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Abstract

The snow leopard (*Panthera uncia*) is an elusive felid, native to the mountains in central Asia. Basic knowledge about the snow leopards' ecology has long been lacking but is advancing with the help of the GPS-technology. GPS cluster analysis can provide insight in the diet and prey selection of elusive predators, such as the snow leopard. Acceleration data from GPS collars can be used to study animal behavior but the two have never been combined to gain more detailed information of the feeding behavior of large carnivores. In this study reference values for activity loggers were derived by behavioral observations on a captive male snow leopard fitted with a GPS collar. These reference values were used to make interpretations on behaviors of free-ranging snow leopards at their kill sites. In the study a discriminant function analysis was used to (1) test the classification fit of the behaviors from the observed snow leopard with the acceleration data and (2) used the discriminant scores to predict behaviors of GPS-collared snow leopards in the wild using the software R (R 2.12.1 with package MASS). The result showed that behavior explained 83.5% and 94.2% of the variability of the activity data of the observed cat when behaviors where separated into seven and three behavioral categories, respectively. The three behavioral categories were high activity, medium activity and low activity. When predicting behaviors on wild snow leopards at kill sites I found that low activity was the dominating behavior at the kill sites with 85% and 88% for female and male snow leopards, followed by medium activity with 15% and 12%, respectively, and high activity with less than 1% for both sexes. This study suggests that cluster analysis in combination with acceleration data can be a used to get a better understanding of snow leopards behaviors at kill sites. Especially when looking at active and inactive behaviors, however by shortening the time interval for which the activity data is calculated this tool can probably also be used to gain a deeper understanding of the behavior of wild snow leopards.

Sammanfattning

Högt bland bergen i Centralasien lever snöleoparden (*Panthera uncia*), ett av världens mest gåtfulla kattdjur. Arten finns i tolv olika länder i Asien och i dagsläget finns mellan 4000-6600 snöleoparder kvar i det vilda. Den är listad som hotad enligt den internationella naturvårdsunionen, IUCN. På grund av att arten lever i så otillgängliga miljöer har grundläggande kunskap om artens ekologi länge saknats. 2008 startade därför organisationerna Snow Leopard Trust, Panthera och Snow Leopard Conservation Fund, en ny långtidsstudie för att öka kunskapen om arten.

Tack vare GPS teknologi kan man nu utveckla forskningen hos svårstuderade arter som till exempel snöleoparden. Genom att analysera kluster (ansamling av GPS-positioner som befinner sig inom 100 m från varandra) kan man få en inblick snöleopardens diet och val av bytesdjur. GPS-halsband kan också användas för att studera djurs beteende med hjälp av accelerationsdata, där aktivitet mäts som accelerationen i två axlar (framåt/bakåt och höger/vänster), men accelerationsdata och klusteranalys har aldrig kombinerats för att få fram mer detaljerad information om rovdjurs beteende vid deras kadaver. I denna studie tog jag ta fram referensvärden för accelerationsdata genom att göra beteende- observationer på en snöleopard i fångenskap som försetts men en GPS-halsband. Jag använde sedan dessa referensvärden för att dra slutsatser om hur vilda snöleoparder beter sig vid sina kadaver. I studien använde jag mig av diskriminantfunktionsanalys för att (1) testa hur bra beteenden från den observerade snöleoparden stämde överens med aktivitetsvärdena och (2) använda denna information för att förutsäga beteendet hos märkta snöleoparder vid slagna byten i det vilda. Jag fann att beteendet förklarade 83,5% och 94,2% av variationen i aktivitetsdata för den observerade snöleoparden när beteenden var uppdelade i sju respektive tre separata beteendekategorier. De tre beteendekategorierna var hög aktivitet, medelhög aktivitet och låg aktivitet. När jag använde referensvärdet/ena för att tolka beteenden hos vilda snöleoparder vid deras kadaver fann vi att låg aktivitet var det dominerande beteendet och att beteendet skiljde sig mellan honor och hanar. Denna studie indikerar att klusteranalys i kombination med accelerationsdata kan används för att få en bättre förståelse av snöleopardens beteende vid dess kadaver, speciellt avseende aktiva och inaktiva beteenden. Genom att förkorta tidsintervallet för vilket aktivitetsdata beräknas kan man troligen använda denna teknik för att få en fördjupad förståelse av vilda snöleoparders beteende.

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Introduction

The activity patterns of mammals is affected by a number of different factors, including environmental circumstances such as temperature (Gebczynski 2006, Beltran & Delibes 1994), season (Manfredi *et al*. 2011), predator-prey interactions (Clousley-Thompson 1961) and competition avoidance (Hayward & Hayward 2007), but also other factors like reproductive status and the sex of the animal (Schmidt 1999, Kolbe & Squires 2007). Felids are in general considered to be crepuscular and nocturnal by nature (Kitchner 1991) and their activity is affected by availability and activity of their prey (Ferguson *et al.* 1988, Beier *et al.* 1995). However, more detailed knowledge concerning feeding ecology and activity patterns are for many felid species lacking.

The snow leopard (*Panthera uncia*) is a highly cryptic, medium-sized carnivore native to the mountains in central Asia. It is estimated that the global snow leopard population range 4000-6600 individuals (McCarthy *et al.* 2003) and the species is listed as Endangered on the International Union for the Conservation of Nature Red List of Threatened Species (IUCN, 2014) and listed on Appendix 1 of the Convention on International Trade in Endangered Species (CITES). The snow leopard is threatened due to habitat loss, lack of natural prey, poaching and persecution, the latter two mainly as retaliatory killing by herders after attacks on their livestock (McCarthy *et al.* 2010)

Because of the snow leopard's secretive nature and the remote inaccessible habitat it lives in, the species is one of the least studied big cats (McCarthy *et al.* 2005). Basic knowledge on the snow leopards' ecology, habitat use, home range size and seasonal movements has long been lacking as well as population parameters such as birth and mortality rates, cub survival and dispersal rates (McCarthy *et al.* 2010). In order to increase the knowledge about the snow leopard, a long term study was launched in Mongolia's South Gobi Province by Snow Leopard Trust, Panthera and Snow Leopard Conservation Fund in 2008.

Most of the knowledge about snow leopard behavior and activity patterns has been gathered in zoos. The ideal way to study animal behavior is by direct observation. However, in the wild it is difficult to study elusive species, such as the snow leopard, since they move great distances in large inaccessible areas (McCarthy *et al.* 2005). Instead, researchers must use indirect methods, such as GPS-telemetry, to gather the data. Analyses of GPS location clusters can provide insight in the diet and prey selection of elusive predators along with spatial information about the kill sites (Anderson & Lindzey 2003, Sand *et al.* 2005, Knopff *et al.* 2010). In addition acceleration data from data loggers in GPS collars have been used to study animal behavior (Gervasi *et al.* 2006, Löttker *et al.* 2009) and the activity data have also been used to get an insight into the feeding activity of leopards (*Panthera pardus*, Fröhlich *et al.* 2012). However, there is no information on what the values from the data loggers corresponds to in terms of behaviors for most animals. In order to interpret activity data from radio-collared wild snow leopards it is therefore important to establish reference values that can be used to validate which behaviors that correspond to the activity values.

There is a lack of information about how carnivores behave at kill sites. Even though GPS cluster analysis as well as the use of acceleration data from GPS collars are well established in behavioral and ecological studies (e.g. Anderson & Lindzey 2003, Gervasi *et al*. 2006, Löttker *et al.* 2009, Merrill *et al.* 2010), the methods have never been combined to gain more detailed information of the feeding behavior of large carnivores despite the fact that both kinds of data are recorded simultaneously in modern collars. The objectives of this study was to (1) derive reference values for activity logger from collared snow leopards and (2) use these reference values to draw conclusions on behaviors of free-ranging snow leopards at their kill sites.

Material and methods

Study area

Snow leopards in Tost Mountains in the South Gobi province, Mongolia (43°11'N, 100°36'E) have been captured and equipped with GPS collars as a part of a long term ecological study since 2008. The Tost Mountains support a relatively high density of snow leopards (McCarthy 2000), as well as a range of large and medium sized mammals including argali (*Ovis ammon*), Siberian ibex (*Capra sibirica*), grey wolf (*Canis lupus*), red fox (*Vulpes vulpes*), and lynx (*Lynx lynx*). Within the study area approximately 230 semi-nomadic herder families live with their livestock comprising around 40 000 goats (*Capra aegagrus*), sheep (*Ovis aries*), camels (*Camelus bactrianus*), and horses (*Equus ferus caballus*) (McCarthy *et al.* 2010).

Data collection

Snow leopards were captured by placing foot-snares at scrape or scent mark sites. Once caught in the snare the snow leopards were immobilized and fitted with GPS collars (see Johansson *et al.* 2013 for details). In 2010 a new type of collar (Vectronic GPS Plus) was employed in the study. The new GPS-collars have been equipped with a dual-axis motion sensor measuring movements both backward-forward (x-axis) and sideways (y-axis). These collars provide an insight into animal activity by continuously delivering x- and y-values ranging from 0 to 255. The accelerometer takes a reading four times per second and calculates the mean value for each five-minute period. This mean value is stored in the internal memory and can be downloaded when the collar is retrieved.

Behavioral observations

To validate which behavior that corresponds to the activity values a captive male snow leopard at Nordens Ark (Hunnebostrand, Sweden. 58°26'N, 11°26'E) was fitted with the same type of collar (Vectronic GPS Plus).The snow leopards at Nordens Ark had access to three different enclosures and the total size is 1949 m^2. The enclosure is constructed on a mountainside and has quite dense vegetation with deciduous and coniferous trees. The snow leopard was observed using instantaneous sampling where his behavior was recorded every 15 seconds. For each 5-minute period, hereafter called Observation Period, I registered his behavior at 20 observation occasions. To be able to compare the behavioral observations with activity values generated by the GPS-collar, the observation time was synchronized with the internal clock of the collar to assure correspondence between datasets. Observations were made between the 27th January and 14th April 2012. The time for each Observation Session varied between 30 to 140 minutes. I recorded 13 different behavior categories (Appendix 1) on a standardized data sheet. In the end only seven categories were used (Table 1), since I did not get enough observation occasions for the remaining eight behaviors to validate them. Also, see statistical section below for pooling of behaviors into three general behavior categories.

Table 1. Ethogram with the seven defined behavior categories that were used for the behavioral observation of the captive snow leopard male at Nordens Ark.

Behavior	Definition
Sleeping	Lying completely still, head down touching the ground with no movement
Lying down	Lying down, keeping the body still but has a lifted head, moving the head and observing the environment
Lying down preening	Lying down whilst preening the body with its mouth or paws
Territory marking	Marking the territory with scrape or scent marks
Eating	Handling and consumption of prey with mouth parts or paws

Walking	The movement where at least one paw touches the ground at all time
High activity	Running, trotting, attacking or dragging a prey

The timing of the Observation Sessions was selected to obtain as many "pure" Observation Periods as possible, e.g. observations were made when I knew the snow leopard was resting, feeding etc. It was important to obtain pure observations in order to verify as many behaviors as possible. I defined pure intervals as 15 or more observations of the same behavior in the Observation Period (see statistical section below for details). Whole carcasses of rabbits and sheep were provided to the snow leopard to simulate feeding behavior of larger prey items. The Observation Sessions were not interrupted if I obtained mixed behaviors, therefore the data set consisted mostly of pure Observation Periods but also some mixed intervals (see Figure 1).

Cluster visits of wild snow leopard

It is assumed that a cluster of GPS locations close to each other indicated a potential kill (see Anderson & Lindzey 2003 for details of this technique). Clusters are defined as ≥2 locations within 100 m distance of each other. Cluster locations were searched intensively for prey remains and snow leopard signs such as scats, tracks and scrapes. Clusters were not visited until two days after the snow leopard had left the site without returning. Prey species was determined by hair and horns for ibex, goats, sheep and argali and by hair and feet for horses and camels. Sex was only possible to determine for ibex and argali, using shape of horns. Age was estimated by counting horn segments for ibex and argali males >2 years, and from horn length for females and young <2 years, and tooth wear and eruption for all species. All carcasses that were encountered at clusters within the time interval when the clusters were generated are considered to have been killed by the snow leopards.

Statistical analyses

I used a discriminant function analysis to (1) examine the classification fit of the behaviors from the observed snow leopard (i.e. known behaviors) based on acceleration data and (2) used the discriminant scores to predict behaviors of GPS-collared snow leopards in the wild using the software R (R 2.12.1 with package MASS). I ran the discriminant function analysis on all Observation Periods from the observed snow leopard where 15 or more observations occasions were the same behavior (i.e. observations ranging from 15 to 20 observations of the same behavior) (n = 102 of 154 observations in total).

I pooled behaviors to “low activity” (sleeping, lying, lying cleaning), "medium activity” (eating, territory marking), and “high activity” (walking and high activity) for my final analyses because it resulted in better classification fit than when using the seven behaviors separately (see Results). I examined if behaviors at kill sites differed between male and female snow leopards by a chi-square test (R Development Core Team) (n = 85,525 predicted behaviors). I partitioned the data to examine which behavior that differed. Similarly, I examined if snow leopards behave differently at kill sites during day and night by a chi-square test where I performed the analyses separately for each sex (R Development Core Team).

Results

Behavioral observations

I conducted behavioral observations on the captive snow leopard for 12.8 hours, which is 154 Observation Periods (5-minute period). During the Observation Periods 13 different behaviors were recorded. The maximum number of different behaviors per Observation Period was eight. Fifty seven % (n=88) of the Observation Periods consisted of one (n=52) or two behaviors (n=36) (Figure 1).

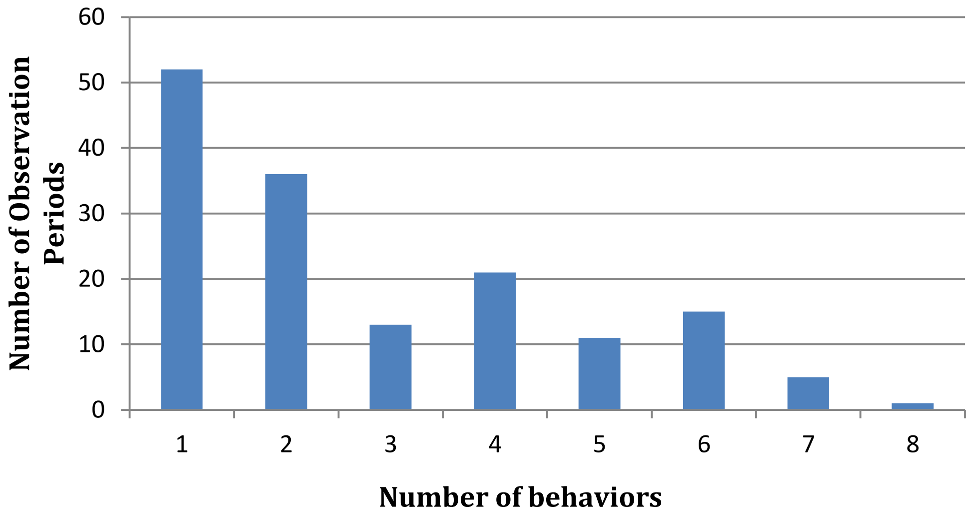

Figure 1. The number of behaviors per Observation Period for a captive snow leopard male in Nordens Ark equipped with a GPS collar. Observation Periods lasted five minutes and consisted of 20 observation points. Timing of observations was selected to minimize number of different behaviors per Observation Period and obtain Observation Periods with as few behaviors as possible.

The majority, 66 % (n=102), of the Observation Periods consisted of pure observation periods (Figure 2).

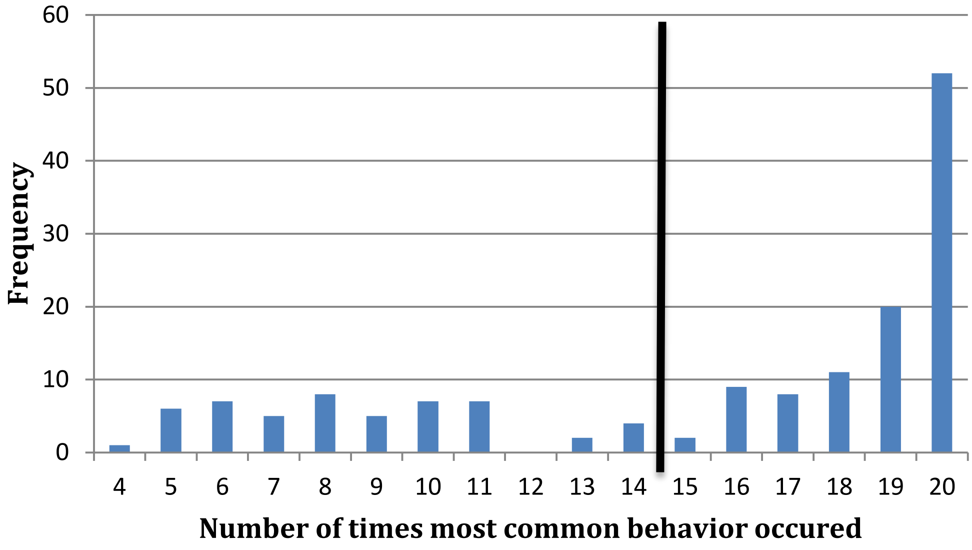

Figure 2. The number of times the most common behavior in the Observation Period occurred for a captive male snow leopard in Nordens Ark equipped with a GPS collar. Pure observations are on the right side of the vertical line. Pure observations periods are classified as 15 or more observations of the same behavior in the Observation Period.

Discriminant function analysis showed that behavior explained 83.5% and 94.2% of the variability of the activity data of the observed cat when behaviors where separated into seven and three behavioral categories, respectively (Figure 3, Figure 4).

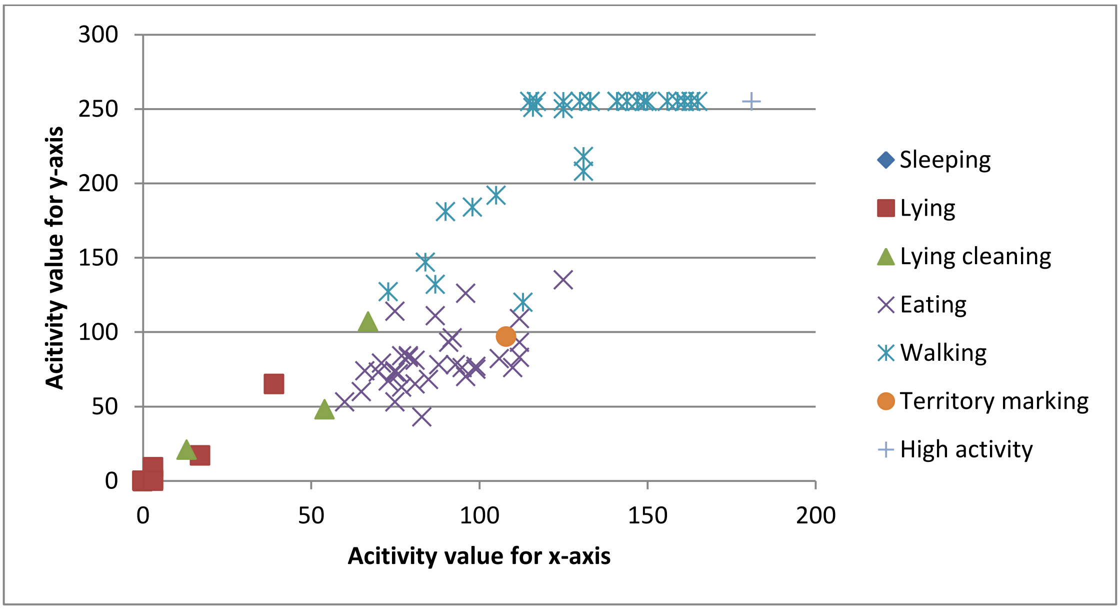

Figure 3. Activity logger values obtained from GPS collared snow leopard male at Norden Ark. Values range from 0-255 where higher values represents more movements. The values on the x-axis represent movements' backwards-forwards, y-axis represents sideways movements. The plot displays the activity values for seven different behaviors obtained from observations of the snow leopard. The values for sleeping (blue diamonds) were close to zero for both the x and y-axis and are hidden behind the symbols for lying (red squares) in the figure.

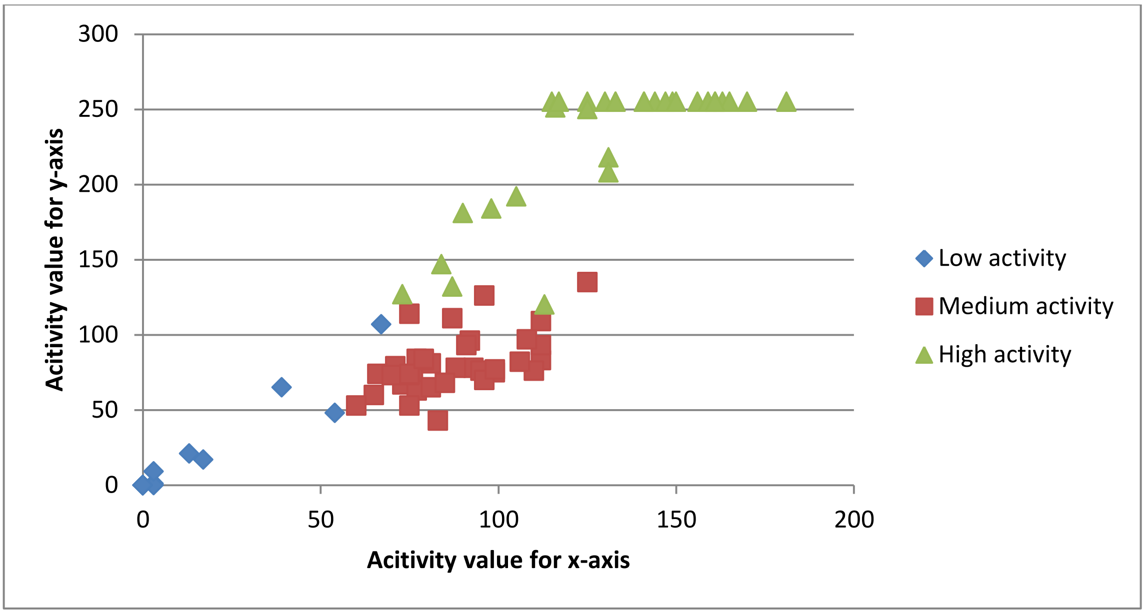

Figure 4. Activity logger values from obtained from a GPS collared snow leopard at Nordens Ark. Values range from 0-255 where higher values represents more movements. The values on the x-axis represent movement's backwards-forwards, y-axis represents sideways movements. The plot displays the activity values for seven behaviors pooled into three behavioral groups.

Field data

In this study acceleration data from 98 clusters containing prey remains (kill sites) were used, from six different collared snow leopards (n = 51,183 predicted behaviors from three females and 34,342 predicted behaviors from three males). Behaviors at kill sites varied between female and male snow leopards ($\chi2_{(2)}$ = 226, P < 0.001): low activity was the dominating behavior at kill sites for both female and male snow leopards with 84% and 88%, respectively, followed by medium activity at 15% and 12%, respectively, and high activity at less than 1% for both sexes (Table 2, Figure 5, Figure 6).

Table 2. Behavior displayed at kill sites for collard wild female and male snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity.

Behavior	Females (n = 51,183 predicted behaviors)	Males (n = 34,342 predicted behaviors)
Low activity	84 %	88 %
Medium activity	15 %	12 %
High activity	1 %	0 %

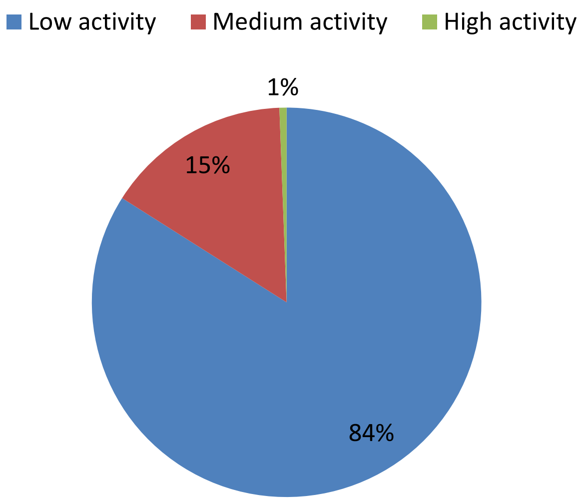

Figure 5. Behaviors displayed at kill sites for collard wild female snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity (n = 85,525 predicted behaviors).

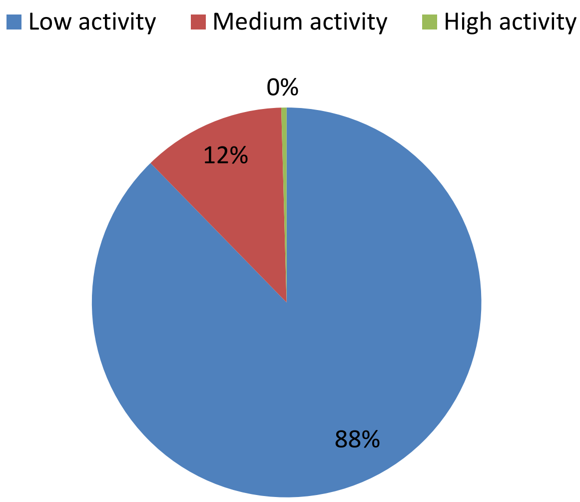

Figure 6. Behaviors displayed at kill sites for collard wild female snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity (n = 85,525 predicted behaviors).

Behaviors at kill sites differed between day and night for female snow leopards ($\chi2_{(2)} = 39$, P < 0.001, Table 3, Figure 7) (n = 51,183 predicted behaviors). There was a similar trend for male snow leopards although not significant at the 0.05 level ($\chi2_{(2)} = 5.32$, P = 0.069, Table 3, Figure 8) (n = 43,342 predicted behaviors).

Table 3. The difference in displayed behavior between night and day for collard wild female and male snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity.

Behavior	Females (n = 51,183 predicted behaviors)		Males (n = 34.342 predicted behaviors)	
	Day	Night	Day	Night
Low activity	84%	83%	87%	88%
Medium activity	15%	16%	12%	11%
High activity	0%	1%	0%	0%

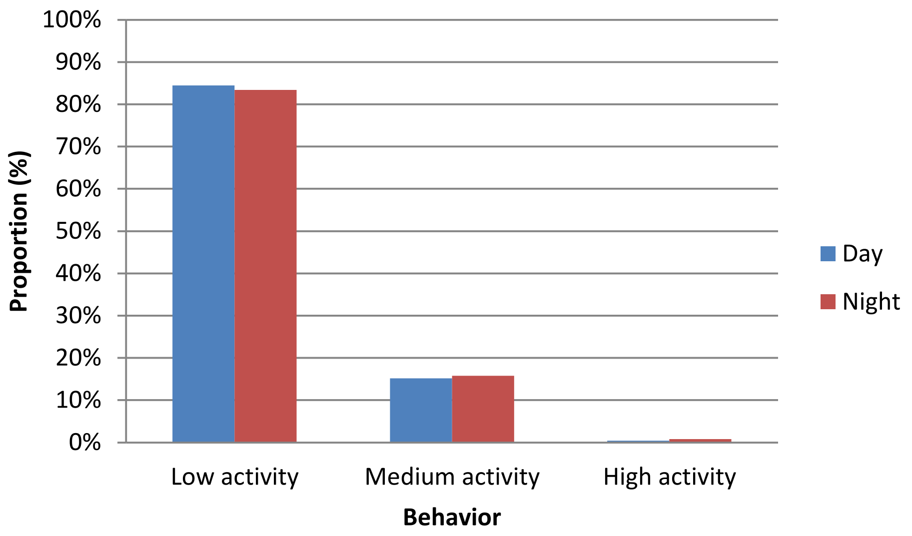

Figure 7. The differences in displayed behaviors during night and day for collard wild female snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity (n = 85,525 predicted behaviors).

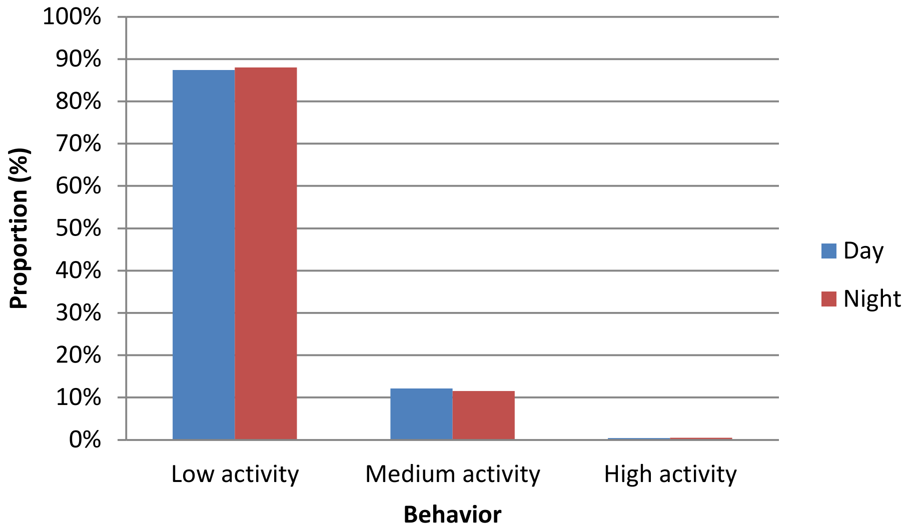

Figure 8. The differences in displayed behaviors during night and day for collard wild male snow leopards in the Tost Mountains in the South Gobi Province. The behaviors were pooled into the larger behavioral categories low activity, medium activity and high activity (n = 85,525 predicted behaviors).

Discussion

In this study, I showed that it is possible to develop reference values for activity loggers from snow leopards. I also found that the reference values appears to provide insight into snow leopards activity patterns at their kill sites, and determine duration and frequency of activities such as low (e.g. resting) and medium activity (e.g. feeding).

Behavioral observations

In this study I acquired detailed information on a captive snow leopards' activity by GPS-collars with acceleration sensors. My analyses showed that the technique was reliable in identifying the activity status of the snow leopard, especially when pooling data into the broader behavioral categories low activity, medium activity and high activity. Similar results have been shown in studies on a variety of species. For example Gervasi *et al.* (2006) found good correspondence between the observed activity in captive brown bears and the acceleration data in the collars. The study could discriminate between active and passive behaviors on brown bears with 94.3% classification fit. In another study on red deer, Löttker *et al*. (2009) showed that they could differentiate resting from feeding/slow locomotion and the latter from fast locomotion with 93 % fit. Even though the result in our study showed an overall high percentage of correctly assigned snow leopard behaviors there are some methodological problems to the behavioral study. Since the activity data are mean values for a five-minute period it means that to get a correct classification fit the snow leopard has to do the same behavior for an extended period. This may not be relevant for high activity behaviors for snow leopards. Löttker *et al.* (2009) mentioned this problem in their study on red deer but also stated that for a species like the red deer this is less of a problem since the species behave relatively constant over time periods of five minutes and usually stays within a behavioral category for a longer period. This is however not the case for high activity behaviors for snow leopards since the species appears to perform these behaviors for a relatively short time as illustrated by the captive male never performing high activity behaviors' for five minutes. This is problematic because within the five minute period a number of different behaviors will occur and thus mixing different activity values. This is a technical problem which could be solved by shortening the time interval for which the activity data is calculated. During the study period I performed behavioral observations when I knew the snow leopard was most likely resting, eating etc. to get as many observation periods as possible with the snow leopard only performing one behavior and yet I still only managed to obtain 52 pure observation periods out of 154. So even though other studies on species like red deer and roe deer (Löttker *et al.* 2009, Heurich *et al*. 2011) only used observation periods consisting of one behavior to get a high classification fit I choose to use periods where 15 or more of the 20 observations points where the same behavior. This might lead to some classification errors where most of them are likely to occur in the behaviors that fall into medium active behaviors because, mixing of high activity and low activity will result in values that fall within the medium activity range. Another problem also mentioned by Löttker *et al.* (2009) is the fact that the behavioral studies where made on animals in captivity. It might be that the behavior of a snow leopard in captivity differs from the behavior of a snow leopard in the wild. I tried to get as natural behaviors as possible by for instance only feeding with whole carcasses to stimulate natural feeding behavior. However, the behavior "walking" was obtained when the captive snow leopard was pacing back and forth on an eight meter stretch. This is a stereotypic behavior which is repetitive (Odberg 1978) and may differ from a cat walking in the wild. Even though the snow leopard was walking constantly the acceleration sensors might be affected by the snow leopard going back and forth. Finally the result is based on the behavioral observations of only one individual which makes the data skewed so further observations of activity on more individuals should be performed to improve the predictive power of the values. However, I suggest that this technique is sufficient for creating a reference value for snow leopards, but the method is species dependent, so it is not possible to apply the values to other felids.

Field data

This study is one of the first to look at how a large felid, such as the snow leopard, behave at a kill site without direct observation. By using the reference value I created from studying a captive snow leopard I was able to gain information of behaviors at their kill sites. I found that low activity was the dominating behavior at the kill site and that the behavior differed between male and female snow leopards. Specifically, this study showed that the snow leopards spent a majority of the time resting, 88 % for males and 84 % for females, and the rest of the time was spent on medium activity. I believe that medium activity in this case corresponds to feeding. An earlier study from Tost Mountains showed that snow leopards normally stay 3-4 days at their kill sites and, that they stay very close to their kills, with a mean distance from the kill of 43-60 m (Grönberg 2011). This is in contrast to other carnivores, like the Eurasian lynx, which move away from the kills between visits with a mean distance from the kills ranging between 1254-1810 m (Falk 2009). As mentioned earlier, classification errors are most likely to occur for medium activity behaviors like eating, because a mixture of low and high activity will result in values that fall within the medium activity range. So for a species like the lynx it would therefore be more difficult to get a good classification fit for eating since they will most likely display a lot of other behaviors in between feeding bouts (e.g. walking between kill and rest sites). However, the snow leopard do not move away from their kills between visits or drag them a great distance (Grönberg 2011), which supports my results that the snow leopard spend most of their time either eating or resting at the kill site. My results show that the females spent less time resting and more time doing medium activity behaviors compared to the males. They also show that the females were more active during the night. These results may suggest that females are more cautious during the day and therefore spend more time being active during the night. One could suggest that the females spent more time eating to be able to leave the kill site faster and go to a secure area but studies have shown that the time spent at the kills does not differ between male and female snow leopard (Grönberg 2011). Some of the collared females had cubs during the study that probably came with them to the kill sites. The higher percentage for medium activity for females might not mean that the females actually ate more than the males but instead may result from the fact that females with cubs were more active at the kills, while solitary males either ate or rested. Further research has to be conducted on the topic to be able draw further conclusions.

GPS radio collars have increased and improved the overall knowledge of carnivores living in remote areas (McCarthy et al. 2005) and for many carnivores helped answer basic ecological questions like prey selection, predation rate and so on. A common approach to estimate predation patterns of carnivores is to identify and visit kill sites by GPS cluster analysis. This method often demands extensive field work during a long period of time (Anderson & Lindzey 2003, Sand et al. 2005). Studying snow leopards in the wild is extremely difficult and time consuming due to the inaccessible areas they inhabit (McCarthy & Chapron 2003). Using activity data to gain insight in predation patterns could act as a complement to cluster visits in the future. For example, studies on Eurasian lynx have shown that it may be possible to detect the presence of a kill by analyzing the activity data in combination with the information from GPS positions. These studies primarily looked at the differences in activity between the days with and without consumption of a prey (Fröhlich et al. 2012, Podolski et al. 2012). Further observation studies to derive reference values for snow leopards can help to discriminate between kill sites and non-kill sites for wild snow leopards which will greatly reduce the time effort required for searching for a prey in the mountains. Using existing data from cluster visits and combining them with activity data should allow researchers to develop a model that can discriminate between kill sites and non-kill sites. Such a model could prove extremely useful to investigate predation patterns in more remote areas since cluster visits could be minimized to the number required to determine proportion of species killed.

In summary, the results suggest that using cluster analysis in combination with acceleration data from GPS collars can be a great tool to get a better understanding of snow leopards activity at kill sites. Especially when looking at active and inactive behaviors but by shortening the time interval for which the activity data is calculated, this method can probably be used to gain a deeper understanding into the behavior of wild snow leopards that is not limited to their behaviors at kills but for general activity patterns. In addition,knowledge on how snow leopards behave at their kills is important not only to increase the knowledge of snow leopard behavior in general but also to improve the welfare and care of snow leopards in captivity. For example, knowing how wild snow leopards behave at their kills will help to establish correct feeding routines for captive snow leopards that are based on behaviors of wild snow leopards and how long time they spend feeding versus performing other behaviors.

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Appendix 1. An ethogram with the 13 behavior categories that were defined for the behavioral observation of the captive snow leopard male at Nordens Ark.

Behavior	Definition
Sleeping	Lying completely still, head down touching the ground with no movement
Lying down	Lying down, keeping the body still but has a lifted head, moving the head and observing the environment
Lying down grooming	Lying down whilst grooming the body with its mouth or paws
Sitting	Sitting down, with straight forelimbs, keeping the body still and moving the head and observing the environment
Sitting down grooming	Sitting down whilst grooming the body with its mouth or paws
Standing	Standing with all four pawns on the ground with the body still, moving the head around and observing the environment.
Standing grooming	Standing whilst grooming the body with its mouth or paws
Walking	The movement where at least one paw touches the ground at all time
Eating	Handling and consumption of prey with mouth parts, or paws
High activity	Running, trotting, attacking or dragging a prey
Playing	Interacting and pouncing with conspecifics in a playful way
Drinking	Standing or sitting down while bending head forward and drinking water
Territory marking	Marking the territory with scrape or scent marks