Swedish University of Agricultural Sciences
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A comparison of commercial scent lures in attracting Raccoon dogs (*Nyctereutes procyonoides*)

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En jämförelse mellan kommersiella lockmedels förmåga att attrahera mårdhund (Nyctereutes procyonoides)

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Abstract

The invasive species raccoon dog (*Nyctereutes procyonoides*) is currently under establishment Sweden and it is vital to discover invading individuals to prevent colonization. The use of wildlife cameras to discover dispersing raccoon dogs have been implemented in the north-European raccoon dog management program. In this study, I test the ability of four commercially available scent lures to attract raccoon dogs to camera stations. The study was conducted in the Åland Islands where raccoon dogs are abundant and the results could improve the effectiveness of the camera stations used in the program. I used 12 sites with five camera stations in each and tested the four lures and one control with no lure in each site. The stations were baited and left undisturbed for a minimum of 11 days. The cameras recorded 18 raccoon dogs distributed over 11 stations and 5 sites. No statistical significant difference (Kruskal-Wallis test) was found between treatments, probably because of the low number of detected raccoon dogs. I believe however the method is useful to detect presence of raccoon dog and the results should give some indications about which lures are most effective.

Sammanfattning

Mårdhunden är ett nytt inslag i den svenska faunan och är nu på väg att etablera sig genom invandrande djur från Finland längs med Norrbottenskusten. Den är ett hunddjur i storlek jämförbar med en räv som härstammar från östra Asien och planterades ut av forna Sovjetunionen som pälsvilt under första hälften av 1900-talet. Den har etablerat sig i stora delar av Europa och är en invasiv art. Invasiva arter ses efter habitatförlust och habitatfragmentering som det globalt sett största hotet mot biologisk mångfald. I enlighet med Riokonventionen om biologisk mångfald ska invasiva arter antingen förhindras etablering, kontrolleras eller utrotas om den utgör ett hot mot ekosystem, habitat eller inhemska arter. Mårdhunden utgör främst ett hot mot inhemska arter och som en vektor för sjukdomsspridning. Den kan lokalt gå mycket hårt åt häckande våtmarksfåglar och amfibier och sprida sjukdomar som rabies och rävens dvärgbandmask. De nordiska länderna har nu ingått ett samarbete för kontroll av mårdhundspopulationerna och förhindra fortsatt spridning. Projektet använder sig bland annat av viltkameror betade med lockmedel som ett varningssystem för att upptäcka förekomst av mårdhund och sändarförsedda mårdhundar för att använda redan invandrade djur till att finna nya mårdhundar. I denna studie jämförde jag fyra kommersiella lockmedels förmåga att locka till sig mårdhundar. Studien utfördes på Åland där mårdhunden är mycket vanlig och resultaten ska förhoppningsvis förbättra varningssystemets effektivitet. Jag testade lockmedlen på 12 områden där jag i varje område hade fem kamerastationer, en för varje lockmedel och en kontroll utan bete. Totalt besökte 18 mårdhundar de olika lockmedlen fördelat på 11 kamerastationer. Flest mårdhundar besökte Caven's HiawathaValley och Hawbaker's Grey Fox 100 med 6 besök vardera, följt av Powder River Paste Bait med 4 besök. Kontrollen och Hawbaker's Grey Fox Food Lure hade ett besök vardera. Ingen statistisk skillnad kunde ses mellan de olika lockmedlens effektivitet på grund av det låga antalet besök. Jag tvingades exkludera tre områden ur studien pga. kameror som hade slutat fungera och endast i fem av de resterande områdena upptäcktes mårdhund. Eventuellt en följd av ett högt jakttryck och att studien utfördes långt in på jaktsäsongen när minst 60 mårdhundar hade skjutits i studiens kärnområde på ca 2000 ha. En studie med fler områden och tätare mårdhundspopulationer hade troligtvis gett bättre resultat. Jag tycker ändå att metoden fungerade bra och jag skulle rekommendera mårdhundprojektet att använda Caven's Hiawatha Valley och Hawbaker's Grey Fox 100 för fortsatta tester.

Introduction

The raccoon dog *(Nyctereutes procyonoides)* is a member of the *Canidae* family and originates from eastern Asia. Its native range extends from the Amur-Ussuri region in southeast Russia and the Korean Peninsula to Vietnam, with a subspecies *N. procyonoides viverrinus* resident in Japan (Sutor 2008). The raccoon dog utilize a large variety of habitat from tempered rain forests to agricultural plains with continental climate (Sutor 2008). Between 1929 and 1955 a total of 9,100 individuals (Helle & Kauhala 1991) of the subspecies *N. procyonoides ussuriensis* were released in the former Soviet Union to increase fauna diversity (Sutor 2008). Successful introductions were made in the St. Petersburg and Novgorod regions in 1935-1936 and soon the populations increased and the raccoon dog expanded its distribution area at an average speed of 40 km per year (Helle & Kauhala 1991).

The first observations in Finland were made in the mid-1930s but regular observations occurred in the mid-1950s in the most south-eastern parts of Finland. From then the raccoon dog expanded its distribution area to the northwest with an annual distance of 30 km and by the mid-70s it had colonized southern and central Finland up to 64-65°N (Helle & Kauhala 1991). Today, the raccoon dog is one of the most common carnivores in Finland and in 2007, 135 700 animals were bagged by Finnish hunters (Hunters' Central Organization in Finland, Internet, 29.01.2011). The raccoon dog also expanded its distribution westwards. The first observation of raccoon dog in Sweden was in the 1940s and in Norway 1983 (Kauhala 1996). However it failed to colonize the new environment but recently the threat of invading raccoon dog has increased and Sweden currently inhabits a small population of raccoon dogs in the northern counties. The southernmost confirmed animal up till 2010 is from Mjällom in the county of Västernorrland (Hallin, Internet, 29.01.2011).

In the study area, the Åland Islands, located in the most southwestern part of Finland in the middle of the Baltic Sea, the first confirmed raccoon dog was a road kill discovered in 1975 in Eckerö in the westernmost part of the Åland Islands (Andersson & Westerberg 2009). Today the raccoon dog is common all over the Åland Islands.

Invasive alien species

The raccoon dog is not a welcomed addition to the European fauna. Historically, many introductions of alien species have had negative impacts on the indigenous species and even caused extinction (see Kauhala 1996). Invasive alien species is considered as the second largest threat to biodiversity, next to loss of habitat and habitat fragmentation (Walker & Steffen, Internet, 20.01.2011). The raccoon dog is considered to be an invasive species and is listed in DAISIE´s “100 of the worst”-list of invasive species in Europe (Delivering Alien Invasive Species Inventories for Europe, Internet, 29.01.2011)

Jeffery A. McNeely at The World Conservation Union (IUCN) listed a couple of definitions of invasive species in a report from the Global Invasive Species Programme (GISP) (McNeely, Internet, 29.01.2011). Some of them fits the history of the raccoon dog, for example, “The probability of a species becoming invasive increases with the initial population size”, “species having larger native geographic ranges are more likely to be invasive than those with smaller native ranges” and “species that is invasive in one country or location is likely to be invasive in an ecologically or climatologically similar country or location” (McNeely, Internet, 29.01.2011). The raccoon dog was intentionally introduced in several locations and over a period of time to ensure establishment (Helle & Kauhala 1991). The raccoon dog’s natural distribution also extends over large areas in eastern Asia with different climate and habitat (Sutor 2008). The raccoon dog is considered an invasive species in the countries it already has established populations in and is likely to be invasive also in Sweden. Other factors contributing to the effective colonization of Europe is the facts that the raccoon dog is a truly omnivorous animal, it has high reproductive potential, it can build up large fat reserves and spend harsh parts of the winter dormant and it is capable to live near human settlements (Kauhala 1996).

The main threat with the introduction of the raccoon dog is the possible effects on biodiversity and as a vector for diseases (Kauhala 1996). A raccoon dog population can have serious negative effects on colonies of waterfowl and may rob up to 85% of the local nests (Kauhala 1996). Kauhala & Auniola (2001) suspected that the raccoon dog had decimated the vulnerable frog populations on islands in Finland. According to the 2010 Swedish Red List (Tjernberg et al. Internet, 29.01.2011), Sweden has 13 amphibian species, of which five are classified in one of the different Red List categories. If the raccoon dog establishes dense populations it adds an additional threat to those already threatened species.

Diseases and parasites

The raccoon dog is a possible vector species for diseases and parasites, e.g. rabies and the fox tapeworm *Echinococcus multilocularis* (Kauhala et al. 2007). In northern Europe possible vectors for wildlife rabies besides the Raccoon dog are the red fox (*Vulpes vulpes*), European badger (*Meles meles*) and semi-feral domestic cats (*Felis silvestris catus*) (Kauhala & Holmala 2006). During the epizootic of wildlife rabies in Finland in the late 1980's 73% of the observed cases were raccoon dogs and only 18% foxes (Holmala & Kauhala 2009). Individual home ranges overlap both within and between species, thus the risk of one infected animal to have contact with other animals and transmitting the disease is high (Kauhala & Holmala 2006). In Finland and from the south-central Sweden and northwards, the fox population densities alone are normally below the threshold value of a rabies outbreak, 6.3 individuals per 1000 ha (Holmala & Kauhala 2006). However, with a medium-sized predator community consisting of fox, raccoon dog, badger and cat, the pooled density reaches well above the threshold (Kauhala et al. 2006). The fox tapeworm was until the 1980s only known to exist in eastern France, Switzerland, southern Germany and western Austria, but has increased its distribution and is now found in 17 European countries (Casulli et al. 2010). It is infectious to humans and several new cases in humans have been described in recent years and the numbers are likely to increase (Casulli et al. 2010). Humans get infected by ingestion of the parasites eggs released in the faeces of infected canids (Eckert et al. 2000) through contaminated food, water, soil, animal fur, or by coming in contact with infected domestic dogs or cats (Rataj et al. 2010). The parasites stage in the intermediate host, including humans, cause tumor like symptoms in the affected organs, mainly the liver, and is lethal if not treated with radical surgery and chemotherapy (Eckert et al. 2000). Population density of fox have been found to be positively correlated to prevalence of *E. multilocularis* (Eckert et al. 2000) so by adding a new canid, the raccoon dog, to the vector community resulting in an increased total vector density could increase the spreading of the parasite and possibly increase the risk of humans getting infected. In central Europe, where the parasite is common, the public is not recommended to eat berries and mushrooms because of the risk of being infected by the parasite (Laurell, Internet, 28.01.2011). This could severely affect the public's relation to the nature and natural resources in Sweden (Laurell, Internet, 28.01.2011).One of the major food sources for the raccoon dog is berries (Kauhala & Auniola 2001) and an infected animal could come in contact with berries later eaten by humans. *E. multilocularis* have never been found in Finland (Kauhala et al. 2007) so the raccoon dogs dispersing into Sweden from Finland is not likely to carry the parasite. However a possible entry way for the parasite into Sweden is by dog- or cat owners from Sweden taking their pets to areas where the *E. multilocularis* is present and returning to Sweden without deworming the animal (Laurell, Internet, 28.01.2011) and with dense populations of vector species, the consequences may be severe.

The North-European Raccoon dog management program

By ratifying the Convention on Biological Diversity, Sweden and many other European countries are bound, through Article 8, h) to "as far as possible and as appropriate: Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (United Nations, Internet, 29.01.2011). IUCN states that invasive species "are a global problem that requires international cooperation and action." (IUCN, Internet, 03.01.2011). In 2009 the Nordic countries were granted the opportunity and funding to build up a joint management project to prevent the invasion of the raccoon dog to those countries not already colonized (Dahl et al. 2010). The three-year project that started in September 2010 is called "Management of the invasive Raccoon dog (*Nyctereutes procyonoides*) in the north-European countries" and is funded by the EU's LIFE programand has a budget of 5.3 million Euro. The project also aims to control the raccoon dog population in Finland to prevent dispersal over the border into Sweden (Dahl et al. 2010). The project uses innovative techniques to discover newly invaded animals and follow already stationary animals. Where there are suspicions that a raccoon dog is present in an area, e.g. if they get a tip from the public, IR/motion trigged wildlife cameras baited with scent lure are put out and any tracks are examined by an experienced tracker. If the suspicions are confirmed great effort is put in to capturethe animals using traps or specially trained hunting dogs (Dahl et al. 2010). The raccoon dog is a monogamous animal with long-term pair bond andthey usually roam and travel together (Helle & Kauhala 1993). The captured animals are therefore fitted with ear tags, a GPS/SMS transmitter, sterilized and released back into the wild, hopefully leading the trackers to other individuals (Dahl et al. 2010). New individuals found by the marked raccoon dog can then be either killed or marked and relocated to a new area. The method is adopted from successful eradication programs of feral goat (*Capra hircus*) populations where captured and radio-collared "Judas goats" were used to find remaining goats (Campbell & Donlan 2005). A system of permanent wildlife camera stations baited with scent lures are also put out along the border between Sweden - Finland, Sweden - Denmark and Denmark - Germany to monitor the population development and detect newly invaded animals (Dahl et al. 2010). The project is using an adaptive management approach where the current available knowledge is used to take the best management actions while collecting more information to improve future actions.

Aim with the study

The aim with this study was to compare four different commercially available scent lures effectiveness to attract raccoon dogs to a wildlife camera station in an area where raccoon dogs are abundant. The results will be implemented in the Scandinavian raccoon dog project to hopefully improve the effectiveness of the camera stations and the overall result.

Material and methods

Study area

The study area is located in the south-eastern archipelago of the Åland Islands, in the municipality of Föglö with a land area of 135 km². The average temperature on the Åland Islands is 5,8°C and in November (when the study was conducted) 2,6°C, however this year the mean temperature in November was -0.9°C, 1.7°C colder than average. The annual precipitation is 631mm and in November 77 mm (Ålands försöksstation, Internet, 29.01.2011). The raccoon dog have been present on the Åland Islands at least since 1975 when the first confirmed finding took place (Andersson & Westerberg 2009). Today strong populations are found all over the landscape even on the smaller 30-60 ha islands. Other medium-sized predators present in the study area are the Red fox, European pine marten (*Martes martes*) and the American mink (*Mustela vison*). Eurasian lynx (*Lynx lynx*) and European badger are rare. The core area for the study where I placed 10 of 12 blocks is about 2000 ha and is a maze of smaller and larger islands. The habitat in the study area is very diverse and contains coniferous primeval forests, mixed forests, deciduous forests, grazed forest, scrubland, clear cuts, large reed beds, fields, grasslands, meadows and marshes. Most habitats are also characterized by thick undergrowth. All together it makes up an ideal habitat producing many different available food sources for the omnivorous raccoon dog. From the summer and up to the point of the study at least 60 raccoon dogs were killed by hunters in the core area indicating a pre-hunting season population density of at least 30 individuals per 1000 ha.

Study design

I selected 12 sites, one block in each, in locations where I expected to find raccoon dogs, e.g. in the forest line adjacent to a field, shoreline or a reed bed. I selected places with homogenous habitat so the result wouldnot be biased by habitat preference within one block.

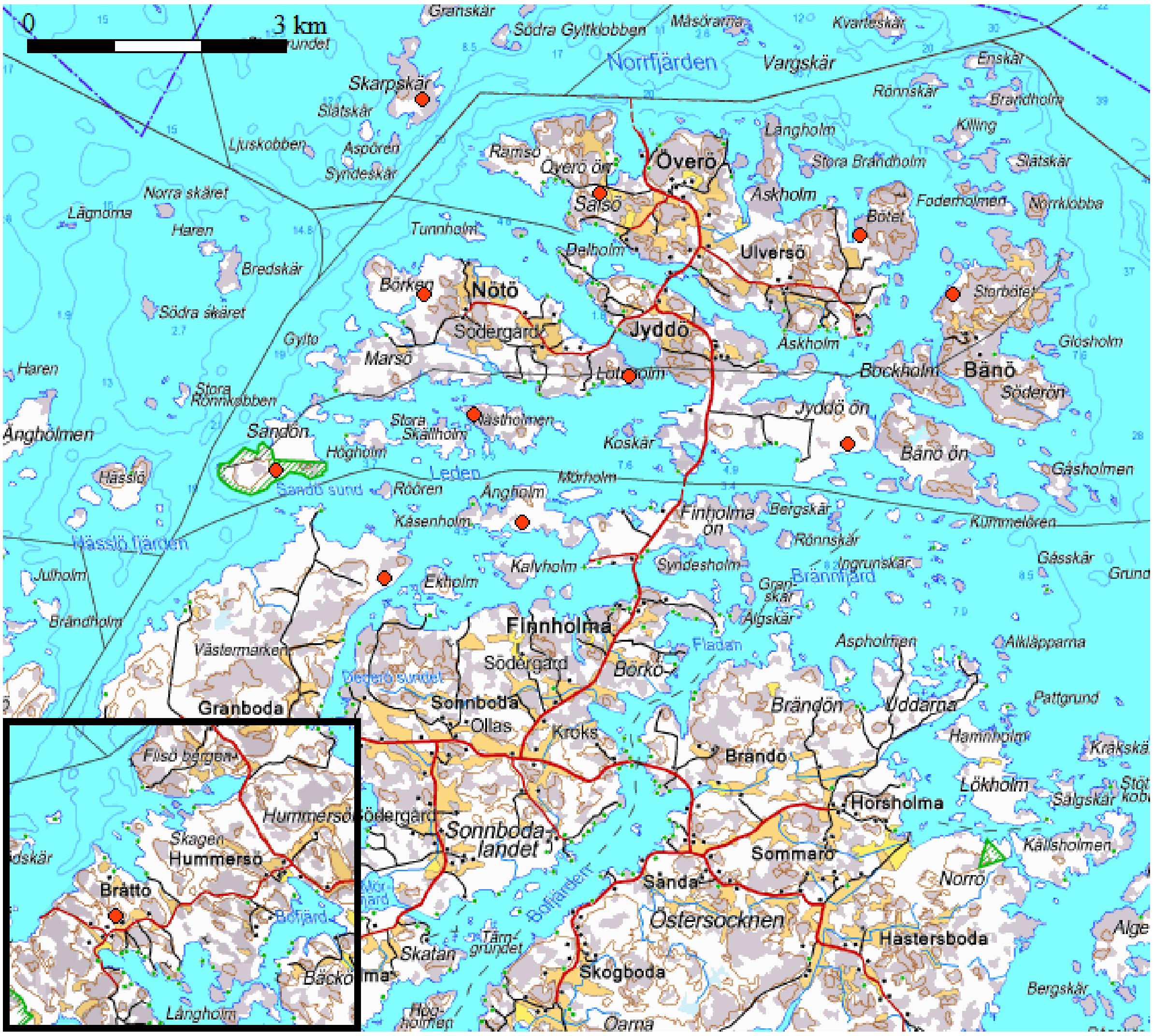

Figure 1: Map displaying the study area and all 12 blocks. The small inserted map displays the last block, about 15 km southwest of the core area.

In good habitat the raccoon dogs home range size can be as small as 150 ha and home range sizes are generally decreasing with increasing population densities among carnivores (Kauhala et al. 2006). It is impossible to differ between individual animals visually and it is unknown if there is individual variation in how strongly raccoon dogs are attracted by different scents. Adjacent blocks were placed at least 1.5 km apart to reduce the risk that one single animal could visit several blocks and bias the results. Eight of the blocks were also separated by water.

After selecting sites for the 12 blocks, I contacted the land-owners to get permission to use their land in the study, and went out scouting the area and selected and prepared the camera stations. By scouting the area on beforehand I could later put up the cameras and baits in a short time period to obtain equal weather conditions between blocks.

In every block I used 5 treatments, 4 lures and one control. The 5 treatments were:

1. Caven's Hiawatha Valley Predator Bait. (http://www.minntrapprod.com)
2. Hawbaker's Grey Fox Food Lure. (S Stanley Hawbaker & Sons, Fort Louden)
3. Powder River Paste Bait. (O´gorman enterprises inc.)
4. Hawbaker's Grey Fox 100. (S Stanley Hawbaker & Sons, Fort Louden)
5. Control, no bait, just a stick.

Caven's Hiawatha Valley and Powder River are meat-based and have a similar look of rotten meat. Hawbaker's Grey Fox Food Lure is a thick syrup and Hawbaker's Grey Fox 100 is a thick liquid natural grey fox gland lure.

The 5 camera stations in each block were placed about 70 meter in between on a straight line to decrease spatial dependence between stations. Domestic dogs (*Canis familiaris*) are known to detect specific odors at distances of over 400 meters (Wasser et al. 2004). A raccoon dog is thus likely to be able to pick up scents from all the lures when passing through the area, but some lures may be more interesting than other. If the stations would be too close to each other it would be a risk that a lure with less attractive scent would be visited just because it was nearby an attractive lure that the raccoon dog chose to seek out and very little effort was needed to visit it too. I recorded which treatment got the first visit in each block to see if the raccoon dogs consistently visited one treatment first. I also recorded which treatment got the first predator visit in each block. When I placed the cameras for example along a relatively straight shoreline, or the edge of a field, I kept the same distance to the shore or field on all stations rather than keeping an absolute straight line. I used a GPS-receiver to keep track of the distance between the camera stations. The treatments were then randomly selected to each station by a lottery scheme.

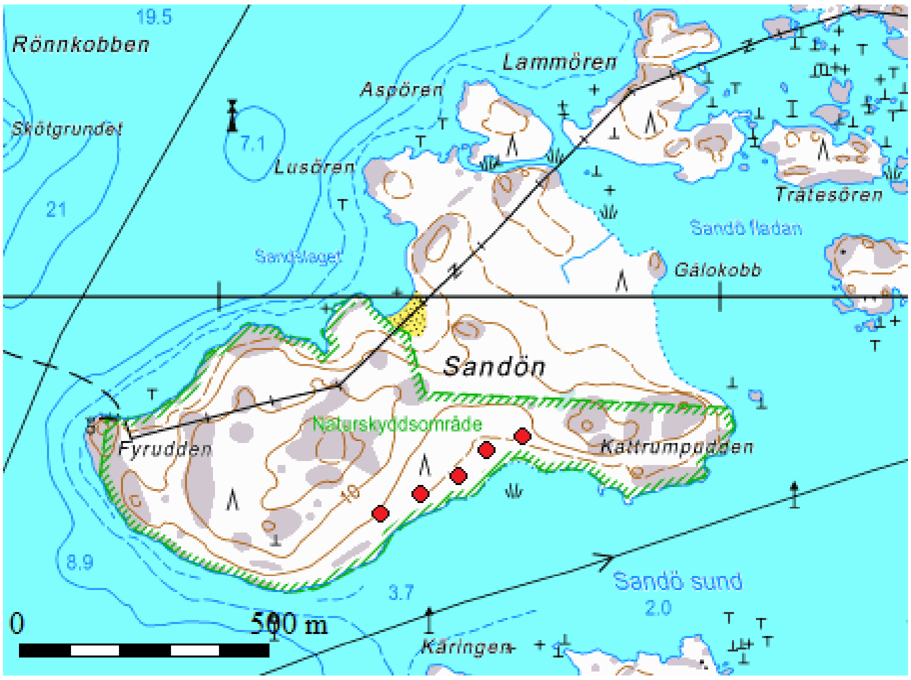

Figure 2: Map displaying how the camera stations were placed within a block.

I used a total of 60 wildlife cameras, 40 ScoutGuard 570 and 20 KeepGuard 550PV cameras. Both are 5 MP IR/motion trigged cameras which operate with IR-light to take pictures in complete darkness. I set them to, when activated by an animal in the viewfinder, take 3 pictures and 1 second delay before taking 3 more pictures if the animal was still present to improve the chance to identify the species by getting pictures from more angles.

The cameras were placed in a way to prevent taking photos on passing by people, either using a natural shield such as a clearing in a dense brush, branches, etc. or a constructed shield of branches and twigs on the sides of the camera forming a sector in front of the camera combined with a natural backstop (Larsson 2009). I also avoided putting up a camera directly on game trails where I saw them so that the animal would have to actively seek out the bait. The cameras were tied to a tree about 30 cm above the ground to ensure that the camera would be activated by a short legged animal like the raccoon dog (Kelly & Holub 2008).

The bait was placed on a stick that was smashed in the end with a hammer, creating a ragged end with separated fibers that the bait soaked into. A pea-sized amount of the Hawbaker´s liquid baits were soaked into the end of the stick and about a teaspoon of the meat-based baits were mashed into the fibers according to the instructions for the bait. The baited stick was then placed about 1.5 m in front of the camera to prevent over-exposed pictures during nighttime due to the strong IR-flash. I installed the camera stations between the 1st and 4th of November and retrieved them between the 15th and 16th of November. Immediately after the bait was in place the camera was activated and the stations were left undisturbed for at least 11 nights (11-15 nights). All cameras within each block were activated and retrieved in the same day, respectively. The instructions for the baits recommend adding new bait after heavy rain falls. However I chose not to since the test period lasted for only 15 nights. Instead I recorded rain data from the area using a simple rain-gaugeand compared the total number of visits per active camera, to the rain measurements to get an indication ofwhether the number of visits declined after a heavy rain fall..

I also recorded which trapping-night the raccoon dogs visited the stations to see if the number of visits declined, and to get an indication on when baits should be refilled. I compared the total number of visits for everynight with the number of active sites.

A raccoon dog was considered a "new" individual if at least one hour had passed since the previous visit. I also recorded if a camera either got a picture of a raccoon dog or not, i.e. the number of camera stations detecting a raccoon dog per treatment, to see possible differences compared to the total number of individuals since it is possible that the same individual returns several times to the same bait.

Statistical analyses

To compare the different treatments ability to attract raccoon dogs and predators, I used the Kruskal-Wallis test, or H-test, used to compare medians between several groups when a normal distribution cannot be assumed (see Bluman 1997). It is a nonparametric test and I test the null hypothesis that there is no difference in the different treatments ability to attract raccoon dogs, to the alternative hypothesis that there is a difference.

Results

A total of 775 trapping-nights, 155 nights per treatment, were undertaken during the study. However 8 cameras divided on 3 blocks, malfunctioned during the study and I chose not to include those blocks in the analysis since it could have biased the results. In two of the three blocks were cameras malfunctioned raccoon dogs had been recorded on the other cameras and at one of the malfunctioning cameras baited with Caven's Hiawatha Valley Predator Bait there were evidence indicating that a predator had visited since the baited stick was gone. On pictures recorded on other cameras I saw animals chewing on the baited stick and it is likely that a predator ran off with the stick. The cameras worked properly in the remaining 9 blocks which makes a total of 575 trapping-nights, 115 nights per treatment. A total of 18 raccoon dogs were caught by the cameras distributed over 11 cameras and 5 blocks. Also Red fox (11 recorded) and European pine marten (4 recorded) were recorded making a total of 33 predators caught by the cameras.

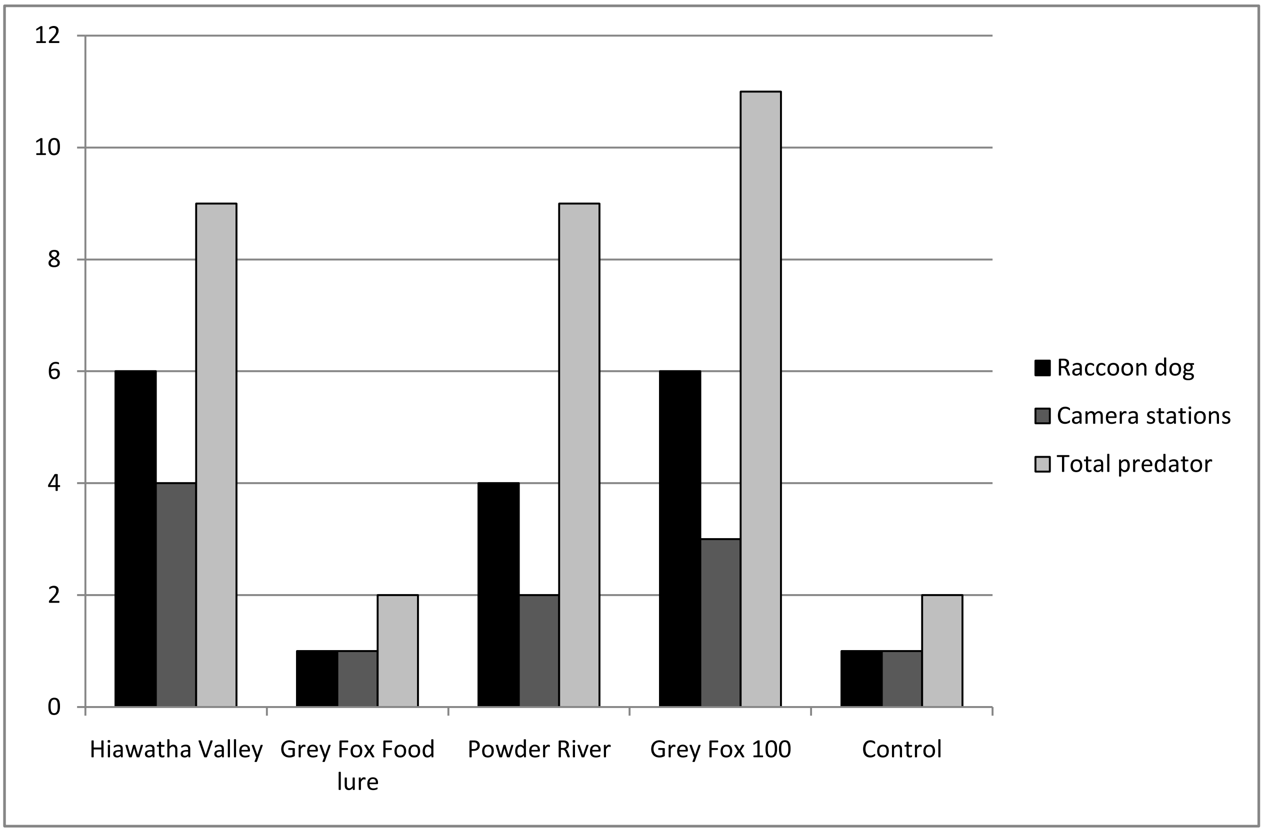

Figure 3: The total number of raccoon dogs detected per treatment, number of camera stations detecting a raccoon dog per treatment, and total number of predators visiting each treatment.

The Kruskal-Wallis test showed no significant difference between the treatments in the number of raccoon dogs detected by the cameras (h=4.11, $\chi^2_{\alpha=0.05}$=9.49, p=0.392). Neither did it show any significant difference between the treatments in recorded other predators (h=3.84, $\chi^2_{\alpha=0.05}$=9.49, p=0.428). I used the h-, and p-value adjusted for ties since a lot of ranks were tied. No statistical test was done on the presence/absence data of raccoon dogs between treatments due to the low sample size. The pattern of the presence/absence data was similar to the count data (fig 3).

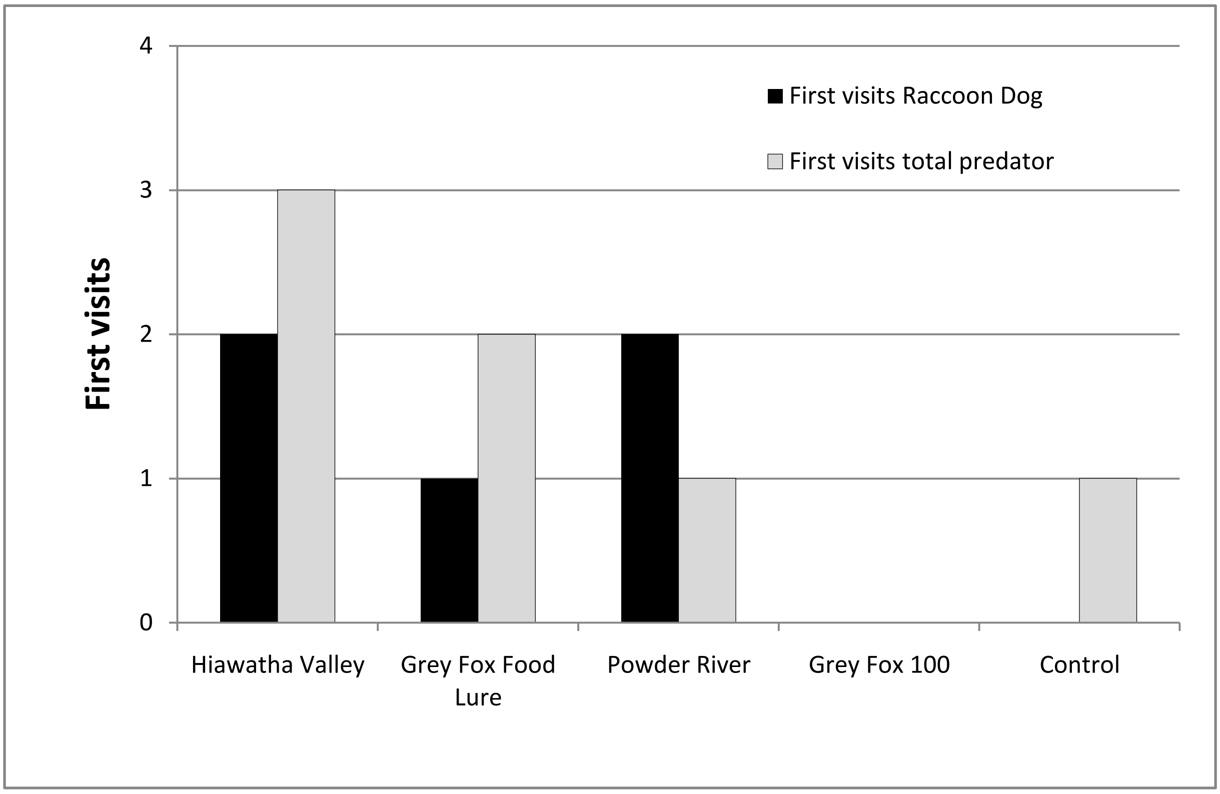

Figure 4: The number of first recorded visit for each treatment in each block for raccoon dog and total predator.

Raccoon dogs had first visited Caven’s Hiawatha Valley and Powder River Predator Bait in two of the blocks, and Hawbaker’s Grey Fox Food Lure in one block. For all predators Caven’s Hiawatha Valley were visited first three times, Hawbaker’s Grey Fox Food Lure two times, and Powder River Paste Bait and the Control both one time. However the Kruskal-Wallis test showed no significant difference to which treatment that recorded the first raccoon dog visit (h=4.80, $\chi^2_{\alpha=0.05}$=9.49, p=0.308) or any predator visit (h=4.51, $\chi^2_{\alpha=0.05}$=9.49, p=0.341). I used the h-, and p-value adjusted for ties since a lot of ranks were tied.

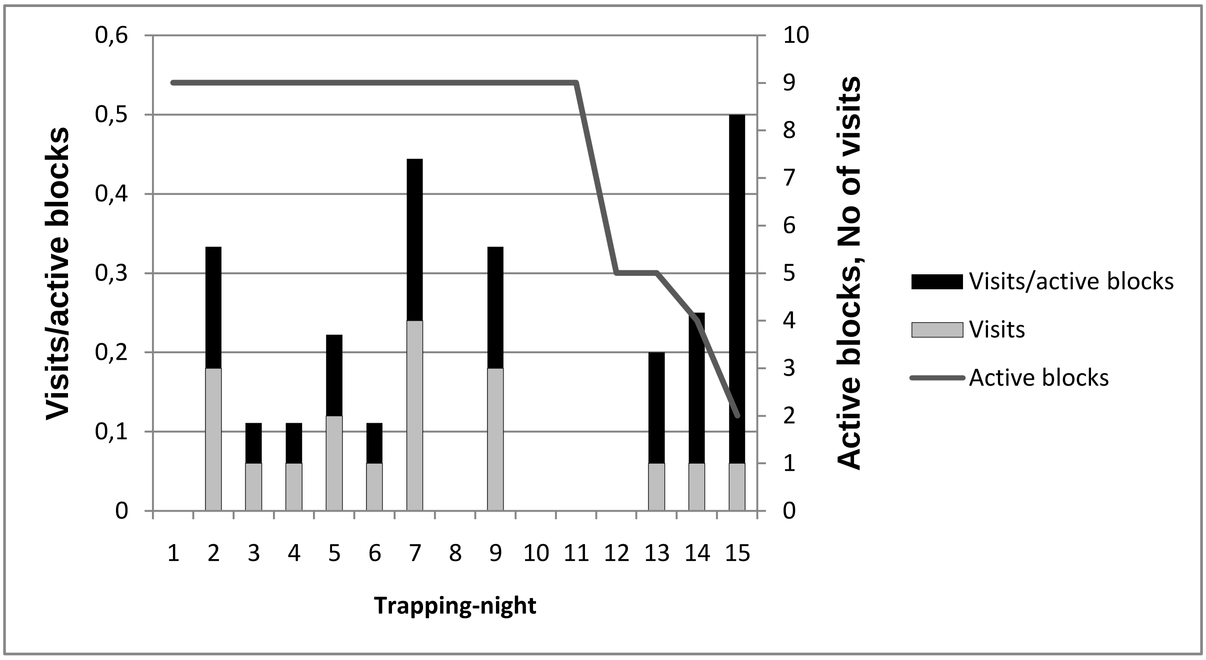

Figure 5: The average number of Raccoon dog visits per active block and trapping-night. The total number of visits and number of active blocks are included to point out that not all cameras were active the same number of nights. The number of active cameras and total number of visits are displayed on the secondary Y-axis to provide a clearer overview of the results.

The data indicates that most of the visits occurred before the tenth trapping-night. Thus a refill of bait and control of the camera should take place not later than after the tenth trapping-night.

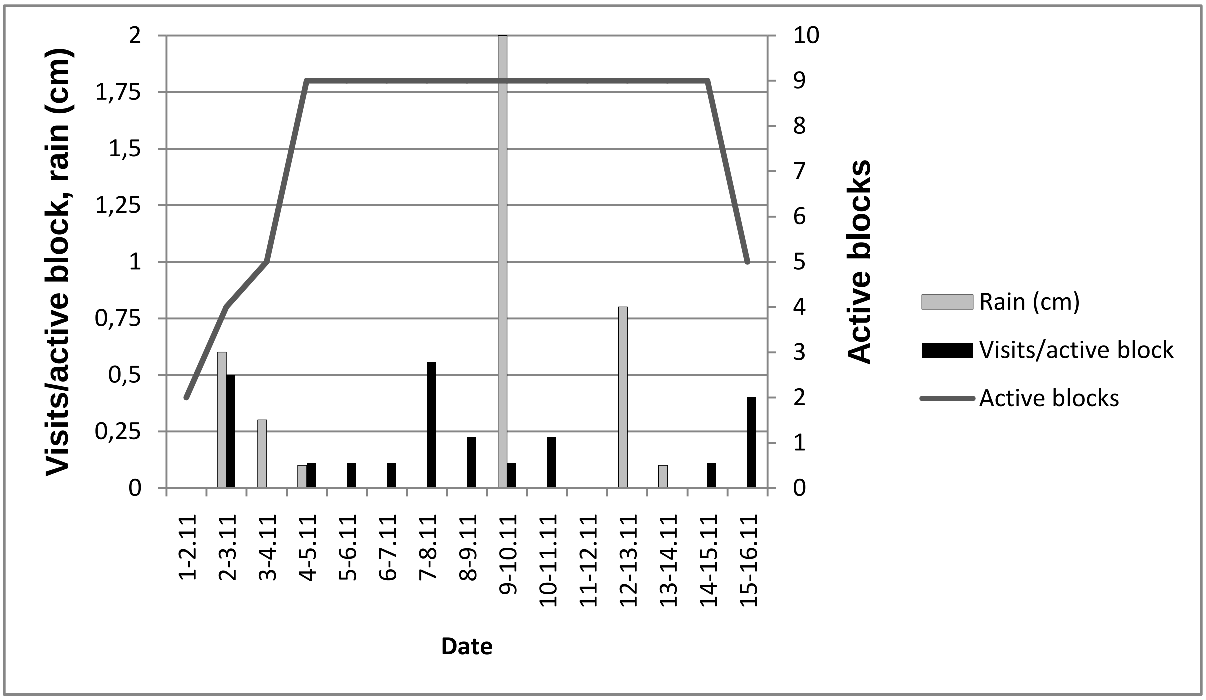

Figure 6: The average number of Raccoon dog visits per active block compared to the rain measurements (cm). The number of active blocks is included to point out the fact that not all blocks were active at the same time (secondary Y-axis).

The comparison with the rain data and number of visits supports the bait manufacturers' recommendations that you should refill the bait station after heavy rainfall. Most of the visits occurred before the 20 mm rainfall between the 9th and 10th of November.

No statistical tests were made for the visits/trapping-night and visits/rain data because of the small amount of data collected, thus the results should be seen only as indications.

Discussion

The results showed no statistical difference between the baited cameras and the control. The results were very varying between sites and only 5 of the 9 blocks were the cameras worked properly detected raccoon dogs, providing inconsistent data and a small sample size. Whether that depends on the fact that at least 60 raccoon dogs were removed from the core area prior to the study and no raccoon dogs were present in some blocks during the time of the study, or that raccoon dogs in those areas weren't attracted to the lures is unknown. For example the block "Skarpskär" was located on a 40 ha large island, and just before the study two raccoon dogs was killed by a hunter on the island. No raccoon dogs were recorded by the cameras and it is possible that the two raccoon dogs removed were the pair inhabiting the island and the juveniles had dispersed to other areas and no raccoon dogs were present on the island. Another possibility is that raccoon dogs were present but simply not attracted to the lures. Only including the blocks where raccoon dogs were recorded in the statistical analysis would increase the statistical strength (although scientifically questionable) although not to a significant level due to the large variations in the results. If the patterns in the 5 blocks where raccoon dogs were detected would have been consistent over 10 blocks, the results would have been statistically significant (h=10.95, $\chi^2_{\alpha=0.05}$=9.49, p=0.027). Thus, increased number of blocks and perhaps denser populations (and/or a study conducted in late summer before the most intensive hunting season) would probably increase the number of detected raccoon dogs and provide a more reliable result. The large number of malfunctioning cameras is however problematic, and may not be solved even if all cameras are thoroughly tested on beforehand. Two or more consecutive trapping efforts, with a mid period refill of bait, and replacement of malfunctioning cameras, would probably also promote reliable data capture and results.

Lure preferences could also be tested on animals in captivity, e.g. on raccoon dogs in a zoo, by cafeteria trials (see Bahlman & Kelt 2007). Naturally, animals in captivity may behave differently from wild animals and the results would have to be supported by field tests. It may however be a time-effective approach to test large number of lures and provide a first selection of lures that should be selected for further field testing.

The number of visits seemed to decline after the 10th trapping-night but in relation to the number of active blocks an increase appeared toward the end of the study, making the results inconclusive. The effect from the rain in the 9th and 10th of November is also inconclusive because of the relative increase in visits toward the end when in general, however, the number of visits declined after the rainfall. Thus, these results give no clear information on if the decline in number of visits was due to the heavy rainfall or that the baits ability to attract raccoon dogs had declined naturally over time. Preferably all sites would be out the same number of trapping-nights and the same time period to exclude variables, but it was not practically possible in this study without more personnel. In this study, when I started retrieving the cameras, chance became a factor toward the end of the study and the active sites were few. A longer study to include more variation in weather with more accurate weather measurements and with varied bait refill among stations would be needed to see possible weather conditions effect on the trapping efficiency of the lures and the lures natural decrease in efficiency. At present, I would recommend following the manufacturers' recommendations to refill the bait stations after heavy rain fall or after the 10th trapping-night to sustain the lures effectiveness.

In a camera trapping study made by De Bondi et al. (2010) they used a 2.25 ha trapping grid with one camera in the center and one camera in each corner of the grid ~100 m between cameras. I chose 70 meters and the cameras placed on a line because it would have been very difficult, not to say impossible, to find suitable sites with homogenous habitat in the study area if I would have used a rectangular design and longer intervals between cameras, because of the fragmented habitat and small islands. In the mainland, with larger areas of homogenous habitat, the rectangular design could be used to decrease the risk that different camera stations within one site would get different possibilities to attract raccoon dogs, e.g. if the camera stations at the end of the line is placed outside of the raccoon dogs home range.

Implementations in the North-European raccoon dog management program

Adaptive management is about making decisions based on the best knowledge currently available while collecting more information to improve future actions. To prevent the invasion of raccoon dogs in Sweden it is vital to act fast. This is the first study that with some success have been able to test the use of baited wildlife cameras to detect raccoon dog occurrence, and although the results showed no significant difference between the treatments I would still recommend the method to be used to detect raccoon dogs. By numbers the Caven's Hiawatha Valley and Hawbaker's Grey Fox 100 lures caught the most raccoon dogs, 6 visits each, followed by Powder River Paste Bait with 4 visits, and Hawbaker's Grey Fox Food Lure and the control with 1 visit each. Also in the total predator category Caven's Hiawatha Valley, Hawbaker's Grey Fox 100 and Powder River Paste Bait attracted more predators. The presence/absence data on raccoon dog (see Figure 3) further supports the indication that Caven's Hiawatha Valley and Hawbaker's Grey Fox 100 was favored by the raccoon dog. The baits I would recommend for use in the North European raccoon dog management program would therefore be Caven's Hiawatha Valley and Hawbaker's Grey Fox 100. During the program more data could be collected to further compare differences between baits and seasonal variations. This study was conducted in November when the raccoon dog is preparing for winter lethargy (Kauhala et al. 2007) and possibly mainly focuses on food. That could have affected which bait was favored by the raccoon dog. For example, in the mating season ranging from February to April (Helle & Kauhala 1995) other lures may work better to attract raccoon dogs in search of a partner or possible rivals. The program is also working on a gland lure extracted from raccoon dogs (F.Dahl, pers. comm.) which could be very effective to attract raccoon dogs in search of a partner.

Volunteering hunters could be involved to operate wildlife cameras. Hunting fox over bait is a common method in Sweden and a well-maintained bait station is very likely to attract also raccoon dogs. The cameras are easy to operate so anyone with access to a computer can run a camera station. If a raccoon dog is caught on camera, the hunter can report the observation and attempts to catch the animal can be directed to the location. The hunter could also try to shoot the animal but a radio tagged animal is much more valuable to the program because it could help to find new individuals so primarily attempts to capture the animal should be conducted. This would be a very cost effective method and would also require very little effort to maintain the cameras.

Knowledge about the dispersal behavior and habitat use of the raccoon dog is crucial for addressing management actions in Sweden. More intensive efforts can then be directed to locations where it is more likely to find dispersing animals and prevent colonization of those areas. It is probably mainly the juveniles that disperse in a stable population but dispersal of adult raccoon dogs have been recorded in Germany, where the population still is in the state of colonization (Sutor 2008). In Southern Finland most of the juveniles leave their home range in September or October (Kauhala et al. 2007) so it is vital that as many wildlife cameras as possible is active during this time. In a study made in northeastern Germany, Drygala et al. (2010) concluded that most juvenile raccoon dogs (55.9% of the studied animals) stayed within 5 km of their natal home range and 8.5% dispersed more than 50 km. Similar results have been recorded in a study in southern Finland where 17% of the juveniles dispersed more than 40 km and 50% of the marked individuals stayed within 5 km of their natal home range (Drygala et al. 2010). The main focus areas to put up wildlife camera stations should therefore be within about 50 km from known raccoon dog populations to achieve more cost effective results.

The raccoon dogs' habitat preference is also of major importance when planning a large scale surveillance program to detect invading animals. It is an omnivorous animal and is consequently able to utilize several different habitat niches wherever a food source is available. In the raccoon dogs' native range in south-east Asia the preferred habitat is forested streams or river valleys and habitat with thick undergrowth such as reed beds and marshes around lakes (Holmala & Kauhala 2009). Raccoon dogs are also known to fish at fish farms (Sasaki & Kawabata 1994) so areas adjacent to fish farms is of high interest when considering permanent wildlife camera locations. In a study made in northeastern Germany, Drygala et al. (2008) identified two different types of raccoon dogs. One 'agrarian type', who utilized a more managed agricultural environment such as grasslands and meadows and included less than 5% of forest cover in their home ranges, and one 'forest type' that used more than 50% of forest habitat in their home ranges. In Russia and Ukraine, raccoon dogs are typically found near water and wet habitats such as swamps, damp meadows and alluvial soils, also gardens and deciduous forests were favored in Ukraine (Holmala & Kauhala 2009). In southeast Finland however, the favored habitat shifts between seasons. In the spring and early summer the raccoon dogs prefer young deciduous forests, fields and watersides while in the late summer and autumn favoring fields, mature deciduous forests and young mixed forests (Holmala & Kauhala 2009). These habitats all have abundant food resources during the utilized period, for example frogs in the watersides in the summer and berries, cereals, insects and small mammals in the fields and forests during the autumn. In south-central Finland the raccoon dog preferhabitats where wild berries are plentiful, such as spruce and mixed-forests (Holmala & Kauhala 2009). This variation between countries makes it hard to predict the raccoon dogs' habitat preference in Sweden, but spontaneously I suggest it mainly correspond to that observed in Finland. The main focus areas when installing wildlife cameras should therefore shift between seasons to increase the probability to detect invading raccoon dogs. In the event of a rabies outbreak in Sweden, the same areas should also be the main target when addressing countermeasures (Holmala & Kauhala 2009).

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Appendix

Table 1: Camera log

Block	Station	Position N	Position E	Camera	Activated	Retrieved	Lure
1. Mjölksund	M1	60°06'14.2''	20°30'23.7''	SG570	4.11.2010	15.11.2010	HiawathaValley
	M2	60°06'14.7''	20°30'21.3''	SG570	4.11.2010	15.11.2010	Kontroll
	M3	60°06'16.8''	20°30'16.5''	SG570	4.11.2010	15.11.2010	Grey Fox 100
	M4	60°06'18.1''	20°30'13.2''	SG570	4.11.2010	15.11.2010	Powder River
	M5	60°06'19.5''	20°30'09.6''	SG570	4.11.2010	15.11.2010	Grey Fox FoodLure
2. Böte	M6	60°06'05.1''	20°33'33.1''	SG570	4.11.2010	15.11.2010	Kontroll
	M7	60°06'08.0''	20°33'32.7''	SG570	4.11.2010	15.11.2010	Powder River
	M8	60°06'10.3''	20°33'32.8''	SG570	4.11.2010	15.11.2010	Grey Fox FoodLure
	M9	60°06'12.2''	20°33'30.6''	SG570	4.11.2010	15.11.2010	HiawathaValley
	M10	60°06'15.2''	20°33'31.6''	SG570	4.11.2010	15.11.2010	Grey Fox 100
3. Börke sund	M11	60°05'29.2''	20°28'05.0''	SG570	4.11.2010	15.11.2010	Grey Fox FoodLure
	M12	60°05'32.1''	20°28'05.2''	SG570	4.11.2010	15.11.2010	Powder River
	M13	60°05'35.2''	20°28'04.8''	SG570	4.11.2010	15.11.2010	Kontroll
	M14	60°05'37.8''	20°28'06.2''	SG570	4.11.2010	15.11.2010	HiawathaValley
	M15	60°05'40.4''	20°28'06.1''	SG570	4.11.2010	15.11.2010	Grey Fox 100
4. Lotsholm	M16	60°05'10.6''	20°30'55.6''	SG570	4.11.2010	15.11.2010	HiawathaValley
	M17	60°05'12.8''	20°30'51.6''	SG570	4.11.2010	15.11.2010	Grey Fox 100
	M18	60°05'14.1''	20°30'46.3''	SG570	4.11.2010	15.11.2010	Kontroll
	M19	60°05'15.2''	20°30'43.0''	SG570	4.11.2010	15.11.2010	Grey Fox FoodLure
	M20	60°05'16.9''	20°30'39.4''	SG570	4.11.2010	15.11.2010	Powder River
5. Bänö	M21	60°05'51.8''	20°34'42.0''	SG570	2.11.2010	16.11.2010	HiawathaValley
	M22	60°05'54.2''	20°34'42.2''	SG570	2.11.2010	16.11.2010	Grey Fox 100
	M23	60°05'55.3''	20°34'46.5''	SG570	2.11.2010	16.11.2010	Grey Fox FoodLure
	M24	60°05'57.2''	20°34'51.0''	SG570	2.11.2010	16.11.2010	Kontroll
	M25	60°05'59.4''	20°34'54.2''	SG570	2.11.2010	16.11.2010	Powder River
6. Jyddööjen	M26	60°04'53.6''	20°33'52.1''	SG570	2.11.2010	16.11.2010	Powder River
	M27	60°04'53.9''	20°33'46.2''	SG570	2.11.2010	16.11.2010	Grey Fox FoodLure
	M28	60°04'53.2''	20°33'41.7''	SG570	2.11.2010	16.11.2010	HiawathaValley
	M29	60°04'51.4''	20°33'36.2''	SG570	2.11.2010	16.11.2010	Grey Fox 100
	M30	60°04'52.1''	20°33'30.2''	SG570	2.11.2010	16.11.2010	Kontroll

Block	Station	Position N	Position E	Camera	Activated	Retrieved	Lure
7. Skarpskär	M31	60°06'42.1''	20°27'48.0''	SG570	3.11.2010	16.11.2010	Grey Fox FoodLure
	M32	60°06'44.2''	20°27'50.0''	SG570	3.11.2010	16.11.2010	Grey Fox 100
	M33	60°06'45.4''	20°27'54.6''	SG570	3.11.2010	16.11.2010	HiawathaValley
	M34	60°06'48.0''	20°27'54.2''	SG570	3.11.2010	16.11.2010	Powder River
	M35	60°06'50.7''	20°27'55.8''	SG570	3.11.2010	16.11.2010	Kontroll
8. Sandön	M36	60°04'24.6''	20°26'49.5''	SG570	1.11.2010	16.11.2010	Powder River
	M37	60°04'25.3''	20°26'44.8''	SG570	1.11.2010	16.11.2010	HiawathaValley
	M38	60°04'24.1''	20°26'39.6''	SG570	1.11.2010	16.11.2010	Grey Fox 100
	M39	60°04'22.1''	20°26'36.1''	SG570	1.11.2010	16.11.2010	Kontroll
	M40	60°04'21.6''	20°26'31.0''	SG570	1.11.2010	16.11.2010	Grey Fox FoodLure
9. Ängholm	M41	60°04'13.3''	20°29'59.4''	KG550PV	1.11.2010	16.11.2010	Grey Fox 100
	M42	60°04'13.9''	20°29'53.5''	KG550PV	1.11.2010	16.11.2010	Powder River
	M43	60°04'13.0''	20°29'47.9''	KG550PV	1.11.2010	16.11.2010	Kontroll
	M44	60°04'11.5''	20°29'44.0''	KG550PV	1.11.2010	16.11.2010	Grey Fox FoodLure
	M45	60°04'11.6''	20°29'39.5''	KG550PV	1.11.2010	16.11.2010	HiawathaValley
10. Nästholm	M46	60°04'47.5''	20°29'04.6''	KG550PV	2.11.2010	16.11.2010	Grey Fox FoodLure
	M47	60°04'48.1''	20°28'59.9''	KG550PV	2.11.2010	16.11.2010	Powder River
	M48	60°04'48.9''	20°28'55.4''	KG550PV	2.11.2010	16.11.2010	Grey Fox 100
	M49	60°04'52.0''	20°28'52.0''	KG550PV	2.11.2010	16.11.2010	HiawathaValley
	M50	60°04'53.8''	20°28'48.1''	KG550PV	2.11.2010	16.11.2010	Kontroll
11. Degerö udden	M51	60°03'47.2''	20°28'05.6''	KG550PV	1.11.2010	16.11.2010	Kontroll
	M52	60°03'49.1''	20°28'09.2''	KG550PV	1.11.2010	16.11.2010	Powder River
	M53	60°03'50.9''	20°28'12.4''	KG550PV	1.11.2010	16.11.2010	HiawathaValley
	M54	60°03'53.4''	20°28'13.3''	KG550PV	1.11.2010	16.11.2010	Grey Fox 100
	M55	60°03'54.4''	20°28'17.9''	KG550PV	1.11.2010	16.11.2010	Grey Fox FoodLure
12. Bråttö	M56	59°59'38.6''	20°19'23.8''	KG550PV	4.11.2010	15.11.2010	Grey Fox FoodLure
	M57	59°59'39.7''	20°19'20.5''	KG550PV	4.11.2010	15.11.2010	HiawathaValley
	M58	59°59'41.1''	20°19'17.7''	KG550PV	4.11.2010	15.11.2010	Powder River
	M59	59°59'42.0''	20°19'14.9''	KG550PV	4.11.2010	15.11.2010	Kontroll
	M60	59°59'44.6''	20°19'09.9''	KG550PV	4.11.2010	15.11.2010	Grey Fox 100