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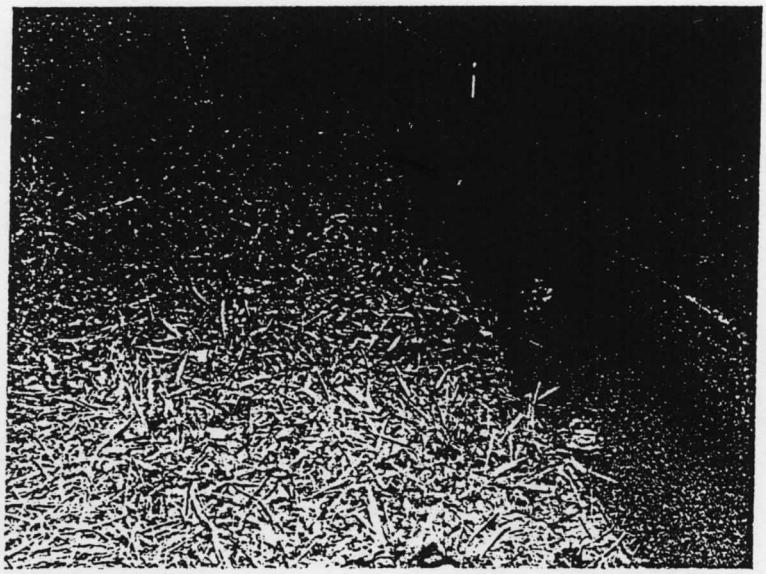

NGOs and engineers in cooperation to reduce amphibian road kills: examples, needs, opportunities and limits

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ABSTRACT
Among many other changes, the enlargement of the European Union will bring, large-scale road construction, such as the new North-South motorway connecting the North and the Adriatic Sea through Poland, Slovakia, Hungary, Croatia and Bosnia and Herzegovina, to the new EU countries and their neighbours to develop the existing infrastructure in that part of the continent. Increase in road density and traffic volume has many environmental effects from habitat fragmentation to pollution and amphibians are known to be one of the animal groups that suffer most by these changes. In Europe and North-America the revealed demographic consequences included the development of extremely unequal sex ratio, low density in the vicinity of sections with high traffic, isolation and local extinction.
Traditionally engineers and biologist cooperated on how to lessen the effect of transportation infrastructure. As a result, amphibian-oriented mitigation measures were built. Based on the fate of such constructions, however, at the beginning of the 21st century NGOs should also play an important part in this process as there is a need to improve the efficiency and increase the number of nature conservation-oriented measures on roads. Several NGOs have already gained experience with working on amphibians or road effects and a number of local groups set up temporary mitigation measures in several countries in cooperation with road authorities and national parks both in Europe and North America. Both primarily politically active and science-oriented NGOs can effectively be involved in such projects in the future due to their experience and large membership, especially in increasing awareness, making large scale road surveys and getting political support. Besides, science-oriented groups can also participate in the planning phase as well as in monitoring and even the construction of permanent mitigation measures.

INTRODUCTION

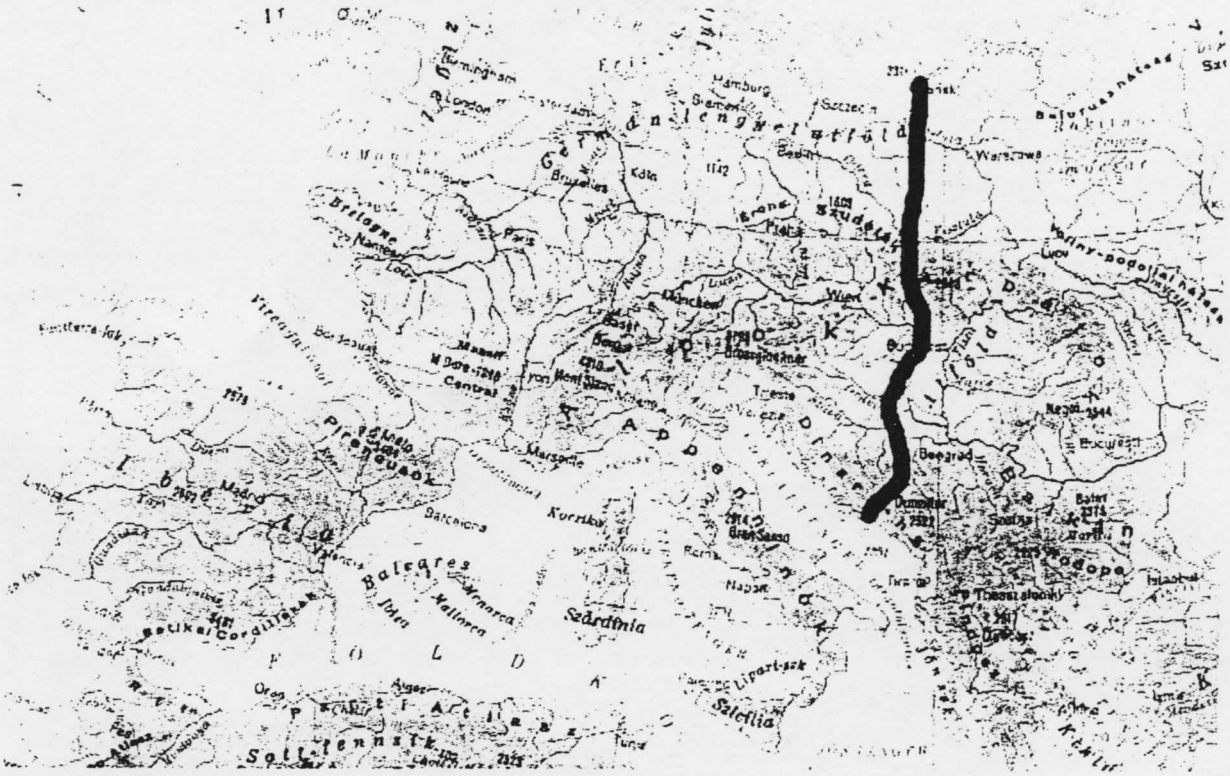
Transportation infrastructure imposes a severe impact on wildlife through e.g. land uptake and habitat fragmentation. Traffic fatalities are another obvious example, which was already noted in the nineteenth century for birds (BARBOUR, 1895). However, studies in new EU accession countries proved that in most cases amphibians are the commonest road victims among vertebrates (BARTOSZEWICZ, 1997; DENAC, 2003; FENYVES, 1989; ONUCZÁN, 1992) due to the bi-phasic amphibian life cycle and the consequent migration among the different habitat types they use. Taking into consideration that due to their size, shape and body characteristics, dead amphibians have a greater chance of being missed during vertebrate road kill surveys (KLINE & SWAN, 1998) and presumably also have a shorter duration on roads than the other groups, the actual road kill ratio is probably more shifted towards amphibians than usually described (HELS & BUCHWALD, 2001), especially if newts and salamanders are migrating (DENAC, 2003, EVANS, 1989; pers. obs.). Besides it is relatively frequent, amphibian road kill also leads to basic demographic changes such as extinction, isolation, extremely unequal sex ratio and low density in the vicinity of sections with high traffic (COOKE, 1995; CSAPÓ et al., 1989; FAHRIG et al., 1995; REH, 1989; VOS & CHARDON, 1998; VOS et al., 2001). Road kill usually causes decline together with other factors (SCHÁD et al., 1999) but even alone it can also be a very important factor. In the Karst of Trieste a considerable difference was found between the presence of *Rana esculenta* complex on the Slovenian and the Italian side (BRESSI, 1999). A factor responsible for this difference was the higher density of the road network in Italy. Though it is rather unusual, in some cases road kill can also be the single reason for decline, such as in the Austrian Alps (LANDMANN et al., 1999).

Because of construction considerations, roads are often situated along the edge of geographical features, which provide different habitats for amphibians that they use e.g. as winter hibernation site, breeding site or summer habitat. As a consequence, a seasonal migration pattern is likely to occur in such road sections that run e.g. between foothills of mountains and floodplains, along large lakes or reservoirs, etc. (RYBACKI, 1995). In other cases, roads cut the same habitat, e.g. wetlands, into smaller fragments causing road kill problems to be present as long as the animals are active. Besides ecological and conservation considerations (general decline of amphibians, protection of International Red Data Book amphibian species, etc.), it also means a hazard for motorists when amphibians migrate in large numbers.

Among many other changes, the enlargement of the European Union will bring, large-scale road construction, such as the new North-South motorway connecting the North and the Adriatic Sea through Poland, Slovakia, Hungary, Croatia and Bosnia and Herzegovina, to the new EU countries and their neighbours to develop the existing infrastructure in that part of the continent, which makes the study and mitigation of road-

related problems especially up-to-date there. Even in neighbouring countries, where the economical situation has made the buiding of amphibian tunnels impossible so far, several reports and articles deal with this issue. In Romania, for example, TÖRÖK (1996, 1998) monitored several road sections in Dobrogea and worked out possible mitigation measures from temporary closing of the road to a drift fence - tunnel system. This paper summarises the need for NGO participation in these processes.

Figure 1. Route of the North – South motorway



UP-TO-DATE STATUS AND EFFICIENCY OF AMPHIBIAN MITIGATION MEASURES IN THE MIDDLE OF EUROPE

Due to the rich natural values still maintained in the Mediterranean, the Carpathian Basin, along the Baltic coast and in adjacent areas (e.g the northeast of Poland) amphibian road kill is exceptionally intensive along several road stretches in the region, such as the 8518 road at the southern shore of Lake Fertõ/Neusiedlersee, where more than 100,000 amphibians cross roads every year (KÁRPÁTI, 1988; FRANK et al. 1991). As a result, amphibian mitigation measures were also applied along several road sections in the region. Due to economical differences, however, countries in the middle of Europe are behind Western Europe in the number of amphibian-oriented mitigation measures (LANGTON, 1989). The first amphibian tunnels were made in 1984 at Vodice in Yugoslavia (today Slovenia) in the region. However, even if ponds were also created, these elements were not joined together to make a system. As a consequence, the first year monitoring indicated little use (VIDIC, 2002).

To describe the present situation in general, results from the monitoring of thirty-one existing mitigation measures, which also included game passages, game bridges and temporary mitigation measures are summarised here. The detailed description of the sites is given by PUKY (2003).

TUNNELS

The investigated tunnels showed a great diversity in many characteristics, such as length, diameter, their connections to the fences. In spite of this diversity, there was no one way tunnel, which was often created e.g. in Switzerland till the 1980s (RYSER & GROSSENBACHER, 1989), among the investigated mitigation measures. Most amphibian tunnels have been made from concrete in the investigated countries (Potential future amphibian crossing sites utilising existing structures, however, also include some metal tunnels made e.g. at stream crossings.). It is the most economical solution and another advantage is, that making similar structures, e.g. to lead rainwater from a steep hillside under the road to a lowland area, is part of the every day engineering practice. At the same time, however, this fact can lead to the lack of consultation on making the plans or even more often on buiding the systems, which may result in inadequate solutions. Both circular and square cross-section tunnels were made in the region with the diameter ranging from 0.48 m to 1 m. They are larger than tunnels built in Lower Saxony between 1979 and 1982 (STOLZ & PODLOUCKY, 1983). It is a positive development showing that experience gained elsewhere has successfully been transfered into the region as a larger proportion of toads use larger tunnels than smaller ones (DEXEL, 1989). The accessibility of the entrance is a key issue in keeping the tunnels work, especially in areas where erosion is considerable. Where it is unavoidable and a lot of material is expected to get into the tunnels, more regular maintenance is necessary. Light shafts are applied in the region, especially at motorways, where they can be put between the sides without getting into conflicts with the traffic. A good compromise to solve this problem is to put this structure into the road shoulder instead of the middle of the road as on road 1201 in Hungary.

FENCES

Similarly to what was found in other studies (e.g. RYSER & GROSSENBACHER, 1989), fences were key elements of the investigated amphibian mitigation measures as their realisation, size, positioning and condition basicly determine the success of the system. They can be quite effective, e.g. ARNTZEN et al. (1995) found that 69% of *Triturus cristatus* could be directed by fences according to their age, migration direction, etc. Maintenance fundamentally depends on their durability as the weather or human influence can affect these elements the most, unless it is made of concrete. Four materials were recorded to use for building fences: concrete, plastic mesh, mesh wire and polythene. Concrete elements are the most durable and also need the least maintenance, however, they are far the most expensive and were installed only at

22.5% of the investigated sites. Plastic mesh fences are of medium durability and cost, while polythene fences should be built in every migration season. Nearly 20% of the cases no fences were set up, which makes the complete mitigation measure without any conservation use. The optimal height of the fences is 45-60 cm. They should be erected vertically with the bottom 10 cm buried into the ground to avoid amphibians getting onto the road under the fence. The top of the fence should be bended towards the directions animals are expected to arrive in order to prevent amphibians climbing over, as it was also suggested by HASLINGER (1989). Fixing the fence is usually done with the help of wooden poles. A potential problem with this design is that it loosens, which should be checked and repaired regularly. Plastic fences are known to need regular maintenance and repair. In Denmark BRIGGS & FRIESENVAENGE (1999) found that after a year many plastic fences were broken by erosion, people and rodents made many holes under the fence. On the other hand, an advantage of plastic fences is that they are flexible and at practically any sites their ends can be turned back to avoid fenced animals getting on the road where the fences end.

TUNNEL - FENCE CONNECTIONS, THE ANALYSIS OF THE SYSTEMS

The investigated tunnel systems considerably differed e.g. in their size, their position in relation to the road and connections between the elements. Some systems did not work because fences were missing, their orientation was inappropriate or they were in bad condition. The distance between tunnels is a key characteristic of the given mitigation measure. In this study the lowest value recorded was 40 m at Kudowa Zdrój, Poland (Not taking into consideration two sites in Hungary, where fences have never been erected, and as such, they have not functioned as amphibian mitigation measures). From a biological viewpoint, the migration radius of amphibians to their breeding site should be decisive in this matter. As amphibian species living in Central-Europe migrate 0.3 and 2.2 km on average (BLAB 1986; NÖLLERT & NÖLLERT, 1995; VERKEHRSMINISTERIUM BADEN-WÜRTTENBERG, 1991;), 80 - 100 m can be considered as optimal distance between tunnels, which is also influenced by the angle fences and tunnels meet (45 degree can be considered optimal, if it is possible to use area next to the road). Some species showed very low rate of using tunnels, e.g. only 12% of *Triturus vulgaris* (22-45% of other European species) crossed through a 0.2 m diameter polymer concrete tunnel (BREHM, 1989). As *T. vulgaris* was reported to cross tunnels in other cases, too (MEINIG, 1989), fragmentation can be compensated even with that species having a small migration radius if tunnels are nearer to each other, especially if additional habitats are made (BEKKER et al., 2001). With one exception, the distance between tunnels were within the optimal distance in the studied Central-European amphibian mitigation measures. The durability and type of tunnel - fence connections is also important. Problems in the functioning of the mitigation measures often originated from inproper guidance of amphibians into the tunnels. Similarly to what BRIGGS &

FRIESENVAENGE (1999) reported from Denmark, gaps between fences and tunnels occured at some Central-European sites with the extreme of 50 m. Naturally, the efficiency of those systems were extremely low. As other previous works, the present study also proved that amphibians crossed mitigation measures with considerably different characteristics. In case of adequate fencing and development of other appropriate conditions (JACKSON, 1996), game passages, game bridges and viaducts would also be adequate for the crossing of amphibians as well as reptiles and small mammals similarly to slightly modified existing culverts (YANES et al., 1995). Along high road mortality sections there is a chance and need for such conservation improvements (e.g. setting up amphibian fences) at several sites (e.g. on the M1 motorway in Hungary) after intensive consultation with other experts. This work is on the way on the A4 motorway in Poland (ELMEROS et al., 2003), where game bridges and tunnels were created the first time in the country in 2002 (MLECZKO-KRÓL, 2003).

SPECIES USING MITIGATION MEASURES, EFFICIENCY

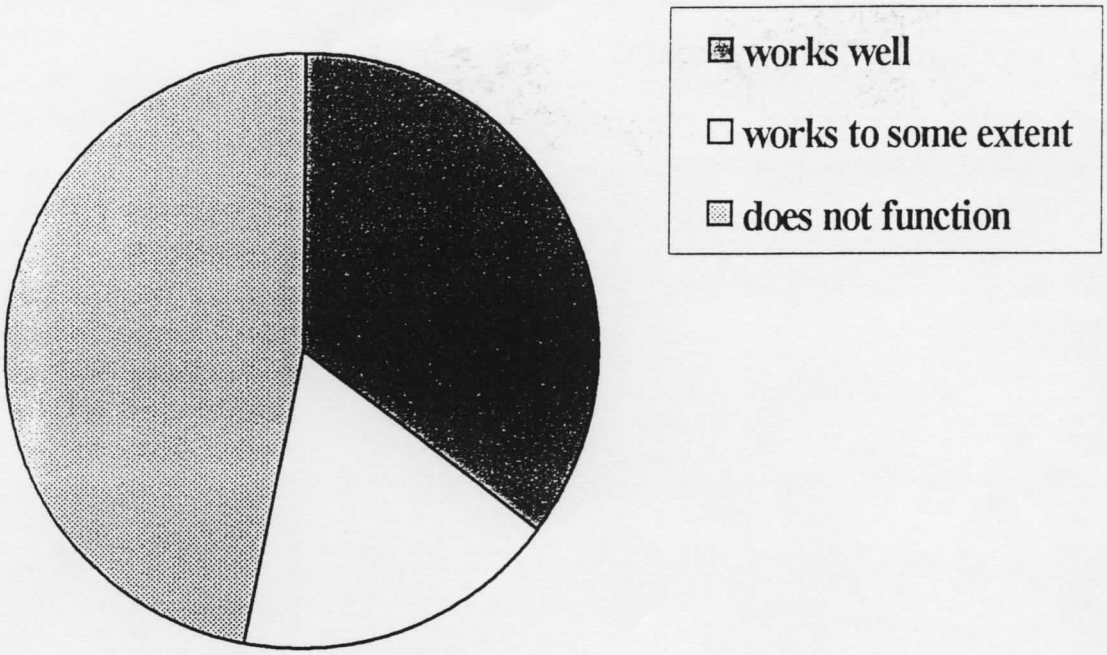
All amphibian species living in the region have been reported to suffer from road kill (BALLASINA, 1989; KÁRPÁTI, 1988; RYSER & GROSSENBACHER, 1989; SCHÁD et al., 1999; SCOCCIANTI, 2001). The investigated mitigation measures proved to help thirteen amphibian species (*T. vulgaris, T. dobrogicus, Bombina bombina, Bufo bufo, B. viridis, Hyla arborea, Pelobates fuscus, Rana dalmatina, R. temporaria, R. arvalis, R. lessonae, R. ridibunda, R. esculenta*) across the road. *Salamandra salamandra* had also been killed on the road at one investigated site, before the amphibian tunnels were built, but because of the different habitat characteristics on the two sides of the road (foothills on one side, which is the characteristic habitat of the fire salamander, floodplain on the other, where it normally does not occur) there is still no evidence that this species uses the tunnels there. Similarly to other regions, the commonest species die the most frequently. According to the local conditions, it is usually the common toad (*B. bufo)* and the agile frog (*R. dalmatina*) or green frogs (*R. esculenta* c.) and the green toad (*B. viridis)* (PUKY, 2001).

The efficiency of the amphibian mitigation measures vary greatly. Some of them provide a good corridor for local amphibian communities under the roads, others practically do not work and their efficiency is below 25% (Figure 2). At these sites problems include improper design, gaps (sometimes up to 30 metres) between the tunnel entrance and the fences or within the fence, missing fence elements, high tunnel entrances and fences overgrown by vegetation.

Most of the mitigation measures were put in good localities and they are estimated to help 1 to 5 million amphibians across roads annually. This number greatly varies between years due to population size fluctuations (considered normal within an order of magnitude) and hydrological

changes. At Lake Fertõ, for example, the number of migrating amphibians dropped from more than 100,000 (KÁRPÁTI, 1988; FRANK et al. 1991) to nearly zero following a half metre decrease in water level, which caused the lake to shrin, to the extent that the lake edge was 2 km-s from the road in 2003. As a result, amphibians hibernated between the road and the water edge and did not used the tunnels (KÁRPÁTI pers. com.).

Figure 2. Efficiency of amphibian mitigation measures in Central-Europe (after Puky and Vogel, 2004)



On the basis of the results, 22 recommendations were worked out to improve the efficiency of road mitigation measures (PUKY, 2003). The most important findings can be summarised as follows: The mitigation measure should be in the centre of migration routes. As these might change from year to year, a mid-term study with data from at least two years is needed to make final strong decisions, also taking into consideration local geographical features and hydrological conditions. Tunnels should be easily accessible and not flooded. Distance between tunnels needs to be determined on the basis of the migration radius of the target species, under normal conditions it is 80 - 100 m. Continuous fences leading amphibians to the tunnels on both sides of the road are imperative for a properly working amphibian mitigation measure. Tunnels should be cleaned every year before the migration period starts. A close cooperation between engineers and biologists specializing in amphibians is of utmost importance to find mutually acceptable solutions. Here the following two recommendations are discussed in detail in relation to NGO involvement:

21., A close cooperation between engineers and biologists specializing on amphibians is inevitable from the planning phase to the actual construction of the mitigation measure to overcome unforeseeable problems and find mutually acceptable solutions. Further negotiations among different agencies and organisations and exchange of expertise is urged in this matter nationally as well as internationally.

22., Especially if the mitigation measure is built in at a lower road, it is important to inform local people as well as the general public on the aim, benefits and functioning of the mitigation measure to get social support as at the beginning of the twenty-fist century the improvement of public relation activities on fauna passages is inevitably needed for the effective protection of wildlife on roads.

POSSIBLE ROLE OF NGOS IN THE DEVELOPMENT OF MORE EFFECTIVE AMPHIBIAN MITIGATION MEASURES

In the future a new, comprehensive strategy needs to be applied using the available regional knowledge and experience to make new, effective mitigation measures and increase the efficiency of the existing ones both on old and new roads and NGOs have an important role in this process. New projects should be at least as much based on conservation-minded planning, building and maintenance as on using more financial resources. The possible role of NGOs are summarised below.

NGOS PROTECT AMPHIBIANS FROM ROAD TRAFFIC

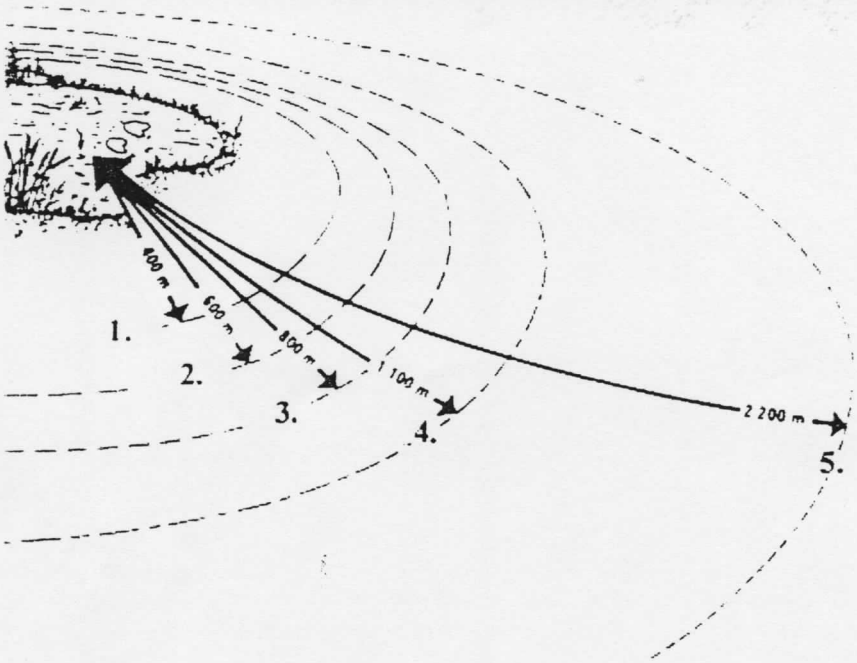
With the exception of Poland in the region, where rather national parks than NGOs make temporary protective measures usually using strong plastic material and metal poles produced by "King Frog" to set up a fence system (WISNIEWSKI, 2001), the same type of activity is rather organised by NGOs, who patrol dangerous road sections with or without fencing since 1987 in the region (PUKY et al., 1990). Different groups, such as Boy Scouts, Ornithological Societies, school groups, etc. organise these activities at sites, which are accessible and where large numbers of amphibians migrate. This activity should be continued and cooperation with the relevant authorities is to increase, e.g. by informing motorists through the radio on localities, where activists are active during the night and providing light reflecting jackets for volunteers.

NGOS BUILD DATA BASES ON DANGEROUS ROAD SECTIONS

NGOs also collect information on amphibian migration. Several international examples such as in the Upper Rhine county of France proves its efficiency. It is especially important because a lot of amphibians are killed on existing roads, also where the traffic is low. Near Szekszárd, Hungary, 100,000 juvenile *B. viridis* was estimated to be killed in summer, 1998, while migrating out from the floodplain of the Danube through a ten kilometre dike section with a traffic density of less than five cars per an hour (PUKY, 2000). As research institutes certainly do not

have the staff to make investigations in roads in such areas it is an important task of local NGOs. However, this is an area where NGOs in general should improve their methodology and data presentation as often only larger categories such as "amphibians", "frogs" or "toads" are given (e.g. CZEININGER, 1998; FENYVES, 1989; ONUCZÁN, 1992), which, even if they can be used well e.g. in comparing the ratio of casualties in different vertebrate groups, should be specified more precisely for modern road studies as e.g. the distance between tunnels should depend on the target species (Figure 3).

Figure 3. Migration radius of amphibians (after Blab, 1986)



1= Triturus alpestris, Triturus vulgaris
2= Pelobates fuscus, Hyla arborea
3= Rana temporaria
4= Rana dalmatina
5= Bufo bufo

In Hungary a long-term conservation survey has been launched with a focus on existing roads near national parks and large wildlife reserves (SIMONYI et al. 1999). Five surveys have been completed in the Danube - Ipoly, Körös - Maros, Balaton Uplands and Bükk National Parks (the latter also included the Mátra and the Eastern-Cserhát Landscape Protection Areas) and in the Zemplén Landscape Protection Area. Altogether a 1,410 km road network has repeatedly been investigated, each section for at least 1.5 years, and each amphibian crossing point was listed and categorised on the basis of a six unit scale (Table 1) according to the number of killed amphibians, estimated population sizes and traffic density. Twenty-six road sections were put into the highest

category. As a result, amphibian tunnels and fences have been built in the Ipoly valley, which also triggered the construction of temporary and permanent mitigation measures elsewhere (PUKY & VOGEL, 2001).

Table 1. Colour code developed to describe amphibian road kill characteristics

Colour code	Number of migrating amphibians	Traffic density	Amphibian road kill	Numeric code
red	high	high	large	1.
yellow	high	medium	large	2.
violet	low	low	small	3.
grey	low	high	small	4.
green	high	low	very small	5.
blue	medium	medium	medium	6.

The building up of such regional or national data bases enables NGOs to give advice, especially on existing roads, on where mitigation measures should be built. This role is also important in improving the distribution of mitigation measures within countries, as they are often unequally distributed, which is partly caused by the lack of information and conservation-minded planning.

NGOS CAN HELP AUTHORITIES IN BUILDING PERMANENT MITIGATION MEASURES

As the example of the New York State Department of Transport shows (WEISKOTTEN, pers. com.) a shared responsibility approach involving nature conservation and road authorities, NGOs and local citizens often brings the best results. Citizens and NGOs can help constructing permanent mitigation measures and this way they reduce the official cost of such installations. Such approach would be beneficial in Middle European countries, too, and NGOs should be ready to offer such help.

NGOS CAN PARTICIPATE IN MONITORING THE EFFICIENCY OF MITIGATION MEASURES

Monitoring existing mitigation measures is an important task both for the investigated sites and future projects. So far, however, only a few studies have assessed the effectiveness of road-related mitigation measures and they focus primarily on large mammals (CLEVENGER et al., 2001b). There is a lack of information in the international literature on the efficiency of amphibian mitigation measures but, for example, a lower percentage of frogs than turtles could be directed into culverts in a North-American study (ARESCO, 2003). The efficiency study of 630 badger tunnels in the

Netherlands (VERENIGING DAS & BOOM, 2002), however, resulted in very similar findings to what was presented in Figure 2., i.e. nearly half of the technical solutions do not function properly due to construction or maintenance problems. These results stress the importance of regular monitoring and skillful NGOs can play an active part in this task.

NGOS CAN EFFECTIVELY CHANGE THE OPINION OF TARGET GROUPS

It is especially needed with three target groups, decision-makers, local people and the general public (PUKY & VOGEL, 2004). In general, positive changes occurred in the approach of decision-makers, such as road builders towards wildlife mitigation measures. At the beginning of the 1990s debates often dealt with the necessity of such constructions and if they should be built at all. By the 2000s, it has rather shifted towards discussions on the number and dimensions of tunnels, how many and what size should be made to protect amphibians, which is a great step forward. However, at the latest Hungarian amphibian tunnel system on a main road in Tolna county, for example, the amphibian fence ends 15 m from a neighbouring bridge, which could have easily been used for making an ecologically better and cheaper solution. To improve the design of mitigation measures a continuous connection with engineers in needed. Local citizens, on the other hand, are especially important to get local support. Personal contacts with the target groups can best be managed with the help of conservation NGOs. Convincing people of the importance of mitigation measures along roads and encouraging them to support their local wildlife tunnels is necessary if the functioning of mitigation measures on transportation infrastructure is to be improved as at present vandalism also lower the efficiency of mitigation measures.

In summary, there is a great need for NGO participation in road-related amphibian mitigation projects. NGOs can be a great help in making large scale surveys to help focussing on the most important areas, get local knowledge inevitably needed to choose e.g. the best sites for mitigation measures. Their participation in nationwide monitoring is again an important task. Finally, they can also support nature conservation on roads by organising effective PR campaigns at the local, national or international level.

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