Exploratory Project ESCAPE XXL
State of the Knowledge and Feedback on Fence Escape Devices for Wild Ungulates.

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Summary

1 Presentation of the project: analyze the state of the art to identify research and improvement opportunities

Appropriately designed fences prevent animal vehicle collisions on roads and railways. In France, most motorway infrastructures and all high-speed lines are fenced. Nevertheless, animals occasionally enter the right-of-way (RoW) when the fences are interrupted (fence ends, road intersections, interchanges, etc.), or in damaged areas. Some of them end up being hit by a vehicle constituting a traffic safety hazard and a wildlife protection issue. One-way emergency exits called "escape devices" and dedicated for animals that have found their way into the RoW have two converging purposes: on the one hand, safety (prevention of traffic incidents) and on the other hand, ecology (reduction of animal-vehicle collisions).

The exploratory project ESCAPE XXL aims to review the practices and knowledge on escape devices developed for ungulates over the last 50 years in France and abroad, as well as to identify future research opportunities in order to optimise the information gained from prior lessons learned.

2 Method: an all-inclusive search of lessons learned on escape devices

ESCAPE XXL focused its research on the escape devices implemented for fauna causing the greatest number of animal vehicle collisions in France, namely roe deer, wild boar and to a lesser extent red deer. Escape devices for other species are cited throughout the report, mainly in North America, in order to support the methodological reflection.

The bibliographic search was based on a wide range of documents including scientific studies, feedback or technical recommendation guides, operational studies, general press, websites or blogs. Search engines were queried in English and French. A technical survey was conducted in France and abroad: only the experiences in France could be documented in detail. Research teams were consulted in the United States for details on escape devices in their geographical region.

In 2020 and 2021, a mini-questionnaire was sent to the French Departmental Federations of Hunters, to the main public or private managers of national road, motorway and rail networks, as well as to practitioners and researchers in France and abroad or via technical networks (AFIE - French Interprofessional Association of Ecological Experts). A more complete questionnaire was used as a support for interviews or was sent for direct information. A digital questionnaire was also sent in English and Spanish to international technical networks (IENE – Infrastructure & Ecology Network Europe, CEDR – Conference of European Directors of Roads, Base Camp / Connectivity Conservation Specialist Group). The integral report explores the data collected until September 2021.

Given the lack of available synthesis on the subject in France and in Europe, one of the difficulties of this project was to identify the right correspondents and the existence of possible data. This survey started a year before the launch of ESCAPE XXL and was then continued in the framework of the exploratory project. For France, data are still to be collected concerning escape devices on the railway network or ongoing monitoring on motorways.

3 Results: an overview and recommendations

3.1 A variety of equipment and the proven use of some

Ungulate escape devices have been found on transportation infrastructure in Europe (Belgium, France, Germany, Netherlands, Spain, Sweden) and North America (Canada, USA). Only those in France could be documented in detail. In Europe, these are ramps, trapdoors, gates and trigger-wired "open-cage" devices (fig. 1). For each type of device, the designs and construction methods are varied. In France, escape devices are almost exclusively installed on the motorway network and on the high-speed rail network.

Ramps (i.e. jump-outs, fig. 2) are mounds of earth installed along fences that provide a gradual slope inside the RoW to allow animals to walk up the mound to get to the top of the fence and then jump out of the RoW. Because ramps are a vertical wall outside of the RoW, they are intended to simultaneously exclude animals from entering the RoW. These jumping mounds are therefore intended for animals capable of jumping (mainly Cervidae). Different shapes and sizes aim to optimise the encounter of an animal running along the fence with the ramps. The drop height is a key factor both in making animals want to jump out of RoW and in preventing animals on the outside from entering. In France, although there is no official recommendation, the survey often indicates drop heights of 1.8 to 2.0 m corresponding to that of the fence. It is recommended that they should be built on a gentle slope, seeking to integrate them into the landscape, rather than being placed in a stand-alone position on flat land. The landing area should preferably be flat: for a North American species, it has even been shown to be beneficial to keep the vegetation clear while maintaining bushes nearby. There should be no gap between the ramp and the fence. These devices have the advantage of being self-sufficient (no reset), long lasting and low maintenance. In some cases, their use by roe deer has been attested, and even by wild boar, which remains to be confirmed. The main disadvantages are land availability and accessibility to earthmoving equipment, as well as the cost of building them. The occurrence of reverse entries is widely studied in North America but not documented in France.

Two types of **passive mechanical devices** (i.e. requiring opening by the animal) are used in Europe. On the one hand, **gates** (fig. 3) are doors with grids or bars that pivot around a vertical axis and are equipped with a return spring that automatically returns to the closed position, as well as with anti-return stops to prevent them from opening in the wrong direction. They are intended for animals likely to push the gate, i.e. wild boar and roe deer. On the other hand, **trapdoors** (fig. 4), that are sized for the passage of the targeted animals and whose flap pivots around a horizontal axis, are mainly used for burrowing animals: badger and wild boar. Gates and trapdoors can be installed singly or in pairs. At this stage, these devices have not been found in North America. Roe deer have been known to use gates and probably trapdoors, but this remains to be investigated. Wild boar have been known to use trapdoors. Both devices have the advantage of being easy to install and move if necessary, and conventional trapdoors are also easy to manufacture (unless patent constraints apply). Both devices are self-sufficient as they operate by gravity (trapdoors) or mechanical return (gates) and they do not require resetting after an animal has left. In theory, they allow several animals to pass in a row. On the other hand, the maintenance of vegetation is very important so that it does not block the opening or, worse, the closing. Snow and frost or even waste can also block the devices. Finally, the design of the gate hinges and their adjustment must be carefully studied beforehand. Regarding the possible reverse use of these devices, no documentary reference has been identified at this stage nor any case mentioned in the survey. Spring-hinged comb gates (i.e. swing gates) have been developed in North America for deer with varying success (fig. 5). This system is not present in France, nor reported in Europe, with one exception in Spain.

Among active mechanical devices where a mechanism is used to allow the animal to exit, an extraction airlock (fig. 6) has been developed in France on motorways and high-speed lines. It is a patented "open cage" system where the percussion of a wire across the passage by an animal triggers the gravity closure of the two doors at the ends and the raising of a side exit hatch. This device is easy to install and move. The disadvantages concern the periodic maintenance of the vegetation, the monitoring of the triggers (by photographic trap with return of the photos on smartphone or by trigger detector) as well as the manual rearming of the device after use. No reverse entries were reported. Other devices exist with automatic opening by the animal, but at this stage their implementation remains to be investigated. Operators can also manually open conventional equipment (e.g. portals or wire mesh gates) in an attempt to extract an animal.

Additional facilities attempt to optimise the use of the various devices but their role has not been precisely studied. For instance, it is possible to try to lead animals being in the RoW to the escape devices by means of diverters (fences, palisades, riprap/rock armour, etc.): this has been shown to be useful for one species of North American deer. This can also be attempted with guiding hedges, although there is a risk of providing cover for the animals. A device that is not visible from the road is generally considered favourable. A visual gap can be created by obscuring the fence on either side of the escape device for instance with heather or keeping vegetation. Scent attractants and salt licks are sometimes used to enhance the detection of escape devices by animals seeking to exit the RoW, attracting their attention only when they pass by, but without attracting from a distance those present outside: the interest of their use is not proven.

3.2 Some general guidelines

Most of the existing devices are not being monitored. Where this is the case, the passage data is not very contextualised (ecological contexts, population dynamics, etc.) and the behaviour of the animals is not documented (trials, returns to the same site, etc.). The disparity of data from non-standardised monitoring, the diversity of designs within each type of device and the wide variety of implementation conditions limit the comparison of results.

Generally speaking, it is accepted that the installation of escape devices is likely to be beneficial to wildlife when leaving road infrastructures. Nevertheless, their implementation has to be studied and verified in conjunction with a wildlife expert. However, recommending them must be tempered when the maintenance of these devices cannot be guaranteed over time.

As a priority, it is necessary to secure the ends of fences in the main section and on interchanges through which animals can enter. It may also be necessary to provide exits for animals when, by following fences on the RoW, they approach the entrance of a bridge or a tunnel where they may cause accidents. Fences near the beginning of concrete safety barriers may also be equipped to facilitate the escape of animals before they decide to wander next to the traffic. Finally, escape devices may also be installed all along areas where high animal populations exist outside the RoW and in where animals are frequently present inside. A relatively even spacing between escape devices is traditionally recommended in the areas concerned (ranging from several hundred metres between escape devices to a few kilometres), but this is constrained by the technical feasibility and wildlife relevance of the locations. The need to move the devices further away from the infrastructure remains to be documented in view of the results of a study in North America. This tempers, if not contradicts, the common view reported of the advantage of placing evacuation devices away from the infrastructure.

It is recommended to ensure prior consultation with neighboring residents to avoid future conflict: for example, disturbing agricultural practices, as well as with the managers of external roads in the immediate vicinity of the planned site, or to ensure the tranquility of the exit zones. It may be advisable to combine different types of escape devices depending on the fauna targeted or to reduce the constraints of rearmament (e.g. extraction airlock and trap door).

4 Avenues for further study and research questions...

In general, ESCAPE XXL advocates that future work should investigate the following 4 axes in the context of wild boar, roe deer and red deer.

Axis 1: characterising the level of use and the rate of efficiency according to the different design modalities within each type of escape device. This will require to define beforehand the notion of efficiency and to investigate both the exit rates and the counter-entry rates (reversals).

Axis 2: characterising the influence of positioning on the use of the system. This will involve trying to understand the animal's motivations for entering and exiting, the role of the characteristics of the interior and exterior environments, the influence of the layout of the fences or the distance from the infrastructure, distinguishing between the motorway and rail contexts.

Axis 3: optimising existing devices. During tests in enclosures or by comparing existing situations, the aim will be to specify the optimal height of ramps and their layout or to optimise the related facilities. It is also a question of studying whether fences located in embankments can be used as escape devices and also whether tilting grids placed in concrete ditches for hydraulic purposes may function as trapdoors.

Axis 4: Ensuring the legal security of projects. This axis aims to specify, in the light of regulations and case law, the constraints on the distance between escape devices and roads or the risk linked to a possible counter-entry or collision on a neighbouring road.

For future comparative in situ studies, one of the difficulties is the presence or absence of animals in the RoW. This depends, among other things, on the population densities and the integrity and robustness of the fences. Monitoring should be carried out over a sufficiently long period (at least 3 years) to cover life cycles, to take into account inter-annual variations and to increase the chances of an animal passing near the escape devices. The analysis must cover both the escape devices that record exits and those where animals were present in the vicinity but did not use them: this is the limit of a posteriori analyses based on positive cases only. A diagram proposes instrumentation radii around the monitored escape devices (fig. 7). Finally, ESCAPE XXL draws attention to the precautions to be taken when testing in a enclosure so as to ensure the safety of the animals, so as to take into account differences in behaviour between individuals and also their possible prior knowledge of the site or the device.

JUMP-OUT		**Earthen escape ramp**	linear form (= along a fence in a straight line)	
			quarter-round shape (= in an angle fence)	
			loading bay shape (= between two retaining walls)	
			U-shape facing away from the right-of-way.	
			other specific forms	
		Ramp on retaining wall	bridge abutment or box culvert headwall used as escape jump with an intentional gap in the fence above.	
		Alternative types	locally lowered fence (with or without shutter)	
			including "slope-jump " = a possibly lowered fence at the foot of a steep embankment that slopes away from the transport infrastructure	
MECHANICAL DEVICE	**Passive mechanical device**	**Classic gate** swinging around a vertical axis with a grid or bar door leaf		
		Swing gate with « comb-shaped » tines (usually curved)		
		Hinged metal trapdoor = horizontal axis drop-down device	classic vertical or inclined trapdoor	without counterweight
				with counterweight
			special one-piece system	
	Mechanical active device	**Animal-triggered wire sluice**	extraction airlock	
		Opening automatically activated by the animal		
		Manually opened by an operator		

fig. 1. Typology of wildlife escape devices

fig. 2. Example of a linear ramp (photos: IMPCF - VINCI Autoroutes / ESCOTA)

fig. 3. Classic double gate (photo: APRR)

fig. 4. Trapdoor (Photo: VINCI Autoroutes - Cofiroute network)

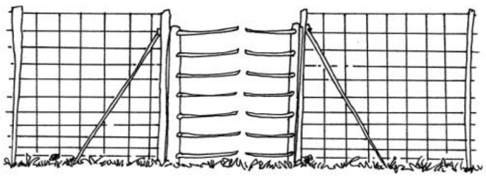

fig. 5. Comb-shaped swing gate (drawing: C. Buton)

fig. 6. Faun'Trap extraction airlock (photo: C. Buton)

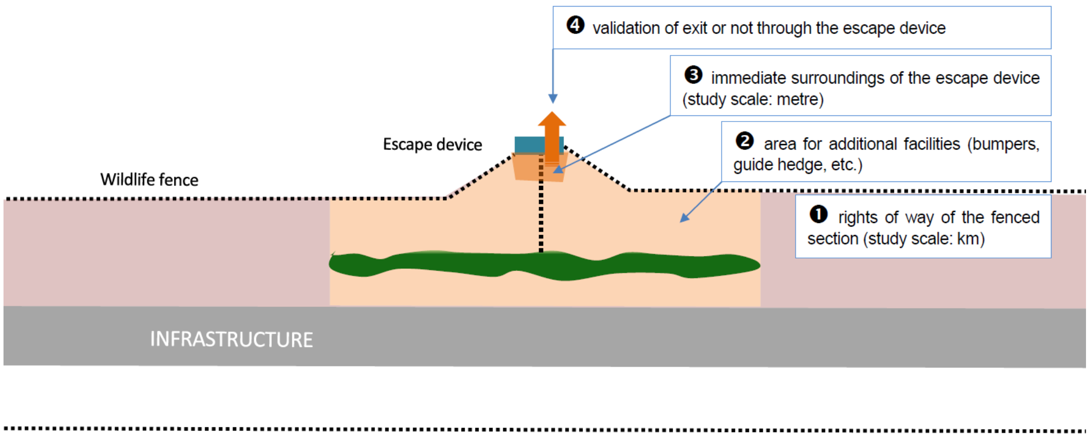

fig. 7.Principle of progressive instrumentation radii around an escape device in future in situ efficiency monitoring