A nine month small mustelid survey across four research sites in the Netherlands

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Abstract: There is a general concern amongst ecologists about the apparent decline of small mustelids in The Netherlands over the past decades. However, little is known about their actual historic and present numbers. To better understand their ecology and the cause of the decline more research into these small predators is a necessity. Between October 2016 and August 2017 four different research sites in the vicinity of Deventer, the Netherlands, were investigated by surveying 64 locations with camera-trap boxes and nest boxes fitted with tracking tunnels with the intention to gather distributional data of small mustelids common weasel (*Mustela nivalis vulgaris*) and stoat (*Mustela erminea*). Three locations were chosen for their small-scale agricultural landscapes, regarded as prime habitat for the target species. One location concerned an open large-scale intensively managed agricultural landscape, regarded as degraded habitat. Weasels were found with both camera-trap boxes and nest boxes but the footprints of weasel and stoat from tracking tunnels could not always be identified to species. Zero stoats were found during this study. Stoats are either very rare or not present at the time of research. Research materials proved not to be suitable for Western polecat (*Mustela putorius*) and other larger mustelids as the limited diameter of the entrance tubes used in the research materials averts entry. There was no clear difference in number of weasel recordings between large-scale agricultural landscape (two recordings) and small-scale agricultural landscapes (one, five and zero recordings) that were included in this study. Striking is the fact that most observations occurred between March and October. The outcome of this study concludes that small mustelid studies require innovative research materials, time consuming methods and harvest meagre results. Based on historical data and recent research results, including this study, it is not possible to provide a better foundation for the status and trend of weasel and stoat. The available data is too minimal. In order to get a better understanding of current status and population trends large-scale, long-term monitoring studies with camera-trap boxes are recommended.

Keywords: common weasel, stoat, Western polecat, stone marten, camera-trap box, nest box, large-scale agricultural landscapes, small-scale agricultural landscapes.

Introduction

Intensification of land use and large-scale agriculture has increased considerably in the Netherlands in recent years, which is the main cause of habitat loss for common weasel (*Mustela nivalis vulgaris* - hereafter called weasel), stoat (*Mustela erminea*) and Western polecat (*Mustela putorius* – hereafter called polecat) and the main reason why small mustelid populations have probably been in decline (Criel

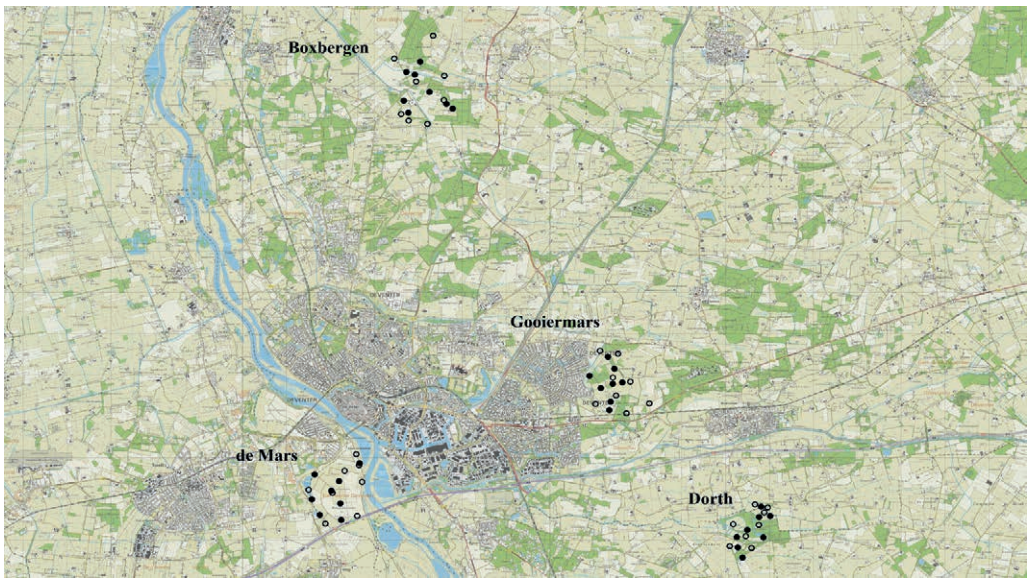

Figure 1. The location of the four field sites around the city of Deventer, the Netherlands. The open dots are locations that were surveyed in period one and two, the closed dots were surveyed in period three and four.

1990, Lange et al. 1994, Twisk et al. 2010, van Maanen et al. 2013, Bouwens 2017, Jonker 2017, Verschoor & Rozema 2017). There is a structural lack of information about the occurrence of small mustelids in the Netherlands (Jonker 2016, Bouwens 2017, Veldman & Troost 2019). To better understand their distribution and habitat use intensive innovative research is a necessity. This study was initiated by the Dutch Mammal Society to do just that and share knowledge and experiences (Westra 2017). In the past fifteen years new research methods are being developed for the notoriously difficult-to-study species group of the small mustelids: Scentinel (King et al. 2007), Camera-trap box or 'Mostela' (van Maanen et al. 2015a), Nest box (Smaal & van Maanen 2017), Audio lures (Schep 2018), Struikrover (van Uchelen & Smaal 2019). This study aims at carrying out a standardised survey, with two of these methods: the camera-trap box and the nest box. The camera-trap box is a box fitted with a camera-trap with short focus lens and open with tubing on one side luring explorative small mustelids in. The nest box is designed as a suitable nesting shelter for small mustelids and is fitted with a tracking tunnel to monitor its use.

This paper presents the results obtained in three sites within small-scale agricultural landscapes regarded as prime habit at for small mustelids and in one site within large-scale agricultural landscapes regarded as degraded or unsuitable habitat. The hypothesis is that, based on landscape features and habitat suitability, small mustelids are present at the first three sites, and not present at the fourth site. If so this may lead to a better understanding and support base for landscape management measures to improve habitat suitability for small mustelids. The main goals were to use camera-trap boxes and nest boxes as research methods for surveying weasel and stoat and to confirm that the research methods are unsuitable for surveying other mustelids. Also a comparison of the obtained results between small-scale agricultural landscape and large open agricultural landscape was desired to test the above hypothesis. Furthermore, this study could provide details about the time of year and in which microhabitat small mustelid surveys are most successful.

Figure 2. Examples of small-scale extensively managed agricultural landscapes at Dorth estate (A) and Gooiermars (B), and an example of large-scale intensively managed agricultural landscape at de Mars (C).

Materials and methods

During a nine month period between October 2016 and August 2017 four different research sites were investigated by surveying 64 locations, 16 within each of the research sites. The research sites were located in the vicinity of the city of Deventer in the province of Overijssel in the east of the Netherlands (figure 1).

Research sites

I selected research sites based on terrain characteristics, after checking aerial photographs, consulting with site managers and extensive field checks. Three sites - Boxbergen, Gooiermars and Dorth - consist of small-scale extensively managed agricultural landscapes with a pattern of linear shaped bushes, ditches, hedgerows and woodlands (figure 2A and 2B). The fourth site - de Mars - is a large-scale intensively managed agricultural landscape with mainly open grassland and some hedges (figure 2C).

Research site 1, Dorth (52.226693 N; 6.290673 E), falls within the category of small-scale agricultural landscape. It is an estate managed by Natuurmonumenten (Dutch Society for Nature Conservation) with a size of roughly 180 ha and situated along the stream Dortherbeek in the province of Gelderland. It contains woodland with historical open

Figure 3. One of the field locations at research site Gooiermars. A hedgerow as an example microsite as used in this study.

waters like moats, ponds, and streams and sandy soil with mixed deciduous and pine forest and extensively managed grasslands. The landscape can be characterised as confined and natural with intensively managed agriculture in the surrounding areas.

Research site 2, Gooiermars (52.256527 N; 6.244048 E), falls within the category of small-scale agricultural landscape (figure 3). It consists of wetland, woodland and grazelands with a size of 200 ha, managed by IJssellandschap (a local foundation for landscape management) and Bannink (local estate). The low lying area is known as the origin of the Zandwetering, a local waterway running westwards towards the river IJssel. The terrain is not accessible for recreational use. Management is aimed at nature and watershed conservation.

Research site 3, Boxbergen (52.320099 N; 6.184706 E), falls within the category of small-scale agricultural landscape. It is a century old estate with an area of roughly 220 ha and is managed by IJssellandschap. Forestry and cattle farming dominate land use in Boxbergen. Slightly sloping sandy soils in the north are overgrown with old growth deciduous forests. The southern part is a mosaic of grassland, pastures and forest. Most agricultural activity is managed intensively and borders between forest and open landscape are sharp.

Research site 4, de Mars (52.235523 N; 6.153145 E), falls within the category of open large-scale agricultural landscape. It is a flood plain of the river IJssel. It has an open typography with grassland and sugar beet farming. De Mars has an area of 200 ha and is managed by IJssellandschap. The soil consists mainly of fluvial river clay that is exploited by intensive large-scale agriculture. Linear shaped landscape features are confined to a few narrow hedges and ditches of which most are situated in the west. The management is aimed at agriculture and wet grassland birds.

Research materials

Camera-trap box

The so called 'Mostela' camera-trap box used in this survey is an instrument which allows camera-trap surveys in thick undergrowth, where otherwise camera trapping is very difficult or impossible. Small mustelids are shy

Figure 4. A camera-trap box designed for surveying small mustelids.

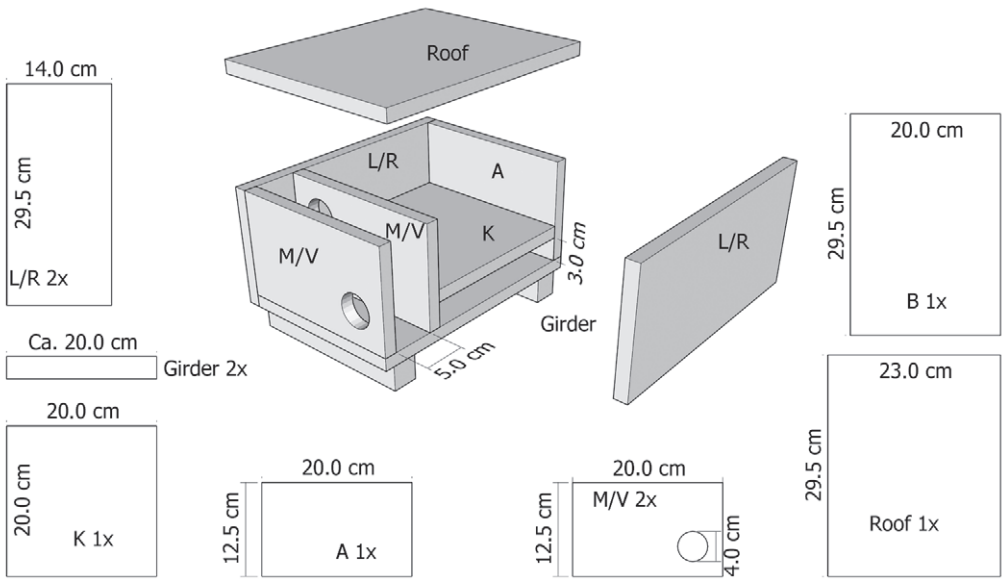

Figure 5. Schematic drawing of a nest box designed for surveying stoats (drawing reconstructed from Criel 1986).

and swift creatures that live most of their lives in dense cover where they are hard to find. This species group is rarely encountered with regular camera-trap surveys and therefore the camera-trap box was developed by the small mustelid workgroup of the Dutch Mammal Society (van Maanen et al. 2013).

The camera-trap boxes consisted of a wooden box measuring 60 cm in length, 30 cm in width and 20 cm in height (figure 4). On one short side of the interior a camera-trap (type Bushnell Trophycam 2016) was placed fitted with a short focus lens apprehended from +2.5 reading glasses. Across from the camera, on the opposite short side there was an open tube with a diameter of 8 cm running

through the box where animals can enter or exit the box on both sides. In the middle of the box fish oil was applied as an attractant. The short focus lens allows the camera-trap to capture sharp images of animals that enter the box. Most of the infrared flash LED bulbs of the camera had to be obscured by duct tape to prevent overexposure of the images. A sticker with location, camera number and coordinates was put inside the camera-trap boxes so that this information was captured on footage each time the camera was triggered.

Nest box

The nest box used in this survey was first developed by the Belgian National Campaign on Protection of Predators in the 1980s (Criel 1986). At the time the aim of the development of this nest box was to be able to quickly create more refuges in an area that is prone to ecological restoration. In recent years the concept was revised to be able to employ the nest box for ecological research (Smaal & van Manen 2017).

The nest box measures 30 cm in length, 20 cm in width, 12.5 cm in height and stands 5 cm off the ground by two small girders (figure 5). Its interior has double flooring and a separate nesting compartment (20x20 cm) to further increase insulation. The entrance consists of a round opening with a diameter of 4.5 cm onto which a separate plastic pipe with a diameter of 8 cm and a length of 40 cm is connected. The measurements of this nest box were customised for stoat but since weasels are similar or smaller in size they also fit inside. The plastic pipe fitted to the front of the nesting box was used as a tracking tunnel by inserting in a small plank on the bottom of the tube with an ink pad situated in the middle. The pad was filled with a mixture of paraffin oil and graphite powder functioning as the 'ink'. Animals entering the nest box walked over the pad leaving footprints on the plank. The plank was painted with blue coloured primer to increase visibility of footprints of animals entering and to be able to easily wipe the plank clean after each check.

Sampling procedures

The exact field locations were chosen on the basis of suitable microhabitats that are important for small mustelids (see figure 3). Suitability of the microhabitats was based on tracks and signs of mustelids that were encountered at the research sites as well as habitat requirements for small mustelids as stated in literature (Lange et al. 1994, Boshi et al. 2015, Twisk et al. 2016, van Tongeren 2017, Westra & Kuiters 2018). Within each research site 16 different locations were sampled randomly, eight with camera-trap boxes and eight with nest boxes fitted with a tracking tunnel. The camera-trap box and nest box locations were often placed in densely overgrown linear structures, such as wooded banks, wood girdles, hedges, forest edges or overgrown ditches. Heaps of pruned branches, cairns and messy farmyards were also chosen as field locations. If there was no sufficient vegetation coverage the research materials were covered with branches and leaves. The research materials were deployed approximately equidistant from each other (between 200 and 300 metres as the crow flies), to enable a regular distribution of sampling units over the research site.

Each of the four research sites were surveyed identically. Research materials were deployed on a total of 64 locations regarded as potential habitat for small mustelids. A total of 16 camera-trap boxes and 16 nest boxes were used simultaneously. In October 2016 four camera-trap boxes and four nest boxes were placed in each of the four research sites. They remained at the first location for roughly 20 weeks until March 2017. An interim check was done halfway, after roughly ten weeks, in January 2017 replacing memory cards in the camera-trap boxes and photographing footprints obtained

Figure 6. Footprints of weasel and / or stoat as obtained by using the plastic pipe at the front of the nesting boxes as a tracking tunnel with a small plank and an ink pad. Male weasel prints and female stoat prints overlap in size, making them impossible to identify at species level.

from tracking tunnels attached to the nest boxes. In March 2017 all 16 camera-trap boxes and 16 nest boxes were moved within each of the four research sites to new locations. At the second location, again, they remained in place for roughly 20 weeks until the end of July / beginning of August when they were removed from the field and the study was terminated. An interim check at the second location was done half way, after roughly ten weeks, at the end of April replacing memory cards and photographing footprints. The ink pads were checked one extra time during the second sampling period in the first half of June. At each check batteries in the camera-traps were replaced if the indicator showed less than two out of four bars. Salmon oil was also refreshed in the camera-trap boxes during each of the two interim checks. The tracking tunnel attached to the nest boxes was wiped clean and the mixture of paraffin oil and graphite was re-applied on the ink pad. Animals were not trapped or handled in any way for this survey so no Dutch laws or regulations on animal welfare apply.

Data analysis

Footprints from the tracking tunnels attached to the nest boxes were analysed in the field and photographed for later species identification in the lab by consulting reference material and literature (van Diepenbeek 2003, 2013, Agnew 2009, Vercayie 2013). However, the shape and size of large male weasel prints and small female stoat prints overlap. This makes it sometimes impossible to identify these prints to species level. In that case I recorded these prints as "weasel/stoat" (figure 6). Photographs of the footprints collected in this study were presented to tracking experts Annemarie van Diepenbeek and Jeroen Kloppenburg for quality control.

Data on memory cards of the camera-trap boxes were inspected on a computer and all information was inserted into a single spreadsheet. Location and date was noted for every species the camera-trap recorded. This study concentrated on gathering distributional data and therefore multiple detections in camera-trap boxes were not archived.

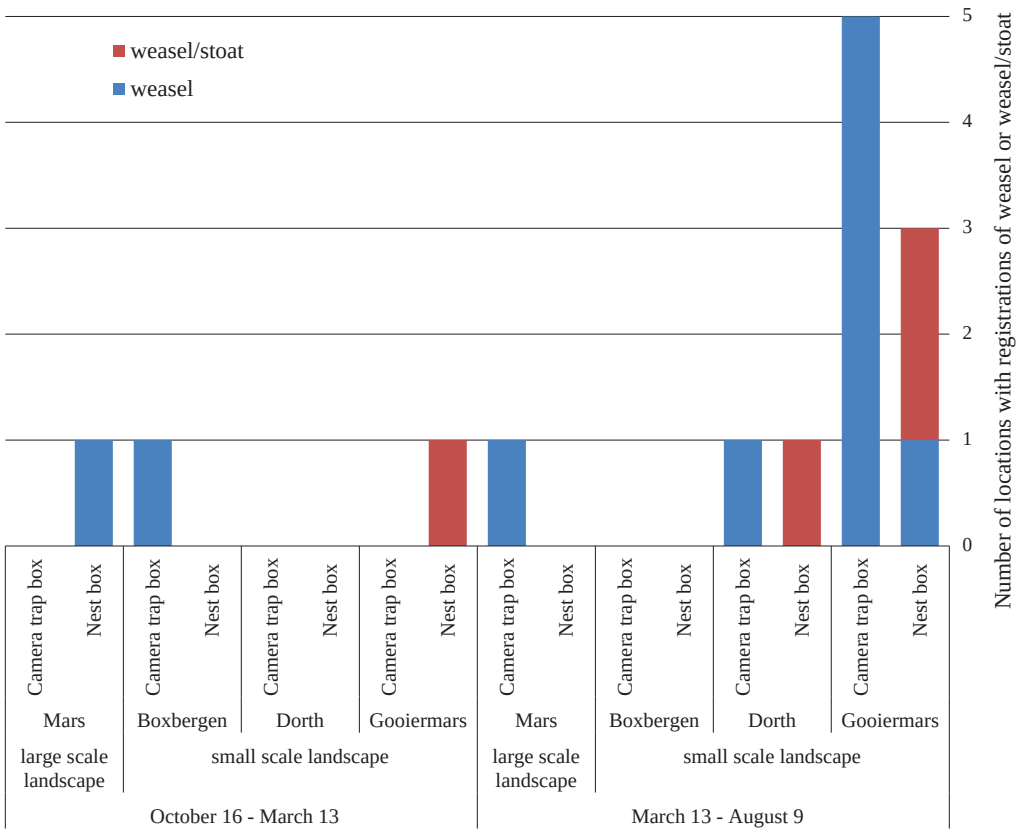

Figure 7. Overview of results at the four research sites. Note that the number of days the devices were active were not exactly the same.

Table 1. Overview of results per research site.

Research site	Category	Results
1. Dorth	Small-scale agricultural landscape	One weasel was registered in a camera-trap box and prints of one weasel/stoat were found in the tracking tunnel of a nest box. Additionally a young stone marten showed itself in one of the Camera-trap boxes.
2. Gooiermars	Small-scale agricultural landscape	Weasel was detected at five locations and weasel/stoat was detected at three locations (figure 9). A polecat showed itself in one of the camera-trap boxes.
3. Boxbergen	Small-scale agricultural landscape	Weasel was detected at one location with a camera-trap box. The camera-trap boxes registered a total of 160,000 photos at Boxbergen, of which only one single photo was taken of a weasel. No results were achieved with nest boxes.
4. de Mars	large-scale open agricultural landscape	Weasel was detected at two locations, one in a camera-trap box and one in a nest box.

Table 2. The average number of days until the first registration of weasel with Camera-trap boxes.

Research site	Species	Research instrument	Start	First registration	Number of days
Boxbergen	weasel	Camera trap box	24-01-17	06-03-17	41
Gooiermars	weasel	Camera trap box	09-03-17	11-03-17	2
Dorth	weasel	Camera trap box	10-03-17	04-04-17	25
Gooiermars	weasel	Camera trap box	20-04-17	06-06-17	47
Gooiermars	weasel	Camera trap box	20-04-17	14-05-17	24
Gooiermars	weasel	Camera trap box	20-04-17	28-04-17	8
Gooiermars	weasel	Camera trap box	20-04-17	26-07-17	97
De Mars	weasel	Camera trap box	23-04-17	19-07-17	87
Average number of days until first weasel registration					41

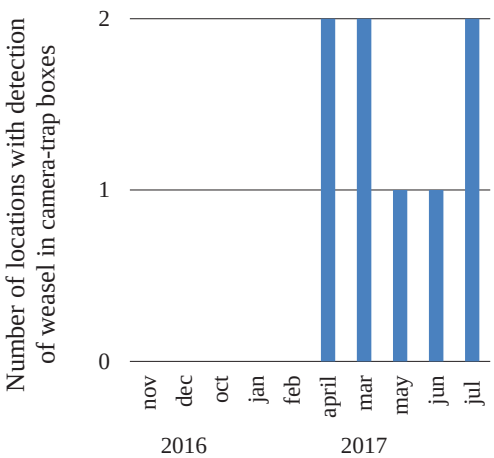

Figure 8. Overview of the number of camera-trap box registrations of weasel per calendar month

Results

During the study one camera-trap box disappeared at a location in research site Boxbergen. Therefore, from a total of not 32 but 31 locations camera-trap deployments (photo series) were collected. Once an SD memory card was found to be defective at a location in research site in Dorth, causing the sample size of the deployment to be halved. In total I collected approximately 490,000 images of 21 species in 3597 sampling days. The 32 nest box locations were interim checked once but the 16 nesting boxes were checked one extra time at the second locations. So a total of five sampling periods can be distinguished: period 1 and period 2 at the first research locations and period 3, period 4a and period 4b at the second research locations. Two nest boxes were flooded during one of the sampling periods in the study, making the tracking tunnel unusable. In a total of 4367 sampling days with 16 nest boxes times five sampling periods minus two flooded nest boxes results in photographs of 78 tracking tunnels. The footprints were studied and identified to species level if possible. The total sampling nights is 7964 for camera-trap boxes and nest boxes combined. An overview of the results at the four research sites is given in table 1 and figures 7 and 8.

Number of locations with observations and observations per research period

Results were achieved at eight out of 31 camera-trap box locations registering weasel (7x), polecat (1x) and stone marten (1x). In addition, results were obtained with five out of 32 nesting box locations, in which weasel prints (2x) and weasel/stoat prints (4x) were registered. As a combined total weasel was registered at nine separate locations (figure 9), weasel/stoat at four separate locations, stoat at zero locations, both polecat and stone marten once. By far the most results can be seen in the last six weeks of survey (figures 10 and 11).

Calculating the average number of days until first detection shows that it takes an

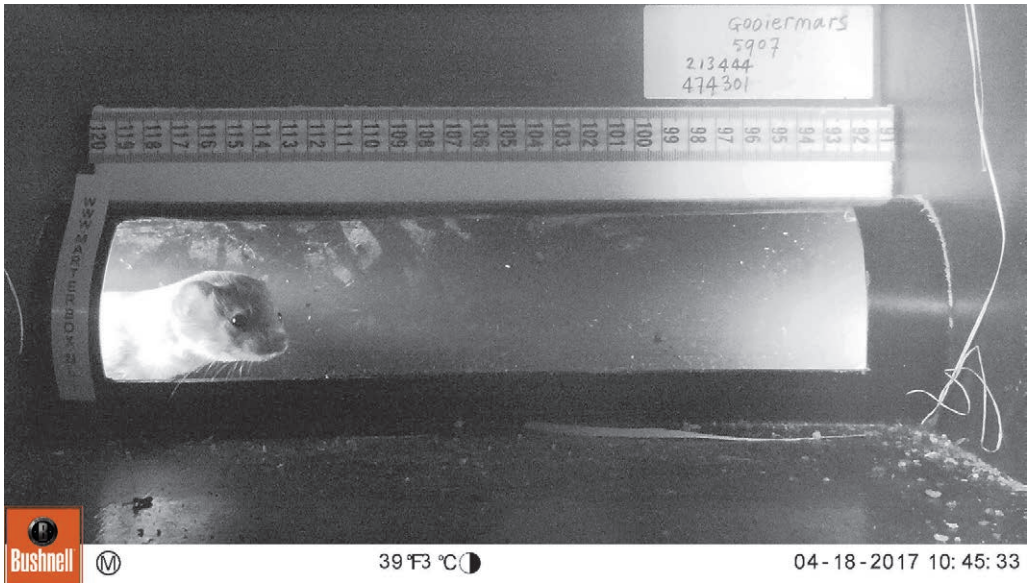

Figure 9. A weasel in a camera-trap box at one of the locations at research site Gooiermars.

average of 41 days for weasels to be registered in this study with a camera-trap box (table 2). The single recorded stone marten and polecat in this study were registered after respectively 31 and 89 camera-trap days.

Other animals also showed themselves in the camera-trap boxes. Not only wood mice and bank voles were registered but also hedgehogs, squirrels, brown rats, a domestic cat, amphibians and a variety of ground foraging birds (table 3).

Discussion

As already stated in the Introduction the intensification of land use, large-scale agriculture and urbanisation has increased considerably in the Netherlands in recent years. This increasement is the main cause of habitat loss for small mustelids and most probably the main reason small mustelid populations have been in decline. Furthermore, the absence of peak years of vole populations, the increase of other predatory mammal populations, like red fox (*Vulpes vulpes*) and stone marten (*Martes foina*), and accumulation of rodenticides from prey animals may have contributed to the decrease of small mustelids in the Netherlands (Douma et al. 2011, Broekhuizen et al. 2016). Stoats prefer low-lying wetland areas, whereas the weasel avoids wetlands (Criel 1990, Lange et al. 1994, Bouwens 2017). As a result, the weasel is likely to be able to maintain itself better in areas with large-scale agriculture (Criel 1990). The stoat appears to be much less numerous than weasel and even seems to have disappeared in parts of our country (van Maanen et al. 2015a).

Weasels were found at nine of the 64 research locations. In addition, footprints of weasel/stoat were collected at four locations. In contradiction to the hypothesis weasels were also found in open large-scale agricultural landscapes regarded as unsuitable habitat. Both camera-trap boxes and nest boxes proved successful in demonstrating the presence of weasels of weasel/stoat. The consultation of the Dutch National Database Flora and Fauna (NDFF) produced no historical data on the presence of stoats within our research locations at the time of this writing. Several road casualties and sporadic field observations in the NDFF indicate that stoats do occur in the east of the

Table 3. The species detected (mustelids in bold) and the number of locations (from a total of 64) where the species was detected during this study.

	Number of locations where detected		
Species	Camera-trap box	Nest box	Total
Mammals			
Wood mouse (*Apodemus sylvaticus*)	28	7	35
Bank vole (*Myodes glareolus*)	26	0	26
Common / Millet's shrew (*Sorex araneus/coronatus*)	19	0	19
Brown rat (*Rattus norvegicus*)	11	1	12
Weasel (*Mustela nivalis vulgaris*)	8	2	10
Greater white-toothed shrew (*Crocidura russula*)	4	0	4
Red squirrel (*Sciurus vulgaris*)	2	0	2
Western hedgehog (*Erinaceus europaeus*)	2	0	2
Soricidae spp.	2	0	2
Feral cat (*Felis catus*)	1	0	1
Pygmy shrew (*Sorex minutus*)	1	0	1
Western pole cat (*Mustela putorius*)	1	0	1
Field vole (*Microtus agrestis*)	1	0	1
Stone marten (*Martes foina*)	1	0	1
Stoat (*Mustela erminea*)	0	0	0
Muridae spp.	0	26	26
Weasel / Stoat (*Mustela nivalis / Mustela erminea*)	0	4	4
Birds			
Eurasian wren (*Troglodytes troglodytes*)	3	0	3
European robin (*Erithacus rubecula*)	4	0	4
Aves spp.	2	0	2
Common firecrest (*Regulus ignicapilla*)	2	0	2
Amphibians			
Common toad (*Bufo bufo*)	8	0	8
No data, camera trap box stolen	1		
No data, memory card error	1		
No data, no clear footprints		6	
No data, nest box drowned		2	

Netherlands. Stoats do show up in camera-trap boxes in other studies (van Maanen et al. 2013, 2015a, 2015b, Soininen et al. 2015, Hollander & Overman 2017). However it is hard to state their absence if target species are not detected. As described above, stoats often occur in lower densities than weasels. The number of detections of weasels in this study is low and therefore it is likely that stoats were present in even lower densities in the research sites at the time of this research and went undetected.

No results for polecat in this study were to be expected as the research materials used were not specifically built for surveying polecats. This is due to the limited diameter of the entrance tubes used in the research materials averts entry by larger mustelids. However, this study yielded the first known record of a polecat documented with a camera-trap box. Also a young stone marten showed itself on camera-trap footage gathered from Dorth estate. This is very surprising and probably due to the explorative nature of the young stone marten in question. The smaller size of the young stone marten made it easier to enter the camera-trap box. However, entry of camera-trap

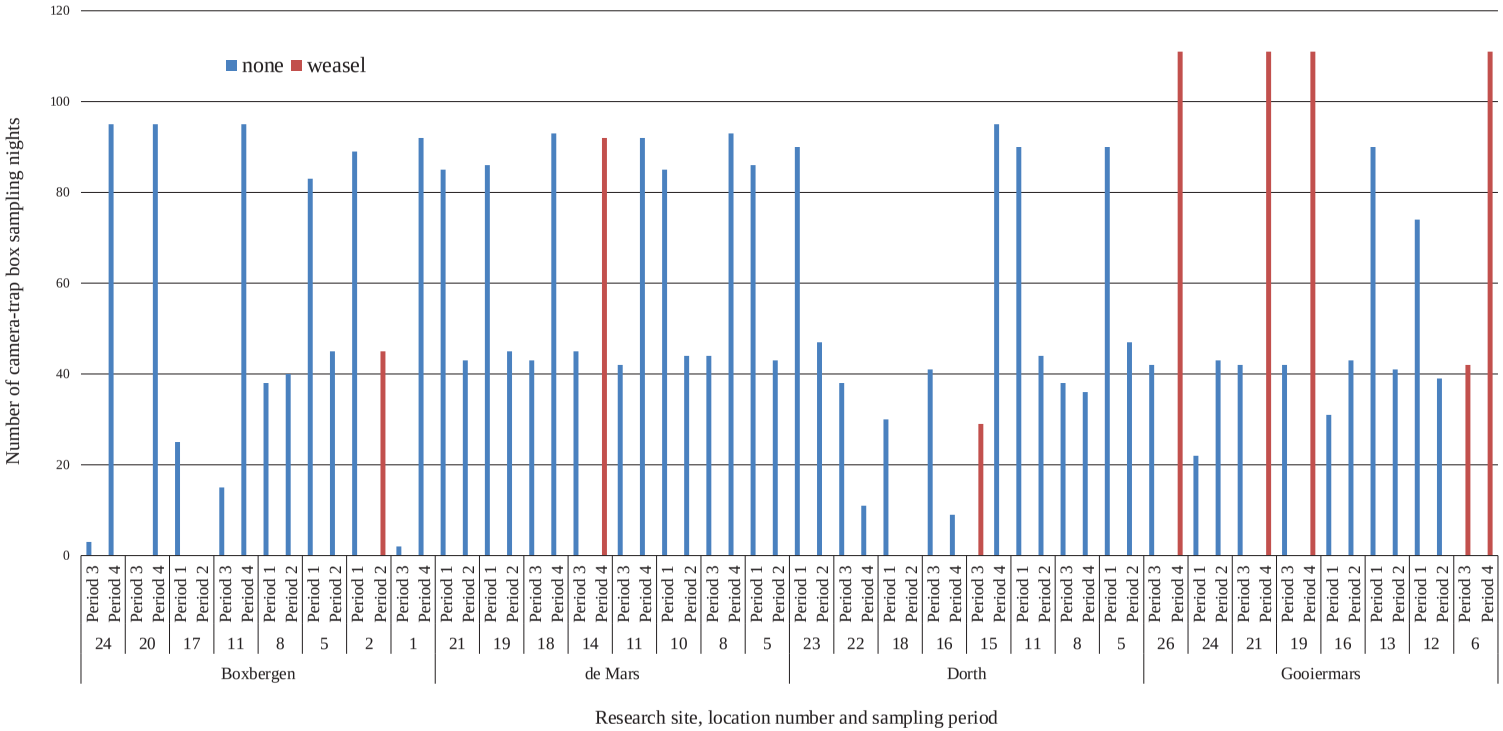

Figure 10. Number of camera-trap box sampling nights ; the locations where one or more weasels had been detected during a certain period are indicated by a red bar.

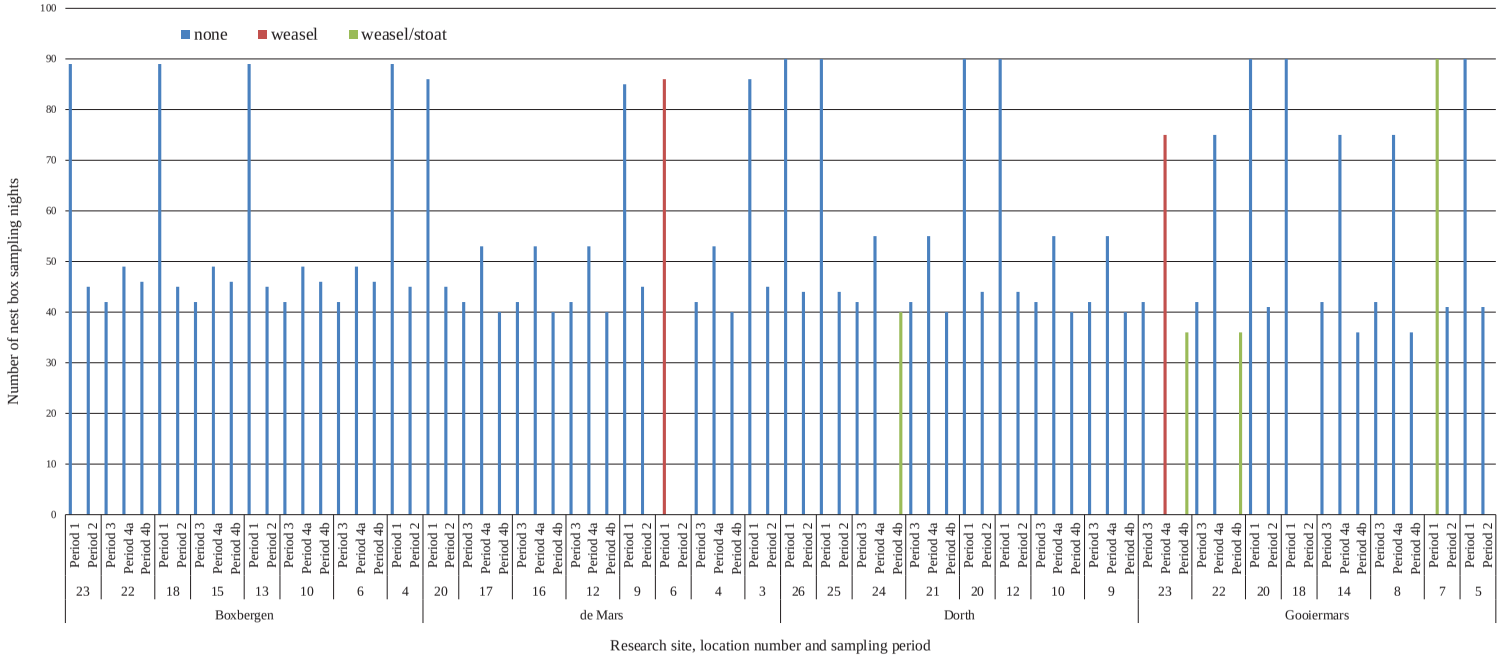

Figure 11. Number of nest box sampling nights ; the locations where one or more weasels had been detected during a certain period are indicated by a red bar; locations with weasel or stoat are indicated by a green bar.

boxes by adult martens is not impossible since a stretched out pine marten (*Martes martes*) managed to enter the camera-trap box of a local volunteer studying mustelids in Dorth estate in April 2018 (Oosterman 2018, unpublished data). Other studies showed that polecats, stone martens and pine martens do not show up in camera-trap boxes (van Maanen et al. 2015a, Hollander & Overman 2017). These observations should therefore be considered as by-catch. However, by-catch of larger mustelids and mammals is desirable in future studies to gather more information about hard to study species. Camera-trap boxes designed for small mustelid surveys have only been in use since 2012 in the Netherlands and there is still a lot to be learned about their effectiveness.

The first 30 of the 40 research weeks yielded little data, whereas the last ten weeks resulted in the bulk of the research results. Even though the extra interim check of the nest boxes during this period may have had an influence, it can be concluded that November through March appears to be a less successful survey period for small mustelids. The results indicate that April, May, June and July seem to be the best period for surveying weasels. Most likely this is weather related since small mustelids are less active during the colder months of the year (Smaal & van Manen 2017, Veldman & Troost 2019). Therefore they travel less distance in these months and the chance of being detected decreases.

Camera-trap boxes do yield the best results with regard to small mustelid surveys compared to tracking tunnels from nest boxes (figures 10 and 11). Tracking tunnels are easily contaminated with large amounts of footprints from small rodents making tracking of small mustelids impossible and short term interval interim checks a necessity and therefore labour intensive. Also, size and shape of small mustelids prints found in tracking tunnels often overlap making identification to species level impossible which is highly undesirable in most ecological surveys. In future studies tracking tunnels are only to be used as secondary method or if distinction between weasel and stoat is not a necessity.

At the beginning of this study intervals of ten weeks between field checks turned out to be too long for the tracking tunnels causing the footprints to be washed away by rain or the ink pads eaten by slugs and mice. Tracking tunnels should ideally be checked at least once every few weeks. Lastly, the sticker with information that was put in the interior of the camera-trap boxes was repeatedly eaten by snails. It is advisable to write down the required information on a piece of paper and to stick it in a plastic sleeve before adhering it in the camera-trap box. This way it cannot as easily be eaten by snails or mice.

Sometimes identification based on limited quality footage from camera-trap boxes proves difficult. Furthermore, small mustelids are swift and generally do not spend more than a few seconds inside a camera-trap box. It is recommended that camera-trap boxes used in any study should utilise the highest quality camera-trap available, with regard to image quality and trigger speed, as it is essential to increase the chance of detection and identification of the species. As an example, 164,000 photos (138 GB) were collected at Boxbergen research site, of which only one single photo captured weasel. Quickest trigger time and dynamic infrared flash intensity being most important features in a camera-trap to be used in a camera-trap box.

The analysis of camera-trap footage is very time consuming and labour intensive. A camera-trap box deployment (series of photos) takes on average about two hours to process manually. Manual processing was the quickest option at the time of this survey. In future studies it is recommended to use camera-trap footage processing software, of which several good options are currently available (Hendry & Mann 2018, Liefting & Jansen 2019).

Fish or fish oil is generally accepted as the most effective lure for small mustelids. It is, however, unclear whether lures are effective

Weasel. *Photo: Paul van Hoof.*

at all (Koenders 2018). There is currently very little literature on the subject in a Western European setting. Therefore, the effectiveness of the use of different types of scent lures and or baits is a subject that needs to be investigated more thoroughly. A pilot study in 2017 using soundtracks of prey animals in distress as a lure did not yield desired results (Schep 2018). Subjects like these need follow up studies because it is likely they can increase the efficiency of the use of camera-trap boxes in small mustelid surveys. Gloves or any other measures against human odour on camera-trap boxes and nest boxes have not been used in this study. This may have had an adverse impact on attraction to small mustelids and thus possibly influenced the results. Some studies imply that human scent masking does not improve capture rates (Muñoz et al. 2014), others imply that human scent might have an negative effect on capture rates (King 1994). Therefore it is advised to take adequate actions in future studies to reduce human scent on research materials and to report results.

Wildlife surveys with use of camera-trap boxes and nest boxes are time consuming. With large quantities of research instruments in the field the risks of defects, battery failure and theft influencing results are high. This can be kept to a minimum by interim checking at least monthly.

The average number of days that a camera-trap box was in the field for a weasel to be detected was 41 days. Also, no detections were made between October and February since all eight weasels were recorded between March and July. It is therefore recommended, in future studies to place the boxes effectively in the field for at least 56 days (eight weeks) outside of the winter season and to not move them within this period but to achieve at least one interim check after four weeks. Furthermore, in future studies the number of observations should be registered to be able to evaluate effectiveness of research materials and approximate density of mustelids.

eDNA is a promising new method for detecting species unique DNA sequences in samples of water, soil, tissue or faeces. Faeces of small mustelids are not easily encountered in the field but if they are they can be easily collected and analysed. This method has currently been tested (S.A. Westra & K. van Bochove, unpublished data). The outcome could be an additional survey method for detection of presence of small mustelids

that can easily be combined with placing and checking research materials in the field.

Seven of the 13 successful research locations in this study were located at the head of linear landscape elements. In future studies, it is recommended that priority be given to research locations at the head of linear elements.

General concern amongst Dutch ecologists about the status of small mustelids has encouraged improvement of legal protection in the past years. In at least five of twelve Dutch provinces the three small mustelid species now have a protective status (Jonker 2016, Bouwens 2017, Veldman & Troost 2019). Many questions did arise about their status and conservation issues. Based on historical data and recent research results, including this study, it is not possible to provide a better foundation for the status and trend of weasel and stoat. The available data are too minimal. In order to get a better understanding of current status and population trends, a large-scale, long-term monitoring study with camera-trap boxes is recommended. This monitoring could have a similar design to this project but the research duration should be at least a few years to increase detection and decrease the missing of weasels/stoats when they are actually present.

Conclusions

Weasel is known to be present in the area and the results of this study confirm this. Weasel numbers demonstrated are very low. It is very difficult and in most cases impossible to distinguish individuals from the research data, and therefore it is impossible to say anything about densities. Comparisons are made between the four research areas based on difference in land use and distributional data of weasel and stoat gathered here.

Stoats could not be detected during this study. The total of one recording of polecat (and one stone marten) during this study can be seen as a lucky shot and is disregarded in this conclusion. The results obtained in this study supports the outcomes of previous small mustelid studies in the Benelux (Criel 1990, van Maanen et al. 2015a): limited results are to be expected when surveying small illusive predatory mammals with camera-trap boxes and nest boxes.

In the Dorth research site - regarded as suitable habitat for weasel – I detected a weasel in one location which was found in the central, heavily forested part of the estate. However, the species was expected more along the extensive pasture areas and the pools that lie therein. It is possible that weasels are influenced by human and pet activity and scent.

In the Boxbergen research site - regarded as suitable habitat for weasel - a total of only one weasel was found in a hedge row, however more results were expected. The sharp transitions from closed to open landscape types at Boxbergen estate means that there are relatively few refuges in comparison with the Gooiermars and Dorth. The intensively managed agricultural lands that are found here makes the site a less suitable habitat compared to Dorth and Gooiermars. A camera-trap box disappeared at one of the locations at Boxbergen estate, so the research effort and the chance of success has been slightly lower than in the other research sites.

The research site of de Mars – regarded as marginal habitat for weasel - is characterised by a very open landscape with a limited number of narrow linear landscape structures. In contradiction to what was expected two weasels were found here. This is possibly due to the natural agricultural practices of field border management that is carried out here since 2016 in combination with the presence of refuges in the western part of the research area adjacent to the winter dike. This is beneficial for small mustelids. It is also known that weasels can adapt to living in open landscapes that are similar to de Mars (Twisk et al. 2016). Furthermore, the above is possibly caused by a sampling issue. If a smaller part of the landscape is suitable for weasels, the chance of detecting them increases in the parts of the

landscape that are suitable. So higher detection might not come from higher weasel presence but from a higher detectability.

In the research site of Gooiermars – regarded as suitable habitat for weasel – weasels were found at five locations, by far the most numerous of the four research sites. What has become clear is that in the Gooiermars much more data have been obtained from the presence of weasel than at other research sites. In contrast to the other research sites only in the Gooiermars does the presence of a large area of apparent suitable habitat actually result in higher densities of weasels. The Gooiermars is characterised by poor soils with wet natural grassland, extensive grazing, and linear landscape elements with sufficient coverage. In addition, a large part of the area is closed to recreational users, which makes the chance of disturbance by people and pets very small. This type of landscape has disappeared in large parts of the Netherlands and with that possibly the weasel and stoat. Despite efforts in this study we know little more about this subject than before and further study to confirm the above is a necessity.

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Samenvatting

Een onderzoek van negen maanden naar het voorkomen van kleine marterachtigen in vier onderzoeksgebieden in Oost-Nederland

Onder ecologen bestaat bezorgdheid over de (al dan niet vermeende) achteruitgang van kleine marterachtigen in Nederland. Er is weinig bekend over hun aantallen in verleden

en heden. Om hun ecologie en de oorzaak van de achteruitgang beter te begrijpen is meer onderzoek naar deze soortgroep noodzakelijk. Om zo mogelijk in deze kennislacune te voorzien heeft de Zoogdiervereniging een ecologisch onderzoek geïnitieerd dat is uitgevoerd door Silvavir ecologisch advies. Tussen oktober 2016 en augustus 2017 werden vier verschillende gebieden in de omgeving van Deventer onderzocht. Daarbij werden 64 locaties met behulp van Nestkasten en Marterboxen geïnventariseerd op het voorkomen van kleine marters. Beide technieken betreffen nieuw ontwikkelde onderzoeksmaterialen om het voorkomen van de kleine marterachtigen wezel (*Mustela nivalis vulgaris*) en hermelijn (*Mustela erminea*) vast te stellen. Aangezien bekend is dat kleine marters een voorkeur hebben voor kleinschalig agrarisch cultuurlandschap werden drie van de vier onderzoeksgebieden in dat type landschap gesitueerd. Eén locatie betrof een grootschalig open agrarisch cultuurlandschap - beoordeeld als aangetast leefgebied. De aanwezigheid van wezels werd zowel met cameravallen als met nestkasten vastgesteld. Voetafdrukken in sporenbuizen waren niet altijd met zekerheid te herleiden tot wezel of hermelijn. Er werden geen hermelijnen geregistreerd. Hermelijnen zijn in de betreffende onderzoeksmaanden óf zeer zeldzaam óf niet aanwezig in de onderzochte gebieden. De gebruikte onderzoeksmaterialen bleken niet geschikt te zijn om het (veronderstelde) voorkomen van bunzing (*Mustela putorius*) vast te stellen omdat de beperkte diameter van de opening van de inloopbuis van de onderzoeksmaterialen de toegang bemoeilijkt. Er is geen duidelijk verschil te zien in de gegevens tussen grootschalig open agrarisch cultuurlandschap (twee registraties) en kleinschalig agrarisch cultuurlandschap (één, vijf en nul registraties). Opvallend is het feit dat de meeste waarnemingen werden gedaan in de periode tussen maart en oktober. De conclusies die uit dit onderzoek getrokken kunnen worden zijn dat: 1. Kleine marterachtigen een onderzoeksuitdaging vormen. 2. Ondanks de inzet van innovatieve onderzoeksmaterialen - waarvan het gebruik veel tijd vergt -, er weinig (positieve) gegevens konden worden verzameld. Op basis van historische data en recente onderzoeksresultaten, waaronder deze studie, is het nog steeds niet goed mogelijk om verantwoorde uitspraken te doen over de status en trend van wezel en hermelijn. Om hier beter grip op te krijgen is grootschalig, langetermijnonderzoek met wildcamera's nodig.

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