Home Range Characteristics and Conservation of Pallas' Cat in Mongolia

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Abstract

The Pallas' cat *Otocolobus manul* is a small felid endemic to Central Asia. Throughout its range, Pallas' cat is under threat from habitat fragmentation, hunting and vermin control programs. Our knowledge of the status of Pallas' cat is limited by our poor understanding of its ecology in the wild; this deficiency also prevents us creating priority based conservation programs for the species. Here we outline preliminary findings on the home range behavior of six Pallas' cats in Mongolia. We speculate on the meaning of the data in terms of the ecology and conservation of Pallas' cats.

Introduction

The Pallas' cat *Otocolobus manul* is a small-sized felid distributed in uplands, hilly areas, grassland steppe and semi desert regions of Central Asia. Its distribution coincides with regions that experience large changes in annual and daily temperature, dropping as low as -40°C, and where deep snow cover does not accumulate. The habitat of the Pallas' cat is also typified by the presence of pikas *Ochotona spp.* and other small rodents, which constitute the bulk of its prey (Heptner and Sludskii, 1992). Morphologically, Pallas' cat has been said to represent the most complete and advanced expression of the feline type. Features such as a long fluffy coat, short spherical skull, large eyes and small, widely set ears, distinguish *O. manul* from other felid species (Heptner and Sludskii, 1992).

The Pallas' cat is currently threatened with extinction throughout its natural range in Asia primarily due to habitat loss, hunting for the fur trade, and vermin control programs that result in depletion of its prey base and direct poisoning (Nowell and Jackson, 1996). Recent concerns about the status of Pallas' cat in the wild have led to a closer examination of factors affecting reproduction in the captive population (Brown et al 2002), and to the first wild study, which investigated the reasons behind the extreme susceptibility of captive kittens to toxoplasmosis (Brown *et al,* 2004 in prep).

Similar to much of our current knowledge concerning the natural history of carnivores in Central Asia, our understanding of Pallas' cat ecology is drawn largely from anecdotal accounts. Yet understanding its ecology is essential if we are to understand the role Pallas’ cats play within mammal assemblages and prioritize current threats to its conservation in the wild.

In this study we describe Pallas’ cat home range size and characteristics in the grassland steppe of Central Mongolia. We relate our preliminary findings to current conservation issues regarding the species and speculate on the meaning of the data.

Methodology

Study Site

The study was conducted in Central Mongolia, approximately 100 km southwest of the Mongolian capital, Ulaanbaatar (fig. 1). The study site spans 600 km^2 and is characterized by undulating grassland steppe (47° 24’ N, 106° 03’ E). The area is about 20 km south of Hustain Nuruu Nature Reserve where the mean January temperature is -25°C (down to -40°C), and the mean July temperature is 20°C (up to 36°C). The average annual rainfall is 270 mm, most of which falls in the summer (Dierendonck and Wallis de Vries, 1996).

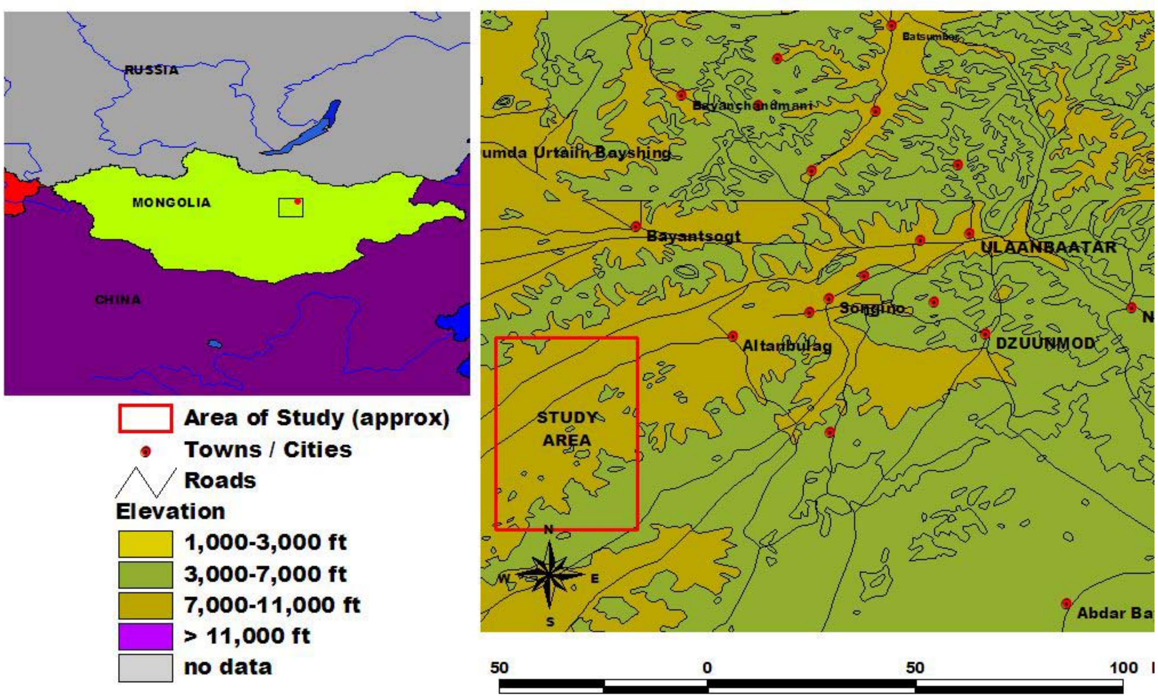

figure 1: Showing Mongolia on the left with the area indicated by the box enlarged on the right, the study area is the area enclosed in the red box approximately 100 km southwest of Ulaanbaatar.

Capture and Radio-tracking

For capture, one to two observers scanned the study area for Pallas' cats using a spotting scope. When sighted, the cat was followed until it sought refuge underground. The underground den site was then excavated. Pallas' cats were manually restrained when found and anesthetized (ketamine hydrochloride; 15 mg/kg body mass; im) by hand syringe. A total of 16 cats were sampled using this method over a period of roughly 100 days (7 adults and 9 juveniles). In two cases, the cat did not receive any anesthesia and radiocollaring was achieved with manual restraint only. These two cats were recaptured at a later date for sample collection .

While under anesthesia, cats were weighed and measurements of total body length, tail length, chest girth, neck girth, right tarsal length, shoulder height, right ear, skull length, and skull width were taken (Kitchener pers. comm.). Biological samples were collected for a concurrent disease study (Brown *et al,* in prep), and tissue sampled for future genetic analysis. A total of fifteen cats were immobilized and measured in this manner. Six cats (2 males, 4 females) were fitted with external antenna radio collars (Advanced Telemetry Systems, Inc., Isanti, Minnesota) weighing less than 3% of the cat's body weight. When fully recovered from anesthesia (after about 2 hours), cats were released close to their point of capture. Re-location of radio-collared cats was facilitated by ground telemetry and global positioning systems (GPS), using triangulation to estimate fixes or, when sited, the distance and direction to where the cat was first sighted was estimated.

Data Analyses

Pallas' cat locations were estimated from 3-4 bearings using the Maximum Likelihood Method (Lenth, 1981) within Locate II software (Nams, 1990), and then converted into Universal Transverse Mercator units in meters (UTM) for home range analyses. Data were entered into and edited using Arcview 3.2 (ESRI, Redlands, CA, USA) Geographic Information System (GIS). Outlying locations and locations that appeared inconsistent with the readings taken immediately before or after were deleted. Two techniques were used to quantify home range area: minimum convex polygons (MCP; Mohr, 1947) and the fixed kernel method, implementing least squares cross validation, which objectively determines the best fit of the model to the data (Worton, 1989). The Estimators were generated using Animal Movement Extension within ArcView 3.2 (Hooge and Eichenlaub, 1999). The distance of each location from the cats arithmetic mean home range centre was calculated using Spider Diagrams (Hooge and Eichenlaub, 1999). Home range overlap between cats was measured using the 100% MCP. The 100% MCP was also used to interpret and compare home range size. The use of MCPs was justified because of the low sample size and temporally clustered nature of fixes that resulted in autocorrelation of results (Swilhart and Slade, 1985), which are not suitable for accurate analyses using kernel methods that generally require larger samples with a more even distribution to maintain accuracy (Seaman and Powell, 1996).

Pallas' cat home range was graphically compared with 21 other felid species by plotting their $\log^{10}$ home range (km^2) verses $\log^{10}$ weight (kg). The data was obtained from radio-tracking studies and mostly compiled from recent reviews. Additional data was obtained from individual studies when this was the only available source.

Results

Home Range

Between the months of December 2000 and October 2002 six Pallas' cats were radio-tracked for between 112 and 636 days (table 2).

				Home range Estimator (km^2)				
ID	Sex	N	Time (d)	MCP 100	MCP 95	MCP 50	FK 95	FK 50
3	F	74	636	168.7	125.7	11.0	58.4	9.6
7	F	39	174	8.8	5.3	0.7	8.1	1.1
9	F	35	174	8.9	6.3	1.1	8.6	1.2
12	F	25	194	93.3	90.1	1.1	70.7	8.6
16	M	18	112	58.5	n/a	1.4	116.0	16.7
71	M	30	469	187.2	156.7	32.2	384.8	88.0

table 2: Individual home ranges (km^2) of Pallas cats using 100% (MCP 100), 95% (MCP 95), and 50% (MCP 50) minimum convex polygon, and fixed kernel estimators 95 % (FK 95) and 50% FK 50 within the study area. Showing sex, number of fixes used for estimates (N), and the time elapsed to gain N.

Fixes were collected for female 7 between Jun. and Dec. 2001. She had a very centralized home range of 8.8 km^2. Locations were on average 927 m and a maximum of 2735 m from the cats arithmetic mean home range centre. Female 9 was tracked over the same time period as 7 and had a similar home range size of 8.9 km^2. Similar to 7, locations never strayed far from the home range centre, averaging 1016 m, with a maximum of 2792 m from the centre. Cat 7 and 9 had adjacent home ranges with an overlapping area of 1.83 km^2, which amounted to 21% overlap in both cats home range. There was no overlap of 50% core areas. Both cats 7 and 9 had kittens during the radio tracking period; both cats died the following winter.

Females 3 and 12 had different home range characteristics than females 7 and 9. Female 3 was tracked between Dec. 2000 and Sep. 2002. Her gross MCP home range was 168.7 km^2. Her home range centre shifted between the two years, moving northeast 5.8 km from year 1 to year 2. Home range covered 14.1 km^2 during the second year (Dec. to Sep.) and 37.8 km^2 in the first year using the same period of coverage. However, when measured for one full year (Dec. 2000 to Dec. 2001) female 3's home range equaled 165.7 km^2, indicating that most range expansion occurred between September and December. Fidelity to a home range centre was weaker in the first year than in the second, locations were on average 3312 m +/- 3078 m from her home range centre in the first year and 1543 m +/- 1062 m in the second. Female 12 had a similarly large home range of 93.3 km^2, measured between Mar. and Sep. 2002. She had low fidelity to home range centre with locations on average 3302 m +/- 3596 m from the arithmetic mean centre. There was no evidence that female 12 had kittens during the radio-tracking period. Female 3 also did not have kittens during the first year of tracking but we are less certain of her status during the second year.

Small core areas were common to all females. Females 7, 9, 3 and 12 had 50% MCP core areas of 0.7, 1.1, 12.9 (1^{st} year), 2.5 (2^{nd} year) and 1.1 km^2 respectively, showing females had a fidelity or preference for an area despite, in some cases ranging widely.

Two male cats were also radio-collared. Male 71 had the largest measured home range of our sample at 187.2 km^2, though this was over a long time period (469 days). Home range measured 29.0 km^2 in the first year from Dec. 2000 to Dec. 2001 and 123.2 km^2 for the 5 month period from May 2002 to Oct. 2002. However, we believe that male 71 ranged more widely during the first year because he was frequently undetectable within the core study area, leaving some uncertainty of the true extent of this male's range. Sample size for male 16 was low (n = 19) and the period of sampling short. His home range equaled 58.5 km^2, measured between Apr. and Aug. 2002. Over the sampling period cat 16's home range shifted 18.9 km southwest, perhaps filling a vacant territory or moving to richer foraging grounds.

Discussion

The home range data collected in this study had many limitations. These included sampling periods that were short, temporally clumped, autocorrelated data with poor coverage and a small sample size. While the data give good indication of real patterns and allow us to form hypotheses regarding Pallas' cat ecology, the limitations reduce the strength of the inferences we make. Home range size presented here was large for a 3-4 kg carnivore. However actual home-ranges, if anything, were probably slightly larger than reported. This is due to the relationship whereby home range size, calculated using MCPs, generally increases with sample size (White and Garrott, 1990), home range asymptotes were also not reached for any of the sampled cats. Moreover, collared cats could not always be located, indicating they were either outside of their assumed ranging area or possibly in a location where the collar signal was blocked by terrain. Thus, home-range sizes were most likely underestimated, although less so for estimates based on numerous fixes.

In order to appreciate the relative size of Pallas' cat home ranges indicated by our data, figure 2 shows the relationship between body mass and home range size in twenty-one other felid species for which data are available. The graph shows that Pallas' cats have an unusually large home range to body mass ratio and are outliers to the general trend in felid species. Other cats that deviate substantially from the trend include Canadian lynx *Lynx canadensis* and the European lynx *Lynx lynx*. The general trend shown ($r^2 = 0.72$, $P < 0.0001$ including the out-lying cats and $r^2 = 0.89$, $P < 0.0001$ not including outliers) exists because home range size generally varies with body size and is influenced by energetic requirements (Lindstedt *et al,* 1986). It has also been suggested that for an animal of a given size, home range area is constrained both by the need to obtain resources sufficient for survival and by decreasing gains relative to costs associated with larger home ranges (Kelt and Van Vuren, 2001). Given these natural constraints, one must question why Pallas' cats have large home ranges and what the consequences of large home ranges are, if they are a consistent ecological feature of the species.

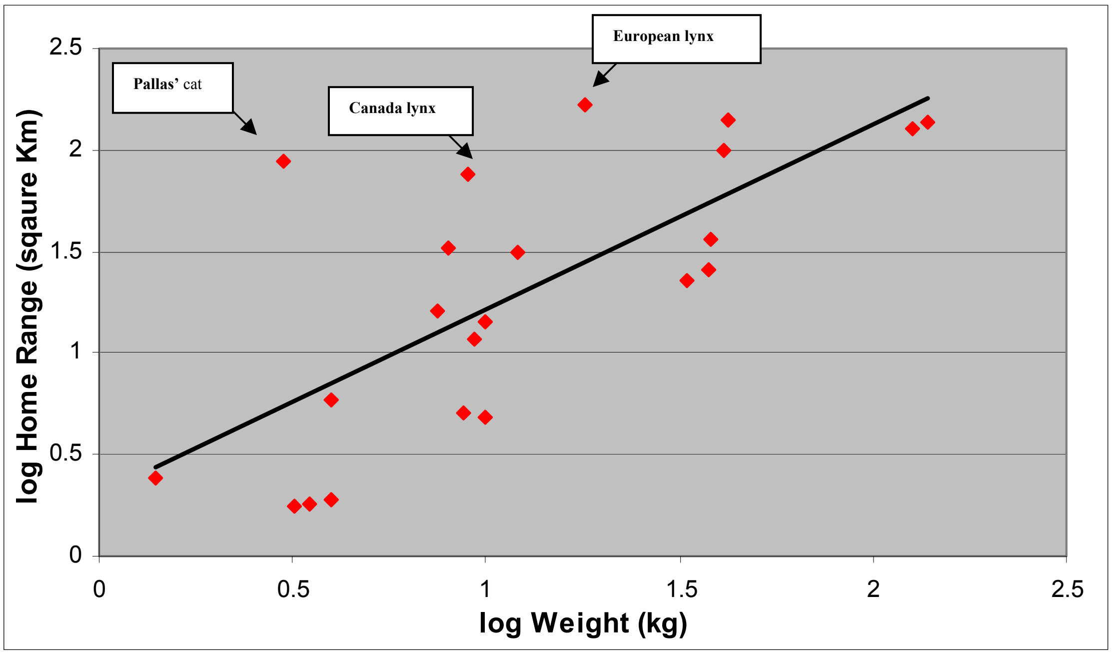

figure 2: Graph of log[10] home range (km^2) vs. Log[10] mass (kg) of 22 cat species for which data are available and including a linear trendline (y = mx + b) as a reference (Nowell and Jackson, 1996; Sunquist and Sunquist, 2002; Dunstone *et al*, 2002; Grassman, 2003). The arrows show the position of Pallas cat, Canadian lynx and European lynx on the graph.

One possible explanation for the large home ranges in this study is that it is an exception and not representative of Pallas' cat ranging patterns. Species generally have local behavioral adaptations to suit area specific conditions and ecology. For example, Canadian lynx have recorded home ranges between 3 and 783 km^2, but mostly have ranges around 75 km^2 (Sunquist and Sunquist, 2002). Macdonald (1983) argued that variation in home range within carnivore societies can be explained by the dispersion of resources, especially food resources. Prey induced changes in home range behavior have been shown in several mammalian predators, including coyotes (Mills and Knowlton, 1991), Canadian lynx (Apps, 1999), and red foxes (Macdonald, 1981), among others. Thus, in areas with a greater prey density Pallas' cat may well have smaller home range requirements, more typical of a carnivore of its size. Indeed, previous estimates of Pallas' cats' home range have been smaller. Heptner and Sludskii (1992) cited the cats range at around 0.8 to 3.1 km^2 on the Selenga River, Russia, however the estimate was based on observational data and the authors acknowledged that the true figures remained unknown. It is very possible that we sampled a population with unusually large home range, in response to low prey density or other factors. However, lack of information means it is currently hard to assess whether our study site represents a good or poor Pallas' cat habitat in terms of prey resources. Information is similarly unavailable for most of the geographical range of Pallas' cats.

As well as prey density, other factors are known to affect ranging patterns in carnivores and may well influence Pallas' cat movements and home range. These factors may include the distribution of snow in winter and the distribution of humans. Pallas' cats are known to be limited by an inability to negotiate deep snow conditions (Heptner and Sludskii, 1992), the distribution of snowy conditions may therefore affect their winter ranging patterns. Indeed, preliminary data indicate that activity times of Pallas' cats are reduced during months with snow cover. Human distribution may also affect Pallas' cat home range because people have historically hunted them. Much of the Pallas' cats range is inhabited by nomadic peoples who move seasonally, Pallas' cat may alter their home range in avoidance of seasonally settled areas.

Interspecific competition between sympatric carnivores can also determine ranging patterns. Interspecific competition occurs when individuals of different species use the same resource, i.e. when there is an overlap in a niche dimension, and supply of that resource is limited (Connell, 1983). Competition may occur due to the sharing of limited resources or be the result of the temporal or spatial avoidance of a dominant guild member causing a reduction in foraging efficiency by exclusion from rich foraging patches (Durant, 1998; Linnell and Strand, 2000). Pallas' cats may experience competitive interactions with other sympatric carnivores, such as the corsac fox *Vulpes corsac*, red fox *V. vulpes*, Eurasian badger *Meles meles*, steppe polecat *Mustela eversmannii*, mountain weasel *M. altaica* and a number of raptors (Mallon, 1985). Red and corsac foxes were frequently observed in our study area.

However, large home ranges were not the only documented patterns. Females 7 and 9 both had relatively small central placed home ranges. This may be partly due to most fixes occurring in the more productive summer months when there may be less need to travel to locate prey, but is also a likely consequence of both females having kittens during the radio-tracking period. Restricted ranging patterns of lactating females have been documented in cheetah *Acinonyx jubatus* (Laurenson, 1995), Eurasian lynx *Lynx lynx* (Breitenmoser *et al,* 2000) and the Iriomote cat *Prionailurus bengalensis iriomotensis* (Krzysztof, 2003), and is a pattern associated with concealing and repeatedly returning to care for young. The decrease in range size is accompanied by an intensification of range use in order to meet the high energy demands of lactation (Laurenson, 1995; Krzysztof, 2003). However, one cannot question that the ability to find sufficient prey in a smaller area than that of normal use is likely to be compromised, unless habitat is strongly selected. This may make mothers and kittens more sensitive to disturbances that affect prey density, such as that posed by rodenticide applications. Alternately, if breeding habitat is strongly selected, the availability of habitat could be a limiting factor on population growth, particularly if rodenticides were to reduce the quality and quantity of available breeding habitats.

Other conservation concerns emerge from our preliminary home range data. Woodroffe and Ginsberg (1998) found that wide ranging carnivores are more vulnerable to threats and susceptible to habitat loss and degradation. This is mainly because ranging behavior mediates contact with human activity, which often accounts for mortality in carnivores. Having a large home range also means living with a greater probability of disturbance within the area of utilization and in the event of habitat protection, less chance that entire home ranges will be protected resulting in greater vulnerability to edge effects.

Small body size creates other potential limitations to Pallas' cat resilience when coupled with large range size. Natural and anthropogenic disturbances can, to some extent, be counteracted by range expansion in many species, which facilitates an increase in the resource base available to them (Macdonald, 1983). However, if Pallas' cats are subsisting near to their metabolic limit, as suggested by their large home range to body mass ratio, then energetic constraints may limit their ability to expand their range when disturbance reduces resource availability.

These concerns may be added to existing fears for Pallas' cat survival stemming from its assumed tendency towards habitat specialization, continued pressure due to hunting and from rodenticide applications depleting their prey base (Nowell and Jackson, 1996). Our unease with the present status of the Pallas' cat in the wild can only be justified if further research is undertaken in the wild, as data is thus far preliminary and incomplete. This study has shown that, while difficult, trapping Pallas' cats for radio-tracking studies is feasible, increasing their potential for scientific study. Targeting future research on how the Pallas' cat is likely to respond in the face of future habitat and prey disturbances and how its ecology varies with habitat will give strength to our efforts to conserve the species in the wild.

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