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Benefits and challenges of collaborating with volunteers: Examples from National Wildlife Roadkill Reporting Systems in Europe

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ABSTRACT

Daily, a large number of animals are killed on European roads due to collisions with vehicles. A high proportion of these events, however, are not documented, as those obliged to collect such data, only record a small proportion; the police only register collisions that lead to traffic accidents, and hunters only collect data on game wildlife. Such reports disproportionately under-records small vertebrates such as birds, small mammals, amphibians and reptiles. In the last decade, however, national wildlife roadkill reporting systems have been launched, largely working with citizen scientists to collect roadkill data on a national basis that could fill this data gap. The aim of this study is, therefore, to describe for the first time, existing projects in Europe, and the user groups that submit data to them. To give a deeper understanding of such projects, we describe exemplar scientific roadkill reporting systems that currently exist in Austria, Belgium, Czechia and the United Kingdom. We define groups of people who contribute to such citizen science activities, and report our experience and best practice with these volunteers. We conclude that volunteers contribute significantly to collecting data on species that are not typically recorded in official databases. To ensure citizen-science projects perpetuate, (I) volunteers need to be motivated by the organisers to participate on a long-term basis, (II) volunteers need support in identifying roadkill species where required, and (III) regular feedback is required on how their contribution is used to produce new scientific knowledge.

1. Introduction

1.1. A conflict between transportation and wildlife

Transport infrastructure density is relatively high in many European countries (Meijer, Huijbregts, Schotten, & Schipper, 2018). Moreover, as much as 50 % of the continent is within 1.5 km of transportation infrastructure, which affects natural habitats of many species (Torres, Jaeger, & Alonso, 2016). The presence of the widespread road system, as well as dense urban street networks in European cities inevitably leads to wildlife roadkill. Roadkill encompasses all animal fatalities in relation to traffic on roads. It is estimated that millions of birds are killed on European roads annually (Erritzoe, Mazgajski, & Rejt, 2003). Amphibians, due to their strong site philopatry often succumb to high roadkill numbers on roads during the breeding season (Beckmann & Shine, 2015; Glista, De Vault, & De Woody, 2008). Roads present a particular threat for species with large movement ranges, but low reproductive rates (usually carnivores), as the high frequency of road-crossing leads to a high probability to be hit by moving vehicles (Berthinussen & Altringham, 2012; Kramer-Schadt, Revilla, Wiegand, & Breitenmoser, 2004). Roads also provide feeding opportunities for birds of prey, especially owls, resulting in high mortality among some species (Bishop & Brogan, 2013).

Whilst large animals (e.g. deer spp.; wild boar, *Sus scrofa*; badgers, *Meles meles*), can cause traffic accidents by direct collision, smaller animals (e.g. red squirrels, Sciurus vulgaris; hedgehogs, *Erinaceus europaeus*; rabbits, Oryctolagus cuniculus) may cause accidents indirectly by drivers using avoidance maneuvers (Conn, Annest, & Dellinger, 2004; Rowden, Steinhardt, & Sheehan, 2008). The police often only record animal-vehicle collisions (AVC) when the outcomes are either human casualties or property damage (both vehicle and infrastructure). Indeed, from our experience, comparing the proportion of

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all AVC recorded in national police databases to data submitted to our reported systems only a small amount is captured by the former (e.g., Bíl, Kubeček, Sedoník, & Andrášik, 2017). In particular, small animals, such as birds, bats, amphibians or reptiles are not part of this potentially rich source of wildlife data. As such, there is a data gap of critical information that could inform both the public, policy makers and researchers about the numbers and diversity of wildlife killed on roads. Direct engagement of the public, as citizen scientists, in reporting AVC is one of the most promising ways to bridge that gap.

1.2. Citizen science approach

Citizen science generally refers to the active participation of people in scientific research (Bonney, 1996; IRWIN, 1995), and biodiversity recording has a wide user base in Europe, with > 70 % of projects related to the field of life sciences (Hecker et al., 2018). Citizen science has experienced an upturn in the last 10 years with hundreds of peer-reviewed articles concerning use of, or analysis of, citizen science data published annually (Bautista-Puig, De Filippo, Mauleón, & Sanz-Casado, 2019). This mode of data collection is increasingly used by environmental protection agencies (Owen & Parker, 2018). In recent years, increased efforts have been made to design citizen science projects in such a way that the data collected can also be used for political decisions (Holdren, 2015; Pocock, Chapman, Sheppard, & Roy, 2014). With the help of new technologies and their networking via the Internet, it is possible to actively involve the general public in a wide variety of research projects efficiently and without major initial barriers (McKinley et al., 2017; Schade, Tsinaraki, & Roglia, 2017; Turrini, Dörler, Richter, Heigl, & Bonn, 2018; Vercayie & Herremans, 2015). Smartphones, for example, contain many sensors, e.g. built-in GPS receiver and useful environmental data recording. Smartphone users are ideally suited to research where it is necessary to cover wide geographic areas and diverse environments, such as spatial mapping of AVC.

The topic of recording roadkill using citizen science as a data collection method is interesting on many levels. First, the financial resources and time allocation to collect data frequently (e.g., on a daily basis) over a large geographic scale are lacking at many universities and other research institutions. Second, both roadkill and living animals on roads pose considerable danger to drivers (e.g., Hothorn, Brandl, & Müller, 2012), and society therefore demands a solution to these encounters from government. Third, depending on the species, roadkill can be a threat to population viability (e.g., Jaeger et al., 2005). Fourth, the avoidance of animal suffering is of high priority.

The aim of this study is to give an overview of National Wildlife Roadkill Reporting Systems in Europe with particular focus on description of the user groups involved in data collection, and the benefits and challenges of collaborating with a largely volunteer base.

2. Examples of National Wildlife Roadkill Reporting Systems

An almost complete overview of roadkill scientific projects globally can be found at http://globalroadkill.net/. Although there are many successful projects in this field of research from around the world (e.g. California/USA, Taiwan). In this work, we focus on describing our collective experience of five selected project examples from Europe and involving volunteers in data collection.

2.1. Srazenazver.cz (Czech Republic)

Srazenazver.cz is a web-map application developed by the CDV – Transport Research Centre. The initial aim was to address traffic safety, but it rapidly expanded to also collate data on roadkill. The system is well used by members of the Czech hunting association to provide evidence of game species. An app also includes collection of roadkill data from time-limited campaigns, such as a four-year test of the efficacy of odor repellents to repel wildlife on multiple roads across Czechia (Bíl, Andrášik, Bartonička, Křivánková, & Sedoník, 2018). Data are used by students from many Czech universities for their final thesis as well as by practitioners, for example the National Road Administrator, as a basis for AVC mitigation plans.

Srazenazver.cz includes animation, based on data submitted, which is used for educational purposes to present spatiotemporal visualization of animal-vehicle collisions. AVC data enter the database from an official police crash database, whilst individual users (citizen scientists) can insert data via web browsers or a mobile application for Android devices. Srazenazver.cz contains automatic data processing such as online maps and graphs (Bíl et al., 2017). Crash or roadkill hotspots, utilizing the KDE + clustering method (Bíl, Andrášik, Svoboda, & Sedoník, 2016) are also generated online, providing visual feedback to citizen scientists.

2.2. Project Roadkill (Austria)

Project Roadkill (https://roadkill.at/en/) was founded in 2013 with the aim of collecting data on road-kill animals in Austria. The focus of the project is on non-game vertebrates, because data on killed game on roads is already available in Austria. Using standalone apps developed by the company SPOTTERON for Android and iOS smartphones or an online form on the project's website, citizen scientists report data on animals encountered as roadkill. The citizen scientists help to check data quality by verifying newly uploaded data and commenting on each entry (e.g., advanced participants can help new participants identify species). To date, three Master-thesis, one PhD-thesis and three peer-reviewed articles have been published on the project (Heigl & Zaller, 2014; Heigl et al., 2016; Heigl, Horvath, Laaha, & Zaller, 2017).

2.3. Animals under wheels (Flanders, Belgium)

The Flemish roadkill monitoring project, 'Dieren onder de wielen' (accessible through dierenonderdewielen.be, literally translated as 'Animals under wheels'), is – as far as we know – the longest running roadkill monitoring project with citizen scientists in the world. It is based on the website waarnemingen.be (the Belgian version of observation.org) where anyone can enter observations of any animal, plant or fungi. Observations of roadkill can be registered on the website or via the associated apps ObsMapp (Android) or iObs (iOS). To allow for more in depth analysis the possibility to monitor transects was added to the website in 2014. Fixed transects can be adopted, although this is not popular, or users can register their own fixed transect (e.g. home - work itinerary) that they monitor on a regular basis (which is comparatively successful). Since August 2018 a more flexible way of search effort registration was added: both apps allow the user to register a route, using a start/stop time and date with a simple start and stop button. This way the user can monitor roadkill everywhere they go, at any time with a minimum of effort, but gaining maximum information on presence *and absence* of roadkill. Since 2015 it has been possible to register roadkill through a single tap on a button and some voice commands (name of the species) in the app 'ObsMapp', allowing drivers to record data safely while driving (Vercayie, Herremans, & Kwak, 2018). Hands-free use of smartphones is allowed in Belgium whilst driving, however, country specific regulations should be checked before using this function in other countries.

2.4. Project Splatter (United Kingdom)

Project Splatter, **S**ocial Media **PLAT**form for **E**stimating **R**oadkill, – (https://projectsplatter.co.uk/) is a citizen science roadkill reporting scheme, based in the UK, run at an educational and research establishment (Cardiff University). Established in 2013, volunteer participants are encouraged to use social media, Apps, or a web form to submit ad-hoc sightings of any wildlife roadkill at any time period of the year. The project aims to identify both spatial and temporal

hotspots of wildlife roadkill, as well as raising awareness of the impact roadkill may be having on species of conservation concern. Just over 50 % of data reports are submitted via an App (Android or iOS), proving it to be the most popular route for data submission. Engagement with the citizen science community is carried out via social media, with weekly 'roadkill reports' providing details of what species have been recorded, and by whom.

2.5. Birds.cz (Czech Republic)

Birds.cz is an online database managed by the Czech Society for Ornithology (https://birdlife.cz) with the aim to collect and manage data about Czech avifauna. Registration of users is mandatory, but no biological background is required. Birds.cz includes a range of specialized modules (monitoring of stork nests, breeding categories, yellowhammer voice recordings, bird ringing data collection, standardized monitoring along transects, etc.). Status of the bird, as well as detailed data (sex, age, moult) can be recorded, including the following four categories, relevant for the topic of animal-vehicle collisions – found dead on road, found dead on railway, found injured on road, found injured on railway. Users can collect data using a web browser or mobile app (Avif Mobile). All data about roadkill (or road-injured) birds are provided through an automated feed to Srazenazver.cz. This feature presents an interesting example of how two separate citizen-science projects can coexist. Automatic scripts detect at midnight every day data which include an attribute of dead or injured bird, and sends the selected records to Srazenazver.cz.

3. Collaborating with various target groups in scientific roadkill data collection

3.1. Groups involved in National Wildlife Roadkill Reporting Systems

We describe below specific groups of people who are adding data to roadkill databases. Volunteers for a National Wildlife Roadkill Reporting System usually meet some the following criteria: they are (I) road-users, (II) have an interest in animal welfare, nature conservation or road safety and (III) have access to internet or a smartphone. In Europe 76 % of the EU-28 adult population uses the internet on a daily basis (Eurostat, 2019), additionally almost everybody uses mobile phones for communication and therefore could potentially contribute to roadkill monitoring projects and become a citizen scientist.

3.1.1. Environmentalists

This group of people usually do not have a fixed area in which they are working, perhaps with the exception of employees of natural parks or large-scale protected areas. Many of them are involved in NGOs focused on nature protection. In general, this group report animal distribution data frequently, and roadkill is no exception. This group is also often highly skilled in species identification, and can provide professional insight to citizen science programs if given the forum to do so, for example via social media. Since the main motivation of many users in this group is wildlife protection, species with higher conservation status might be over-represented compared to common species. Field activity of this group of users often corresponds with periods of fair weather, since data collection is often a side-activity during field trips or leisure and is not part of user's job or duties (as is the case for police, road crew and hunters); as a result, there may be significant temporal bias in data reporting.

3.1.2. Hunters and gamekeepers

Hunters and hunting-area administrators usually only report roadkill within their hunting grounds, seldom adding data outside their areas of interest (Bíl et al., 2017; Heigl et al., 2016). Additionally, bias may exist in reporting effort due to the fact that any roadkill reported animal will reduce the hunting bag allowed. National legislation in many European countries (e.g. Czechia), will lower the number of game that can be shot if many are lost as roadkill, such that hunters may be motivated to not report data. Moreover, hunters are generally mainly interested in game species and are less inclined to put effort in monitoring of non-game species.

3.1.3. Road maintenance crews

Road maintenance crews have to, as a part of their occupation, clean roads, road shoulders and road verges from all objects which could influence traffic safety. They are therefore among the first who encounter roadkill. Only a few published papers mention this group of people as being successfully engaged in roadkill reporting (e.g., Shilling & Waetjen, 2015). Often the data collected have been reported to the local authority by a member of the public, and the accuracy is high as the aim is for the authorities to find and remove the carcass that may be causing an obstruction. Project Splatter, in the UK, has obtained over 15,000 wildlife roadkill reports after requesting local authority data.

3.1.4. Police

Another non-voluntary group of reporters constitute the police. Whilst they report accidents with animals to national traffic accidents databases species are seldom identified. On the other hand, police databases are usually spatially homogenous, but they logically miss all roadkill that did not cause a traffic crash, and there are, of course, an unknown portion of traffic crashes involving wildlife which were not reported for various reasons.

3.1.5. Drivers

Many drivers and their passengers can be part of any of the above and below mentioned groups. Typically, data is recorded by a passenger as using a phone whilst driving is illegal in many parts of Europe and many other countries. Some novel approaches were recently developed to help drivers or passengers to add data from moving vehicles, e.g. input by voice recognition in the apps 'ObsMapp' (associated with the observation.org group of nature data portals) (Vercayie et al., 2018) and 'Avif Mobile'.

3.1.6. Commuters

This group includes both drivers, but also bus and car passengers and cyclists who commute a *regular* route. Their data can be used for analyses of both spatial but also for temporal evolution of roadkill as they can be considered as "structured" (i.e., presence/absence data) instead of "ad-hoc" observations. Some projects (e.g. Animals Under Wheels, Belgium) reach out to commuters to monitor their home to work route on a regular basis or offer adopting a chosen road. Indeed, certain modes of transport are well suited for collecting roadkill data (see www.sciencebybike.com).

3.1.7. Inhabitants of cities

Towns and cities have specific environmental conditions which favor existence of certain species. A typical animal which is frequently reported as a roadkill in cities in Western and Central Europe is the European hedgehog (*Erinaceus europaeus*). Roadkill reporting is possible by drivers due to the congested traffic, but also by passengers or pedestrians from sidewalks.

3.1.8. Students

This group includes children from elementary schools up to university students. Certain citizen science activities are suitable for young children, but roadkill reporting is not so attractive and for safety reasons the focus of young children on roads should be on traffic. High school and university students are often interested in protection of the environment and thus they are an ideal group to become volunteers (Heigl & Zaller, 2014). Project Splatter, based in Cardiff University, and project Roadkill, based at the University of Natural Resources and Life Sciences Vienna provide opportunities for final year students to carry

out their research dissertations using the citizen science collected data (e.g. https://roadkill.at/en/successes/master-theses). Indeed, both projects were initiated by an undergraduate student.

3.2. How do the data differ with regard to the groups?

It is useful to target different user groups to become citizen scientists in a roadkill monitoring project, because their submitted data can differ. For example, analyzing data from Srazenazver.cz we find the police registered mainly large mammals and domestic animals (e.g. dogs) while volunteers registered carcasses of a wide variety of wild species. Certain species were only registered by volunteers, for example all amphibians, reptiles, the majority of birds, and small mammals (Bíl et al., 2017). Similarly, spatial bias can occur due to user group; hunters report mainly from their hunting areas and from low level roads, whereas citizens reported mostly in sub-urban areas and high level roads (Heigl et al., 2016).

3.3. Spatial and temporal accuracy of volunteer data

Traffic accidents attended by the police are often accompanied by accurate GPS position and time in European countries, therefore having high spatial and temporal accuracy. Records reported by volunteers, however, can be geographically restricted, with data lacking in very rural areas with few observers. The contrast with police data is they will record wherever an accident occurs. Therefore, nation-wide or even regional geographic analyses can seldom be based solely on volunteer data, so lacking spatial and temporal homogeneity.

The temporal part of data is often not accurate beyond a given day for citizen science submitted data. The majority of wildlife vehicle collisions usually occur during the night, between sunset and sunrise (e.g., Bartonička, Andrášik, Duľa, Sedoník, & Bíl, 2018; Kruuse, Enno, & Oja, 2016), when there is considerably lower traffic volume than during the day. Reporters thus often find carcasses which were killed many hours before. On the other hand, the number of unreported cases is high for small animals, as within a few days or even hours they are scavenged or flattened by traffic to an unrecognizable state (Ratton, Secco, & Rosa, 2014; Santos & Ascensão, 2019; Santos, Carvalho, & Mira, 2011; Schwartz, Williams, Chadwick, Thomas, & Perkins, 2018; Slater, 2002). Some volunteers tend to be more active during weekends (also see Courter, Johnson, Stuyck, Lang, & Kaiser, 2013). Higher volunteer activity during summer months, can lead to over-representation of certain species as their number on the roads for is highest during spring and summer (due e.g. to juvenile dispersal, which constitutes a substantial proportion of AVC, i.e. for birds (Erritzoe et al., 2003)).

3.4. Species identification

The species knowledge of participants is very different and is influenced by their background. Users with biological or environmental background and hunters are often able to correctly identify species, age and sex of animals, while the latter (age and sex) is seldom provided by other groups. Moreover, most databases do not allow for storing of detailed biological information beyond species. Therefore, information on the age and/or sex of game species is not reported by hunters, even though they could often provide it. Due to rapid degradation of carcasses (Erritzoe et al., 2003), it is often difficult to identify small species.

In order to increase data quality in terms of species identification project Roadkill (Austria) profiles the different animal species that are killed on roads most frequently on their website. In addition, there is the possibility for any individual to comment on any entry via the app (which is also possible in birds.cz database), for example if a photo is uploaded, and the species identification given by the submitter is incorrect. This approach is very well accepted by the participants and so species knowledge is passed on to new participants or the project team is supported in checking the data quality by reporting wrong entries.

3.5. Number of users and their observations

The number of observations per participant varies considerably, a common feature of all citizen science projects, that generally corresponds to the 90-9-1 rule (Haklay, 2018; Nielsen, 2006), where 90 % of the participants provide no to very little data, 9 % provide data now and then and 1 % provide data frequently. As of August 2018, some 4,255 unique observers added one or more observations of 321 different species, adding up to a total of 83,847 observations of roadkill in Flanders (northern part of Belgium, 6.5 million inhabitants, 13,521km^2). With a mean density of 6.2 roadkill per square km or 1.7 per km of road it is probably one of the densest datasets of roadkill gathered solely by citizen scientists in the world.

Concerning 'Project Roadkill' (Austria), more than 650 participants reported more than 10,000 vertebrates since 2013. Srazenazver.cz had 573 unique users (in March 2019) and 339 of them (59 %) added at least one record. The majority of records - 59,074 were added by Police (80 %), however. The largest group of volunteers were hunters and gamekeepers. In the UK between 2013 and March 2019 Project Splatter (UK) has received over 60,000 roadkill reports, from 1,941 individual participants. Whilst some volunteers have remained with the project for many years the mean duration of time spent interacting with the study is 164.20 days ± 8.47. Over half of participants (51.4 %) report for just one day, with 11 % reporting over 10 times, and a small minority participating over a long time period.

Birds.cz currently contains nearly 3000 records of birds killed or injured by transportation since 2011. Only 86 4 % of users recorded a roadkill bird from 2069 users who added at least one record in 2018. The total number of users, who recorded data since 2011, was 230. The majority of roadkill data comes from a small percentage of users, however. Some 50 % of records was added by just 5 users (2 % of all users), whilst 90 % of records was attributed to 28 % of users.

3.6. Focus species

Data submitted by volunteers who only occasionally register roadkill can be biased towards observation of larger or more notable (e.g. rare) species (otter, *Lutra lutra*; polecat) and more common or 'pest' species (e.g. brown rat, *Rattus norvegicus*) may be under-represented, when compared to data gathered by volunteers carrying out more standardized route counts where all species are recorded.

4. Benefits and challenges of working with various target groups

4.1. Expected impact of work conducted by volunteers

Many citizen science projects are solely scientific. Roadkill topic projects rank, however, among those which are of wide public interest. Road administrators can, for instance, obtain valuable information about locations with high roadkill rates (hotspots) which may be closely related to places of traffic safety concern.

Project Roadkill (Austria) established partnerships with NGOs, which use the collected data to identify hotspots of amphibians to set up new temporal mitigation measures (e.g. amphibian fences). In Belgium the same is done within Natuurpunt, the nature conservation NGO running the roadkill monitoring project. At the same time this NGO collaborates with institutions from the Flemish government to produce in depth analyses of roadkill hotspots. In the UK, Project Splatter has provided data and analyses for the Highways Agency to assess the feasibility of road mitigation to reduce wildlife roadkill. Those projects that work closely with local government and NGOs to communicate their results back to the public regularly will likely have the greatest impact. Two of the biggest advantages of carrying out roadkill monitoring with citizen scientists are the possibility for scientists to gather

data over a wide geographic area and simultaneously raise awareness about the impact of roads on animals.

4.2. The challenge of developing a user community and keeping volunteers engaged

Long term activity is a big challenge for any citizen science project and organizers must innovate to keep volunteers engaged after the first wave of promotion and excitement about the new project has passed (Silvertown, 2009). In general, for citizen science projects, initial motivations include "contributing to scientific research" (Forrester et al., 2017; Jennett et al., 2016; Nov, Arazy, & Anderson, 2011; Raddick et al., 2013), enjoyment (Eveleigh, Jennett, Lynn, & Cox, 2013); Forrester et al., 2017) and an interest in the science (Buesching et al., 2015; Eveleigh et al., 2013; Frensley et al., 2017; Raddick et al., 2013).

Feedback, personal recognition and a project's positive effect on the community are thought to promote retention. However, participants leave a study due to lack of social interaction, difficulties working online, and no obvious 'real-world' benefit to the study (Frensley et al., 2017). Additionally, lack of time can cause participants to leave or contribute less (Frensley et al., 2017; Jennett et al., 2016). Community feedback is a crucial aspect of any citizen science program, and online projects can readily provide such feedback. For example, Project Splatter, in the UK, provides a weekly report on which species have been seen that week, and who the top reporters are, whilst *Srazenazver.cz* provides real-time feedback via their web-based maps and graphs.

In principle to engage in a roadkill monitoring project the participants should be able to determine species of vertebrates. Species identification is complicated by the fact that animals killed on roads may look considerably different compared to animals that died of other causes. But this issue can be addressed in several ways. Firstly, participants can be educated to improve their identification skills. E.g. Project Roadkill (Austria) is working on an online identification guide of roadkill animals to help new participants (https://roadkill.at/en/profiles) and in Belgium the same NGO coordinating the roadkill monitoring project also educates its volunteers through nature education courses. Secondly, data can be checked during or after registration by different validation mechanisms, e.g. the Austrian project is conducted directly by the Institute of Zoology in order to easily access the zoological knowledge needed to identify the reported animals of different animal groups. On the Belgian website records which have a photography included can be checked, when necessary, by a team of 56 volunteer mammalogists, herpetologists and ornithologists.

4.3. Limitations and barriers to volunteer involvement

Several issues are related to the direct involvement of volunteers in roadkill reporting. We identified potential application misuse, erroneous species identification, concerns of personal safety and lack of enthusiasm as risks to projects. Potential application misuse was sometimes considered as an issue, particularly when roadkill reporting is not restricted to already registered users. The projects mentioned require usually a registration via an e-mail. Then a user is allowed to enter data which are then linked to respective e-mail addresses, so possible fraud users can easily be blocked. Moreover, using e-mails as a minimal link to the identity of a data contributor allows for the app administrators to be able to contact the observers if needed in the validation process. Other applications are, however, fully opened to everyone. Potential misuse is partially limited if photographs are required alongside a record.

Certain barriers which limit full public engagement to roadkill reporting still exist. Personal safety of citizen scientists is of concern when they are engaged in roadkill data collection. Reporting roadkill along rural roads is a dangerous activity if reporters are walking on the side of the road. Personal protective equipment (e.g. safety vest) should to be worn. Personal safety and a liability for citizen science project managers over safety of contributors could present a limit to conduct the roadkill data gathering. The situation is much more optimistic, in this view, when data are reported within urban areas.

5. Conclusions

Roadkill reporting systems are tools which have the potential to engage active citizens and to help to increase public participation in both traffic safety and nature conservation. Widespread use of smartphone technology, mobile apps and social networks allow incorporation of the public into research and traffic safety practices. We described five concrete examples of how citizens are currently involved as volunteers in both research and practice related to roadkill. Data, collected by them help professionals (e.g., traffic safety experts, conservationists, and biologists) study the impacts of roads on wildlife and how and where to mitigate this impact.

We conclude that the role of volunteers in this kind of research is positive, in general, as the records collected help to gather data on species which are commonly omitted in official crash databases. Volunteers, however, need to be motivated by the organizers to stay with the project, they must have support concerning species identification, if necessary, and feedback that their input is very valuable and appreciated must be provided.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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