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Camera trap study of Persian leopard in Golestan National Park, Iran

Golestan National Park has long been believed to be the reserve holding the highest number of Persian leopards *Panthera pardus saxicolor* in Iran and the world. The park has also been recognized as being under intense pressure from rampant local poaching. In 2011, we initiated a survey to 1) ascertain the status of this top predator, and 2) shed light on the challenges and pressures within the park. After 2,777 trap-night efforts of camera trapping, we identified 20 leopards comprising 10 males, 7 females and 3 of undetermined sex. We estimated 27.0±4.61 leopards using CAPTURE software and calculated a population between 23 and 42 leopards with 95% accuracy. The population density was determined to be 2.63 individuals per 100 km². Low numbers of prey species were recorded through the camera trapping survey (except for wild boar). Further research on poaching leopard and its prey is underway to better understand the conservation problems.

Iran, with its remarkable diversity of terrain, flora and fauna, has received little conservation attention in the recent decades and only a small proportion of its natural landscapes have been effectively protected (Firouz 2005, Darvishsefat 2006). Large carnivores with their sizable home ranges, low densities, demanding habitat requirements and charismatic appearance have been widely chosen as flagship species throughout the world to ensure protection of a vast range of organisms and ecosystems (Linnell et al. 2000, Bowen-Jones & Entwistle 2002). With the extinction of the two largest felids of Iran in the last century (Asiatic lion *Panthera leo persica* and Caspian tiger *P. tigris virgata*), the Persian leopard remains the largest felid of the country and acts as a symbol of conservation efforts in recent years (Farhadinia et al. 2009, Ghoddousi et al. 2010). The Persian leopard can be found in both arid mountainous and forested parts of Southwest and Central Asia as well as in the Caucasus, but Iran is recognized as its major stronghold with more than half of its global population (Kiabi et al. 2002, Khorozyan et al. 2005). The Persian leopard is known to be the largest subspecies of leopard and is categorized as "Endangered" on the IUCN Red List of Threatened Species (2008). Poaching due to depredation of livestock, habitat fragmentation and lack of natural prey are among the known threats to this species in Iran (Kiabi et al. 2002, Ghoddousi et al. 2010).

Fig. 1. A transition landscape form Golestan national park (Photo A. Kh. Hamidi).

In January 2011, Golestan National Park GNP was chosen by the Persian Wildlife Heritage Foundation PWHF as the initial site for conservation efforts focusing on leopards following the Persian Leopard Project in Bamu National Park (Ghoddousi et al. 2010). The initial goal was to 1) assess the status of leopards using scientifically robust methodologies 2) identification and evaluation of threats and developing priorities and solving the conservation problems in a sustainable manner.

Study Area

GNP is located in the northeast of Iran and was the first area designated as a nature reserve in the country (1957). It is uniquely situated in the mountainous terrain, spanning eastwards from the humid deciduous forest to steppes and arid plains, with mean annual precipitation between 150 and 700 mm in the east and west, respectively (Fig. 1; Akhani 2005). This UNESCO Biosphere Reserve comprises an area of 874 km², which together with its buffer zone is considered a prime habitat for Persian leopards (Kiabi et al. 2002, Darvishsefat 2006). A guesstimate of 30-45 individuals suggests that GNP holds the largest leopard population of all Iranian protected areas (Kiabi et al. 2002). The Caspian tiger once existed in the park and the last specimen of this subspecies was killed there in 1958 (Firouz 2005). Therefore, we chose GNP for conducting this research because of its high leopard density and long history of conservation.

Methods

We used camera traps to estimate the population size of leopards using their unique coat patterns for individual identification (Karanth & Nichols 1998, Henschel & Ray 2003). For logistical convenience, we divided GNP into three blocks based on vegetation cover (forest and steppe zones) and park features (north and south of the highway passing through the forest zone; Fig. 2; Karanth et al. 2004). The semi-desert plains region of the park was not covered by camera traps because of its historically few leopard sightings.

Camera trapping took place in each block sequentially, with 30 camera trap stations used in the first two blocks and 20 stations in the third block because of its smaller size. The team deployed 40 camera traps (DeercamTM, Park Falls, WI) throughout all three blocks. On average, devices were used for 45

days as described by Ghoddousi et al (2010) for Bamu National Park, Fars Province, Iran. However, contrary to the study in Bamu we used only one camera trap per station in GNP due to the high risk of theft and steep terrain (Wang & Macdonald, 2009). Although the use of one camera/station can underestimate animal densities and part of the capture history can be used in the analysis, such bias is minimized when fast and reliable cameras are used (Negroes et al. 2012). When possible, we identified sex of each leopard from external genitalia or general appearance.

We used software CAPTURE v. 2.0 (Colorado State University, Fort Collins, USA) to estimate the leopard abundance (Karanth & Nichols, 1998). We calculated population density by dividing the estimator of population size by the effective sampled area estimated using half of the mean maximum distance moved (HMMDM) strip around the camera trap station boundary (Henschel & Ray 2003, Karanth et al. 2004, Ghoddousi et al. 2010). We calculated relative abundance index for the wildlife of GNP, defined as the number of independent captures per 100 trap-nights (the sum of the days cameras were operating). Independent captures were defined as 1) consecutive photographs of different individual leopards 2) consecutive photographs of individual leopards taken > 0.5 hours apart, and 3) non-consecutive photographs of individual leopards (Ghoddusi et al. 2010).

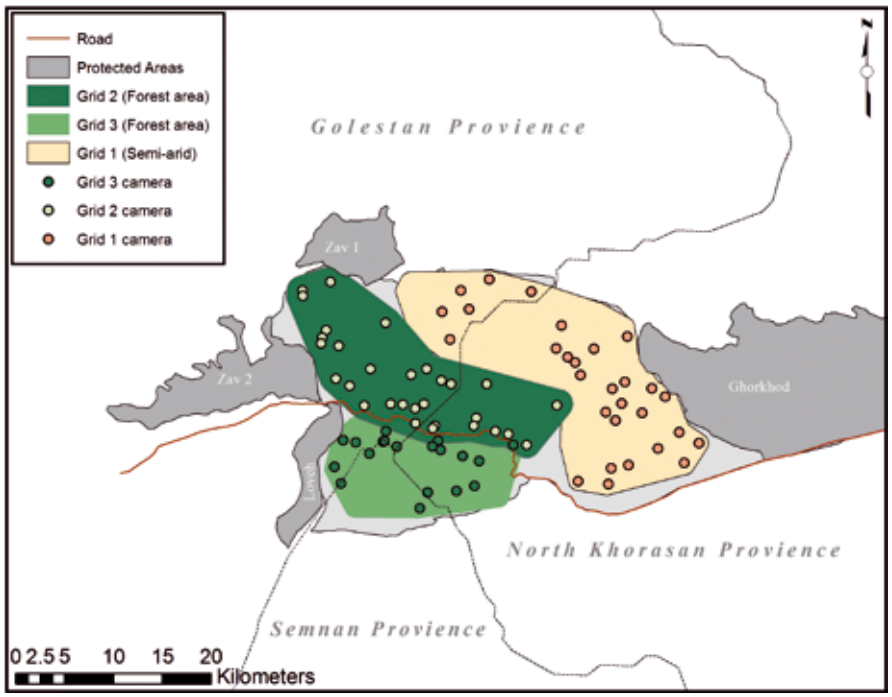

Fig. 2. Illustration of different blocks divided based on vegetation type and park features. In each block, camera-trap points have been shown by different colors.

Results

We conducted camera-trapping survey between January and December 2011. We expected a total of 4,031 trap-nights from 83 camera trap stations. Unfortunately, cameras at 20 stations were stolen or vandalized and the number of trap-nights dropped to 2,777. In total, 78 photographs of leopards (62 of which were independent) at 33 stations (52%) were captured. Photographs from different flanks of the leopards were separated: 39 left-flank photos have revealed 20 individuals and 23 pictures were taken from the right side have photographed 18 individuals. Out of 20 leopards counted from the left-flank pictures, 10 were males, 7 females and 3 undetermined (Fig.3).

Sampling occasions from all three blocks were collapsed into 11 occasions, which may increases the capture probability per trapping occasion but does not affect the abundance estimate and reduces its standard error (O'Connell et al. 2011). The M_0 model (constant probability of capture) of CAPTURE software estimated 27.0 ± SE 4.61 leopards for GNP. The Jackknife estimator yielded the 95% confidence interval of 23 - 42 leopards. The density was estimated as 2.63 individuals per 100 km^2 based on HMMDM sampled area of 1,024 km^2. The relative abundance indices of leopard, its main prey species and other larger carnivores were calculated and, apart from the wild boar Sus scrofa, the remaining prey species showed low levels of abundance (Table 1).

Discussion

The population estimate has reconfirmed that GNP holds a significant population of Persian leopard despite the fact that the high number of stolen cameras may have led to underestimates of population size. Our estimate of 27.0±4.61 (23 - 42) leopards is similar to the estimate of 30 - 45 animals that Kiabi et al. (2002) derived for GNP primarily from direct observations and local know-

Table 1. The relative abundance index of large mammals in Golestan National Park using camera traps.

Species	Average no. of individuals/photo	Relative abundance (no. independent pictures/100 camera trap nights)	Species Occupancy (no. stations species photographed in %)
Leopard *Panthera pardus*	1	2.7	33 (52%)
Brown bear *Ursus arctos*	1	1.4	15 (23%)
Wolf *Canis lupus*	1.25	0.18	4 (6%)
Wild boar *Sus scrofa*	1.1	15.41	54 (85%)
Urial *Ovis vignei*	1.74	1.69	13 (20%)
Bezoar goat *Capra aegagrus*	2.6	0.46	1 (1%)
Red deer *Cervus elaphus*	1.08	0.46	8 (12%)
Roe deer *Capreolus capreolus*	1	0.39	8 (12%)
Indian crested porcupine *Hystrix indica*	1.05	3.02	16 (25%)

Fig. 3. A dominant male Persian leopard photographed by camera-traps (PWHF/P4L/Panthera/Golestan DoE).

ledge. This population is possibly one of the largest, if not the largest, among all protected areas of Iran (Kiabi et al. 2002) and throughout the entire distribution area of the Persian leopard (Khorozyan et al. 2005). Furthermore, the density estimated in GNP is higher than in the only other camera-trapping study conducted in Iran (1.87 leopard per 100 km^2, Bamu National Park, Ghoddousi et al. 2010). Unlike Bamu NP, which is surrounded by human landscapes, GNP is well connected with other natural landscapes by functioning corridors and has three protected areas adjoining its boundaries (Zav Protected Area, 143 km^2, Loveh PA, 36 km^2 and Ghorkhod PA, 432 km^2). For this reason, leopards have a much better chance of survival in a long-term perspective in GNP than in other protected areas of Iran, most of which are isolated.

As evident from the relative abundance indices, ungulates (except for the wild boar) show low levels of abundance, which signifies the pressure imposed by poaching in GNP. Also, among the large mammals of the park, wild boars and leopards have the widest occupancy and the other prey species showed low distribution. The assessment of distribution, abundance and structure of prey populations in GNP is now underway with the collaboration of PWHF, Georg-August-University Göttingen, Germany and Panthera, USA. As the next step, the team will identify, map and evaluate the principal threats to leopard and its prey in GNP and will delve into human-leopard conflicts, as one of the drivers of direct leopard poaching in GNP.

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