The Arabian Leopard *Panthera pardus nimr* conservation breeding programme

Jane Budd, Kristin Leus

Abstract. Captive breeding has the potential to play a pivotal role in conserving threatened species, among others by providing a healthy "safety net" population with which to buffer dwindling numbers in the wild. The Arabian Leopard *Panthera pardus nimr* is Critically Endangered on the IUCN Red List. Captive breeding is an essential component of conservation for this species. Many experts are of the opinion that the chances for survival of the Arabian Leopard in the wild are much reduced without the potential for reintroduction of animals. The captive breeding programme has been operating on a regional level since 1999, although the first Arabian Leopards registered in the studbook were caught in 1985. The current living population consists of 42 males, 32 females, and three unsexed leopards; nineteen are wild caught (of which 3 are siblings) and a substantial number of these do not actively participate in the breeding programme. The program focuses on ensuring a genetically sound population that closely resembles the wild population. Current and predicted trends within the population are compared with recommended trends and graphically illustrated using dedicated population management software, PM2000.

Key words. Captive breeding, Arabian Leopard, population trend, population modelling.

Introduction

The Arabian Leopard *Panthera pardus nimr* (Hemprich & Ehrenberg, 1833) is a Critically Endangered subspecies of the Common Leopard and lives in a rapidly decreasing and highly fragmented habitat (AL JUMAILY et al. 2006, BREITENMOSER et al. 2006, EDMONDS et al. 2006, JUDAS et al. 2006, QARQAZ AND ABU BAKER 2006, SPALTON et al. 2006). Once a population has become extremely small and fragmented, even a complete reversal of all anthropogenic threats might be insufficient to save the population, because it is now also susceptible to demographic and genetic stochasticity. In such situations, conservation activities directed towards mitigation of the human-caused threats may need to be supplemented with intensive management of the population, and/or individuals themselves. Captive breeding is one form of intensive management of populations, which when formally integrated into the overall conservation strategy for a threatened species, subspecies or population, can fulfill a number of different functions, such as providing individuals for genetic or demographic supplementation, providing individuals for reintroduction in areas where the taxon has gone extinct, providing a genetically and demographically healthy "safety net" population for the wild population etc.

The establishment of a captive breeding programme was a first important step in preventing the complete extinction of the Arabian leopard, even though not all leopards held in captivity on the Arabian Peninsula have yet been integrated into the programme (EDMONDS et al. 2006). Provided sufficient knowledge on the biology and husbandry of the species

Biodiversity Conservation in the Arabian Peninsula
Zoology in the Middle East, Supplementum 3, 2011: 141-150.
ISSN 0939-7140 © Kasparek Verlag, Heidelberg

exists, breeding individuals in the relative safety of captivity, under expert care and sound management may provide an insurance against extinction (LACY 1994).

Conservation breeding efforts for the Arabian Leopard concentrate on maintaining a genetically and demographically sound captive population that serves as a "safety net" for the subspecies and guarantees its survival in captivity. The Strategy for the Conservation of the Leopard in the Arabian Peninsula (BREITENMOSER et al. 2010) endorses the role of the captive breeding program as a genetic back-up population and encourages international cooperation and partnership in achieving this goal.

Reintroduction, or re-establishment, is defined as an attempt to establish a viable free-ranging population of a species in an area which was once part of its historical range but from which it has become extinct (IUCN 1995). The process for reintroduction of captive-born animals into the wild is long and requires careful, science-based preparation and management well in advance of any potential releases. The problems faced by reintroduction efforts involving captive-born felids are immense but will not be discussed here as they have been comprehensively reviewed elsewhere (BREITENMOSER et al. 2001).

Regional programme

The captive breeding programme has been operating at a regional level since 1999, although the first Arabian Leopards registered in the studbook were caught in Oman in 1985. During the 1990s additional institutions within the Arabian Peninsula began to acquire Leopards and the need for a coordinated breeding programme became a priority (EDMONDS et al. 2006). The current population consists of 42 males, 32 females, and three as yet unsexed animals. The current living population is derived from 14 founders. A large proportion of the captive population does not actively contribute to the breeding programme, including seven potential founders (living unrelated individuals of wild origin) that do not have living descendants. There are nine institutions registered in the captive breeding programme, which is coordinated by Jane BUDD at the Breeding Centre for Endangered Arabian Wildlife in Sharjah, UAE (Table 1). The Regional Studbook was first published in its present form in 1999 and was upgraded to an International Studbook in 2009. Annual conservation workshops hosted by the Environment and Protected Areas Authority (EPAA), Sharjah since 2000 provided the platform from which regional cooperation was initiated. Breeding loan agreements have enabled numerous animal transfers between institutions from Saudi Arabia, Yemen, Oman and the UAE. Improved cooperation and information sharing (including the publication of leopard husbandry guidelines in 2009) have also enabled successful breeding in several institutions that previously had little or no breeding success. In total, 93 cubs (in 55 litters) have been born since the inception of the captive breeding programme, 63 (68%) of which survived beyond the first year, 11 (12%) died within one year and 19 (20%) died within 30 days. Fig. 1 and Fig. 2 demonstrate that much of the population growth in this population has occurred in the last 10 years since regional cooperation was initiated.

The Arabian Leopard studbook provides a common goal for the captive breeding programme and encourages cooperation between all participating institutions and countries. It provides recommendations on how best to manage the captive population to grow towards the target population size, to maintain genetic diversity, and to eventually create or select founder populations for reintroduction.

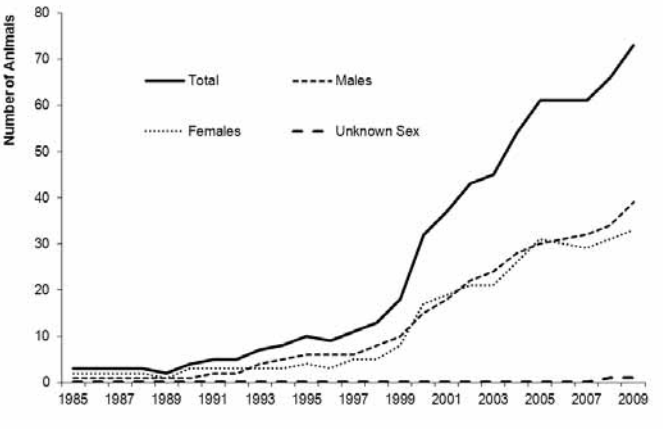

Fig. 1. The captive population of Arabian Leopards comparing males and females since 1985.

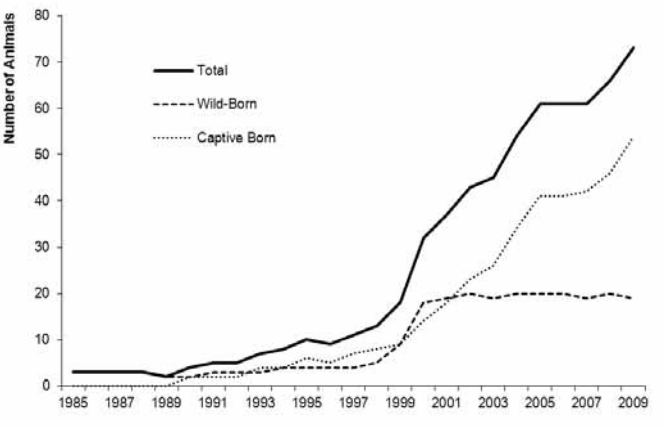

Fig. 2. The captive population of Arabian Leopards comparing wild-born and captive-born animals since 1985

Genetic and demographic analysis and management

The studbook for the Arabian Leopard is maintained using the software program SPARKS (Single Population Analysis and Records Keeping System) (ISIS 2004). Together with analysis software PM2000 (POLLAK et al. 2007) it allows genetic and demographic analysis and management of the captive population.

Age pyramid. An age pyramid shows the distribution of various age groups among males and females in a population. As can be seen from the age pyramid for the managed captive population of Arabian Leopard (Fig. 4) as per 30 November 2010, a large number of females are now 14 years old and will soon no longer be producing offspring. This has the potential

Table 1. Number of Arabian Leopard held in breeding facilities on the Arabian Peninsula as per 30 November, 2010. OMBC = Oman Mammal Breeding Centre, NWRC = National Wildlife research Centre, ADWC =Abu Dhabi Wildlife Centre, AAWPR = Al Ain Wildlife Park and Resort, BCEAW = Breeding Centre for Endangered Arabian Wildlife.

Country	Institution	Numberof Leopards			
		Total	♂	♀	unsexed
Oman	OMBC, Seeb	4	2	2	0
Saudi Arabia	NWRC Taif	9	6	3	0
United Arab Emirates	ADWC, Abu Dhabi	1	1	0	0
	AAWPR, Al Ain	1	1	0	0
	Al Bustan Zoolog. Park, Sharjah	5	3	2	0
	BCEAW, Sharjah	28	17	11	0
	Nakhlee Estate, Dubai	5	1	1	3
Yemen	Sana'a Zoo, Sana'a	6	2	4	0
	Ta'iz Zoo, Ta'iz	18	8	10	0

to negatively affect the population growth rate. It is also important to note that three of the six females represented in this age class are unrepresented founders and should therefore be included in the captive breeding programme as a matter of urgency. There are also more reproductive males than females, which could also result in a potential slump in population growth.

Founder representation. The genetic diversity of a population represents its evolutionary potential and higher levels of gene diversity tend to be correlated with higher fitness (REED & FRANKHAM 2003). Maintaining as much wild genetic diversity in the captive population as possible is important if the captive population is to provide a good genetic back up for the wild population, for captive population fitness and to increase the chances of reintroduction success.

Two factors are important in determining how successful a captive population is in maintaining the genetic diversity of the wild population: (1) the number of founders (ideally at least 20; LEUS & LACY 2009) and (2) how the founders, and their descendants, are combined in future breeding. Ideally all founders would have large and equal numbers of descendants. The captive population of Arabian Leopards currently has 14 founders and 7 potential founders (= wild caught animals without living descendants), and shows an uneven spread of descendants per founder (Fig. 5), which means that the captive population does not accurately reflect the genetic make-up of the wild population as the number of true founders is relatively small, the genes of some founders are overrepresented whereas others are not represented at all.

No founders should be prevented from breeding in this still small, young population (the fact that some founder lines are overrepresented can be addressed by managing the breeding of the next generations) but unrepresented founders should breed as a matter of urgency to increase the proportion of wild genetic diversity maintained in the captive population.

Maintaining genetic diversity. The world zoo and aquarium community currently recommends the retention of at least 90% of the gene diversity of the wild population in a captive population for the duration of the captive programme (or for 100 years for very long term programmes) (LEUS & LACY 2009). Analysis using PM2000 shows that under its

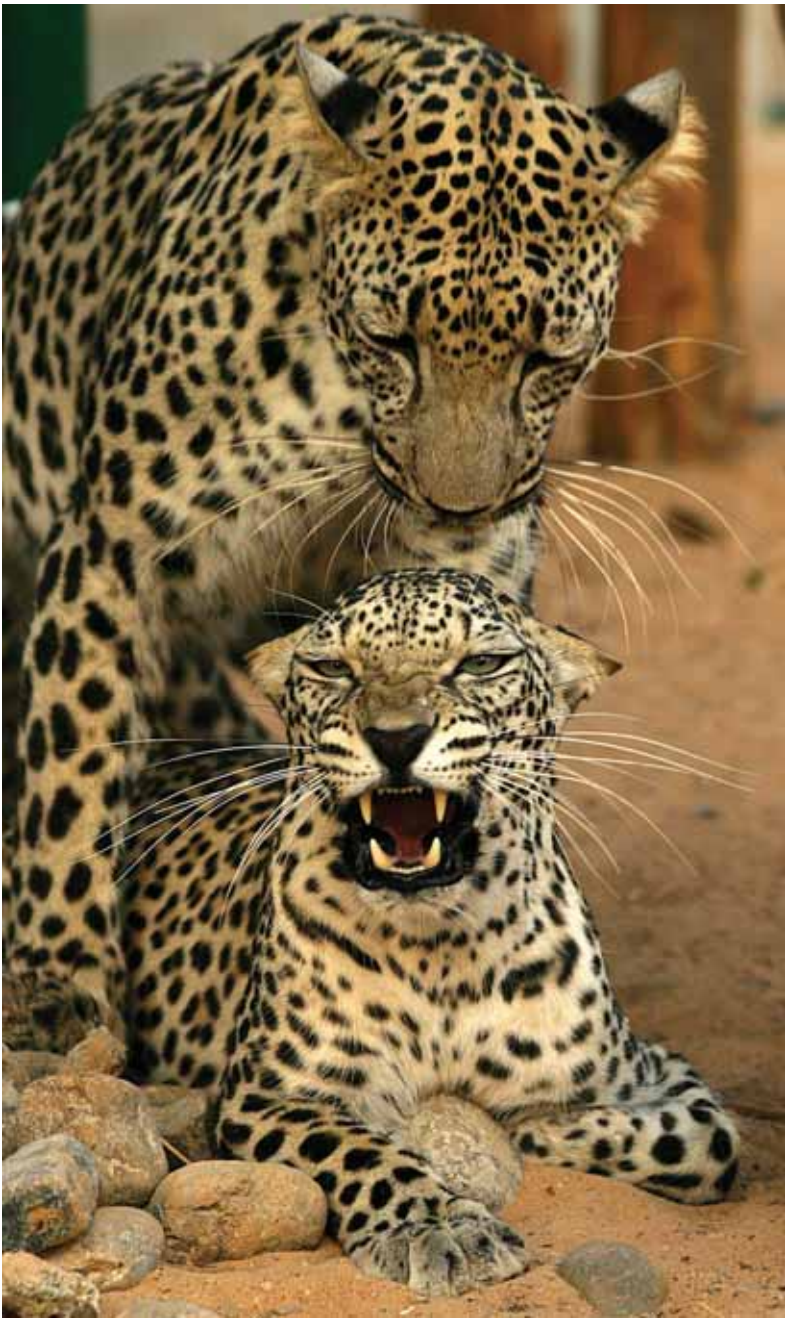

Fig. 3. The Arabian Leopard *Panthera pardus nimr* is Critically Endangered and captive breeding is an essential component of conservation for this species (photograph: Jane BUDD).

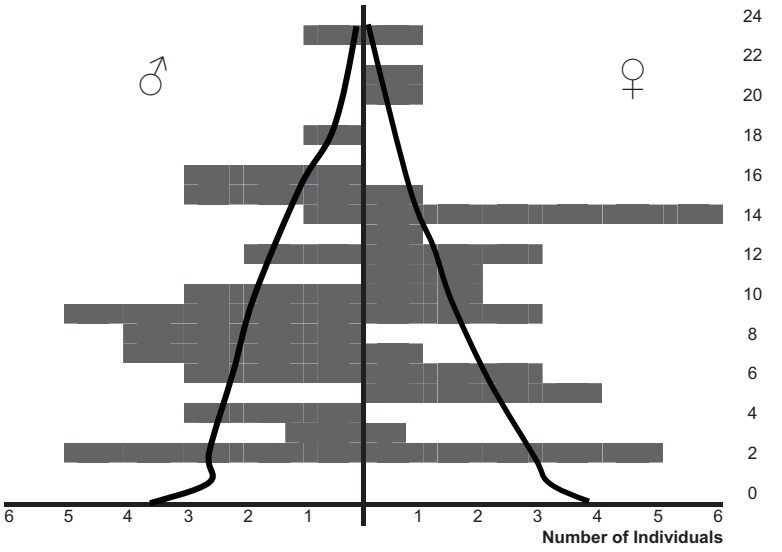

Fig. 4. Age pyramid for the Arabian leopard managed captive population on 31 December 2009. The x-axis shows the number of animals represented in each age and sex group and the y-axis represents age in years. The red line represents the shape this graph should be for a stable population (Graph produced with PM2000; POLLAK et al. 2007).

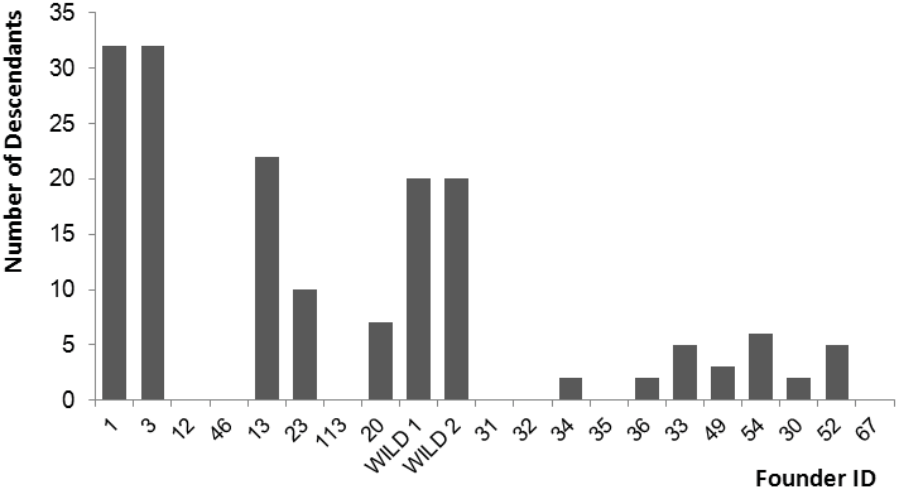

Fig. 5. The number of descendants produced by each founder animal in the captive population of Arabian Leopard (Graph produced with PM2000; POLLAK et al. 2007).

current conditions, the captive population of Arabian leopards will very rapidly lose genetic diversity (Fig. 6, Table 2) and will fall below 75% of gene diversity retained after about 70 years.

Current status of the captive population

The first scenario in Table 2 and Fig. 6 assumes that the population will remain at its current size as there is very little opportunity for growth within the current participating institutions due to space constraints. However, the current population size will not allow retention of a sufficient amount of genetic diversity. With the current annual growth rate of 3.3%, the captive Arabian Leopard population would need to increase to 170 animals in order to retain 80% of the gene diversity of the wild population for 100 years (Table 2, Fig. 7). Maintaining 80% of the diversity of the wild population means that the next generation can be expected to have an average level of inbreeding of 20%. If the average level of inbreeding in the population was 25%, this would mean that average relatedness would be equivalent to brother and sister, which can be expected to have consequences for fitness. Maintaining more gene diversity (e.g. 90%, see above) would therefore be better.

To achieve retention of gene diversity of 86% for 100 years, the annual population growth rate of the Arabian leopard population would need to increase to 10%, the seven unrepresented founders (Fig. 5) must breed, and the population would need to increase to 300 individuals (Table 2, Fig. 8). It should be noted that the growth rate during the foundation phase strongly influences the amount of gene diversity that can be retained in the captive breeding programme (LEUS & LACY 2009). A steep growth rate is important to ensure that each founder is allowed to produce many offspring.

Other potential scenarios to help retain gene diversity close to 90% would be (a) to reduce the duration of the programme (for example, if reintroductions are planned in the short to medium term (e.g. LEUS & LACY 2009), assuming the situation in the wild is appropriate to safely receive the reintroduced population), or (b) to sporadically include further founders; but taking these from the wild should not be considered before a thorough analysis of the consequences to the wild population is conducted (LEUS & LACY 2009). The Arabian leopard captive breeding programme, in close consultation and collaboration with the overall conservation strategy for the species, needs to determine which strategy is most appropriate and feasible, and set clear genetic and demographic population targets.

Table 2. The retention of gene diversity in the captive population of the Arabian Leopard after 100 years, under different scenarios. For all scenarios, generation time = 8 years, ratio of effective population size to true population size = 0.33 and current gene diversity retained = 91%. K = carrying capacity, λ = yearly growth rate, PF = number of the current potential founders that will start breeding, GD = gene diveristy (Calculations produced with PM2000; POLLAK et al. 2007).

Scenario	% GD retained after 100 years
K = 73 / λ = 0.033 / PF = 0	70%
K = 170 / λ = 0.033 / PF = 0	80%
K = 300 / λ = 0.100 / PF = 7	86%

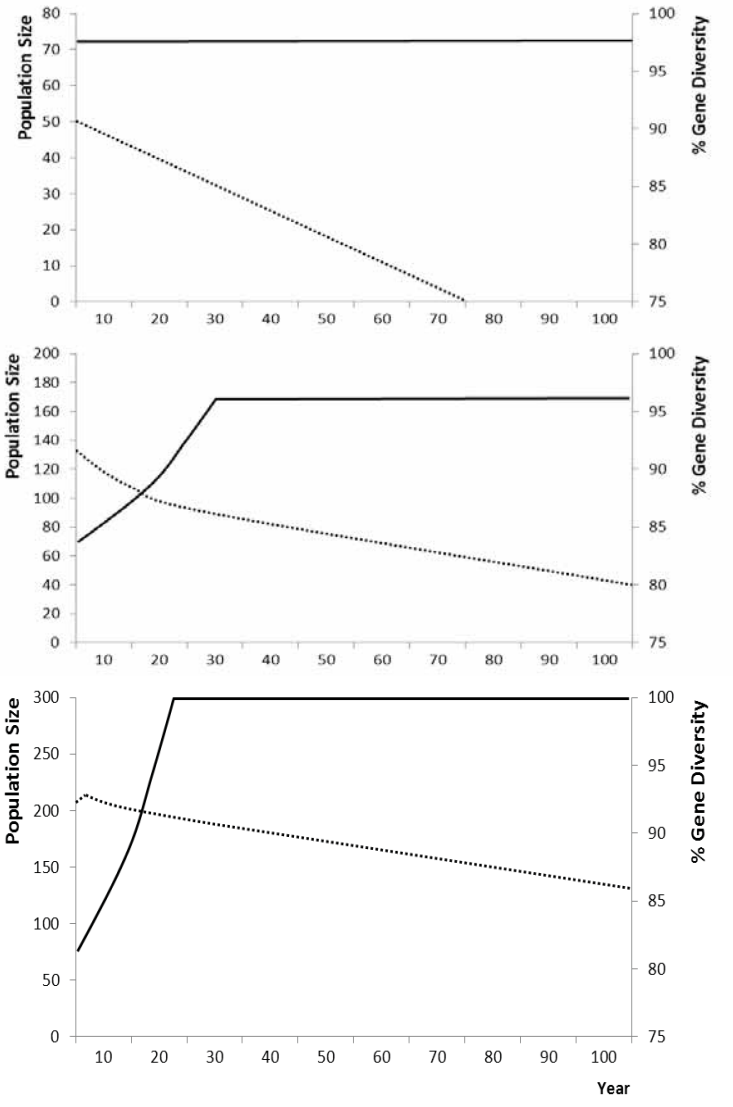

Fig. 6-8. Fig. 6 (top): The future retention of gene diversity in the captive population for the Arabian Leopard assuming the population stays at its current size of 73 and that the population grows at the current rate of 3.3% per year, with a generation length of 8 years. The current gene diversity is 91%. The ratio of the effective population size to the true population size is 0.33. – Fig. 7 (middle): The potential retention of gene diversity in the captive population for the Arabian Leopard assuming the population increases to 170 animals but maintaining the current population growth rate and generation length. It is only possible to maintain 80% of the original gene diversity. – Fig. 8 (below). The potential retention of gene diversity in the captive population for the Arabian Leopard assuming the population increases to 300 animals, the population growth rate increases from 3.3% to 10%, and the seven unrepresented founder animals contribute to the population. The maximum achievable gene retention in this scenario is 86% – Solid line: population size; dotted line: gene diversity. Graphs produced with PM2000, see POLLAK et al. (2007).

Fig. 9. The current living captive population of the Arabian Leopard consists of 74 individuals (photograph: Jane BUDD).

International and regional cooperation

The Arabian Leopard captive breeding programme focuses on maintaining a genetically sound population that closely resembles the wild population. Cooperation between institutions holding Arabian Leopards is essential to ensure representation of all the wild-caught animals. Additional institutions must be included in the captive breeding programme in order to further expand the growth potential of the population. Sudden losses in the population as a result of disease or natural disaster are a very real problem for the Arabian Leopard captive breeding programme as there are few institutions housing large populations of Arabian Leopards.

References

AL JUMAILY, M., D. P. MALLON, A .K. NASHER & N. THOWABEH (2006): Status report on Arabian leopard in Yemen. – Cat News Special Issue 1: 20-25.

BREITENMOSER, U., C. BREITENMOSER-WURSTEN, L. N. CARBYN & S. M. FUNK (2001): Assessment of carnivore reintroduction. p. 241-281. In: J. L. GITTLEMAN, S. M. FUNK, D. MACDONALD & R. K. WAYNE (Eds), Carnivore Conservation. – Conservation Biology 5, Cambridge University Press, Cambridge.

BREITENMOSER, U., C. BREITENMOSER, D. MALLON & J.-A. EDMONDS (Eds) (2010): Strategy for the conservation of the Arabian leopard in the Arabian Peninsula. – Environment and Protected Areas Authority, Sharjah, UAE.

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

EDMONDS, J. A., K. J. BUDD, A. AL MIDFA & C. GROSS (2006): Status of the Arabian leopard in the United Arab Emirates. – Cat News Special Issue 1: 33-39.

EDMONDS, J. A., K. J. BUDD, P. VERCAMMEN & A. AL MIDFA (2006): History of the Arabian Leopard Captive Breeding Programme. – Cat News Special Issue 1: 40-43.

JUDAS, J., P. PAILLAT, A. KHOJA & A. BOUG (2006): Status of the Arabian leopard in Saudi Arabia. – Cat News Special Issue 1: 11-19.

ISIS (International Species Information System) (2004): SPARKS (Single Population Analysis and Records Keeping System), Version 1.54. – International Species Information System, Eagan, MN.

IUCN (1998): Guidelines for re-introductions. Prepared by the IUCN/SSC Reintroduction Specialist Group. – IUCN Gland (Switzerland) & Cambridge (United Kingdom), 10 pp.

LACY, R. C. (1994): Managing genetic diversity in captive populations of animals. P. 63-89. In: M. L. BOWLES & C. J. WHELAN (Eds), Restoration of endangered species. – Cambridge University Press, Cambridge.

LEUS, K . & R. C. LACY (2009): Genetic and demographic management of conservation breeding programs oriented towards reintroduction. p. 74-84. In: A. VARGAS, C. BREITENMOSER & U. BREITENMOSER (Eds), Iberian Lynx ex situ conservation: An interdisciplinary approach. – Fundación Biodiversidad, Madrid.

POLLAK, J. P., R. C. LACY & J. D. BALLOU (2007): Population management 2000, version 1.213. – Chicago Zoological Society, Brookfield, IL.

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

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

Authors' addresses: Jane Budd, Breeding Centre for Endangered Arabian Wildlife, P.O. Box 29922, Sharjah, UAE. – Kristin Leus, Conservation Breeding Specialist Group, European Office, Copenhagen Zoo, p/a Annuntiatenstraat 6, 2170 Merksem, Belgium. – Email: jane.budd@bceaw.ae.