

## Distribution pattern of the Persian leopard (*Panthera pardus saxicolor*) in Iran

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This study is a new attempt to identify the latest distribution pattern of the Persian leopard (*Panthera pardus saxicolor* Pocock 1927) in its entire range in Iran. Furthermore, the paper aimed to analyse the climatic factors in the current range of the leopard in the country. The study was performed in 138 sites (56 protected areas, 34 non-protected areas and 48 meteorology stations) throughout the country for a duration of four years starting in 2002 using rapid survey techniques and collection of secondary data. A total of 74 protected and non-protected areas are reported here as the leopard detection sites in the country. Although leopards have a wide distribution in Iran, results indicate that 69% of them are found in the northern part where a large tract of forests is regarded as one of the most important habitats for leopards in the country. In general, the leopards are mostly found in habitats with 0 to 20 days per year of ice cover and 58% of its identified range in the country have 3,100-3,600 sunny hours per annum. Leopards inhabit a wide range of temperature, *i.e.* from -23.10 to +49.40 °C however, they are more often found in areas with temperature of 13 to 18 °C. The majority (66%) of leopard distribution areas receive more than 200 mm of rain per year. Findings of this research would help the researchers in conducting further regional studies in the leopard distribution range described in this paper. It is also recommended that occupancy modeling on a regional scale should be conducted where leopards are present.

**Key words:** *Panthera pardus saxicolor*, Persian leopard, distribution map, climatic factors, distribution range, protected areas, non-protected areas, meteorology stations, Iran

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## INTRODUCTION

The leopard (*Panthera pardus*) is known to be the most adaptable *Panthera* species which is found in a wide variety of climate types (Beer *et al.* 2005, Bailey 1993) ranging across most of sub-Saharan Africa, the Middle East and Far East, northwards to Siberia and southwards to Sri Lanka and Malaysia (Bothma 1998, Alderton 2002). However, habitat conversion, declining prey populations, commercial exploitation and active persecution contribute considerably to losses of the individuals (Asadi 1997, unpublished report; Balme & Hunter 2004, Kolowski & Holekamp 2006). Despite the catholic nature of the leopard (Grassman 1997, Lekagul & McNeely 1977, Mills & Harvey 2001, Alderton 2002, Hayward *et al.* 2006) which has enabled it to survive in a wide range of environmental conditions, the Persian leopard (*Panthera pardus saxicolor* Pocock 1927) is classified as an endangered subspecies by IUCN (2009).

Although leopard is considered as a wide ranging species in Iran, there are few and scattered documentations particularly in terms of leopard distribution range within the past decades. Joslin (1988) reported that leopards were found widely in Iran and their occurrence is mainly associated with the two mountain chains of Alborz and Zagros. Harrison (1968) had plotted the distribution of the species while Etemad (1985, in Persian) reported several leopard detections as well as morphological and biometric data from leopard individuals detected from various parts of the country. More recently, studies by Kiabi *et al.* (2002) revealed that 550-850 individuals of leopards live in Iran while Khorozyan *et al.* (2005) estimated that a total number of less than 1,300 individuals of Persian leopard are left in the Middle East. Sanei (2005, 2007: in Persian) documented the Persian leopard distribution range, its associated species, habitat types as well as morphological and biometric data from various provinces of the country.

Knowledge on current distribution of the species is critically essential in the formulation of a conservation and management plan for the species in the country. This study is a new attempt to describe the distribution pattern of the Persian leopard in its entire range in Iran. An analysis of climatic factors in the regions with known leopard populations may help researchers identify other areas where leopards may persist. Therefore, a further objective of this study is to come up with an understanding of the role of climatic factors in determining the present leopard distribution range in the country.

## MATERIALS AND METHODS

**Study area.** Iran is a high plateau with 1,623,779 km<sup>2</sup> area located between 44° 02' to 63° 20' E in southwest Asia. There are significant distinctions in climatic factors and geographic features in different parts of Iran and the altitudes in most parts of the country are more than 1,200 meters above sea level. The average annual rainfall in the southwestern forests of the Caspian Sea is more than 2,300 mm. However, drought condition is common, particularly in the sandy hills of the Lut plateau that usually occurs for several years (Firouz 2000).

The study was implemented in 138 sites including 56 protected areas, 34 non-protected areas and 48 meteorology stations (Figure 1; see also Appendix 1) around

## Persian leopard distribution range

the country. To assess the role of climatic factors in determining the leopard distribution, a total of 48 meteorology stations were selected. The selected stations are the ones nearest to the sites identified as leopard detection areas (Appendix 1).

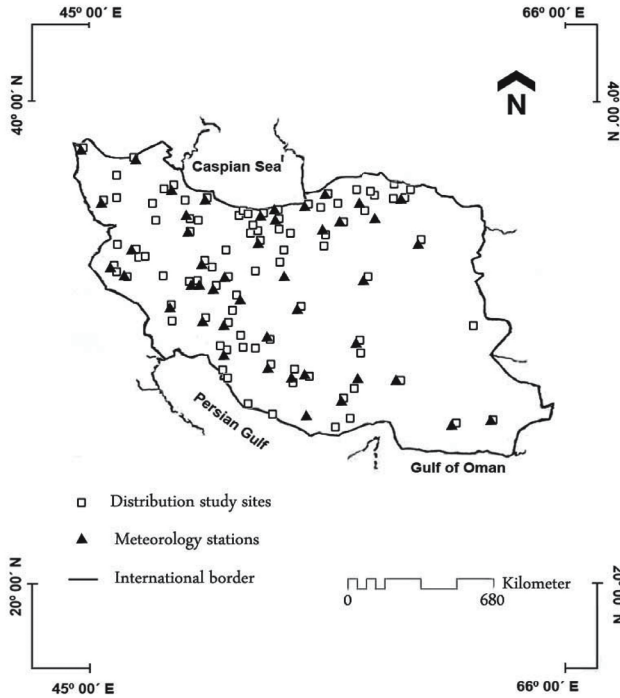


Figure 1. Location of Persian leopard (*Panthera pardus saxicolor* Pocock 1927) distribution study sites in Iran.

**Distribution studies.** The study was conducted over a time span of four years starting in 2002 and covering a total of 90 sites. To collect the data on current leopard range in country, staff from the Department of Environment (DoE) of each state filled up questionnaires dealing with new reports of direct observations of leopards, attacks on humans or livestock and leopard's secondary signs such as tracks or feces. Daily and annual reports from protected areas in each state detailing reports of conflicts as well as camera-trapping results were also studied. Subsequently, interviews were conducted with the local people, shepherds and guards of DoE (in protected areas) on their knowledge of leopards and other wild animals of the area. Site visits and detection/non-detection studies were done based on direct observations and secondary signs (e.g. tracks, scats and scratches on the trees) of leopards in a cluster of sites which had been obtained from reports, questionnaires and interviews. Field surveys for the whole study period were done by first author and a network of local people around the country who are skilled in techniques to achieve the objectives of

the study was established. It should be noted here that distribution map provided in this study is the outcome of both field surveys and secondary data collection. Consequently, a questionnaire checklist of abiotic factors such as types of detection (direct, indirect), locations, dates and other related observations was filled up for each study site. For this study, Iran is divided into four main regions *i.e.* north, east, west and south based on 32° 58' N - 54° 37' E to record the findings. These divisions were in accordance with the objectives of the study. ArcGis version 9.1 was used for mapping.

**Climate data.** Data were obtained from 48 meteorology stations (either synoptic or climatology) during a five-year period (1999-2003). Meteorology stations that are close to the study sites with confirmed leopard presence (Figure 1) were selected. Consequently, the average mean monthly data on different meteorological factors (*i.e.* temperature, rainfall per year, sunny hours per year and the number of ground ice covered-days per year) in each station were obtained from annual meteorological record books of Iran (1999 to 2003).

## RESULTS

**Distribution of leopard.** Distribution map of the leopards has been verified in 74 out of 90 study sites (82.22%; see also Table 1, Figures 1 & 2). However, 69% of recorded leopard signs were in the northern part whereas only 31% of them were in the south. A total of 55% of leopards has been detected in protected areas while 45% of them were found in non-protected habitats (Table 1). The presence of leopards outside of protected areas and not inside them is particularly remarkable in Angooran Wildlife Refuge and Protected Area located in Zanjan Province. Since leopards have been reported frequently from non-protected areas of the province (*e.g.* highlands of Parangin and non-protected habitats of Tarom Township) while there had not been any sign of leopards in Angooran (WR/PA) for almost three decades (Moradi 1999). Although, there is a lack of detailed information concerning leopard distribution and population trends within the region over the last several decades, anecdotal information obtained from local people suggest that leopard distribution in the west (Kurdistan Province) has declined severely. Several livestock-leopard and human-leopard conflicts have been reported from various places such as Rakhshan, Bazman and Saravan in Sistan and Baluchestan Province, Ariz in Yazd Province, Ghazvin Township in Ghazvin Province and Daregaz in Razavi Khorasan Province. Sanei (2007) revealed that the leopard caused the second highest level of conflicts next to wolf (*Canis lupus*) in 2002 and the third highest level of conflicts in 2003, after the wolf and brown bear (*Ursus arctos*). Some other conflicts included a leopard attack on a local shepherd in 2001, an attack on a dog in 2002, as well as on a goat and sheep in 2002-2003. These reports came from places around Khar and Touran National Park in Semnan Province.

## Persian leopard distribution range

Table 1. Locations of leopard detections in Iran.

Northeast			Northwest		
Site name	Status		Site name	Status	
	P	N-P		P	N-P
Tandooreh	X		Kiamaki	X	
Ghorkhod	X		Arasbaran	X	
Sarani	X		Marakan	X	
Sarigol	X		Kolah Qazi	X	
Salook	X		Muteh	X	
Khosh Yeilagh	X		Manesht & Ghalarang	X	
Golestan	X		Khojir	X	
Jahan Nama	X		Sorkheh Hesar	X	
Naiybandan	X		Lar	X	
Ghuchan		X	Jajroud	X	
Torbat-e-Heydarieh		X	Varjin	X	
Toroud		X	Kavir	X	
Biarjmand		X	Central Alborz	X	
Forumad		X	Sorkh Abad	X	
Gorgan		X	Parvar	X	
Gonbad-e-Kavus		X	Tooran	X	
Tabas		X	Bisotun	X	
			Garmsar		X
			Avaj		X
			Kamyaran		X
			Gilangharb		X
			Noshahr		X
			Lahijan		X
			Amol		X
			Pol-e-Sefid		X
			Kojur		X
			Sari		X
			Boozin & Marakhil	X	
			Varmanjeh*	X	
			Haftad Gholeh	X	
			Khalkhal		X
			Ilam		X
			Ab Bar		X
			Khoramdareh		X

Table 1. Cont.

Southeast			Southwest		
Site name	Status		Site name	Status	
	P	N-P		P	N-P
Hormod	X		Qamishlou	X	
Rochun	X		Tang-e-Sayyad	X	
Khabr	X		Sabz Kuh	X	
Saravan		X	Bamoo	X	
Iranshahr		X	Dena	X	
Neyriz		X	Mount Khiz-o-Sorkh	X	
Bam		X	Oshtorankuh	X	
Zarand		X	Khansar		X
Haji Abad		X	Dezful		X
Siah Kuh of Ardakan	X		Izeh		X
			Mianjangal	X	
			Eghlid		X
			Azna		X

P = Protected area; N-P = Non-Protected area; X = Leopard detection.

\*Denotes protection status during the research period; status was changed thereafter.

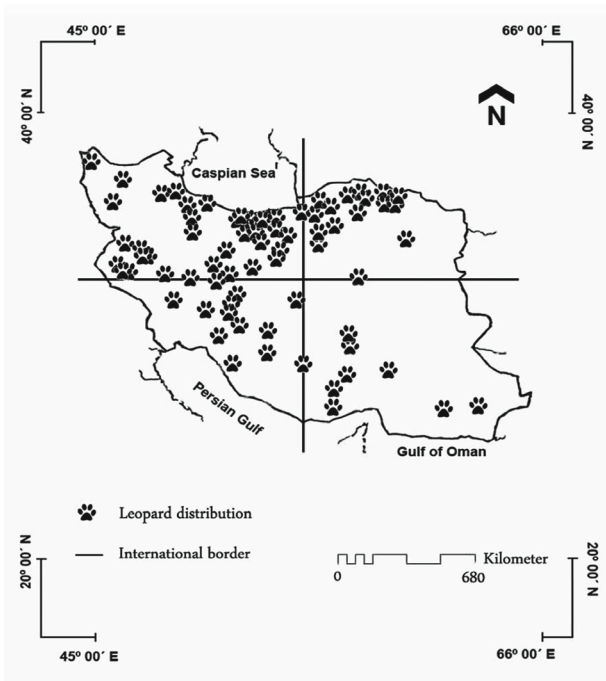


Figure 2: Distribution of leopard in Iran [Note: This map is an extension of the map reported by Sanei (2007)].

## Persian leopard distribution range

**Climate.** Results indicated that leopards survive in a wide range of temperature ranging from -23.10 to +49.40 °C. However, most of their distribution in the country was found at areas with mean annual temperature of 13 to 18 °C of which 53% of these are located at the northwest. In addition, 62.5% of the areas with high temperature averages (23-28 °C) are found in the southeastern region of the country.

A total of 66% of the leopard locations were found in areas with more than 200 mm of rain per year. However, only 4% of its distribution has average rain of more than 1,200 mm per year. Almost 42% of leopard habitats are in the northwest with 200-400 mm of rain per year. In addition, less than 11% of their habitats in the northwestern region have less than 200 mm rain per year. Almost 70% of their distribution in the southeast are also throughout areas with less than 200 mm rain per year.

Furthermore, results suggested that leopards in Iran are mostly distributed throughout areas with ice cover from 0 to 20 days per year. However, 35.7% of the leopard distribution in northwestern Iran has 80-100 icy days per year. Even though 58% of leopard distribution was throughout the areas with 3,100-3,600 sunny hours per year, almost 77% of its distribution in northwestern Iran has less than 3,100 sunny hours per year. More than 80% of its distribution in the northeast, southeast and southwest is in areas with 3,100 to 3,600 sunny hours per year. As shown in Table 2, habitats which are distributed in the southern part of the country received more sunny hours per year. In contrast, those areas which are in the western part of the country had more days where the ground was covered with ice.

Table 2. Analysis of climatic factors<sup>1</sup> in areas with leopard detection in Iran.

	Direction	Parameter			
		Average temperature (°C per year)	Rain (mm per year)	Ground ice-covered days (per year)	Sunny hours (per year)
Mean	Northeast	17.9	233	42.83	2879.29
	Northwest	14.4	522	60.02	2656.28
	Southeast	22.1	118	22.91	3458.06
	Southwest	17.2	421.50	55.12	3456.92
Minimum		3.0	24.00	0.00	1662.80
Maximum		27.7	1364.60	142.00	5171.90
Most observed in leopard range		13.0-18.0	≤ 200	0-20	3100-3600

<sup>1</sup>Source: Annual Meteorological Records of Iran from 1999 to 2003.

## DISCUSSION

The study indicated that leopards have a wide distribution in Iran. However, this is mostly associated with the two mountain chains consisting of Alborz running northwest to northeast and Zagros from northwest to the south. This fact is also reported almost two decades ago by Joslin (1988) when human disturbances and habitat destruction were considerably less than the present time. Results also revealed that most of the leopard areas are found throughout the northwest region which crosses these mountain chains. Previous study by Kiabi *et al.* (2002) also indicated that leopards are more abundant in the northern part of the country compared to the southern part. There are also a few scattered mountains in the middle, east and south where leopards were found (Figure 3). It should be added that the Hyrcanian forests located in the north and along the Alborz chain are considered as one of the most important habitats for leopards in the country. Various species of potential leopard preys such as wild pig (*Sus scrofa*), wild goat (*Capra aegagrus*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) are found in these forests. Sanei and Zakaria (2008) indicated that 88% of leopard distribution sites (in the same study sites as in the current study) in habitats with mountainous forests are located in this area. Most of the desert areas are located in the east where the two main deserts, namely: Lut and Kavir are situated. Except for the scattered mountains located in these places, most of the desert areas are unsuitable for this species due to low prey base and absence of water.

The results showed that 34% of leopard distribution receives less than 200 mm rain per year. Generally, Iran being considered as a dry country hence, the distribution records showed that leopards did not prefer areas with little annual rainfall. However, temperature is highly variable even on a regional scale and it may have influenced distribution of the leopards directly or through prey availability which is affected by vegetation cover. The implication of ice-covered terrain is that such terrain will result in a leopard being denied adequate supply of prey for survival. Thus, leopards will follow the seasonal migrations of prey (mostly wild sheep and wild goat) away from ice-covered terrain. It is therefore not unusual to find leopards migrate from high altitudes to the lower terrain especially in the months of January, February and March.

In a number of sites (*e.g.* Lashgardar in the State of Hamedan), there has been no sign of leopards for many years. However, it is believed that non-detection of cryptic and low-density species such as leopards in some sites (particularly those with sufficient food sources and suitable habitats) does not imply that the species was truly absent there (MacKenzie 2005).

The present work recommends that further studies should be conducted on leopard occupancy modeling based on detection/non-detection surveys on a regional scale and for a multiple year-time frame. Identification of leopard main corridors in its current distribution particularly between the main national parks (with leopard detection) and their surrounding leopard habitats is critical to prevent isolation of subpopulations. The Department of Environment of Iran conducts annual wildlife counts in various habitats which provide plenty of useful information regarding



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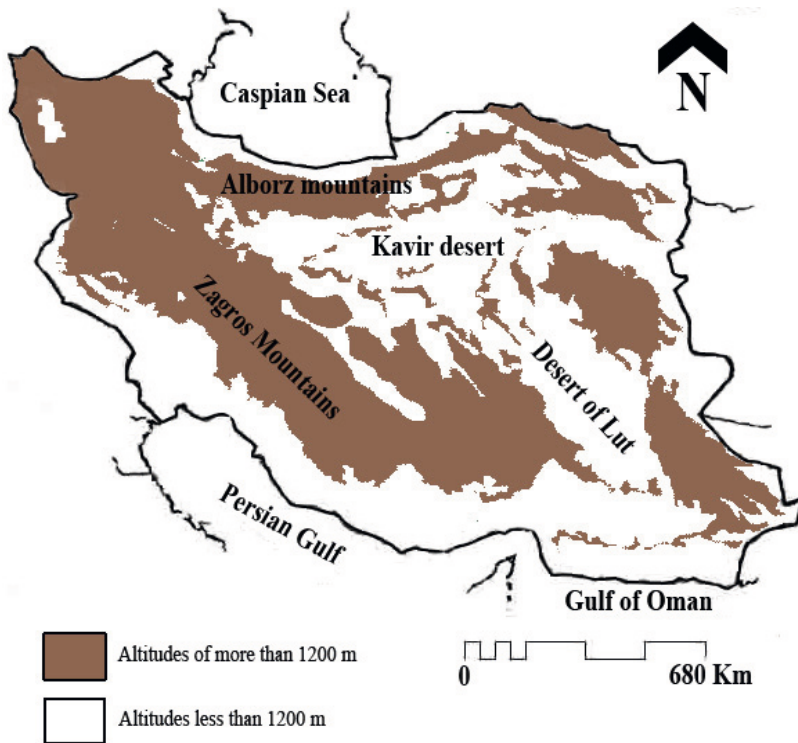


Figure 3. Locations of the two main deserts of Kavir and Lut as well as Alborz and Zagros mountainous chains and regions with altitudes of more than 1,200 m above sea level (Iran).

wildlife status. Therefore, it is suggested to re-organize these surveys in a systematic manner to obtain reliable population trends of prey species.

## CONCLUSION

The findings presented here exemplify an understanding of the latest distribution pattern of the Persian leopard in Iran. Leopards were detected in 74 out of a total of 90 study sites. However, 69% of the leopard locations were found in the northern part of the country. Almost 45% of these sites were found in non-protected areas. Results show that the species can survive in a wide range of climate types. However, they were mostly found in areas with annual average temperature of 13 to 18 °C, with more than 200 mm of rain per annum; grounds covered with ice for 0-20 days per year and 3,100-3,600 sunny hours per annum.

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### Appendix 1. Locations and types<sup>1</sup> of meteorology stations in Iran.

No.	Station's Name	Type	Province	No.	Station's Name	Type	Province
1	Kalibar	Sy	East Azarbaijan	24	Fasa	Sy	Fars
2	Naghadeh	Sy	West Azarbaijan	25	Eghlid	Sy	Fars
3	Khalkhal	Sy	Ardabil	26	Lar	Sy	Fars
4	Khansar	Cl	Esfahan	27	Avaj	Sy	Ghazvin
5	Najaf Abad	Sy	Esfahan & Bakhtiari	28	Kamyaran	Cl	Kurdistan
6	Ilam	Sy	Ilam	29	Baft	Sy	Kerman
7	Abali	Sy	Tehran	30	Bam	Sy	Kerman
8	Lordegan	Sy	Chahar Mahal	31	Zarand	Sy	Kerman
9	Sabzevar	Sy	Razavi Khorasan	32	Gilangharb	Cl	Kermanshah
10	Ghuchan	Sy	Razavi Khorasan	33	Do Gonbadan	Sy	Kohgiluyeh & Boyer Ahmad
11	Torbati-e- Heydarieh	Sy	Razavi Khorasan	34	Gorgan	Sy	Golestan
12	Dezful	Sy	Khuzestan	35	Gonbad-e-Kavus	Sy	Golestan
13	Izeh	Sy	Khuzestan	36	Noshahr	Sy	Gilan
14	Ab Bar	Sy	Zanjan	37	Lahijan	Cl	Gilan
15	Khoramdareh	Sy	Zanjan	38	Azna	Sy	Lorestan
16	Toroud	Cl	Semnan	39	Aligudarz	Sy	Lorestan
17	Biarjmand	Sy	Semnan	40	Amol	Sy	Mazandaran
18	Forumad	Cl	Semnan	41	Pol-e-Sefid	Sy	Mazandaran
19	Garmsar	Sy	Semnan	42	Kojur	Cl	Mazandaran
20	Saravan	Sy	Sistan & Baluchistan	43	Sari	Sy	Mazandaran
21	Iranshahr	Sy	Sistan & Baluchestan	45	Arak	Sy	Markazi
22	Shiraz	Sy	Fars	46	Haji Abad	Sy	Hormozgan
23	Neyriz	Sy	Fars	47	Ardakan	Cl	Yazd

<sup>1</sup>Cl = Climatology station, an observation station which measures one or several climatic elements; Sy = Synoptic station, one where observations are made based on the processes of the general atmospheric circulation taken during synoptic hours of 00:00, 06:00, 12:00 and 18:00, Universal Time. (World Meteorological Organization 1989).

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