



LIFE
DINALP
BEAR



**Report of the effectiveness of
implemented measures for
reducing traffic-related mortality of
brown bears on Rijeka – Zagreb
highway: confirmation and
demonstration of the best practice
method**

Action C4: Decrease of traffic-caused bear
mortality

Prepared by: Bojan Vivoda, Đuro Huber and Slaven Reljić

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Zagreb, 2019

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1 INTRODUCTION

Traffic infrastructure significantly and in many ways affects the wildlife habitats through which it passes and wild animals as well. In addition to direct habitat losses, motorways cause population and habitat fragmentation, degradation of habitat quality and direct wildlife road-kills when crossing roads.

Traffic accidents involving wild animals (especially bears) are also risk for road users: facing major economic damages (damage to vehicles, treatment costs, health care costs of injured persons), loss of lives, but also significant animal mortality, including loss of trophies.

According to the aforementioned, the presence of wild animals and even domestic animals on Rijeka-Zagreb highway is a potential danger for all participants in the traffic.

The functional permeability of the motorway section comprises dedicated wildlife crossings (the "Green Bridge") but also other transport facilities that represent potential crossings for wildlife such as the bridges, viaducts and tunnels.

On the section of the A1 motorway (the total length of the Lučko node to the Bosiljevo node - 67.3 km), the functional permeability is very poor and it is about 1.5%, whereby the place to cross for wildlife on the route Zagreb – Karlovac almost does not exist.

On the A7 motorway (length 16.11 km) there is not a single object that could be used wild animals as a crossing, so for them this motorway is not permeable, although it passes through the area that connects Gorski Kotar with Čičarija, or Istria.

On the A6 motorway (length 81.5 km) there are 15 passages under the motorway, 11 tunnels and 1 Green bridge (dedicated crossing for wildlife). The total length of the passage and the crossings for wild animals is 14,2 km or 17.4%, so this motorway section has the best permeability for wild animals.

Despite protective measures (protection fences on the entire route of the motorway) and the possibility of crossing the motorway above or below road (tunnels, viaducts, bridges), but also via specialized crossing for wild animals (green bridge), a number of wild animals used to cross the motorway or enter the enclosed area of the motorway.

In addition to the abundance, distribution and life needs of certain species of wildlife and the quality of the protective fence, the appearance of the animals on the motorway may be caused by the attractiveness of inadequate waste or previously harmed animals, but also the result of predatory activities of wild or domestic canids.

As the vehicles on the motorway operate at very high speeds, the behavior of wild animals is unpredictable (often even aggressively). By applying preventive technical measures that prevent animals from entering the motorway area, and followed by intervention of a well-coordinated and trained emergency team that can successfully remove a wild animal from the motorway with minimal material damage, minimal risk for strictly protected species, and minimal endangerment of traffic participants and participants of the intervention.

The aim of this study was to analyze traffic accidents with wildlife on the Rijeka-Zagreb motorway in the period of Life Dinalp Bear project. That includes the extent of the road-kills of wild and domestic animals as well as the frequency of traffic accidents related to the part of the motorway, the daily and annual dynamics of traffic incidents and, taking into the account the placed counter-measures within Life project.

2 IMPLEMENTED COUNTERMEASURES FOR REDUCING TRAFFIC-RELATED MORTALITY OF BROWN BEAR ON RIJEKA – ZAGREB HIGHWAY

Activities for reducing traffic-caused bear mortality are subdivided into two sub-actions:

- implementation of several technical countermeasures for reducing bear-vehicle collisions by providing either more safe road crossings over state roads and railways, by enabling safe bear escapes out of the highway (when they do come on the highway) and more importantly preventing bear highway crossing with electrification of fences along dangerous highway sections or by warning drivers about the animal;
- supporting activities for rising general awareness of public and end-users about this issue.

2.1 Project actions

In the framework of the implementation of part of the Project "Managing the population and protection of brown bears in the northern Dinarides and Alps" (LIFE DINALP BEAR) led by the Motorway Rijeka-Zagreb Ltd., the following technical countermeasures have been installed:

1. There are 30 unilateral (one-way) doors for animal exit: 20 small doors with dimensions of 100x50 cm and 10 large doors with dimensions of 200x120 cm on the motorway sections from Vuk Gorica to Vrbovsko.
2. Six jump-out ramps were built as the rock embankment (Gabions) inside the wired protective fence of the motorway. The ramps reach the height of the highway fence and allow the animals to jump outside the fenced part of the highway.
3. 23 metal waste containers were delivered, containing 80 liter plastic bins. Containers have a mechanism to open which prevents access for animals to debris.
4. The installation of the electrical fence on the 12 selected sections on both sides of the highway Rijeka – Zagreb from Vukova Gorica to the tunnel Vrata in total length of 72km is completed. The fence is mounted on the outside of the protective wire fence, mostly directly with the existing wire mesh fence or up to 1 m distance. The pillars of the electric fence were installed and a wire (with five threads per pillar) was installed, including insulators, fittings and other equipment and 12 electrical appliances that were placed in the installed electro-cabinets on substations.

Beside technical countermeasures an emergency team was established in case of the brown bear on the motorway.

2.1.1 Electric fence

The installation of the electric fence was completed by the contractor on June 30th 2015 on 12 sections. The test release of electrical fence voltage was conducted on the July 1st 2015, after the setup of the electrical fence and the first technical inspection by the contractor was conducted in same period. It was found that on most sections there were significant losses of voltage, all up to 99% since the area within the existing protective wire fence in many places have not been adequately cleansed from bushes and shrubs, or that the applicable Standard of the regular maintenance of highways was not fully fulfilled. From the completion of the electrical fence installation work it has been invested a significant additional effort and resources to meet the requirements of the maintenance standard related to the maintenance of the protective wire fencing and the cleaning of shrubs and bushes.

Electrical devices and devices for mobile turning on or off of the electricity are installed in accordance with the technical specifications of the contract. Electrical equipment (electric guard) for electric fences on the motorway operate at a voltage of 220V, electrical current is 5 J and resistance of 500 ohm, with output voltage 12,000 V. The devices are set in protective cabinet which are mounted on the highway substations. For all electrical devices contractor delivered manufacturer's statement of conformity.

The maintenance of 72 kilometers of electrical fence have been more difficult than expected because of the ground morphology and vegetation growth which requires a lot of manual work.

During 2016 and 2017 the installed fence, ramps and doors were maintained and cleared from growing grass and shrubs. Occasionally the wires and poles (pillars) of the electrical fence were repaired and straightened. The electrical fence is constantly monitored for its proper operation which finally results in noticeable decrease of bear appearance within fenced area of the motorway and finally bear-vehicle collisions, which so far did not happen in the 2016.

Table 1 Electric Fence sections

| SECTION NUMBER | ELECTRICAL FENCE SECTION | ZG-RI HIGHWAY SECTION | LENGTH (m) |
|-------------------|---|-----------------------|------------|
| 1 | Passage "V. Gorica" - Interchange "Bosiljevo 1" | Karlovac-Bosiljevo | 16.386,00 |
| 2 | Interchange "Bosiljevo 2" - Bridge "S. Drage" | Bosiljevo-Vrbovsko | 5.808,00 |
| 3 | Bridge "Osojnik" - Tunnel "V. Gložac" | Bosiljevo-Vrbovsko | 6.674,40 |
| 4 | Bridge "Kamačnik" - Bridge "Lazi" | Vrbovsko-Ravna Gora | 6.855,60 |
| 5 | Bridge "Jablan" - Tunnel "Čardak" | Vrbovsko-Ravna Gora | 4.362,00 |
| 6 | Tunnel "Vršek" - Green Bridge "Dedin" | Ravna Gora-Delnice | 5.761,20 |
| 7 | "Dedin" Green Bridge - Bridge "Delnice" | Ravna Gora- Delnice | 4.586,40 |
| 8 | Viaduct "Delnice" - Tunnel "Lučice" | Ravna Gora- Delnice | 1.602,00 |
| 9 | Interchange "Delnice" - Tunnel "Sopač" | Ravna Gora- Delnice | 7.149,60 |
| 10 | Tunel "Sopač" - Bridge "Golubinjak" | Delnice-Vrata | 2.112,00 |
| 11 | Bridge "Golubinjak" - Tunnel "Sleme" | Delnice-Vrata | 3.072,00 |
| 12 | Tunnel "Sleme" - Interchange "Vrata" | Delnice-Vrata | 7.762,80 |
| Total Length (m): | | | 72.132,00 |

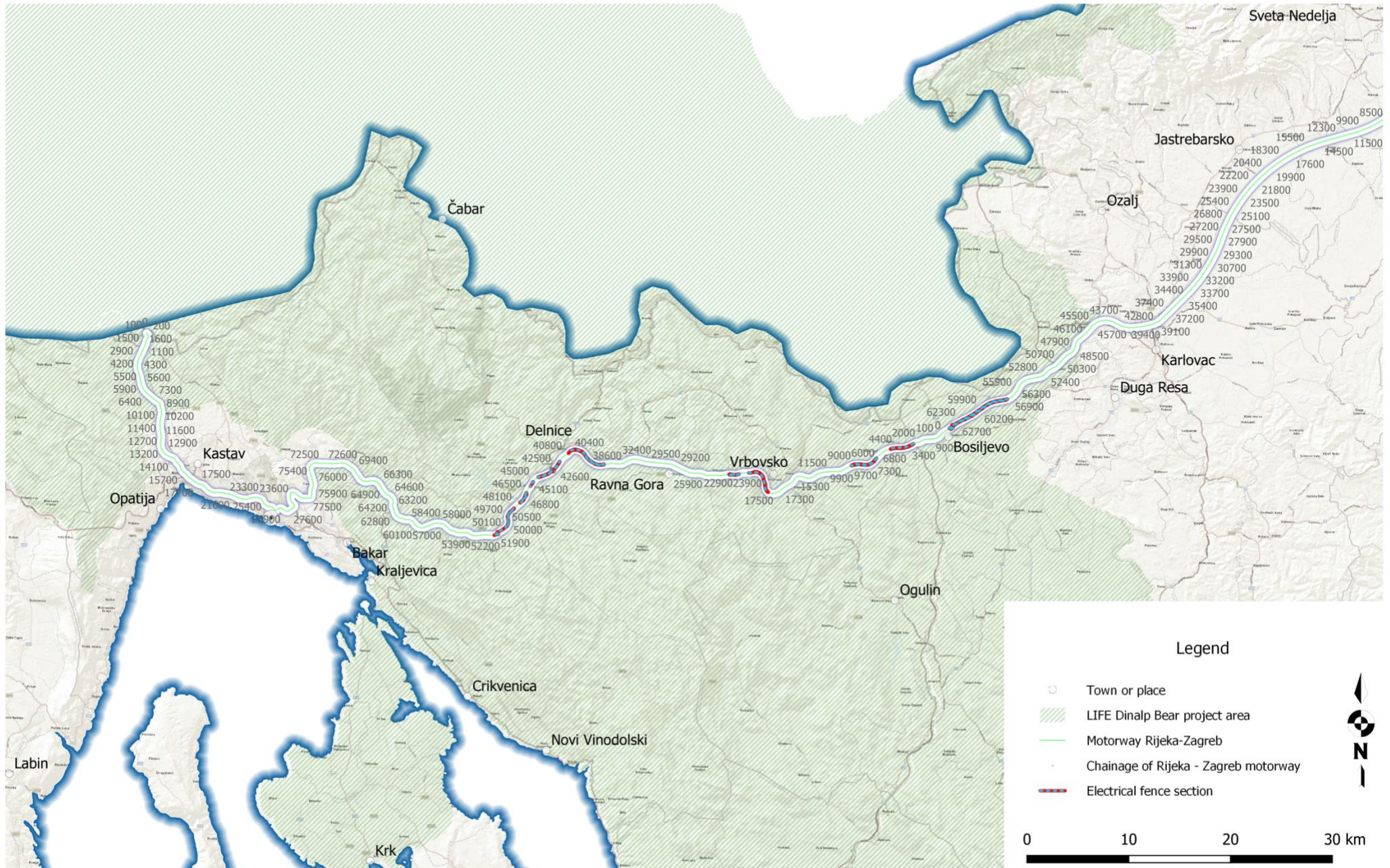




Figure 1 Electric fence

2.1.2 Waste Bins

The "bear resistant" waste bins were set up to prevent attracting wildlife to the highway. The waste bins are placed along the route of the motorway at the rest places where the motorway users stop in case of malfunction or necessity and have opportunity to discard the waste from the vehicle. The installed waste bins are used frequently without the occurrence of bears or other animals in the motorway area that would be attracted by waste.

The waste bins are metal containers with a lid (with gasket, hinges and lifting handle) on the upper side and a plastic bucket inside which can be removed through the door on the back, that is secured with a lock with a key. Containers are made of steel sheets 1.5mm thickness and dimensions: 900x 900x1100mm, the plastic waste bin volume is a 80 liters.



Figure 2 Waste bins

2.1.3 Jump-out ramps and one-sided doors for animal exits

In the event that a bear or other large animal still enters the fenced area of the highway, we set up 30 one-way exit doors, which are closed by itself, and six jump-up ramps, which allow animals to safely leave the premises. In the most problematic places, two different types of exit doors are used, which allow the animal to open the door by pushing the inside out. Jump ramps are the same height as the highway fence and allow the animals to jump out of the enclosed part of the motorway.



Figure 3. Jump-out ramp



Figure 4. One-sided door (bigger)



Figure 5. One-sided door (smaller)

3 ANALYSIS OF WILDLIFE ROAD-KILLS ON MOTORWAY RIJEKA – ZAGREB

3.1 Analysis methodology

For the purpose of the preparation of this study, data on the road-kills of wild and domestic animals were analyzed in the period from 2016 - 2019. In the area of Motorway Rijeka – Zagreb, the following sections were analyzed: A6 Bosiljevo-Rijeka (81.5 km), A1 from Zagreb (Lučko node) to the Bosiljevo node (67.3 km) and the section A7 Rupa – Rijeka (16.11 km).

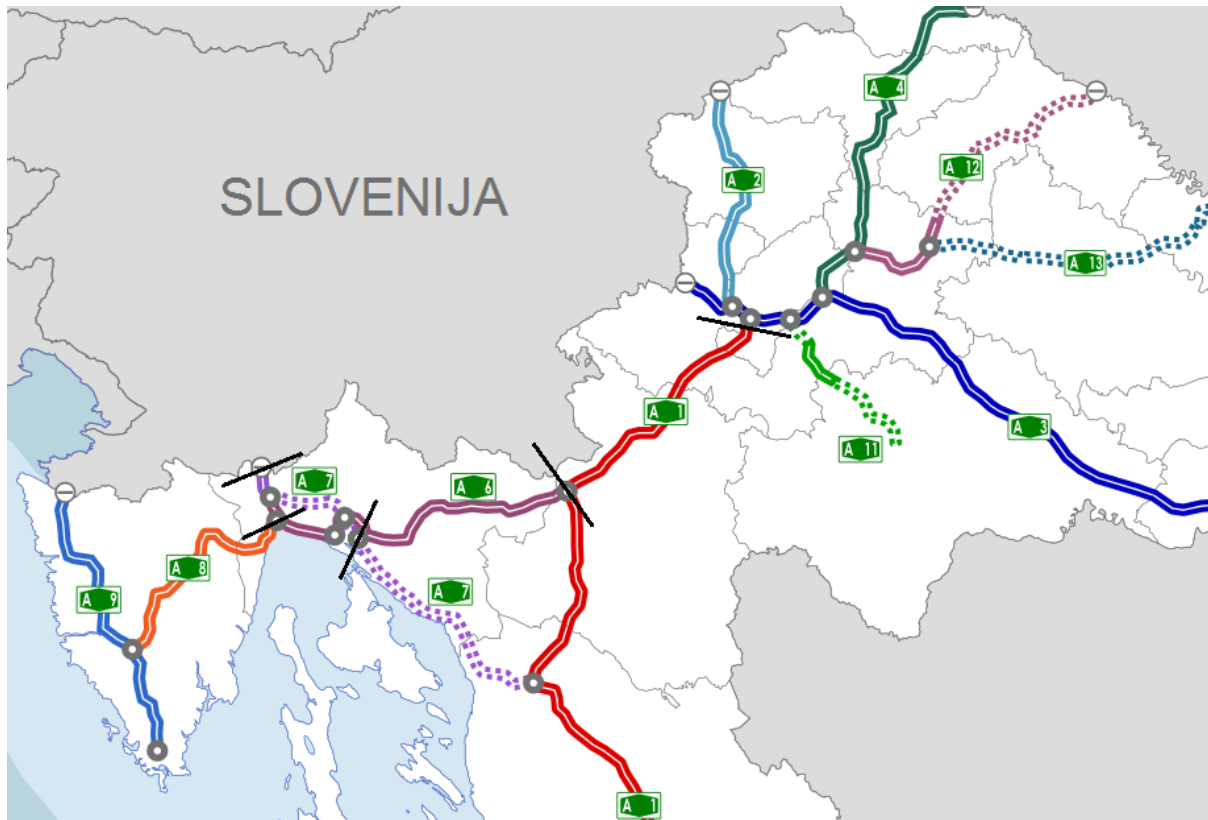


Figure 6. Display of analyzed sections of the motorway A1, A6 and A7

The information about animal reports on the motorway used for the analysis was collected through the following means: by the motorway users (alert to the Center for maintenance and traffic control), service 112, motorway patrolman, police and other persons.

Data was collected systematically with the following details about the event: time and date of the alert, location (stationary), type of animal, indication of whether, information if the alert is true or false and the existence of a collision, or the collision of the vehicle with the animal as well as data on the consequences of the collision (material damage, number of injured and fatalities).

When processing the data, data in which the presence of the animal was recorded as "unknown" and was not involved in a car accident was removed from the analysis. All

the reports were taken as true, as there is a possibility that the animal had left the motorway independently until the arrival of the patrol.

A total of 733 cases of animal occurrence in the Rijeka-Zagreb motorway area were processed, i.e. 137 cases of casualties during 2016, 2017 and 2018.

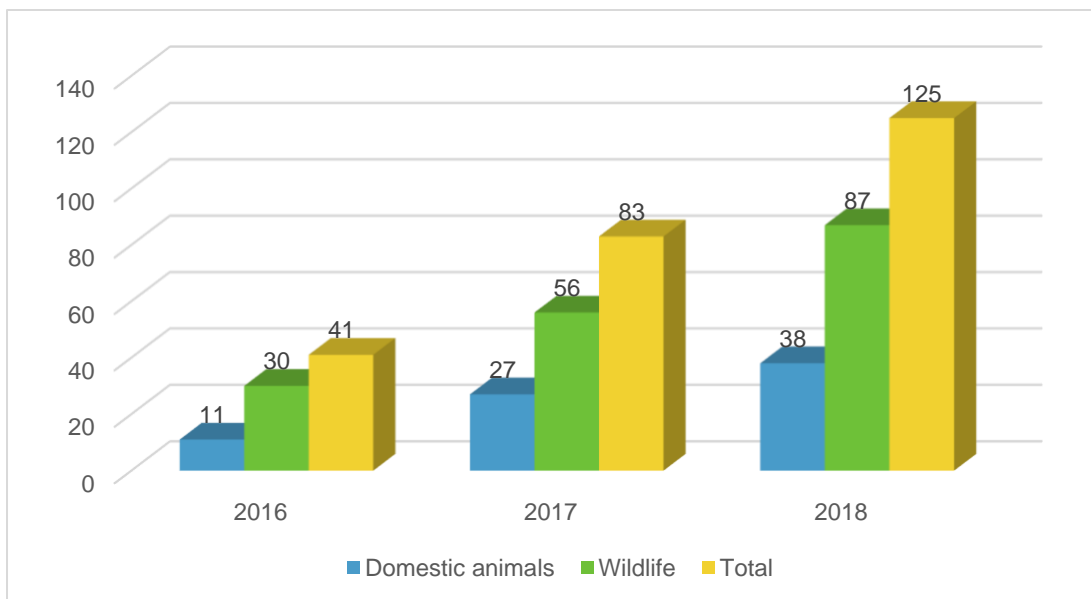
There were no injuries or fatalities of the drivers or passengers in the traffic.

The processing of results identified the most critical motorway sections with the highest number of incidents with wild and domestic animals, in total but also by species.

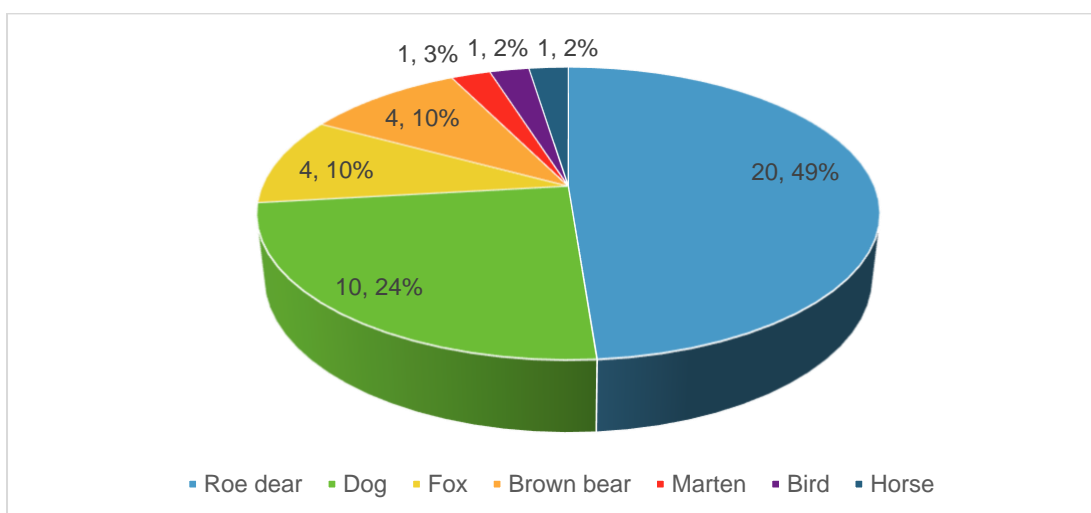
The main species in the area of the analyzed motorways were roe deer (*Capreolus capreolus L.*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa L.*), brown bear (*Ursus arctos L.*) and other protected species, wolf (*Canis lupus L.*) and lynx (*Lynx l.*), as are all present in this area of the project.

3.2 Analysis of wildlife roadkill on Motorway Rijeka – Zagreb (Section A1)

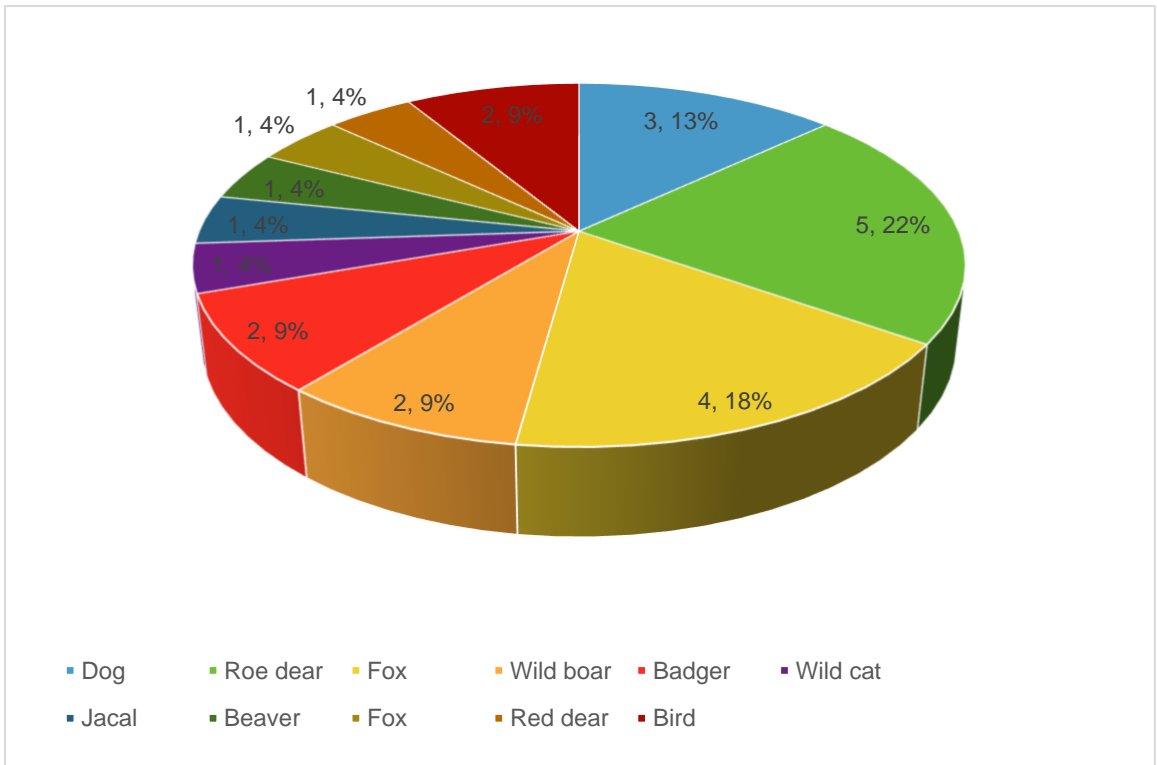
During 2016, on the analyzed section of the A1 motorway, from Zagreb to Bosiljevo, in the first 6 months, a total of 92 animals were observed, during 2017 156 animals, and in 2018 148 animals. In the analyzed period from 2016 till 2018, a total of 396 observations of animals were reported inside the motorway fence. Wild species that were predominantly observed in the area of the motorway are deer and fox, and from domestic animals most commonly seen species is dogs. It is particularly interesting how relatively large number of deer observations within the motorway fence (55% of all animals observed) were accompanied by a relatively small proportion of traffic accidents (21% of the causes of traffic accidents) in the investigated period. It is also interesting that the relationship between observation and traffic accidents changed from 30% in the period 2014-2015, to 22.7% in the period 2016-2018, which could indicate more efficient operation of motorway workers in removing animals from the enclosed motorway area.



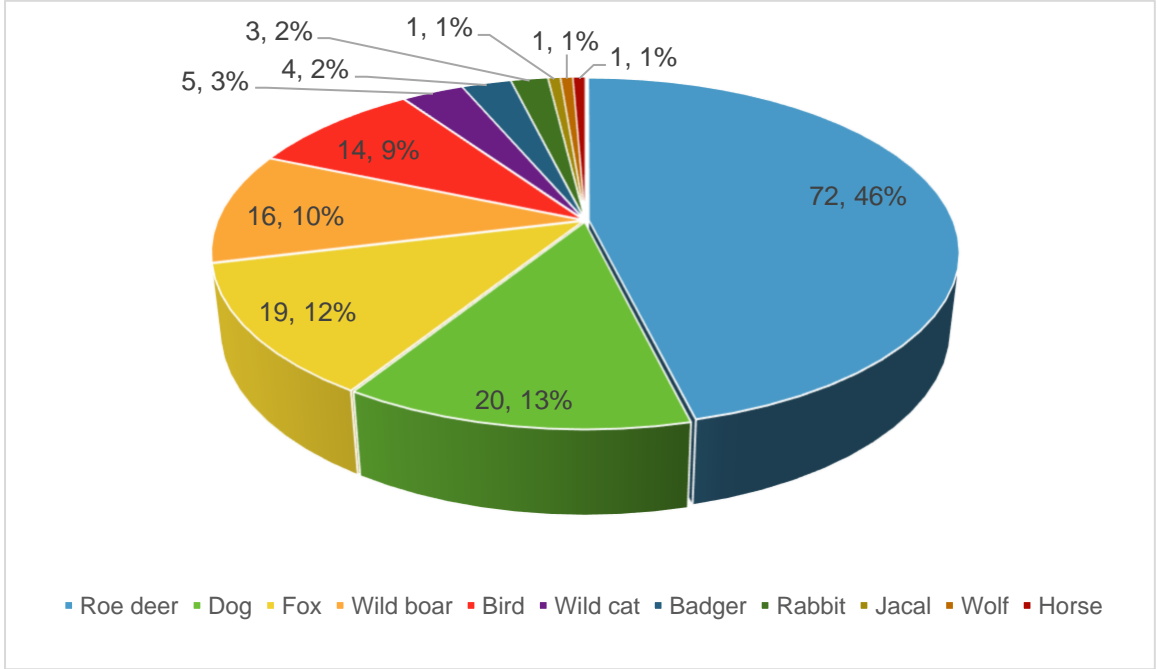
Graph 1. Observed animals on the A1 motorway section (Zagreb – Bosiljevo)



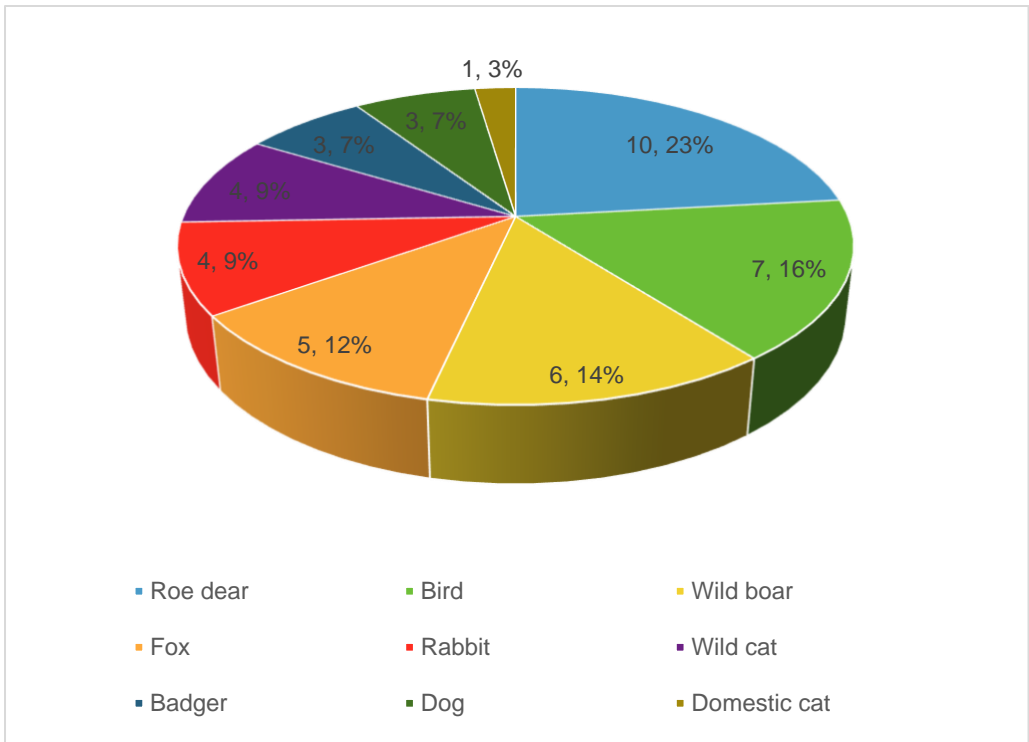
Graph 2. Species of animals seen on the A1 motorway section during 2016



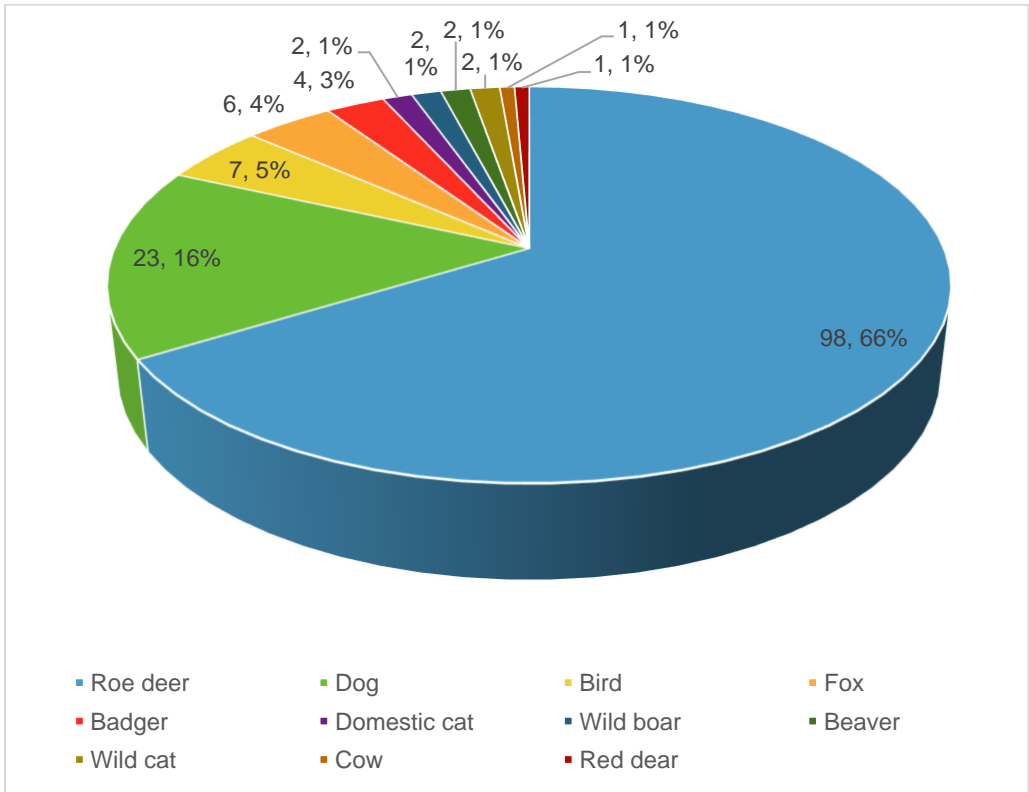
Graph 3. Types of animals that participated in traffic accidents on the A1 motorway section during 2016



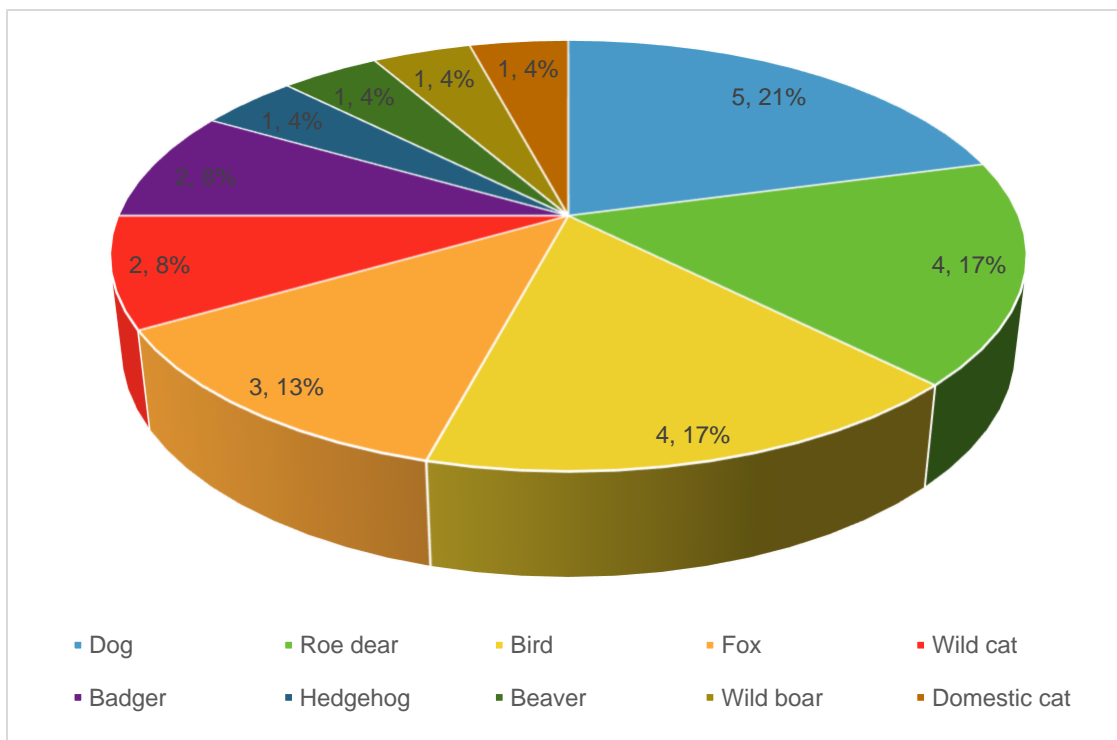
Graph 4. Species of animals seen on the A1 motorway section during 2017



Graph 5. Species of animals that participated in traffic accidents on the A1 motorway section during 2017



Graph 6. Species of animals seen on the A1 motorway section during 2018



Graph 7. Species of animals that participated in traffic accidents on the A1 Motorway section during 2018

Table 2. Observed animals on the A1 motorway section during 2016 - 2018

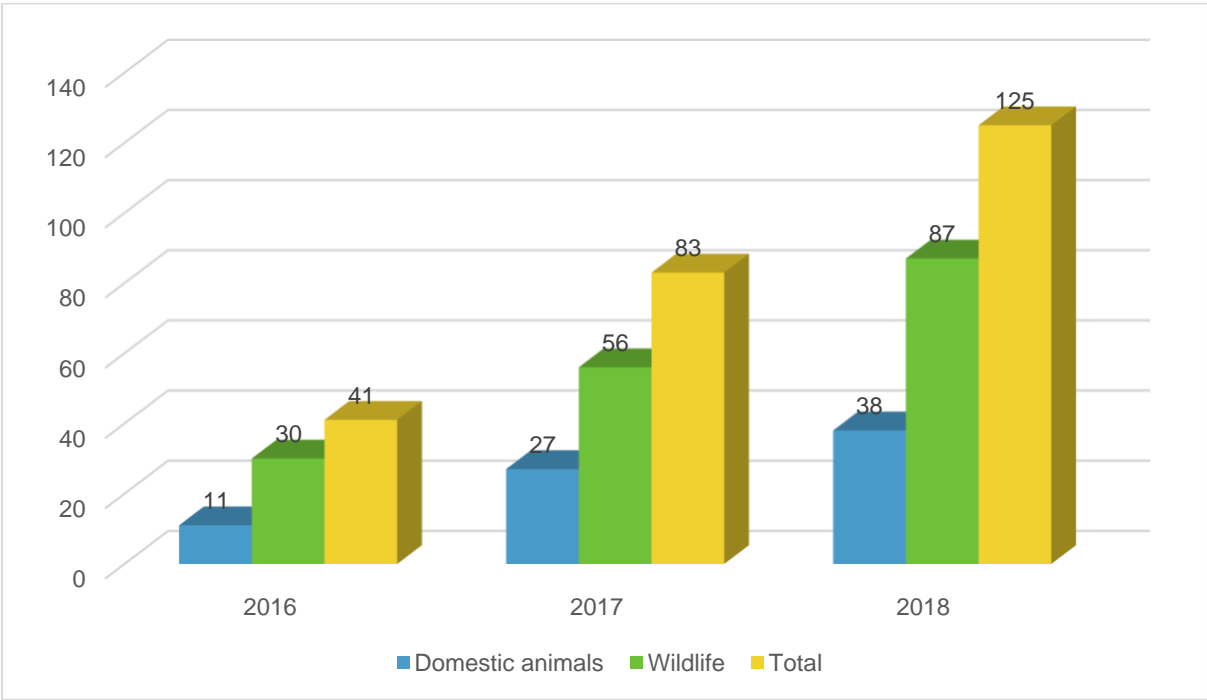
| Type | N | % |
|--------------|-----|----|
| Roe deer | 217 | 55 |
| Dog | 72 | 18 |
| Fox | 33 | 8 |
| Wild boar | 22 | 6 |
| Bird | 21 | 5 |
| Badger | 11 | 3 |
| Domestic cat | 7 | 2 |
| Rabbit | 3 | 1 |
| Domestic cat | 2 | 1 |
| Red deer | 2 | 1 |
| Beaver | 2 | 1 |
| Jackals | 1 | |
| Cow | 1 | |
| Wolf | 1 | |
| Horse | 1 | |
| Total | 396 | |

Table 3. Species of animals that participated in traffic accidents on the A1 motorway section during 2016-2018

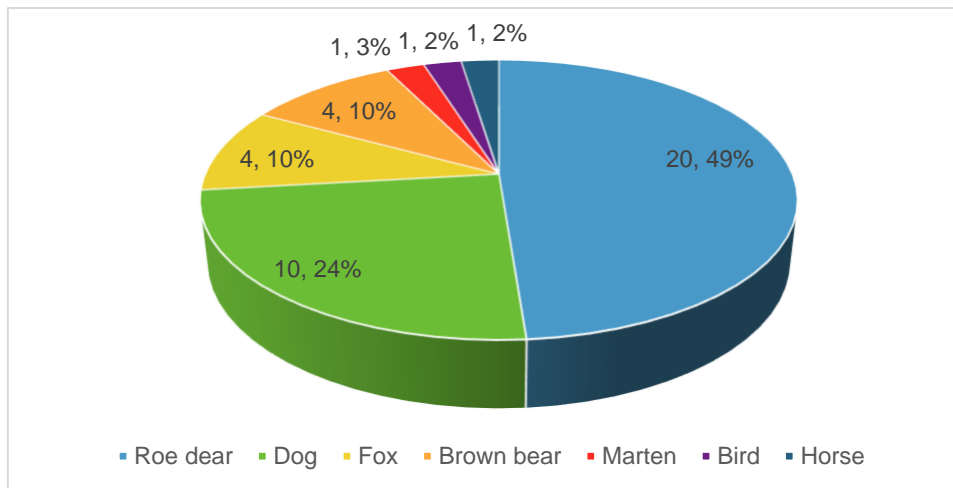
| Type | N | % |
|--------------|----|----|
| Roe deer | 19 | 21 |
| Bird | 13 | 15 |
| Fox | 12 | 13 |
| Dog | 11 | 12 |
| Wild boar | 9 | 10 |
| Badger | 7 | 8 |
| Domestic cat | 7 | 8 |
| Rabbit | 4 | 5 |
| Domestic cat | 2 | 2 |
| Beaver | 2 | 2 |
| Jackals | 1 | 1 |
| Rabbit | 1 | 1 |
| Red deer | 1 | 1 |
| Hedgehog | 1 | 1 |
| Total | 90 | |

3.3 Analysis of wildlife roadkill on Rijeka motorway – Zagreb (A6)

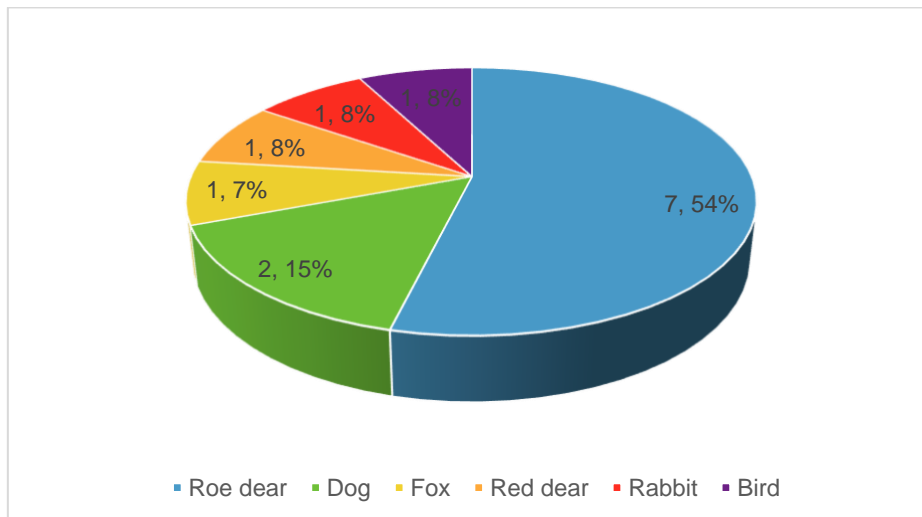
On the analyzed section of the A6 motorway, during the first 6 months of 2016, 41 animals, during 2017 83 animals and in 2018 125 animals were observed in the fenced area of the motorway. A total of 249 observations of animals, inside the motorway fence, were recorded in the investigated period. In the observations of the wild species the predominant species is the deer, and from the domestic dogs. In contrast to the previous section, here the percentage of observed deer (52% of all animals observed) is significantly closer to the percentage of all traffic accidents caused by the collision with the deer (50% of all collisions). In addition, it should be noted that of the total number of animals observed, only 11.2% caused a car accident, which is a major improvement compared to the period 2014 – 2015 (identified in the previous analysis), which indicates more efficient operation of motorway workers in the removal of animals from the enclosed motorway area before causing the accident. The investigated section of the motorway passes through the area of bears habitat, which is evident from the records of spotting animals on the motorway. Nevertheless, there were no recorded vehicle collisions with the bear in the analyzed period. The electric fence, with the length of 72 km, set within the LIFE Dinalp Bear project, is probably the reason for no collisions.



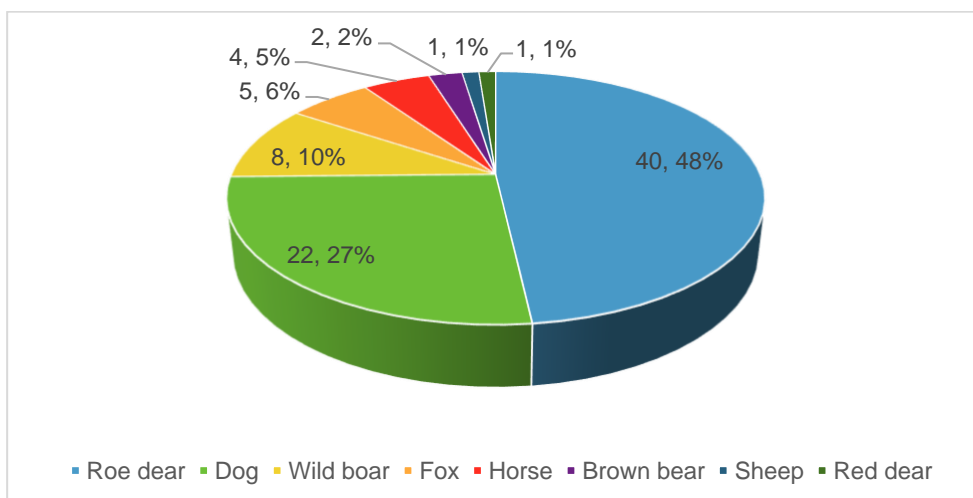
Graph 8. Observed animals on the A6 motorway section



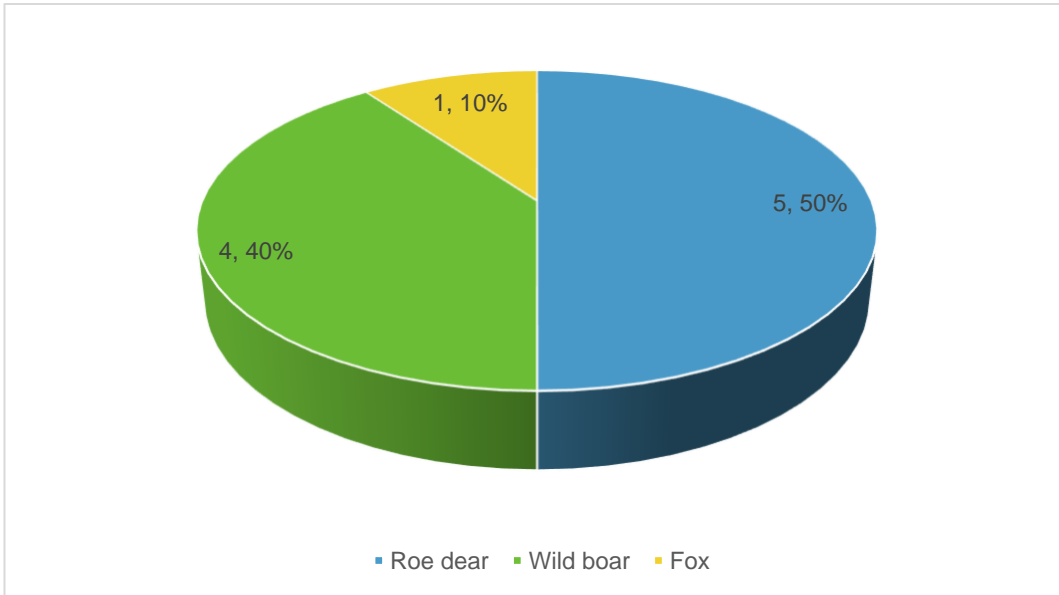
Graph 9: Animal species observed on the A6 motorway section during 2016



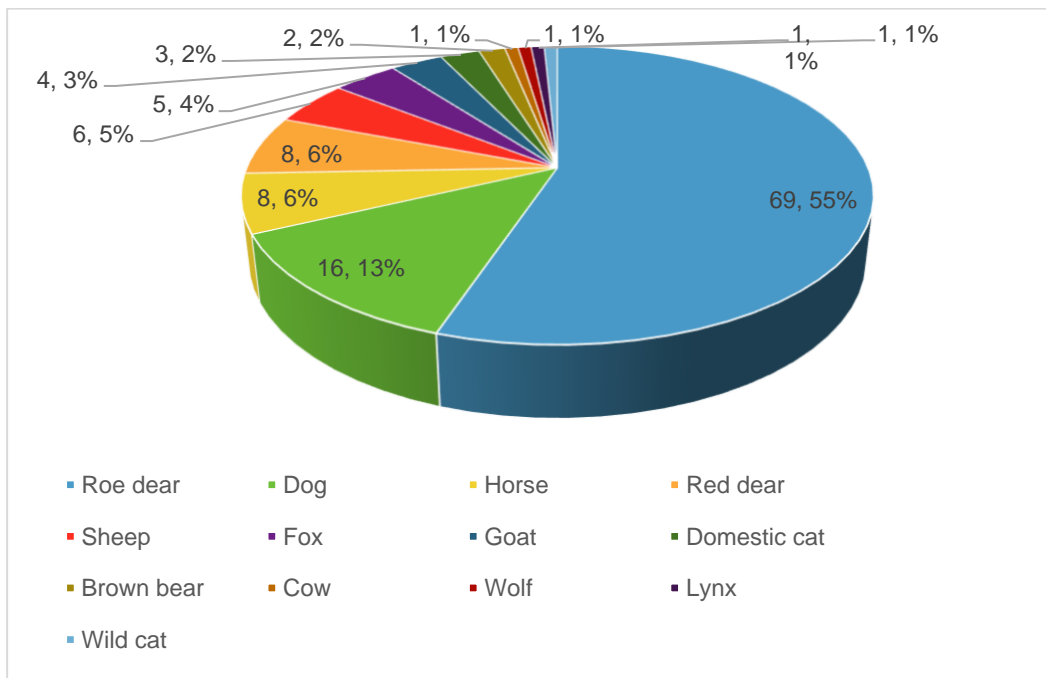
Graph 10, Species of animals that participated in traffic accidents on the A6 motorway section during 2016



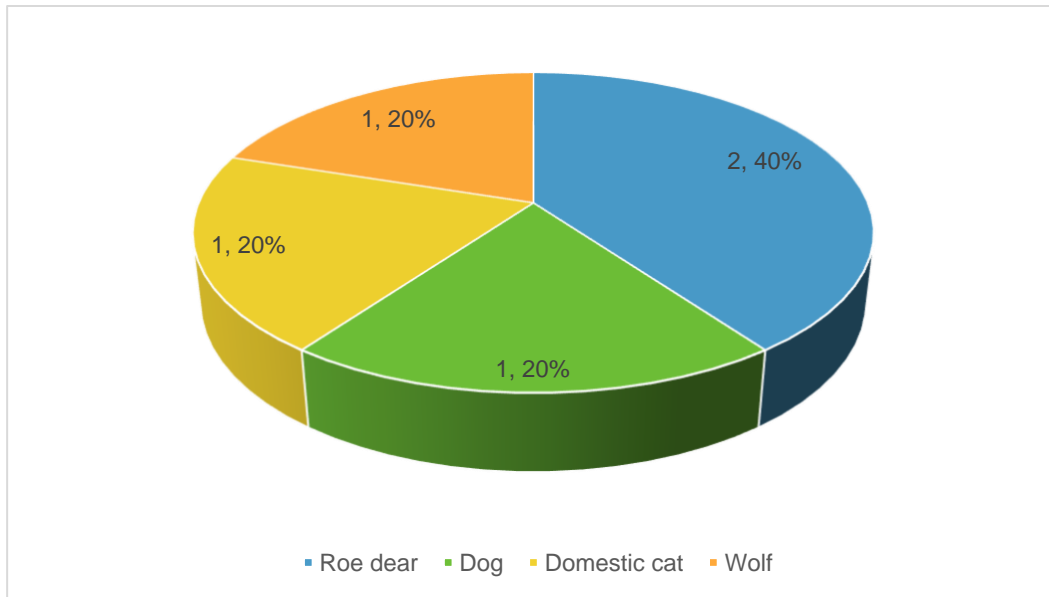
Graph 11 Animal species observed on the A6 motorway section during 2017



Graph 12. Species of animals that participated in traffic accidents on the A6 motorway section during 2017



Graph 13. Animal species observed on the A6 motorway section during 2018



Graph 14. Species of animals that participated in traffic accidents on the A6 Motorway section during 2018

Table 4. Observed animals on the A6 motorway section during 2016 – 2018

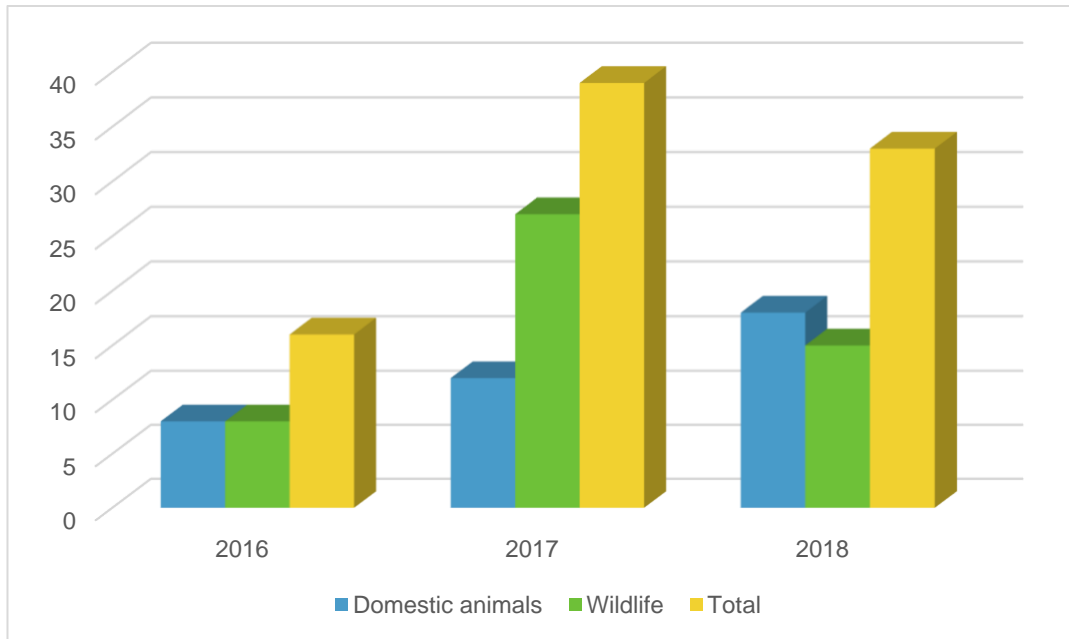
| Type | N | % |
|--------------|-----|----|
| Roe deer | 129 | 52 |
| Dog | 48 | 19 |
| Fox | 14 | 6 |
| Horse | 13 | 5 |
| Red deer | 9 | 4 |
| Wild boar | 8 | 3 |
| Bear | 8 | 3 |
| Sheep | 7 | 3 |
| Goat | 4 | 2 |
| Domestic cat | 3 | 1 |
| Marten | 1 | |
| Bird | 1 | |
| Cow | 1 | |
| Wolf | 1 | |
| Lynx | 1 | |
| Domestic cat | 1 | |
| Total | 249 | |

Table 5 The species of animals that participated in traffic accidents on the A6 motorway section during 2016 – 2018

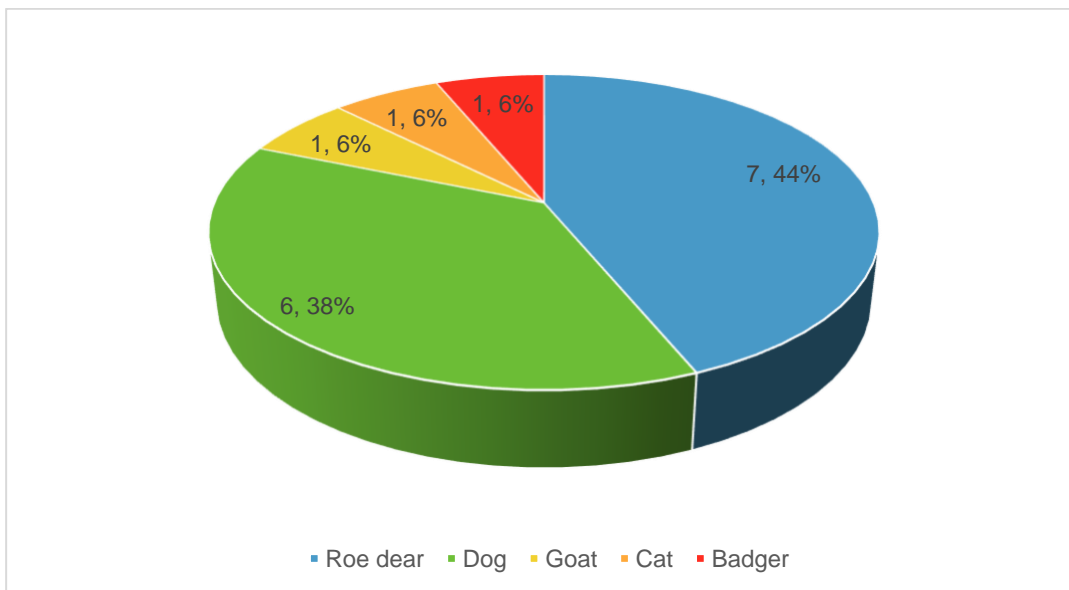
| Type | N | % |
|--------------|----|----|
| Roe deer | 14 | 50 |
| Dog | 3 | 11 |
| Wild boar | 4 | 14 |
| Fox | 2 | 7 |
| Red deer | 1 | 4 |
| Rabbit | 1 | 4 |
| Bird | 1 | 4 |
| Domestic cat | 1 | 4 |
| Wolf | 1 | 4 |
| Total | 28 | |

3.4 Analysis of wildlife roadkill on the motorway Rijeka – Zagreb (A7)

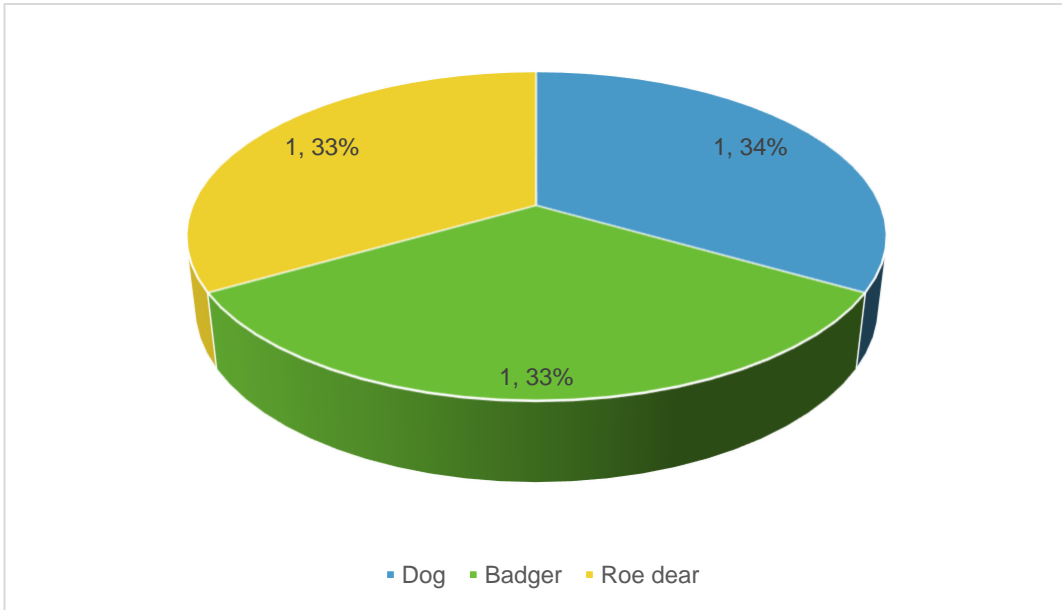
On the analyzed section of the A7 motorway, during the first 6 months of 2016, 16 animals, in 2017 39 animals, and in 2018 33 animals, were observed within the motorway fence. A total of 88 animal observations were recorded in the investigated period. In the observations of the wild species the predominant species is the deer, and from domestic dogs with equal representation (41% of deer, 39% dogs). On the other hand, data regarding collisions differs significantly, so the deer is represented by 45% of the causes of traffic accidents, and the dog by 25%. Compared to the period 201-2015 in which only 19% of the animals observed caused a car accident, in the period 2016-2018 this incidence increased slightly to 21.5%. The share of domestic animals on the motorway remains worryingly high, as well as in the previously analyzed period.



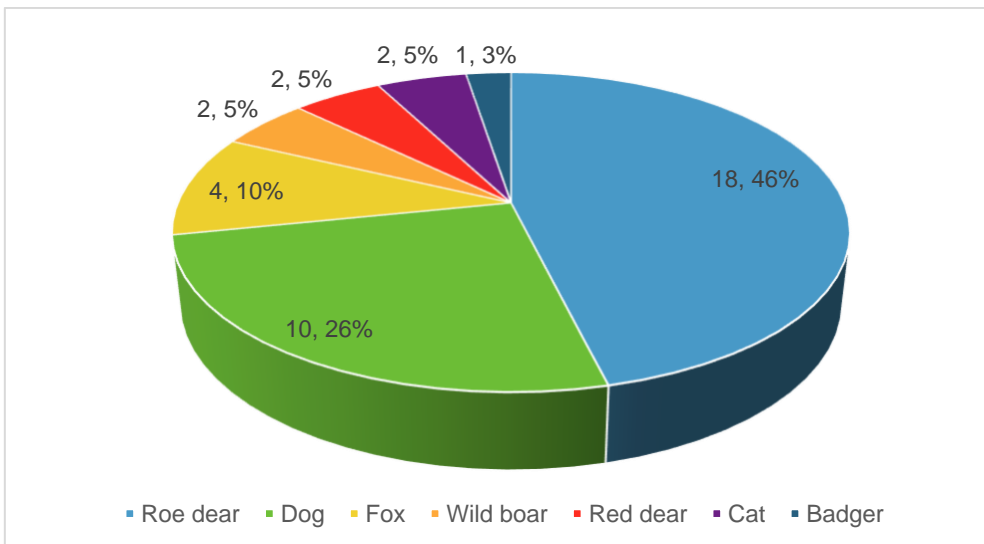
Graph 15. Observed animals on the A7 motorway section



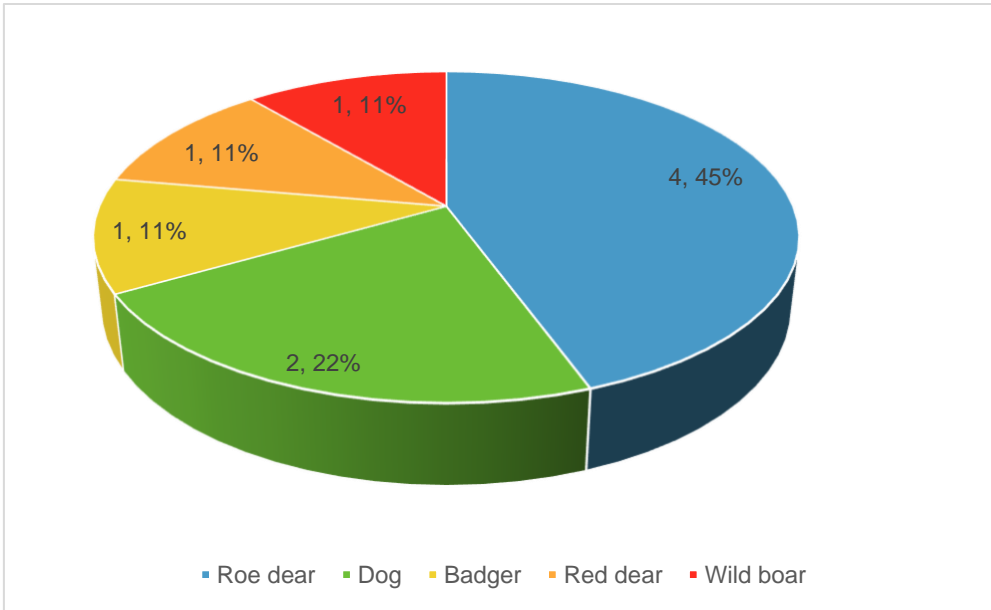
Graph 16. Species of animals seen on the A7 motorway section during 2016



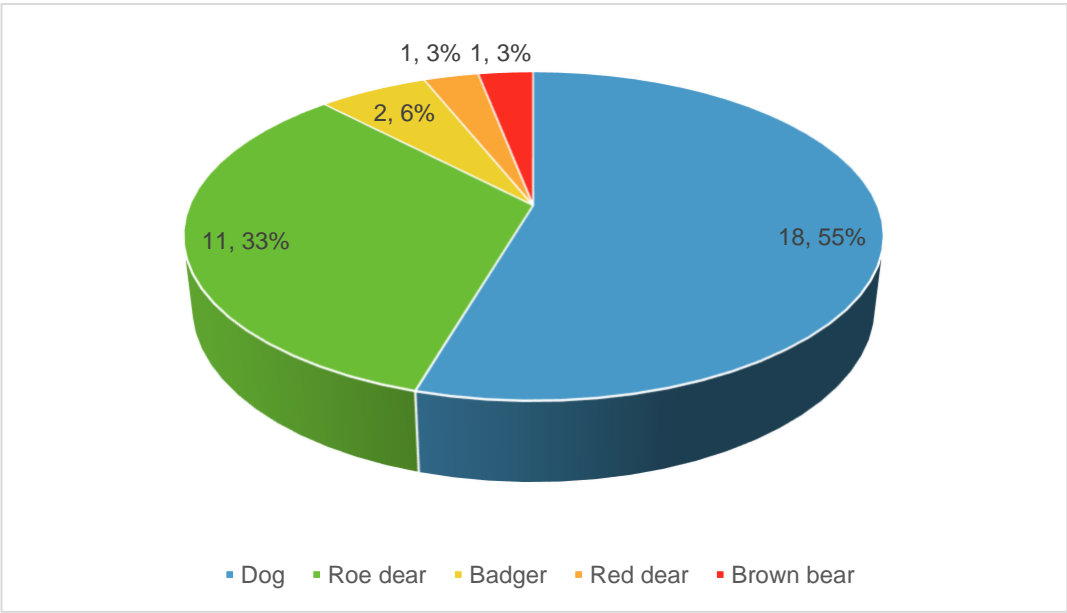
Graph 17. Species of animals that participated in traffic accidents on the A7 motorway section during 2016



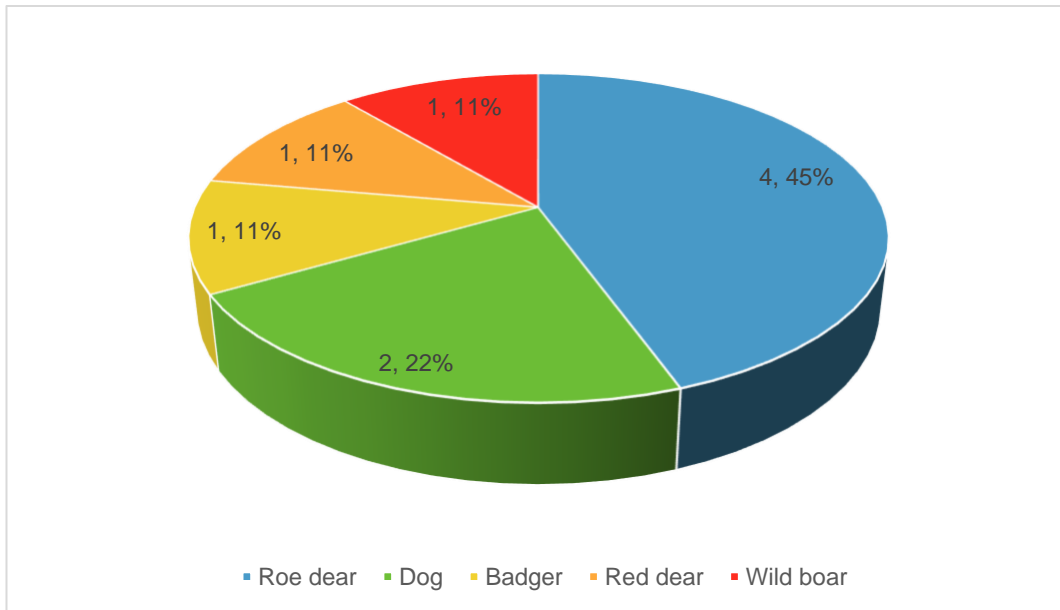
Graph 18. Species of animals seen on the A7 motorway section during 2017



Graph 19. Species of animals that participated in traffic accidents on the A7 motorway section during 2017



Graph 20. Species of animals seen on the A7 motorway section during 2018



Graph 21. Species of animals that participated in traffic accidents on the A7 Motorway section during 2018

Table 6. Observed animals on the A7 motorway section during 2016 – 2018

| Type | N | % |
|--------------|----|----|
| Roe deer | 36 | 41 |
| Dog | 34 | 39 |
| Badger | 4 | 5 |
| Fox | 4 | 5 |
| Red deer | 3 | 3 |
| Domestic cat | 3 | 3 |
| Wild boar | 2 | 2 |
| Bear | 1 | 1 |
| Goat | 1 | 1 |
| Total | 88 | |

Table 7 The species of animals that participated in traffic accidents on the A7 motorway section during 2016 – 2018

| Type | N | % |
|-----------|----|----|
| Roe deer | 9 | 45 |
| Dog | 4 | 25 |
| Badger | 4 | 20 |
| Red deer | 1 | 5 |
| Wild boar | 1 | 5 |
| Total | 19 | |

3.5 Roadkill dynamics on Rijeka-Zagreb motorway

Analyzing the overall dynamics of the occurrence and roadkill of domestic and wild animals, on the entire section of the Rijeka-Zagreb motorway, it is noticed that wild species are dominated by deer and foxes, and from domestic the dogs. In the case of accidents caused by animals, beside deer, foxes and dogs, wild boars and birds, in 10% of cases each, are involved only on the motorway section A1 between Zagreb and Karlovac (Graph 22).

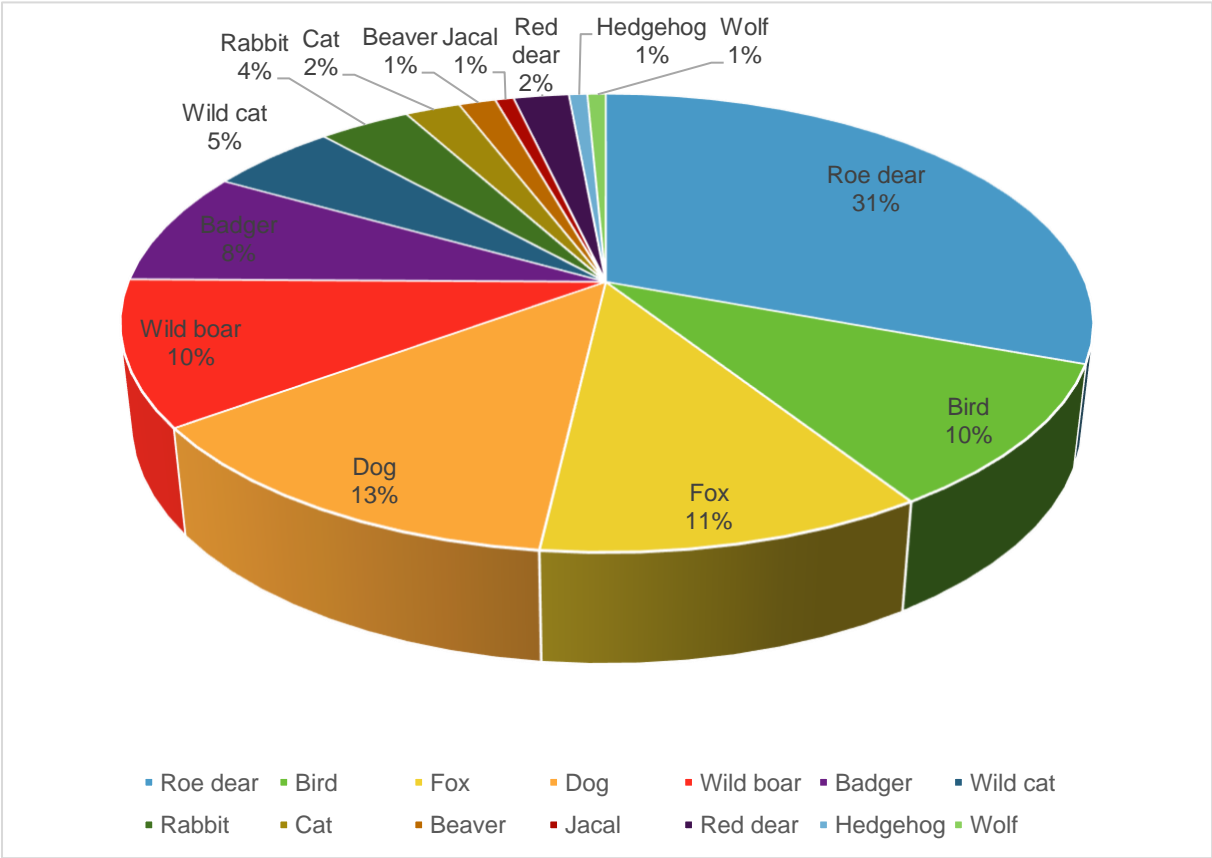
Very interesting is the index of observations and the roadkill of animals per kilometer of the motorway (Table 9). Namely, comparing these indexes between 2014 and 2015 and the analyzed period 2016 till 2018, it is evident that there is a significant decline in the number of observed animals within the motorway fenced area in section A7. On the other hand, if we look at the number of traffic accidents caused by collision with animals, the share is increasing. The data also shows that the number of animals observed on other sections is approximate to the first explored period, while the number of traffic accidents caused by animals is in decline.

Table 8. Total depiction of observed and fatalities of animal species in the motorway area during 2016 - 2018

| Type | N | % |
|-----------------------|------------|------------|
| Roe Deer | 381 | 51.9 |
| Fox | 51 | 6.9 |
| Wild boar | 32 | 4.4 |
| Bird | 22 | 3 |
| European Badger | 15 | 2 |
| Red dear | 14 | 1.9 |
| Brown bear | 9 | 1.2 |
| Domestic cat | 8 | 1.1 |
| European Brown Rabbit | 3 | 0.4 |
| Beaver | 2 | 0.3 |
| Wolf | 2 | 0.3 |
| Jackals | 1 | 0.1 |
| Lynx | 1 | 0.1 |
| Marten | 1 | 0.1 |
| Hedgehog | 1 | 0.1 |
| Dog | 154 | 21 |
| Horse | 14 | 1.9 |
| Domestic cat | 8 | 1.1 |
| Sheep | 7 | 1 |
| Goat | 5 | 0.7 |
| Cow | 2 | 0.3 |
| Total/Total | 733 | 100 |

The frequent occurrence of domestic animals of great mass, horses and cows in the area of the A6 motorway section, the Kikovica node, and the 72 km (TJO Čavle) are troubling. One case of occurrence of cows in the A1 motorway area, in 2018 at 25th km. In the case of a collision of vehicles with these types of animals, we can expect

large material damage to the vehicle, as well as injury to the driver or other passengers in the vehicle.



Graph 22. The Overall frequency of animal species in road accidents on the motorway

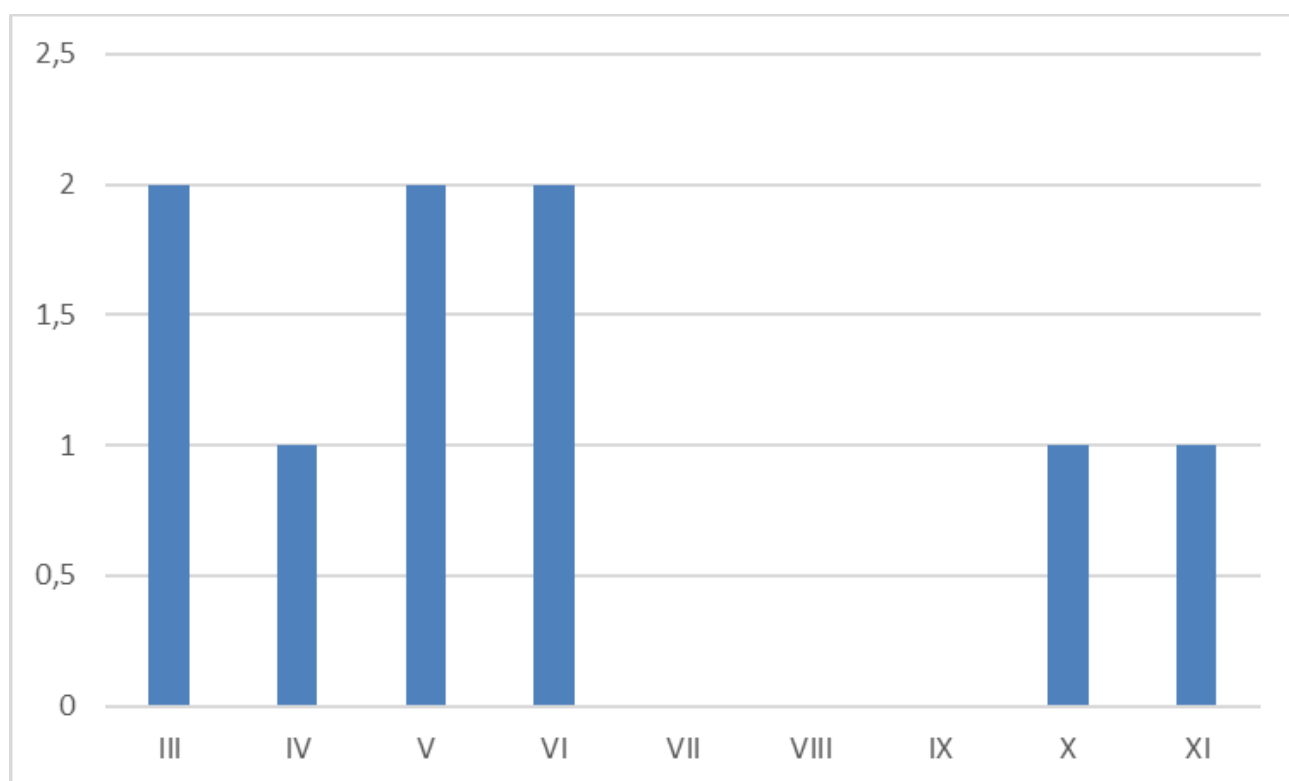
Table 9. Index of observations and roadkill of animals on the motorway area during 2016-2018

| Road no. | Road Length (km) | Total number of observed animals | Total number of animals fatalities | Average number of animals observed/km/yr. | Average number of animal deaths/km/yr. |
|--------------------|------------------|----------------------------------|------------------------------------|---|--|
| Period 2016 -2018. | | | | | |
| Motorway A1 | 67.3 | 396 | 90 | 1.96 | 0.45 |
| Motorway A6 | 81.5 | 249 | 28 | 1.01 | 0.11 |
| Motorway A7 | 16.11 | 88 | 19 | 1.82 | 0.39 |
| Total | 164.91 | 733 | 137 | 1.48 | 0.28 |

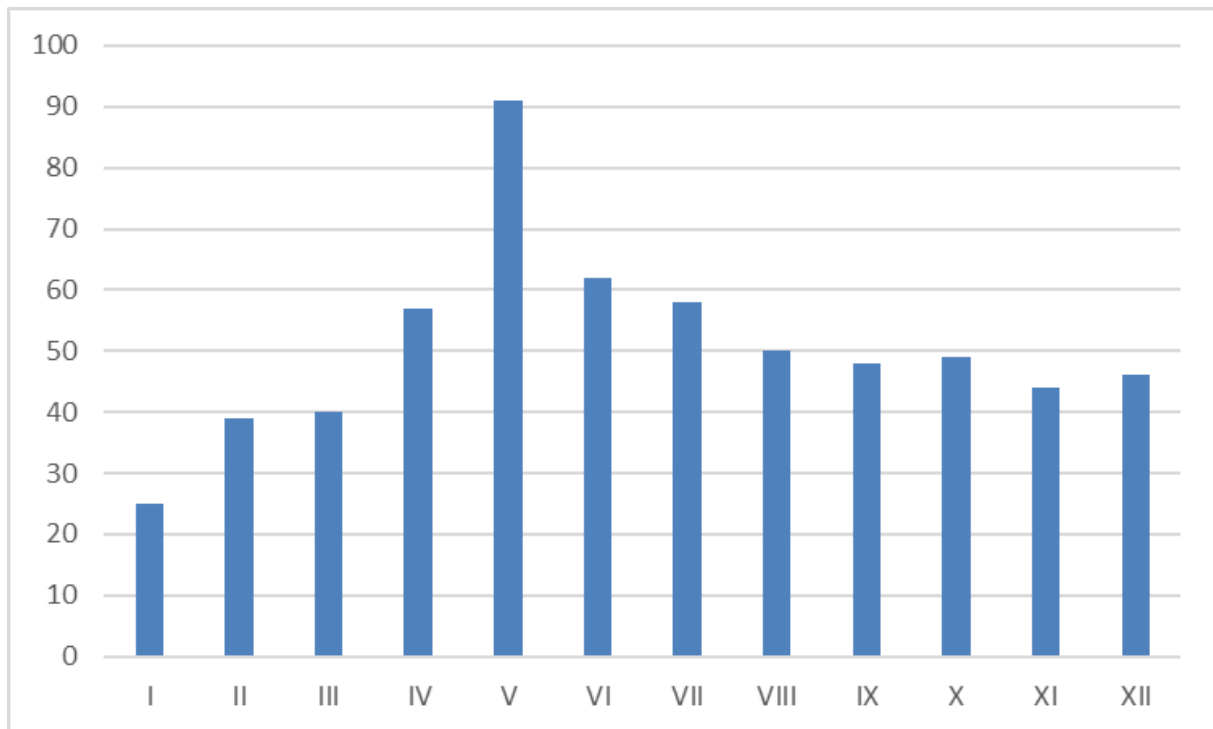
Table 10 Appearance of bears on motorway sections Rijeka-Zagreb

| Motorway | 2016 | 2017 | 2018 |
|--------------|----------|----------|----------|
| A1 | 0 | 0 | 0 |
| A6 | 4 | 2 | 2 |
| A7 | 0 | 0 | 1 |
| Total | 4 | 2 | 3 |

*There was no traffic accident with a bear on the motorway sections Rijeka - Zagreb during period of monitoring (after implementation of technical countermeasures)



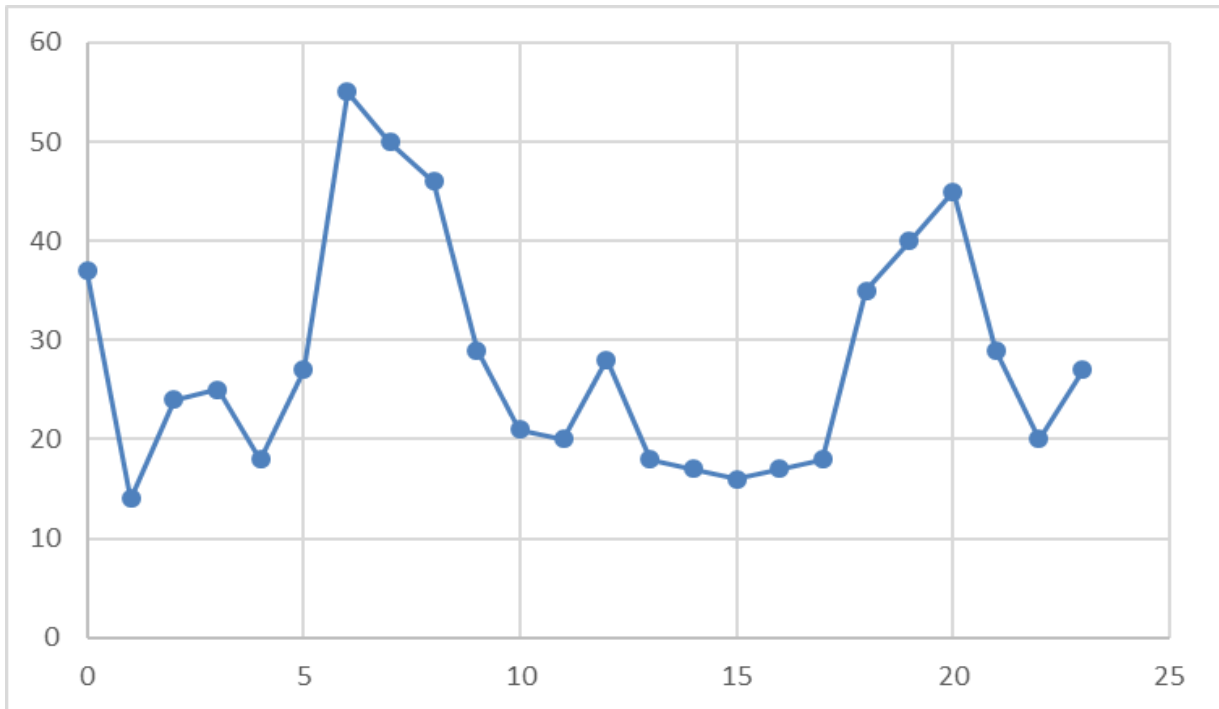
Graph 23 The monthly dynamics of the appearance of bears on the sections of the motorway Rijeka-Zagreb



Graph 24 The total monthly dynamics of animals in the motorway area (analysis included data for 2017 and 2018)

The total annual dynamics in the area of the analyzed motorway shows a pronounced spring cyclic as a consequence of the annual life rhythm of wildlife which implies a daily movement cycle, the period of reproduction and seasonal migration to more favorable habitats or free-living areas.

The causes of the increased collisions with roe deer, as the most numerous, or the most common species in the motorway area in spring, can be explained by intensified activity after the winter months, the increased search for food along the edges of roads that become green before other wildlife areas and in the conquest of new living space.



Graph 25. Total daily occurrence dynamics of wildlife in the motorway area

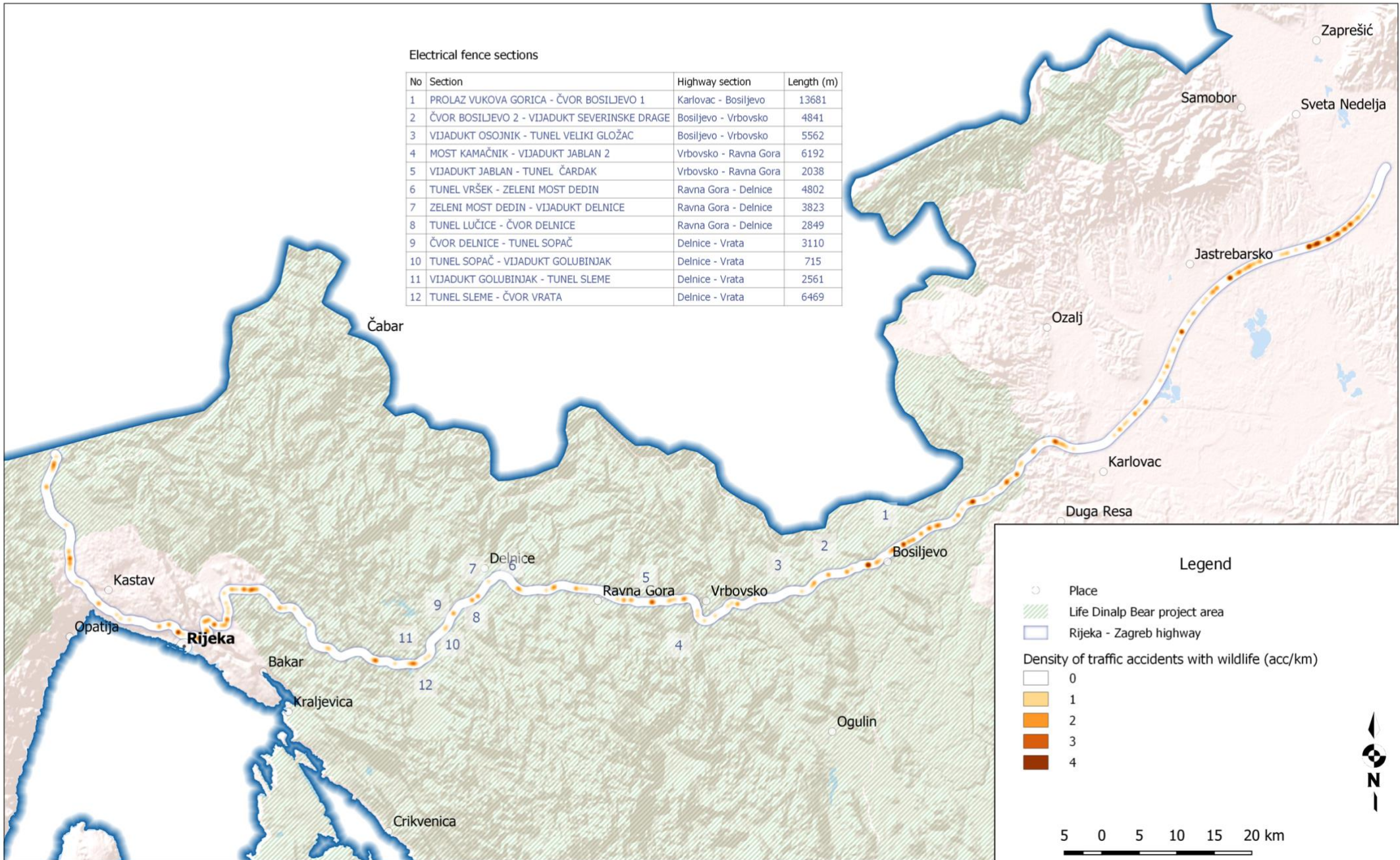
We can conclude that the analysis of wildlife roadkills regarding the part of the day, reveals that the most critical part is a period of reduced visibility (morning, evening and night). The most critical periods during the day are in the early morning from 06 to 09 hours and in the evenings, from 18 to 21 hours. As shown in Graph 25, animals appear in the motorway area also during the day, when the visibility and the possibility of observing animals is good, however, due to the high speed of vehicle movement, the possibility of driver reaction is limited.



LIFE DINALP BEAR project

Electrical fence sections

| No | Section | Highway section | Length (m) |
|----|--|-----------------------|------------|
| 1 | PROLAZ VUKOVA GORICA - ČVOR BOSILJEVO 1 | Karlovac - Bosiljevo | 13681 |
| 2 | ČVOR BOSILJEVO 2 - VIJADUKT SEVERINSKE DRAGE | Bosiljevo - Vrbovsko | 4841 |
| 3 | VIJADUKT OSOJNIK - TUNEL VELIKI GLOŽAC | Bosiljevo - Vrbovsko | 5562 |
| 4 | MOST KAMAČNIK - VIJADUKT JABLAN 2 | Vrbovsko - Ravna Gora | 6192 |
| 5 | VIJADUKT JABLAN - TUNEL ČARDAK | Vrbovsko - Ravna Gora | 2038 |
| 6 | TUNEL VRŠEK - ZELENİ MOST DEDIN | Ravna Gora - Delnice | 4802 |
| 7 | ZELENİ MOST DEDIN - VIJADUKT DELNICE | Ravna Gora - Delnice | 3823 |
| 8 | TUNEL LUČICE - ČVOR DELNICE | Ravna Gora - Delnice | 2849 |
| 9 | ČVOR DELNICE - TUNEL SOPAČ | Delnice - Vrata | 3110 |
| 10 | TUNEL SOPAČ - VIJADUKT GOLUBINJAK | Delnice - Vrata | 715 |
| 11 | VIJADUKT GOLUBINJAK - TUNEL SLEME | Delnice - Vrata | 2561 |
| 12 | TUNEL SLEME - ČVOR VRATA | Delnice - Vrata | 6469 |

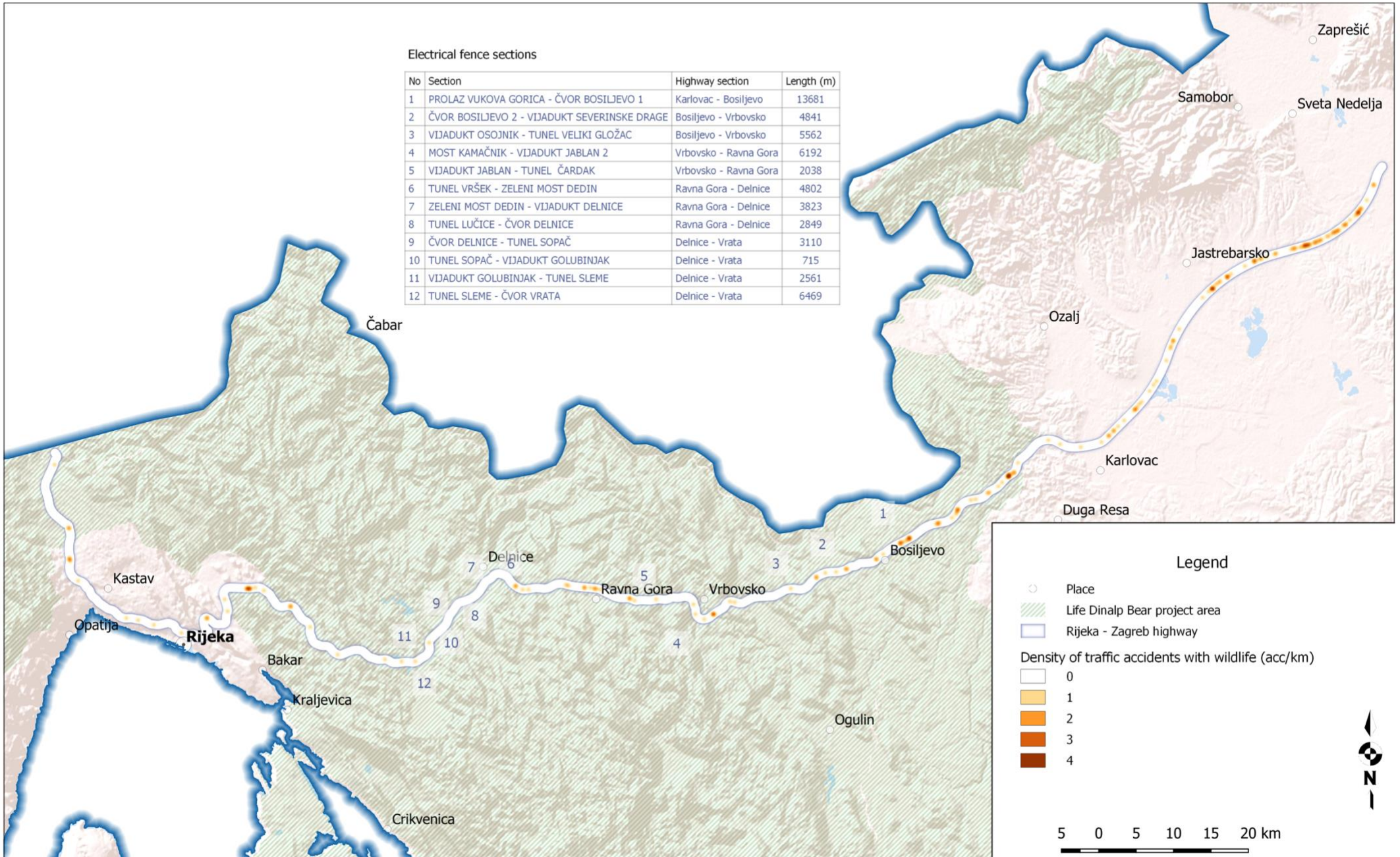




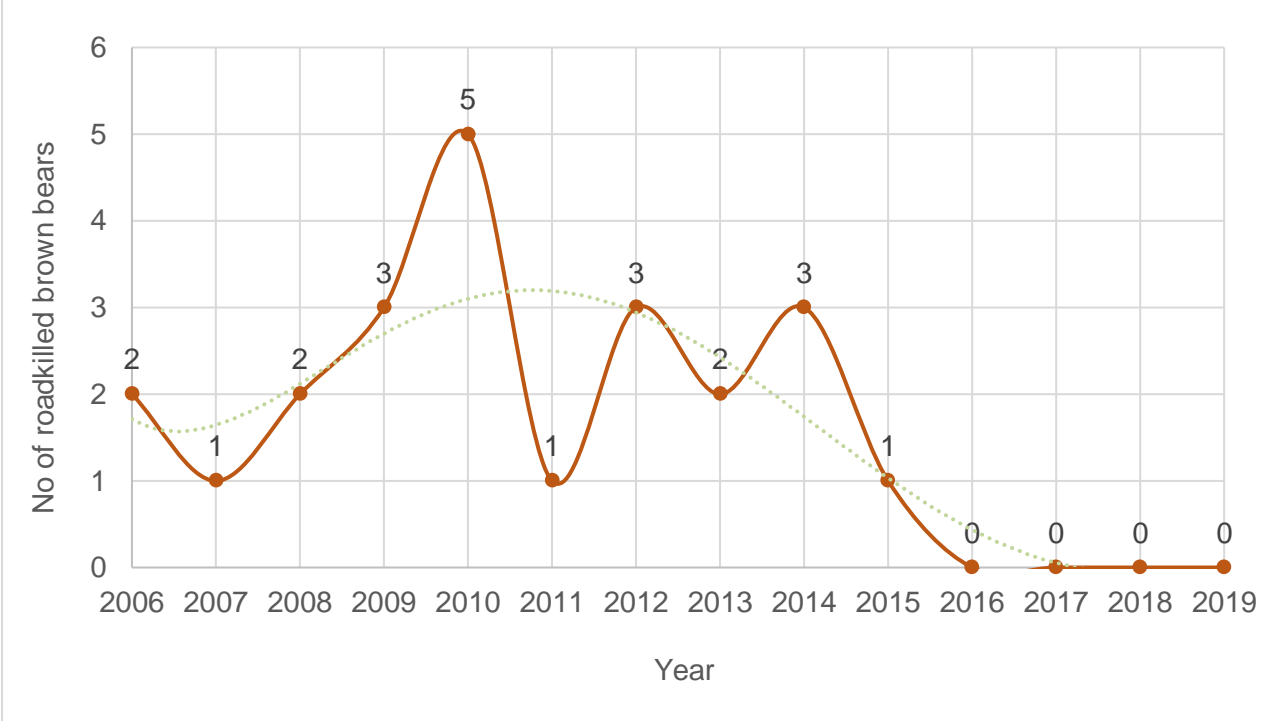
LIFE DINALP BEAR project

Electrical fence sections

| No | Section | Highway section | Length (m) |
|----|--|-----------------------|------------|
| 1 | PROLAZ VUKOVA GORICA - ČVOR BOSILJEVO 1 | Karlovac - Bosiljevo | 13681 |
| 2 | ČVOR BOSILJEVO 2 - VIJADUKT SEVERINSKE DRAGE | Bosiljevo - Vrbovsko | 4841 |
| 3 | VIJADUKT OSOJNIK - TUNEL VELIKI GLOŽAC | Bosiljevo - Vrbovsko | 5562 |
| 4 | MOST KAMAČNIK - VIJADUKT JABLAN 2 | Vrbovsko - Ravna Gora | 6192 |
| 5 | VIJADUKT JABLAN - TUNEL ČARDAK | Vrbovsko - Ravna Gora | 2038 |
| 6 | TUNEL VRŠEK - ZELENİ MOST DEDIN | Ravna Gora - Delnice | 4802 |
| 7 | ZELENİ MOST DEDIN - VIJADUKT DELNICE | Ravna Gora - Delnice | 3823 |
| 8 | TUNEL LUČICE - ČVOR DELNICE | Ravna Gora - Delnice | 2849 |
| 9 | ČVOR DELNICE - TUNEL SOPAČ | Delnice - Vrata | 3110 |
| 10 | TUNEL SOPAČ - VIJADUKT GOLUBINJAK | Delnice - Vrata | 715 |
| 11 | VIJADUKT GOLUBINJAK - TUNEL SLEME | Delnice - Vrata | 2561 |
| 12 | TUNEL SLEME - ČVOR VRATA | Delnice - Vrata | 6469 |



3.6 Brown bear's mortality

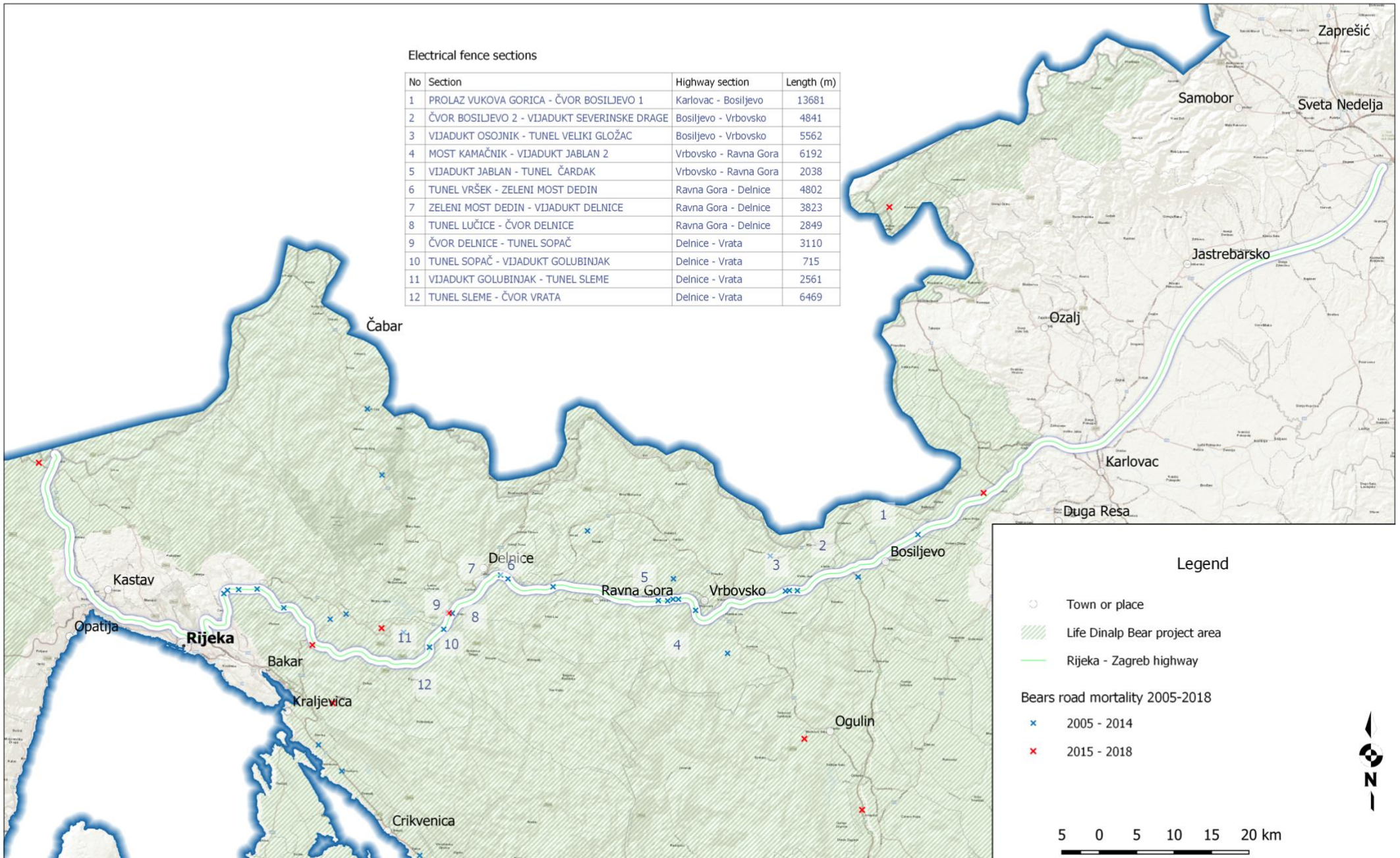


Graph 26. Brown bear's mortality on Rijeka - Zagreb motorway

LIFE DINALP BEAR project

Electrical fence sections

| No | Section | Highway section | Length (m) |
|----|--|-----------------------|------------|
| 1 | PROLAZ VUKOVA GORICA - ČVOR BOSILJEVO 1 | Karlovac - Bosiljevo | 13681 |
| 2 | ČVOR BOSILJEVO 2 - VIJADUKT SEVERINSKE DRAGE | Bosiljevo - Vrbovsko | 4841 |
| 3 | VIJADUKT OSOJNIK - TUNEL VELIKI GLOŽAC | Bosiljevo - Vrbovsko | 5562 |
| 4 | MOST KAMAČNIK - VIJADUKT JABLAN 2 | Vrbovsko - Ravna Gora | 6192 |
| 5 | VIJADUKT JABLAN - TUNEL ČARDAK | Vrbovsko - Ravna Gora | 2038 |
| 6 | TUNEL VRŠEK - ZELENI MOST DEDIN | Ravna Gora - Delnice | 4802 |
| 7 | ZELENI MOST DEDIN - VIJADUKT DELNICE | Ravna Gora - Delnice | 3823 |
| 8 | TUNEL LUČICE - ČVOR DELNICE | Ravna Gora - Delnice | 2849 |
| 9 | ČVOR DELNICE - TUNEL SOPAČ | Delnice - Vrata | 3110 |
| 10 | TUNEL SOPAČ - VIJADUKT GOLUBINJAK | Delnice - Vrata | 715 |
| 11 | VIJADUKT GOLUBINJAK - TUNEL SLEME | Delnice - Vrata | 2561 |
| 12 | TUNEL SLEME - ČVOR VRATA | Delnice - Vrata | 6469 |



4 CONCLUSIONS

By examining the animal incidence records on the Rijeka-Zagreb motorway, it is evident that the data are more accurate year after year, which contributes significantly to the possibility of producing quality data analyses and applying analysis results. In addition, it should be noted that the staff of the Centre for maintenance and traffic control are doing a thorough work on the collection of data on the occurrence of animals on the motorway. Also, they are coordinating the road patrols in solving the problems with animals, including members of the formed emergency team.

The results of the analysis of the occurrence of animals on the Rijeka – Zagreb motorway differ depending on the motorway section. The largest index of animal intrusions per kilometer of the motorway was recorded on the section A7 and A1, and the smallest on the A6 motorway (Table 9). The casualty Index per km of the motorway is the largest on the A1 motorway section and the smallest on the A6 motorway (Table 9). The causes of this dynamic can be explained mainly as the result of countermeasures that were placed through the Life Dinalp Bear project and to some extent by the permeability of the motorway which is defined by specialized crossings and road objects (tunnels, bridges, viaducts) and proximity of settlements. According to the above, the maximum permeability is on the A6 motorway, while the one on section A1 is negligible, and the A7 does not exist.

In the analyzed period the traffic incident with a brown bear in the motorway area was not recorded, which certainly is a result of the installation of the electric fence and the presence of the emergency team for the bear on the Motorway Rijeka- Zagreb.

In Croatia 23 bears were killed on Rijeka-Zagreb motorway (A6) in the period from 2006 to 2019. Besides a high contribution to the total mortality, traffic-related bear mortality has also important indirect threat for brown bears: a vehicle collision with a bear has a high-risk factor for road safety and the economy, and thus contributes to the growing conflict between bears and humans and can worsen the public attitudes toward brown bears in general.

Mitigation measures for reducing traffic-caused bear mortality on the Rijeka - Zagreb motorway are important from two aspects: decreasing bear mortality and risk to drivers and passengers, respectively.

The performance of the countermeasures undertaken in the Life Dinalp Bear project shows a significant drop in traffic accidents during 2015 up to date (1 car accident) with a brown bear on the sections of the highway Rijeka – Zagreb. The result of this project action (C4) exceeded the original goal of the project since the mortality of the bears on the Rijeka-Zagreb motorway was reduced to zero in the last four years, and the goal was to reduce mortality for 50% which means mortality up to two bears per year.

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