Annex 1

Summary of key trials and their results

In this appendix more information is given in support of the trial monitoring and outcomes table presented in the progress report for Action C1.

Contents

1) Auchnerran 2017-2018 (GWSDF)

Auchnerran occupies 1,030 acres (417 ha) of hill-edge land in Aberdeenshire, established in late 2014. It is a highly typical hill-edge sheep farm:

20% arable/ploughable (game crops, cover crops); Silage and brassicas; 30% pasture; 40% rough grazing; 10% wood/other

The site has a high population of rabbits, and also clusters of rats were expected. Other animals considered were deer and scavenging animals.

Fig. 1-1 Auchnerran site

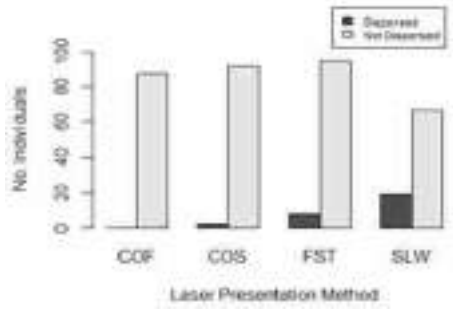


Fig. 1-2 Results from variation of approach speed

GWSDF were the first to conduct trials, beginning in early January 2017. Trials included the use of handhelds and autonomics and detailed trial plans were drawn up that included controls in order to establish the response of the rabbits to the laser.

The first trials used handhelds and were aimed at both measuring the response of the rabbits to the laser beam, and other factors like day / night, speed at which laser beam approached, pattern, group size of multiple rabbits. The number of rabbits targeted in these trials was in excess of 1300 rabbits.

Overall, the outcome of these trials was a low response rate was observed ~25%, and the nature of the laser path and speed, and number of rabbits did not affect results significantly.

An autonomic trial was planned and began operation. It consisted of moving two autonomic lasers around nine positions, Fig. 1-3, every 4-5 days. Two positions were control points. Each position was monitored by

Fig. 1-3 Autonomic trial multiple positions

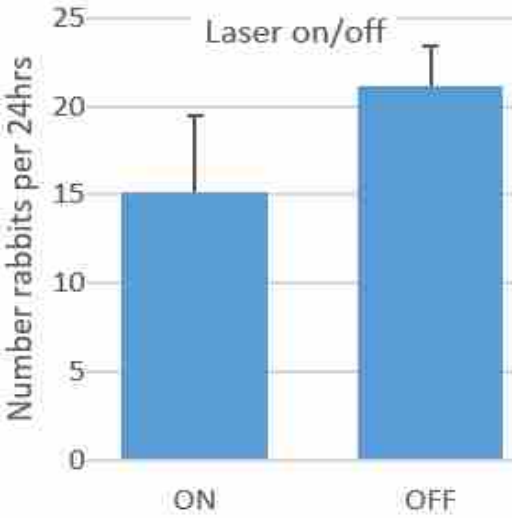


Fig. 1-4 Autonomic trial results

two trail cameras, one looking at the projection zone, one just outside. This trial was not completed as it suffered some problems with the autonomic laser and subsequently with HSE restrictions following their site visit. Fig. 1-4 is a summary of the data that was gathered, this suggests some effect on the presence of rabbits, i.e. a reduction when the laser is on, but this result is not statistically significant.

2) Auchnerran 2018 – 2019 (GWSDF)

Handheld trials during this time focused on comparing the impact on rabbit behaviour of varying laser output power and of laser colour.

Power output was adjusted by means of a filter screwed onto the front of the device. Output was verified using equipment at the University of Aberdeen. The laser was moved around in the normal way close to rabbits with the laser at different power outputs plus the usual control (not switched on). N=1,328 rabbits, 445 separate encounters.

Green, blue, red and yellow lasers were used in a similar fashion and rabbit behaviour recorded. N=324 rabbits, 274 encounters. Both trials were carried out at dusk over several days, as usual.

Results: Rabbit response rate was lower with the reduced power output, but still reasonable, Fig. 2-1, and green and blue lasers were most effective, Fig. 2-2.

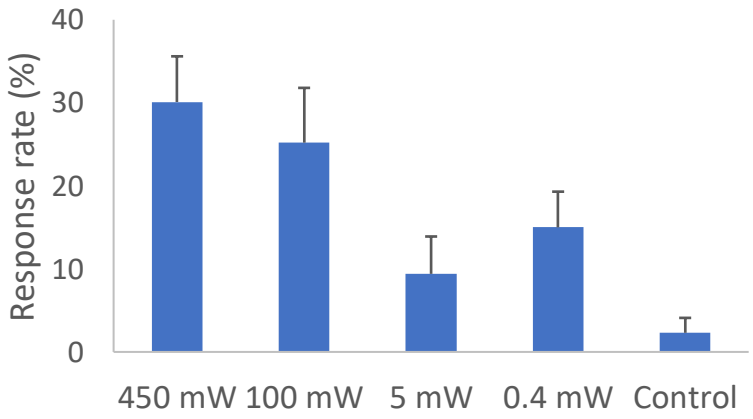


Fig. 2-1 Mean (+standard error) response rate of rabbits to exposure of varying laser power

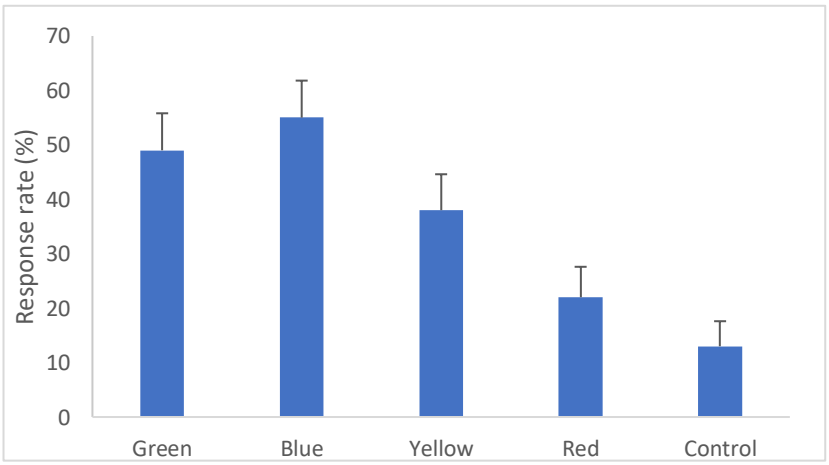


Fig. 2-2 Mean (+standard error) response rate of rabbits to exposure to differing laser colours

Conclusions: This raises the possibility of using reduced power lasers as a deterrent, likely primarily at night. This is significant because it does not require additional safety measures (e.g. supervising the laser when in use at full power in unenclosed spaces). The results also suggest green and blue lasers would be most effective deterrents.

3) Auchnerran 2017-2018 (GWSDF)

Following the HSE ruling that autonomic lasers were not to be used unsupervised in open areas, we conducted two rat trials in two disused barns made secure with Herris fencing (Fig 3-1).

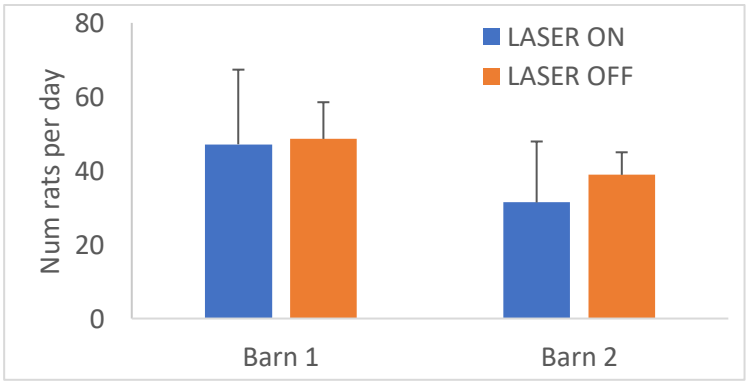
Fig 3-1: One of the sealed barns where rat trials were conducted with autonomic lasers.

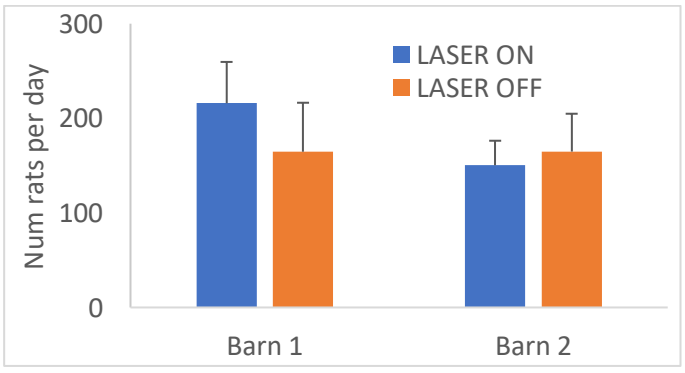
A small pile of grain was placed at one end of each barn to focus rat activity, monitored by two trail cameras, with a laser at the opposite end of each building. Lasers were in place (but inactive) during the baseline monitoring period when data from the cameras were used to identify the 'normal' level of rat activity.

When trials began, one laser in one barn was switched on (24hrs/day) for approx. 5 days in trial one, 1-3 days in trial 2. This laser then remained off whilst the laser in the other barn was switched on, and so on. N=11,471 mean rat encounters – not necessarily different individuals.

Results: Some technical issues with cameras and lasers caused frustrations for data collection, but a simple comparison of rat activity with lasers on and off suggested no clear impact of the laser. There was a huge amount of variation in daily rat activity due to unknown causes.

Fig 3-2: Results of two trials testing the deterrent effect of the autonomic lasers on rats.





4) Shotwick (LJMU)

Shotwick is a small trial site, Fig. 3-1**Error! Reference source not found.**, used at the beginning of the project to practice the use of Laser Fence equipment, and develop monitoring techniques such as animal behaviour monitoring and grass height measurements.

An autonomic was installed in Shotwick with aim to exclude a small flock (n=7) from the corner of a plot that was frequently grazed. Camera traps were deployed.

The autonomic was positioned in paddock 2 and a projection zone was programmed to cover one corner of the paddock ("e") in Fig. 3-1. The sheep's enclosure was in the opposite corner ("d") and they grazed daily through both paddocks.

Fig. 3-1 Shotwick Site showing two 20m x 60m paddocks, 1, 2, connected via a path, c.

Fig. 4-2 Responses of sheep to Laser: (L) Sheep avoids beam by running away, (R) sheep ignores beam

A mixed response was observed, Fig. 4-2. Grass height analysis was conducted taking multiple measurements in the laser projection zone in paddock 2 and the control area in paddock 1("b"), over the period of the trial. Results are presented in Fig. 4-3.

The grass height data suggests that the autonomic laser did reduce the grazing in the laser projection zone.

Animal behaviour monitoring, where trail camera video clips are reviewed manually and a behaviour is ascribed, suggests that the sheep were perturbed by the laser, spending more time being "vigilant" or alert when the laser is projecting, and so probably less time grazing.

5) Bickley Hall Farm (LJMU)

Bickley Hall Farm is managed by the Cheshire Wildlife Trust (CWT), a conservation and wildlife charity. It consists of hay meadows and pastures, with sheep and cattle grazing.

Fig. 5-1 Bickley Hall - "The Warren" trial site

The main trial site used was "The Warren", believed to be a mediaeval artificial rabbit warren. Trials began in 2017 but had to be modified in September for health and safety reasons. A 100mW green autonomic was used to scan an area on one face of the mound. Trail cameras (up to six) were originally employed, but were producing many "blank" videos. It was decided that some form of CCTV camera would give more insight into the behaviour of rabbits, and other animals, on the Warren, filling in the gaps between trail cameras. To facilitate this, a radio link was set up over the 850mm to the CWT offices and the recorder. Initial results, analysing trail camera clips, showed the same low response rate of the rabbits reacting to the laser as had been reported early in the project's trials.

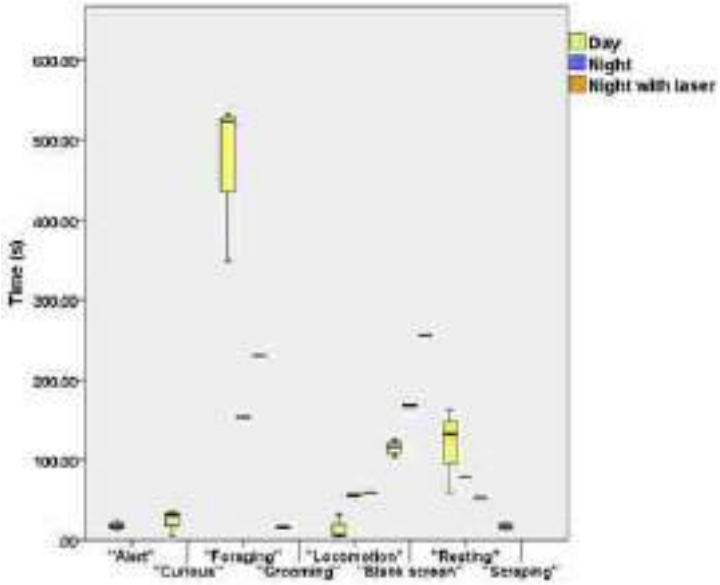


Fig. 5-2 Sept 2017 behavioural data

At Bickley grass height analysis was conducted, this suggested some initial impact of the laser to reduce grazing when laser was present, followed by habituation. Later behavioural data, Fig. 5-2, suggested that rabbits

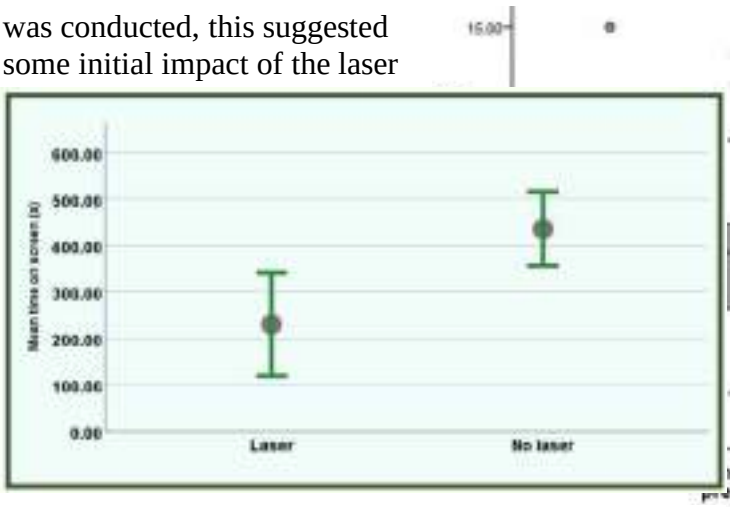


Fig. 5-3 Time in view of CCTV vs Laser On / Off

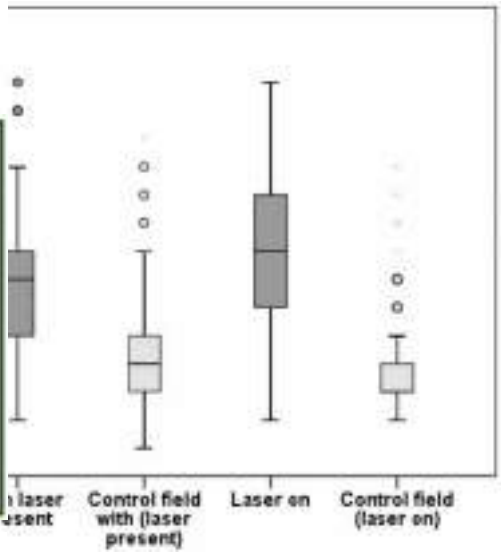


Fig. 4-3 Grass height measurement data

spent less time foraging, more time moving and there was more “blank” screen time when the laser was being projected.

Later analysis of CCTV video, carried out during Covid-19, looked at the prevalence of rabbits in the laser projection zone. This showed, Fig. 5-3there was a statistically significant reduction of time rabbits were on screen, indicating a deterrent effect.

Badgers were present at Bickley, some handheld work was conducted but a planned trial could not proceed because of Covid-19 restrictions.

6) Cuarterola, Cucanoche and Eoloarroz (ACA)

The farms of the Angel Camacho Group are located in the province of Seville. These farms are devoted to extensive rainfed crops, such as cereals, mainly sunflower.

They are areas with a large influx of animals, both birds and mammals, which causes great economic losses in the vast majority of cases. In the case of Cucanoche and Cuarterola we find farms that are highly affected by rabbits.

Angel Camacho carried out trials on the mentioned farms since the beginning of 2018. At the beginning, the tests were carried out mainly with autonomic lasers, but due to the problems of working with animals in such a large area, it was decided to focus the work on manual lasers.

Tests were carried out on crops such as sunflower, oats and wheat, studying plots with the same characteristics and working only on one of them, with the aim of comparing the final productions obtained at the end of the campaign.

In this way, tests were carried out in rabbits, which were carried out both during the day and at night, in order to see how the ambient light affected the type of response shown by the animals, tests in which it was clearly seen as a low ambient light level obtained better results, both in speed and success rates.

Two areas near the main tower were chosen, which were located halfway between an area of rabbit burrows. the areas were controlled with night cameras for 24 hours. It was decided to stop using this type of device and work remotely during daytime hours and at dusk with manual cameras and the handheld lasers.

The result obtained was not as expected compared to the tests that had been carried out on rice with birds and practically no difference was seen between the sunflower and oat productions obtained when comparing the plots in which it had been implemented. (12-13% of success with mammals)

	RABBITS	RODENTS	BIRDS
GREEN	5%	6%	85-95%
BLUE	13%	12%	80-85%
RED	12%	15%	65-75%%
YELLOW	4%	5%	85-90%

In Cuarterola, one of the biggest problems is the damage caused by rabbits in the olive trees and the losses caused by thrushes and blackbirds. the tests focused primarily on these animals. Rodent tests were carried out on agricultural plots during the season and on farms during autumn, although the number of rodents was relatively low. (12-15% of success with rodents).

The rice tests were carried out in the same way using the manual laser mainly and practically all the tests in birds focused. In this way, we obtained a large amount of information that

allowed us to know in a more effective way the operation of the laser system, and how the different colours affected the results to a greater or lesser extent.

Factors such as ambient light, the colour of the laser beam, the age of the animals, or the type of activity they were performing at the time of the tests notably affected the type of response obtained.

7) Wölferlingen (BCG)

At the Wölferlingen trial site in Germany, the laser fence's effectiveness has mainly been tested on deer and boars. Over three consecutive years, wildlife and their reaction to automated laser devices have been monitored by wildlife cameras on two separate fields near one another, as illustrated in Figure 7-1.

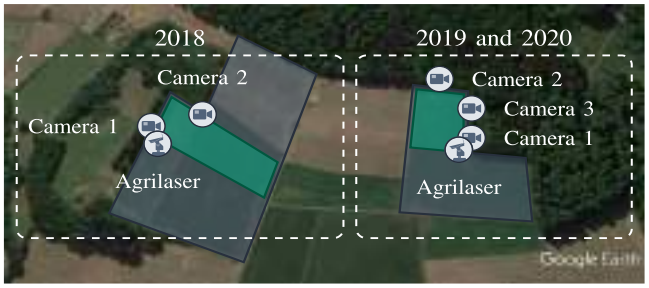


Fig. 7-1 The setup of the trial sites

During these tests a total of 4493 videos have been recorded over 443 days. Of these videos, 131 contain footage of both animals and the laser. In 87% of these videos, the animals seem to ignore or not see the laser. In almost all other videos, the animals slowly move away. It is unclear whether it is the laser that causes them to do so.

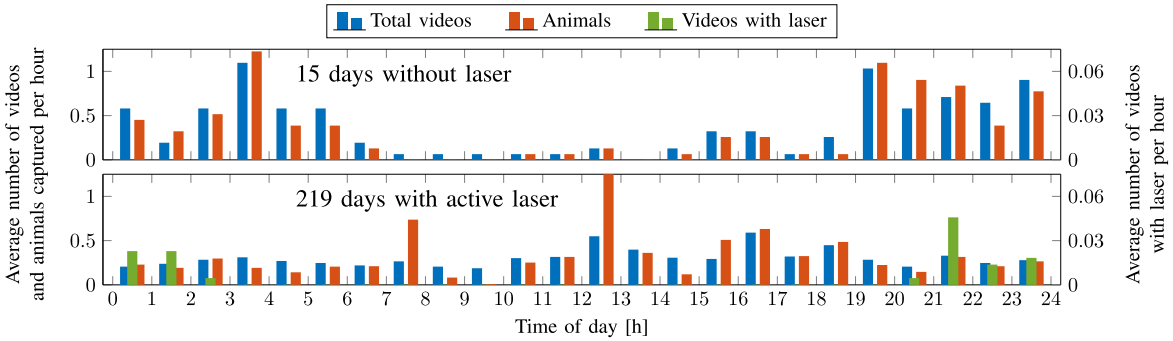


Fig. 7-3 The difference in animal activity between fifteen days in which the laser was inactive and 219 days in which the laser was active, both during the 2020 replication trials

During the 2020 replication of the trial however, the laser was turned of for fifteen days at the beginning of the trial. During the remaining 219 days of the trial, the laser was active during the night. Figure 7-3 shows the average amount of recorded videos, animals spotted, and videos with a visible laser per hour of the day during those two periods. The data do show that there is less registered animal activity when the laser is active.

Not only automated, but also handheld laser devices have been tested for repelling animals. During field tests in 2018, some animals seem to respond better to laser light when it is being actively aimed by a human operator. Figure 7-3 shows an example of a hare, that clearly moves away from a laser that is actively aimed to move the hare in a specific direction. Such a method is often called a *detect-and-deter* method could potentially be implemented in automated laser devices for future research.

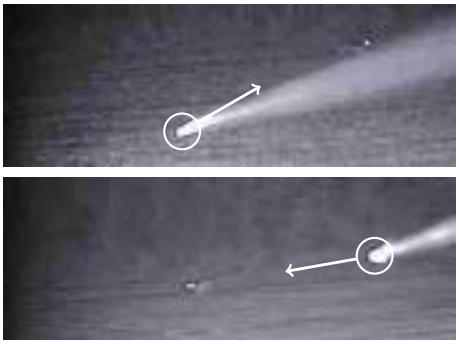


Fig 7-3 Hare reaction to an actively aimed handheld laser

8) Welsh Mountain Zoo (LJMU)

The Laser Fence project had been introduced to the Sciurus LIFE project that was looking to prevent grey squirrel entry into red squirrel areas. Could Laser Fence assist with this? Following several meetings trials were arranged at the Welsh Mountain Zoo, using a range, that is frequented by grey squirrels.

Fig. 8-1 Range at Welsh Mountain Zoo used for trials with grey squirrels

From November 2018 to February 2019, several lidded bait boxes were mounted in the range, using whole peanuts as bait. Handheld lasers were operated from a raised platform some 20m away from bait boxes 6 and 7 shown in Fig. 8-1. In February 2019 the set up was simplified to just two bait boxes placed at the end of the wooden frame that had been holding boxes 6 and 7. These boxes were made of transparent Perspex, to allow the laser beam to enter the boxes as some squirrels sat inside the original wooden boxes. A new set of trials were conducted including the new coloured handheld lasers, and an acoustic device, Bird Gard™. This device emitted random sounds believed to be deterrent to grey squirrel. This part of the trial was designed to see if there would be the possibility of "learnt behaviour" where the animal learnt to associate the laser spot with deterrent sounds. Fig. 8-3 is a scatter graph of the average times the squirrels spent at the bait boxes for each treatment. Similarly, measurements were made of how long the squirrels took to return to the bait boxes, Fig. 8-2.

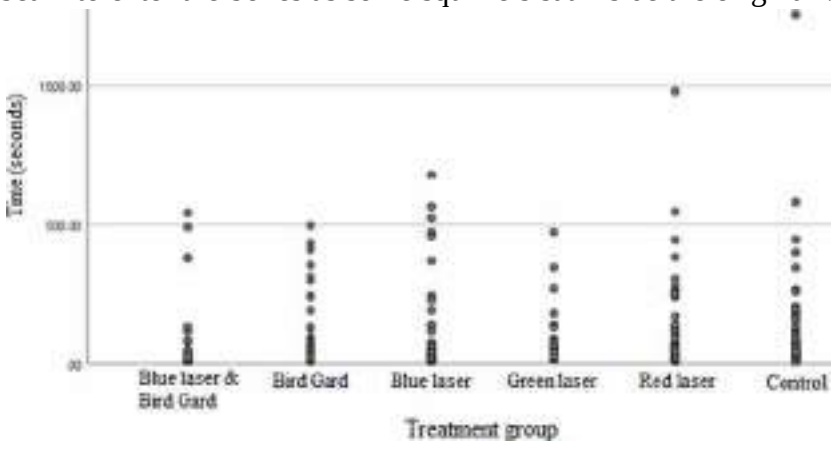


Fig. 8-3 Average time at bait station

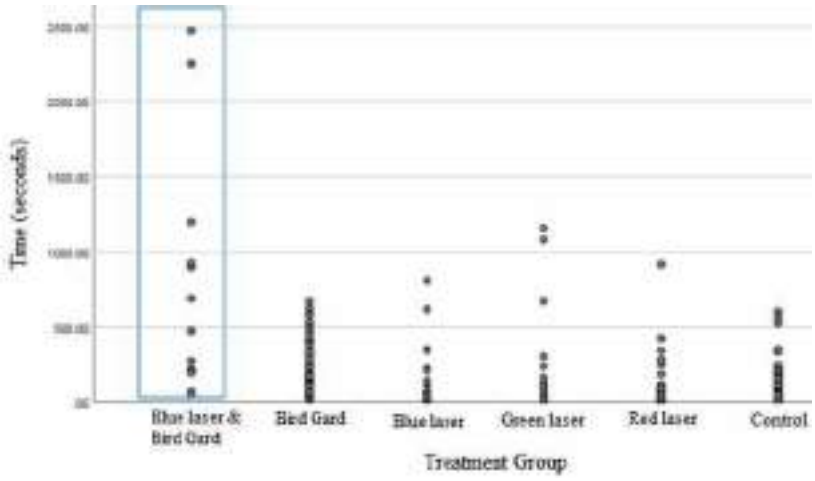


Fig. 8-2 Average time taken to return to the bait station

The results showed that none of the treatments had a significantly greater effect on the time spent at bait, while the Bird Gard and Bird Gard plus blue laser had a significant effect.

9) RSPB Burton (LJMU)

Fig. 8-1 Laserfence handheld mounted on a tripod, and overlooking fields at RSPB. Also mounted was a night vision scope and IR illuminator

RSPB Burton Marsh is home to many bird species, but also Badgers. Badgers are a concern to RSPB, as they take eggs of migrant birds in the breeding season. However, the public also want to see badgers as well as birds. The reserve allowed trials at Burton Point to see if Laser Fence might control badger. The site provided an elevated area that allowed good visibility to the surrounding fields. There is also a bait station close to the viewing platform. Having the night-vision scope and laser attached to a tripod meant the badgers could be easily tracked and targeted at distances up to 300m. Fig. 9-2 is a still taken from a video captured on the night vision scope. The badger had been moving to the right and the laser reversed its direction.

Fig. 9-2 Badger targeted at approx. 300m. The badger is just above the centre of the cross wire

Over 17 evening visits, 23 badgers were able to be targeted with either a 500mW green laser or 500mW blue laser. Fig. 9-3 shows the summary results, 18 of the badgers were persuaded to move in another direction by the application of the handheld laser. This represents a 78% response rate. Note that this does not imply an instant response, sometimes some pestering application is needed.

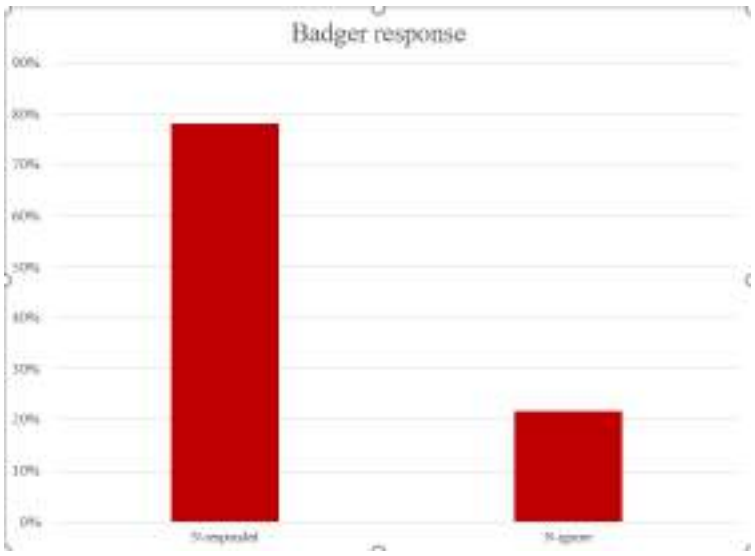


Fig. 9-3 Response rate in deterring badgers (23 badgers in total)

It was noted that it was more difficult to move a badger when it was at the bait station, and in one case a particularly bold, and believed to be older, badger foraged for a while before moving off.

This result, though, is encouraging it is felt that the badger could be a good application for Laser Fence. It may be particularly relevant to the dairy cattle / badger issue in the UK.

10) Cheshire Farm B (LJMU)

Cheshire Farm B is an arable farm with mixed crop principally used to provide bedding and feed for the dairy farming operations of Grosvenor Farms. The farm had been recommended by Bickley Hall Farm as a possible site for rat trials. The farm buildings include grain stores and a grain drying tower. Trail cameras were fitted to gain evidence for the presence of rats, Fig. 10-1. Cameras were placed in the grain dryer tower.

Fig. 10-1 Autonomic set up to "protect" a bait chart

The farm manager indicated that rodenticide records would be available. It was decided to conduct a trial in the basement of the grain dryer.

A green autonomic was set up to "protect" a bait tray. The aim of the trial was to capture activity on the bait tray as well as measure the weight of the bait. The latter did not appear to work well, as weight sometimes increase.

Analysis of trail camera data suggested that 49% of rats responded quickly to the laser.

Unfortunately, there were several interruptions and disturbances to the trials during the period trials were being attempted and eventually when a harvest was due, it was advised to move the laser out as the atmosphere would be very dusty and this could potentially be damaging to the Laser Fence equipment.

The farm manager indicated that there were badgers in the farm's fields. Despite several late evening visits to the farm, Fig. 10-2 looking for these animals, none were spotted. Trail cameras were set up. Although a badger was caught on camera, it was only one of two or so, and so it was concluded that the site would not be suitable for any form of badger trial.

Fig. 10-2 Midsummer's Eve 2018 - looking for badgers

11) Cheshire Farm A (LJMU)

Cheshire Farm A concentrates on arable farming – growing wheat, barley, oil seed rape and grass. In addition, it provides haulage and grain storage facilities to agriculture and food manufacturing industry. Control of rat access to the storage areas is critical to the business and is traditionally managed by rodenticide and shooting.

The first trial was conducted in one grain shed, and a wall mounted autonomic was used “to protect” a bait tray. The tray was monitored by trail cameras. However, the number of rats were low, and after a period the shed was emptied and used to store furniture. Meanwhile a “rat run” was identified in another shed behind a grain cleaning machine, and so the autonomic was moved to project on to the rat run area. Principal analysis was to look for instant response on the trail camera clips. Again, there was a low count of rats, and hardly any video clips captured animal / laser interaction.

The following winter the farm manager reported that rats were now entering the grain store area with the grain cleaner from the combine harvester shed on the other side of the grain shed wall. The autonomic system was relocated to the combine shed to address this entry point. As well as trail cameras mounted to cover the rat run on the top of a breeze brick wall, the CCTV system was moved from Bickley Hall to provide continuous coverage. During this trial a blue autonomic laser became available and was fitted. The laser on the autonomic system was regularly turned on or off each week, so that the laser was projecting (37 days total) or not projecting (39 days total), and the number of rats were present was counted. The results showed a 46% reduction in the number of rats when the laser was projecting.

Finally, he autonomic was modified to carry a green and a blue laser head, Fig. 11-1, and moved to another grain store to protect an identified rat entry point from inside the grain store. Only trail cameras were used to monitor for animals. This trial was curtailed by the Covid-19 restrictions. There were 14 days without the laser, 15 days with the green laser and 16 days with the blue lasers. There was a 72% reduction in rats with the green laser and 94% reduction with the blue laser. Such results were encouraging.

Fig. 11-1 Dual headed blue / green autonomic system inside a grain shed

12) As Neve (IRIS)

To evaluate the impact of the laser on large mammals (wild boar, foxes), an autonomous system was installed in an agricultural field (pastures, corn) in As Neves, Autonomous Community of Galicia.

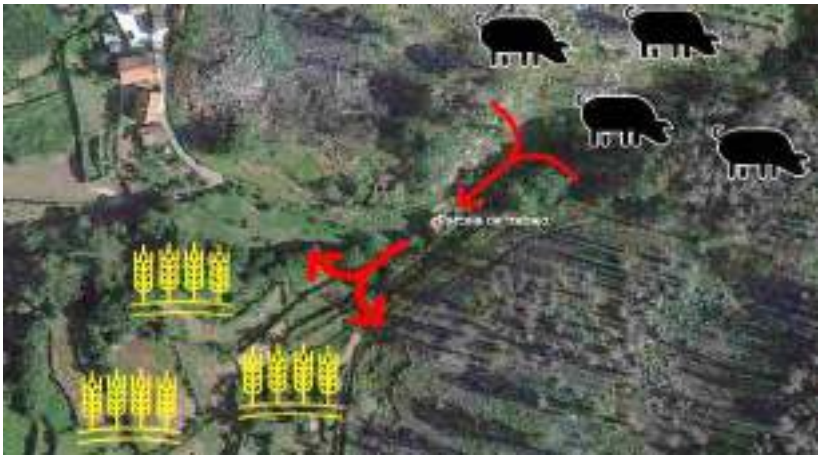


Fig. 12-1 Study Area

It is a closed plot with stone walls whose most sensitive access is a narrow passage located facing the adjacent forest area, with quite a lot of large weeds.

Fig. 12-3 Automatic scanning of the Laser Fence system after sunset

Fig. 12-3 Female wild boar with two boars walking on the plot on 28 Feb. 2020 at midnight

To study the animals that enter the laser area, two infrared sensor cameras capture a 60s video when motion is detected. The trial has been conducted from November 2019 to June 2020. More than 500 video clips have been recorded, of which 38 show clear images of wild animals. 8 positives occur covering wild boar, foxes and badgers in which the laser is making a sweep. No clear reaction to the presence of the laser is detected. The number of animals captured in each month are shown in, Fig. 12-4.

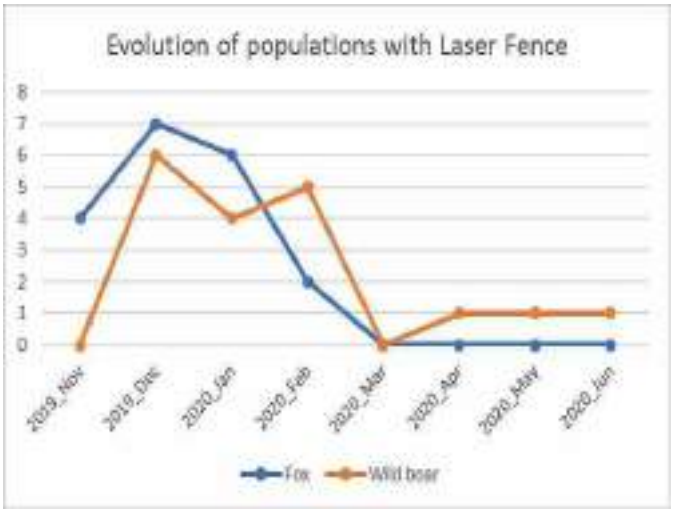


Fig. 12-4 Evolution of animal detections

It appears that there is a decrease in activity in the area. However, the number of animals detected and/or the time interval sampled may not be sufficient. It is possible that the reduction in activity of wild boar and foxes is due exclusively to seasonal or survival factors (hunting, for example). Despite this, the results offer some hope. It is possible that the Laser Fence system will influence the behaviour of animals in the medium and long term and could deliver a real benefit. To check this, data from the same area should be taken at least two years in a row (to minimize the weight of seasonal/hunting factors), the number of laser test plots should be increased and intermediate control plots should be included by installing camera traps.

13) Companarios de Azaba (Volterra)

Campanarios de Azaba is a biodiversity reserve that works on the conservation of the integration of human traditional activities with the environment. Its located in Salamanca province, and it limits with the Portuguese border. It is a dehesa ecosystem which has been modified by human activities that combine agricultural and livestock activities. These dehesas ecosystems are an exceptional example of how human activities in an equilibrium can maintain the ecosystems services that natural environments provide.

Mapa propia. Transectos realizados en la reserva Biológica Campanarios de Azaba. Fuente: elaboración

Fig. 13-1 Paths followed to plan trials

The site serves as a habitat for wild boars, deer, marten, fox, hare and boar. Fig. 13-1 shows the paths that have been followed to develop the trials.

The trials started in 2019, and it included the use of handhelds laser of blue and green beams. 62 trials were done following different transects. The trials were carried out at sunrise and sunset. Table 1 summarises these trials, with analysis in Fig. 13-2 and Fig. 13-3.

Table 1. Results of the tests carried out by species. Source: own source.

	Reaction		No reaction	TOTAL (replications)
	(blue beam)	(green beam)		
Deer	4	1	9	14
Roe deer	2	2	2	6
Beech marten	0	0	4	4
Fox	2	0	10	12
Hare	0	0	6	6
Wild boar	4	3	13	20

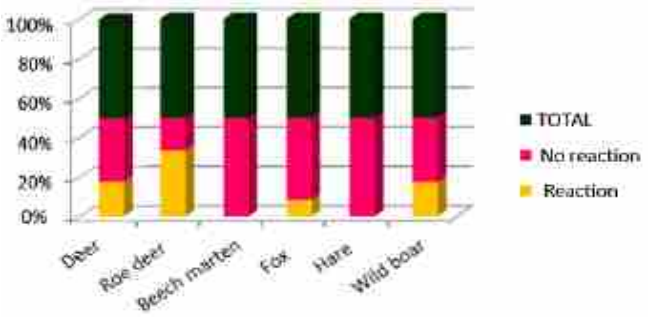


Fig. 13-2 Analysis of reaction data against species

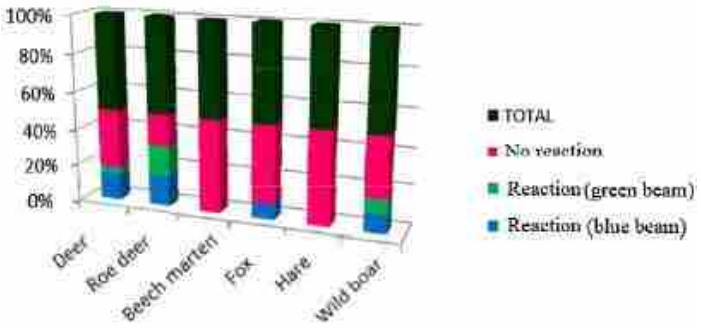


Fig. 13-3 Analysis of reaction data against colour of laser

14) Sierra de la Culebra (Volterra)

Taking into account the risk that the current growth of wolf packs in the northern half of the Iberian Peninsula means for livestock, it has been desired to test the effectiveness of the laser with some wolf packs from the Iberian Wolf Centre of Castilla and León - Félix Rodriguez de la Fuente located in the Sierra de la Culebra (Zamora).

The trials were done together with the veterinary and the wolf management team of the centre. A green beam laser was used to develop these trials and there were done with daylight around 11 am. As it is shown in the following picture wolves did not react to the laser beam, they even lay down or pass beside the green beam point. The experts in wolf behaviour explained that it might be because it is hard for the animals to see the laser during the day.

Despite that, would be important to repeat the trials this winter during sunset to compare the behaviour of the animals because it is at this time of the day when the number of attacks increases.

Fig. 14-1 Wolf Reaction to Green Laser (1)

Fig. 14-2 Wolf Reaction to green laser (2)