens. Observations were carried out mainly during the day from 9:00 am to 17:00 pm. Every recorded dead animal was determined visually using the field guide of ARNOLD & OVENDEN (2002). For each species are given a valid Latin and common name, place of death, age group (juvenile, subadult, adult). Probable date of death of recorded dead specimens was established the following way - the animals with daily activity presumed to have been killed in the day when we found them, and for animals with nocturnal activity – the day or night before. After recording each dead specimen it was removed from the road to avoid double counting.

The following measurements were taken for the studied road sections: cover type, width of the road (in meters), the volume of traffic (average number of vehicles passing per hour and average speed of passing cars) and data on climatic conditions (air temperature, cloud composition and rainfall) at the time of finding the animal (Table 1).

Statistical analysis. The differences in the number of killed amphibians and reptiles on the three types of roads were examined using t-test for independent samples. Because the data didn't have normal distribution it was normalized using the arcsine transformation (FOWLER *et al.*, 1998). The differences between the equal and the observed monthly distribution of road kills and the distribution of cadavers in relation of the climatic conditions were processed using χ^2 test. The Spearman correlation was used to find any dependence between number of killed animals and average 1-hour traffic intensity (number of vehicles per one hour) by month. For the statistical

processing of the data we used the software package "Statistica 7.0" (StatSoft Inc., 2004).

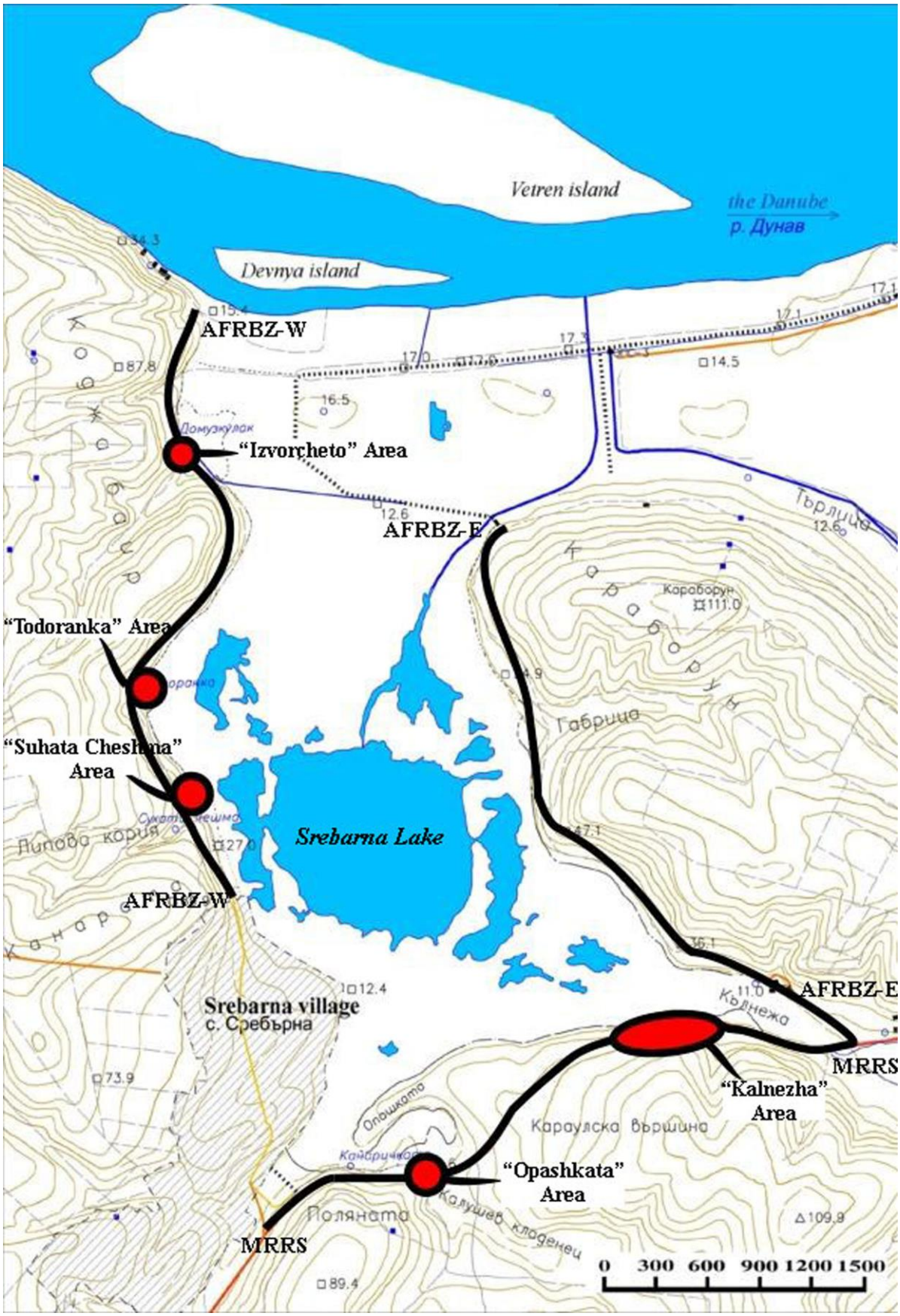

Fig. 1. Map of the location of the studied road sections in the buffer zone of Biosphere Reserve "Srebarna".

Table 1. Characteristics of the studied road sections.

Parameters / Road sections	AFRBZ-W	AFRBZ-E	MRRS
Cover type	grovel	grovel	asphalt
Width of the road (m)	4	4	6
Mean number of passing vehicles (number/hour)	1.91	1.09	63.09
Mean speed of the passing vehicles (km/h)	35	35	70

Results

The average number of recorded vehicles and other characteristics on the three types of roads for 1-hour per month during the study period is shown in Table 1. For the entire period of study in the three studied road sections a total of 15 dead specimens of amphibians belonging to 4 species (*Bombina bombina, Hyla arborea, Bufo bufo, Bufo viridis*) and 70 dead specimens of reptiles belonging to 8 species (*Emys orbicularis, Ablepharus kitaibelii, Lacerta viridis, Podarcis tauricus, Podarcis muralis, Natrix natrix, Coronella austriaca* and *Dolichophis caspius*) were recorded (Table 2).

Table 2. Distribution of the recorded dead animals by species in the three studied road sections in BR "Srebarna" Legend: t.c. – number of recorded dead specimens, %t – percentage within the class, %t.k. – percentage from the total recorded dead animals.

Species	AFRBZ-W			AFRBZ-E			MRRS		
	t.c.	*% t*	*%t.k.*	*t.c.*	*% t*	*%t.k.*	*t.c.*	*% t*	*%t.k.*
Amphibia									
Bombina bombina	2	11.11	4.08	-	-	-	-	-	-
Hyla arborea	3	16.67	6.12	-	-	-	2	50.0	6.67
Bufo bufo	4	22.22	8.16	-	-	-	-	-	-
Bufo viridis	9	50.0	18.37	-	-	-	2	50.0	6.67
Total Amphibia	**18**	**100**	**36.73**	**-**	**-**	**-**	**4**	**100**	**13.34**
Reptilia									
Emys orbicularis	1	3.22	2.04	-	-	-	-	-	-
Ablepharus kitaibelii	1	3.22	2.04	12	66.67	66.67	-	-	-
Lacerta viridis	9	29.03	18.37	1	5.55	5.55	8	30.77	26.67
Podarcis tauricus	9	29.03	18.37	-	-	-	-	-	-
Podarcis muralis	1	3.22	2.04	-	-	-	-	-	-
Natrix natrix	8	25.82	16.33	2	11.11	11.11	13	50.0	43.33
Coronella austriaca	2	6.46	4.08	-	-	-	-	-	-
Dolichophis caspius	-	-	-	3	16.67	16.67	5	19.23	16.66
Total Reptilia	**31**	**100**	**63.27**	**18**	**100**	**100**	**26**	**100**	**86.66**
Total animals	**42**	**100**	**100**	**18**	**100**	**100**	**300**	**100**	**100**

From the results displayed at Table 2 is evident that the majority of the dead animals in the buffer zone of the reserve were recorded at the western anti-fire road (AFRBZ-W) – 18 amphibians and 31 reptiles, followed by the main road Ruse-Silistra (MRRS) with 4 dead amphibians and 26 reptiles and the least cadavers were recorded at the eastern anti-fire road (AFRBZ-E) – 0 amphibians and 18 reptiles. Comparing the mortality of the amphibians between the two fire roads and the main road, no comparisons showed any

statistically significant differences (t-test, p>0,05).

We identified several areas, where regular amphibian and reptile migration on the three studied roads occur and we discovered most cadavers here (Fig. 1):

1. Anti-fire road in the western part of the buffer zone of the reserve (AFRBZ-W).

✓ "Suhata cheshma" area – a dry ravine with length of 3 km along arable land in the upper part. During the rainy season water drains through this ravine and flows into the lake. In this section of the road (located about 30 meters from the lake) there are header pipes, built in under the road, with diameter 1 m, through which rainwater drains to the lake and prevents flooding the road. This kind of set header pipes can act as ecological corridors for the amphibians and reptiles, but it seems the animals do not use them.

✓ "Todoranka" area - a dry ravine with length of 500 meters, located in acacia array. This mortality at this spot is lower, since at the upper part of the road, there are not many suitable habitats for amphibians and reptiles and the migration rate here is relatively low.

✓ "Izvorcheto" area - a dry ravine with length of 2 km of arable land in the upper part. During the rainy season water drains through this ravine and flows into the lake. In this section of the road, there are also two built-in header pipes, with diameter 1 m.

2. Main road Ruse – Silistra (MRRS)

✓ "Kalnezha" area – a small river with very low flow, which flows under the road into the southeastern part of the lake. Over the road, there are mixed tree plantations on limestone terrain that offers suitable wintering areas of amphibians and reptiles. During the breeding season, migrating to the lake, many of the amphibians are run over when crossing the road. In this section, there are no built-in header pipes.

✓ "Opashkata" area – part of the Srebarna Lake, surrounded from a small forest and arable land.

There is no correlation between the number of road-killed amphibians and reptiles on AFRBZ-E overall and average 1-hour traffic intensity by month. For AFRBZ-W we recorded a positive very strong, statistically significant correlation between the number of dead amphibians and traffic volume ($r_{Spearman}$=0.81) and low positive correlation for the dead reptiles ($r_{Spearman}$=0.34), but it was not statistically significant, so we discard it as accidental. For MRRS again we recorded a positive strong, statistically significant correlation between the number of dead amphibians and traffic volume ($r_{Spearman}$=0.67) and no correlation for the dead reptiles ($r_{Spearman}$=-0.04).

As shown on Fig. 2 the majority of the found dead animals were recorded in sunny weather at air temperature between 23-28°C (χ2=61.041, df=13, p<0.05). The species recorded in cloudy weather were *Podarcis muralis, Natrix natrix* and *Bufo bufo*. The only species recorded dead in rainy weather were *Bufo viridis* and *Natrix natrix*.

The monthly dynamic of the traffic induced mortality of the amphibians and reptiles (Fig. 3) shows that most of the cadavers are recorded in the spring time (April-May) and in the late summer – early autumn (July-September) (χ2=63.001, df=11, p<0.05).

Discussion

On the territory of the Biosphere Reserve "Srebarna" are recorded 12 species of amphibians and 15 species of reptiles (BESHKOV, 1998), which is why it is designated as important herpetological area (IHA) in Bulgaria (BISERKOV *et al.,* 2005). The registered by us amphibian and reptiles, killed by automobile traffic in the buffer zone of the reserve represent significant portion of the batracho- and herpetofauna occurring in the reserve.

The majority of the studies on the topic in Bulgaria so far show that the highest mortality among amphibians and reptiles is recorded at high intensity traffic roads (MOLLOV, 2005; KAMBOUROVA-IVANOVA *et al.*, 2012). Our results did not confirm this pattern. The reason for this is that we encountered several hot spots, where

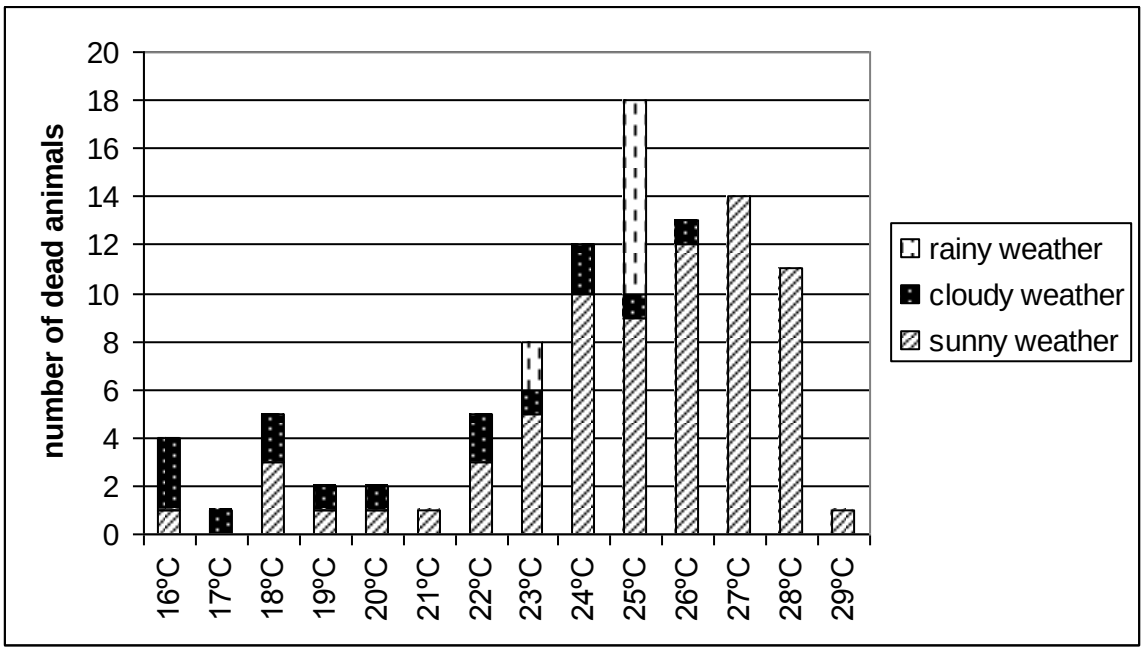

Fig. 2. Distribution of the registered dead amphibians and reptiles on the three studied roads according to the air temperature and the weather conditions.

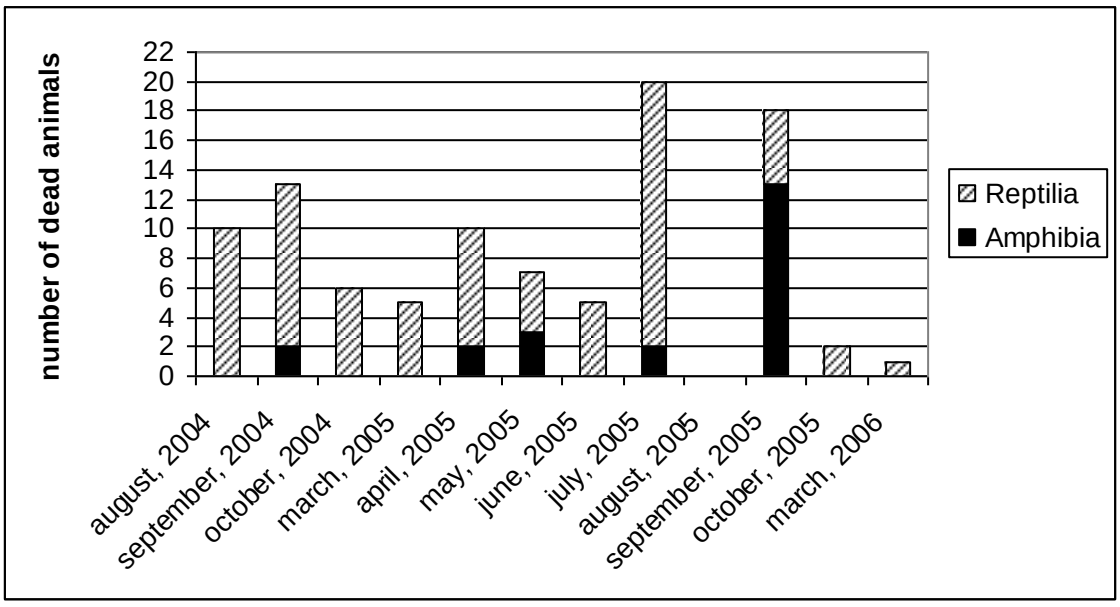

Fig. 3. Monthly dynamics of the registered dead amphibians and reptiles on the three studied roads during the whole period of study.

regular migrations of amphibians and reptiles between the lake and the surrounding terrestrial habitats occur (described in the following section). Namely on these hot spots most of the mortalities were recorded.

There are three such hot spots on AFRBZ-W, two at MRRS and none at AFRBZ-E. Furthermore, the reason for the registered low mortality at AFRBZ-E is the mounting of a barrier on this road in 2004. Only certain authorized vehicles had access to this road from that point on.

The registered by us positive correlation between the traffic volume and number of killed amphibians is reported by other authors as well. MAZEROLLE (2004) reported that amphibian road mortality correlates with the variation in traffic intensity. According to MOLLOV (2005) the amphibian mortality in the city of Plovdiv correlates with the intensity of the traffic although the author did not processed his results statistically. KAMBOUROVA-IVANOVA *et al.* (2012) on the other hand did not register any correlation between the traffic intensity and the dead vertebrate animals (amphibians and reptiles included).

Almost all reptiles, especially the lizards are more active in sunny weather and that is the reason why there are more casualties from the traffic then. However, some amphibians like the toads are active and migrating in cloudy and rainy weather and sometimes during such migrations, more casualties from a certain species can be observed. CARR & FAHRIG (2001) pointed out that another determining factor of the amphibian's road mortality rate is their agility. Ervin and Fisher (2001) showed that the climate conditions also influence the road mortality rate of the amphibians, considering the fact that they are more agile at damp weather.

Our results for the monthly dynamic of the traffic induced mortality of the amphibians and reptiles; make perfect sense since in the spring all amphibians migrate to the lake from their hibernation sites for breeding and some of the reptiles migrate in the search of food. In the autumn begins the other migration from the lake to the surrounding dry land where the hibernation sites of the amphibians and reptiles are. KAMBOUROVA-IVANOVA *et al.* (2012) reported that the highest road induced mortality in amphibians is in May and September. They also recorded an astonishing autumn migration (hundreds of road kills) of the marsh frog (*Pelophylax ridibundus*) at a second-class road near Pazardzhik town. Oddly, we did not record any dead green frogs during the current study. Perhaps the low speed of the vehicles on the studied roads and the greater agility of these frogs, compared to the toads is a factor benefiting them and leading to their survival on the buffer zone in the reserve. KAMBOUROVA-IVANOVA *et al.* (2012) also reported highest road induces mortality among reptiles in September and the lowest in July. Our results confirmed these results, be we also recorded high reptilian mortality during the summer as well. In our opinion the climatic condition in the wetland are different than the area studied by the above mentioned authors and this may lead to a higher activity among the reptiles, especially *Ablepharus kitaibelii* and *Natrix natrix*, in the buffer zone of the reserve.

According BISERKOV *et al.* (2005) one of the main priorities for the conservation of herpetofauna in Bulgaria is set out for building protective structures (fences and transient tunnels) to the road network in areas at high risk of wild land animals. It is notable that the protective fencing associated with the transient tunnels under the roads act as ecological corridors at the micro level and are an integral part of ecological networks. Moreover, in most cases there are transitional tunnels, because these are built in the construction of roads for drainage of rainwater and small streams (JACKSON, 1996), but it remains to be building the protective fences.

Such drainage pipes lie on the shores of lake at an average of about 30-35 meters, and in some places, such as at the critical points (hot spots). The pipes drain the rainwater into the lake, and usually most of the year they are dry, but during the infusion of water from the Danube River, the pipes are permanently full with water for the period from March to July, and sometimes lasting until about September. Perhaps this is the main reason why the amphibians and reptiles rarely or never use these pipes to cross the roads. A new system of conservation measures is needed to take place in the buffer zone of the reserve in near future in order to protect the batracho- and herpetofauna. Also in our opinion in the conservation management plans of the protected area and the safety measures taken for protection of rare and endangered amphibian and reptile species, the road

density and the automobile traffic should be considered as an important factor influencing negatively their populations. On the spots where the roads divide the breeding sites from the feeding and the hibernation sites, the road mortality represent a great threat to the populations of many amphibian and reptiles species.

The organization of further, more serious and thorough studies on the influence of the automobile traffic on the amphibian and reptile populations in the country is needed.

Conclusions

1. For the entire period of study in the three studied road sections a total of 15 dead specimens of amphibians belonging to 4 species and 70 dead specimens of reptiles belonging to 8 species.

2. The majority of the dead animals in the buffer zone of the reserve were recorded at the western anti-fire road (AFRBZ-W) – 18 amphibians and 31 reptiles, followed by the main road Ruse-Silistra (MRRS) with 4 dead amphibians and 26 reptiles and the least cadavers were recorded at the eastern anti-fire road (AFRBZ-E) – 0 amphibians and 18 reptiles.

3. Several "hot spots", where most cadavers were recorded, are identified – three on AFRBZ-W, two at MRRS and none at AFRBZ-E.

4. For AFRBZ-W and MRRS we recorded a positive very strong, statistically significant correlation between the number of dead amphibians and traffic volume and low and no correlation, respectively for the dead reptiles.

5. The majority of the found dead animals were recorded in sunny weather at air temperature between 23-28°C. The species recorded in cloudy weather were *Podarcis muralis, Natrix natrix* and *Bufo bufo*. The only species recorded dead in rainy weather were *Bufo viridis* and *Natrix natrix*.

6. The monthly dynamic of the traffic induced mortality of the amphibians and reptiles shows that most of the cadavers are recorded in the springtime (April-May) and in the late summer – early autumn (July-September).

References

ARNOLD N., D. OVENDEN. 2002. *A field guide to the Reptiles and Amphibians of Britain and Europe.* Harper Collins Publishers.

ASHLEY E.P., J. T. ROBINSON. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point causeway, Lake Erie, Ontario. - *Canad. Field Natur.,* 110: 403-412.

BESHKOV V. 1998. Classes Amphibia and Reptilia (Amphibians and Reptiles). In: Michev T., Geprgiev B., Petrova A., Stoyneva M. (Eds.), *Biodiversity of the Srebarna Biosphere reserve: Checklist and Bibliography,* pp. 85-86. MOEW, Co-published by Context & Pensoft, Sofia.

BISERKOV V., B. PETROV, B. NAUMOV, V. BESHKOV, D. DOBREV, D. DUHALOV, P. STOEV, K. HRISTOV, I. IVANCHEV. 2005. Conservation of the biodiversity of Amphibians and Reptiles – achievements and future tasks. In: Petrova A. (Ed.), *Current state of Bulgarian biodiversity – problems and perspectives,* pp. 283-292. Bulgarian Bioplatform, Sofia. (In Bulgarian).

CARR L., L. FAHRIG. 2001. Effect of Road Traffic on Two Amphibian Species of Differing Vagility. - *Conser. Biol.*, 15: 1071-1078.

CICORT-LUCACIU A.-S., S.-D. COVACIU-MARCOV, H.V. BOGDAN, I. SAS. 2012. Implication upon Herpetofauna of a Road and its Reconstruction in Carei Plain Natural Protected Area (Romania). - *Ecologia Balkanica,* 4(1): 99-105

CLEVENGER A., B. CHRUSZCZ, K. GUNSON. 2001. Drainage culverts as habitat linkages affecting passage by mammals. - *Journal of App. Ecol.*, 38: 1340-1349.

ERVIN E., R. FISHER. 2001. *Factors Influencing Road-related Amphibian Mortality in Southern California,* Road Ecology Center, September 24, 2001, Paper Ervin2001a. Scholarship Repository, University of California, [http://repositories.cdlib.org/jmie/Ervin2001a.]

FAHRIG L., J.H. PEDLAR, S.E. POPE, P.D. TAYLOR, J.F. WEGNER. 1995. Effect of road traffic on amphibian density. - *Biol. Conser.*, 73: 177-182.

FORMAN R. 1995. *Land Mosaic: The Ecology of Landscapes and Regions.* Cambridge, UK, Cambridge University Press.

FOWLER J., L. COHEN, P. JARVIS. 1998. *Practical statistics for field biology.* Chichester: John Wiley & Sons.

HAWBAKER T., V. RADELOFF. 2004. Roads and Landscape Pattern in Northern Wisconsin Based on a Comparison of Four Road Data Sources. - *Conser. Biol.*, 18: 1233-1244.

JACKSON S. 1996. Underpass systems for amphibians. In: Evink, G., Garrett, P., Zeigle, D., Berry, J. (Eds.), *Trends in Addressing Transportation Related Wildlife mortality, Proceedings of the Transportation Related Wildlife Mortality Seminar.* pp. 58-61. State of Florida Department of Transportation, Tallahassee, FL.

JOCHEN A., G. JAEGER, L. FAHRIG. 2004. Effects of Road Fencing on Population Persistence. - *Conser. Biol.* 18: 1651-1657.

KAMBOUROVA-IVANOVA N., Y. KOSHEV, G. POPGEORGIEV, D. RAGYOV, M. PAVLOVA, I. MOLLOV, N. NEDIALKOV. 2012. Effect of Traffic on Mortality of Amphibians, Reptiles, Birds and Mammals on Two Types of Roads Between Pazardzhik and Plovdiv Region (Bulgaria) – Preliminary Results. - *A. Zool. Bul.*, 64: 57-67.

MAZEROLLE M. 2004. Amphibian Road Mortality in Response to Nightly Variation in Traffic Intensity. - *Herpetol.* 60: 45-53.

MODEV S. (1994): Hydrological aspects of the reconstruction of the Srebarna Reserve. In: *Proceedings "Sustainable use of the land and management of water resources in the watershed of the Srebarna Biosphere Reserve"*, pp. 107-138. Silistra. October 1994, Ministry of Environment. (In Bulgarian).

MOLLOV I. 2005. A study of the influence of the automobile transport on the amphibians in urban environment. In: Yankov, P., Petrova, A., (Eds.), *Proceedings of Student Scientific Conference "Biodiversity conservation and protected territories management"*, pp. 82-88. 17.XII.2005, Bulgarian Biodiversity Foundation, University of Sofia, Faculty of Biology, Sofia. (In Bulgarian)

SMITH L.L., C.K. DODD. 2003. Wildlife mortality on U.S. Highway 441 across Paynes Prairie, Alachua County, Florida. - *Flor. Scient,* 66: 128-140.

StatSoft Inc. 2004 STATISTICA (data analysis software system), version 7. Available at: [www.statsoft.com.]

VOS C.C. 1997. Effects of road density: A case study of the moor frog. - *See. Ref.* 21: 93-97.

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