When curiosity saves the cat

Using lures to increase effectiveness of camera traps when studying Pallas’s cat (Otocolobus manul)
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Summary

Large predators are notoriously difficult to study due to their shyness, their often nocturnal lifestyle and large spatial requirements amongst other things. They often live solitarily in inaccessible habitats which makes it very difficult for scientists to learn more about them or even know how large their populations are. This is a big problem for conservation biologists trying to help the species since effective conservational efforts require vast knowledge about the species ecology, its behavior, habitat preferences and social structure. The Pallas’s cat (*Otocolobus manul*) is such a species that is extremely difficult to study in its natural habitat. It is a small, feline predator that inhabits the vast, rocky steppes of the Mongolian grasslands and its solitary lifestyle makes them sparsely distributed and hard to spot. Due to technical progress, the need to directly observe wild animals has decreased, and methods for monitoring populations remotely has recently become very popular. One of these methods, which is becoming increasingly common, is camera trapping. A camera trap is a remotely triggered camera which takes a picture or a short video-sequence when triggered by for example movement, heat or a manual switch (a lever, pressure-plate etc. which the animal manipulates). To increase the effectiveness of the camera trap and get as many pictures as possible, the cameras are sometimes fitted with a bait or a lure to attract the target species.

This study is aimed towards finding a good, reliable lure that will attract wild Pallas’s cats to camera traps and by that learn more about their behavior and distribution. The individuals used in this study are a pair of Pallas’s cats at the Nordens Ark zoo in Sweden. Pallas’s cats have never been targets for similar test but the lures used in this study are documented to work on other feline species, both domesticated and wild. Lures chosen for closer examination are: (1) recordings of sounds emitted by other Pallas’s cats (2), recordings of sounds emitted by pikas (*Ochotona princeps*), the Pallas’s cats primary prey (3), catnip oil and (4) valeriana extract. Unfortunately, the results were unambiguous and there was no clear preference for any of the lures, even if the cats showed interest in all lures they were exposed to. Especially promising were the cats interest in catnip oil and the pika vocalization lure. The method can however be used in the future for testing other potential lures or test the same lures on other Pallas’s cats.
Abstract

Four different lures for use in field studies to attract wild Pallas’s cats (*Otocolobus manul*) in combination with camera traps were tested. Lures chosen for closer examination were; (1) recordings of sounds emitted by other Pallas’s cats (2), recordings of sounds emitted by pikas (*Ochotona princeps*), the Pallas’s cats primary prey (3), catnip oil and (4) valeriana oil. Individuals chosen for testing were two zoo-kept Pallas’s cats in their enclosure at Nordens ark zoo in Hunnebostrand, Sweden. The results showed no statistical difference between the different lures in a Freidman test but catnip and prey item vocalization -lures induces the strongest responses in the cats.

Key words: Pallas’s cat, camera trapping, auditory lures, olfactory lures.
Introduction

The possibility to monitor the number and activity of a population is often essential for conservation of the most endangered species (O’Connell, et al., 2011), but some species are more difficult to monitor than others. Species with few individuals, are difficult to capture in traps or living in remote areas are notoriously difficult to study (O’Connell, et al., 2011) and this might make effective conservation efforts impossible. Camera traps is a non-invasive, cost-efficient way to monitor populations and collect data without handling or capturing individuals (O’Connell, et al., 2011) which suits studying this kind of difficult species perfectly.

The camera trap data is comparable with data from capture-recapture studies (Balme, et al., 2007) but without the often traumatic and invasive capturing of the sampled individuals. Technical progress has led to cameras becoming smaller, more automatic and cheaper and this has contributed to them being used more frequently in a wide array of studies (O’Connell, et al., 2011). Methods have been refined with the technologic development of the cameras and the increased use of them (O’Connell, et al., 2011). Recently, models for assessing population dynamics and population structure of wild species has been developed using data from camera traps (O’Connell, et al., 2011).

Large carnivores are generally very difficult to study due to their often solitary and nocturnal lifestyle, paired with elusive behavior and large spatial requirements (Monterroso, et al., 2014; Balme, et al., 2007). They often occur at very low densities, which makes the efforts to obtain reliable population estimates difficult (Balme, et al., 2007). The Pallas’s cat (*Otocolobus manul*) is a small, feline predator which occurs in sparse numbers in the grasslands and montane steppes of Central Asia (Ross, et al., 2015). Their rareness and shyness in combination with their preference for remote habitats makes them inherently difficult to study, and efficient use of camera traps would seem to be a well suited way to study this species.

This study aims to find an olfactory or auditory lure that can be used to attract Pallas’s cats to camera traps in field studies. The lure should be cheap, easy to obtain, reliable and possible to handle in rough terrain. Lures chosen for closer examination are: (1) recordings of sounds emitted by other Pallas’s cats, (2) recordings of sounds emitted by pikas (*Ochotona princeps*), the Pallas’s cats primary prey, (3) catnip oil, and (4) valeriana extract. This method for investigating potential lures could also be used for future tests of potential lures that could be used in similar experiments.
Background

The Pallas’s cat

The Pallas’s cat is a small, feline predator native to the central Asian steppes, and thought to be most abundant to the Grasslands of Mongolia, inner Mongolia and the Tibetan plateau (Ross, 2009). Even in optimal habitats, Pallas’s cats have only been observed in small numbers of only two to six cats/100 km$^2$ (Ross, et al., 2015). Outside aforementioned areas, the species is considered rare and it is currently listed as Near threatened in the IUCN Redlist and in CITES in Appendix II (trade is closely monitored to prevent risk of extinction (CITES, 2016)) (Ross, 2009). Threats towards the Pallas’s cat includes habitat fragmentation, fur trade, use in traditional medicine and loss of prey base due to vermin control programs, although the exact impact of these factors on the population is impossible to evaluate due to the lack of knowledge about the species’ ecology (Ross, 2009). Pallas’s cat is mostly found in mountainous areas, steppes and rocky outcrops and their distribution appears to be limited by snow cover as they are rarely found in areas where the mean 10-day snow cover exceeds 10 cm (Ross, 2009).

Their ecology is poorly studied due to their rarity and secretive behavior (Ross, et al., 2010) but the low densities are believed to be a result of interspecific predation which forces the Pallas’s cats to choose habitats with both good cover from predators while still provide prey for the cats themselves (Ross, et al., 2012). Access to marmot burrows or other available cavities to provide dens is also crucial for the Pallas’s cat (Ross, et al., 2010) and this restricts their habitable areas. They keep much larger territories than what could be expected of a cat of the Pallas’s cats’ size (Ross, 2009). They also seem to prefer rocky habitats, mountain steppe and ravines and avoid human settlements in their choice of denning sites (Ross, et al., 2010).

Male home ranges overlap several females' home ranges, which suggests a polygamous mating system (Ross, 2009). Evidence from radio-collar data suggests that the choice of female Pallas’s cats’ home ranges is resource-based while males adjust their home ranges to accommodate several females, which contributes to the sparse distribution of the population (Ross, 2009). The assumptions are based on radio collar data from 25 cats and suggested that male home ranges varied between 21 to 207 km$^2$ (mean 98.8 ± 17.2 km$^2$), female home ranges varied between 7.4 to 125.2 km$^2$ (mean 23.1 ± 8.9 km$^2$) (Ross, 2009). Different males’ territories were also found to overlap and the lack of dynamic interactions between males in the radio-collar study (avoidance or attraction) suggests that males do not claim territory towards each other and that males pursue all females within their home range during the breeding season, regardless of other competitors in the same area (Ross, 2009). Scratch marks and puncture wounds found on captured males during the breeding season would indicate that males fight, should they encounter each other (Ross, 2009). The lack of territoriality could also be due to the difficulties associated with maintaining boundaries of such large home ranges (Ross, 2009).

Pallas’s cats show no avoidance to unoccupied human camps in the summer while selecting dens significantly further away from the same camps in the winter when the camps were occupied (Ross, et al., 2010). This indicates that they are flexible in their behavior and adapt to presence and absence of humans, but also show strong avoidance towards humans. If
humans move into Pallas’s cats’ areas, this would further decrease their already limited options of available habitats and likely affect the survival of the species. Luckily, due to human nomads migrating to riverine waters and their animals grazing sites during summer, Pallas’s cats are in some areas relatively undisturbed by human presence during the summers when they rear their young (Ross, et al., 2010). However, areas without rivers as focal points does not have this advantage and the reproductive success and recruitment in these areas can be jeopardized (Ross, et al., 2010).

Camera trapping
Non-invasive methods have become more and more popular as they can survey large areas and several species at the same time at low cost (Monterroso, et al., 2014). Camera trapping has been proven to detect more species than other non-invasive methods such as hair snares and a lot more sampling effort would be required to reach similar success rates as camera traps (Monterroso, et al., 2014).

Remote camera traps are often preferred when studying the shyest and most elusive carnivores due to the abundant data return paired with minimal labor, and with the probably lowest inherited bias of all device-based survey methods (Kays & Slauson, 2008). The low bias of camera traps is contributed to the permanent nature of the data it collects; photographs often provide unambiguous species identification (Kays & Slauson, 2008). Data can be collected without subjectivity from the collector, and the automatic nature of the data collecting also provides a consistent result (Kays & Slauson, 2008). The cameras are always restricted by technical limitations such as duration of the batteries and number of pictures it’s able to store before it needs to be emptied (Kays & Slauson, 2008). When conducting camera trap research in cold climates and on high altitudes it is important to know that cold temperatures can significantly reduce the battery life (Jackson, et al., 2005). High altitudes are also associated with high levels of infrared light and the chosen equipment must function despite of this (Jackson, et al., 2005).

Even if the biases of this method is less than with other methods of species inventory, there are still potential biases to consider with the collected data. It is important to be aware of that not all individuals of a population have the same chance of being captured by a camera trap, and that some individuals are more likely to be captured than others depending on sex, age, social status and trap placement (Jackson, et al., 2005). Individuals of shy species such as snow leopards (*Panthera uncia*) can learn to avoid camera traps after being photographed once (Jackson, et al., 2005) which may skew results in capture-recapture model studies. It is important to choose camera trap placement carefully but to do so requires knowledge about the studied animals’ behavior and routines. Studies conducted on coyotes has brought a lot of insight in the effect of social status on the probability of being captured in camera traps. Sequin et. al. (2003) studied radio collared coyotes in a well-known population to investigate if there were any demographical biases in camera trap material. It turned out that individuals identified as alphas were significantly underrepresented in the photo-captures for all cameras in the study (Sequin, et al., 2003). Several alphas in the study were radio collared and was observed to change their movements when cameras were installed and were recorded close to cameras on occasion but not close enough to be captured on tape (Sequin, et al., 2003). Social status also affected the coyotes’ response to human activity: alphas were prone to find a
vantage point and observe humans in their territory while transient individuals preferred to leave (Séquin, et al., 2003). The age of the animal did not have a significant effect on the probability of being captured on camera, indicating that avoidance was not a learnt behavior (Séquin, et al., 2003).

As with all sampling methods, the sampling method (placement, duration, lures etc. in camera traps) highly impact which individuals that will be captured. A very successful camera trap survey managed to document all individuals of a large family group of spider monkeys (Ateles belzebuth) and map the species’ life history based on material from well-placed cameras close to a known geophagy site (Galvis, et al., 2014). The success was accounted to knowing that the monkeys use the same branches to access the site every time and these branches could be rigged with cameras (Galvis, et al., 2014). This resulted in pictures of all individuals in the group on several occasions and in different life-stages over the years (Galvis, et al., 2014). Camera traps have the advantage of not being occupied after capturing one individual, as in opposite to other kinds of traps (Oliveira-Santos, et al., 2008). This eliminates the problem that the probability of capture decreases due to the reduction of available traps (Oliveira-Santos, et al., 2008). Another advantage of using camera traps is that they prevent habituation to humans. Direct observation of species can habituate the individuals to human presence and dull crucial flight-responses in species that are victims of hunting and poaching (Doran-Sheely, et al., 2007). This should be considered a huge benefit for camera traps, especially when studying species that holds a commercial value, such as the Pallas’s cat. In the case of the Pallas’s cat, the camera traps are more likely to prevent

Use of lures in conservation research

Valeriana

Valeriana extract has been successfully used in several studies where feline predators have been the target (Melovski, et al., 2008; Monterroso, et al., 2011; Monterroso, et al., 2014). When carnivores were presented with a broad range of different lures, valeriana induced rubbing behavior in four out of seven carnivorous species and was the second most effective lure next to lynx urine (Monterroso, et al., 2011). Valeriana also seemed to increase the effect of lynx urine when combined by Monterroso et al. (2011). European wildcat (Felis silvestris silvestris), which could be expected to respond most alike with Pallas’s cat of the tested species, spent on average most time investigating the valeriana sample (Monterroso, et al., 2011). Valeriana was also the only lure that triggered rubbing behaviors in European wildcat (Monterroso, et al., 2011). Although only half of the investigated species spent time interacting with the valeriana (Monterroso, et al., 2011), the general interest in valeriana by the European wildcat suggests that valeriana should be a good attractor for small felines.

Catnip

The effect of catnip on felids is so widely known and well documented that it is commonly referred to as the catnip response. The catnip response is known to consist of four different behaviors: (1) sniffing, (2) licking and chewing with head-shaking, (3) chin- and cheek rubbing and (4) head-over rolling and body rubbing (Tucker & Tucker, 1988). The extent and intensity of the behaviors varies among individuals and species. The active ingredient of catnip is the lactone nepetalactone, which is a cyclic ester and has, beside its intoxicating
effect on felines, been shown to have a strong repellant effect on several species of insects (Eisner, 1964).

Catnip has shown great response in attracting both feral and domestic house cats (*Felis catus*) (Kay Clapperton, et al., 1994). Kay Clapperton et al. (1994) tested several different lures in different constellation on house cats and found that cat nip was a strong attractant and induced full cat nip response in 50% of the cats and most of the remaining cats still showed interest in the cat nip, even if they did not rub, lick or bite the sample. Their result indicate that house cats show interest in cat nip even though they are not genetically determined to respond to it. Other studies including house cats indicates that the response also is independent of sex, age and gonad state (castrated/spayed/intact) (Palen & Goddard, 1966). The cats tested by Palen & Goddard (1966) were tame house cats ranging in age from 6 months to 10 years and the owner of each cat reported similar behavior in the study as to previous exposure to catnip; cats that had earlier responded to catnip did so in the study and vice versa. Palen & Goddard (1966) reported similar results as Kay Clapperon et al. (1994) in the fraction of cats reacting to the catnip; about 50% of cats in both studies displayed a reaction. The cat nip response is found in a broad range of feline species (Tucker & Tucker, 1988). The response has shown tendencies to be species-specific for undomesticated felids (Hill, et al., 1976). Lions seems to be much more receptive to the effect of cat nip than for example bobcats, cougars and tigers (Hill, et al., 1976).

**Auditory lures**

Auditory lures have the advantage of being more stable in all temperatures and weather conditions than for example olfactory lures (Moseby, et al., 2005). As compared to olfactory lures or edible bait, they do not require continual refreshment (Moseby, et al., 2005). Pallas’s cats can be active diurnally but activity levels were seen to increase during twilight and night with activity being more crepuscular than nocturnal (Ross, 2009). Timing is critical when choosing the appropriate time to play an auditory lure. The pattern of activity combined with scat analysis suggests that Pallas’s cats are separating themselves in time from other predators, thus minimizing raptor encounters and potential interference competition by for example red foxes, corsac foxes and grey wolf who all are nocturnal (Ross, 2009), while also timing the period during the day when its prey species are most active. Results also suggested that Pallas’s cats do not hunt during the night; two available, but nocturnal, rodents (Siberian jerboa (*Allactaga sibirica*) and Campbell’s dwarf hamster (*Phodopus campbelli*)) were never found in scats (Ross, 2009; Ross, et al., 2010). This implies that the auditory lures should be played during twilight and daytime to hopefully catch the time of day when Pallas’s cats are active and searching for prey.

**Pallas’s cat vocalization**

No studies on using auditory lures on Pallas’s cats have been conducted, but studies on other felids have been conducted, for example where feral cat vocalization was used as an auditory lure on feral cats, which had positive results (Moseby, et al., 2005). Moseby et al. (2005) also tested both olfactory and auditory lures to compare success rates when trapping feral cats (*Felis catus*). Their result indicated that prey item vocalization (artificial bird twittering in this study) and vocalization of conspecifics (artificial meowing) were equally effective lures and significantly more appealing to the cats than the olfactory lure used (cat urine and feces).
However, the authors discussed that the failure of the olfactory lure could be attributed to the extremely hot weather, which made the smell samples dehydrated and caused them to lose their smell (Moseby, et al., 2005).

**Prey item vocalization**

The most frequently eaten prey by the Pallas's cat population in central Mongolia, based on scat analyses, were Daurian pika (*Ochotona dauurica*), Mongolian gerbils (*Meriones unguiculatus*) and mountain voles (*Alticola semicanis*) (Ross, 2009; Ross, et al., 2010). Selection for pikas was significantly greater in the summer than winter, whereas they ate proportionally more steppe rodents in the winter (Ross, 2009). However, steppe rodents were preyed upon proportionally less than was available in both seasons, and thus the Pallas’s cats were deemed to have a strong preference for pikas (Ross, 2009).

On the Tibetan plateau, the plateau pika (*Ochotona curzoniae*) is a pika species within the Pallas’s cats’ distribution and it is a keystone species of the Tibetan plateau (Smith & Foggin, 1999), why it is fair to assume that the plateau pika and the Daurian pika fill the same niche in their respective distributions. Each species were found to be the main food source for Pallas’s cats in both the Tibetan plateau (plateau pika) (Smith & Foggin, 1999) and central Mongolia (Durian pika) respectively (Ross, 2009; Ross, et al., 2010). Efforts to obtain recordings of either of the two pika species sympatric with the Pallas’s cat was unsuccessful, but Daurian pikas and plateau pikas are described as having a similar alarm call as the American pika (a short, high whistle) (Chapman & Flux, 1990) and the prey item sound chosen for the study is such an alarm call from the American pika.
Material and Method

The animals used in this study were two adult, reproductively active, individuals: one female and one male kept in an all-year around enclosure at the Nordens Ark zoo in Hunnebostrand, Sweden. The female was born on the Jihlava zoo in the Czech Republic and the male was transferred from Port Lynphne in Great Britain. Both arrived to Nordens Ark in the spring of 2011. The pair was introduced to each other upon arrival and has only been separated on a few occasions, for example when the female have had cubs.

One trail camera (Reconyx, HC600 HyperFire Covert Camera) was set up in the Pallas’s cat enclosure on the 24th of November 2015, in order to allow the cats to habituate to the novel object. The purpose of the early introduction was to make sure that recorded interactions with the camera did not depend on the cat’s curiosity towards new objects but interest in the later coming lures placed in connection to the camera. The lures used in the study were placed in a wooden test-box attached to the outside of the enclosure above the camera. The test-box had a drilled hole in the side facing the net to allow for the scent or sound to be administered to the cats.

Smell test

The two olfactory lures were tested from 19th of January to 19th of February in 2016. The two olfactory lures used were valeriana extract oil (Z-aim professional hunting equipment, Valeriana extract olja, 30 ml) and catnip oil (F&T Fur Harvesters Trading Post, Catnip Oil, 30 ml). They were injected into clean sponges inside plastic jars and kept with the lid on in separate plastic bag when not in use. 5 ml of the valeriana oil was used and 1 ml of the catnip oil, as recommended by retailer. The two jars were prepared before the first test day. On the morning of the first test day when an olfactory lure was to be used, the lid was removed from the plastic jar containing valeriana scent lure and the jar was taped to the inside of the test-box, covering the drilled hole and with the sponge exposed towards the enclosure. This allowed the Pallas’s cats to smell the lure but not to reach the lure or the test-box. The lure was left for 24 hours until the camera trap was revisited to collect data from the cameras’ SD-memory card and change the batteries. To clearly see the effect of each lure, there was a 48-hour control period between each lure where the test-box was empty but the camera still taking pictures and data was collected with the same method as during the days with a lure. After the 48 hour of control period has passed, the jar containing the catnip scent lure was applied to the test box in the same way as the valeriana sample and left for 24 hours. This cycle was repeated until each lure had been tested five times.

Sound test

The auditory lures were used from 22nd of February to the 3rd of March in 2016. Two different sound recordings were used in this part of the study. The first was a recording of Pallas’s cat vocalization by David Barclay, studbook keeper of Pallas's cat, in Highland Wildlife Park in Scotland. The second one is a recording of American pika vocalization (Ochotona princeps) by Jeff Rice from Stevens pass, King County in Washington (Audio file copyright 2010, the Western Soundscape Archive at the University of Utah J. Willard Marriott Library (http://content.lib.utah.edu/cdm/singleitem/collection/wss/id/2735/rec/1)).
The sounds were played on full volume from a mobile phone (Samsung Galaxy S3, GT-I8190N, Android version 4.1.2). A manual test was made where the researcher played the Pallas’s cat recording outdoors to estimate the range of the sound by backing away from the source slowly until it could no longer be heard. This test yielded an outdoor range of approximately 13-15 meters which well encompasses large parts of the enclosure.

The sounds were used for a test period of ten consecutive days were one sound was played twice a day on predetermined times (6:00 AM and 6:00 PM) for five minutes and then changed for the next day. The chosen five-minute time periods were once at 6:30 PM and 6:30 AM to match the Pallas’s cats’ diurnal rhythm and expose them to the sounds when they are supposed to be most active in the wild according to Ross (2009). Pictures were collected at 08:00AM every morning while changing batteries and retrieving the phone.

The collected pictures were divided into three groups; (1) during 6:30 AM sound replay, (2) a control period between playbacks and (3) during 6:30 PM playback. Interactions before 6:30 PM were not included in the statistical analysis, since they were deemed not to be relevant to the sound to be played at 6:30 PM. All interactions before that could also be residuals from the 6:30 AM playback before the daily collection of pictures which should not be included in the dataset for the two next playbacks.

The sounds were used for a test period of ten consecutive days were one sound was played twice a day on a predetermined time (6:00AM and 6:00PM) for five minutes and then changed for the next day. The phone was placed in the test box at 3:00PM in the afternoon, set to play the pika vocalization, and the sound was later played at 6:00PM. The phone was then left in the test box overnight and retrieved at 8:00AM the following morning, after the 6:00AM playback of the same lure as the previous night, while changing batteries in the camera and emptying the cameras SD-memory card. The phone was then charged, the Pallas’s cat vocalization was set and the phone was put back in the test box at 3:00PM. This cycle was repeated until both lures had been played ten times each.

**Definition of interaction with lure**

Interaction with lure or camera was defined by pictures of one or both animals in the enclosure showing clear interest in the camera or its immediate surrounding. For olfactory lures, behaviors including sniffing and looking right into or immediately beside/above the camera counted as interactions. Pictures where the individual obstructed large parts or the entire lens counted as an interaction as well as pictures where the front part of an individual e.g. face, head, shoulder or neck area were visible and the cats’ attention was in the direction of the camera as in nose and face directed towards the camera lens (see pictures 1-4 in figure 1). Pictures of the cats’ back parts e.g. hind legs, tail and back was not included as interaction as they often depicted cats’ moving away from or passing by the camera without showing interest of the lure or the camera (see pictures 5-8 in figure 1). For auditory lures, remaining in close proximity of the camera with head lifted and ears perked (interpreted as a listening behavior) also counted as an interaction with the lure. When testing auditory lures, interaction with lure or camera was defined by pictures of aforementioned behaviors only while the sound lure was played and up to 15 minutes after (for a total of 20 minutes per test). Concerning olfactory lures, no such time limitations were used.
Figure 1, pictures 1-4 are examples of pictures not included in the analysis due to not meeting one or more criteria for interaction with camera or lure while pictures 5-8 are examples of pictures included in the analysis.
Statistical analysis
The pictures extracted from the camera were transferred to an external hard drive and the pictures deemed to show interaction with a lure were counted. Both total number of pictures for the specific day and the number of interaction pictures were registered along with information about outdoor temperature, weather and amount of feed given to the cats by zookeepers. Time in minutes before approaching the lure was also recorded for the olfactory lures to explore shyness of the lure or if habituation took place. This measurement is called “latency” in the following results. Mean number of interactions per day was calculated for all four lures and regression analysis was used to determine if number of interactions was dependent on time, decreasing or increasing with number of exposures to the lure. Some anecdotal data was also collected in personal observations, such as aggressive interactions between individuals or other unusual behaviors. When calculating mean number of interactions for each of the lures, the number of interactions with the two playbacks on the same day were summarized to one single test day to be more comparable to the result from the tests with olfactory lures.

A Friedman test was also performed, comparing all four lures to determine if there was any statistical difference between reactions to the different lures and try to find the lure which induced the strongest reaction. The four different lures (catnip, valeriana, Pallas’s cat vocalization, pika vocalization) were used as comparative conditions in the test (columns) and the different test days as subjects (rows) in the test matrix.
Result

During the entire 62 day test period, a total of 63,985 pictures were collected from the camera, 15,557 (24.3%) of them during testing of auditory lures and 48,428 (75.7%) of them while testing the olfactory lures. 1,979 of these pictures (3%) were selected as pictures of interactions with a lure and included in the analysis. Mean interactions with respective olfactory lures for each test day were 79.6 (±70.19 SD) interactions for catnip and 26.2 (±30.28 SD) interactions for valeriana. The regression analysis showed that number of interactions per test day was not dependent on time for catnip ($R^2 = 0.0201$, see figure 2) and number of interactions decreased over time for valeriana ($R^2 = 0.6614$, see figure 3). Mean number of interactions per test day for the auditory lures were 34 for pika vocalization (±61.36 SD) and it also provoked the strongest initial reaction of the two auditory lures with 118 pictures of interaction on the first exposure. Corresponding numbers for the Pallas’s cat vocalization lure was 54 pictures of interaction on the first exposure and a mean number of 18.8 (±24.8 SD) interactions per day for the five test days. Both of the auditory lures showed decrease in number of interactions over time in the regression analysis ($R^2 = 0.31$ for Pallas’s cat lure, see figure 4 and $R^2 = 0.23$ for pika vocalization, see figure 5).

Friedman test

There was no statistical difference in how many pictures were taken when using the different lures ($p=0.26$). Using an $\alpha$ of 0.05 and 3 degrees of freedom ($4-1=3$) the chi-square value was 7.815. Calculating the $x^2$ of the Friedman test using the different lures as treatments and the different exposures of the lure as subjects we get a $x^2$ value of 4.02 and therefore we cannot reject the null hypothesis stating that there is no statistical difference between reactions to the different treatments. Catnip scored the highest mean ranking (3.4) and pika-sound scored the lowest (1.9), valeriana (2.6) and Pallas’s cat sound (2.1) were intermediate.

Differences in latency

The average latency for the catnip scent lure was 512.8 minutes (ca 8.5 h) and 658 minutes (ca 11 h) for valeriana. When plotting the latency over time the initial response and early interest for the two different lures were vastly different. The cats took 1,174 minutes (20.5 h) to investigate the valeriana scent lure the first time they were exposed to it but approached it after 14 minutes the second time, whereas the catnip scent lure gave almost the opposite reaction as they investigated the lure after 222 minutes (3.7 h) after the test box was baited with the lure the first time but not until after 829 minutes (ca 14 h) during the second exposure of the lure (see Figure 6). The valeriana scent lure gave progressively longer and longer latency as the cats were exposed to it more times while the catnip lure maintained low latency (and a fast response) up until the fifth and last exposure to the lure.
Figure 2. Number of interactions plotted against number of exposures to the catnip scent lure.

Figure 3. Number of interactions plotted against number of exposures to the valeriana scent lure.
Figure 4. Number of interactions plotted against number of exposures to Pallas’s cat vocalization lure.

Figure 5. Number of interactions plotted against number of exposures to the pika vocalization lure.
Figur 6 Comparison in latency to approach the two different olfactory lures over time.
Discussion

Auditory lures

Both auditory lures gave a strong response in the tested cats the first time they were played but after the initial reaction there was little to no response at all. There is always a possibility for faults in the equipment and that the lure did in fact not play for various reasons. Even though, it is unlikely since the phone used for playback was checked every day and test calls were made before each day of testing. There is also a possibility that the cats were too far away from the camera to hear the lure while it was playing. This is difficult to disprove but the initial reaction to the sound suggests that the sound was loud enough to be heard at least from the most frequently used part of the enclosure.

A possible explanation for the drop in interest is habituation. It is likely that the cats quickly learned that there was no prey and no rival at the source of the sound and chose to ignore the repeated tests. This will although have to be verified at other locations and with other test subjects. If habituation took place it is not necessarily a reason do discredit the auditory lures but it is important to be aware of this. The lures can still be used in the field but not too long at the same location and with the knowledge that it might only attract each individual once at a site. This could even be preferred in population density estimates if the individuals are hard to distinguish in camera trap data. With the recorded Pallas’s cats’ call it is also important to keep in mind that this study was conducted in the known territory of a reproductively active male with a susceptible female during or immediately after breeding season; the male (which was the one who responded to the recorded Pallas’s cat call) might have been extra susceptible to this kind of stimuli. There was a vast amount of pictures showing the male Pallas’s cat patrolling the fence and the enclosure indicates a high level of activity but comparatively very few interactions with the camera.

The pika vocalization lure induced a very strong reaction in the cats the first time they were exposed to it. This is perhaps not unexpected since prey should be very motivating to approach by a predator. The timing of playback might although be important when conducting this kind of studies. Studies using auditory lures as a way of inventorying wild lions showed that the lions were almost completely unresponsive to auditory lures consisting of prey item vocalizations when they were preoccupied with a carcass (Ogutu & Dublin, 1998). The responsiveness was also highly seasonal as the lions were less prone to react when migratory wildebeest were present, i.e. high prey availability, than when the prey was absent (Ogutu & Dublin, 1998). This could indicate that the response to a prey item lure is dependent on the current state of the individual; a full Pallas’s cat might not respond to a call while a starved one might. Pallas’s cats kept in the park were fed every day during the course of the study and could not be counted as hungry or starving at any point during the trials and this might have affected the result. Since they did show a great deal of interest in the camera and the lure, they probably did it out of curiosity. Since they are not fed live prey they might have been motivated by the outlook of being allowed to hunt something. It is fair to assume that a wild Pallas’s cat is more prone to go hungry, but also be less motivated to waste energy on pursuing a prey when they are full in comparison to the zoo kept individuals. When using prey item vocalization as a lure in field studies on population, estimates might have to take into account that a cat might be too full to approach the lure.
Olfactory lures
As for the olfactory lures, the decrease in interest from the cats was more prominent in the valeriana scent lure than in the catnip scent lure, which gave a more irregular and almost random response with each exposure. This could indicate that the valeriana was interesting at first but less and less interesting as they were exposed to it several times, or that the scent lost its potency over time. The lures were kept in sealed plastic containers in plastic bag when not in use during the four-week long study and were deemed to maintain the smell without being replaced for the entire time. The used lures were supposed to last at least a month in open air according to retailer. The sample was smelled before every application to detect changes or decreases in the smell but nevertheless, critical components of the lure could have evaporated during the course of the study. The valeriana sample showed a decrease in number of interactions with the lure over time. This could be due to the Pallas’s cats habituating the lure or a decrease in smell of the lure.

The lack of the same connection for the catnip lure either indicates that the smell did not decrease over time and that the variation in interaction is due to other factors, or that the cats did not habituate to the smell of catnip. If this study is to be repeated, the sponges could be completely replaced after each use, with that it would be easier to conclude if the failing interest depends on habituation or decrease in smell. The Pallas’s cat could have been shy or intimidated by the olfactory lures. One interesting behavior that was noted was that at the first exposure of catnip it took nearly 24 hours before the Pallas’s cat male showed interest in the test-box. If the cats did not discover the lure or if they avoided the lure is impossible to determine from these data. There is evidence of avoiding behavior towards catnip in other wild felines in other studies. For example, two adult cheetah had to be excluded from a study on the effect of catnip on undomesticated feline species since they would not approach catnip or the experimental equipment (Hill, et al., 1976).

The effect of catnip on Pallas’s cat has actually never been investigated properly but was not found to induce a response in one single tested Pallas’s cat by Todd (1962), as sited by Tucker & Tucker (1988). Since the original article by Todd (1962) can’t be accessed there is no further information on how or where the experiment was conducted. Tucker & Tucker (1988) also found a genetic component of the reaction to cat nip and concluded that the response is inherited with an autosomal dominant gene. This is interesting to keep in mind for this study since there are no sources on whether or not Pallas’s cats possess this gene. Black-footed cats (*Felis nigripes*) were shown to habituate to the smell of catnip when exposed to it on multiple occasions so the authors discussed the possibility that *F. nigris* are not as affected by catnip as other species (Wells & Egli, 2004) and this might hold true for Pallas’s cats as well. Even though the tested Pallas’s cats in this study showed interest in the catnip lure, there were no recordings of any behaviors associated with a strong catnip response, which indicates that these particular Pallas’s cats do not possess the genes that triggers a strong catnip response. It might although be possible that the high location of the test box prevented the cats from rolling and rubbing in the catnip scent and even though these specific cats does not possess the gene, other Pallas’s cats might.
Applying results on wild populations

The Pallas’s cats used in the study was described as tame and social compared to other zoo-kept Pallas’s cat by the zookeepers at Nordens Ark. However, they were also described as shyer and more withdrawn during mating season than in the summer. The fluctuations in the Pallas’s cats’ behavior might have been to the advantage of this experiment since it was conducted during the mating season and the cats withdrawn behavior should more closely resemble the behavior of wild Pallas’s cats.

Studies on coyotes have suggested that some demographics are more prone to approach traps than others (Sacks, et al., 1999). Individuals proved to be more unlikely to be captured in their own territory and transitioning coyotes more often fell in the traps than territorial ones (Sacks, et al., 1999). This was credited to the fact that the coyotes knew their territories well and might avoid a new object in the territory where as a transitional individual could not make that distinction (Sacks, et al., 1999). Even though coyotes have a different social structure than Pallas’s cats, the individual behaviors could be quite similar. Pallas’s cats keep home ranges, they are shy by nature, and it is reasonable to assume that they might react similarly to the coyotes investigated by Sack et. al. (1999).

The alphas coyotes where more often photographed outside the boundaries of their territories which further supports the theory that they were able to avoid the cameras only if they knew they were there beforehand (Séquin, et al., 2003). If they were able to detect cameras by sight or smell they should be able to do it outside their territory as well (Séquin, et al., 2003). Alphas were also observed to track human activity from a distance within their territory unlike individuals of beta- and transient groups and they should by that be more likely to learn the placements of the cameras (Séquin, et al., 2003). It is worth noting that the investigated population of coyotes had been exposed to trapping and capturing for research purposes before this study was conducted and might be extra careful around humans. Pallas’s cats also claim large territories and are described as shy towards humans, and thus we might expect similar response from them and this might explain why capturing them in camera traps so far has been difficult.

Further studies

To improve the results, the lure box should be placed in the line of sight of the camera. The Pallas’s cats seem not to be interested in the camera and placing it further into the enclosure should not be a problem. This would make it easier to interpret the pictures and determine whether the cats actually show interest in the lure or are just passing by the camera or investigating something else in close proximity of the camera. A common way to test effectiveness of different lures are preferences tests where the subject is presented with several options and preferences are recorded. Although this study was not aimed towards finding the preferred lure in a choice, it is about finding the lure that singlehandedly attracts Pallas’s cat best and works the most times.

Lynx urine should probably be the next substance to try using for a Pallas’s cat lure. Lynx urine has proven to be an effective lure on a broad variety of carnivorous species, including feline species such as European wildcat (Monterroso, et al., 2011). Good results were obtained even though the lynx was not a native species for the tested species (Monterroso, et
al., 2011). The scent promoted rubbing and investigating behavior in most of the other tested species in the study and it suggests that the scent of the large predator promotes these kind of behavior in other carnivores (Monterroso, et al., 2011). In its range, lynx is known to kill other species of carnivores (Palomares & Caro, 1999) which motivates the response to be attracted to and investigate the urine to evaluate the threat. Studies also indicate that this response is inherited and exposure to a competitive carnivore attract other carnivores even though the two species never have been in contact with each other (Harrington, et al., 2008). Pallas’s cats are preyed upon by larger, sympatric predators (Ross, et al., 2015) and should show similar attraction if exposed to the scent of such a predator even they are naturally allopatric.

Ross (2009) found that predators sympatric with the Pallas’s cat included grey wolf (Canis lupus), corsac fox (Vulpes corsac), red fox (Vulpes vulpes), Eurasian lynx (Lynx lynx), Siberian polecat (Mustela eversmanni), Marbled polecat (Vormela peregusna) and Eurasian badger (Meles meles) and Pallas’s cats occasionally fall victim to these predators. A total of 17 Pallas’s cats killed by predators were found and post mortally examined during Ross’ (2009) two-year study of the cats, ten were collared cats included in the study, seven were uncollared that were found in the field or by locals. Most of the predation were from raptors, seconded by domestic dogs and third by red fox (Ross, 2009), therefore urine, anal secret or other lures based on scent from dogs and foxes could also be considered in further studies.

Although there might be a chance that Pallas’s cat reacts aversively to the scent of a potential predator and it should be thoroughly tested before experiments are attempted in the wild since Pallas’s cats’ choice of home range seems to be strongly influenced by predation risk. According to (Ross, 2009) Pallas’s cats consistently choose rocky habitats were the prey density is lower than in the steppe habitat but the predation risk also was lower. This indicates that Pallas’s cats adjust their choice of habitat in relation to predation risk and it should be considered a big influence on Pallas’s cat behavior (Ross, 2009). Using predator-scent lures could potentially drive the cats away from their home range. Studies on mustelid communities show that inferior species change their behavior in the presence of larger competitors and show clear signs of avoiding the competitor, both spatially and temporally (Harrington, et al., 2008) which is not a desired effect on the Pallas’s cat. Same study although indicates that even if the inferior species avoid the competitor temporally, it will still be attracted to and investigate the foreign smell, probably to assess the strength of the competitor (Harrington, et al., 2008).
Conclusion

It is hard to recommend a lure to use for attracting wild Pallas’s cats to camera traps based on the results of this study. It could although provide a base and a method for testing lures for future use in field studies. The lure that got the highest score on its first exposure was the pika vocalization and the second highest score on initial exposure was the catnip scent lure. These two are possible candidates for using as camera trap lures in field studies, they are both cheap, easy to obtain and easy to handle in rough terrain but more Pallas’s cats should be tested before drawing any conclusions on the effectiveness of these lures for this specific species.

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