Camera photo-trapping of the endangered leopards (*Panthera pardus*) in Armenia: a key element of species status assessment

FINAL REPORT

Written by:

Igor Khorozyan
ARMENIAN LEOPARD CONSERVATION SOCIETY
Mashtotz Ave. 48/17, Yerevan 375009, Armenia
E-mail: leopard_am@yahoo.com
Web: www.persianleopard.com

Submitted to:

PEOPLE'S TRUST FOR ENDANGERED SPECIES
15 Cloisters House, 8 Battersea Park Road, London SW8 4BG, UK
E-mail: enquiries@ptes.org
Web: www.ptes.org

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PREAMBLE.

The geographical region of Caucasus, including the countries of Armenia, Azerbaijan, Georgia and south of European Russia, is located within the Caucasus Biodiversity Hotspot and a "Vulnerable" Ecoregion as identified by WWF and Conservation International (Fig. 1). The rarest mammalian species of this region is the Persian leopard (*Panthera pardus saxicolor = P.p. ciscaucasica*) which is listed as "Endangered" in the national Red Data Books and in 2002 IUCN Red List of Threatened Species. Most likely, viable populations of this big cat have already disappeared outside Armenia (Badridze et al., 2000; Gadjiev, 2000; Penzikov, 1986) and southern Armenia (Ararat, Vayots Dzor and Siunik Provinces) seems to stay the leopard stronghold in the whole region due to its connectivity with northern Iran where significant leopard numbers still live (Kiabi et al., 2002) (Fig. 2a-c). At the same time, several individuals still survive in extreme south-east of Azerbaijan's Nakhichevan Republic which adjoins northern Iran and southern Armenia (E. Askerov, pers. comm. – Fig. 2d). Some predators may also penetrate from Iran to Talysh Mountains in south-eastern Azerbaijan.

Unfortunately, the leopard conservation in the Caucasus has been aggravated by existing political tension between Armenia and Azerbaijan, two countries which hold full responsibility for saving the region's leopards. The Armenians can study and preserve this predator in Meghri, Bargushat ridges, south of Zangezour ridge (locality Bohaqar), Gndasar Mt./Noravank Canyon area and Khosrov Reserve (No. 1, 2, 4, 7, 8, 9 in Fig. 2c). The Azerbaijani can do that only in extreme south-east of Nakhichevan in Zangezour ridge (No. 3 in Fig. 2c). Most of long Zangezour ridge which connects southern Armenia and Nakhichevan with Khosrov Reserve and its corridor Gndasar Mt./Noravank Canyon area stretches right along the Armenian-Azerbaijani state border and is thus closed for any wildlife research and/or conservation by either party (No. 5, 6, 10, 11 in Fig. 2c).

The first scientific efforts to study the leopard ecology in Armenia were started by us in 2001 in the country's premier protected area, Khosrov Reserve in south-western part of the country, and in its wildlife corridor with southern Armenia, Gndasar Mt./Noravank Canyon area (Ararat and Vayots Dzor provinces – see Fig. 2a, b; Khorozyan and Malkhasyan, 2002; Khorozyan, 2003). Such aspects as feeding habits, predator-prey relationships, feeding competition, space use and distribution, human impact and the essential conservation measures are emphasized in these publications. After that, it became essential to estimate the leopard density and status in Siunik Province. This information would be a strong tool in the hands of scientists, conservationists, authorities, local people and donors striving to save the leopard from extinction in the Caucasus.

This report summarizes information deriving from the research project which took place in Meghri region of Siunik Province and continued from December 2002 to November 2003. Its overall aim was to estimate the leopard density, structure and spatial distribution in the study area and define the crucial importance of this information for the development and maintenance of workable conservation.

Immediately upon the completion of production of this report it will be translated into Armenian and Russian to be distributed among the scientists, conservation authorities, environmental non-governmental organizations and local people in Armenia. Its original English version will be posted on our website <www.persianleopard.com> by the end of the year 2003.

Fig. 1. *The Caucasus biodiversity hotspot and position of Armenia in it. Sources: websites www.biodiversityhotspots.org and www.cepf.net*

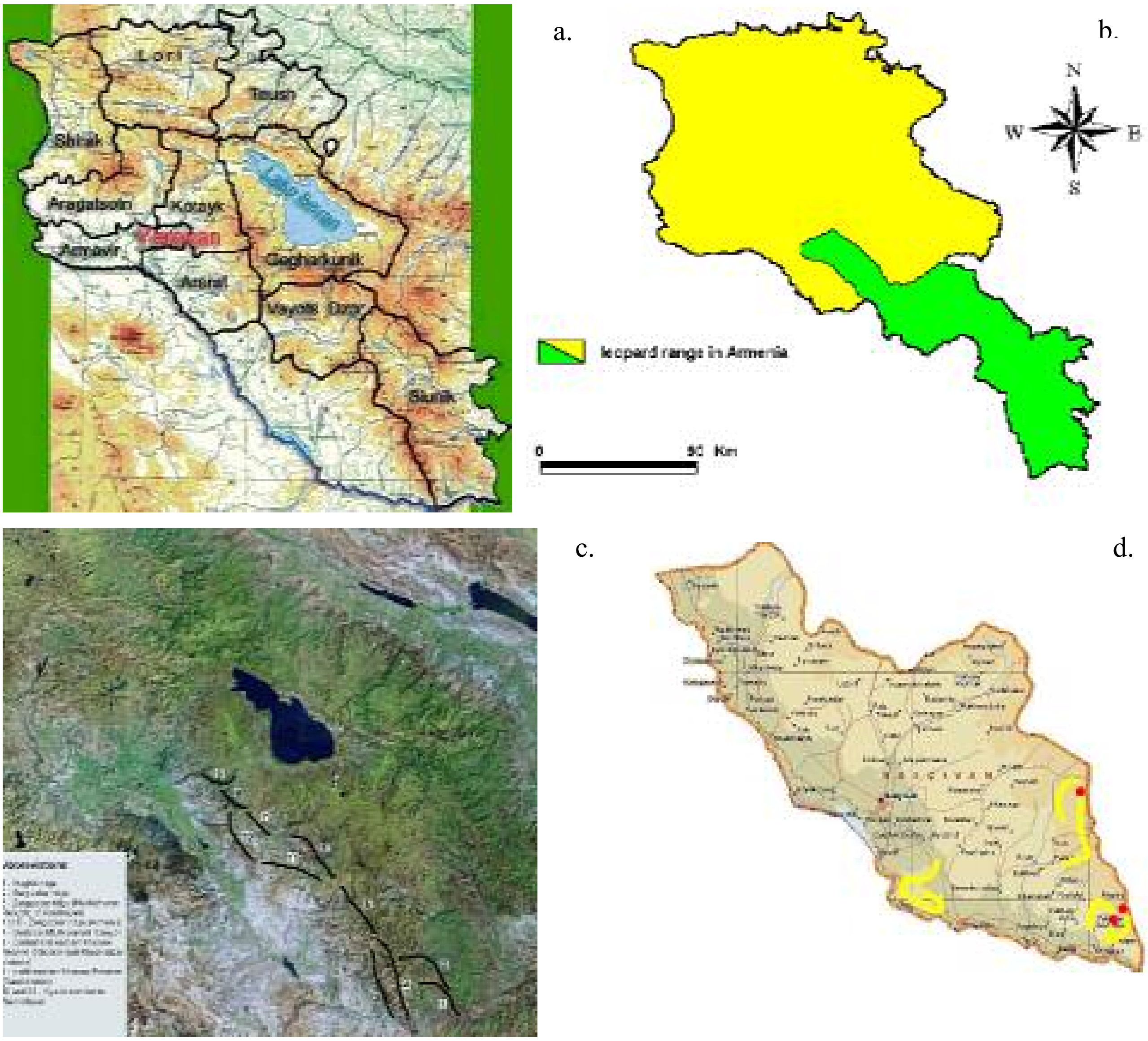

Fig. 2. *The provinces of Armenia (a), leopard range in the country (b), the principal mountain rid ges determining the current leopard distribution in the Caucasus (c) and the leopard search routes and record sites in Nakhichevan Republic of Azerbaijan (d). Sources: Office of WWF Programs in Armenia (a and c), S. Asmaryan, Center for Ecological Studi es, Armenia (b) and E. Askerov, Office of WWF Programs in Azerbaijan (d).*

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<u>Chapter 1</u>: CAMERA PHOTO-TRAPPING.

Introduction.

Camera photo-trapping (PT) is an advanced technique which allows to photograph elusive and rare animals living in challenging environments either through detection of body heat (passive PT) or when the infrared beam emitted by device is broken by passing animal (active PT). Analysis of the pictures collected by this method may give very important information about the population size and density if the target species has body markings, for example spots or stripes, which are individually distinguishable. The statistical program CAPTURE makes it possible to make the estimations taking into account such variables as individual heterogeneity, behavioral response to photo-traps, time and their combinations (Karanth, 1995; Karanth and Nichols, 1998).

The PT has widely been used to study the size and structure of populations in different wild cat species around the world. For the leopard, this approach is used in Ivory Coast (Jenny, 1996), Oman (Spalton, 2000), Russian Far East (Miquelle et al., 2003), Zanzibar (Anonymous, 1998) and Morocco (Jensen and Romanski, 1990). Some information about the leopard PT is available also from literature which describes the use of this method for the tiger (*Panthera tigris*) research and monitoring (Karanth and Nichols, 1998; Kawanishi, 2002).

Methods.

The studies were conducted in January - November 2003 in Meghri region chosen by WWF Caucasus leopard project No. GG0015.01 (Switzerland) for the establishment of the first leopard-targeted protected area in southern Armenia. This study area encompassed the large portion of Shvanidzor forestry of Meghri Forest Farm (*leskhoz*) which sits astride the Meghri ridge. It was located between the villages Nuvadi on the south, Shvanidzor on the south-west, Tsav on the north and the state border with Azerbaijan on the east (Fig. 3).

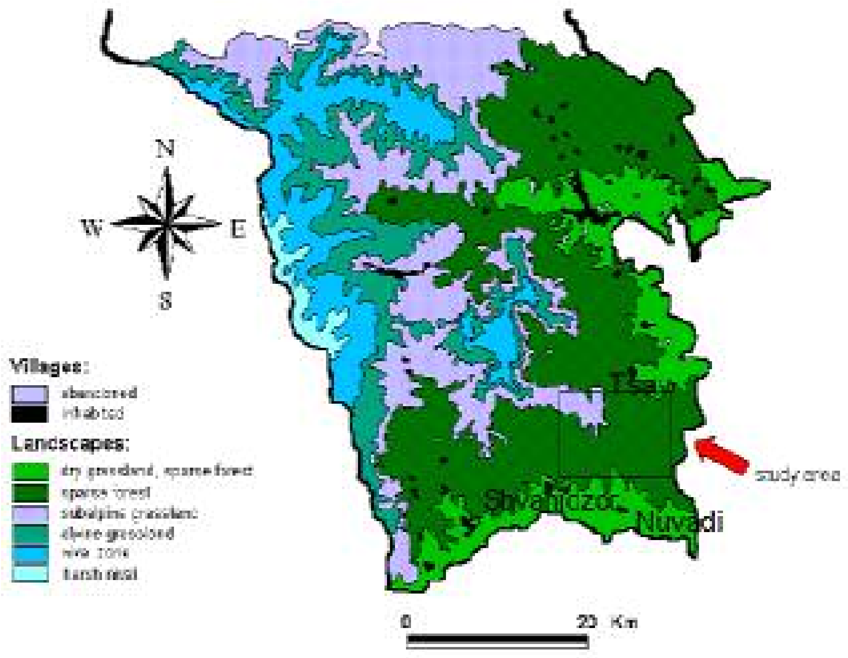

Fig. 3. *The study area in Meghri region of Siunik Province, s outhern Armenia. Produced by S. Asmaryan, Center for Ecological Studies, Armenia.*

This region contains the most rugged terrain in Armenia, with decline from over 2000 m down to 380 m in Arax riverside right on the border with Iran. The relief represents an array of numerous mountain ridges, deep and precipitous canyons covered mainly by sparse juniper forest with dry grassland (Fig. 3). Meghri is the warmest dry subtropical area in Armenia, with mean annual air temperature 13.8^{o}C. Mean annual precipitation makes 259 mm, maximum of which falls in March - June (51.6-55%) and minimum in July - August (6.6-11%) (Manasyan et al., 2002). However, the period December 2002 – May 2003 had unbelievably harsh winter and we succeeded to work only a few days in January and March. In this period, the air temperatures reached -25-30^{o}C and therefore were even below the extreme minima recorded so far in this region (-22^{o}C) (Manasyan et al., 2002).

Four TrailMaster® camera photo-trap units (USA), hereinafter referred to as units, were set up on the leopard trails unambiguously identified by us on a basis of presence of leopard scats, tracks, sightings by local people, prey signs, watering places and trail intersections. For correct unit operations and productive work in the wild, we referred to manufacturer's manuals, professional advices (W.D. Goodson, A.A. Canedi and M. Farhadinia) and papers Karanth (1995), Karanth and Nichols (1998), Karanth et al. (2002) and Kucera and Barrett (1993). Each unit consisted of TM 35-1 camera kit (Canon A1/Prima AS-1; 35 mm, weather-proof, auto-focus, auto-flash and auto-wind), TM 1550 infrared (IR) transmitter and TM 1550 active IR trail monitor (receiver) that activated the camera and recorded the date, time, event and photo capture each time the IR beam emitted by transmitter is broken by a passing animal. Throughout the study, we used the 36+ exposure 35 mm negative color film Kodak Professional ProFoto 100 (UK) and long-life batteries Duracell Plus (Belgium). This film gave us the best quality pictures. Apart from date/time set in camera and receiver, the following technical parameters were set in receiver according to manufacturer's manual: No. of unit (Un01, Un02, Un03, Un04), camera sensitivity 0.35 sec. (period needed for IR beam to be broken for registration of event), camera delay 15 min. (time span between two subsequent photographs), 12 h regime of night photographing from 21:00 to 9:00 and baud rate 9600 of data transfer to TM Data Collector and TM StatPack software. We used the "Flash on" mode in night photographing, because in Canon cameras it does not cause delays and the red-eye reduction which could startle animals (W.D. Goodson, pers. comm.).

Transmitter and receiver were mounted at the opposite sides of a trail so that the IR beam would be at the leopard's chest level ca. 45 cm above ground. Having set the unit, one of us walked through the IR beam to check whether the event is registered. We left the mounted units unattended between the days of unit setup and removal so that not to leave the human scent on the trail.

The cameras were positioned at the points allowing to photograph the animal from either flank and thus identify its individuality and possibly sex/age category from the produced picture – the 8 m long cable connecting the camera with receiver allowed to easily manipulate with camera placement. We used both horizontal and vertical positioning of the cameras, but the horizontal one is much better as allowing to capture the broader scope of space in front of the camera. Also, we tested many ways to mount the cameras and decided finally to place them in such a way that the camera's viewfinder window is at the same height than the receiver window and looks at the point in the middle of the straight line between the transmitter and the receiver. So, we placed the cameras at quite low height and at more distance from the trail than receiver in order to photograph as wide range as possible – on average, at about 3 m from the trail (Karanth, 1995). Joslin (1977) states that "distance from the camera does appear to be important in that the photographic success ratio is higher the further away the camera is from the [photo-trap] station".

For correct positioning of the cameras, we carefully studied the photo-trap pictures of the leopards taken elsewhere and posted at the websites <www.tigrisfoundation.nl> and <www.michaelnicknichols.com>.

The sampling effort was measured in terms of trap-nights as the sum of the numbers of days individual units were employed over the sampling occasions. The sampling efficiency was measured as the number of leopard pictures produced per 100 trap-nights (Karanth and Kumar, 2002).

After each sampling occasion, information stored in the receiver's event memory was downloaded to TM Data Collector and then to TM StatPack software for statistical data analysis. Also, data from TM Data Collector were manually re-written to the standard TrailMaster® event data pads for handy reference. To facilitate accurate data registration and trouble-shooting, all units and films were given unique ID's (e.g., unit marked Un01-1 meant the unit Un01 set up in the sampling occasion 1). As we also recorded geographical data (longitude, latitude and elevation) of each unit in an occasion by means of Magellan 310 hand-held GPS device (USA) for further GIS mapping using ArcView GIS 3.2a software (USA) (Fig. 3), it was easy to track data flow.

Results & Discussion.

We undertook the sampling effort 250 trap-nights, but have not obtained any leopard picture (sampling efficiency = 0). This result causes disappointment, but does not essentially mean that the leopard has gone forever from Armenia.We think that three factors are principally responsible for nil capture probabilities of the leopards in southern Armenia, even though this region is recognized as the species' stronghold in the country and in the whole Caucasus: (1) intrinsic elusiveness of this predator, making it very seldom photographed, (2) expected dominance of transient individuals in population and (3) rarity of the predator in the country. Below, we discuss these issues in details.

Elusiveness. The leopard is an exceptionally cryptic animal and its capture probabilities by camera photo-traps are very rare, random and unpredictable even where this felid is relatively common. For example, in four national parks of India (Kanha, Kaziranga, Nagarahole and Pench) the leopard densities are at least twice as much as those of the tiger (K.U. Karanth, pers. comm.), but the index of relative abundance is 0.18-5.44 for the leopard vs. 5.3-14.7 photo-captures/100 trap-nights for the tiger (Karanth and Kumar, 2002; Karanth and Nichols, 1998).

Dominance of transients. Small leopard populations subjected to pressure of natural and/or anthropogenic factors consist mainly of transients (also called "vagabonds" or "floaters") which are in constant search for unoccupied appropriate areas for establishment of individual home ranges (Danov, 1985; Pikunov and Korkishko, 1992). Having no certain area for living, the transients roam over vast territories with unpredictable movement patterns. We do not know where the resident breeding leopards with regular and conservative movements over the same trails live in Armenia, and even the fact that we found the predator signs on the trail (scats, scrapes, prey remains) does not necessarily mean that the leopard will definitely pass by the unit and thus photograph itself in the period when the unit is positioned. So, our choice of the place where to mount the unit was mainly blind; as a result, we possibly used photo-trapping in areas where only transients live.

The possible prevalence of transients in Armenian population can be indirectly corroborated by low rates of territorial marking by scrapes which is a prerogative of the resident adult animals. The transients do not have their own home ranges and thus do not mark them to communicate with other leopards (V. Lukarevsky, pers. comm.).
This factor may underlie the statement that the felid densities deriving from photo-trapping are more reliable in high-density areas than in low-density ones. Karanth and Nichols (2002) give an example when 451 trap-nights brought not a single tiger picture in the area where the tigers were definitely known to exist. In such cases, the authors strongly suggest to use the inexpensive spatial studies (e.g., scat counts and other methods of relative abundance surveys based on distribution of presence signs) as a worthwhile alternative. The detailed description of our experience in using scat counts to estimate the leopard density in southern Armenia is given below in Chapter 2.

Rarity. The commonness of the leopard and plentiful information about it in Sub-Saharan Africa creates a very misleading opinion that this cat is out of the risk of extinction due to its capability to co-exist with high human densities (Woodroffe, 2000, 2001). Meanwhile, it experiences the hard times today in Asia where ever-increasing human population, habitat destruction, persecution and depletion of wild prey resources leave fewer and fewer chances for the predator to survive in many parts of this continent. Out of 8 leopard subspecies listed in 2002 IUCN Red List of Threatened Species, 7 originate from Asia which are classified as either "endangered" (4 subspecies) or "critically endangered" (3). So, the difference in status of African and Asian leopard populations should be clearly understood and taken into account when making the management decisions about this species.

Possibly, the most alarming situation is in the Middle East, from Turkey and Caucasus to Arabia and Afghanistan. The leopard is not legally protected in many countries of this region, nor it is studied or managed over most of the territory. Across 19 countries, in 11 (58%) this species is definitely or most likely extinct, in 6 (32%) it is very endangered and only two countries (10%) are expected to contain more or less safe populations of this felid – Iran and Afghanistan (Shoemaker, 1993).

Contemporary leopard research and conservation publications coming from the Middle East are handful. The most in-depth study of this carnivore has been conducted in Turkmenistan since early 1980s (Lukarevsky, 2001). Some existing information was summarized recently about the leopard in Iran (Kiabi et al., 2002). Several papers describing the present leopard status in Turkey (Masseti, 2000; Ullrich and Riffel, 1993) are dealing with indirect evidence of the cat presence and the old museum specimens, while the field-based projects have begun only recently (camera photo-trapping - B. Avgan, pers. comm.). In 1970-1980s, the leopard was extensively studied in Israel, but now local population seems to be doomed to extinction, if not already gone, due to its geographical isolation and existence of only one breeding female whose offspring is always killed by non-siring males (Ilani, 1990). Even though the leopard research was undertaken recently in Oman (Spalton, 2000), no practical efforts are done to curb the severe hostility of people in Arabian peninsula to this felid and its population continues to go down to maximum 1-2 dozens of individuals across this vast area (P. Vercammen, pers. comm.). In Armenia, the leopard research and conservation projects were initiated in 2001 and have been running ahead since then (Khorozyan, 2003; Khorozyan and Malkhasyan, 2002).

The possibility of local extinctions in mammalian carnivores is much higher in areas with high human densities, but the negative attitudes fueled by anti-predator governmental policy, trade and socio-political/economic development may accelerate the loss of local populations at much higher rates than predicted irrespective of human density (Woodroffe, 2000, 2001). In the Middle East, the dominating threat to the leopard existence is poaching which is facilitated by easy access of local people to firearms and is done to minimize the actual or would-be damage to animal husbandry (Turkmenistan, Iran, Arabian countries) or simply from fear of encounter in spite of the nil effect on livestock or people (Armenia). The statements that “the urge to kill carnivores is in human instinctive behavioral repertoire, like the hatred for snakes” (Sillero-Zubiri and Laurenson, 2001) and that panic and hypnotized condition of humans and primates from seeing the leopard spots can be embedded in genes (Conniff, 2001) are fully applicable to this region. Hence, the risk of extinction of local leopard populations would be expected to correlate well with increasing human densities (Woodroffe, 2000). In particular, in Armenia the leopards live mainly in southern Armenia where the density of rural people is minimal; human density is also low around the important leopard refuge, Khosrov Reserve, as local villagers of Azerbaijani origin fled in early 1990s during the warfare (Khorozyan, 1999).

The key factors determining the low leopard density in Armenia are narrow prey base, habitat use by people, poaching and wild fire (Khorozyan, 2003; Khorozyan and Malkhasyan, 2002).

Living in rough terrain makes local leopards spend much more energy than somewhere else in the plains, therefore they will survive only by feeding on nutritious and easy-to-catch medium-sized ungulates. The best choice is the bezoar goat (*Capra aegagrus*) which fully meets the leopard’s requirements to its staple prey: prey availability, abundance, size, vulnerability, and behavioral response in a given place and time. The predator-prey relationships are very fine-tuned in this pair and, not surprisingly, local people call the leopard “the goat shepherd”. An additional advantage is that other co-existing predators take this prey only by chance, generally avoiding the cliffy barren lands where the leopards and goats live, and do not act the serious feeding competitors. Alternative prey species, wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*), do not substitute the goat and, if taken, greatly increase the chances for competition with numerous gray wolves (*Canis lupus*). The boars are able to retaliate viciously and thus are taken reluctantly, with preference given to seasonaly available piglets and juveniles (Khorozyan and Malkhasyan, 2002). Such a strong association with just a single prey species makes Armenia’s leopards prone to extinction if the bezoar numbers decrease from some natural or anthropogenic factors. Poaching and livestock breeding are the major threats to these ungulates.

The habitat use by people is confined to livestock breeding, harvesting of edible herbs and deforestation. Livestock grazing is most intense in the areas of Khosrov Reserve and its wildlife corridor Gndasar Mt./Noravank Canyon in south-western Armenia, which is an important leopard stronghold in the country (Khorozyan, 2003), but is small-scale and thus insignificant in southern Armenia. It lasts from spring to late autumn and is spread over the wild grasslands serving as pastures. The edible herbs bulbous-rooted chervil (*Chaerophyllum bulbosum*), falcaria (*Falcaria vulgaris*), star-of-Bethlehem (7 species of *Ornithogalum* spp.), horse fennel (2 species of *Hippomarathrum* spp.) and some others have been widely collected in local mountains in the period April-August. Deforestation is non-commercial and limited by collection or cutting of firewood; thus, it is most common in late autumn before the winter cold comes. All these factors pose a rather serious disturbance factor for the leopard prey which may cover long enough distances to escape from disturbance and leave territorial leopards deficient in food.

Poaching has been the principal threat to the leopards and their staple prey in southern Armenia, as since early 1990s when this region was engaged in military conflict with neighboring Azerbaijan over Nagorno Karabakh, local population holds numerous firearms as a guarantee of safety. Local carnivores are sometimes shot by villagers for fear of encounter (all species) and in revenge of livestock losses (wolf, brown bear), but never for trophy or income generation. Abundance of firearms in private ownership is an objective factor which has to be dealt with: 89% of the border of Siunik Provincei s with Azerbaijan and the whole region is considered as the “borderline territory” having only limited connectivity with other parts of Armenia (10.2% of total border) (Manasyan et al., 2002).

The wild fire is a common problem in xerophilic juniper forests in the highlands of Khosrov Reserve and southern Armenia (Meghri region) (Fig. 4). It can originate both naturally from intensive direct sunlight or artificially from human carelessness. Whatever the way it comes, the wild fire burns down the large areas of good habitats and urges the prey populations to migrate away from the peril. Local people and conservation authorities are limited in financial and logistical resources to do the timely firefighting, but strive to do their best.

Fig. 4. *A tract of natural forest destroyed by wild fire near Shvanidzor village. Picture by I. Khorozyan, this project.*

Despite no leopard pictures were obtained by us, we found the predator presence signs – scats and scrapes. In more details, we describe their occurrence in Chapter 2. Another two leopard records represent the temporary shelter used by female and her grown-up cub(s) (Table 1).

Table 1. *The leopard records during the period of this study (2003).*

Date	Coordinates	Elevation, m	Description
Apr. 21	38°57'42N/46°28'02E	1228	The den inside a cliff niche hidden in lush vegetation on a trail to the brook. Based on numerous scattered remains of eaten bezoar goats and roe deer, scats and tracks we suppose that this shelter was used for rest by a female leopard with 2 (?) grown-up cubs.
Jun. 15	38°57'16N/46°28'07E	1224	Fresh hairs and a big piece of skin of the wild boar near this den. These remains were absent in mid-May (Fig. 5).

As a result, our efforts look very similar to the project of photo-trapping highly endangered South China tiger (*Panthera tigris amoyensis*) in China where 392 trap-nights brought no tiger pictures, but indirect presence signs were found, and it was thus concluded that no viable population is left in the wild for long-term survival (Anonymous, 2002; Muntifering, 2001). However, this failure has not disappointed researchers and conservationists and spurred the development of multimillion-dollar China Action Plan for Saving the South China Tiger (www.savechinastigers.org). It was concluded that the extreme rarity of this subspecies necessitates the conservation actions to concentrate on work with rural people rather than on wasting time and money in search of a few survivors in remote mountains. Also, such low-density populations of the big cats will greatly benefit from inexpensive techniques of population status monitoring and spatial studies as the surveys of presence signs (scats, tracks) (Karanth and Nichols, 2002) – see Chapter 2.

Learning from the lesson of South China tiger, we also insist on implementation of in-depth community-based conservation activities which would allow to alleviate human pressures on the leopards and their prey in Armenia: anti-poaching patrolling, professional training, population monitoring, public education, ecotourism and enforcement of technical assistance to key conservation bodies responsible for wildlife protection. First steps are already done through the project “Conservation of the leopard in the Caucasus Ecoregion” supported by WWF-International (Switzerland), but much more is to be done through involvement of wider strata of public, scientists, governments, conservationists and donors.

Also, in the year 2004 we plan to strengthen local capacities for biodiversity conservation in southern Armenia by means of participation in wildlife monitoring, professional training, education, technical assistance and public communication campaigning. The leopard will serve the flagship species in these efforts.

Now, the Ministry of Nature Protection of Armenia has been considering the possibility to establish the wildlife sanctuaries in most of Meghri Forest Farm what will significantly improve conservation in southern Armenia.

Fig. 5. *The wild boar skin piece supposed to be left from the leopard's feast. Locality Ernadzor. Picture by I. Khorozyan, this project.*

APPENDIX: The problems with use of camera photo-traps in Armenia.

All available information about felid photo surveys describes application of this technique mainly in tropical lowland habitats, hence in some aspects it can be of little use to those scientists working in highland mountainous conditions. The only study using felid camera photo-trapping in the mountains is that done by Arturo and Patricia Canedi in Argentinean Andes, but no reports and publications are produced from this work so far (A. Canedi, pers. comm.). Below, we share our views on the problems we faced during our leopard camera photo-trapping project in southern Armenia, as it may give some insights to planning, study design and implementation of this approach in the whole region of the Middle East and in the mountains in general.

Weather. The winter 2002-2003 was incredibly snowy, misty and cold all over Armenia. In southern Armenia which lies in subtropical zone and enjoys the warmest climate in the country (Manasyan et al., 2002), air temperatures dropped below to -25-30^{o}C, snow cover reached 70-100 cm deep and the period of strong snowfalls, mist and sleet extended up to late April or even May. We failed to normally work in this period and undertook insignificant sampling effort (25 trap-nights), as the photo-traps positioned with the infrared beam to extend on the leopard chest level (45 cm from the ground) were simply sunk in snow and stopped operation. Also, in this period we were seriously limited by availability of warm lodgings for camping and had to arrange the trip routes taking into account the location of lodgings and the short daytime period. So, our research was confined to the areas relatively close to villages what significantly reduced the chances to capture the human-shy leopards.

The snow is a principal factor limiting distribution of the leopards in the northernmost areas of their global range – Caucasus and Russian Far East. As this cat has very high foothold pressure and thus fails to hunt in deep snow, in both these regions it inhabits the south-exposed cliffy areas where snow melts fast (Heptner and Sludsky, 1972, Pikunov and

Korkishko, 1992). Based on our talks to local people and field experience, we knew *a priori* which places could harbor the leopards in deep-snow conditions, but this year they all were inaccessible to us and also seemed to be too snowy for the leopards themselves. As a result, we did not know exactly if the predators were present in the places we chose for camera photo-trapping.

Theft or damage by rural people. This is a potential problem, since local people go to mountains for collection of edible plants, hunting, firewood collection/cutting and livestock breeding. We used to spread a word and thus raise local awareness about our photo-trapping activities as wide as possible, but were not absolutely sure that somebody will not take or damage the devices. As a result, half of our sampling occasions were short (4-7 days) and confined to the periods when we stayed in the field and could check the safety of photo-traps. We checked safety through the monitoring of people entering the study area by known trails and not by re-visiting the positioned devices, as this will leave strong human scent disturbing natural movements of wild animals.

To make the photo-traps least visible, we never attached them to the woody posts as used elsewhere (A. Canedi, pers. comm.; Karanth et al., 2002). Instead, we mounted the units in the most unobtrusive way to the base of the sturdy trees to leave them unnoticed by wildlife and local people.

Lack of trees suitable for mounting the photo-traps. The cliffy areas where the leopards and their staple prey, bezoar goats, live, are generally treeless, but even if the trees are present they are thin, with rough bark and crooked, so the sturdy trees appropriate for mounting the units on are infrequent. All this makes a problem with choosing a right tree. According to photo-trap manufacturer's guidelines, it is absolutely essential to attach the devices to (1) *sturdy* trees which are resistant to winds and do not disturb the alignment between the infrared transmitter and the receiver for producing the false events and photographs; and (2) *vertical* trees which will keep the infrared beam horizontal and most likely to be broken by a passing animal. To comply these requirements, we used the aluminum wire to firmly attach the units on the trees and the pieces of tree branches as shims to ensure the vertical position of devices (Fig. 6). Also, we gave the narrower position to the steel brackets which fix the units to the trees; this makes the units well pressed into the wood by bracket prongs.

The Velcro straps provided by manufacturer for fixation of photo-traps are too weak and always need to be firmly knotted as simple straps and fortified by wire.

The same can be said about mounting the photo cameras. The tripods provided by manufacturer are unsatisfactory if used alone, hence we attached the cameras to the trees additionally by boot laces or aluminum wire.

Fig. 6. *Attachment of photo-trap units to crooked and thick-barked trees in the mountains using aluminum wire and tree branches as shims. Locality Darband. Picture by I. Khorozyan, this project.*

<u>Improper operation of TrailMaster® photo-traps</u>. During the field operation of our photo-traps, we had many troubles and their causes are not fully understandable to us.

In all sampling occasions, the units registered too many events in a very short period of time. Initially, that could be caused by lack of our experience with proper alignment of the infrared transmitter and the receiver. Later we got more skills and knowledge in this field, consulted with TrailMaster manufacturer B. Goodson and wildlife researchers, read relevant publications in the hope to find the clues, but again obtained hundreds of false events. When we set the camera delay (the time period between two subsequent photographs) 1-2 minutes, such an operation of photo-traps made the whole film wasted for useless pictures within several days or so. Even when we increased the delay to 15 minutes, the film was completely shot in about 4 days. So, the increase of duration of sampling occasions from 4-7 days to about 30-35 days did not make any positive change, as the film was over several days after we positioned it on a trail and we naively hoped that the longer period of sampling will increase the capture probability.

This problem can be caused by many factors: technical troubles, small fast-moving animals, interference with the Sun's infrared energy, precipitation, etc. Interestingly, similar conclusion was made by Kawanishi (2002) who conducted a thorough wildlife study in Malaysia and made a comparative analysis of efficiencies of two models of photo-traps, TrailMaster (TM) and Camtrakker (CT). She states that TrailMaster is very prone to technical malfunctions when it is difficult in the field to ascertain which component fails first (25 in TM vs. 4 in CT) and to unknown extrinsic factors (25 in TM vs. 0 in CT). In general, she claims that the nil photos due to unknown reasons make the principal problematic feature of TM.

An insurmountable problem for us (and it is for all researchers working with photo-traps in the field!) was our impossibility to identify the factors disturbing the whole system on place, as we could do that only after we return home and develop the film shot in the unit. We inevitably had to lose time and make improvements only during the next field trip.

As we spent substantial financial, logistical, technical and human resources during this camera photo-trapping project and undertook significant physical efforts in Armenia's precipitous mountains, but faced these problems and obtained not a single incontestable evidence of the leopard existence, we conclude that photo-trapping is not expedient for wildlife research and monitoring in the country. We do not expect some better results if we develop our experience or if the TrailMaster photo-traps become available to other scientists in Armenia, as the performance of this model is only slightly relevant to experience in device operation and its lower quality is caused rather by its technical characteristics (Kawanishi, 2002).

Chapter 2: DENSITY ESTIMATION FROM SCAT COUNTS.

Introduction.

Today's conservation practices require from scientists obtaining so much needed information about the carnivore densities and their change in time and space. Meanwhile, the carnivores are notoriously difficult to count because: (1) they live at naturally low densities over vast areas; (2) under serious human pressures they retreat to remote hardly accessible areas and lead cryptic life; (3) developing countries which accommodate most of living predator species do not have sufficient financial, technical and/or human resources essential for up-to-date and long-term research, monitoring and conservation of these animals (Gese, 2001).

To overcome this problem, developing countries should emphasize the development, verification and application of non-invasive, simple, reliable and cost-efficient methods of estimating the carnivore densities. Use of relative abundance indices (RAI's) and their correlation (if any) with the real density values appears to be the most promising technique, since it allows potentially to estimate the densities from scat counts, track counts and similar procedures without disturbing the target animals themselves. The carnivore densities may also correlate with rainfall (Martin and de Meulenaer, 1988) and/or prey biomass (Carbone and Gittleman, 2002; Fuller and Sievert, 2001), but we think that such a relationship is possible only in prey-rich and low-human environments where anthropogenic pressures do not affect the predator abundance (Woodroffe, 2000).

The idea of employing the RAI's in terrestrial mammal studies was suggested and described first in 1980s with a skeptical opinion that they cannot give any quantitative information about the species numbers and are able only to indicate whether a species is present or absent in a given area (Nowell and Jackson, 1996). Since then, the scientific attitudes have shifted towards the recognition of importance of this issue and a number of efforts are practi cally undertaken so far to determine if the correlation between the RAI's and animal densities really exists – and it does, at least in some rodents (Walker et al., 2000), ungulates (Dzieciolowski, 1976) and carnivores (canids – Gese, 2001; Wilson and Delahay, 2001; ursids – Kendall et al., 1992; felids – Beier and Cunningham, 1996; Fox et al.,1991; Ramakrishnan et al., 1999; Smallwood and Fitzhugh, 1995; Stander, 1998; Van Sickle and Lindzey, 1991). In practice, the scats provide much more available material for studies than other predator presence signs, hence the fecal RAI (fRAI, No. scats found per 10 km of trails walked) can be a strong tool in drawing inferences about the population density provided a reliable monotonic and linear relationship between these parameters is established (Karanth et al., 2003).

Below, we describe the strong correlation which we found between the fRAI and actual density in different leopard populations across Sub-Saharan Africa and Asia. Further, we use this correlation to estimate the density of the endangered Persian leopard in southern Armenia. And, at last, we discuss the importance of this information for planning, implementation and management of conservation of this vanishing cat and other wildlife in Armenia.

Methods.

The studies were carried out in snow-free seasons of 2003 (April – October) in the same study area as camera photo-trapping (Fig. 3). The leopard scats (Fig. 8) were identified on a basis of our field experience and the general criteria described in literature: characteristic "segmented" shape with mean diameter ca. 2.7 cm (range 2.0- 3.0 cm), pointed ends, many lobes and the place of scat deposit (propensity to use trails along the ridge tops and mark them with scats when traveling) (Edgaonkar and Chellam, 1998; Johnson et al., 1993; Karanth and Sunquist, 1995; Lukarevsky, 2001; Norton et al., 1986; Rabinowitz, 1989; Ray and Sunquist, 2001). We defined "scat" as the cluster of individual feces deposited in a single act of defecation. The location of scat sites (coordinates and elevation, m) and the daily distances walked (DW, km) were measured by handheld Magellan GPS 310 device (USA). Throughout the study, we used the long-lasting AA-cell alkaline batteries Duracell Plus (Belgium): a pair of batteries were enough for two days of continuous operation of GPS. As the odometer in this GPS measures the straight-line distances, we multiplied them by the factor of terrain roughness 1.3 to obtain the real DW. Oli (1997) uses the factor 1.25. The factor's value resulted from simultaneous operation of GPS odometer and vehicle odometer in a driving off-road vehicle and the comparison of same-distance measures from both odometers. In total, 17 scat sites were recorded and 200.6 km were walked.

The fecal relative abundance index fRAI (No. scats n/10 km DW) was calculated as shown in eq. 2-1:

$$fRAI = n \times 10/DW \qquad \text{(eq. 2-1)}$$

For obtaining the general relationship between the fRAI and population density in the leopard, we have taken the scientific area-specific data available from Bothma and le Riche (1994a), Lukarevsky (2001), Ray and Sunquist (2001), Martin and de Meulenaer (1988), Jenny (1996), Spalton (2000), Pikunov and Korkishko (1992), Ramakrishnan et al. (1999) and two official websites of the key national environmental authorities. They are presented in Table 2 and illustrated in Fig. 7. The density data represent the "gross density", i.e. total number of adult residents, cubs, sub-adults and transients known to utilize a given area. The relationship between the fRAI and leopard density D (individuals/100 km^2) derived from data in Table 2 plus zero point (no scats bear no leopard density); it looks as follows (eq. 2-2):

$$D = 0.58\ fRAI + 0.72 \qquad \text{(eq. 2-2)}$$

Statistical significance: $F_{1,7} = 47.44$, $P = 0.000$, $r^2 = 0.87$. The lower and upper limits of 95% confidence interval (CI) of the slope and intercept in eq. 2-2 were calculated as the mean ± 1.96 statistical error (SE) of the mean (Nichols and Karanth, 2002b; Quinn and Keough, 2002). The 95% CI makes from 0.38 to 0.78 for the slope and from -1.62 to 3.08 for the intercept.

As the intercept did not differ significantly from zero (t = 0.73, P = 0.489), we set intercept at zero and obtained another eq. 2-3:

$$D = 0.61\ fRAI \qquad \text{(eq. 2-3)}$$

Statistical significance: $F_{1,8}$ = 81.64, P = 0.000, r^2 = 0.91. The 95% CI of the slope makes from 0.46 to 0.77.

As the r^2 values from intercept (eq. 2-2) and no-intercept (eq. 2-3) linear models cannot be compared, we checked which one of them is best fit to real observations and compared their variances of residuals $e_i = D_{i,observed} - D_{i,estimated}$. No-intercept model had lower variance than intercept model (5.795 vs. 6.154), indicating its higher statistical power.

As eq. 2-3 provides the most accurate relationship between fRAI and D (zero intercept, linear shape and slope equal to constant-proportion index – Walker et al., 2000), we used only it in our leopard density calculations.

To test the normality and homogeneity of variance of D, we have plotted e_i against fRAI's. No obvious pattern of the residual plot indicates that both these assumptions are met. Normality of D was also proved by Shapiro-Wilk test (P = 0.010). The effect of an apparent outlier (datum from Ivory Coast marked by white circle in scatterplot of Fig. 7) on linear relationship in Fig. 7 was assessed as insignificant due to the Cook's distance statistic D_i less than 1 (0.322).

To see the effect of variation of fRAI on variation of the density estimates, we have calculated the density estimates in two ways: (1) without variation of fRAI (mean fRAI); (2) with variation of fRAI (limits of 95% CI of fRAI).

All statistical procedures were performed in SPSS 9.0 for Windows software package (SPSS Inc., USA). A wonderful book by Quinn and Keough (2002) was our invariable guidebook.

Table 2. *The area-specific data on fecal relative abundance index (fRAI) and the leopard density (D) across its range in Africa and Asia ranked with increasing D.*

Habitat and area	fRAI, No. scats/10 km walked	D, ind./100 km^2	Description	References
Hyper arid rocky habitat, Jebel Samhan Nature Reserve, Oman	2.35	0.11	47 scats/200 km; 5 ind./4500 km^2	Spalton, 2000; Ministry of Information of Sultanate of Oman: www.omanet.com
Juniper sparse forest and barren cliffy lands, Meghri region, Armenia	0.65	0.40	17 scats/200.6 km	This study
Mountainous juniper and pistachio sparse forest, Western Kopetdag, Turkmenistan	1.05	0.48	172 scats/1633 km; 23-25 ind./5000 km^2	Lukarevsky, 2001
Vegetation-free precipitous cliffy lands, Central Kopetdag, Turkmenistan	5.53	1.23	146 scats/264 km; 25-30 ind./2200 km^2	Lukarevsky, 2001
Dunes and sandveld savanna, Kalahari Gemsbok National Park, South Africa	0.70	1.30	1 scat/12.4 km in males and 1 scat/21.0 km in females; 5 ind./400 km^2	Bothma and le Riche, 1994a; Martin and de Meulenaer, 1988
Mixed coniferous-broadleaf forest, Kedrovaya Pad Reserve, Russian Far East	2.54	3.91	91 scat/358 km; 7 ind./179 km^2	Pikunov and Korkishko, 1992
Mixed tropical deciduous forest, Kalakad-Mundanthurai Tiger Reserve, India	8.70	5.02	0.87 scat/km; 41 ind./817 km^2	Ramakrishnan et al. (1999); Ministry of Environment and Forests of India: www.sanctuaryasia.com
Tropical moist evergreen forest, Tai National Park, Ivory Coast	4.76	8.69	1 scat/2.1 km; 1 ind./9-14 km^2	Jenny, 1996
Tropical moist evergreen forest, Dzanga-Sangha Special Dense Forest Reserve and Dzanga-Ndoki National Park, Central African Republic	33.33	20.00	150 scats/45 km; minimum 1 ind./5 km^2	Martin and de Meulenaer, 1988; Ray and Sunquist, 2001

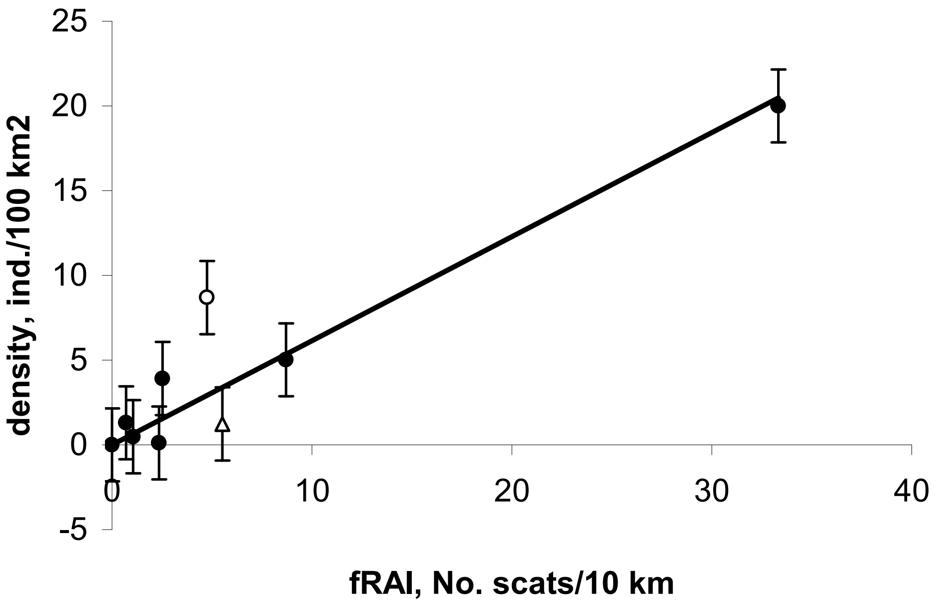

Fig. 7. *The relationship between the fecal relative abundance index (fRAI) and the actual leopard density defined statistically by eq. 2-3 and expressed as the scatterplot with standard error bars. The datum from Central Kopetdag region in Turkmenistan, where the leopards feed principally on bezoar goats and are thus expected to have similar defecation pattern as in Armenia, is marked by white triangle. White circle indicates the outlier datum from Ivory Coast. See Table 2 for details on data used.*

Results.

Statistical information derived from the leopard scat counts in southern Armenia is presented in Table 3.

Table 3. *Basic statistics from the leopard scat counts in southern Armenia. 95% CI = 95% confidence interval.*

Parameter	Value		
	total	mean	95% CI
Daily distance walked (DW, km)		9.6	7.8 - 11.4
Total No. scat sites	17		
No. routes walked	21		
No. routes with leopard scats	8		
Total distance walked (sum of all DWs), km	200.6		
Fecal relative abundance index fRAI (No. scats/10 km DW)		0.6	0.2 - 1.1
Leopard density estimated from fRAI (ind./100 km ^{2}) (see eq. 2-3)		0.4	0.3-0.5 if variation of fRAI ignored; 0.1-0.9 if variation of fRAI taken into account

Variation of density estimates significantly increases when variation of fRAI is incorporated to calculations.

Discussion.

A. Estimating the density from scat counts: methodological considerations.

The critical issue related to accurate estimation of the animal population density from the sign counts is the statistical reliability and robustness of correlation between the relative abundance index and actual density in a target population. Jenelle et al. (2002) indicate three essential requirements to the validity of this approach: (1) broad applicability over different habitats and populations; (2) independence of parameters in the relationship; and (3) precision of calibration of the relationship, i.e. acceptable and meaningful level of uncertainty. Below, we discuss these aspects in relation to the index-density relationship in the leopard populations presented in scatterplot of Fig. 7.

Broad applicability of approach. This requirement would mean the similarity of defecation and movement patterns of the leopard over the entire range in Sub-Saharan Africa and Asia. The number of scats produced by individual leopard is statistically dependent on average body mass of prey consumed (Karanth and Sunquist, 1995; Khorozyan and Malkhasyan, 2002; Mizutani, 1999) and is supposedly stable due to the common range of masses of prey taken by this predator in different habitats (20-50 kg). This statistical relationship was initially found in cougars (*Puma concolor*) living in colder mountains, but was later acknowledged also for the felids from warmer habitats, even though it was *a priori* thought that more hairs of prey will induce more defecations in colder conditions. The distances walked by the leopard are determined principally by hunger which forces to cover long distances in low-prey areas (Bothma and le Riche, 1990). The intensity of leopard movements is also influenced by weather which stimulates longer travels in mild or cold days than in hot days (Bothma and le Riche, 1994b). However, it is unlikely that the carnivores living in colder environments move more than in tropics and we think that this rule is applicable only to seasons in a specific area and not to different areas. For example, low air temperatures in the Caucasus or Russian Far East will not provoke intensive movements of the leopards because deep snow makes them slump (Heptner and Sludsky, 1972; Pikunov and Korkishko, 1992).

Even though data presented in Table 2 and Fig. 7 come from absolutely different habitats and climates, they produce a uniform pattern of the index-density relationship in the leopard. Neither effect of weather on scat visibility to researchers via fecal decay nor prey species appear to affect it. Like in Armenia, the bezoar goat makes the staple prey for the leopards in Central Kopetdag of Turkmenistan (Lukarevsky, 2001) and the datum from this area is well-fitting the relationship (see white triangle in Fig. 7). Hence, we expect that this figure provides a robust tool for estimating the leopard density also in Armenia.

Independence of parameters in a relationship. This requirement implies that the parameters in relationship must be obtained by independent research methods in the same area and in the same time frame. This is a case for information in Table 2: the leopard densities were determined by sighting records, tracking, radio-telemetry and camera photo-trapping, whereas the scat counts were done independently to describe the territorial marking behavior of local predators.

Precision of calibration of the relationship. This requirement can best be illustrated by the 95% confidence interval (CI) of both the index and the density estimate. The index is a random value dependent on many factors affecting the scientist's accessibility to the carnivore movement routes: trail structure, substrate structure, weather, general landscape features, spatial preferences of the species, sampling effort, unequal manpower skills and generally unpredictable chances to find a sign (pers. observ; Lukarevsky, 2001). As a result, variation of index itself will increase variation of the density estimates (Table 3) and all efforts must be made to minimize it. This methodology needs standarization in order to maximize sampling effort, observability (probability of detection of a species' signs) and spatial sampling (proportion of cells surveyed in a grid of all cells known to contain a species) (Gese, 2001; Nichols and Karanth, 2002a, b).

Cost-efficiency and ease of field operations are the principal factors making the wildlife researchers from developing countries eager to use the scat counts in practice instead of traditional, but expensive, radio-telemetry and camera photo-trapping. The density estimates deriving from the scat counts can be a good starting point for justification and initiation of urgent conservation actions when no time and money are available for more comprehensive studies.

The practicality of scat counts also makes it a preferable tool in spatial research and monitoring of low-density populations of big cats in which the technologically advanced techniques, such as camera photo-trapping, give less reliable density estimates than in high-density populations (Karanth and Nichols, 2002).

The strong advantage of scats in comparison to such signs as scrapes and tracks is their higher availability. The scrapes have been produced principally in breeding season and the tracks can be detected and realiably identified only on snow and in areas with soft substrate (clay, sand, dust or mud) not exposed to vehicular traffic, strong precipitation, wind or livestock trampling (Fox et al., 1991; Van Sickle and Lindzey, 1991). The scats can be easily found in snow-free seasons and places, but their presence can be obscured by litter in forests.

Fox et al. (1991) state that the low-density carnivore populations will produce less signs due to the lower range overlaps between individuals and less tension in maintenance of a population's social structure. As a result, the sign surveys may underestimate the predator abundance in low-density areas. We argue this, as the low density also makes the animals to produce and advertise their signs more conspicuously and frequently, otherwise the potential mates will not know about each other's presence and fail to meet for breeding.

B. The estimate of the leopard density in southern Armenia.

The index-density linear relationship described by eq. 2-3 and Fig. 7 above provides a statistically robust tool in non-invasive estimation of densities of the world's leopard populations from scat counts. According to it, the leopard density is estimated to be very low in our study area in southern Armenia – about 0.4 individuals per 100 km^2 (Table 3). The principal factors making this big cat endangered and prone to imminent extinction in the country are described above in Chapter 1.

Southern Armenia plays a crucial role for the leopard conservation in Armenia and in the whole Caucasus due to its connectivity with northern Iran which offers quite intensive exchange of individuals over the state border between these countries. Plenty of remote and hardly accessible habitats and low population density makes the expensive and time-consuming research of this carnivore unfeasible. This limitation makes us almost sure that the scat counts is the best methodology to be used in Armenia to study the leopard population status, trends and distribution (if accurately performed and standardized throughout the project) and has no adequate fully substitutable alternatives.

The only possible alternative to estimate the leopard density and distribution in Armenia's mountains non-invasively could be the snow track counts from helicopters. This method has been successfully used for the cougars in the mountains of USA (Van Sickle and Lindzey, 1991). However, it cannot be employed in the country for three reasons: (1) low availability of helicopters, especially when immediately needed on the first or second days after snowfall, as required by Van Sickle-Lindzey's methodology; (2) prohibitively high cost of helicopter use; (3) strict prohibition of helicopter use in southern Armenia which is considered by militaries and state security officials a "borderline territory" as squeezed between Azerbaijan and Iran.

Efficient conservation of the leopard is impossible without regular monitoring of its status in different study areas and within a certain area over time. The areas holding the highest values of the relative abundance index and, hence, population density should be considered as Priority Leopard Conservation Areas (PLECA's) and deserve priority actions. The scat counts can serve a valuable methodology in this work, provided more efforts are undertaken to standardize it as indicated above in Discussion, subsection A. In this particular case, standardization aims at maximization of daily distances walked, expansion of geographical representativeness of the trails and making them similar in study areas or time periods to be compared during repeated sampling. To do this, Kendall et al. (1992) suggest to maximize the number of sampled trails (even at the expense of trail length) and choose the seasons which offer the best accessibility of the trails and preservation of scats. We absolutely agree with this opinion, adding that just an effect of seasons on sampling effort may underlie the seasonal variation of index-density relationship and not the seasonal variation of the studied species' behaviour as claimed by the authors (Dzieciolowski, 1976; Walker et al., 2000). Gese (2001) concedes, saying that precision of the approach can be increased by increasing sampling effort (= more trails walked) and/or increasing the length of trails if dealing with a far-ranging species. Wilson and Delahay (2001) state that the sign surveys should be conducted in the same seasons to ensure similar fecal decay rates, defecation patterns and visibility of scats to researchers, all factors which may seriously affect the accuracy of density estimation by scat counts.

In Armenia's mountains, the period from late spring to early autumn is most optimal for scat sampling due to the highest possible accessibility of the leopard trails.

A good way of increasing the sampling effort in the mountains is horse-riding instead of walking on foot. However, the trained horses are very scarce in Armenian villages and good saddles are deficient. They become available for research only in winter after all hard agricultural work is completed, but this season is inappropriate for scat counts.

The carnivores living in mountains show strict preference of the ridge tops and/or drainages for easy and straightforward movements (Fox et al., 1991; Khorozyan, 2003; Khorozyan and Malkhasyan, 2002; Lukarevsky, 2001; Smallwood and Fitzhugh, 1995). Hence, sampling of their signs should be geographically confined to these topographical features and associated habitats and not be randomly distributed over space. In the latter case, numerous sampling sites of zero sign occurrence will intersperse with relatively few sites of high occurrence, bringing about unacceptably high variation of the relative abundance index. As a result, the derivative density estimate will have a too wide range of little practical value. Also, topography specific sign surveys will enable to maximize the sample size and sampling effort at substantially reduced cost (Smallwood and Fitzhugh, 1995).

As the leopard population in Armenia is very small, its decline for just a few individuals can be catastrophic, especially if adult females are eliminated. To detect such a subtle change in abundance, the standardization of scat counts must be given a very careful attention. Beier and Cunningham (1996) say that the failure to detect a change is most severe just in small threatened populations. Fortunately, population decline is easier to be detected by the sign surveys than an increase; to do this reliably, first of all the scientists should increase the number of sampled trails.

Apart from maximization of sampling effort, two more factors are essentially to be considered, validated and applied: correct identification of the target species' scats and spatial design of a study.

<u>Correct identification of the scats</u>. As in any carnivore species, the structure and general aspect of the leopard scats depends on the prey eaten, weather and some other factors, but generally they look as described above in Methods (Fig. 8). The personal field experience, skills and knowledge of the researcher are of primary importance in correct identification of the scats and the careful study of accompanying features (e.g., tracks around the scat deposit) allows to significantly improve it.

The scats produced by co-existing carnivores should be studied as well. For example, in this study we can state that the leopard scats found in southern Armenia can be sometimes confused with those produced by the Eurasian lynx (*Lynx lynx*) and gray wolves. Wherever we find the scats, we search for the tracks around and this allows to find a difference. The lynx tracks and scats are frequently arranged in a very circuitous way, as the lynx like to move out of the trail and inspect the scrubs and trees for hiding prey; in opposite, the leopard tracks and scats are lined up straightforwardly. The lynx and leopard tracks have similar rounded shape without claw prints, but are clearly different in size. Also, the lynx scats contain much more remains of the small prey, rodents and European hare (*Lepus europaeus*). The wolf and leopard scats often contain the wild boar hairs, hooves and bones, but the wolves live in much less cliffy areas and often defecate on the scrub branches what the leopards never do. The brown bears (*Ursus arctos*) are common in Armenia and frequently co-exist with the leopards, but their feces are never mistakable, looking like the cow pats and consisting mostly of vegetarian material. In our study area in southern Armenia, the lynx and wolves are generally rare and the bears live mainly at lower elevations from where they raid to orchards in villages for feeding. So, the possibility of confusion of the leopard and other carnivores' scats in this study was minimal.

That the scats found by us belonged to the leopard was confirmed by their visual identity with the dried scats of the male Persian leopard from the Yerevan Zoo (name "Zombis", studbook No. 433) used in artificial scats-and-scrapes lures to attract the wild-ranging leopards in the study area (for details, see Chapter 3) (Fig. 8).

The development of advanced high-tech approaches, such as fecal bile thin-layer chromatography (TLC) and fecal genotyping, can significantly contribute to accurate identification of the scat origin in felids. At this moment, genotyping is still very costly in these carnivores (Ernest et al., 2000; Palomares et al., 2002). TLC is a cost-efficient and reliable way to distinguish the cat species whose scats are studied, but may also fail to do so (Ray and Sunquist, 2001). This failure is caused by small sample size and weathered condition of old scats which significantly decrease the naturally low levels of measurable bile acids (Taber et al., 1997). Selection of the best methodology on a basis of comparison of all possible options in testing process allows to maximize the efficiency of TLC in identification of felid species from scats collected in the field (C. Bilgin, pers. comm.;

Cazon and Suhring, 1998). Particularly, it was found out recently that the leopard scats can be distinguished by TLC from the scats of wolf and lynx (two sympatric carnivores co-existing with the leopard in Armenia) and this work needs further research (Birand et al., 2001).

Fig. 8. *Visual similarity of the scats found in the wild (left) and the scats taken from the leopard in the Yerevan Zoo and used for scats-and-scrapes lures (right). Left: Spitak Champa ridge, locality Dacheqi Mot. Picture by I. Khorozyan, this project.*

Spatial design of a study. As the scat counts "capture" the individual animals irrespective of their sex, age and resident status, it is very important to maximize the study area. Ideally, it should be larger than the "threshold area", i.e. the minimum area of high-quality habitat capable to support population viability of a particular species, estimated to equal 412 km^2 for the safe leopard populations (Smallwood, 2001); otherwise, extrapolation of area-specific density over the larger range will double-count the individuals moving between the study areas. Such maximization is also needed to obtain a balance in sampled leopard population, since the males occupy larger home ranges, move longer distances and defecate more frequently (Bothma and le Riche, 1994a).

Here we face a hidden trap, since the enlargement of study area is seldom realistic and wherever the leopard is endangered its "threshold area" will accordingly increase up to thousands of km^2. In Armenia, we suppose the "threshold area" to be at least 5000 km^2 (Khorozyan, 2003). This will inevitably cause a serious problem with logistical support due to very rough terrain and poor quality of the dirt roads within the leopard range in the country.

Despite these obstacles, we will strive to expand the study area and identify the PLECA's in the country. As the first step, we have produced the GIS map of southern Armenia covered by grid of 16 km^2 cells. We will continue to use scat counts cell after cell until all leopard range in Armenia (Fig. 2b, c) is embraced by the survey. This will allow also to measure the leopard's observability and proportion of range occupied (Nichols and Karanth, 2002a).

In this project, we have found the leopard scats in 8 cells of total size 128 km^2 (Fig. 12). It is still too early to say how large is local PLECA and where exactly it is located, as the neighboring cells not yet studied by us may contain worthy quantities of the leopard scats.

Chapter 3: USE OF LURES.

Introduction.

Scent-marking of the core areas of the home ranges by urine spraying and scat deposition is a common strategy used by the leopards to leave messages to conspecifics about their land tenure and reproductive status (Bothma and le Riche, 1995; Lukarevsky, 2001; Pikunov and Korkishko, 1992). In felids, the vomero-nasal organ, a specialized chemoreceptor, enables to discriminate individual odors from these olfactory signals (Feldman, 1994).

Below, we describe a short-term field effort to test the ability of the leopard-specific urine-based pheromone lure and scats-and-scrapes lure to attract local wild-ranging leopards. We believed that the leopard(s) ranging over our study area would be attracted by lures as the artificial signs of presence of some unknown alien "leopard" around. Potentially, this technique may unambiguously detect the leopard presence and, like scat counts, contribute to identification of Priority Leopard Conservation Areas (PLECA's) which deserve urgent area-specific actions.

This method looks very similar to the scent-station surveys used widely to assess the carnivore species distribution and estimate population density through the scent-station visitation index (Anonymous, 1999; Gese, 2001; Travaini et al., 1996).

This is the first effort to see if the lures we used do really work for the wild leopards in southern Armenia. If successful, we will continue and expand use of lures all over the leopard range in Armenia (Fig. 2b, c).

Methods.

The pheromone lures (PHL) were produced by M. Gauthier from Envirotel Inc., Canada on a basis of urine collected from estrous and non-estrous females kept at Sierra Endangered Cat Haven (Dunlap CA, USA) and Mulhouse Zoo and Botanic Garden (France). The urine samples were collected overnight in the den areas of enclosures. Full information about the sampled animals is given in Table 4.

These lures were represented by two forms (solid and liquid) and types (Mix #1, CS and Mix #2, PK). The solid lures were made with plaster of Paris, they looked as the hexagon-shaped pills with perimeters 18 cm (upper side) and 21 cm (bottom) and weighed 50-60 g. The types differed by additives used to prepare the lures. The lures were stored in Ziploc plastic bags in refrigerator at $4^{o}C$ in aluminum foil (solid) and dark 100 mL bottles (liquid).

The scats-and-scrapes lures (SSL) represented the scrapes made by ourselves and marked by the sun-dried scats collected from male Persian leopard Zombis kept at the Yerevan Zoo (studbook No. 433).

The sampling occasions were distributed as follows: 28 August – 3 September, 2003 (3 PHL's and 6 SSL's placed in Nuvadi area), 30 September – 10 October, 2003 (checkout of lures in Nuvadi, 3 PHL's and 4 SSL's placed in Bohaqar area), 4-9 November, 2003 (checkout of lures in Bohaqar) (Fig. 9). In total, we used six pheromone lures and ten scats-and-scrapes lures. Information about their placement is given in Table 5.

Table 4. *The captive female leopards whose urine was sampled and used for preparation of pheromone lures (PHL).*

Subspecies	Studb. No.	Name	Birth	Reprod. status	Zoo
Amur leopard *P.p. orientalis*	445	Kalara	8/11/97	estrous	Sierra Endangered Cat Haven (SECH), USA
P.p. orientalis	446	Kuan-Yin	8/11/97	estrous	SECH
P.p. orientalis	447	Nan-Ying	8/11/97	estrous	SECH
Persian leopard *P.p. saxicolor*	329	Shaheen	3/6/90	pregnant	Mulhouse Zoo and Botanic Garden, France

Table 5. *Geographical information about the lure sites. N = Nuvadi area, B = Bohaqar area. The lures which gave the leopard response signs (scrapes) are marked by* ***bold face****.*

Lure	Date	Coordinates	Elevation, m	Place
Pheromone lures				
PHL1 (CS2)	Aug. 29, 2003	39°00'07N/046°25'58E	2293	Dacheqi Mot, N
PHL2 (CS1)	Aug. 30, 2003	39°01'35N/046°25'21E	2349	above the path Dacheqi Mot-Tsav, N
PHL3 (CS3)	Aug. 31, 2003	38°58'58N/046°24'32E	1871	Spitak Champa ridge, N
PHL4 (PK4)	Oct. 5, 2003	38°59'22N/046°07'34E	1946	Shish Qar, B
PHL5 (PK5)	**Oct. 6, 2003**	**38°59'52N/046°09'02E**	**1935**	**cliff near waterfall, B**
PHL6 (PK6)	Oct. 7, 2003	39°01'18N/046°09'11E	2523	Bash Yurt ridge, B
Scats-and-scrapes lures				
SSL1	Aug. 29, 2003	39°00'16N/046°25'42E	2304	Dacheqi Mot, N
SSL2	**Aug. 29, 2003**	**39°00'05N/046°26'05E**	**2308**	**Dacheqi Mot, N**
SSL3	Aug. 29, 2003	39°00'07N/046°26'29E	2262	Dacheqi Mot, N
SSL4	**Aug. 30, 2003**	**39°00'45N/046°25'27E**	**2316**	**near the road Dacheqi Mot-Tsav, N**
SSL5	Aug. 30, 2003	39°01'50N/046°25'14E	2269	near the path Dacheqi Mot-Tsav, N
SSL6	Aug. 31, 2003	38°59'35N/046°24'34E	2045	Spitak Champa ridge, N
SSL7	Oct. 5, 2003	38°59'08N/046°07'34E	1950	Shish Qar, B
SSL8	Oct. 5, 2003	38°59'24N/046°07'42E	1946	Shish Qar, B
SSL9	Oct. 7, 2003	39°00'39N/046°09'01E	2359	Bash Yurt ridge, B
SSL10	Oct. 7, 2003	39°01'19N/046°09'15E	2499	Bash Yurt ridge, B

At each lure site, we put one solid lure on the ground on a trail and sprayed one bottle of the liquid lure on a way to and from the solid lure. We placed the lures along the ridge tops near boulders, agglomerations of stones and only once did that near the juniper tree and in open highland dry grassland; all in the typical leopard habitat (**Fig. 10**). Position of all lure sites was measured by GPS.

The scent-station visitation index (SVI) was calculated as in **Travaini et al. (1996)**:

$$SVI = (\text{No. responses}/\text{Total No. lure sites}) \times 1000 \qquad \text{(eq. 3-1)}$$

This index was calculated separately for SSL and PHL and for study areas, and in total terms.

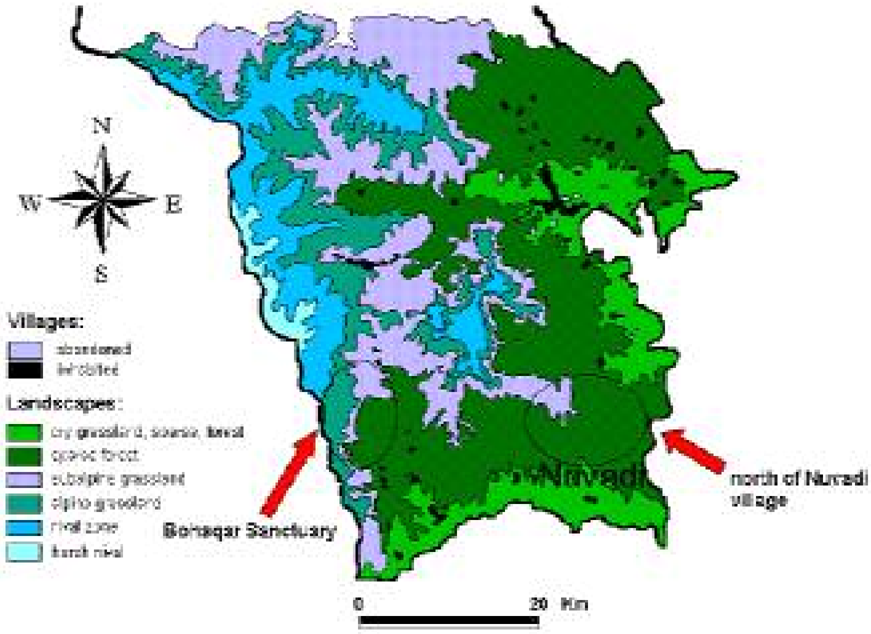

Fig. 9. *The study areas where we tested the effect of lures on the leopards. Produced by S. Asmaryan, Center for Ecological Studies, Armenia.*

Fig. 10. *The typical structure of ridge tops used by the leopards for movements in southern Armenia. Locality Dacheqi Mot. Picture by I. Khorozyan, this project.*

Results & Discussion.

Fortunately, we have found the leopard response to three lures: two scats-and-scrapes (SSL2 and SSL4) and one pheromone lure (PHL5) (**Table 5**). In all cases, it looked as the intensive scrapes; all they were photographed (**Fig. 11**) and mapped (**Fig. 12**).

<u>Response to lure SSL2</u>. The scrape size was 42 cm x max. 18.5 cm and represented a piece of shallow digging of depth ca. 1 cm with some grass taken off with the roots.

Response to lure SSL4. The scrape size was 43.5 cm x max. 20 cm, again as a digging with clawed away grass.

Response to lure PHL5. The grass was heavily trampled down around, the scrape was produced at the foot of the cliff and had dimensions 40 cm x max. 22.5 cm.

Fig. 11. *The sites where the lures SSL4 (left), SSL2 (center) and PHL5 (right) were placed and the leopard scrapes produced at each site (beneath). Picture by I. Khorozyan, this project.*

The scent-station visitation indices (SVI) of lures in both study areas were distributed as shown on **Table 6**.

Table 6. *Distribution of the scent-station visitation index (SVI) in lures and study areas.*

Study area	Pheromone lure (PHL)	Scats-and-scrapes lure (SSL)	Total
Nuvadi	0	333.3	222.2
Bohaqar	333.3	0	142.9
Total	166.7	200.0	187.5

According to data in this table, the leopards visit the lures more frequently in Nuvadi area than in Bohaqar area. Also, it shows that the SSL's seem to be more efficient than the PHL's in attracting the carnivores. However, given the fact that we used only limited number of lures, we cannot state now which lure is better and which area contains more leopards. At this stage of work, we can only say that both these lures work, and nothing more. Only after more lures will be used in many areas over the entire leopard range in the country, we will be able to answer the crucial questions: Where the leopards live? Where are the Priority Leopard Conservation Areas (PLECA's) located and of what sizes they are? What are the leopard densities in PLECA's estimated from scent-station visitation index (SVI)?

In this very beginning of the work, we are very encouraged by success of use of lures in the Persian leopard research and conservation in Armenia and we will seek for opportunities to raise funds to continue these activities. Obviously, much more lures must be used to cover as wider areas as possible to maximize the scent-station visitation rates.

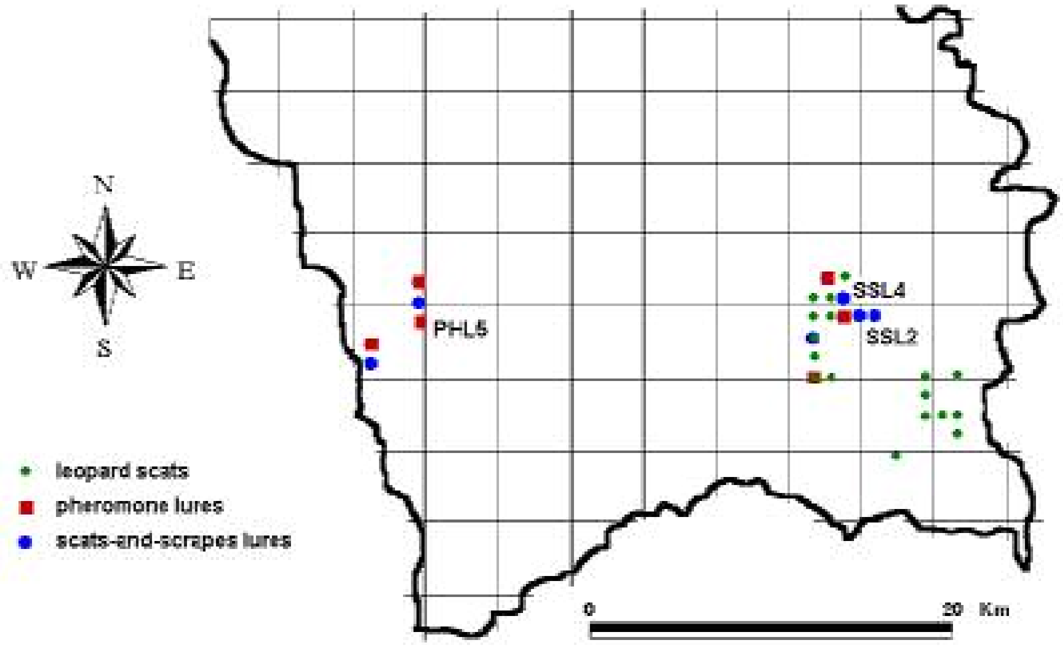

Fig. 12. *Distribution of lure and scat sites in southern Armenia over the grid of 16 km² cells. The scats-and-scrapes lures (SSL2, SSL4) and pheromone lures (PHL5) which got the leopard response are indicated. Produced by S. Asmaryan, Center for Ecological Studies, Armenia.*

We did not test the lures which are known to attract the captive felids, but their usefulness in the wild is yet to be tested: such substances are Calvin Klein's "Obsession for Men" cologne for the ocelot (*Leopardus pardalis*) and cheetah (*Acinonyx jubatus*) (**Anonymous, 2003**) and pulverized allspice (*Pimenta dioica*) for the leopard (**J. Maynard, pers. comm.**). Nor we used the commercially available products for attracting the bobcat (*Lynx rufus*), cougar and wild cat (*Felis sylvestris*) as they could produce the non-specific effect and capture other carnivores (**M. Gauthier, pers. comm.**). **Miquelle et al. (2003)** were the first to use the general feline Lenon lure to attract the Amur leopard to the camera sites, but it is unclear whether their unbelievably high capture rates (112 photo-pictures/4 months of sampling, or sampling efficiency about 93.3 pictures/100 trap-nights) result from effect of this lure or from use of significant number of photo-traps (24) which allowed to cover the wider study area. But even at most optimistic scenarios kept in mind, it is hard to believe that the rarest leopard subspecies numbering only about 30 wild individuals can show such high capture rates.

The leopards are known to be efficiently baited by sun-rotten viscera and blood of domestic livestock (**Conniff, 2001; L. Hanssen, pers. comm.**). We did not use this approach, as it can potentially cause habituation to visiting villages for preying on livestock and provoke inevitable elimination of predators by rural people. That was a reason for us also not to use the live or dead feral dogs, of which the leopard is very fond (**Pikunov and Korkishko, 1992**).

Chapter 4: IMPLICATIONS FOR CONSERVATION.

Focal species make the core part of biodiversity conservation in the Caucasus. The notion "focal species" was introduced to practice in order to identify the threatened or endangered flagship, umbrella, keystone and indicator species whose preservation will safeguard existence of all lower-level biological resources and habitats they live in. As a result, specific Conservation Action Plan is required for each focal species to prevent its decline and disappearance.

In the Caucasus, two species of carnivores, eight species of ungulates and six species of fish are classified as focal species. The leopard is among them. The Caucasus office of World Wide Fund for Nature (WWF) based in Tbilisi, Georgia, has prepared in 2003 the draft version of "Action Plan for Conservation of Focal Species and Their Habitats in the Caucasus Ecoregion". It contains the tentative itinerary of long-term (by 2023) and medium-term targets (by 2013) and immediate actions (by 2008) essential for achieving the overall objective – increase of total leopard numbers in the Caucasus by 40% by the year 2023 (**N. Zazanashvili, pers. comm.**).

The "Biodiversity Strategy and Action Plan for the Republic of Armenia" published by the Ministry of Nature Protection in 1999 has formulated the list of urgent activities which includes the development and implementation of individual Action Plans for conservation of key endangered species (e.g., leopard) within the period 2000-2004. This plan has just remained on paper.

In Armenia, the leopard has the "endangered" status and is protected by "Law on Animal World" (2000).

The history of leopard research in the country is short, but eventful and productive: one monograph describes ecology of this predator in Khosrov Reserve (**Khorozyan and Malkhasyan, 2002**) and one paper is about the man-leopard conflict for space in Khosrov Reserve and its corridor Gndasar Mt./Noravank Canyon area (**Khorozyan, 2003**). We will continue investigations and status monitoring by scat counts (Chapter 2) and use of lures (Chapter 3) – see Chapter 5 below for the list of proposed activities.

The leopard conservation in the country has launched only in early 2003. The relevant activities include population monitoring, operations of anti-poaching squads, preparations for establishment of new leopard-targeted sanctuaries, educational campaigns, technical assistance and public campaigning through mass media. Much more efforts are essentially needed to continue and expand research and monitoring, battle with poaching, professional training, public education and dissemination of information and technical support (Chapter 5, section D).

Information obtained by us in this project is interesting and valuable, since it allows to carry out the leopard studies and population monitoring throughout entire range in Armenia by means of scat counts and use of lures. These techniques are fully feasible, cost-efficient and compliant to local conditions and mentality. We can say with conviction that our relentless field work raises public interest and willingness of local rural communities to be involved and assist. No doubt, the sincere words "Welcome! Our land is your land and our home is your home!" said by local people are the best compliments for our efforts which engender optimism and sweet feeling of being helpful.

As a practice shows, no any conservation program in the world will succeed if local people are not listened and their needs are ignored. The province of Siunik in southern Armenia where we carried out this project and which is the leopard stronghold in the whole Caucasus (**Fig. 2a-c**) is possibly the poorest in the country. Even though it provides vital transportation corridor between Armenia and Iran and thus contributes to successful trade between these countries, only small portion of local people gets benefit from it. Mining, which flourished in Soviet times before 1990, begins its slow recovery from collapse and is still small-scale. So, most rural people must rely on agricultural production from their own orchards, crop fields and pastures. Meghri region is famous for its warm subtropical climate, fertile soils and plenty of cultivated fruits (pomegranate, fig, apricot, persimmon, quince, lemon, etc.), but its remoteness from the capital Yerevan impedes the market development. Poverty and very limited areas of good pastures do not enable people to keep many livestock, so animal husbandry is not an important economic factor in the region.

Economic hardship leaves to rural people no other alternative but to use natural resources (edible and medicinal plants, mushrooms, game, fire wood) and neglect nature conservation. That is why we always strive to cooperate with locals, talk to them and explain the importance of conservation for the benefit of their own and wildlife. Fortunately, in almost all cases we succeed to break the ice of disbelief to us as to "snobby city guys" and make people open for discussions and proud of their local knowledge (which is really invaluable to us!). We enjoy support and hospitality by many local people.

A very important result of this project was the fact that it provided an essentiall justification for establishment of two new leopard-targeted sanctuaries in Meghri region and stimulated this development. Both they are located within the areas of Meghri Forest Farm – one to the north of Nuvadi village and another one in Bohaqar area near the border with Nakhichevan Republic (**Fig. 9**). Now we are working out the Management Plan of these sanctuaries which will be submitted soon to the Ministry of Nature Protection for approval.

Given this situation, in the next Chapter 5 we propose the list of activities which we think are most important and timely now for the leopard conservation in Armenia.

Chapter 5: FOLLOW-UP ACTIVITIES.

Here we describe the activities that we intend to carry out in the future and deserve the priority in fund-raising.

A. Camera photo-trapping.

This technique will not be continued.

B. Scat counts.

This method is most useful and expedient for further country-wide implementation. The following aspects need advancement:

- Development, validation and application of thin-layer chromatography (TLC) of fecal bile acids for enhancement of correct identification of the leopard scats as opposed to traditional identification based on visual characteristics of scats;

- Estimation of how efficiently the leopard scats are identified by TLC vs. scat morphology;

- Assessment of the effects of TLC vs. scat morphology on precision of density estimates;

- Standardization of scat counts by means of maximization of daily distances walked and geographical representativeness of the trails searched for scats during the best sampling season (late spring to early autumn);

- Large-scale implementation of this approach throughout the leopard range in south-western and southern Armenia (Khosrov Reserve; its corridor Gndasar Mt./Noravank Canyon; Zangezour, Bargushat and Meghri ridges) in order to identify the Priority Leopard Conservation Areas or PLECA's (**Fig. 2b, c**).

C. Use of lures.

The lures appear to be a promising and cost-efficient way to attract the wild leopards to the scent stations and thus confirm the leopard presence or absence. GIS mapping of lure sites which get the leopard response (mainly scrapes) allows to identify the PLECA's. It is still uncertain whether the scent-station surveys may estimate the carnivore densities; more efforts are needed to perform accurate calibration and analyze the role of factors which affect the rates of animal visitation to scent stations and distort the density estimates.

We will seek the opportunities for funding this work in relation to the leopard in Armenia.

D. Conservation.

The following conservation activities need support and urgent implementation throughout Armenia:

- Involvement of local conservationists (regional nature conservation inspectors, reserve rangers and foresters) in monitoring of leopard and its principal prey species;

- Professional training of reserve rangers, inspectors, foresters and border guards on Armenian-Azerbaijani and Armenian-Iranian state borders;

- Educational campaigns among rural schoolchildren and adults (livestock keepers, hunters, plant gatherers);

- Production and placement of road blocks and stop signs at the entrance points in forest farms and reserves to curb poaching;

- Technical assistance and provision of financial support to regional conservation bodies;

- Public communication campaigning, i.e. publication of papers in newspapers and scientific journals, production of radio and TV programs, presentation of reports to the Ministry of Nature Protection.

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