Detecting and monitoring small mammals with trail cameras

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Abstract: We have developed a device, the Struikrover®, for detecting and monitoring small mammals in the wild. This device is a trail camera encased in a tube. Through a study, covering 2590 trap nights and the analysis of over 130,000 pictures, we evaluate optimal camera settings and the intervals between refreshing the bait and compare our results with related studies in the Netherlands. We recommend taking pictures rather than videos, at a setting in which two pictures are taken each time the device is triggered, with a pause of one minute after the camera is first triggered. We also recommend leaving the Struikrover in place for 3-4 weeks to maximize its efficiency in terms of the number of species identified. The Struikrover proves to be a good option for detecting mammals up to the size of a western polecat (*Mustela putorius*). For larger animals we assume that a standard stand-alone trail camera is the better option. To cover the whole spectrum of mammal species a combination of Struikrover with a stand-alone trail camera would be ideal.

Keywords: methods, camera trap, monitoring, non-invasive, rodent, shrew, mustelid, Struikrover.

Introduction

One of the most fundamental challenges in conservation biology is how to determine species distribution and richness. For example, it is difficult to detect small mustelids in the field due to their unpredictable and mobile behaviour and low densities. In an earlier study (Smaal & van Manen 2017), in which we tried to collect data about the occurrence of weasels (*Mustela nivalis*) we experienced this low detection rate. In that study we tested several non-invasive and time efficient methods, such as track tubes and nest boxes with track tubes. Nest boxes proved to be relatively successful, but the results were not completely satisfactory, because the tracks of male weasels and female stoats (*Mustela erminea*) were hard to differentiate. Methods that use DNA identification (Jones et al. 2004) cannot be applied without the (expensive) aid of a laboratory, so we started experimenting with trail cameras. These are generally used for medium-sized to large mammal species (Hoffmann et al. 2010), but occasionally for species such as red squirrel (*Sciurus vulgaris*) and fat dormouse (*Glis glis*). In an Italian study small mammal species (weasel, shrews - *Sorex* spp.) were detected occasionally by other means, but were missed by the trail cameras (Di Cerbo & Biancardi 2013).

We started with standard stand alone trail cameras, but soon found out that problems arise with dense or tall vegetation, which hampers a trail camera capturing weasels. Focus distance, in most cameras more than one metre, turned out to be a second problem since, at that distance, small mammals may not be detected or when detected may not be identified.

In order to tackle these problems we have

developed the Struikrover®: a tube with an internal trail camera. Struikrovers can provide clear pictures of almost all small mammal species that occur in a study area, allowing one to not only be able to capture weasels but, just as importantly, potential prey, competitors and predators. However since some small mammals, such as rodents, can be very numerous or persistently present, the processing of thousands of pictures can become a problem. This article describes the Struikrover and explains how to set up the cameras in order to reach a reasonable balance between the information obtained and the storage of, and time needed to process, data. We also compare results of Struikrover trials with those of other methods, such as standalone trail cameras and nest boxes for weasels.

The Struikrover concept

The Struikrover is a plastic tube painted in camouflage colours, with a diameter of 20 cm, with one end cut at an angle of 45°, and the other end closed (figure 1). Its longer side (the bottom) is 40 cm. The tube contains a tray with a trail camera at the closed end of the tube and a sardine can at the entrance. The tray fixates the distance between camera and sardine can, and can be attached to the tube preventing its removal by larger animals. On the top of the tube, just in front of the camera, there is a clear pane of plexiglass with a diameter of 10 cm, which provides the sensors in the camera with extra light, in order to avoid the overexposure of pictures in sunny conditions. The focus of the camera is adjusted with a reading glass (for most camera types +3 dioptres) in order to reduce the focal distance to 35 cm.

The tube is sufficiently robust to protect the camera from trampling (by cattle or sheep) and provides an unobstructed view. Vegetation in close range of the subject (which can cause overexposure at night) is thereby avoided. The tube also hides the camera (figure 2) and prevents the motion trigger from reacting to moving objects that are outside the camera's view range. The horizontal plane of the tube should be slightly angled towards the front end, to avoid rain entering it and the baited front end should be pushed a little into the soil or vegetation, so that small animals, such as shrews, will not be obscured by the rim of the tray. When the Struikrover is in position the sardine can is punctured at the top end without spilling the oil (as any spillage might lure the animals away from the camera's view).

Most camera types work with infrared led lamps in dark conditions. In some types the intensity of light can be reduced. Because a Struikrover takes pictures at very close range even the strongest light reduction is not sufficient to avoid overexposure. In most types of cameras we therefore reduced the light source by covering the lamps with (green) tape. The light sensors, however, should not be covered, otherwise the camera will always experience dark conditions and, especially during daytime, the pictures will be overexposed.

Methods

In order to test the Struikrover we set up a number in a study area, in and around the Drentsche Aa river valley (6.64°E, 53.03°N) where we had previously (in 2014-2016) set out nest boxes for weasels (Smaal & van Manen 2017). Most of the Struikrovers were in marshes and semi-natural grasslands, mown once a year in late summer or autumn. Some Struikrovers were placed in other habitats, such as heaths and woodland. In most cases we chose linear vegetation elements or vegetation transitions. A detailed description of the area can be found in Spek et al. (2015).

The data cover the period from 5 February 2018 to 19 January 2020. The Struikrovers were set out at 92 locations for 14-491 days, and the bait was refreshed 202 times (sessions), covering 2590 trap nights. A total of 131,717 pictures were taken and transcribed into a file. These could be reduced to 57,746

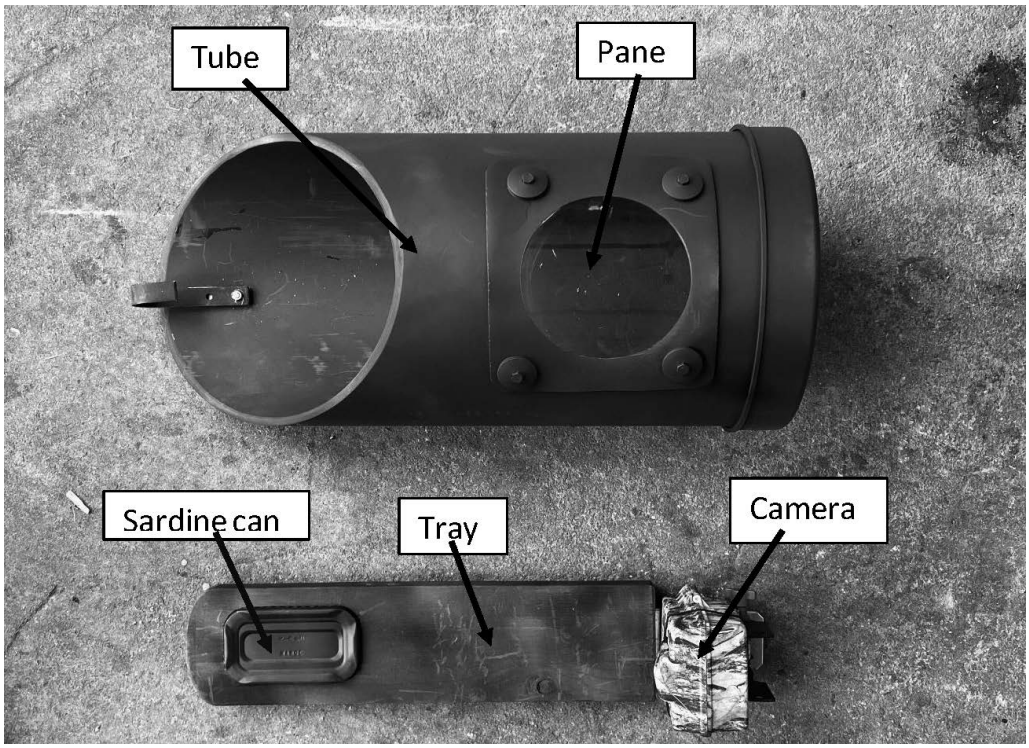

Figure 1. A Struikrover.

Figure 2. The 45° angel helps camouflaging the Struikrover and improves exposure of visiting animals during daylight. Taarlo 30-11-2022. *Photo: Matthijs Smaal.*

Table 1. Detection of mammal species in Struikrovers, expressed as the absolute number of sessions in which species were detected (number) and relative to the total of 202 sessions (%).

Species		Number	%
Western hedgehog	*Erinaceus europaeus*	3	1.5
Common shrew	*Sorex araneus*	56	27.7
Pygmy shrew	*Sorex minutus*	54	26.7
Water shrew	*Neomys fodiens*	12	5.9
Greater white-toothed shrew	*Crocidura russula*	2	1.0
Brown hare	*Lepus europaeus*	3	1.5
Rabbit	*Oryctolagus cuniculus*	2	1.0
Bank vole	*Myodes glareolus*	92	45.5
Common vole	*Microtus arvalis*	46	22.8
Field vole	*Microtus agrestis*	14	6.9
Water vole	*Arvicola amphibius*	1	0.5
Harvest mouse	*Micromys minutus*	31	15.3
Wood mouse	*Apodemus sylvaticus*	73	36.1
Yellow-necked mouse	*Apodemus flavicollis*	75	37.1
Brown rat	*Rattus norvegicus*	12	5.9
Weasel	*Mustela nivalis*	61	30.2
Stoat	*Mustela erminea*	12	5.9
Western polecat	*Mustela putorius*	10	5.0
Pine marten	*Martes martes*	17	8.4
Beech marten	*Martes Foina*	35	17.3
Otter	*Lutra lutra*	3	1.5
Badger	*Meles meles*	8	4.0
Red fox	*Vulpes vulpes*	8	4.0
Roe deer	*Capreolus capreolus*	9	4.5

moments when a camera was triggered (triggers). Triggers by an identified animal are referred to as 'captures'. Calculations were made in Excel.

Results

Species range

During this study we recorded 24 species of wild mammals, of which small woodland species were most frequently captured (table 1). Other mammals included feral cats (*Felis catus*) and domestic dogs (*Canis familiaris*). Beside mammals we recorded 23 bird species, 2 reptiles and 2 amphibians.

Photo or video?

In the experimental stage we started with videos, but soon found out that extracting data from videos, even when they are very short, is extremely time consuming compared to processing pictures. Apart from the higher energy consumption (which has implications for the cameras' battery life) and much larger file size, the videos took several seconds to start after the device was triggered. In pictures this was always less than a second, so videos (theoretically) miss more captures.

The number of pictures

Most camera traps have an option to take a

series of pictures, often within one or two seconds, for each time the device is triggered. Multiple instant-pictures reduce the chance of missing an animal, but increase file size and the number of pictures to be analysed. During a pilot in the same area, when we still worked with three pictures per trigger and only some of the species captured were analysed (data not incorporated in the rest of this article) we checked the added value of more than one picture per trigger for captures of western hedgehog (*Erinaceus europaeus*) (13), water shrew (*Neomys fodiens*) (50), weasel (57) (*Mustela nivalis*), stoat (*Mustela erminea*) (19), western polecat (*Mustela putorius*) (1), pine marten (*Martes martes*) (4), beech marten (*Martes foina*) (42), otter (*Lutra lutra*) (1), badger (*Meles meles*) (4) and red fox (*Vulpes vulpes*) (8). Most animals were captured on the first picture (185 out of the total of 199). The second picture added 13 new captures (4 water shrews, 3 weasels, 3 stoats, 2 beech martens and 1 red fox). The third picture captured one additional weasel, that was not recorded on the first and second. This leads us to suggest a setting in which two pictures are taken each time the device is triggered.

Setting interval

Many animals visited the Struikrover only briefly. In the sample of 199 captures, most animals left the device within 1-2 seconds. Most camera traps have an option to set a minimum interval before the device will trigger again. Setting this interval reduces the number of redundant captures of the same individual (at the expense of battery life and memory space), but also may result in missing captures of new" species. To quantify the risk of setting an interval we analysed 61 sessions in which no interval was set. In these sessions traps were triggered 25,788 times, resulting in 301 session-species combinations. In 11,769 cases (46%) the devices were triggered within a minute from the previous trigger. In 11,558 cases, the species (and probably the individual) was the same as the previous one but in 211 cases the next species was a different one. This might have resulted in missing a species during the whole session, but effectively this was true in only four (1.3%) session-species combinations: one common shrew (*Sorex araneus*), one bank vole (*Myodes glareolus*), one common vole (*Microtus arvalis*) and one weasel would have been missed if an interval had been set.

In terms of reducing the number of pictures and missing valuable observations, we suggest setting the minimum interval at one minute. The benefits of having a longer interval are outweighed by the higher risk of missing species.

The duration of sessions

Since we worked with bait (canned sardine), it may be assumed that its attractiveness changed over the course of time. The period after which we removed the Struikrover or refreshed the sardine bait was not fixed, but ranged between 14 and 40 days. In some cases the session finished due to camera failure or dead batteries.

The increase in captures between day zero and day one partly resulted from switching on the devices around noon of day zero (figure 3), so day zero was actually only half a day. Since this initial increase was more than two-fold (actually three-fold) we believe that it took individuals some time to discover the Struikrover. Initially they returned often but after a few times probably learned that, despite the smell, there was no reward and lost interest. After 20 days interest levelled off and we assume that the local mammals no longer found the Struikrover an object of attraction. This pattern held true in new locations and sites where the bait was refreshed. The obtained pattern is mainly down to abundant species with small home ranges, such as bank vole, but the mechanism is probably valid for

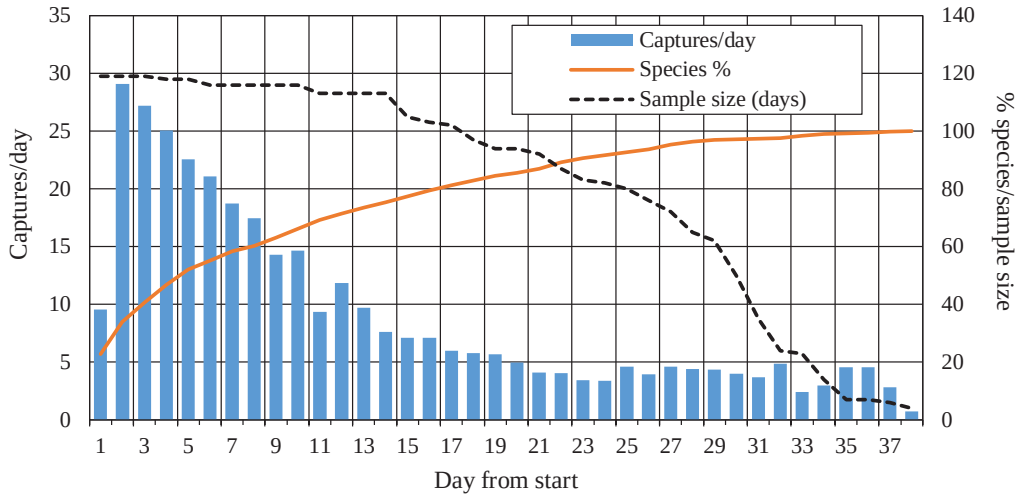

Figure 3. Number of captures and accumulated number of species by day after the start of a Struikrover session. The mean number of species per session had declined to 5.25 species by day 38.

most species attracted by the odour of canned sardine.

The mean cumulative number of species detected sharply increased during the first days a Struikrover was set out or after the bait was refreshed, and later levelled off, almost perfectly (R^2=0.988) following a logarithmic curve that can be expressed by the formula y = 23.569ln(x) + 15.114. According to this model after one week 61% of all species had been recorded, 77% after two weeks, 87% after three, 94% after four and 99% of all species after five weeks.

Keeping in mind the reduction in attractiveness of the bait, we suggest a session duration of three or four weeks being optimal in terms of efficiency when one wants to cover many sample points with a restricted number of devices and in a limited time frame.

Comparing the detection rate of weasel for Struikrovers and nest boxes

We previously monitored weasels in the Drentsche Aa river valley using nest boxes (Smaal & van Manen 2017). Five of these nest boxes were still operational in 2018 and 2019 and a Struikrover was placed within ten metres of each one . We compared visits of weasels to the nest boxes with the paired Struikrover over the months in which the Struikrovers functioned for at least 21 days (*n*=67 months).

In 33 cases both devices recorded no weasels, in ten cases weasels were recorded in both, in eight cases weasels were recorded in a nest box, but not captured in the paired Struikrovers and in 16 cases they were recorded in the Struikrover but not in the nest box. The monthly numbers of visits of weasels in nest boxes and in paired Struikrovers were clearly correlated (figure 4) but Struikrovers proved to be about 50% more effective in registering weasels. In addition it was easier to distinguish weasels from stoats by photographs than by their tracks in the nest boxes.

Discussion

Comparing results with other trail camera research

The Struikrover is designed to detect small mammals up to the size of a marten and

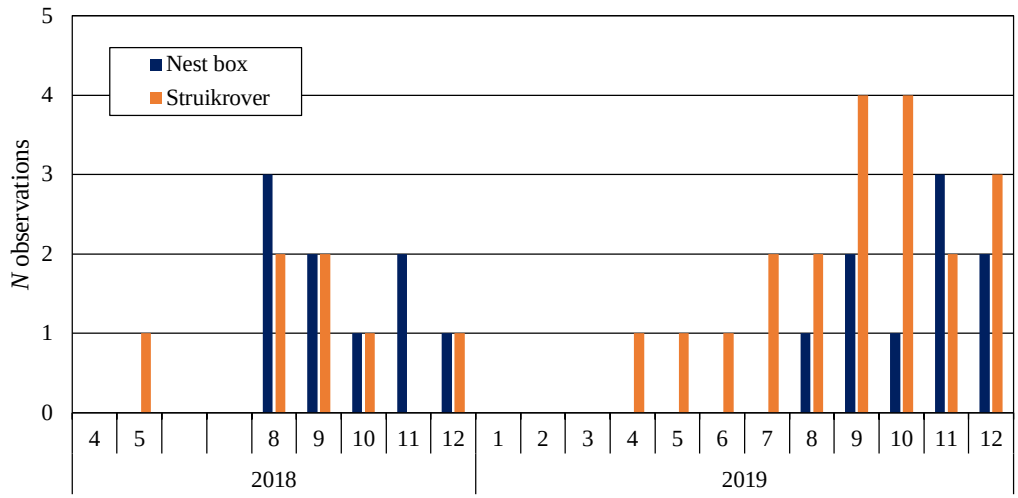

Figure 4. Monthly visits of weasels to five nest boxes, compared with captures in Struikrovers that were placed within 10 m from the nest boxes. Data are lacking for June and July 2018. In April 2018 and in January through to March 2019 no weasels were recorded by either method.

is actually quite similar to the TubeCam, described by Ratnaweera et al. (2017), developed to tackle similar problems that we faced in capturing small mustelids. Due to the short-distance focus and the restricted view the Struikrover is probably less effective in capturing larger animals such as red fox, badger and roe deer (*Capreolus capreolus*). We are not able to prove this since we did not set standard stand-alone trail cameras in the same area. Nevertheless there are a few data sets available that provide some circumstantial evidence. During the winter of 2014 a study was carried out close to our study area in the northern part of the province of Drenthe (Hasper & van Manen 2015) and during the winter of 2015 this was repeated in a more wooded part in the centre of Drenthe. In both cases the locations were baited with fish waste with a trail camera set at 1.2-2 m distance. Another study, in the north of the country (the provinces of Friesland, Groningen and Drenthe), was done by the Dutch Mammal Society in the context of the national survey of western polecat and pine marten, in which cameras were mounted at about 1.5 m from sardine cans, fixed to trees: the Bubo project. We compare the results of these studies noting that the duration of sessions was slightly higher in Struikrover (29 days) and Bubo (35 days) than in the two studies with fish waste (22 and 23 days respectively).

Although we tried to reduce the influence of regional differences on species composition by selecting only results from the northern part of the Netherlands, we cannot rule out an effect of specific location, habitat and season or year that may have affected the results obtained by the different methods. In general however standard stand-alone trail cameras captured relatively fewer small mammals up to the size of a weasel (table 2), either because these animals remain elusive or cannot be detected or identified from the pictures. The relative low presence of larger mammals in the Struikrover may be a result of the position, which is often in relatively dense vegetation. Larger animals probably prefer trails or shorter vegetation when exploring a home range. A prominent exception is the wood mouse (*Apodemus sylvaticus*), which is much more frequently captured by standard stand-alone cameras than would otherwise be expected by its size. Possibly this species is

Table 2. Species captured by Struikrover (only sessions of at least 21 days) compared to the results of the Bubo project and two studies with unmodified trail cameras baited with fish waste (see text). We present the mean number of sessions in which each species was recorded (1= in all sessions, 0= not recorded with this method).

Method	Struikrover	Bubo	Camera	Camera
Bait	Sardine oil	Sardine oil	Fish waste	Fish waste
Period	2018-19	2017-19	2013-14	2014-15
Sessions	89	27	49	35
Days	2590	942	1065	789
Western hedgehog	0.01	0.15	-	-
Common shrew	0.52	0.00	0.00	0.00
Pygmy shrew	0.49	0.00	0.00	0.00
Water shrew	0.06	0.00	0.00	0.00
Greater white-toothed shrew	0.02	0.00	0.00	0.00
Brown hare	0.03	0.26	0.16	0.09
Rabbit	0.02	0.00	0.02	0.00
Bank vole	0.87	0.22	0.00	0.11
Common vole	0.45	0.00	0.00	0.00
Field vole	0.12	0.00	0.00	0.00
Water vole	0.01	0.00	0.00	0.00
Harvest mouse	0.31	0.00	0.00	0.00
Wood mouse	0.70	0.59	0.35	0.89
Yellow-necked mouse	0.72	0.00	0.00	0.00
Brown rat	0.10	0.19	0.00	0.06
Weasel	0.49	0.04	0.00	0.00
Stoat	0.08	0.00	0.00	0.00
Western polecat	0.09	0.11	0.10	0.09
Pine marten	0.12	0.22	0.33	0.40
Beech marten	0.24	0.30	0.35	0.54
Otter	0.01	0.00	0.00	0.00
Badger	0.03	0.26	0.53	0.54
Red fox	0.03	0.37	0.73	0.57
Raccoon dog	0.00	0.00	0.12	0.03
Roe deer	0.09	0.70	0.65	0.69
n species	26	14	12	13
Maximum this method	14	5	2	4

not confined to denser vegetation like other small mammals. Also it is easily recognised, even from a distance, by its big, light-reflecting, eyes.

We advise using a Struikrover for detecting or monitoring mammals up to the size of a western polecat. For larger animals we suppose an standard stand-alone trail camera is the better option. To cover the whole spectrum of species a combination of both would be ideal.

In summary we recommend to:
- Use photos instead of videos;
- Set the camera for taking two pictures at each trigger, with an interval of one minute between triggers;
- Leave the device three to four weeks at one site or refresh the bait once a month;
- Use Struikrovers for detecting or monitoring species up to the size of a western pole-

Struikrovers proved to be effective in detecting animals up to the size of a western polecat, thanks to the shortened focus and the ability of operating in dense vegetation. Taarlo, 1-8-2021. *Photo: Matthijs Smaal.*

The Struikrover performs well in detecting small species like the pygmy shrew, that was registered 5.548 times during this study. Taarlo, 26-9-2021. *Photo: Matthijs Smaal.*

cat, but use standard stand-alone cameras when aiming for larger animals;
- List all recordings, since this may reveal interesting patters such as activity patterns over the course of a day or season, especially in abundant species (see van Manen & Smaal 2021).

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References

Di Cerbo, A.R. & C.M. Biancardi 2013. Monitoring small and arboreal mammals by camera traps: effectiveness and applications. Acta Theriologica 58: 279–283.

Hasper, H. & W. van Manen 2015. Registratie van roofdieren met cameravallen in Noordoost Drenthe in de winter 2013-14. Stichting Boomtop, Assen, the Netherlands.

Hoffmann A., J. Decher, F. Rovero, J. Schaer, C. Voigt & G. Wibbelt 2010. Field Methods and Techniques for Monitoring Mammals. In: J. Eymann, J. Degreef, C. Häuser, J.C. Monje, Y. Samyn & D. VandenSpiegel (eds). Manual on field recording techniques and protocols for All Taxa Biodiversity Inventories and Monitoring, Part 2: 482-529. Belgian National Focal Point to the Global Taxonomy Initiative, Brussels, Belgium.

Jones, C., H. Moller & W. Hamilton 2004. A review of potential techniques for identifying individual stoats (*Mustela erminea*) visiting control or monitoring stations. New Zealand Journal of Zoology 31: 193-203.

Ratnaweera, N., R. Ratnaweera & D. Früh 2017. Developing a new method to detect small mustelids. In: 32nd European Mustelid Colloquium 15-17 November 2017. Book of Abstracts: 27.

Smaal, M. & W. van Manen 2017. Monitoring weasels (*Mustela nivalis*) with nest boxes. Lutra 60: 19-26.

Spek, T., H. Elerie, J.P. Bakker & I. Noordhoff 2015. Landschapsbiografie van de Drentsche Aa. Van Gorcum, Assen.

van Manen, W. & M. Smaal 2021. Circadian and ultradian rhythms in free living bank voles (*Myodes glareolus*). Lutra 64 (2): 73-80.

Samenvatting

Het registreren en monitoren van kleine zoogdieren met cameravallen

De meeste kleine zoogdieren brengen een groot deel van hun leven door in dichte vegetaties en zijn daardoor nauwelijks te registreren met standaard cameravallen. De focusafstand van cameravallen bedraagt meestal iets meer dan een meter en plaatsing in vegetaties levert veel valse triggers en onscherpe, overbelichte foto's op. Om deze problemen te tackelen, ontwikkelden we de Struikrover. Dit is een 35 cm lange, schuin afgezaagde pvc-buis met een diameter van 20 cm, aan het rechte einde afgedekt met een dop. In de buis ligt een plank, met aan het ene einde een cameraval en aan het andere einde een blikje sardine, waarin aan de kopse kant een gaatje is geprikt. Dit dient als lokmiddel, met name om dieren scherp en gecentreerd in beeld te krijgen. De lens van de cameraval is voorzien van een brillenglas dioptrie +3 en in de meeste gevallen is de infraroodbelichting van de camera afgeplakt met groene tape om overbelichting te voorkomen. Boven de camera zit in de buis een venster, om er overdag voor te zorgen dat, via de lichtsensoren, zoveel mogelijk in daglichtmodus wordt opgenomen. De schuin afgezaagde rand van de buis zorgt eveneens voor een betere belichting overdag en maakt de Struikrover minder opvallend in het veld. Tijdens een onderzoek in- en in de buurt van het beekdal van de Drentsche

Aa bij Loon (Drenthe) hebben we het gebruik van de Struikrover en met name de instellingen van de camera geëvalueerd, gedurende 2590 draainachten. We gebruikten de foto- in plaats van video-modus, omdat de camera bij foto's sneller aanslaat, foto's minder opslag en een lager batterijverbruik vergen en het minder tijd kost de informatie om te zetten naar een databestand. Veel cameravallen hebben de mogelijk om meerdere foto's te nemen per trigger. In een subset van 199 registraties, konden 185 op de eerste foto correct worden gedetermineerd. In 13 gevallen was een tweede foto nodig en in één geval leverde alleen de derde foto uitsluitsel. In termen van efficiency zijn twee foto's optimaal. Daarnaast kan bij de meeste cameravallen een rusttijd worden ingesteld nadat een opname is gemaakt, om teveel opnames van hetzelfde individu te beperken. In een subset van 61 gevallen hebben we geen rusttijd ingesteld en dit leidde tot 25.788 triggers (en een veelvoud aan opnames). In 46% van de gevallen werd binnen een minuut een nieuwe serie foto's gemaakt. Daarbij ging het in 98.2% om dezelfde soort en waarschijnlijk dus hetzelfde individu. In 1.3% werd binnen de rusttijd van een minuut een soort geregistreerd die anders op die locatie niet zou zijn vastgesteld. Door een rusttijd van een minuut in te stellen, kan veel batterij- en opslagcapaciteit en verwerkingstijd worden bespaard ten koste van gering informatieverlies. In de loop van de tijd waarin een Struikrover op dezelfde locatie lag zonder aas te verversen, liep het aantal waarnemingen terug, evenals het aantal nieuwe soorten dat werd geregistreerd. Na drie weken werd ongeveer 87%, na vier weken 94% van de soorten gedetecteerd. Bezoeken van wezels (*Mustela nivalis*) aan speciaal daarvoor ingerichte nestkasten (Smaal & van Manen 2017), vergeleken met registratie door een op enkele meters Struikrover, leverde een licht betere detectiekans door de Struikrover op. Hoewel vrijwel alle in het gebeid voorkomende zoogdiersoorten werden vastgelegd, waren Struikrovers minder effectief in het vastleggen van de grotere soorten dan los opgestelde cameravallen. Soorten kleiner dan een bunzing (*Mustela putorius*) werden, met uitzondering van bosmuis (*Apodemus sylvaticus*), echter zelden tot niet geregistreerd zonder Struikrover.

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