Leopard in Armenia's Khosrov Reserve: Spots, Rosettes and Population Genetic Status

by Igor Khorozyan[1]

Abstract

In anticipation of proper laboratory analyses, which we plan to perform soon with our Polish and US colleagues, we have carried out a morphological study to predict how significant is genetic diversity and its implications for conservation of the leopard (*Panthera pardus*) population in Armenia's Khosrov Reserve. The leopard population in Armenia, particularly in Khosrov Reserve, is predicted to be genetically diverse as a continuous portion of the Iranian pool, and its genetic wealth completely depends on individuals immigrating regularly from northern Iran.

The leopard is very rare in Armenia, where human disturbance and poaching make this cat teetering on the brink of extinction throughout its distribution area in the country's south and south-west (Khorozyan, 1999a). Recently, it was thought that small population size might impinge on its long-term viability by creating favorable conditions for inbreeding, leading to reduced genetic variation. Probability of this impairment is highest in Khosrov Reserve in the south-west (Khorozyan, 1999b). To test this hypothesis, it has become necessary to study the genetic background of the leopard population in Armenia. In this felid, the genetic status has been studied only in captive-bred animals, which can be very inbred (Miththapala *et al.*, 1996), but the situation in the wild may even be worse when unfavorable factors, minimized in captivity (feeding competition, diseases, climatic extremes), come into force. Cases of mating between close relatives and possible inbreeding depression are already recorded in geographically restricted leopard populations from the Russian Far East and Israel (Nowell and Jackson, 1996).

Significant variation in coat pattern has been one of the most obvious visual expressions of an animal's high genetic diversity, as shown in Iberian lynx (*Lynx pardinus*) (Beltran and Delibes, 1993) and cheetah (*Acinonyx jubatus*) (Caro and Durant, 1991). In its turn, loss of hererozygosity increases fluctuating asymmetry (FA) of bilateral traits, i.e. a normally distributed subtle and non-directed deviation from perfect bilateral symmetry caused by imperfection of individual developmental processes, and less important traits, whose asymmetry will not endanger an individual's survival, provide the most informative signal of FA, as in the cheetah (Wayne *et al.*, 1986). Therefore, estimation of coat pattern variation and FA can serve as a useful tool in foreseeing the level of genetic diversity in felids when appropriate laboratory analyses are not available. In this work, we have measured both these indicators in the leopard population in Khosrov Reserve.

Methods

Skins and mounted specimens kept in the state museums and private ownership were studied (Table 1). Size and density of rosettes on shoulders and sides were used as criteria for classification of coat patterns, and each specimen was assigned to have a certain coat pattern. As mounting causes the skin to stretch and expand the rosette size by ca. 10% (H. Kazaryan, pers. comm.), we used the appropriate correction. Six meristic (countable) bilateral traits used elsewhere for identification of individual leopards (rows A-E of mustacial spots and spots beneath the eyes) (Miththapala *et al.*, 1989) were employed in our FA study. Individual and cumulative indices of FA, I_{FA} and $I_{FA}(c)$, were calculated for each trait of an individual animal by common formulae $I_{FA} = |L_i - R_i|/(L_i + R_i)$ and $I_{FA}(c) = SI_{FA}$, where L_i and R_i are the number of spots of a certain category i (i = 1N) on left and right side of muzzle, respectively. N is the number of traits analyzed for FA, in our case N = 6. The index of mean asymmetry $I_{FA}(c)/N$ was calculated for each animal studied (Wayne et al. 1986). Normal distribution of values of individual I_{FA} and $I_{FA}(c)$ was tested around the mean zero through measuring their skewdness and kurtosis. As such studies of FA have never been carried out on the leopard, we performed a preliminary pilot study of the facial photos of captive leopards (13 Amur leopards *P.p. orientalis*, four Persian leopards *P.p. saxicolor* and nine Chinese leopards *P.p. japonensis*) from Aalborg Zoo (Denmark), Exotic Feline Breeding Compound and Sierra Endangered Cat Haven (California, USA) using reference information (inbreeding coefficient/sex/age of individuals) from Shoemaker (1999). Statistical analysis of data was performed using the standard manuals and operated by Statistica® program package, version 5.0, 1995.

Table 1. Information on the leopard specimens from Khosrov Reserve used in this study. Abbreviations: SK – skin, SM – stuffed material. Sources: [a]Institute of Zoology, Yerevan, Armenia; [b]V. Wuchrer-N. Agulyan's private collection, Yerevan; [c]G. Hovhannisyan's private collection, Garni village; [d]the Hunter's Shop, Yerevan; [e]Museum of Natural History, Yerevan.

Source	Museum No.	Harvest date
SK1[a]	6435	1950s
SK2[a]	6436	1950s
SK3[b]	–	early 1950s
SK4[c]	–	Jan 2000
SM1[a]	6437	1950s
SM2[a]	6438	1950s
SM3[a]	–	1950s
SM4[d]	–	mid-1950s
SM5[e]	241.1	May 18, 1960
SM6[e]	241.2	May 18, 1960

Results

There are three coat patterns, defined as morphs, in the leopards in Armenia: A (small rosettes, densely grouped together), C (large rosettes, more or less distant) and B (intermediate). Morphs A and B have statistically significant differences in rosette size on sides and rosette density on shoulders; morphs B and C – in rosette size on shoulders and rosette density on shoulders; morphs A and C – in rosette density on shoulders only (Table 2). Indices I_{FA} and $I_{FA}(c)$ of facial spots did not show statistical significance of normal distribution in any trait studied. Mean asymmetry (′ 100 times) ranged from 0 to 3.2 per specimen and did not differ in morphs. It was low compared with that obtained by Wayne et al. (1986) in the cranial characters of genetically diverse African and Asiatic leopards (range 3.2-13.2, average 6.2) and this difference was highly significant. However, it was similar to mean asymmetry in pilot study leopards, which were both non-inbred and inbred (range 0-16.2, average 5.6). We cannot provide an explanation for this other than that the skull and its structures tend to be more asymmetric than facial spots, even with good genetic background of animals. Males and adults had higher correlation of increase of FA with inbreeding than females and young, respectively.

Table 2. Morphometrics (1 - rosette diameter, cm and 2 - density, units/10 cm²) of the leopards (*P. pardus*) in Armenia. Abbreviations as in Table 1.

Morph	Specimens	Shoulders		Sides	
		1	2	1	2
A	SK1, SK2, SK3	2.2±0.16	0.7±0.03	3.4±0.22	0.2±0.03
B	SM1, SM2, SM4, SM5	2.7±0.05	0.5±0.02	4.7±0.04	0.2±0.01
C	SK4, SM3, SM6	3.7±0.18	0.4±0.01	5.4±0.25	0.1±0.03

Discussion

Our results, extrapolated in terms of coat pattern polymorphism, absence of detectable FA in facial spots and low values of individual mean asymmetry, show indirectly that the leopard population in Khosrov Reserve was genetically diverse in 1950-1960s. Obviously, this could be a result of frequent immigration of leopards to Khosrov Reserve through southern Armenia from neighboring northern Iran where these cats were common (B. Gutleb, pers. comm.) and, consequently, diverse in genetic structure. Until the present time, leopards were relatively common in northern Iran and their immigration to southern Armenia is regular (H. Kazaryan, pers. comm.), so we can speculate that the population genetic status of the leopard in Armenia is still good. Only one sample (SK4) was available to us from today's leopards of Khosrov Reserve, and we need more to test this.

Just as southern Armenia's leopard pool is connected with adjacent territories in Iran, Khosrov Reserve has a linkage with southern Armenia. The evidence is a medium-sized leopard (most likely, a young dispersing male rather than an adult female) which was seen at night near Elpin village to the south-east of Khosrov Reserve in early March 2000, and a young leopard, possibly the same individual, which was encountered near Rind village, south of Elpin, in mid-March 2000 (H. Kazaryan, pers. comm.). A leopard with a European hare (*Lepus europaeus*) in its mouth was glimpsed while crossing a motorway near Gnishik village in fall 1999. In spring 2000, an individual was observed repeatedly in Noravank canyon (Fig. 1).

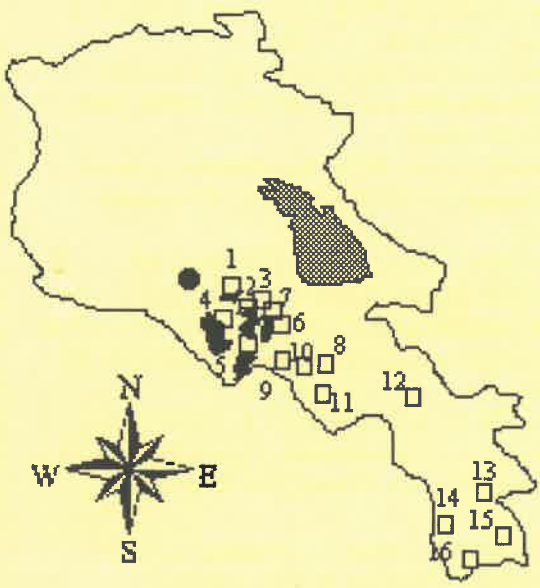
In all likelihood, these active movements and visibility of the leopard(s) were caused by opening of a land tenure in NE Khosrov Reserve's Tapchan Yallah gorge, where an adult male leopard was poached in January 2000. Later, we took sample SK4 from that male. As a corridor between Khorsov Reserve and southern Armenia, only Noravank canyon, fringing the border of Azerbaijan's Nakhichevan province, is predominantly used (pers. obs.). It is unclear whether it serves merely as a movement conduit or provides also the habitats where the animals can live and breed, but such a "monopoly" of Noravank corridor may pose a serious threat to dispersal pattern since current man-made factors (presence of roads between villages, human disturbance and complete disappearance of permanent water sources since 1997 when Gnishik stream was carried away to irrigate the Rind village) become alarmingly active. In these circumstances, the corridor itself will act as a "sink" when only few or no moving animals reach the recipient body of Khosrov Reserve (Dawson, 1994). Hence the Khosrov population will be increasingly extinction-prone from the "edge effect", genetic and ecological factors. Without this corridor, the reserve is unlikely to maintain viability of local leopard population, even in the short run, as its size (292 km²) is smaller than the critical reserve size (345 km² for high-quality habitats and 10,695 km² for poor environments), i.e. the area for which the Woodroffe and Ginsburg's (1998) model predicts a 50% persistence of predators, calculated by us for *P. pardus* earlier (unpubl. data).

As we have established the Leopard Record Monitoring Network-Armenia in summer 1999, following publication of the first input data in Khorozyan (1999a), we continue to receive regular data of leopard records in Khosrov Reserve, Noravank canyon and southern Armenia from local informers (Fig. 1).

Fig. 1. The leopard records in Armenia in 1990s and 2000
– Yerevan city, black areas
– Khosrov Reserve, points 9-11
– Noravank canyon, pointa 12-16

Description of points:

(1) Garni river bank, 1993, (2) Bayburd village, mid-1990s and Jan 1999, (3) Davagez ridge, Oct 1998 and Oct-Nov 1999, (4) Between Chimankend and Sovetashen villages, Jan 2000 (2 animals killed), (5) Between Chimankend and Karabalar villages, Mar 2000, (6) Kakavaberd ridge, Dec 1999, (7) Tapchan Yallah gorge, May 1999 and Jan 2000 (1 killed), (8) near Ekhegnadzor town, 1992, (9) Elpin village, early March 2000, (10) Rind village, mid-March 2000, (11) Gnishik village, fall 1999 and spring 2000, (12) Goris-Kapan highway, 1995, (13) Hostoop Mt., near Kapan town, Nov. 1997 (1 killed), spring-fall 1998, (14) Kaputjuh Mt., spring-fall 1998, (15) Tsav village, 1995 (1 killed), (16) Meghri village, March 2000 (1 killed)



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[1] Armenian Leopard Conservation Society
PO Box 5, Yerevan 375010, Armenia
E-mail: <leopard_am@yahoo.com>

CITES Secretariat Criticises African Governments' Reporting of Leopard Exports

The CITES Secretariat informed the Conference of the Parties (COP 2000) in Nairobi in April that the entire reporting process of leopard exports should be reformed and standardized.

In a report (CITES 2000) to the COP, the Secretariat said that "most of the Management Authorities seldom report before the deadline established...and usually only after several reminders have been sent... the Secretariat is concerned that the intended purpose of the reporting system has not been fully achieved and that exporting parties regard the requirement as a burden rather than a reflection of the type of quota control administration that each Party should apply in order to manage exports based on such quotas".

Eleven African governments agreed in 1983 to set quotas, now totalling 2,085 a year, on exports of leopard trophies and skins and to submit annual reports. The Secretariat said that some reports might not adequately reflect the level of quota management in some of the exporting countries, adding: "The Secretariat considers that the entire process should be reformed and standardised."

The report said that the data provided were of little use because there was insufficient discrimination between skulls, hunting trophies and skins, which might be derived from the same leopard and separately exported and reported.

"Because exports can take place in a year some time after the removal from the wild...the trade data prior to 1997 are of little value as reported exports frequently consist of specimens derived from different quota years. Concerning future trade, the Secretariat will not be able to monitor the use of annual quotas effectively unless information about tags, which must from 1997 onwards include the year of removal from the wild, are included in special reports, and preferably also in annual reports".

Current Quotas

State	Quota
Botswana	130
Central African Republic	40
Ethiopia	500
Kenya	80
Malawi	50
Mozambique	60
Namibia	100
South Africa	75
United Republic of Tanzania	250
Zambia	300
Zimbabwe	500

The Secretariat said that, in accordance with directions by the COP in Harare in 1997, it had recommended to the Parties that import of leopard trophies and skins from Kenya, Tanzania, Zambia and Zimbabwe be suspended until further notice because they had not met the reporting requirements.

Despite its criticisms, the Secretariat declared that the current level of offtake was generally much lower than the quota level.

(Editor: Because of the difficulty in counting secretive leopards, the population in Africa is unknown. A CITES-sponsored status survey in 1986 used a computer model based on a relationship between leopard densities, habitat type and rainfall (Martin & de Meulenaar 1988). It predicted a population total of 714,105. However, leopard specialists on the ground said that leopards were often absent from areas where the model predicted their presence and the total was an over-estimate.)

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