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Research article

# Wildlife-vehicle collision liability in Europe: A review of existing approaches and their implications

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ABSTRACT

We present an overview of wildlife-vehicle collision (WVC) liability covering 36 European countries. We reviewed approaches to WVC liability which are currently in effect across Europe and their potential consequences for WVC reporting. To obtain relevant information, we conducted a survey, including a web-based questionnaire. We retrieved answers to questions related to human fatalities from WVC, the existence of WVC databases, roadkill data systems and recommendation for drivers in the event of WVC.

In 19 countries, no one is liable when a motorized vehicle collides with a wild animal. In the remaining countries, road managers or road owners may be liable as well as drivers or hunters, either consistently or under certain conditions. Liability can, in some countries, be changed after a legal assessment. Human fatalities due to WVCs have been reported in 27 countries, with approximately 90 deaths annually across European roads. The number of injured people and estimates of socio-economic losses were not possible to obtain at a European level as many countries lack reliable databases.

We discuss how existing WVC liability across countries provoke some actors to transfer liability to another actor or avoid reporting these incidents altogether. WVC underreporting in certain national databases is one of the consequences of the existing WVC liability rules in the given countries. This fact reduces the potential to identify hotspots and define appropriate mitigation measures. In conclusion, we propose several procedures for modifying WVC liability that could enhance wildlife protection and road safety.

## 1. Introduction

Wild animals die or are injured on roads in high numbers every day. As many as 194 million birds and 29 million mammals may be killed each year on European roads (Grilo et al., 2020). Traffic accidents involving wild animals are called wildlife-vehicle collisions (WVC). Concerning WVC with large vertebrates, the most frequently reported species in Europe are wild ungulates, specifically roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*) (Langbein et al., 2011; Rodríguez-Morales et al., 2013; Kučas and Balčiauskas, 2020; Mayer et al., 2021). Wild ungulates as well as some medium-sized animals (e.g., the European brown hare (*Lepus europaeus*), European hedgehog (*Erinaceus erinaceus*), mesocarnivores such as the red fox (*Vulpes vulpes*) and the European badger (*Meles meles*)) are among the most visible victims of vehicle-animal encounters. High numbers of WVC in Europe reflect dense road networks and a traffic of a certain critical intensity (see Seiler, 2005; Seiler and Helldin, 2006; Thurfjell et al., 2015; Bíl et al., 2020a), but also partially increasing wildlife populations (Linnell et al., 2020; Valente et al., 2020; Carpio et al., 2020; Mayer et al., 2021). As an example, wild boar populations have been increasing in numbers across Europe since the beginning of the 1980s (Massei et al., 2015; Náhlik et al., 2017; Tack, 2018).

The smaller the animal, however, the lower the chance that such a collision will negatively affect the vehicles and their passengers. Thus, such incidences are less likely to be reported by drivers. Drivers' manoeuvres to avoid collisions, even with smaller wildlife, may result, however, in a crash with other road users, objects or trees (e.g., Williams and Wells, 2006; Rowden et al., 2008; Balčiauskas et al., 2024; Bíl et al., 2024) and may hence not be attributed to wildlife but registered as a regular road accident (Seiler and Jägerbrand, 2016). Thus, the likelihood of WVC to be reported and registered as such is subject to a variety of factors and will differ between species and countries.

In this work, we distinguish between 'WVC' and 'Roadkill', by referring to 'WVC' as an event when a vehicle (usually a motor vehicle) collides with a wild animal. As a result, the animal dies, but it can also leave the scene injured and die later (Jung et al., 2024). The number of all WVC that are recorded in national databases varies and can depend on wildlife species (Bíl et al., 2017; Shilling et al., 2020), the degree of vehicle damage and whether humans were injured (Seiler and Jägerbrand, 2016). 'Roadkill', on the other hand, is defined as a dead animal, killed by a vehicle, and typically found at or near a road. Roadkill is usually (but not exclusively) a small animal which was killed without causing any significant vehicle damage (Fig. 1). Large animals can also be found, however, dead on roads. In the case of smaller animals, the vehicle damage (if any) is likely not reported to a WVC database and therefore no record of the incident exists.

WVC, particularly those resulting in vehicle damage or passenger injuries, are often reported to the authorities (Conover et al., 1995; Pynn and Pynn, 2004; Huijser et al., 2008; Langbein et al., 2011; Jakobsson et al., 2015; Meister et al., 2016; Balčiauskas et al., 2024). They also pose significant liability issues (Abra et al., 2019) as it is not always evident who should be responsible under concrete circumstances for WVC. While liability for traffic accidents as well as collisions with domestic animals is usually well established from traffic regulations, the situation with WVC is different because wild animals are involved and hence a different group of actors (apart from drivers and road authorities and managers, also hunters, wildlife agencies, managers of natural areas, municipalities, etc.).

The objectives of this study are to (1) analyse current WVC liability approaches across Europe, (2) compare practices related to WVC liability among countries, and (3) discuss how these practices could influence the behaviour of drivers and other actors involved.

## 2. Data and methods

In the first phase, a team of co-authors was assembled, consisting of respondents who represented their respective countries or specific regions and states. These individuals had the required knowledge about this issue and were willing to confirm the validity and completeness of the information. At the same time, they were also willing to contribute to the development of the publication. They were either academics conducting research in zoology, geography, and wildlife ecology or practitioners with a background in game management.

To obtain structured answers on the WVC liability approaches across Europe, a web-based questionnaire, via Google Forms, was prepared. The questionnaire is accessible at: https://forms.gle/7hjWKYW7vs7Yuhbf9. For the full version of the questionnaire, see Appendix A. The questionnaire included questions about differences in WVC liability, followed by questions on WVC and roadkill data collection. It also explored the responsibility for WVC data collection (e.g., police, road

administrators or hunters), whether there are any volunteer applications to collect data in the given country, or if any unique circumstances exist. The questionnaire further contained questions about recommended procedures when WVC occur, quantification of damages, and possible compensation.

In general, the structure of the data requested was as follows: 1) animals involved and passenger fatalities from WVC, 2) WVC liability, 3) vehicle damage compensation, and 4) information on WVC and roadkill databases.

After completing the first phase of the questionnaire survey, the team carried out internal discussions in order to revise the responses and further clarify differences in approaches to this issue. Since some countries have certain regional specifics, they were represented by more than one contributor (Germany, Italy).

## 3. Results

Representatives of 36 European countries joined this study and responded to the questionnaire. Due to the differing levels of WVC and roadkill data recording and the absence of these systems in certain regions, some responses were incomplete.

### 3.1. Animals involved in WVC and human fatalities

The most frequently reported animals involved in vehicle collisions were ungulates, primarily roe deer. In some countries, also wild boar (e.g., Spain) and white-tailed deer (*Odocoileus virginianus*) (Finland) were reported as the animals most frequently colliding with motor vehicles. In certain countries with a lower abundance of ungulates (i.e., Greece, Portugal), mesocarnivores were found to be the most frequent victims of collisions with motor vehicles. It should be noted that the absence of a country-wide WVC database (or a traffic collision database where animal species are specified, see below) in certain countries means that the information about the species was only based on the respondents' assumptions and could not be independently verified.

Human fatalities resulting from WVC have been reported from 27 out of 36 (75 %) European countries. In 21 cases, these claims were based on data from official sources (e.g., police, hunting association, road administration). It was only estimated or inferred from media information for the other countries since reliable or accessible data sources were missing (Table 1). As a result, information on human injuries from WVC was even more problematic to obtain during this survey.

### 3.2. WVC liability and compensation

In 19 countries (Albania, Austria, Belgium, Bulgaria, Czechia, Denmark, Estonia, Finland, Germany, Ireland, Latvia, Luxembourg, Moldova, Montenegro, Netherlands, Norway, Portugal, Slovakia and the United Kingdom) no one is liable for a WVC incident. In Switzerland, a driver who hits an animal is liable and must report wildlife collisions. Liability for vehicle damage is usually handled through insurance. In Serbia, the hunters and hunting ground managers are liable but only in case of game species. In Italy and Slovenia, road managers may be held liable for WVC.

Representatives of 14 out of 36 countries (39 %) indicated that WVC liability within countries differs according to certain factors, such as the presence of wildlife warning signs and wildlife fencing, road class, road owner, driver compliance, the animal species involved, hunting activity or where WVC occurs, i.e., inside or outside a protected area, depending on who is responsible for wildlife management. These countries include Bosnia and Herzegovina, Croatia, Cyprus, France, Greece, Hungary, Italy, Kosovo, Lithuania, Poland, Romania, Slovenia, Spain, and Sweden (see Table 2).

The difference in WVC liability according to road class (Table 2) reflects the special status of motorways, which are usually fenced. The 'road owners' group also includes companies holding concessions for managing toll motorways. The 'Driver law compliance' group covers situations where drivers collide with animals while speeding or driving under the influence of alcohol or drugs. Differences in WVC liability based on animal species reflect the fact that hunters are liable only for hunted species, and sometimes only during the hunting season. In Lithuania, additional responsibility is assigned to the driver if the WVC involves a protected animal.

Exceptions from the WVC liabilities stated above have also been reported from a number of countries. These cases always involve the participation of a court. For example, in the Netherlands, where a liability claim may be sustained if it can be assessed whether there has been a breach of contract by the road infrastructure manager or whether the driver concerned could reasonably have prevented the WVC. Hunters were sometimes also found liable at court in Romania (e.g., Tribunalul Olt, 2020) or Czechia (Vindicia, 2023).

#### 3.2.1. Compensation claims

In certain countries (e.g., Bosnia and Herzegovina, Serbia, and Switzerland), hunters can be compensated when game animals are killed by motor vehicles on roads. In Hungary and Slovenia, drivers should by law compensate the hunters if they were at fault for the accident, e.g.,

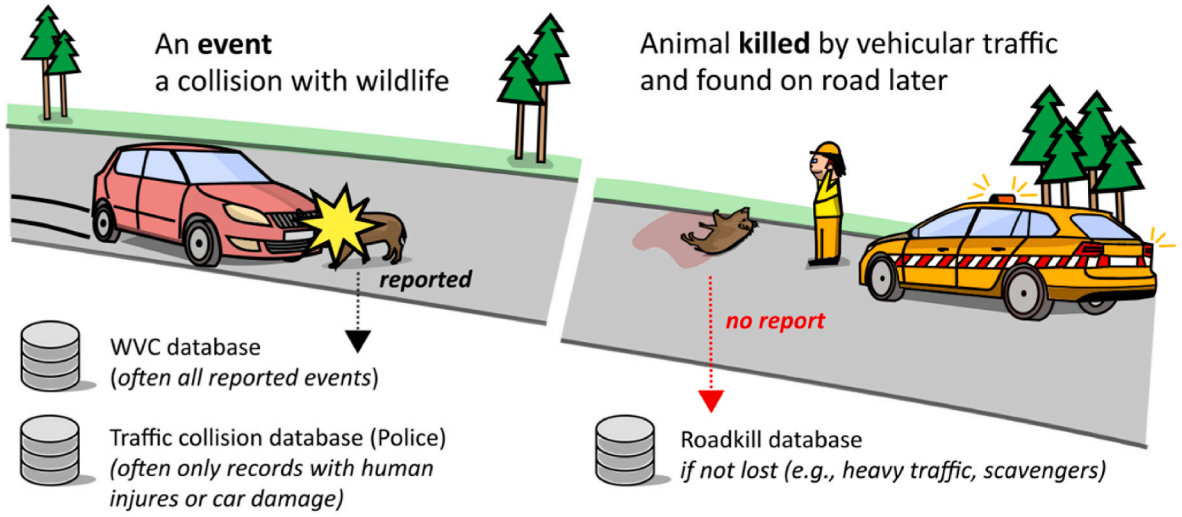


**Fig. 1.** An explanation of the differences between WVC and roadkill and the three types of databases used: traffic collision, WVC and roadkill.

**Table 1**
Human fatalities due to WVC per country.

| Country | Are there human fatalities from WVC? [a] | How many on average per year? | Data source [b] |
|---|---|---|---|
| Albania | N/A | – | Media |
| Austria | Yes | 2 | Austrian Road Safety Board |
| Belgium | Yes | Less than 1 | AWSR/Stabel (DG Statistiques - Statistics Belgium) |
| B&H | N/A | – | – |
| Bulgaria | Yes | 1 | Police |
| Croatia | Yes | Less than 1 | Croatian Hunting Assoc. |
| Cyprus | No | – | Police |
| Czechia | Yes | Less than 1 | Police (https://nehody.cdv.cz/) |
| Denmark | Yes | Less than 1 | Danish Road Directorate |
| Estonia | Yes | Less than 1 | Estonian Police and Border Guard Board, Estonian Transport Administration |
| Finland | Yes | 3 | Statistics Finland |
| France | Yes | 11 | Police |
| Germany | Yes | 10 | Statistisches Bundesamt |
| Greece | Yes | 2 | Media |
| Hungary | Yes | Less than 1 | Police |
| Ireland | No | – | Police |
| Italy | Yes | 14 | Media |
| Kosovo | No | – | Police |
| Latvia | Yes | 1 | Latvian State Roads |
| Lithuania | Yes | 1 | Lithuanian Police Traffic Surveillance Service |
| Luxembourg | N/A | N/A | N/A |
| Moldova | N/A | N/A | N/A |
| Montenegro | No | – | Police |
| North Macedonia | No | – | Police |
| Netherlands | Yes | 2 | Dutch Hunting Association |
| Norway | Yes | Less than 1 | The Norwegian Public Roads Administration |
| Poland | Yes | 12 | Krukowicz et al. (2022) |
| Portugal | Yes | Less than 1 | Media |
| Romania | Yes | N/A | Police |
| Serbia | Yes | N/A | Media |
| Slovakia | Yes | Less than 1 | Police |
| Slovenia | Yes | Less than 1 | Media, Est. |
| Spain | Yes | 6 | Traffic Administration |
| Sweden | Yes | 5 | National Police and Transport Administration |
| Switzerland | Yes | Less than 1 | Federal Roads Office FEDRO |
| UK | Yes | 15 | RSPCA (2015), Est. |

[a] - N/A means that there is no traffic crash database with WVC as a category and no information was found when searching for web sources.
[b] Est = estimated.

**Table 2**
Countries where respondents indicated that WVC liability differs with respect to certain factors.

| Country | Road class | Road owner | Presence of warning signs | Driver law compliance | Animal species |
|---|---|---|---|---|---|
| B&H | Yes | No | No | Yes | Yes |
| Croatia | Yes | Yes | No | Yes | Yes |
| Cyprus | Yes | No | No | No | No |
| France | No | No | No | No | Yes |
| Greece | Yes | Yes | Yes | Yes | No |
| Hungary | Yes | No | No | No | No |
| Italy | Yes | Yes | No [a] | Yes | No |
| Kosovo | Yes | No | Yes | Yes | Yes |
| Lithuania | No | No | Yes | No | Yes |
| Poland | Yes | No | No | Yes | No |
| Romania | Yes | No | Yes | Yes | Yes |
| Slovenia | No | No | Yes | Yes | Yes |
| Spain | No | No | Yes | Yes | Yes |
| Sweden | Yes | No | No | Yes | No |

B&H - Bosnia and Herzegovina.
[a] This varies regionally. In some areas, if there is a wildlife warning sign, the region will not reimburse drivers, while in others, they will.

**Table 3**
A list of roadkill reporting systems available across Europe.

| Country | Application | Link |
|---|---|---|
| Austria | Roadkill | https://roadkill.at |
| Belgium/ Flanders | Waarnemingen.be | https://waarnemingen.be |
| Belgium/ Wallonia | Observations.be | https://observations.be |
| Bulgaria | SmartBirds | https://www.smartbirds.org |
| Croatia | HLS | https://dekra-hls-portal.powerappsportals.com/hr-HR/Customer-Notice/ |
| Czechia | Srazenazver.cz | https://srazenazver.cz |
| Cyprus | CyRos | https://cyroadkills.org |
| Estonia | Nature observations database | https://lva.keskkonnainfo.ee |
| Germany | Das Tierfund-Kataster | https://tierfund-kataster.de |
| Greece | LIFE Safe-Crossing | Available from Google Play |
| Greece | iNaturalist [a] | https://greece.inaturalist.org |
| Ireland | The National Biodiversity Data Centre [b] | https://biodiversityireland.ie |
| Italy | LIFE Safe-Crossing | Available from Google Play |
| Latvia | Mednis | Available from Google Play |
| Luxembourg | iNaturalist [a] | https://inaturalist.lu |
| Netherlands | Waarneming.nl | https://waarneming.nl |
| Netherlands | Telmee.nl | https://telmee.nl |
| Poland | Zwierzęta na Drodze | https://zwierzetanadrodze.pl |
| Portugal | LIFE LINES [c] | https://lifelines.uevora.pt/index.php/data/?lang=en |
| Romania | Road.Kill | https://road-kill-registration.green-web.eu |
| Slovenia | Lisjak | https://lisjak.lovska-zveza.si/login |
| Spain | Observation.org | https://observation.org/ |
| UK | Deer Aware | https://www.deeraware.com/ |
| UK | Project Splatter | https://projectsplatter.co.uk/ |

[a] A citizen-science project is being used globally for observations of animals.
[b] The former roadkill reporting system was called biology.ie. Currently the site is inactive, and the data has been uploaded to the National Biodiversity Data Centre.
[c] Currently stopped due to a lack of funding for maintenance.

when driving too fast. In practice, however, this very rarely occurs. Other countries do not provide hunters with any compensation for game animals killed on roads, on the contrary, hunters can be even requested to pay for the damages caused by a WVC if a hunt was organised during the same day or ended within 12 h before, as in, e.g., Spain.

Compensation from WVC usually means that the liable party has to pay for the losses experienced by the aggrieved party. Situations in which no coverage is paid involve drivers who are liable, their vehicle was damaged, but they did not report the WVC or when a game animal is killed on a road and, the event is not recorded as a WVC, but the carcass is found as roadkill by a member of a local hunting association.

### 3.3. Source of information on roadkill and WVC

#### 3.3.1. Reporting roadkill of small animals

Incidents with small animals are rarely recorded in official traffic collision or WVC databases, as they almost never result in a traffic accident. However, in certain countries, volunteers can record roadkill in mobile or web-based applications (see Table 3). In this case, the most frequently reported road-killed animals are usually smaller mammal species. This has to be taken into consideration when comparing the information on the most exposed species among countries. For example, in Flanders (Belgium) the hedgehog (*Erinaceus europaeus*) is the most frequently reported road-killed species. It is also probable that in other countries hedgehogs will be among the most frequently road-killed animals (e.g., in Bulgaria, see Kambourova-Ivanova et al., 2012 and Cyprus, see Vogiatzakis et al., 2022) but are underreported due to their size.

#### 3.3.2. Country-wide and regional WVC databases

Traffic collision databases often include specifications on WVC (Table 4). Certain countries have, because of their historical and administrative development, regional systems, such as Germany (e.g. in Bavaria), Italy (e.g., South Tyrol), and Spain (e.g., Catalonia, Basque country). In some countries, e.g., Spain and France, road operators (public or private) collect data on wildlife species killed on their roads. However, these specific databases are often not linked, which complicates providing an overview on a national level.

Country-wide information on WVC, accessible either openly or under certain restrictions, is therefore available from 21 countries (Table 4). Information on WVC is sometimes available, but without specifications of the animal species involved (e.g., Slovakia). In certain countries (e.g., UK), the country-wide traffic collision database only contains information about a "hit animal" but without a distinction between wildlife and domestic animals (DataGovUK, 2024). In Wallonia (Belgium), a database at the regional forest administration about the mortalities of red deer (*Cervus elaphus*), including accidents in traffic, exists, while the police collects data only in case of injury to drivers or passengers.

## 4. Discussion

This survey presents the first overview of WVC liability and WVC data availability covering almost all European countries. WVC are common and growing in Europe, resulting in millions of road-killed animals every year (Langbein et al., 2011; Grilo et al., 2020) and causing rising concern. Despite this fact, the risk of human fatalities from a direct hit with wildlife remains rather low (Bíl et al., 2024), with the exception of countries with high population densities of moose (*Alces alces)* (Niemi et al., 2017). From this survey, approximately 90 human fatalities occur due to WVC in Europe yearly. This is certainly not an accurate figure since some human fatalities are not registered as WVC, e.g., accidents caused by evading manoeuvres when a driver or a motorcyclist tries to avoid a direct hit with an animal (Conn et al., 2004; Rowden et al., 2008; Balčiauskas et al., 2024; Bíl et al., 2024). In addition, many people are injured as a result of WVC. Socio-economic impacts (including vehicle and road infrastructure damage) can also be significant as shown by a variety of studies (Langbein et al., 2011; Sáenz-de-Santa-María and Tellería, 2015; BDS, 2024). Reliable data on injuries and economic losses at the European level cannot be obtained, however, from this survey.

### 4.1. Information about WVC and roadkill

Information about WVC usually comes from both traffic collision databases or national WVC databases (Shilling et al., 2020). While certain countries already have databases running for many years, which include identification of the species involved, other countries do not have any. This means that estimations of WVC in those countries remain extremely difficult to undertake. In countries with federal systems of state administration or countries with autonomous regions (such as Germany, Italy, Spain, and Belgium), responsibility for WVC data maintenance lies not only with the national government, but also with some regions or states. This means that collecting information and producing an overview for the entire country can be difficult (e.g., Germany, Italy).

Roadkill databases, usually maintained by volunteers (including hunters) or research institutions, cannot fully replace the official WVC databases, because they are not able to guarantee countrywide coverage of all WVC events and do not include a major proportion of large animals the carcasses of which are removed by road maintenance teams. Such databases are often sustained only through the enthusiasm of a few individuals. Maintaining long-term engagement is a significant challenge for such citizen science projects (Silvertown, 2009; Frensley et al., 2017; Bíl et al., 2020b; Swinnen et al., 2022). For example, in Ireland, a roadkill app (biology.ie) was launched by an NGO but is no longer updated. Road management institutions (e.g. the French National Road Administration) sometimes build their own roadkill database, based on patrol surveys, including information on the animal species involved (Guinard et al., 2023). Simultaneously, WVCs that result in human injury or fatality are recorded in a national WVC database, however, without any information on the animal species involved.

In some countries (e.g., Slovenia, Hungary), where roadkill data are mandatorily collected by hunters, such roadkill databases can offer an important and relevant insight into wildlife mortality, including smaller species (e.g., mesocarnivores), and in the case of large mammals (ungulates, large carnivores) can be a very good proxy for WVC with those species (Faragó and László, 2017). Collisions with wildlife are underreported, however, in both roadkill and WVC databases. WVC databases do not contain information about small species and roadkill databases are generally not spatially and temporarily homogenous (Bíl et al., 2017). The situation in WVC reporting, even with national WVC databases, could become worse in the near future. For example, in Czechia, WVC currently account for 60 % of all traffic collisions recorded outside urban areas. To reduce workload, the police explore ways to simplify WVC registrations, particularly when no human injury or significant material damage occur. Similar simplified reporting has also been introduced in other countries (e.g., Norway, Spain). One possible solution, that has been proposed in countries where hunters have strong organisation and resources to maintain a high-quality database, is to shift the reporting responsibility to local volunteer hunters, as has been done in Finland and the Netherlands, where they provide official assistance to the police in the case of WVC. The coordination of traffic, road and police authorities to integrate their traffic collisions databases could provide, however, the most accurate vision of the phenomenon, allowing to collect a large number of traffic collision data. The use of new technologies and AI will help to undertake this cooperation.

**Table 4**
Availability of information about WVC and species involved in WVC: national level.

| Country[a] | Information on WVC available[b] | Information about species available |
|---|---|---|
| AL, BA, BE[c], CY, DE[c], EL, IT[c], MD, ME, NL, MK, RO, SI, UK | No | – |
| BG, DK, FR, LU, RS, SK, PL, XK | Yes | No |
| AT, CH, CZ, EE, ES, FI, HR, HU, IE, LV, LT, NO, PT, SE | Yes | Yes |

[a] Country codes from Eurostat (2024).
[b] *As a separate field in a traffic collision database which distinguishes wildlife from other causes of accident including collisions with domestic animals, or in a country-wide WVC database.*
[c] Only on a regional basis.

### 4.2. How can WVC liability influence the actor's behaviour regarding willingness to declare the events?

It has been shown that WVC liability varies considerably across Europe. Wildlife, including game species, are usually owned by the state or belong to no one. When game animals are killed, their carcasses may either belong to the landowner, the local hunter's association (which is renting the given land or is responsible for game management on the assigned hunting grounds), the local municipality or to no one. Different approaches to WVC liability may influence the attitude of the actors involved, regarding their willingness to declare an event. Below we discuss how the behaviour of these actors could be influenced.

#### 4.2.1. Drivers

Drivers are usually instructed how to act when a WVC takes place. Calling the police is often mandatory, particularly when large ungulates are involved. Usually, it is not legally required to call the police if an accident occurs with a small animal such as hedgehog, hare, red fox, or

Mustelids. Drivers might have, however, some difficulties in convincing insurance companies for the compensation of the damage without having a police record.

In some countries, drivers are not liable, and damages are compensated by insurance companies if their insurance covers WVC. Therefore, they are incentivized to report WVC in order to receive compensation. The police sometimes report cases of fraud (see e.g., Pižlová, 2017; Doubek, 2019) when drivers, who collided for other reasons, were trying to persuade an insurance company that it was due to a collision with a wild animal. In countries where car insurance is considered expensive, e.g., in Ireland and Lithuania, drivers sometimes do not report WVC damage even if it is covered under comprehensive car insurance. This is because it may lead to losing their no-claims bonus leading to an increase and driving up the car insurance costs in subsequent years.

Driver willingness to report WVC incidents is likely to be low if they do not have special WVC insurance and therefore will not receive compensation. In such cases even poaching, albeit unintended, has been reported as drivers compensated themselves for car damages by taking the struck animal with them. It can also be expected that drivers, when liable, will have the tendency not to report WVC to the police. In contrast, in South Tyrol (Italy), people are allowed to take road-killed game species home but only during hunting season. This could be seen as a kind of compensation. Another reason drivers often fail to report a WVC is that, in places like Italy where wildlife is classified as *res nullius* (nobody's property), drivers have to personally sue the wildlife management agency to receive reimbursement. This legal process can be costly and time-consuming, which discourages many drivers from pursuing a claim. In general, drivers are motivated to report a WVC primarily if there is a reasonable chance of receiving compensation—and typically only when the damage to their car is substantial.

In all the above-mentioned cases, when drivers do not report their collisions with animals, these records are lost in the respective WVC database (Huijser et al., 2008). Thus, this is an additional source of WVC underreporting.

#### 4.2.2. Road owners and managers

Road administrators, i.e., road concession companies which operate fenced motorways, are expected to keep animals off roads (Abra et al., 2019). In the case of WVC, they sometimes have to compensate drivers. Such a situation has been reported from several European countries (Bosnia and Herzegovina, Croatia, Hungary, Italy, Greece). In Spain, on the other hand, road managers are liable under certain circumstances related to mitigation measures application. In Croatia, the state covers the costs of a WVC if the driver is not at fault and the WVC takes place on a secondary road.

Logical steps, taken by this group of actors, would be installing WVC safety measures, such as fencing to keep wildlife off the roads. It will then depend on the legislation of a given country if fenced roads have to be complemented with wildlife crossing structures in order to restore landscape connectivity. Fencing will otherwise pose a barrier to wildlife movement with additional negative consequences for populations and ecosystems (Jaeger and Fahrig, 2004; Bischof et al., 2017).

Another option, which road managers might have, is to transfer the liability to other actors. This can be seen in Spain and Slovenia where road managers are considered liable only when a WVC takes place within road stretches with no wildlife warning signs or where fences (if they exist) are not properly maintained. The liability in these cases is transferred to drivers, or to hunters if a hunting incident took place shortly before the event. As a result, an increase in the number and length of road stretches that are provided with such signs can be expected. Wildlife warning signs have proven to be ineffective, however, in reducing roadkill (e.g., Huijser et al., 2008) and more of such signs along roads may speed up driver habituation to situations where signs occur, but animals are never observed.

In some cases, there have been recorded legal cases where drivers, whose vehicles were damaged, successfully applied compensation from the road administrators or hunters. Such a case was reported from Romania where a WVC was caused by a wild boar. This event took place on a national, unfenced road. The court ruled for the road administrator and for the game manager to pay compensation to the driver as they were considered responsible for the road safety and the game species, respectively (Tribunalul Olt, 2020). A similar case has been reported from Portugal where the national motorway company was convicted due to the crash of a driver as a result of a WVC. It was, however, an unprecedented case, given that, in recent years, more than 400 drivers tried, without success, to hold the company responsible for similar accidents (Oficial de mecânica, 2010). It is evident that involving civil courts may lead to a reassessment of liabilities for WVC.

#### 4.2.3. Hunters

In countries where hunters are liable for WVC with game species (e.g., Bosnia and Herzegovina, Serbia, Slovenia), there is a motivation for them to keep game animals off roads. It is also possible that they will be motivated to increase the harvest, aiming to decrease the populations of species that are mostly involved in WVC (ungulates mainly) in their hunting ground, if the fines (when WVC liability is applied) are significantly higher than their incomes from hunting activity. Moreover, as in the case of road managers, hunters are also in such cases (e.g., in Slovenia) motivated to urge road managers to increase the number of wildlife warning signs on their hunting grounds, achieving the same effect as described above.

In certain countries (Austria, Croatia, Czechia, Finland, Germany, Hungary, Kosovo, Lithuania, Romania, Sweden), hunters have been allocated annual quotas for game harvest. Animals killed on roads consequently lower these quotas. This means that hunters are discouraged from reporting these events. In other countries, where hunters are compensated for animals killed by cars (e.g., in Bosnia and Herzegovina, Serbia, Switzerland), such motivation does not exist, and they should be more inclined to report a WVC. In Hungary and Croatia, hunters are only compensated if the driver is to blame for the accident, e.g., by exceeding the speed limit. It happens that drivers do not report WVC for that reason in those countries. There are also countries where hunters are obliged to meet harvest quotas and face penalties, such as monetary fines or loss of hunting rights (e.g., in Slovenia). They are therefore motivated to report all roadkill. In certain countries (e.g., Croatia, Czechia, Spain), if hunting activity takes place in the vicinity of the WVC location, then drivers can be compensated by the insurance of the local hunting association.

### 4.3. Options for modifying WVC liability rules

Among all the co-authors that contributed to this survey, coming from countries that vary in legal frameworks for wildlife management, it was difficult to reach full consensus on an optimal approach to the WVC liability rules. All changes in liability have to align with the goals of improving traffic safety and simultaneously, enhancing wildlife protection. Additionally, they should not discourage reporting WVC. This will help increase the reliability and the amount of accurate WVC data, which will allow for better understanding of the impact of traffic on wildlife and targeted mitigation measures.

Shifting WVC liability to drivers could be considered at road sections with wildlife-warning signs, particularly on roads without fencing. Shifting liability to drivers at such road stretches may improve the effectiveness of installing such road signs, as collisions will then have (legal) consequences for the driver. Installation of these signs has to be evidence driven i.e., based on data (see section 4.4.). Drivers who drive carelessly could lose their insurance.

Shifting WVC liability to hunters during hunting periods, when game is more likely to cross roads, should motivate hunters to carefully plan the locations and organization of their hunts, including temporarily installation of portable warning signs. Hunters who keep too high populations of ungulates (for private or commercial hunting pleasures) could be forced to pay for WVC mitigation measures. Shifting liability to

road managers, particularly those who operate fenced roads could also be considered, as drivers have a legitimate reason to expect that no large animals will be present on a fenced roadway. Administrations who withhold information about road safety for drivers or do not obtain this information through monitoring or WVC databases could be forced to contribute to driver insurance costs.

### 4.4. Good practice suggestions to reduce WVC hazard

Solutions which focus on minimization of WVC should be based on relevant scientific findings and recommendations and these should follow good practice (e.g., Van Der Ree et al., 2015; Rosell et al., 2023). This means that WVC mitigation should not increase landscape fragmentation.

Wildlife traffic warning signs should be placed at a limited number of locations where the highest risk of collision have been identified in order to avoid driver habituation (Huijser et al., 2015; Jägerbrand et al., 2018). More effective, albeit more costly, are intelligent warning systems such as warning signs activated by Animal Detection Systems (ADS) (Huijser et al., 2008; Rytwinski et al., 2016; Grace et al., 2017) that are illuminated when an animal is detected close to a road at the same time a vehicle is passing or during specific, high-risk periods, which are related to daily and seasonal variation in animal activity (Steiner et al., 2014; Kruuse et al., 2016; Niemi et al., 2017; Favilli et al., 2018; Kučas and Balčiauskas, 2020; Mayer et al., 2021). Additionally, the selection of such locations has to be based on reliable data and appropriate analysis methods to identify locations where WVC tend to concentrate in relatively short sections of roads, known as hotspots (e.g., Litvaitis and Tash, 2008; Favilli et al., 2018; Bíl et al., 2019; MacDougall et al., 2024).

The quality and permeability of wildlife fences has to be regularly monitored. Particular attention has to be paid at intersections, which are the most exposed locations where animals can enter motorways (Cserkész et al., 2013; Sedoník et al., 2023; Al Sayegh Petkovšek et al., 2025). Road managers should preferably install wildlife fences in combination with fauna passages to exclude animals from roads and guide them to safe crossing facilities. Adapting existing structures, such as bridges, can both mitigate WVC hazards and be cost-effective, especially when resources are limited.

Game populations should be managed in such a way that unnaturally high population numbers are avoided, especially in areas with unfenced roads (e.g., Neumann et al., 2020). Drivers should be extra aware of wildlife during dusk and dawn (Haikonen and Summala, 2001), and in certain habitat configurations, e.g., forest edges, mosaic landscapes with a mix of open fields and dense vegetation (Seiler, 2005) and adjust driving behaviour and speed accordingly.

The collection of data on the animal species involved in national WVC databases would be beneficial as it would help to evaluate the impact of traffic on wildlife and facilitate international comparisons. It would also be helpful when estimating socio-economic costs. Currently, this is only possible in countries with robust systems of WVC reporting, e.g., in Sweden (Gren and Jägerbrand, 2019).

## 5. Conclusions

We presented an overview of the liability for WVC in Europe and found that several approaches are in effect. They encompass liability for drivers, road managers or owners, local municipalities, regions, wildlife management agencies and hunters of the surrounding hunting grounds. In certain countries, WVC liability is further transferred to other actors under special circumstances and thus is not unified, even within one country.

The inadequate or substandard recording systems in many countries make it challenging to accurately estimate the overall losses from WVC. We estimate that WVC result in about 90 human fatalities annually in Europe, but information on severely injured people cannot be reliably obtained as such data are not always registered or are highly incomplete. The same is true for socio-economic losses from WVC which present a considerable burden to societies, as shown in countries with reliable data sources. WVC liability seems to have an effect on reporting and is thus among the causes of WVC underreporting.

Understanding different liability practices will help to interpret the WVC statistics from various countries. Harmonisation of approaches, related to WVC recording across Europe, would be useful, as well as the introduction of WVC information systems in countries where they are not yet present. An improvement of data registration will also result on robust databases that will identify the most problematic road stretches which is the basis for identifying the best mitigation measures to reduce the conflict.

WVC are caused by a multitude of factors that are quite well understood but nevertheless, in their combination, largely unpredictable. This implies that liabilities for WVC have to be shared among the involved actors, including drivers. Every actor needs to take responsibility and ensure taking sufficient precautions to reduce accidents with wildlife – small and large.

## CRediT authorship contribution statement

**M. Bíl:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Conceptualization. **L. Balčiauskas:** Investigation, Data curation. **M. Bílová:** Writing – original draft, Data curation. **S. Cellina:** Writing – original draft, Data curation. **F. Favilli:** Writing – original draft, Data curation. **D. Gačić:** Writing – review & editing, Writing – original draft, Data curation. **E. Guinard:** Writing – original draft, Data curation. **M. Heurich:** Writing – original draft, Data curation. **N. Ivanova:** Writing – original draft, Data curation. **J. Junghardt:** Writing – original draft, Data curation. **O. Keuling:** Writing – original draft, Data curation. **M. Kruuse:** Writing – original draft, Data curation. **Q. Kukalaj:** Writing – original draft, Data curation. **J. Langbein:** Writing – original draft, Data curation. **P. Laube:** Writing – original draft, Data curation, Writing – original draft, Data curation. **A. Licoppe:** Data curation. **P. Masaryk:** Data curation. **W. Maślanko:** Writing – review & editing, Writing – original draft, Data curation, Writing – review & editing, Writing – original draft, Data curation. **M. Mayer:** Writing – original draft, Data curation. **A. Moroney:** Data curation. **R. Moț:** Writing – review & editing, Writing – original draft, Data curation. **D. Mrđenović:** Data curation. **A. Náhlik:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Conceptualization. **A. Nebunu:** Writing – original draft, Data curation, Writing – original draft, Data curation. **V. Nezval:** Writing – original draft, Data curation. **M. Niemi:** Data curation. **B. Pokorny:** Writing – original draft, Data curation. **M. Psaralexi:** Writing – review & editing, Writing – original draft, Data curation. **S. Ralevic:** Writing – original draft, Data curation. **S. Ricci:** Writing – original draft, Data curation. **Ch. M. Rolandsen:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **C. Rosell:** Data curation. **S.M. Santos:** Writing – original draft, Data curation. **A. Seiler:** Writing – original draft, Data curation. **W. Steiner:** Data curation. **K.R. R. Swinnen:** Data curation. **N. Šprem:** Writing – review & editing, Writing – original draft, Data curation. **A. Trajçe:** Writing – original draft, Data curation. **V. Trpeski:** Data curation.

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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. a list of questions exported from the questionnaire used in the survey

[1] Does WVC liability vary with respect to any factor (e.g., road class, road owner, presence of a warning sign, animal species) or is it the same in all cases in your country?
[2] Who is liable when a WVC takes place in your country?
[3] Does the WVC liability vary by road class in your country? (e.g., motorway/primary/secondary/local road)
[4] Please specify who is liable when a WVC takes place on the motorway/primary/secondary/local roads in your country:
[5] Does the WVC liability vary according to road owner or by the presence of concession? (e.g., public versus private roads)
[6] Please specify who is liable when a WVC takes place on a public and private road in your country.
[7] Does WVC liability vary by the presence of a warning sign?
[8] Please specify who is liable when a wildlife-vehicle collision (WVC) occurs within a road section marked by warning signs and when it happens outside of those marked sections.
[9] Does WVC liability vary with respect to driver compliance?
[10] Does WVC liability vary by animal species? (e.g., common, endangered/protected species)
[11] Please specify how the liability vary among species in your country.
[12] Does WVC liability vary with respect to any other factor than those already mentioned?
[13] Please specify which factors, in addition to those already listed, affect WVC liability.
[14] Who is responsible for gathering data on WVC? (i.e., a vehicle which collided with an animal is at the scene, a driver calls assistance, …)
[15] Who is responsible for gathering data on roadkill (i.e., only a dead animal found at/near the road)
[16] Is there an official (police) traffic collision database in your country?
[17] Does the official (police) traffic collision database in your country specify a WVC as a concrete kind of accident? (e.g., a collision with a wild animal)
[18] Does the official (police) traffic collision database in your country also contain information about species? (e.g., a collision with roe deer, wild boar)
[19] Is there a state-wide(!) application in your country where volunteers can add roadkill data? (e.g., an animal found dead on/ near a road)
[20] What is the name of the state-wide application in your country where volunteers can add roadkill data?
[21] Are there any specifics about WVC data collection in your country? (e.g. there is no WVC data at all, we have a special WVC unit recording, hunters have to maintain WVC database, etc.)
[22] Is there a recommended approach in your country as to what to do when a driver is involved in a WVC?
[23] Carcass management: who is responsible for removing carcasses on or near the road? (e.g., dead roe deer)
[24] Are there any specifics in the process of removing carcasses from or near the road?
[25] Is information on material costs of WVCs available in your country? (e.g., police data, reports from insurance companies)
[26] What are the mean yearly material costs of a WVC in your country (in €)? Please describe how the costs you presented were estimated.
[27] Can hunters/hunting ground managers/hunting tenant claim compensation for game animals killed on roads?
[28] Who pays compensation for dead game animals (i.e., animals killed by vehicles)?
[29] Describe/estimate how the WVC liability in your country affects the behaviour of actors involved in the WVC issue.

## Data availability

Data will be made available on request.

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