Arabian Leopard *Panthera pardus nimr* status and habitat assessment in northwest Dhofar, Oman (Mammalia: Felidae)

by Marcelo Mazzolli

Abstract. The Arabian Leopard *Panthera pardus nimr* is considered Critically Endangered by the IUCN and published information about this subspecies is scarce. We assessed the status of the species on the border of one of the most important remnants of its current range, the Dhofar mountain range. In this border area, the relative abundance of leopards (0.067 scats per kilometre) was found to be seven times lower than that reported from prime habitat areas in Dhofar. This result suggests that the leopard occurs in this border area in low numbers or uses it only intermittently. This is compatible with expected sub-optimal conditions found along the borders of the species' ranges. Furthermore, herders have reported that leopards used to be encountered more frequently in earlier times, which is also supportive evidence of higher vulnerability of this big cat along the edge of its distribution area. However, the habitat of the study area was found to be in relatively good condition, harbouring the leopard's main prey species and a number of regionally threatened large mammalian fauna, including the Nubian Ibex *Capra nubiana*, Arabian Gazelle *Gazella gazella*, Rock Hyrax *Procavia capensis*, Striped Hyaena *Hyaena hyaena sultana*, Caracal *Caracal caracal schmitzi* and Arabian Wolf *Canis lupus arabs*. Causes of the leopard decline in the area remain unclear, but given the availability of prey it is possible that human interference may have led to the retraction of the leopard's range.

Key words. Arabian Leopard, *Panthera pardus nimr*, prey availability, distribution range, population density, habitat, Middle East.

Introduction

The Arabian Leopard *Panthera pardus nimr* (Hemprich & Ehrenberg, 1833) is a subspecies of the leopard that inhabits the Arabian Peninsula. It is adapted to live in arid and semi-arid regions, so it has small body size and a pale coat. The range of the leopard in the Middle East has been severely reduced (e.g. Arabian Peninsula - BREITENMOSER et al. 2006, SPALTON et al. 2006, AL-JOHANY 2007, Caucasus - KHOROZYAN & ABRAMOV 2007), and the quality of their habitats is known to have become impoverished in the Arabian Peninsula. The conservation status of this leopard subspecies is of global concern since recent estimates suggested that fewer than 250 individuals remain in the wild (BREITENMOSER et al. 2006). Consequently, the Arabian Leopard is ranked in the highest category of threats - Critically Endangered - by the 2008 IUCN Red List of Threatened Species (IUCN 2008), and in the highest level of concern regarding its trade (CITES Appendix 1).

The Arabian Leopard has disappeared from large areas of its historical range because of habitat modification, direct persecution and prey decline. QARQAZ & ABU BAKER (2006), for instance, reported the former use of stone traps to catch leopards in Jordan, and such traps were used in Yemen as recently as in 1999 to catch leopards alive for sale to zoos and private collections.

The Dhofar mountains in southern Oman are considered the best habitat for the Arabian Leopard in the country and perhaps over its entire range. Prey populations are believed to be the healthiest in the Arabian Peninsula (STUART & STUART 2007), and the only place within the leopard range in the Peninsula to harbor a sizeable reserve (the 4,500 km^2 Jabal Samhan

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Nature Reserve). STUART & STUART (2007) did not find an evidence of continued occurrence of any wild ungulate species in southern Musandam (Oman) and adjoining areas of United Arab Emirates (UAE) and by examining consumed prey items concluded that local leopards fed mainly on exotic goats and Cape hare *Lepus capensis* (Linnaeus, 1758).

This article details a survey to assess the Arabian Leopard's status and habitat conditions along the species' northernmost distribution in the Dhofar mountains, thus increasing the species existing baseline information for management and conservation purposes.

Material and methods

Study area. The Dhofar mountains form a narrow girdle with a maximum width of 23 km that extends for 400 km east to west along the Indian Ocean coast (Fig. 1). The 75-km stretch of mountains and the 8-km wide plain located along the coast of the Arabian Sea receive annual monsoon rains. The main geographic features in the study area are wadis, dry river beds that may flood during the monsoon. The study area encompassed an area of roughly 30 x 30 km located between the Wadi Amat and Wadi Uyun, near the villages of Mudday and Aybut. The area is situated on the northern fringes of the Dhofar mountains, beyond which lies the vast Arabian desert known as the 'Empty Quarter'.

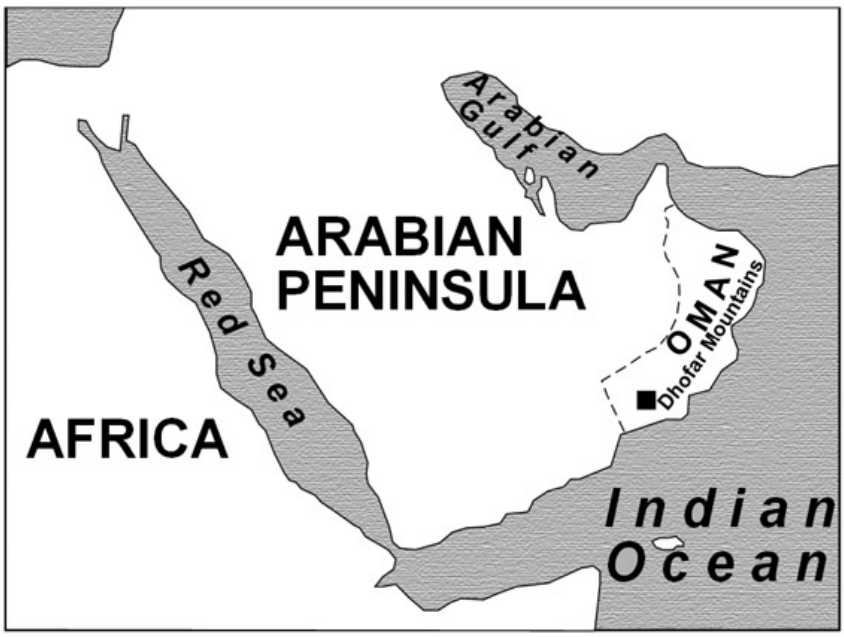

Fig. 1. Location of the study area (black square) in northwest Dhofar Mountain, in the Sultanate of Oman.

Previously, the study site was surveyed only once, in 2004, when intensive rains hampered completion of field activities (H. M. HIKMANI, pers. comm.). During the survey, a preliminary camera trap assessment carried out by local scientists revealed the presence of wolves *Canis lupus arabs* (Pocock, 1934) and Gordon's Wild Cats *Felis silvestris gordoni* (Harrison, 1968),

and the leopard approximately 20 km south of the study area. The study area is largely uninhabited and expected to be a good habitat for the Arabian Leopard and its prey (SPALTON et al. 2006). It is also known to harbour the Nubian Ibex *Capra nubiana* (F. Cuvier, 1825) (IUCN - vulnerable), the Arabian Gazelle *Gazella gazella* (Pallas, 1766) (IUCN - Vulnerable), the Hyrax *Procavia capensis* (Pallas, 1766) (IUCN – Least Concern) and top carnivores such as the Arabian Wolf, the Striped Hyaena *Hyaena hyaena sultana* (Pocock, 1934) (IUCN – regionally threatened) and the Caracal *Caracal caracal schmitzi* (Matschie, 1912). Dromedaries *Camelus dromedarius* (Linnaeus, 1758), known in the area simply as camels, can be found almost everywhere. Contrary to earlier suggestions, there is some evidence that they were once living as wild animals throughout the Arabian region (NOWAK 1999). Umbrella thorn acacia *Acacia tortilis* (Forskål) dominates on the bottoms of the *wadis* (Fig. 2).

Fig. 2. Overview of the main base camp in the bottom of Wadi Amat and among the acacia trees. Escarpments are also shown. Photo: M. V. REENEN.

The Uyūn topographic map was used as the main reference for the sampling grid and for navigation purposes. It was indexed as NE 39-12F at 1:100,000 scale and produced under the supervision of the Head of the National Survey Authority (NSA), Sultanate of Oman, using aerial photographs dating from 1993 and field updates by NSA in 1999. Grid data were in Universal Transverse Mercator projection and datum WGS 84, covering the zones 39 and 40. A GIF image of the area was imported into the basic GIS and freeware program TrackMaker (Geo Studio, Belo horizonte, Brazil - www.gpstm.com). A grid of 2 x 2 km of the study area featuring the main wadis was uploaded onto the expedition's GPS units (GPS60, Garmin, Kansas, USA) to aid navigation and recording of data. Each cell was coded with numbers in the X axis and letters in the Y axis. As the work progressed, more wadis were digitised along with additional features such as access roads, base camp and water pumps. The topographic map was edited in Adobe

Photoshop to subtract features and leave only the wadis in the final map. Narrow wadis within the sampled grid cells became fragmented during the editing process and needed to be redrawn.

Surveys and data analysis. Data were collected with the help of volunteers recruited by Biosphere Expeditions (UK). They were trained to recognise tracks and scats, take photographs of species and signs, and collect potential leopard scats for identification to the base camp. This procedure was a way to control any possible bias that would have been produced by volunteers.

Absence of species records does not necessarily mean that the species is absent, particularly if it is rare or cryptic. It is for this reason that resampling is usually required to obtain a reliable pattern of a species presence (MACKENZIE et al. 2002). During this study, however, resampling was not implemented, as signs remained *in situ* for long periods before being erased (unlike in rainy areas) despite occasional winds, possibly due to soil structure and protection provided by escarpments. There was plenty of area with sand for track imprinting, as shown (in the results) by the number of quadrats in which tracks of ungulates were found. In spite of a lack of temporal resampling, multiple simultaneous sampling (several groups formed by volunteers, spread out in the wadis and over the ledges at the same time) provided spatial resampling to some extent. Sampling was carried out on foot and usually started at the bottom of the wadi. Groups were instructed to cover at least two full grids each day, and at least two promising ledges (those that were long enough to be used as trails) were sampled in each cell.

Sampling was designed to provide a pattern of the presence/absence and habitat preferences of the leopard, its main prey species (such as ibex, hyrax and gazelle) and other species whose records might infer habitat quality for leopards (hyaena and wolf). We assume that the presence of resource-demanding carnivores such as the hyaena and wolf, that are increasingly uncommon in areas that have been modified by man, is an indication of a relatively good habitat. It is taken into consideration that issues related to the correct identification of signs of other species may have hampered a broader biodiversity assessment.

The main landscape features were categorized into wide wadi, narrow wadi, ledge/escarpment, bottom wadi, ridge, slope and saddle. Wide wadis were considered to be those at least 100 m wide, such as most of the main wadis Amat and Uyun. Escarpments and slopes were features of the (dried) river banks classified according to steepness, ledges were trails present along escarpments, ridges were the (flat) top of the hills, and saddles were formed by upper river bottoms. Secondary wadis (those that branched from the main wadis) were usually where narrow wadis and saddles were found.

Results

The survey covered a total of 134 km (in a straight line), and 51 cells of 2 x 2 km (Fig. 3). This was considered an adequate sample size, considering that occupancy statistics require a minimum of 7 cells to be surveyed (MACKENZIE et al. 2002). Nine scats identified as belonging to the Arabian Leopard (Fig. 4) were found, and were generally associated with narrow wadis. Leopard scats have a segmented shape, diameter ranging from 2 to 3 cm, pointed ends, and many lobes (KHOROZYAN 2003). No fresh tracks or other signs of recent presence of the Arabian leopard were found.

Fig. 4. Typical leopard scat, found during the survey in the study area.

Although no fresh evidence of the leopard was found, evidence of the presence of its most important prey species was abundant. The gazelle (51 records in 29 cells), ibex (46 records in 27 cells), and hyrax (51 records in 30 cells) were found in more than half of the cells surveyed. The presence of hyena (23 records in 16 cells), a carnivore with large resource requirements, also suggested that the study area provides suitable habitat for large predators. Volunteers were asked to record the presence of a species only once for each cell, thus the larger number of records than the number of cells means that some cells have been either re-sampled in different occasions, or simultaneously sampled by multiple volunteer groups.

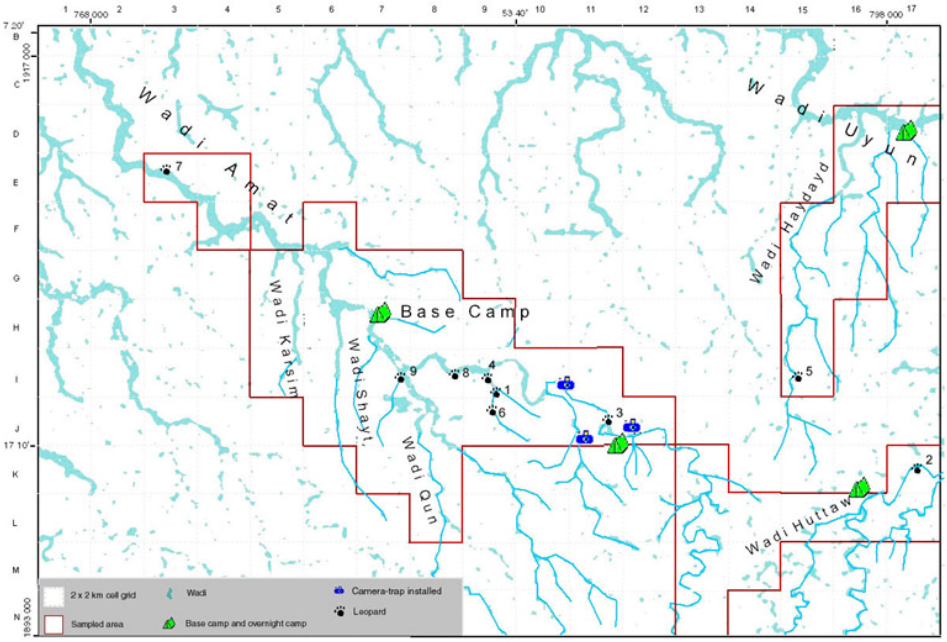

Fig. 3. Topographic map of the study area modified to show only the wadi system. The 2 x 2 km cells surveyed, expedition base, and overnight camps were added. Coordinates are in UTM datum WGS 84 and Degrees and Minutes. Cell coding is also shown, with numbers in the X axis and letters in the Y axis. Locations where leopard scats have been found in the Wadis Amat, Haydayd, and Huttaw are also highlighted.

Other mammal species such as the Porcupine *Hystrix indica* (Kerr, 1792) (n=6, tracks), Cape Hare *Lepus capensis* (Linnaeus, 1758) (n=2, sighting) and small rodents *Acomys* sp. and *Meriones* sp. (n=2, sighting) were also found. Tracks of foxes were common and some of them were identified as the Red Fox *Vulpes vulpes arabica* (Thomas, 1902) by their larger size. The gazelle was one of the most frequently recorded species, with tracks and scats found 73% of the time in wide wadis in contrast to narrow wadis (Tab. 1). Unlike the gazelle, the ibex was recorded 88% of the time in narrow wadis, was only occasionally seen, and avoided crossing the bottom of wadis except those narrower than 40 m. Hyrax colonies were seen frequently and their alarm calls were also often heard. They preferred ledges and escarpments of both narrow and wide wadis. Hyaena tracks were found mainly on the bottom of wide wadis and occasionally in narrow wadis and on ledges.

Table 1. Distribution of records for the most commonly found mammals according to habitat feature.

	Habitat type						
	Wide wadi	**Narrow wadi**	**Ledge/ escarpment**	**Bottom of wadi**	**Ridge**	**Slope**	**Saddle**
Gazelle	17	5	1	4	2	2	0
Ibex	2	15	9	1	1		1
Hyrax	8	13	10	1	0	2	0
Hyaena	8	3	1	4	0	0	0

Discussion

Frequency of leopard signs was calculated so that it could be compared to those previously recorded for the species. Data collected support that leopards occur in low numbers locally. In the Jebal Samhan Nature Reserve in Dhofar, frequency of leopard signs was 94 (scats and scrapes) over a distance of 200 km, *i.e.* 0.47 signs per km (SPALTON 2000), and very similar to that given by JACKSON & HUNTER (1996) on snow leopards. The current survey, in contrast, resulted in a frequency of 0.067 leopard signs (scats) per km, seven times less frequent than in the Jabal Samhan Nature Reserve. GHODDOUSI et al. (2008) provided a detailed and useful description of signs left by Persian Leopards but unfortunately frequencies were not given.

It is now generally acknowledged that leopard track counts are strongly and linearly correlated with true leopard density (STANDER 1998, BALME et al. 2009), although the slope of this relationship is *a priori* unknown and needs to be calibrated *in situ*. The cases of exceptions, such as low track occurrence within the high leopard density zones are usually caused by intolerable, localised disturbances. Regardless of that, the higher the number of leopard tracks the higher its density.

After 134 km of surveys in the study area, no fresh evidence of leopards was found – the scats were dry and old and no tracks or scrapes were seen in the sandy grounds. Track encounter rates are available in the literature for the African leopard, varying from one encounter at every 16 km to every 36 km in good leopard habitat (STANDER 1997, BALME et al. 2009, GUSSET & BURGENER 2005). In the marginal and arid environment of Namibia, perhaps somewhat resembling the conditions found in the study area, encounter rates were much lower, resulting in one track set at every 225 km (Etosha National Park), and one at every 211 km (Khorixas district) (STANDER 1999).

Although there was no indication of leopard hunting, local goat herders agreed that their losses to predation were frequent in the past but are now nil in spite of herding practices remaining the same as before. The reported reduction in livestock depredation incidents, and the absence of recent signs of leopard on the edge of their monsoon distribution in western Dhofar, are both supportive evidence that leopards have reduced their range and may only be seasonally present within the study area.

Arabian Leopards certainly prefer habitats with rugged terrain and greater prey availability as productive as Persian Leopards do (GAVASHELISHVILI & Lukarevskiy 2008), resources that are scarce in the areas from where they have retreated. This study, for instance, has

shown that escarpments, and particularly narrow wadis, harbour the greatest concentration of prey species. Indeed, even the gazelle, which prefers the plains, were found to frequently travel across slopes and escarpments.

The margins of the leopard distribution in northwest Dhofar open into the flat and wide country, so do not contain optimal habitats for the species, which becomes susceptible to population decline and range loss. Leopards have thus persisted only in the rugged country which harbors a wide variety of prey species and provides shelters, shade and trapped water.

Causal factors of leopard decline are likely to stand out in range borders. It is indeed expected that leopard populations will not recover as fast as they do in prime habitat, where chances of survival, and thus recruitment, are higher. This particular situation provides an ideal scenario for conservation studies and experiments, such as compensation for livestock depredation, that may lead to answers regarding the causes of the leopard's decline. The importance of detecting the causes of leopard decline in detail cannot be ignored. Diagnosing the causes of population decline is the main component of virtually all projects aimed at saving threatened species from extinction (NORRIS 2004). Although the current study design was not intended to estimate population densities of prey species, it was found that prey was present in the study area in considerable numbers, leading to the notion that perhaps poaching of leopards following livestock depredation may have been the main reason behind leopard decline. There is, however, virtually no assessment of leopard depredation on livestock in the Arabian Peninsula (BREITENMOSER et al. 2006). As acknowledged by some authors within the leopard's Middle East range (KIABI et al. 2002, KHOROZYAN 2005), it is difficult to access poaching information because leopard hunting is prohibited and herders are afraid of reprisal. Information on livestock depredation would be more readily available if a livestock compensation system or other system that bring benefits and interaction regarding leopard issues with communities were in place. In the study site in Dhofar, this could be accomplished with the help of over 40 rangers from the Ministry of Environment that regularly patrol the Dhofar mountain range. These rangers come from the same local villages that may be interacting with leopards and are likely to be trusted with depredation information. By the time of this field research they had the logistic support necessary to accomplish their tasks of regularly patrolling the mountain ranges and wadis.

It is important to consider, however, that even if the poaching of leopards is found not to be currently taking place, it should not be disregarded as a driving force that may have led to leopard population decline in the past, as has been the case with the leopard in the Caucasus (KHOROZYAN & ABRAMOV 2007). For example, KHOROZYAN (2005) found reduced leopard predation on livestock in Armenia, but also found that the leopards were nearly absent from the mountain grasslands or crossed them only opportunistically (KHOROZYAN 2003), the same areas that are the most suitable for animal husbandry, an indication that leopards have been nearly wiped out from these grazing areas. Cases of leopards that have been poached out in the Middle East are not difficult to find in current literature (e.g. KHOROZYAN 2005, AL-JOHANY 2006, KHOROZYAN & ABRAMOV 2007). Poaching, often after depredation, has been found to be the main threat to leopards by some authors (e.g. KIABI et al. 2002). When tolerated, however, leopard populations may live near human settlements. For instance, leopards are known to inhabit areas with human densities as high as 258 people per square kilometer in India (ATHREYA & BELSARE 2006), and the presence of tourists has been found not to be a main factor affecting leopard abundance in Africa

(BAILEY 1993). If leopards in the Middle East share a similar behaviour with their Indian and African counterparts, their absence from natural habitats that harbour wild prey and livestock strongly suggest that they have been poached out from these areas.

Attention must be given regarding poaching after livestock predation as it may regain momentum should the leopards be given a chance to recolonize areas on the border of their current range, as shown by the recently recorded presence of leopards in the Caucasus (e.g. BUTKHUZI 2004). The Arabian Leopard, like its Persian neighbour, may also have the opportunity to recolonise portions of its previous distribution or increase in numbers in the border areas of its range provided that adequate conservation conditions are given. Nevertheless, poaching after livestock depredation may have to be managed concomitantly to ensure the establishment and permanence of a founder population.

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References

AL-JOHANY, A. M. H. (2007): Distribution and conservation of the Arabian Leopard *Panthera pardus nimr* in Saudi Arabia. – Journal of Arid Environments 68: 20-30.

ATHREYA, V. & A. BELSARE (2006): 'Carnivore Conflict': support provided to leopards involved in conflict-related cases in Maharashtra. – Wildlife Trust of India, New Delhi, 46 pp.

BAILEY, T. N. (1993): The African leopard: ecology and behavior of a solitary felid. Columbia University Press. – New York, 429 pp.

BALME, G. A. , L. T. B. HUNTER & R. SLOTOW (2009): Evaluating methods for counting cryptic carnivores. – The Journal of Wildlife Management 73: 433-441.

BREITENMOSER, U., D. MALLON & C. BREITENMOSER-WÜRSTEN (2006): A framework for the conservation of the Arabian leopard. – Cat News Special Issue 1: 44-47.

BUTKHUZI, L. (2004): Breaking news: leopard in Georgia. – Caucasus Environment 2: 49-51, Georgia.

GAVASHELISHVILI, A. & V. LUKAREVSKIY (2008): Modelling the habitat requirements of leopard *Panthera pardus* in west and central Asia. – Journal of Applied Ecology 45: 579-588.

GHODDOUSI, A., A. K. HAMIDI, T. GHADIRIAN, D. ASHAYERI, M. HAMZEHPOUR, H. MOSHIRI, H. ZOHRABI & LEILA JULAYI (2008): Territorial marking by Persian Leopard (*Panthera pardus saxicolor* Pocock, 1927) in Bamu National Park, Iran. – Zoology in the Middle East 44: 101-103.

GUSSET, M. & N. BURGENER (2005): Estimating larger carnivore numbers from track counts and measurements. – African Journal of Ecology 43: 320-324.

IUCN (2008): The IUCN/SSC Red List of Threatned Species. – IUCN, Gland.

JACKSON, R. M. & D. O. HUNTER (1996): Snow leopard survey and conservation handbook. International Snow Leopard Trust U.S. Geological Survey, Biological Resources Division. – Seattle, 154 pp + appendices.

KHOROZYAN, I. (2003): Habitat preferences by the endangered Persian Leopard (*Panthera pardus saxicolor* Pocock, 1927) in Armenia. – Zoology in the Middle East 30: 25-36.

KHOROZYAN, I. (2005): The Persian leopard prowls its way to survival. – Endangered Species Update 22: 51-60.

KHOROZYAN, I. & A. ABRAMOV (2007): The Leopard, *Panthera pardus* (Carnivora: Felidae) and its resilience to human pressure in the Caucasus. – Zoology in the Middle East 41: 11-24.

KIABI, B. H., B. F. DARESHOURI, R. A. GHAEMI & M. JAHANSHABI (2002): Population status of the Persian leopard (*Panthera pardus saxicolor* Pocock, 1927) in Iran. – Zoology in the Middle East 26: 41-47.

MACKENZIE, D., J. D. NICHOLS, G. B. LACHMAN, S. DROEGE, J. A. ROYLE & C. A. LANGTIMM (2002): Estimating site occupancy rates when detection probabilities are less than one. – Ecology 83: 2248-2255.

NORRIS, K. (2004): Managing threatened species: the ecological toolbox, evolutionary theory and declining-population paradigm. – Journal of Applied Ecology 4: 413-426.

NOWAK, R. M. (1999): Walker's mammals of the world. 6th edition, vol. II. – Baltimore, 1936 pp.

QARQAZ, M. & M. ABU BAKER (2006): The Arabian leopard in Jordan. – Cat News Special Issue 1: 9-10.

SPALTON, J. A. (2000): The Arabian leopard in Oman. – Cat News 32: 6-7.

SPALTON, J. A., H. M. AL HIKMANI, M. H. JAHDHAMI, A. A. A. IBRAHIM, A. S. BAIT SAID & D. WILLIS (2006): Status of the Arabian leopard *Panthera pardus nimr* in the Sultanate of Oman. – Cat News Special Issue 1: 26-32.

STANDER, P. E. (1998): Spoor counts as indices of large carnivore populations: the relationship between spoor frequency, sampling effort and true density. – Journal of Applied Ecology 35: 378-385.

STANDER, P. E. (1999): Conservation of lions and other large carnivores in Etosha National Park and Khorixas District, Namibia. Population ecology and long term monitoring of free-ranging populations in a marginal and arid environment. – Predator Research Program, Quarterly Report (November 1999), Namibia, 8 pp.

STANDER, P. E., K. LLAU, N. LUI, T. DABE & D. DABE (1997): Non-consumptive utilisation of leopards: community conservation and ecotourism in practise. – Proceedings of a Symposium on lions and leopards as game ranch animals, Onderstepoort 50-57, South Africa.

STUART, C. & M. STUART (2007): Diet of leopard and caracal in the northern United Arab Emirates and adjoining Oman territory. – Cat News 46: 30-31.

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