

BEST PRACTICE GUIDE

for monitoring and recording
fauna mortality data
from roadkill





Coordination of the edition

Nuno M. Pedroso, Sofia Eufrázio, Pedro A. Salgueiro, Tiago Pinto, António Mira (University of Évora)

Contributions

André Oliveira, Carmo Silva, Denis Medinas, João Craveiro, Luís Guilherme Sousa, Sara Santos (University of Évora).

Photography credits

André Oliveira (AO), Ana Sampaio (AS), Carmo Silva (CS), Francesco Valerio (FV), Joaquim Pedro Ferreira (JPF), Luis Guilherme Sousa (LGS), Nuno M. Pedroso (NMP), Pedro Alexandre Salgueiro (PAS), Rui Lourenço (RL), Sofia Eufrázio (SE), Tiago Pinto (TP).

Graphic design

Rui Belo

ISBN


978-972-778-235-2

Edição

Universidade de Évora

Citation:

Pedroso, N.M., Eufrázio, S., Salgueiro, P.A., Pinto, T., Mira A. (2022). Best practice guide for monitoring and recording fauna mortality data from roadkill. LIFE LINES Project. Universidade de Évora. ISBN: 978-972-778-235-2.



With the expanding network of transport infrastructures in Portugal over the last decades, roadkill became an imposing reality. In some parts of the country, this is the main non-natural cause of death for wildlife species. Therefore, it is crucial to obtain information on roadkill, namely the species and locations concerned, in order to determine the specific causes and to define appropriate mitigating measures.

This **best practice guide** gathers and presents the procedures for the collection and treatment of information from recorded fauna roadkill, based on the experience acquired in the framework of the LIFE LINES (LIFE14 NAT/PT/001081) project and others, such as MOVE project, conducted by the University of Évora. This guide presents basic or introductory aspects related with the implementation of a roadkill monitoring plan and is mainly directed to those involved in environmental monitoring, municipalities or local governances, and even concerned citizens. By offering the essential bases to adopt best practices for monitoring and recording roadkill, this guide is expected to help developing actions to mitigate fauna mortality and to increase road safety at local and national scales.



Common Barn-owl (*Tyto alba*) | LGS

Index

The LIFE LINES project	6
Project Objectives	7
The impacts of roads on wildlife mortality	8
Importance of biodiversity	8
The different impacts of roads	9
Road traffic legislation in Portugal	10
Roadkill monitoring	11
Definition of target species for monitoring	12
Mortality depends on the type of road	14
The persistence of carcasses influences the sampling frequency	15
Roadkill varies seasonally	16
Monitoring speed matters	18
Monitoring implementation	19
Procedures	19
How to register	22
LIFE LINES App	22
Creation of an automatic registration system	22
Record on paper, GPS supported	23
Automatic methods of monitoring	23
Identification roadkill animals	24
Domestic animals	24
Wild Animals	25
Amphibians	27
Reptiles	29
Birds	32
Mammals	32
Sharing and dissemination of data	37
Data	37
The value of information	39
Complementing the information from roadkill records	
– The example of LIFE LINES Project	41
LIFE LINES App	42
Bibliography	43

The LIFE LINES Project

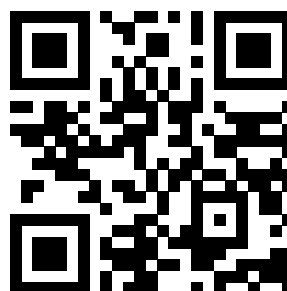
Thousands of animals die every year in linear transport and energy infrastructures, either killed on roads or rails, or by electrocution or collision with medium- and high-voltage power lines. This increased mortality impacts the preservation of biological diversity, but there are solutions to minimize their effects.

The **LIFE LINES project – Linear Infrastructure Networks with Ecological Solutions** (LIFE14NAT/PT/001081) was developed to contribute to the creation of a **Green Infrastructure** that promotes **refugia for plants and animals**, and their safe **movement along the linear infrastructures**, ensuring ecosystem services and thus mitigating the negative impacts of those structures on biodiversity.

The project was coordinated by the Universidade of Évora and involves the following partners: Universidade de Aveiro, Faculdade de Ciências da Universidade do Porto, Municipalities of Évora (CME – Câmara Municipal de Évora) and Montemor-o-Novo (CMMN – Câmara Municipal de Montemor-o-Novo), Infraestruturas de Portugal S.A., MARCA – Associação de Desenvolvimento Local, and QUERCUS. LIFE LINES is also in close collaboration with GNR (Guarda Nacional Republicana), REN – Redes Energéticas Nacionais SGPS S.A. and E-REDES. The project focuses on the promotion and recovery of biodiversity in an area that is still well preserved but where a number of linear infrastructures might endanger some local populations of animals and plants.

The linear transport infrastructures are one of the main subjects addressed in this project. Among many other actions, LIFE LINES deployed and tested several measures to minimize the impacts of roads, including the promotion of safe road passages, and mitigation of animal roadkill, and developed a National Fauna Roadkill Database and a mobile app to allow the active contribution of the public to data collection.

FIND OUT MORE AT
LIFELINES.UEVORA.PT



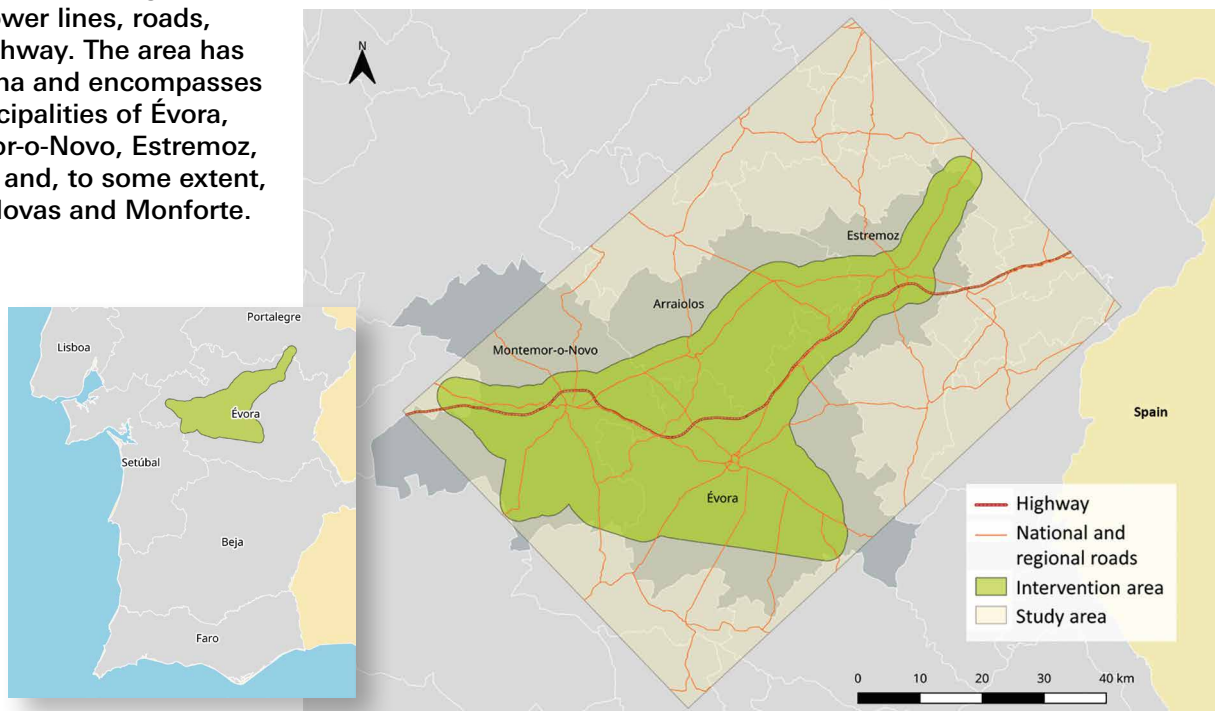
The intervention area of LIFE LINES is crossed by the main land transport corridor between Lisbon and Madrid. There is a high density of power lines, roads, and a highway. The area has 210,000 ha and encompasses the municipalities of Évora, Montemor-o-Novo, Estremoz, Arraiolos and, to some extent, Vendas Novas and Monforte.



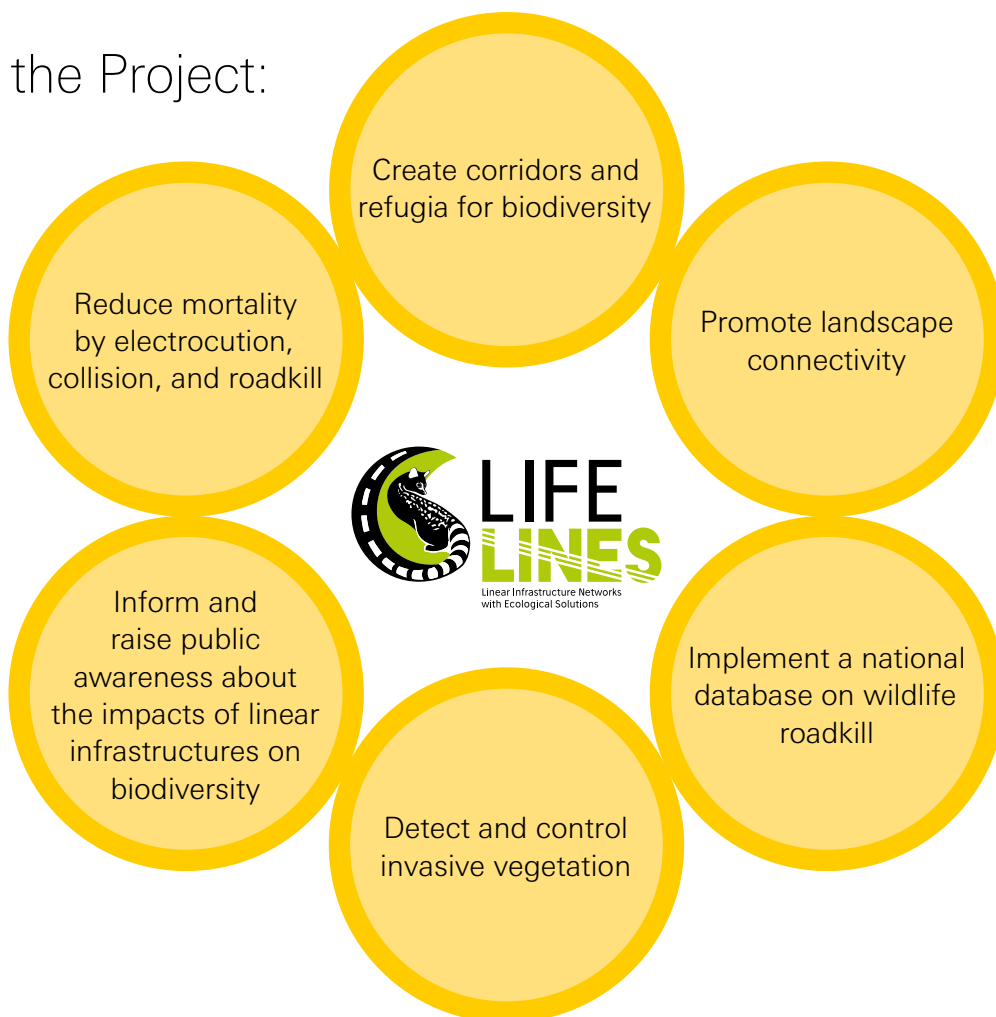
2015-2021



Central Alentejo



Objectives of the Project:



The impacts of roads on wildlife mortality

Biodiversity and its importance

Biodiversity, the variety of life on Earth in all its forms, includes the number and abundance of species, the genetic variability and the diversity of ecosystems, and the interactions between all these components.

Biodiversity contributes to our daily lives in ways that we take for granted such as clean air, fresh water, good quality soils, pest control, or mitigation of climatic changes. These so-called ecosystem services can be classified into three categories: (1) Provision (economic/resources, consumption, production); (2) Regulation/Support (ecologic); and (3) Cultural (recreation, education, science).



The different impacts of roads

Although roadkill is the more visible impact of roads on fauna, other factors are equally or even more detrimental for the populations of animals and plants living in the surrounding areas.

The destruction of habitats where the road is built is the first impact.

Then, there are the effects of the presence of the road – which acts as a barrier –, the traffic noise, and the car-lights which frighten and drive animals away; moreover, the fences along the road hinder the passage of some species across the road. The pollution caused by the gases from exhausts, motor oil or fuel leaks, or even the garbage thrown away by drivers and passengers, degrade the surrounding area through contamination of water-courses.

However, roadsides can also represent refugia and means of dispersal for some animals, such as small mammals (mice and shrews) and butterflies. There can also grow native plants, thus increasing floristic diversity, especially where the surrounding habitat is less diverse, such as agricultural or intensively grazed lands.



Tawny Owl (*Strix aluco*)

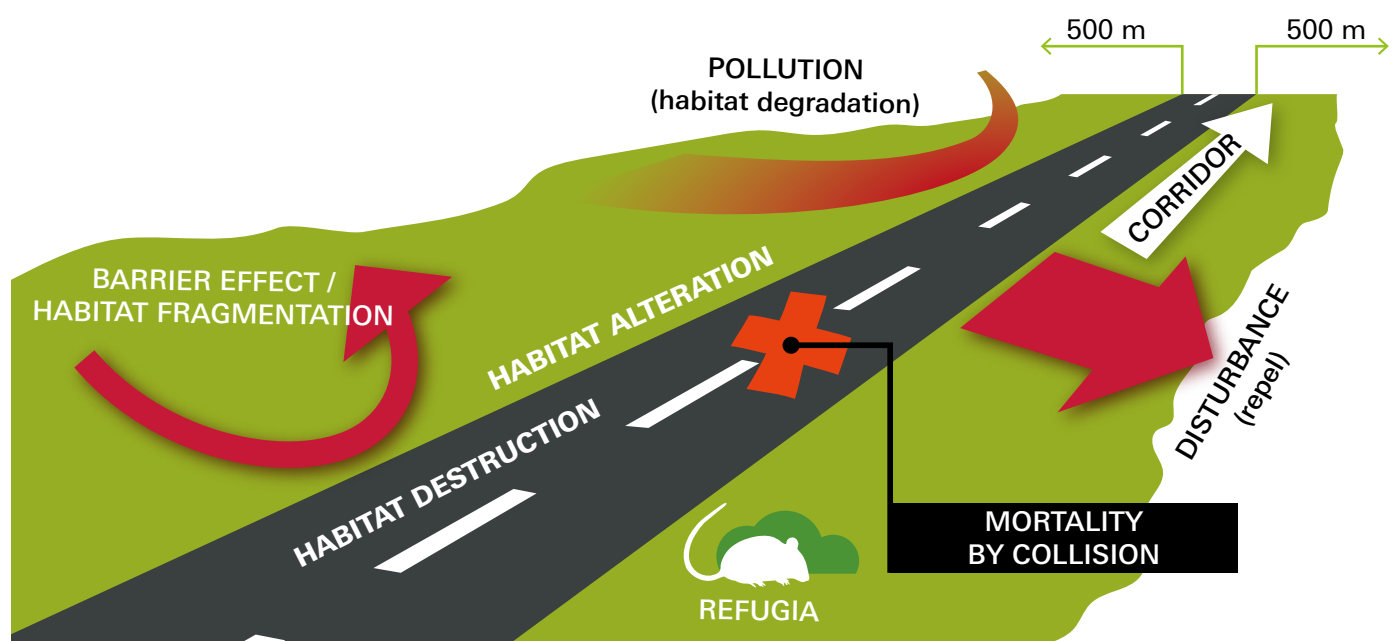


Figure adapted from Seiler 2002

Road traffic legislation in Portugal



LGS

In Portugal, the Road Traffic Code addresses fauna in roadways by means of specific traffic signs. These signs aim at promoting the safety of drivers, since roadkill might cause car accidents, either by collision with medium- or large-sized animals, or as a result of drivers' reactions when trying to deviate from animals they find on the road.

The presence of these signs can also reduce the number of roadkill, as they inform the driver that animals are frequently found on that stretch of the road.

At present, there are three such traffic signs: a generic Sign A19b – Animais selvagens (wild animals), one concerning a specific species, the A19c – Lince-ibérico (Iberian lynx), and another dedicated to amphibians (A19d – Anfíbios).

The vertical road sign concerning amphibians was proposed in the framework of the LIFE LINES project and was installed by Infraestruturas de Portugal (beneficiary partner) in early 2019, in segments of roads EN114 and EN4 (Évora district) where previous monitoring had shown high roadkill of amphibians.

Both the sign for amphibians and the sign for Iberian lynx were approved on the 20th of April 2020, in the revision of the Traffic Sign Regulation (RST) approved by the Implementing Decree nº 22 -A/98, of 1 of October, thus becoming included in the Road Traffic Code.



Sign A19b
Animais selvagens (wild animals)



Sign A19c
Lince-ibérico (Iberian lynx)



Sign A19d
Anfíbios (amphibians)

Roadkill monitoring



To correctly evaluate the impact of mortality by roadkill, it is essential to obtain reliable information, focused on the intended goals.

The monitoring of animal mortality must take several aspects into account:

- Definition of target species for monitoring;
- Acknowledge that mortality varies according to the type of road;
- The persistence of carcasses of animals killed on the road varies among animals groups;
- Mortality varies according to the season of the year;
- Monitoring speed, when using a vehicle, matters.



Definition of target species for monitoring

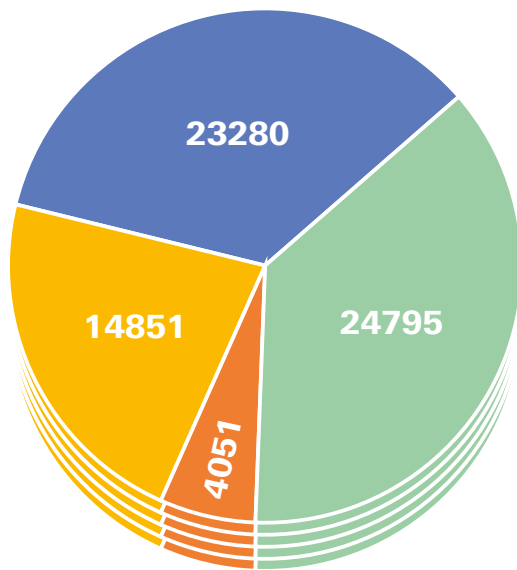
Ideally, a complete study of mortality by roadkill should include all the groups of terrestrial vertebrates, from mammals, to amphibians, reptiles and birds. The mortality of each group, within the group, and of each species varies with multiple factors, from the intrinsic characteristics of the species (e.g., if they move slowly, if they fly), to the type of environment surrounding the road (e.g., forest areas might have more bird species, areas with water availability such as ponds or streams favour the presence of amphibians), to the structure of the road itself (e.g., curves reduce the timely detection of animals, long straight segments favour high speeds, broader sections increase the size of the obstacle for animals). These factors affect different species differently, so a wide range of groups and species should be monitored whenever possible.

If the number of sampled species must be reduced, the selection of species or groups of species should always be preceded by a pre-monitoring of the road, or of the sites where it will be built, ideally for one year, to evaluate possible seasonal variations of mortality among groups. With the obtained results, it is then possible to make the most adequate selection for the future monitoring plan.

Adding the experience from the MOVE project, which started in 2005, to the results obtained by Universidade de Évora in the framework of LIFE LINES until February 2021, it was possible to record more than 66 000 roadkill (vertebrates). And, contrasting with what might be expected from the apparently more commonly found animals on roads (e.g., medium-size carnivores, hedgehogs, or owls), the most impacted groups of animals are amphibians and small birds (Passeriformes).



Eurasian Buzzard (*Buteo buteo*) | LL



AMPHIBIANS



REPTILES



BIRDS



MAMMALS

However, there are several factors determining the vulnerability of a given group of fauna to roadkill in a certain road or part of a road. Those might be related with some environmental characteristics near the road, such as watercourses or ponds, which favour the presence of amphibians, or the proximity of bat shelters, or simply because certain rare species naturally occur in the surrounding areas or feed on the roadsides (such is the case of the Iberian lynx, whose main cause of non-natural mortality is roadkill).

In short, it is important to monitor all groups of vertebrates, not only because we are not able to predict all those factors and how they alter the risk of roadkill, but because it is the most adequate way to ensure the best estimate of traffic impacts in a stretch of a road. Even for non-threatened species, monitoring ensures a continuous survey of the populations, identifying and preventing potential changes in their distribution, occurrence or viability. The quantification of mortality and of its causes will be important to define global plans of biodiversity conservation to counteract its declining trend at the global level.



Project developed by Unidade de Biologia da Conservação (Conservation Biology Lab), Departamento de Biologia, Escola de Ciências e Tecnologia, Universidade de Évora

Started in 2005 | Daily sampling route (37 km-100 km) to record roadkill | Roads between Montemor-o-Novo, Évora and Arraiolos.

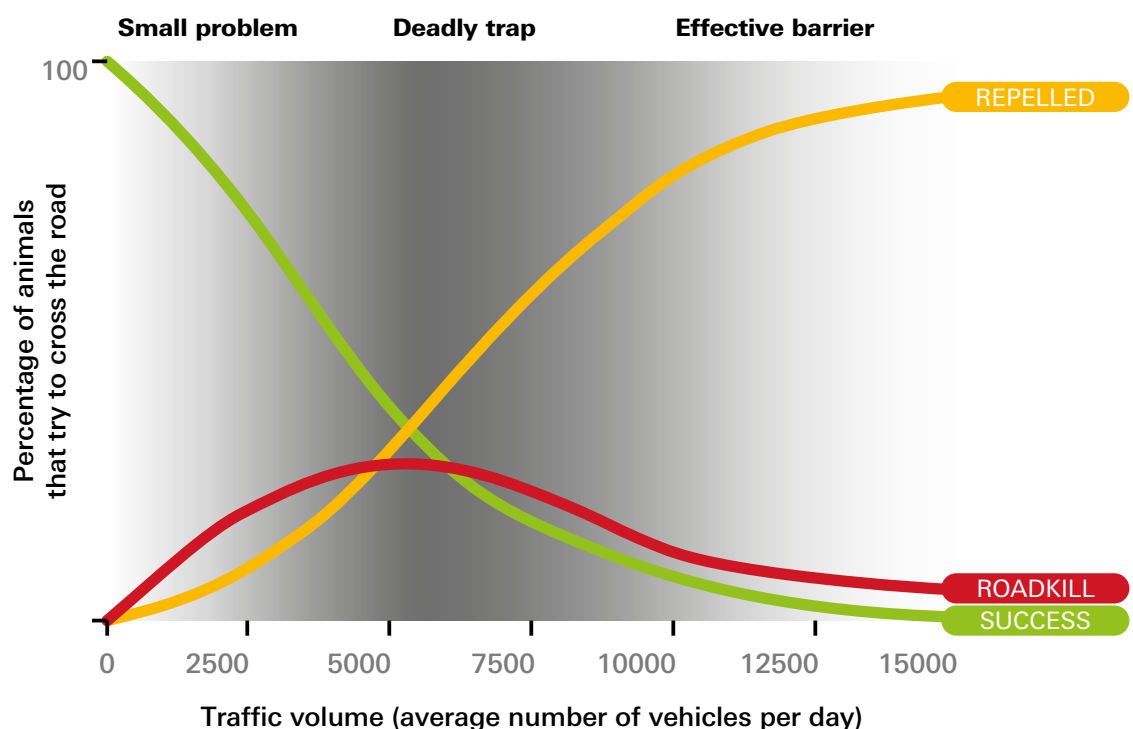
Mortality depends on the type of road

Another type of factors influencing the persistence on the road and number of roadkill are traffic flow density and speed. However, more traffic does not always lead to higher mortalities.

The road is an obstacle, and heavy traffic (> 10 000 vehicles/day) can create an additional barrier effect. The noise and the movement of vehicles drive the animals away or restrain them from crossing the roads. This effect is more significant in the main roads (e.g., highways) due to the presence of guard rails or fences along the road, which hinder the access of animals to the pavement.

In roads of intermediate traffic volume (2500-8000 vehicles/day), the barrier effect is smaller, but the traffic is still relatively heavy, a combination of factors leading to a higher number of collisions with animals and roadkill. These are also the most common type of roads in Portugal and in many other regions of the world, so their impact is quite significant.

In roads of lower traffic (< 2500 vehicles/day), the success of animal crossings is higher and the barrier effect smallest, resulting in less collisions.



Adapted from Seiler & Helldin 2006

The persistence of carcasses influences the sampling frequency

The time that a roadkill carcass persists on the road depends on it being washed or dragged away. This can be quite rapid in the case of smaller animals, like amphibians, or longer in the case of mammals and birds of medium size. Weather conditions and traffic volume also influence this persistence: high precipitation washes or drags the carcasses away from the road, and higher traffic flows lead to the rapid destruction and disappearance of the carcasses. Also, some of them can be removed by opportunistic predators or by scavengers.

In a study developed by the MOVE team (see Santos et al., 2011), based on one year of roadkill records, the average persistence time of each fauna group was calculated. It also allowed to predict sampling scenarios with different budgets. For each group, the sampling frequency necessary to ensure an acceptable probability of persistence (50% and 70%) was estimated, also allowing to identify the sites of higher roadkill risk.

Taxonomic Group	Average number of days carcasses remain on the road	Monitoring Frequency	
		Low budget (50% probability of carcass persistence)	Medium/high budget (70% probability of carcass persistence)
Frogs	1	Daily	Daily
Salamanders	1	Daily	Daily
Small lizards	<1	Daily (in the afternoon)	Daily (in the afternoon)
Snakes	1	Daily	Daily
Tortoises	3	Every two days	Every other day
Small birds	1	Daily	Daily
Large birds	4	Every three days	Every other day
Birds of prey	6	Every four days	Every other day
Bats	<1	Daily (early morning)	Daily (early morning)
Small mammals (mice, voles and shrews)	1	Daily	Daily
Lagomorphs (rabbits and hares)	2	Every other day	Daily
Hedgehogs	4,5	Every three days	Every other day
Carnivores	9	Every eight days	Every three days
TOTAL	1	Daily	-

Table adapted from Santos et al. (2011)

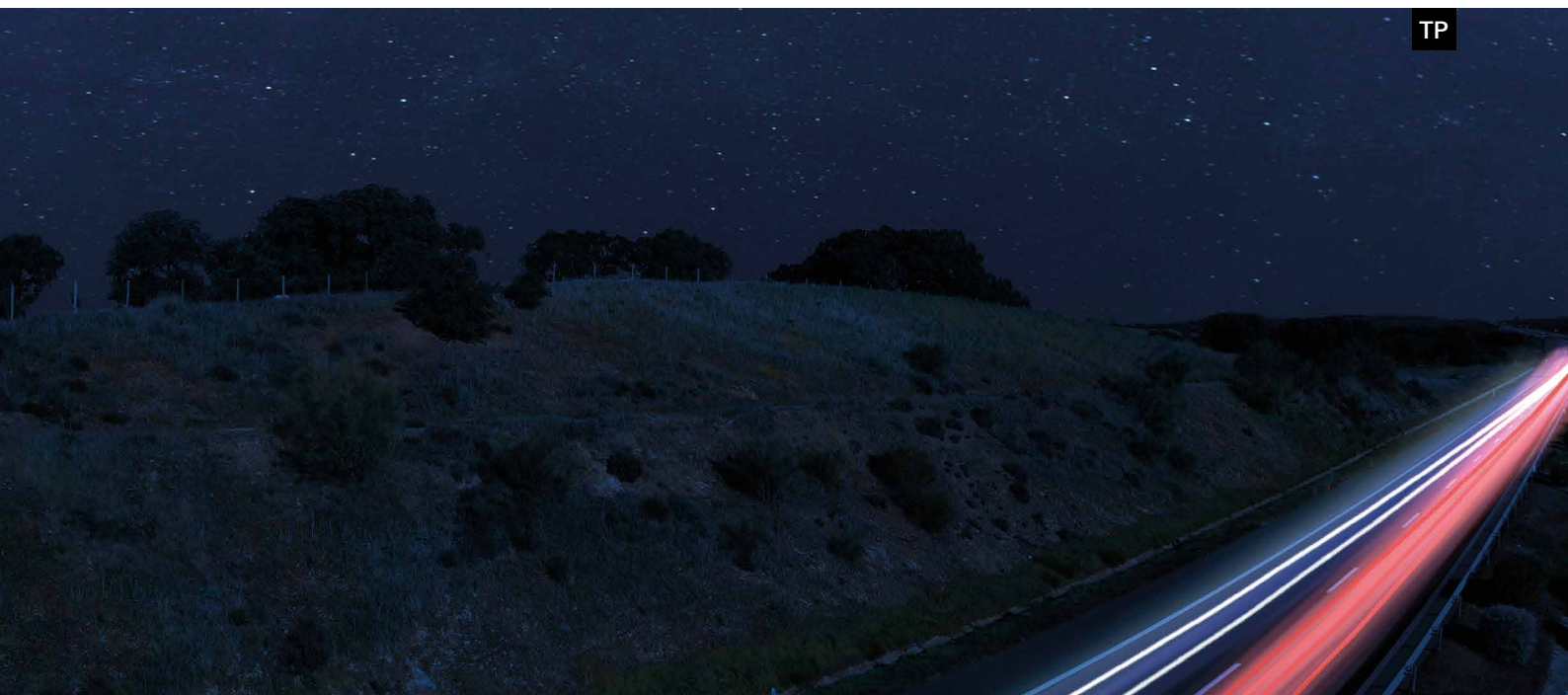
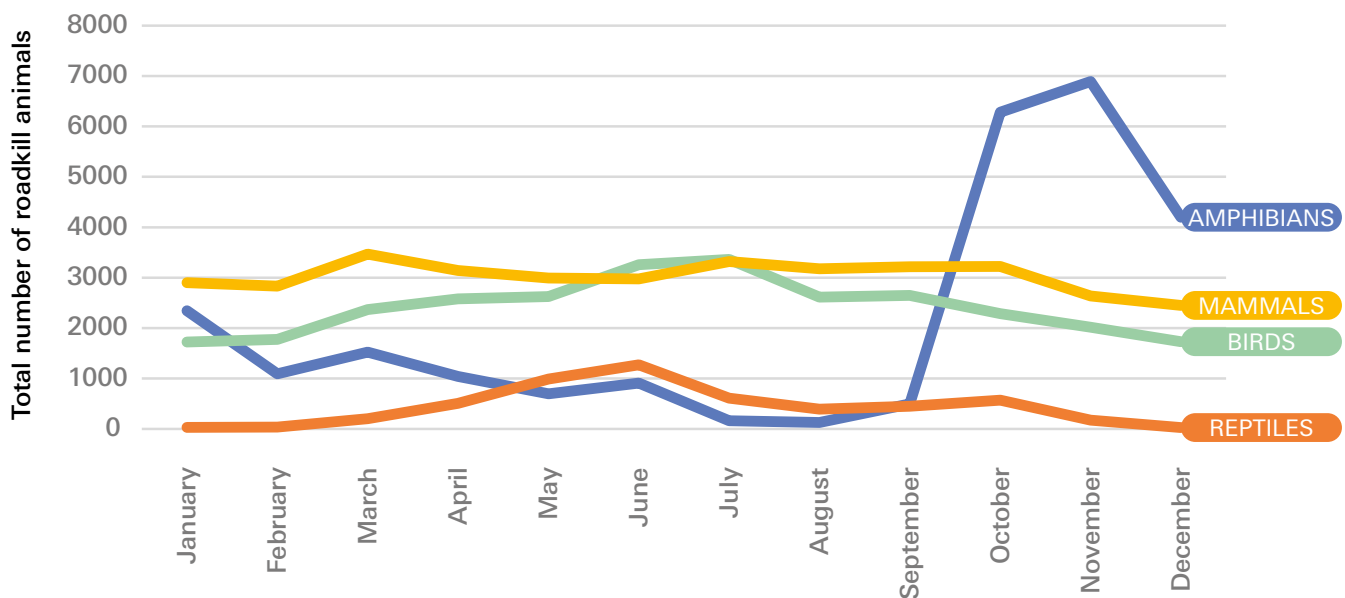
If the monitoring periodicity is much longer than the persistence (e.g., weekly samplings) the actual number of dead animals is underestimated because many of them have meanwhile been removed or destroyed.

In the case of daily (or very frequent) monitoring, the observers should remove the carcasses from the road, to avoid counting the same animal more than once.

Roadkill varies seasonally

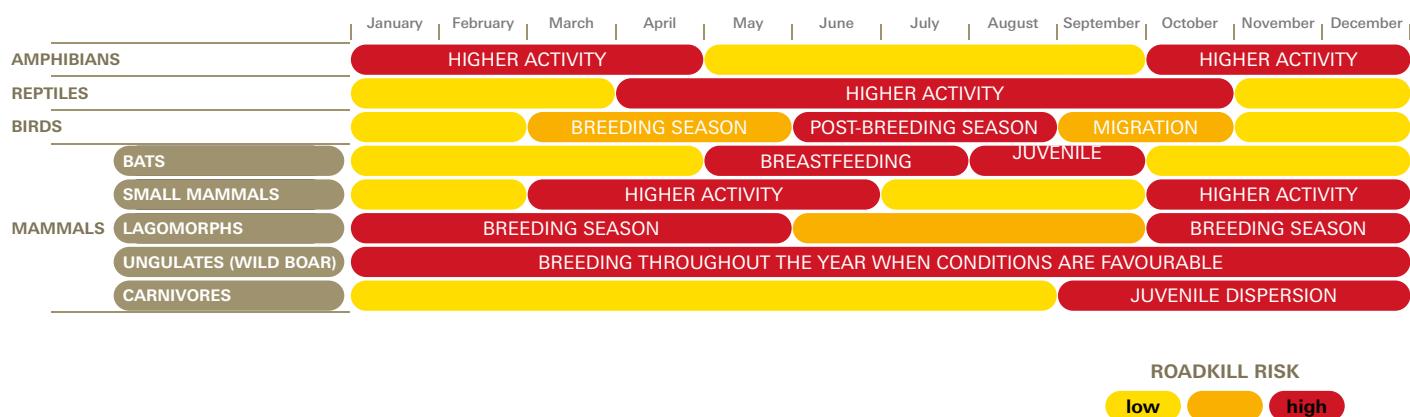
The same study (Santos et al. 2011) informs that, to obtain a realistic scenario, it is necessary to monitor systematically and at regular intervals, and that monitoring should last at least one year, to account for seasonal variations in roadkill of different groups.

From the evaluation of the national database on roadkill, such variations are clearly perceived:





However, if economic or temporal limitations impose a shorter period of sampling, the selected monitoring periods should correspond to those when the animals are more active and, therefore, more prone to collision and roadkill. These periods normally correspond to mating, dispersal or migration seasons, but they may vary with the weather conditions. The information on the most critical periods for each group can be found in the section of this guide dealing with the identification of species; however, a summary is presented here:



Monitoring speed matters

Comparing the data obtained from the projects MOVE and LIFE LINES with data from other entities collaborating with the LIFE LINES project (see more detailed information in section “Data Storage”), big differences are noticed in the number of records and in the affected groups. These differences might be related with different monitoring speeds – approximately 30 km/h (MOVE and LIFE LINES) and 60-70 km/h by most of other entities.



Higher speeds affect the capacity to detect small animals. Groups such as amphibians, passerines, bats and small mammals are underestimated in comparison with medium- to large-sized animals such as carnivore mammals, hedgehogs or birds-of-prey, which are much easier to detect at higher monitoring speeds.

If all the species, or small-sized species, are to be monitored, the recommended speed of monitoring is 30 km/h. If only medium- and large-sized animals, such as carnivore mammals or ungulates are targeted, an appropriate monitoring speed is 60 km/h.

		AMPHIBIANS		REPTILES		BIRDS				MAMMALS				
						BIRDS of prey								
						Passerines	Aves de rapina diurnas	Aves de rapina noturnas	Other birds	Small mammals	Bats	Carnivores	Ungulates	Domestic
30 km/h		23280	4051	22476	74	1413	832	4876	2139	1538	94	1219		
70 km/h	 Other entities	611	2147	680	287	2894	1980	300	20	20813	1766	11837		

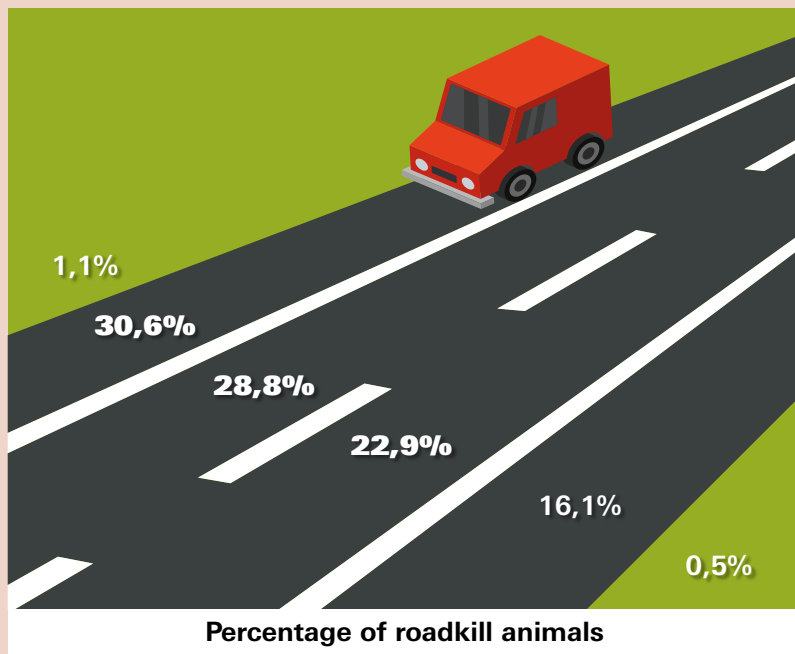
Data gathered between January 2005 and January 2021; Source: National Roadkill Database

Monitoring implementation

Procedures

The procedures to monitor roadkill take the speed, location, frequency and time of the day into account. They might include some specific variations, depending on the targets being all fauna or just a few groups. When the monitoring is carried out from a vehicle, the following recommendations apply:

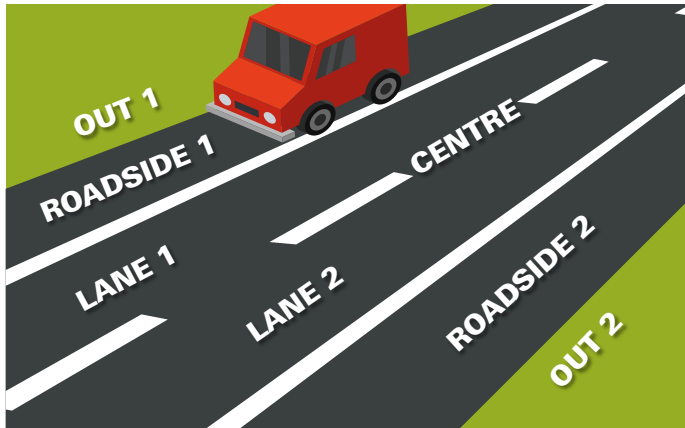
- The speed of monitoring should be approximately 30 km/h, or a little higher if only medium- to large-sized animals are targeted;
- The roadsides should be surveyed (paved and non-paved zones), as well as both road lanes;



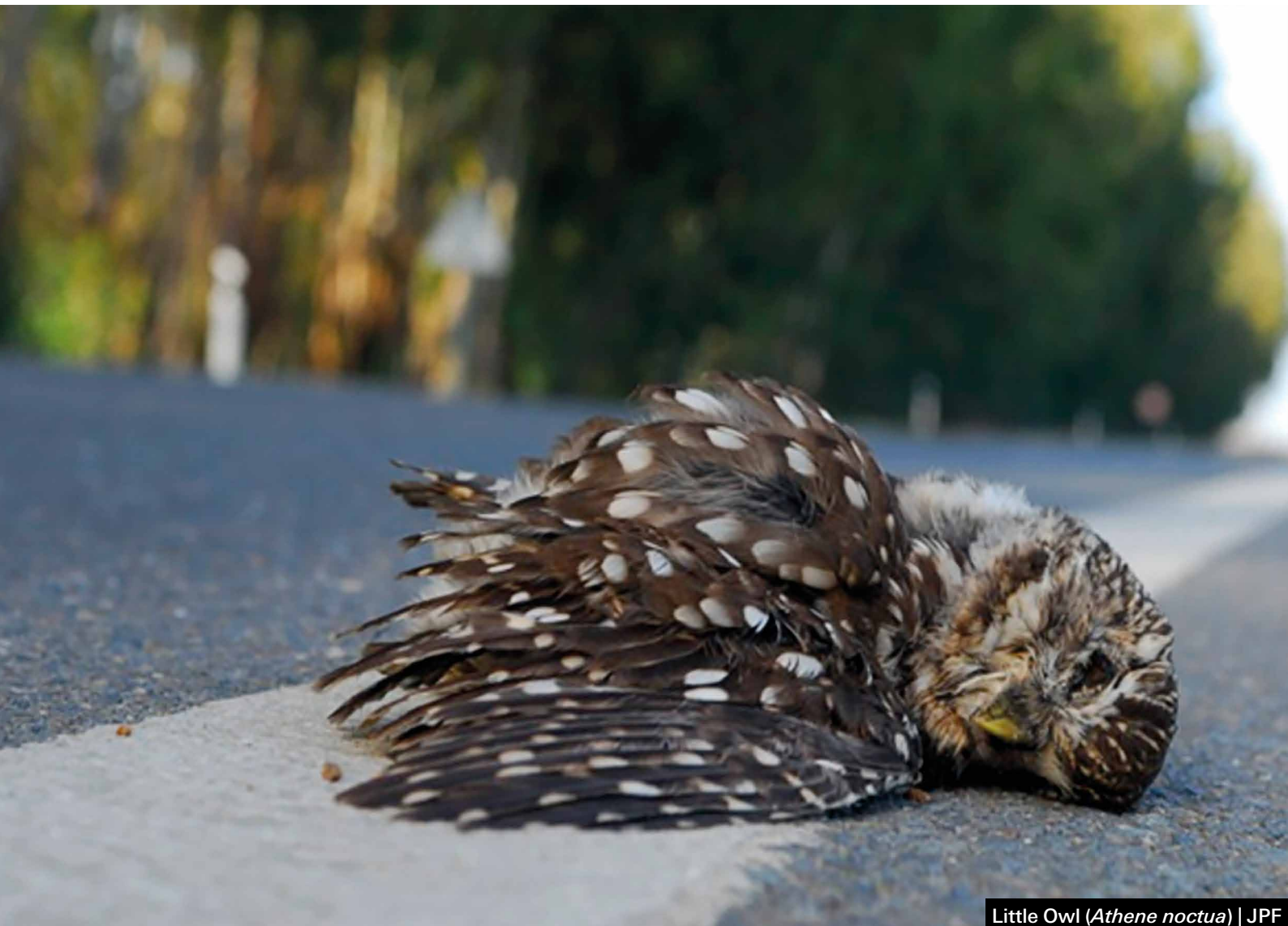
The car should, whenever possible, proceed on the paved roadside, so that it causes the least disturbance to the other vehicles. The observer must survey the carcasses that might be present in all the road lanes and roadsides and record their location.

According to the mortality data collected by the MOVE and LIFE LINES projects, more animals are recorded on the roadside where the monitoring vehicle circulates (30.6%) (roadside1) and it drops to less than half (16.1%) on the opposite roadside (roadside 2).

- In the case of daily monitoring, the direction should change every day, to maximize the detection of roadkill on both sides of the road.



- For most fauna groups (except reptiles), the survey should begin in early morning, within one hour after sunrise.



Little Owl (*Athene noctua*) | JPF



AO



Lesser horseshoe bat
(*Rhinolophus hipposideros*) | LL



European robin (*Erithacus rubecula*) | LL

The variables to be recorded for each roadkill depend on the objective of the study. If a simple counting of number of individuals per species/group is the goal, then it is sufficient to record:

- The species or the closest taxonomic group on which it is included;
- The location (preferably with GPS coordinates);
- Date and hour.

If a more detailed monitoring is possible, than other information can be recorded, such as:

- Sex;
- Age;
- Condition of the carcass (intact/smashed);
- The location on the road;
- The category of time since roadkill occurred (old/recent).

It is also possible to collect samples of fur and/or muscle for subsequent genetic analyses.

How to register

The way to record roadkill depends on the objective, the duration and the periodicity of the study. If it is a simple civic contribution and a single record, requiring no regular collection of specific data, the available tools developed for this purpose, such as the LIFE LINES App, can be used. If the establishment of a long-term monitoring program is the aim, gathering a substantial volume of data in the framework of an environmental evaluation, scientific project or other, the App still can be used, but depending on the details of the information needed, a specific system may be needed to record the occurrences, involving the use of field forms linked to a GPS, or an automatic system developed for the purpose.



LIFE LINES APP

Any citizen can contribute to the collection of information on roadkill, through the LIFE LINES App. This only requires an Android smartphone, and to download the LIFE LINES App through Google Play. This App is only available in Portuguese. You must register and confirm the registration through email. When you find a roadkill, select the group and/or species, if you are able to identify it; if not, you can choose the option “Não sei” which is available at every group menu. The submission of the record must always be accompanied by a photograph, so that the technicians are able to validate the observation, confirming or correctly identifying the species. Do not forget to activate the smartphone’s GPS! See further details on the use of the App at: <https://lifelines.uevora.pt/index.php/app-life-lines/>.



CREATION OF AN AUTOMATIC REGISTRATION SYSTEM

An Open Source tool available to manage this kind of data is, for example, the Open Data Kit (ODK). This application allows the collection (both online and offline), management and use of data through simple forms. ODK runs in all the Android devices and allows the collection of data such as GPS coordinates, photographs and other relevant information for the users. These data can be stored in the application servers or in a user-specific one. For further details, visit <https://getodk.org/>.

For other systems (e.g., IOS, Windows) there is the Enketo tool, which works in a similar way to ODK. Further details can be found at <https://enketo.org/>.

RECORD ON PAPER, GPS SUPPORTED

Another option, when resources are scarce, is to use a paper form to record the roadkill and a GPS device (or a smartphone with the same function) to mark the places where carcasses are found.

Inevitably, this procedure is more time-consuming and prone to errors; an automatic system provides almost instantaneous and more reliable information.

AUTOMATIC METHODS OF MONITORING

Adding to the conventional monitoring methods, a mobile platform is also commercially available to detect and automatically record roadkill.

In the framework of the project, a Mobile Mapping Systems (MMS) model was developed to detect amphibians and passerines killed on roads. The MMS consists of a high-definition camera with an integrated GPS device, which collects images, subsequently processed with a software that allows the detection and identification of animals.

The MMS can be easily coupled to any vehicle and the monitoring can be performed by any person, regardless of his/her experience in sampling, in any kind of road and covering road full width; it only requires sampling at a low and constant speed (e.g., at 20-30 km/h about 80% of carcasses can be detected).

An automatic system is independent of the observer, thus allowing the uniformization of roadkill monitoring methods, with clear advantages such as the reduction of the survey time and the collection of information on small animals, for which the low detectability often leads to underestimates of the real impact of roads on their populations.

The MMS3 is the more recent version, and the instructions for mounting and operating it are available upon request addressed to the developers (the team coordinated by Neftalí Sillero, at Faculdade de Ciências da Universidade do Porto).



Safety above all!

When monitoring roadkill, you must always ensure your safety and the safety of the other drivers. So, make sure that the vehicle and the monitoring people are properly signalled, with visual information such as lighted equipment and reflective jackets. During the process, turn the dipped headlights and the warning lights of the vehicle on, to better alert the other drivers about your slow movement.

If you use the App to submit an observation, keep safe. Do not use it while driving and do not make any dangerous move. Pay attention to the other vehicles on the road when you stop yours and step out to record a roadkill.

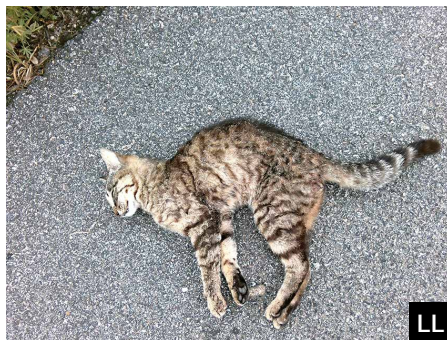
Identification of roadkill animals

Following, we show some examples of vertebrate species subject to the highest mortality rates in Portuguese roads (source: National Roadkill Database — LIFE LINES).

For each fauna group, a brief description is presented as well as examples of the species of that most often are found killed on the roads, showing the main characteristics for their identification. For wild species, photos of a living and of a roadkill animal are indicated, as well as information on size and other physical traits, their distribution in Portugal and their relative abundance.

DOMESTIC ANIMALS

Among domestic animals, cats and dogs are the most frequent roadkill. In contrast with wild fauna, these roadkill do not present a seasonal pattern. However, they are recorded mainly in urban or peri-urban zones, of high population density, where the abandonment and escape of these animals are highest.



Cat (*Felis silvestris catus*)



Dog (*Canis lupus familiaris*)



Iberian Painted Frog (*Discoglossus galganoi*)

WILD ANIMALS

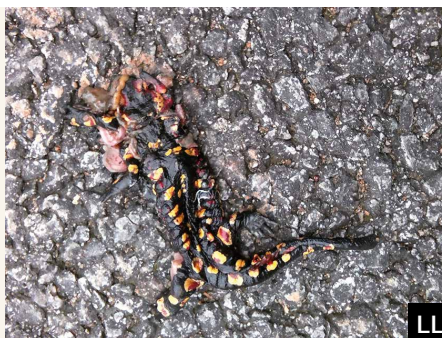
AMPHIBIANS

The Amphibians include the salamanders, newts, toads, frogs and tree frogs, and they are one of the groups most affected by roadkill. Due to their small size and fragile body, they remain on the road for a short time after being hit. They are also more difficult to detect when the monitoring speed increases.

These animals are more vulnerable to roadkill when they move from and to water bodies, during the dispersal and mating seasons. These movements occur in rainy or very humid nights, and when temperatures are mild, normally from Autumn, with the first rains, until late Spring.

Salamanders and newts

Amphibians with tail, long body and short limbs. They differ from lizards because they have a naked skin.



Fire salamander
Salamandra salamandra

- Length: up to 25 cm
- Black body, with yellow and/or red markings
- Widespread throughout Portugal
- Common

Sharp-ribbed newt *Pleurodeles waltl*

- Length: up to 30 cm
- Grey-coloured body, with a lateral row of orange warts
- Occurs mainly in the Centre and South of Portugal
- Common

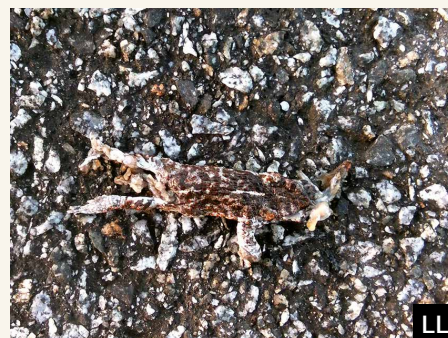


Frogs and toads

Amphibians with short and stubby bodies, tailless, with protruding eyes and powerful hind limbs adapted for leaping.

Natterjack toad *Epidalea calamita*

- Length: up to 10 cm
- Body of variable colour, with warts, and a light-coloured in the middle dorsal line (which may be missing in a few animals)
- Protuberant eyes, with horizontal pupil and lemon-coloured iris
- Widespread throughout Portugal
- Common



Common toad *Bufo spinosus*

- Length: up to 20 cm
- Brownish body, with warts (may have other colours)
- Protuberant eyes, with horizontal pupil and orange-reddish iris
- Widespread throughout Portugal
- Common



Western spadefoot toad *Pelobates cultripes*

- Length: up to c. 10 cm
- Dorsally coloured with large dark patches patterns, which might vary from yellowish to olive
- Protuberant eyes, with vertical pupils
- Edged dark callus ("black nail") on the hind foot
- Occurs mainly in the Centre and South of Portugal, only sporadically in the North





LGS

Ladder snake (*Zamenis scalaris*)

REPTILES

The reptiles include snakes, lizards, geckos and tortoises. It is the group with less recorded roadkill. The most vulnerable species are the snakes, that seek roads for thermoregulation. The periods when they are more vulnerable to roadkill are those of highest activity, i.e., the mating season in Spring and subsequent dispersal of juveniles, until Autumn.

Lizards and small lizards

Reptiles with elongated bodies and generally well developed limbs and a tail.



TP



LL

Algerian psammodromus *Psammodromus algirus*

- Length: up to 9 cm (tail not included)
- Brownish body, with two parallel yellow stripes along the body
- Large dorsal and overlapping scales, resembling roof-tiles
- The males exhibit a reddish head during the mating season
- Widespread throughout Portugal
- Common

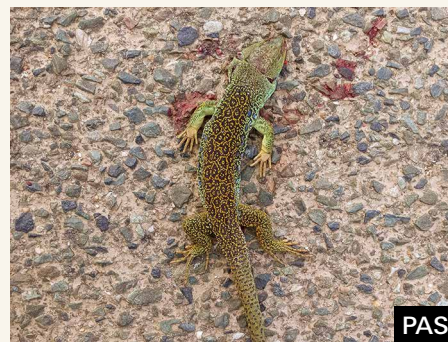
Ocellated lizard

Timon lepidus

- Length: up to 26 cm (without the tail)
- It is the largest lizard in Portugal
- Greenish body with blue spots and yellowish belly
- Juveniles are brownish and have white spots all over the body, and might be mistaken with juveniles of the Iberian emerald lizard
- Widespread throughout Portugal
- Common



TP



PAS

Snakes

Reptiles with elongated bodies, with no limbs.

Ladder snake

Zamenis scalaris

- Length: up to 1.65 m
- Yellowish body, with two longitudinal dark stripes
- In juveniles, the dorsal stripes are linked by transverse lines, resembling a ladder
- Widespread throughout Portugal
- Common



LGS



LL

Montpellier snake

Malpolon monspessulanus

- Length: can reach more than 2 m
- With scales over the eye, resembling a pronounced "eyebrow", typical of this species.
- The males are olive-green and exhibit a dark blotch near the "neck"; the females normally present a well-defined light-brown and cream pattern.
- Widespread throughout Portugal
- Common



LGS



LL

Horseshoe whip snake

Hemorrhois hippocrepis

- Length: up to 180 cm
- Light-coloured body with large dark patches
- Occurs mainly to the south of the Douro river
- Common



TP



LL



Common chaffinch (*Fringilla coelebs*)

BIRDS

Birds have the highest number of roadkill, and nocturnal birds-of-prey and passerines are the most affected groups. The former (e.g., owls) are frequently hit by vehicles because they use roadsides for hunting for instance small mammals, cross the roads between habitat patches, or are blinded by car headlights. The passerines are frequent victims of roadkill due to their abundance and diversity, and are caught during their short movements in the habitats adjacent to the roads. Some birds-of-prey and corvids are also vulnerable to roadkill because they feed on dead animals that remain on roads and roadsides.

It is in late Spring and in Summer that the probability of bird roadkill is highest, since it is the period when chicks, still inexperienced, leave their nests and become independent. By the end of Summer and Autumn, mortality might also increase due to migrations, however, with lower values than in the previous season.

Owls

Generally heavily-built birds, with a characteristic face-shield with large, frontal eyes.

Tawny owl

Strix aluco

- Length: 37 - 43 cm
- Wingspan: 81 - 96 cm
- Brownish plumage, with light mottling; round head
- Dark eyes and yellowish bill
- Widespread throughout Portugal
- Common



Barn owl

Tyto alba

- Length: 33 - 39 cm
- Wingspan: 80 - 95 cm
- White belly, orange-greyish back
- White, heart-shaped face
- Widespread throughout Portugal
- Common in the Centre and South of Portugal



Little owl

Athene noctua

- Length: 23 - 28 cm
- Wingspan: 50 - 57 cm
- Brownish plumage with white spots; round head
- Yellow eyes
- Widespread throughout Portugal
- Common



Small birds

Small to medium-size birds, with wide morphological diversity.



Eurasian blue tit
Cyanistes caeruleus

- Length: 10 - 12 cm
- Blue cap and white face, short beak; yellow breast and blueish wings
- Widespread throughout Portugal
- Common



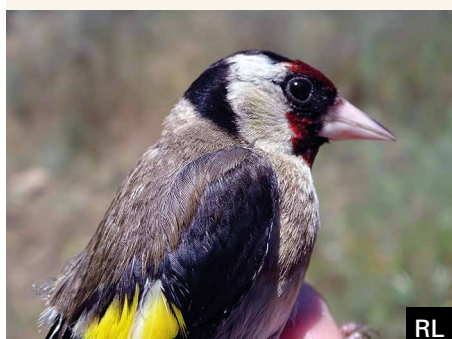
Eurasian Blackcap
Sylvia atricapilla

- Length: 13 - 15 cm
- Greyish plumage, brownish back
- Head with a conspicuous cap, which is black in males and reddish-brown in females and juveniles
- Widespread throughout Portugal
- Common



House sparrow
Passer domesticus

- Length: 14 - 16 cm
- Brownish back plumage
- Grey and brown head, and black throat (male); brownish head with a cream-coloured line above the eye (female)
- Widespread throughout Portugal
- Common



Goldfinch
Carduelis carduelis

- Length: 12 to 14 cm
- Brown plumage, black wings with broad yellow bar
- Black and white head, with a red mask
- Widespread throughout Portugal
- Common



LGS

European hedgehog (*Erinaceus europaeus*)

MAMMALS

This group includes bats, insectivores (e.g., hedgehogs, shrews, moles), rodents (e.g., mice, squirrels), carnivores (e.g., foxes, badgers), lagomorphs (rabbits, hares) and ungulates (e.g., wild boar, red deer).

In general, the probability of mammal roadkill increases during the breeding and dispersal seasons, and these are different among the mammal groups.

For the most common species of bats, such as *Pipistrellus* spp., roadkill peaks between late August and early September, corresponding to the period of greatest activity and the first flights of the young. Lactating females are more vulnerable between May and July, when they need more food and water, and hence perform more flights. However, for the most threatened species, as many cave bats, roadkill usually occurs during the migrations between the mating and hibernation roosts, in early Spring and late Autumn, when the mortality of the more common species is lower. For this reason, the monitoring of bats should extend from March to October.

Small mammals, which include rodents (e.g., mice and rats) and shrews, are among the most frequent victims of roadkill. The highest number of deaths occurs in periods of higher activity, in Spring and Autumn. Due to their small size, they are difficult to detect and are rapidly removed from the road, thus risking underestimation in some studies.

Regarding lagomorphs, particularly the wild rabbit, there is a high number of roadkill year-round, with a slight decrease in Summer. Rabbits stand among the most vulnerable species, as they often build their burrows and breed on road slopes.

The mortality of ungulates is recorded year-round, with a slight increase in Autumn-Winter, coinciding with the peak of breeding season. However, wild boars (the species with the highest number of roadkill in this group) reproduce year-round, whenever the conditions are adequate.

Although with less roadkill than other groups, carnivores are much more affected due to their small populations. Some threatened species, such as the Iberian wolf and the Iberian lynx, present high roadkill numbers, with peaks in late Summer-Autumn, when the pups become independent and disperse.

BATS

Small flying mammals, with wings consisting of a thin membrane of skin between the fingers, alongside the body.



General characteristics of the group:

- Length: 3.3 to 10.3 cm + tail 2.2 to 6.6 cm (depending on the species)
- Brownish or greyish fur, depending on the species
- Very small eyes
- They might be mistaken for mice, and the wings are the characteristic that most easily helps to identify them
- The distribution depends on the species

Kuhl's pipistrelle (*Pipistrellus kuhlii*)

INSECTIVORES

Small mammals that often fed on insects and other invertebrates. They include the hedgehogs, shrews and moles.

Shrews

General characteristics of the group:

- Length: 4.0 to 8.8 cm + tail 2.4 to 6.4 cm
- Greyish or brownish fur
- Short tail, pointed muzzle and small eyes
- The distribution depends on the species, some are common. The rarer species
- Occur mainly in the center and north of the country



Greater white-toothed shrew
(*Crocivura russula*) | CS

RODENTS

Small mammals, with characteristic well-developed incisor teeth.

Mice and rats

General characteristics of the group:

- Length: 7 to 27 cm + tail 5 to 25 cm (depending on the species, rats being larger than mice)
- Greyish, brownish or reddish fur, depending on the species
- The tail can be short or long; the garden dormouse has black eye markings and the tail has a terminal tassel of hair
- The distribution varies with the species, but they are often common



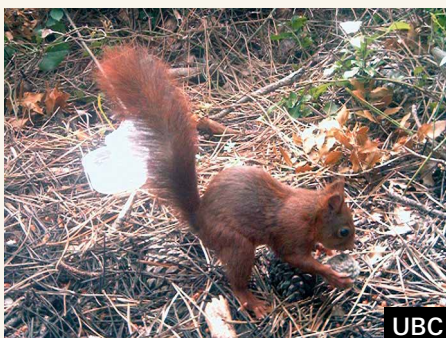
Wood mouse (*Apodemus sylvaticus*)

Squirrels

Red squirrel

Sciurus vulgaris

- Length: 19 to 24 cm + tail 15 to 21 cm
- Brownish/reddish fur on the back, lighter in the belly
- Paint-brush ear tufts
- Long and fluffy tail
- Occurs in the North and Centre of Portugal but it is expanding
- Relatively common



LAGOMORPHS

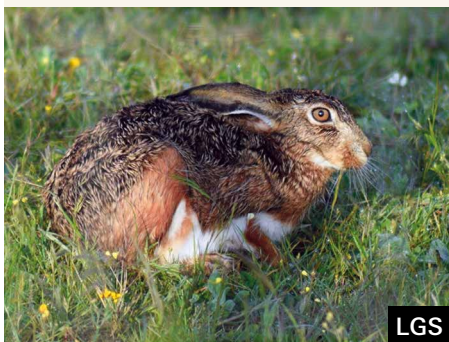
Small to medium-size mammals, herbivores, with well-developed hind limbs, appropriate for leaping, and long ears.



Wild rabbit

Oryctolagus cuniculus

- Length: 34 to 45 cm
- Greyish fur
- White tail
- Long ears
- Widespread throughout Portugal
- Abundant in some areas, rare in others due to diseases



Iberian hare

Lepus granatensis

- Length: 41 to 51 cm (head + body); tail 22 to 26 cm
- Brown fur
- Longer ears than the wild rabbit, with dark spots at the end
- White tail with a dark stripe
- Widespread throughout Portugal
- Common

UNGULATES

Mammals with hooves, generally large-sized.



Wild boar

Sus scrofa

- Length: 110 to 155 cm
- Homogeneous dark greyish-brown fur
- The piglets present horizontal stripes
- Widespread throughout Portugal
- Common

CARNIVORES

Group of predator mammals, from small to large size.

Red fox

Vulpes vulpes

- Length: a little more than 1 m, 40 cm of which correspond to the tail
- Hair colour is variable (reddish, yellowish, greyish) and hairy tail with a white tip
- Widespread throughout Portugal
- Common



European badger

Meles meles

- Length: up to 1 m, including the tail
- White head, with two lateral dark stripes that cross the eyes
- Widespread throughout Portugal
- Common



Stone marten

Martes foina

- Length: 65 to 80 cm, tail included
- Dark-brown fur, with a white “bib” that can extend to the shoulders (characteristic of the species)
- It can be mistaken for the European pine marten (*Martes martes*) but the latter only occurs in the North of Portugal and the yellowish “bib” is only on the chest
- Widespread throughout Portugal
- Common



Genet

Genetta genetta

- Length: about 90 cm, including the tail, which can be almost as long as the body
- Pointed muzzle
- Greyish fur with circular darker spots
- Light-coloured tail, with well-marked dark rings
- Widespread throughout Portugal
- Common



Sharing and dissemination of data

DATA STORAGE

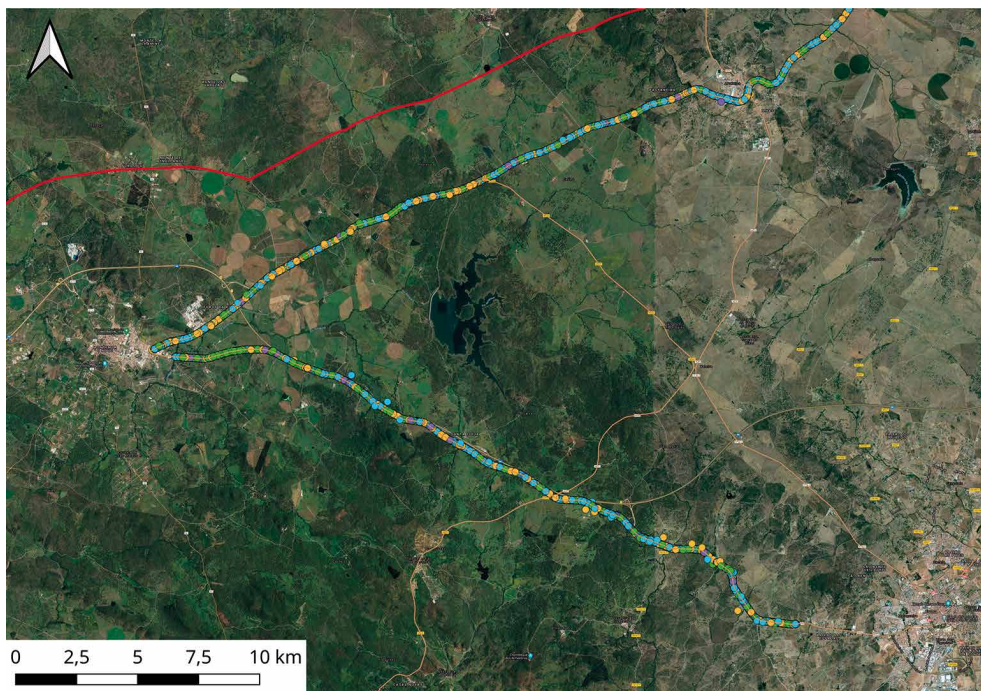
It is not possible to produce science and make applied conservation without information. Therefore, all the information obtained from roadkill is extremely important to design the best strategies to minimize their impact.

The data - from several scientific projects, public and private road operating companies, road safety institutions, and even common citizens -, were scattered, in different sources and formats; no common platform existed to gather all the information under a single standardized and georeferenced system, available to all.

To fill this gap, the LIFE LINES project developed the National Roadkill Database (Base de Dados Nacional de Registos de Atropelamento de Fauna), jointly created by the University of Évora and Infraestruturas de Portugal. This tool allowed to gather

all the information and use to identify roadkill hotspots that might represent an increased risk to drivers; to evaluate the negative effects of existing roads on animal communities; and to design plans to mitigate roadkill in roads already existent or to be built. These data can also be used for other purposes such as scientific publications or outreach activities.

The Database is available at the LIFE LINES website (<https://lifelines.uevora.pt/>). So far, it comprises data from organizations such as the University of Évora and other academic institutions, Infraestruturas de Portugal



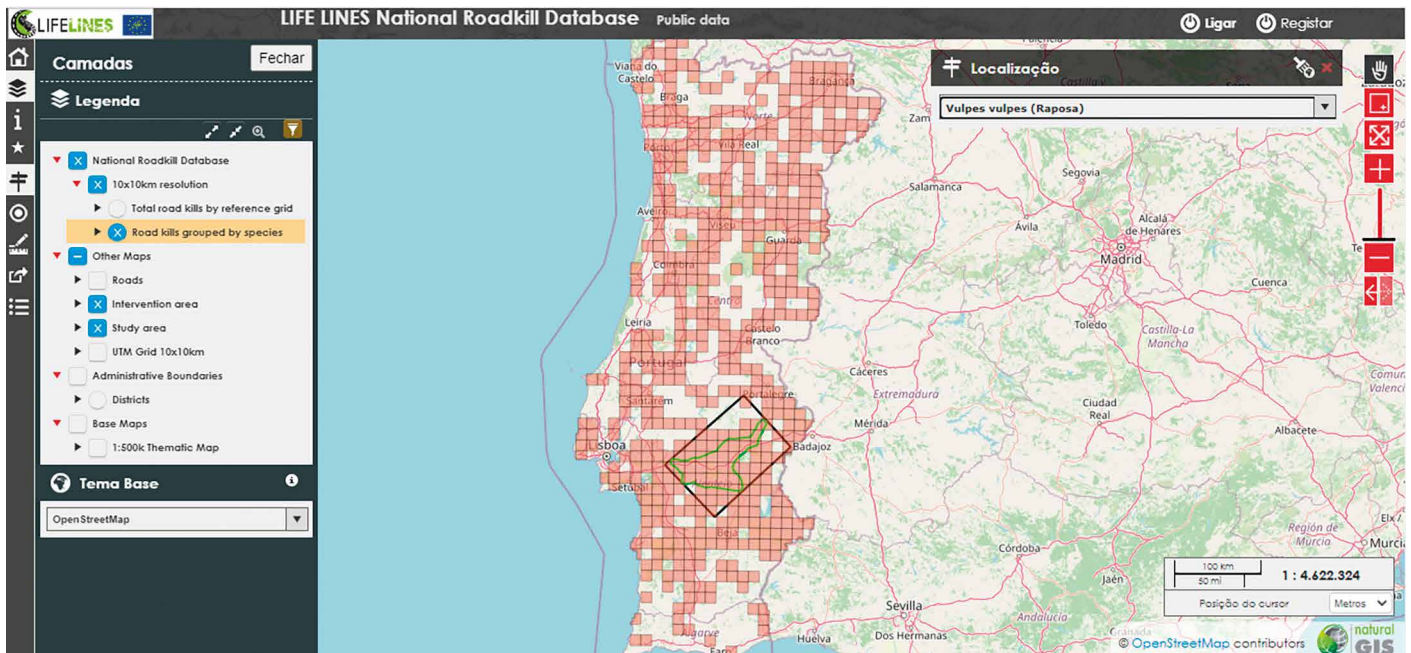
Records of roadkill, collected in the framework of the projects MOVE and LIFE LINES

S.A. and several road concessionaries, police (GNR), ICNF and individual citizens who have been contributing through the App or by sending the records to app.lifelines@uevora.pt.

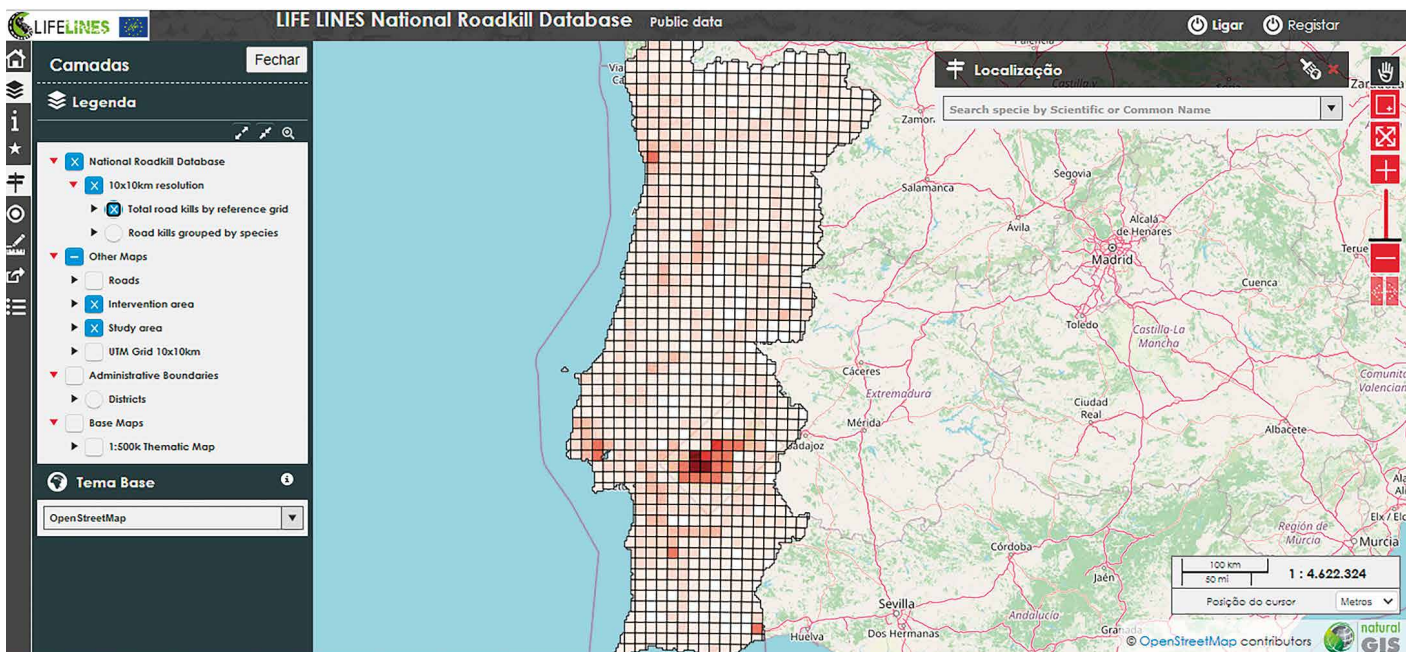
We call road related companies and entities, traffic security authorities, conservation agencies and citizens in general, to establish or contribute to roadkill monitoring programs, by recording carcasses found on the road, and sending the information to the Database, contributing to its enrichment and, hence, making it increasingly relevant to promote the sustainability of linear infrastructures and to improve road security.

ACCESS TO THE DATABASE

The data can be viewed in 10x10km square resolution [here](#); more specific data can be requested through the [form](#) available at the LIFE LINES website.



Layout of the National Database of Roadkill Records.



It is possible to see total data, or to search for a given species.

Learn [here](#) how to browse through the National Roadkill Database.

The value of information

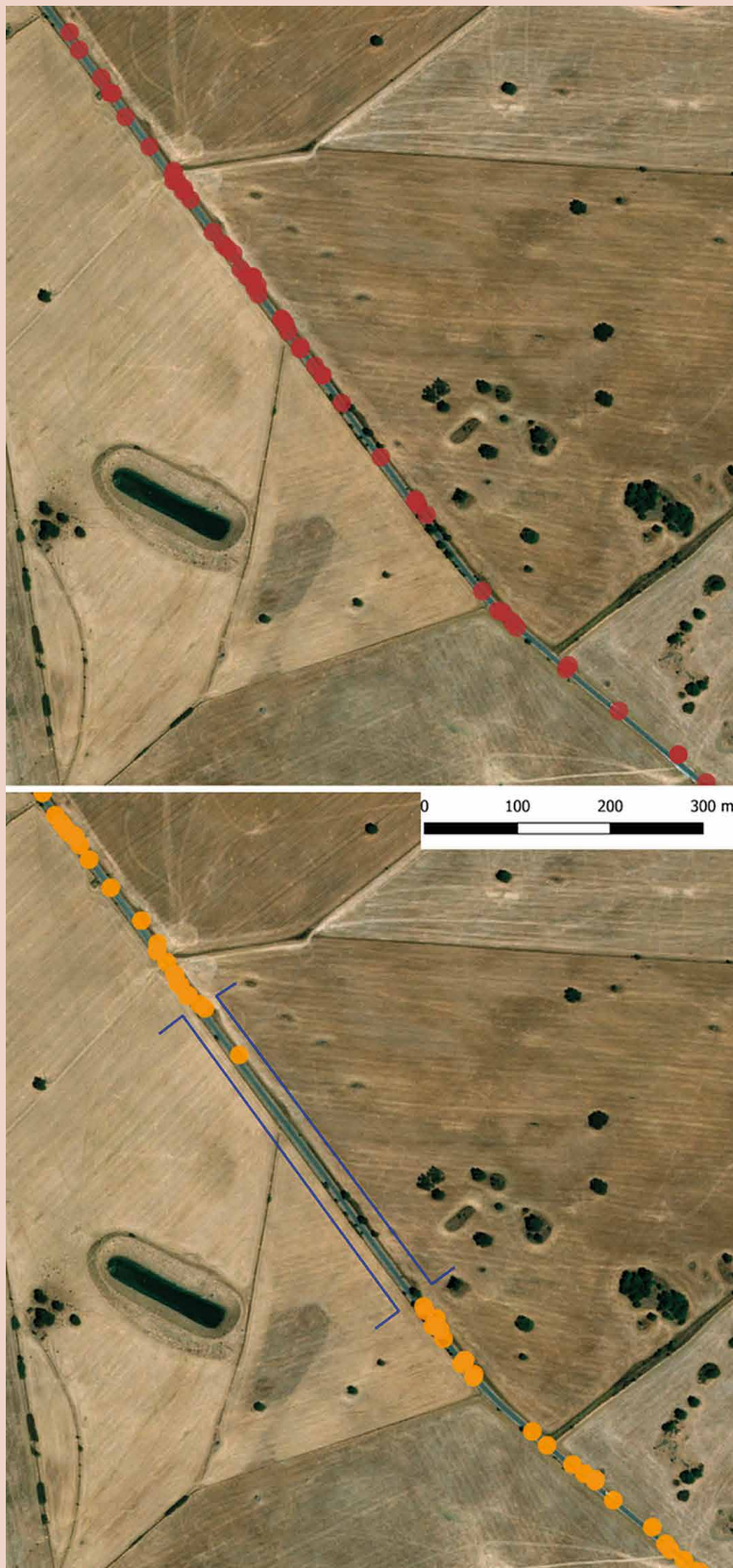
The data on roadkill allow to identify hotspots of mortality, i.e., those locations where the highest roadkill rates are found. This information is essential to propose roadkill mitigation actions which, in many places, are a serious problem for road safety, mainly when they involve collisions with large-sized animals such as wild boar or red deer.

The best strategy to minimize the negative impacts will depend on the site and on the type of road. Actions such as the installation and adaptation of passages for fauna, or the use of pre-existing ones such as culverts (that animals have been found to use), fences, walls to elevate flight height or road signs can all be applied in road stretches where high fauna mortality is recorded.

CASE STUDY

The roadkill monitoring performed for several years in the framework of the MOVE project allowed to identify the road stretches where the risk of roadkill was highest. Values higher than expected were found in several sections of road EM529, a municipal road managed by Évora municipality. This was primarily promoted by the proximity of ponds, important reproduction habitats that seasonally attract amphibians. The road crosses their migratory paths, thus explaining the high number of roadkill. A technical solution was therefore required. In the framework of the LFE LINES project, and together with Évora municipality, a barrier for amphibians was installed along a segment of this road where the characteristics (e.g., width of the roadside) and surrounding topography allowed it without increased risks for road traffic. These barriers were complemented with specific tunnels for amphibians, so that while the former prevented them from crossing the road, the latter allowed them to reach the opposite side of the road, thus ensuring safe migrations and dispersal movements, to and from the breeding areas. The implementation of these structures led to a significant reduction of mortality in this group of animals in this part of the road, as shown by subsequent monitoring. Identifying the causes of roadkill allowed to develop and apply solutions that now have a positive impact on the sustainability of the transportation network. Con-

tinuously feeding the Database will support the replication of these kind of solutions to mitigate the negative effects of roads on animal populations.



Amphibian mortality records before (red dots) and after (yellow dots) the placement of barriers on a section of the EM529 municipal road (blue lines in the figure below).

Complementing the information from roadkill records

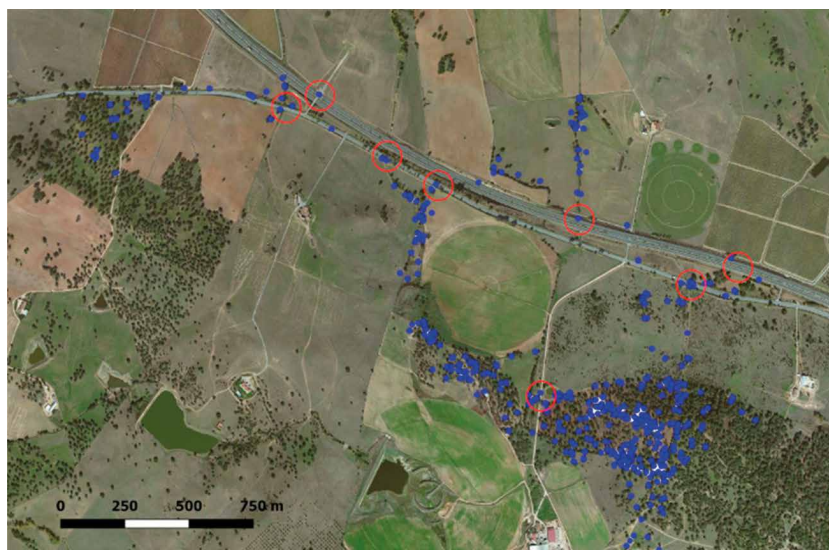
– The example of LIFE LINES Project

Crossing the information about the location of recorded roadkill with data about the movement, abundance, reproductive ability or the behavior of species allows to develop tools that support decision, such as maps of probability of movement or occurrence of species, identification of ecological traps or underlying barrier effects, thus defining target places for intervention as well as adequate measures to minimize the impacts of the road on local fauna. However, this is not always possible for all projects or activities.

In LIFE LINES, complementarity information was gathered for genets, through tagging and following them through telemetry. In this case, it was possible to know the places where the genets came close to the roads and to detect potential places of roadkill for this species.



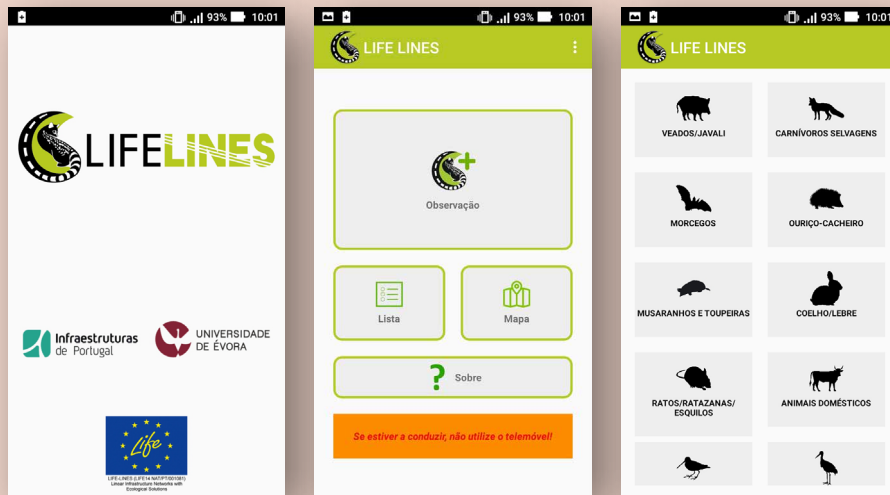
Attachment of a transmission device to a genet (*Genetta genetta*) at the Vet Hospital.



Locations of a genet monitored in the framework of the project, and identification of the areas where it came close to the road (red circles).

LIFELINES APP

Download the **LIFE LINES** application on **Google Play** and collaborate with us in the registration of roadkill animals. Your observations will be part of a national database. In addition, they will help us to understand the reasons why animals cross the roads in certain locations and implement measures to reduce wildlife road mortality. Be a part of this team and help us to conserve our species!



If you find an animal that has been struck but is still alive, please contact the police line SOS Ambiente e Território, GNR - SEPNA (808 200 520).

BIBLIOGRAPHY

- Bencatel, J., Sabino-Marques, H., Álvares, F., Moura, A.E. & Barbosa, A.M. (2019). *Atlas de Mamíferos de Portugal*, 2ª edição. Universidade de Évora, Évora.
- Colino-Rabanal, V.J., Lizana, M. & Peris, S.J. (2011). *Factors influencing wolf Canis lupus roadkills in Northwest Spain*. European Journal of Wildlife Research 57, 399–409.
- Ferrand de Almeida, N., Ferrand de Almeida, P., Gonçalves, H., Sequeira, F., Teixeira, J. & Ferrand de Almeida, F. (2001) *Guias FAPAS Anfíbios e Répteis de Portugal*. Fapas. Porto
- Loureiro, F., Pedroso, N.M., Rosalino, L.M., Santos, M.J. (Eds) (2012). *Um Olhar Sobre os Carnívoros Portugueses*. Carnivora. Lisboa.
- MacDonald, D. & Barret, P. (1993). *Mammals of Britain & Europe*. Harper Collins Publishers. London
- Mullarney, K., Svensson, L., Zetterström, D. & Grant, P. J. (2012). *Guia de Aves - Guia de Campo das Aves de Portugal e da Europa*. Assírio & Alvim. Stockholm
- Purroy, F. J., & Varela, J. M. (2005). *Mamíferos de España: Península, Baleares y Canarias*. Lynx Edicions. Barcelona.
- Santos, S.M., Carvalho, F., Mira, A. (2011). *How long do the dead survive on the road? Carcass persistence probability and implications for road-kill monitoring surveys*. PLoS ONE 6(9): e25383
- Seiler, A. (2002). *Effects of Infrastructure on Nature*. In: Trocmé, M.; Cahill, S.; De Vries, J.G.; Farrall, H.; Folkesson, L.; Fry, G.; Hicks, C. and Peymen, J. (Eds.) (2003). *COST 341 - Habitat Fragmentation due to transportation infrastructure: The European Review*, pp. 31-50. Office for Official Publications of the European Communities, Luxembourg.
- Seiler, A., Helldin J.O. (2006). *Mortality in wildlife due to transportation*. In: Davenport J., Davenport J.L. (eds) *The Ecology of Transportation: Managing Mobility for the Environment*. Environmental Pollution, vol 10. Springer, Dordrecht.
- Sousa Guedes, D., Ribeiro, H., Sillero, N. (2019). *An Improved Mobile Mapping System to Detect Road-Killed Amphibians and Small Birds*. ISPRS Int. J. Geo-Inf. 2019, 8, 565.

RECOMMENDED BIBLIOGRAPHY

- Davenport, J. & Davenport, J.L. (2006). *The Ecology of Transportation: Managing Mobility for the Environment*, vol. 10, Dordrecht, The Netherlands: Springer, Environmental Pollution Series.
- ICNB (2008). *Manual de apoio à análise de projectos relativos à implementação de infra-estruturas lineares*. Instituto da Conservação da Natureza e Biodiversidade. Relatório não publicado. 65pp.
- Santos, R.A.L., Santos, S.M., Santos-Reis, M., Picanço de Figueiredo, A., Bager, A., Aguiar, L. M. S., Ascensão, F. (2016). *Carcass Persistence and Detectability: Reducing the Uncertainty Surrounding Wildlife-Vehicle Collision Surveys*. PLOS ONE 11(11): e0165608.
- Trocmé, M., Cahill, S., de Vries, J.G., Farrall, H., Folkesson, L., Fry, G., Hicks, C. & Peymen, J. (eds) (2003). *COST Action 341 - Habitat fragmentation due to transportation infrastructure: The European review*, 129-173. Office for Official Publications of the European Communities, Luxembourg.
- Van der Grift, E.A., Seiler, A., Rosell, C., Simeonova, V. (2017) *Safe roads for wildlife and people*. SAF-EROAD Final Report. CEDR Transnational Road Research Programme Call 2013: Roads and Wildlife. CEDR, Brussels.



The LIFE Programme is a EU's funding instrument created to contribute to the implementation, updating and development of EU environmental and climate policy and legislation by co-financing projects with European added value.

The LIFE Nature and Biodiversity sub-programme supports projects that aim at the conservation and restoration of threatened natural habitats and to protect species of priority conservation in the EU, as well as innovating and demonstration projects on the conservation of biodiversity.

LIFE LINES (LIFE14 NAT / PT/ 001081) – Linear Infrastructures Networks with Ecological Solutions – is co-funded up to 60% by the UE LIFE Programme – Nature and Biodiversity, with a total budget of 5,540,485 €, and duration from August 2015 to May 2021.



Project contacts:

Email | info.lifelines@uevora.pt

Website | <https://lifelines.uevora.pt>

Facebook | www.facebook.com/lifelinesconservation

Vimeo | <https://vimeo.com/user48795863>

Co-financed by:



LIFE-LINES (LIFE14 NAT / PT / 001081)
Linear Infrastructure Networks with
Ecological Solutions 60% co-financed
project by the LIFE - Nature and
Biodiversity Program of the European
Commission

Coordinating beneficiary:



Associated beneficiaries:



Collaborators:

