



Photo: Morten Günther, NIBIO

The Animal Sense warning system

Low-cost technology to prevent animals from being killed by traffic

When free-ranging animals encounter traffic on roads or railways, it may have fatal outcome. In Europe, collisions between vehicles and animals have increased the last 40 years, causing economic losses and serious welfare concerns. Today there is no technological solution to prevent such collisions in the rough, arctic climate that represents most parts of Norway. By using small and energy-efficient radio transmitters moulded into headcollars, researchers have now developed and tested a system for warning traffic when semi-domestic reindeer are nearby the road. Tests on more than 700 reindeer over three consecutive winter seasons are promising.

MEASURES TO PREVENT COLLISIONS BETWEEN ANIMALS AND TRAFFIC

Collision between vehicles and animals on roads and railways is an increasing problem both in Norway and Europe (Hughes *et al.*, 1996, Knapp *et al.*, 2004, Rolandsen *et al.*, 2015). In Norway this is due to

increased traffic and speed, but also snow conditions and polar nights represent risks (Figure 1, 3). Such collisions result in serious socioeconomic losses, but they also represent a considerable welfare issue for animals and people. In Norway, more than 3000 semi-domestic reindeer have been



Figure 1. Semi-domestic reindeer killed in a car-collision on E6 just south of Sjørelva at Saltfjellet in February 2018 (photo: Svein Morten Eilertsen).

killed by the railway the last 10 years (Rolandsen *et al.*, 2017, Stanimirov *et al.*, 2018). Reports from BaneNor show that in 2017, 514 reindeer were killed on the “Nordlandsbanen”, a 729 km railway track in Mid- and Northern Norway. The losses of reindeer in 2017 on this railway distance alone represented a cost of 500 000 €. Reindeer is a highly gregarious species, and as many as 80 animals have been killed by the train in the same incidence. Railway statistics for the Saltfjellet distance (66 km) show that most reindeer are killed between October and March, and numbers peak in January (Rolandsen *et al.*, 2017). Corresponding statistics are not available for public roads, but the challenge is similar.

AIM OF RESEARCH

Between 2018 and 2020 the Swedish-Norwegian research group within the INTERREG project Animal Sense has developed and tested a new electronic warning system based on low-cost radiotechnology. The system alerts the drivers when reindeer are in or close to roads. The aim of the project was to test the operation reliability and preventive effect of the system, under arctic winter conditions. An ultimate goal was to develop and produce a cheap and reliable warning system applicable for all domesticated grazing animals close to roads and railways and release it into the Nordic market.

SYSTEM REQUIREMENTS

Semi-domestic reindeer are free-ranging and are handled by humans only 2-3 times per year. This implies that the reindeer industry demands transmitters with battery capacity lasting at least one year. It should also be light-weight and not susceptible for icing. The technology should also be low-cost so that many animals can be instrumented, and it should operate reliably over time in an arctic winter climate.

TESTING THE “ANIMAL SENSE WARNING SYSTEM”

For three consecutive winter seasons (2018-2020) a total of 724 semi-domestic female reindeer from



Figure 2. The 2019 generation of the flashlight receiver (left) and the transmitter integrated in a reindeer collar (right) (photo: Johannes Karlsson).

three different siida-units at Saltfjellet reindeer district were equipped with radio transmitters moulded into plastic neck collars (Figure 2, 3, Table 1) (Hansen *et al.*, 2019). The animals were released together with the rest of their flock in an area at Saltfjellet, located close to the Arctic Circle (66° N). The main road (E6) cuts through this pasture area in south-north direction and the distance is collision-prone. The receivers (approximately 40 every year) were mounted on road sticks with 100-meter intervals, along the 4 km test distance. Whenever a reindeer with transmitter was located within 50-100 m proximity to a road stick, the receiver flashlight (RF) was activated and started blinking red (Figure 3). The receivers were programmed to activate neighbor receivers as well to warn drivers in advance and give them time to reduce speed. The warning system is developed and designed by the Umeå University Embedded Systems Lab. The technology within the transmitters is based on regular 805.15.4866 MHz radio waves. Estimated battery life of the transmitters was 5 years. The transmitter is small, light-weight (12 g) and production costs were about 10 €.

A supervisor from Mesta (Norwegian entrepreneur providing infrastructure services) checked the receivers during the three test periods by driving slowly in a car with a transmitter passing all the RFs. Receivers that were not activated by the transmitter during the test period were registered. This logging of receiver operation was performed at least every second week, but for some occasions (especially in 2020) bad weather conditions made logging impossible due to minimal visibility. Some of the receivers were connected to GSM via SIM cards and these uploaded activity logs to a database on the web for further control. Random checks of battery capacity and casings were performed on 180 transmitters (2019 generation) and 39 transmitters (2020 generation) after being kept in a freezer for 4 ½ months. The

number of semi-domestic reindeer, both with and without transmitters, that were killed by cars in the test distance was recorded.

PROMISING RESULTS

Saltfjellet reindeer herding district lost 15 reindeer due to car-collisions in the district (Storjord-Saltfjellet turistsenter) from December 2017 until test start (March 14th). No reindeer (with or without transmitters) were hit by cars during the test period in 2018 (March-April) and 2019 (February-March) (Table 1) (Hansen et al., 2019). Due to bad weather and difficult grazing conditions most of the reindeer that were instrumented with transmitters had to be moved to the coast early in January 2020. However, no reindeer were hit by cars in the period from when the warning system was mounted (December 9th 2019) to the reindeer were moved approximately one month later.

The logs from Mesta showed that the battery capacity of the receivers had increased from 2 months in 2018 to 3 months in 2019. In 2020 the batteries in the receivers lasted 4 months. A random check of 180 transmitters half way in the test period 2019, however, showed that 35 % had stopped working. The reason being weakness in new microcontrollers implemented in this generation of transmitters. Before the 2020 test season these microcontrollers were replaced and the operation reliability of 39 transmitters randomly tested was 94.9 % after 5 months in operation. Four and a half months of these, the transmitters had been kept in a freezer (-18 °C).

Table 1. Key numbers and results from the tests of the electronic warning system “Animal Sense” 2018-2020.

	2018	2019	2020
Number of female reindeer with radio-collars	305	238	181
Number of receiver flashlights	41	39	35
Km test distance	4	4	3,5
Test period	March-April	February-March	December-January*
Number of reindeer killed within test distance during test period	0	0	0

*Due to longer periods of bad weather and difficult grazing conditions most of the reindeer were moved away from the test area in early January 2020, and the test period was thus restricted to approx. one month.

There was continuous development of technology and casings during the research period. The last generation of RFs seems to have increased battery capacity, mostly due to small adjustments in software. It is however quite easy to change batteries in the receivers mounted on road sticks along the road. The overall battery capacity of both transmitters and receivers is now considered satisfactory.

The warning system may have a general preventive effect, as the driver likely will reduce speed and increase attention when observing blinking lights. Researchers plan to measure the preventive effect of the warning system in 2021, using measurements of speed both in- and outside the test area. Since reindeer are highly gregarious animals, it might not be necessary to instrument the entire flock. Results



Figure 3. The illustration shows how the electronic warning system will work for reindeer along roads (animation: Johannes Karlsson).

from all three test periods show that no reindeer, neither with or without radio collars, were killed in collisions within the test area. Furthermore, it is probably sufficient to set up and manage the warning system during the winter season, when the risk of collisions is most prominent.

POTENTIAL FOR FURTHER APPLICATIONS OF THE TECHNOLOGY

This electronic warning system is intended as a supplement to deer fences. Together with fences this warning system will be able to cover several of the collision-prone distances in Norway. Electronic warning does not fragment the reindeer pasture areas or disturb wildlife and human traffic. If the reindeer herders have mobile receivers, they may place these alongside stretches of road before moving their herd, i.e. during the seasonable flock allocation.

A warning system that works for reindeer will with small adjustments also be beneficial for several farmed animals that graze free-range pastures during summer. It is for example a common problem that grazing animals aggregate in tunnels in warm summer days, which may cause considerable risk of collisions along both roads and railways. A further development of the system lies within connecting the activity log by a receiver with a mobile application that car drivers and train operators can download and thus get real-time information about road and railway stretches at risk.

Today there is no technological solution in operation that can reduce collisions between trains and reindeer at Norwegian railways. We are considering adjustments of our electronic warning system for the railways as well (Hansen et al., 2019; Wagner et al., 2019). Fitting all receivers with SIM cards will enable text messages with positions to be sent to both train operators and reindeer herders when an animal has activated a receiver.

Another potential for extended use of the reindeer transmitters is animal identification. Each tag has a unique ID and this could be matched with information on owner, age, sex and other animal-based data. As a valuable tool for the future, we think it might be possible to scan a whole reindeer herd wearing transmitters by using a drone carrying a receiver (Aspholm & Jørgensen, 2016). A fourth application is automatic detection and matching of mothers to their calves at the yearly calf marking. This will however

require some development of the transmitter/receiver system.

CONCLUSION

The Animal Sense electronic warning system is promising when it comes to reducing risk of collisions between reindeer and cars. No reindeer with or without transmitters were killed by cars inside the test distance through the test periods of 2018, 2019 and 2020. The operation reliability is considered satisfactory. Several improvements were done during the test periods, but further documentation of the preventive effects of the system and its operation over time in arctic winter conditions are still necessary, before the system can be mass-produced and released into the public market.

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