

Status of the Arabian Leopard in Saudi Arabia

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The historic range of the Arabian Leopard presumably extended over a large part of Saudi Arabia. Analysis of the scarce historic and recent records suggests that the range has decreased by 90 % since the beginning of the 19th century, with an annual rate of range loss close to 10 % in the last 15 years. During the period 1998-2003, 19 reports were recorded, of which only 4 can be confirmed, distributed in 2 main areas. 1) the escarpment of the Asir Mountains between Al Baha and Abbah (600-2400 m), where high prey density may still be found near permanent water flows, and 2) the drier Hijaz Mountains north of Madinah (< 2000 m), where potential prey density is low. Considering home range sizes and densities calculated for other leopard populations in different ecological contexts, the potential population was estimated at 60-425 individuals in a range of 4000-19,635 km². Population viability analysis projected a mean time for first extinction of 11.3 years from 1998. The decline is mainly attributed to habitat fragmentation and degradation and direct persecution. The increase in over-grazing, and encroachment into once remote areas by road construction since the 1970s have induced important biodiversity loss affecting the whole food chain. Prey availability has decreased throughout leopard range, which has presumably led the leopard to alter its diet towards live-stock and other domestic animals. This increases the unpopularity of the species, and persecution by local people. The leopard is officially protected in Saudi Arabia; however, despite the high proportion of land protection (4.1 % of the country), there is an obvious lack of protected areas that encompass the leopard's remaining range. Recommendations stress the need for extensive surveys to update current status and distribution of the Leopard, and to develop *ex situ* and *in situ* conservation programs.

وضع النمر العربية في المملكة العربية السعودية جاكي جوداس، باتريك بالات ، عبدالرحمن خوجه وأحمد البوق

الملخص:

التوزيع الجغرافي التاريخي للنمر العربية في المملكة العربية السعودية من المحتمل أنه يغطي مساحات كبيرة منها. ويظهر التحليل للإشارات التاريخية النادرة والتسجيلات الحالية ميلا الى انحسار توزيعها بنسبة 90% منذ بداية القرن التاسع عشر الميلادي. بمعدل انخفاض سنوي للانتشار بحوالي 10% خلال الخمسة عشر سنة الماضية. خلال الفترة من 1998-2003م سجل 19 إشارة عن تواجد النمر العربية. منها أربعة فقط يمكن تأكيدها. وتتوزع في منطقتين رئيسيتين (1) المنحدرات الجبلية لسلاسل جبال عسير بين الباحة وأبها (600-2400م)، حيث يتوقع توفر كثافة عالية من الفرائس قرب منابع المياه الدائمة. (2) في جبال الحجاز الجافة في شمال المدينة (حوالي 2000 م) حيث احتمال انخفاض كثافة الفرائس. واستنادا على قطاعات التحرك والكثافة لمجموعات من النمر الأخرى في بيئات مختلفة من دراسات سابقة. قدرت أعداد النمر في المملكة بشكل تقريبي بين 60-425 نمر في مساحات بين 4000-19.635 كم². وقد حددت تحقيقات للمجموعات القابلة للحياة للنمر في المملكة زمن متوسط لبداية انقراضها قدر بـ 11.3 سنة من 1998م. الانحسار مرتبط بشكل أساسي بتفتت البيئات وتدهورها، وللمعاناة المباشرة، وزيادة الرعي الجائر، والانتهاكات البيئية للمناطق النائية عبر إنشاء الطرق من السبعينيات الميلادية 1970م، كل ذلك فاقم من فقدان التنوع الاحيائي، مما أثر على كامل السلسلة الغذائية، وانخفض توفر الفرائس في كامل نطاق التوزيع للنمر العربية، والذي من المحتمل أنه دفع النمر لتبديل غذائها باتجاه المواشي والحيوانات المستأنسة الأخرى. زاد ذلك من انخفاض التعاطف الشعبي مع النمر واستهدافها من السكان المحليين. النمر محمية وفق أنظمة المملكة العربية السعودية. وبالرغم من ارتفاع مساحة المناطق المحمية لمساحة المملكة (4.1% من المساحة الكلية) فإن هناك ندرة منها في المناطق المتبقية للتوزيع الجغرافي للنمر. تركز التوصيات على الحاجة الماسة لإجراء مسوحات حقلية لتحديث تقرير وضع النمر الحالي ومعلومات توزيعها الجغرافي ولتطوير برامج لحمايتها في البرية والأسر.

Status and distribution

Historically, the Arabian leopard *Panthera pardus nimr* was probably found in a large part of Saudi Arabia, excluding sand dune areas (Nafud, Rub al Khali). Its range extended all along the mountains bordering the Red Sea coast, from the Jordan border in the north to

Yemen in the south (Gasperetti et al. 1985, Harrison & Bates 1991). Early travelers on the pilgrimage route to Mecca (Lady Anne Blunt 1881, Dougherty 1888, Carruthers 1909) reported its presence inland in the Hail area and a review of the Saudi toponymy (site na-

mes composed of "nimr") suggested that its distribution could have extended inland as far east as the Riyadh region.

The Arabian leopard may currently be found in only small isolated populations in remote and rugged areas of the western Sarawat and Hijaz Mountains.

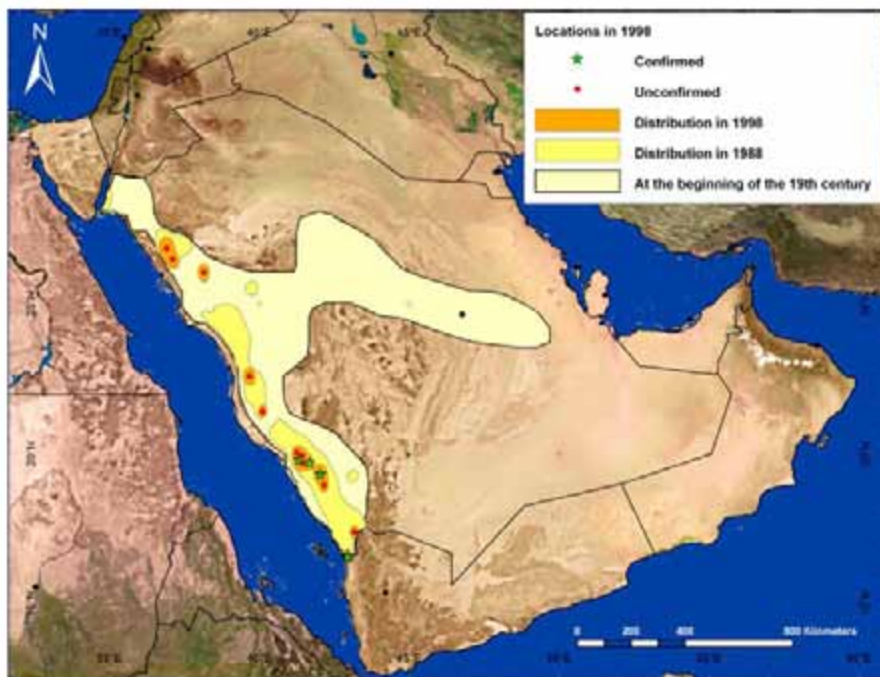


Fig. 1. Distribution change of the Arabian Leopard in Saudi Arabia from the beginning of the 19th century to 1998. Light yellow: distribution at the beginning of the 19th century; middle yellow: distribution in 1988; dark yellow: distribution in 1998. Green stars confirmed presence in 1998, red dots unconfirmed presence in 1998.

In this study, during the period 1998 to 2003, leopards were reported from 19 locations, of which 4 can be considered confirmed (Appendix I). Fourteen of these locations are distributed in 2 main areas, whereas the other 5 are isolated, single reports (Fig. 1). The most important area, in number of reports and size, is located in the Asir Mountains (Fig. 2) between Al Baha and Abha along a large steep escarpment, about 250 km long and 20–30 km wide. At 3 locations (Jibal Shada, Al Atifa and Wadi Khatayn), presence of the species was confirmed by killings, several reports of sightings from different witnesses, livestock killed, and presence of tracks and signs. The most recent record was obtained in Wadi Khatayn (south of Biljurashi) in 2002. However, camera traps deployed in the area during 2002 and 2003 failed to obtain pictures of leopards. The second most important area is located near Al Wahj, north of Madinah, in the Hijaz Mountains. In spite of several reports of the presence of leopards here, none could be clearly confirmed. A recent survey (Budd 1999) did not produce any more evidence, although leopard presence was strongly suspected. Four of the isolated locations, 3 in the Asir mountains and 1 near Jebel Nahr (Hijaz

mountains), could also not be confirmed (R. Ajaj, pers. comm.). The fifth location (P. Paillat, pers. comm.) in Samtah near the Yemen border was documented in 1999 with pictures of 2 individual leopards killed.

A survey conducted between 1996 and 2002, based on enquiries among local shepherds and hunters, listed 65 sightings of leopards at 42 sites (Al-Johany 2007) mainly distributed in the Hijaz mountains (around Madinah and Al-Ula) and secondarily along the Asir mountains. These unconfirmed records largely overlapped the possible range assessed for the period 1990–2005 in this status review.

The total potential range in 1998 was estimated to cover between 4,000 km² (considering only the 4 confirmed locations) and 29,724 km² (all locations), with 19,635 km² and 10,089 km² in the Asir and Hijaz mountains respectively (see Judas *et al.* 2004 for details of the analysis). Comparing ecological studies of leopard conducted in areas of Africa with comparable rainfall (Bothma & Le Riche 1984, Stander *et al.* 1997), with preliminary results of radio-tracked leopards in Oman (A. Spalton, pers. comm.), and considering a likely gradual fall-off in density towards the

edge of the distribution range (Brown 1984, Caughley *et al.* 1988), the potential leopard population in 1998 was estimated to range between 60 and 425 individuals. Based on the distribution ranges estimated for different periods (Judas *et al.* 2004), the leopard's range has decreased by around 90 % since the beginning of the 19th century with an annual rate of range loss close to 10% in the last 15 years. With such a rate of decrease, the potential population size in 2004 could range between 16 and 111 individuals for the whole of Saudi Arabia. Population viability analyses using Vortex 8.42 (Lacy *et al.* 2001) projected a mean time to first extinction of 11.3 years as from 1998, that is, two years from now.

Threats

The decrease in Arabian leopard populations is mainly due to habitat fragmentation, habitat degradation and direct persecution. In Saudi Arabia, habitat loss began several centuries ago with tree cutting to meet the wood demands of growing iron and copper industries (Collenette 1999). This was already largely developed by the 16th century. Tree cutting and deforestation still occur in the southern Hijaz Mountains for charcoal production, an important local industry (Biquand *et al.* 1990). In the last twenty years, government policy has encouraged the expansion of pastoralism and agricultural intensification so as to achieve national self-sufficiency in the production of meat and agricultural products. Construction of new tracks and roads in the escarpment has enabled encroachment into once remote areas. Considerable development of highways occurred between 1985 and 1990 (Gasperetti & Jackson 1990). Along these new access roads, unplanned and uncontrolled urban development has been taking place without any Environmental Impact Assessment and/or management plan. Rehabilitation and irrigation of terraces and water supplies with tanks allowed otherwise unsustainable development and intensified encroachment upon natural habitats.

The diversity, abundance and distribution of leopard prey species are declining all over the Kingdom, alongside habitat loss. Abundant and well distributed in former times, gazelles and ibex

have been extirpated from many areas, and remaining populations reduced to a few individuals by over-hunting. Widespread use of firearms has intensified the process. Where gazelles and ibex still occur, hunting parties are regularly organised during the summer (e.g. at Al Fiqrah, Biquand *et al.* 1990). Hyrax, thought to be an important part of the leopard's diet, is also heavily hunted. Even if the species still appears to be well distributed within the Asir Mountains, high hunting pressure will undoubtedly reduce their abundance significantly. Overgrazing by goats, sheep, camels and feral donkeys increased in the 1970s, and contributed significantly to biodiversity loss. Excessive use of vegetation reduced plant diversity, which, in turn, affects the whole food chain from primary producers to top predators.

Direct persecution, through pursuit of trophies or other products, and livestock protection, is the third important threat weighing on the leopard population's fate. Sport hunting is a common practice in Saudi Arabia. Leopards do not often appear to be the sought-after game, but are recognized as valuable hunting trophies that honour the bravery of the hunter (Seddon 1996). In the same way, Bedus who killed animals such as wolf, caracal, hyena, baboon and leopard in wadis around their camp hung them on trees at the roadside, presumably as a demonstration of their skill. However, many killings of leopards can be attributed to livestock protection. When preying on goats, sheep, young camels or other domestic animals, leopards interfere with human activities and are seen as direct competitors (Nader 1996). With the decrease of natural prey species, they have no choice but to alter their diet to livestock, which increases their unpopularity. In most cases, they are also considered as a threat to humans. As a result, leopards are hunted in all their range (Biquand & Boug 1989) using different methods. Poisoning was common in the 1980s, when the Ministry of Agriculture distributed free anticoagulant rat killer. This poison was mixed with crushed glass and metal particles to induce internal haemorrhage (Biquand *et al.* 1990, Biquand & Boug 1992). This practice seems to have stopped around 1985, un-



Fig. 2. Presence of leopards is still reported around Jebel Khurs in the Asir Mountains (Al Baha area; Photo J. Judas).

like trapping. Old fashioned rock traps were largely used in the past. Leopards caught in such traps, or walled in their lair with stone and cement, were left to starve to death or to reach a weak condition, then killed (Gasperetti *et al.* 1985). Rock traps are no longer used, but have been replaced by metal cage traps that are easy to carry and move in the field, baited with goat meat. Shooting and poisoning were considered as the main causes of decline by Nader (1989).

Recognition by local people that wildlife can represent a source of profit also prompts them to kill or catch leopards. As long as benefits were fairly low, leopard remains were presumably sold as extra income and leopards were not killed specifically for this purpose. The fat was collected and sold for medicinal purposes (Nader 1996). Skins and teeth were available in the souk of Khamis Mushayt in 1985. The skin was sold for US\$ 270. In 1994, the National Wildlife Research Centre (NWRC) was informed that a skin was for sale in Abu Dhabi market for US\$ 15,000. In 1997, one live leopard was sold at auction for US\$ 4,800 in Al Khawbah market near the Yemen border. A live leopard can be sold for up to US\$ 50,000. Existence of a market for live animals (Fig. 3) with increasing prices eases the development of traffic. One young female was sold on the black market from Yemen to Saudi Arabia in April 2001; two other animals

coming from Yemen were sold in Saudi Arabia in summer 2001. The different threats weighing on leopard survival are strongly interrelated and can only be solved if tackled in their entirety.

Habitat

Leopards in Saudi Arabia are now confined to remote and rugged areas of the Sarawat Mountains, shared between the Hijaz in the north and the Asir in the south. The Hijaz mountains consist of a broken chain that rarely exceeds 2,000m a.s.l. and receives very little rainfall (<200mm/year, Child & Grainger 1990). Higher elevations are vegetated with Mediterranean *Juniperus phoenicia*, with the slopes being broken by dry wadis, where leopards have been reported. In the Asir mountains, leopards live along the steep escarpment, parallel to the Red Sea coast, that drops from up to 2,400 m to around 600 m a.s.l. The top of the escarpment and highlands are heavily built up and cultivated (Evans 1995). The craggiest and highest parts are shaded by Afro-tropical juniper cloud-forest *Juniperus procera*, whereas gentler slopes are covered by dry vegetation associations of *Acacia asak-Commiphora* spp. or *Acacia seyal-Commiphora* spp. with succulent plants (*Adenium obesum* or species of Euphorbiaceae). Steep slopes of volcanic rock, poorly vegetated, alternate with impressive bare granite



Fig. 3. Sacred baboon *Papio hamadryas*, potential prey of the leopard, caught in a trap set by local people to catch leopard in wadi Khatan. Illegal trapping represents an important threat on the species in Saudi Arabia (Photo J. Judas).

boulders (Jabal Shadah, Wadi Oshar, Fig. 4). These areas offer suitable shelter and shade, such as caves and tree cover that leopards need (Kingdon 1997). In Al Atifa area, they use steep rocky slopes half way up the escarpment, where a network of caves has formed under huge rocks fallen from the cliffs. The valley beds at the foot of the escarpment are generally densely wooded with tree species reaching 10-12 m in height (*Ziziphus*, *Ficus*). Despite the fact that higher elevations of the Asir mountains (>2,000 m, south of Al Baha) can receive a considerable amount of rainfall (>500 mm/year), permanent waterholes or rivers are rare. It has been suggested that the presence of permanent water all year long could be a typical habitat requirement of leopard (Edmonds *et al.* 2002, Harrison & Bates 1991). However, the presence of water where leopards still occur could be the result of range reduction rather than a necessary condition. Leopards will drink every day when possible, but can survive without water for months (Haltenorth & Diller 1985). Permanent water promotes development of rich vegetation and so higher food availability at all food chain levels, which would favor leopard existence. In Wadi Khatayn and Wadi Oshar, south of Biljurashi, a permanent river, which allows the development of a rich wildlife and potential prey, appear

to be particularly favorable for leopards. Narrow gorges with evergreen vegetation (*Phoenix reclinata* palm trees, and the rare *Mimops angustifolia*) contain waterholes up to mid-summer and many fresh and shaded rocky crevices. Moreover, the remoteness of these sites limits human disturbance.

Protected Areas

Historically, Saudi Arabia has a long local community-based tradition of control and use of natural resources through the "hima" system (Evans 1994). For example, the Hima Al Fiqrah, where leopards could presumably still survive, ensured habitat protection in order to maintain traditional honey production (Biquand *et al.* 1990). No grazing was allowed, except for a few local livestock. However, this system is increasingly neglected in the whole Kingdom due to population growth and spread associated with transport of water and livestock fodder.

Since 1986, Saudi Protected Areas, established following IUCN criteria, are managed by the National Commission for Wildlife Conservation and Development (NCWCD) in Riyadh. Emphasis is given to in situ conservation which aims to maintain and recover viable populations of wild species in nature within their known natural range (Abuzinada 2003). This system of protected areas

also provides a legal framework since hunting and wood cutting are prohibited inside them. Sixteen Protected Areas have been created so far, mainly terrestrial, covering 90,017 km², i.e. 4.1 % of the country's area. However, the former presence of leopards has only been revealed in Raydah and Jebel Shadah, covering 9 km² and 50 km² respectively.

Prey species

The diet of the Arabian Leopard has never been studied in Saudi Arabia. Scat analyses in similar habitats of Oman (Muir-Wright 1999) showed that the main prey species were, in order of importance, the Arabian gazelle *Gazella gazella*, Nubian ibex *Capra ibex*, Cape hare *Lepus capensis*, rock hyrax *Procavia capensis*, bird species, porcupine *Hystrix indica*, Ethiopian hedgehog *Paraechinus aethiopicus*, small rodents and insects. In Palestine, the diet was mainly composed of hyrax and ibex (90 %) and porcupines (5 %; Ilany 1990). In Saudi Arabia, Child & Grainger (1990) also suggested that diet could be mainly composed of hyrax and similar size prey. Nubian ibex and gazelles could have been an important part of the diet of leopards in the past, but nowadays, the distribution range of these ungulates is reduced to small isolated populations. In order to survive, leopards have no choice but to alter their diet according to prey availability. Hyrax are still quite common in the western part of the kingdom, and leopards in parts of Africa have been shown to prey mainly on this species (Stuart & Stuart 1995). Whether or not predation on primates occurs in the Asir Mountains is debatable. Broken skulls of sacred baboons *Papio hamadryas* discovered under rock shelters of Wadi Khatayn (South of Al Baha) indicate that predation does occur, but the predator has not been clearly identified. Kummer *et al.* (1981) suggested that predation upon monkeys is presumably rare, whereas recent changes in baboon ranging habits have been attributed to leopard population change (Biquand *et al.* 1989). If they do occur, attacks on baboons should be at night when they are asleep among rocks (Shortridge 1934 cited in Kingdon 1977). Since leopards are known to be an opportunistic predator, we can suppose that they will also prey upon species like partridges

(*Ammoperdix heyi*, *Alectoris melanocephala* and *A. philbyi*), porcupines, hares and even fishes, frogs and turtles that are still abundant in some places. Nevertheless, following the general decrease of wildlife populations and reduction in natural habitat, leopards have also shifted their diet towards domestic animals (Fig. 5) that are a much easier prey to catch. Predation upon goats, sheep, young camels and feral donkeys has been reported (Biquand 1989, Biquand & Boug 1992). Leopards may also prey on domestic dogs at night around or even inside camps. Leopards may sometimes scavenge. A local Bedu mentioned a leopard briefly seen at night in headlights, fleeing from the carcass of a mammal that had been hit by a car on the Biljurashi escarpment.

Domestic animals

Livestock production is widely distributed all over the kingdom. Mixed herds of sheep and goats may number up to 500, but are more often in the order of 200 in open areas and around 100 in rugged areas. Grazing systems are extensive. Herds are left all day long to graze in natural vegetation patches and taken by shepherds between these patches, sometimes helped by sheepdogs. In the mountains they used to move along slopes of wadis. However, herds do not spend the night alone on the field anymore, but return to the camp, where they receive additional fodder like alfalfa. More than 40 years ago, people used to spend the night in the mountains and put the lambs into small stone corrals to protect them from predators (leopards, caracals, hyenas or wolves) or to prevent them suckling so as to be able to milk ewes more efficiently. Grazing rotations are walked on a daily basis, but also depend on seasons and green vegetation patches that are highly variable in the arid environment. The grazing range of a herd used to be limited by daily walking distances. However, development of roads made new temporary settlements possible in previously remote areas. Movement of herds is assisted by trucks and the expense is supported by the government (Nasser & Esber 1995). In many cases, Saudi livestock owners have other income as well as keeping livestock and let the control of flocks to Sudanese or Ethiopian shepherds.



Fig. 4. Wadi Khatan near Biljurashi. Granite boulder rocks interspersed by densely vegetated riverbeds represent a typical leopard habitat in the escarpment of the Asir Mountains (Photo J. Judas).

Legal Status

Arabian leopard is classified as Critically Endangered in the IUCN Red List, and listed in CITES Appendix I. The GCC (Gulf Cooperation Council) agreement endorsed in December 2001 included the Arabian Leopard in its policies of cross border conservation. In Saudi Arabia, hunting is restricted under the National Hunting Law, Decree No M/26 dated 25/5/1398 (2/5/1978) and decree No 457 dated 13/3/1399 (10/2/1979). Decree No M/22 from 1986 sets out NCWCD's official remit for protected areas, and Decree No 128 from 1995 concerns regulations governing a "Wildlife Protected Areas System" including selection, establishment and management of wildlife protected areas (Seddon 1996). All forms of hunting are officially prohibited in Protected Areas managed by NCWCD, but the presence of leopards has been attested from only 2 of them. A Wild Animals and Birds Hunting Act, an Act on the Trade in Endangered Wildlife Species and their Products, and an Environmental Code have been promulgated in 1999, 2000 and 2002, respectively (Mésochina, pers. comm.).

Conflicts and Public awareness

The public awareness programme aims

to induct a conservation ethic in farmers and the public. Contacts are established with local people, but on an irregular basis. NCWCD has produced posters on threatened animals of the kingdom, that are not specifically designed for the leopard conservation, but that include the species. NCWCD has developed a training centre where people (rangers, teachers etc) from Saudi Arabia or the other Gulf States can receive information and training on environmental monitoring, environmental management, and techniques of field study. A stuffed leopard is on display in the Natural History Museum at NCWCD. NWRC has produced two short video reports in relation to leopard conservation.

People and institutions

Three organisations are involved in leopard conservation in Saudi Arabia:

- The National Commission for Wildlife Conservation and Development (NCWCD) is a governmental agency, directed by Prof. Dr. A. Abuzinada, established in Riyadh in 1986 by Royal Decree No. M/22 and which has the mandate to "Develop and implement plans to preserve Wildlife in its natural ecology". The NCWCD has created two committees: The Carnivore Advisory Group (CAG) under the chairman of Dr. I. Nader and

Table 1. Origin of Arabian Leopards acquired by the NWRC

Studbook reference	Micro-chip	Name	Origin	Place of capture	Event	Date	Birth date	Sex	Age (years)
stdbk #20	00-0070-012E	Rachid	wild	Wadi Oshar (ev. Yemen)		16.05.97	~1996	M	10
					transfer to Sharjah	06.05.03			
stdbk #23	00-0070-02DF	Al-Jezira	wild	Yemen (Wa'ada)		22.07.98	~1995	M	11- 12
					transfer to Sharjah	20.11.00			
					return to Taif	05.05.03			
stdbk #28	00-01C70FD6	Lina	captive	BCEAW	birth	18.01.00	18.01.00	F	7
					transfer fo NWRC		30.04.06		
stdbk #30	00-0070-06E7	Aicha	wild	?		28.04.00	Feb-99	F	8
stdbk #46	00-01CD-B059	Kadeeja	wild	?		22.04.01	~1991	F	16
					transfer to Sharjah	06.05.03			
stdbk #49	00-01CE-3DE4	Samtah	wild	Jizan area (ev. Yemen)		21.05.02	~1999	F	8
					transfer to Sharjah	30.04.06			
stbk #57	00-060D-561D	Morkel	captive	BCEAW	birth	16.05.03	16.05.03	M	3
					transfer to NWRC	30.04.06			

supervision of the secretary General of NCWCD, Prof. Dr. A. Abuzinada, and The Arabian Leopard Working group, constituted on 7 January 1996.

- The National Wildlife Research Centre (NWRC), created in 1988 in Taif, is in charge of captive breeding and reintroduction of viable populations of houbara bustard and Arabian oryx in Saudi Arabia. A programme of leopard captive breeding (Fig. 6) and field investigations has been initiated. An Arabian Leopard Captive Breeding Working Group (ALCBWG) has been created in relation with NCWCD.

- The King Khaled Wildlife Research Centre (KKWRC) located in Tumamah, 30 km north-west from Riyadh, is mainly involved in conservation and captive breeding of gazelles and ibex. Genetic analyses of leopard samples have been initiated.

Ongoing work

Conservation strategy

On 26 February 2001, the Arabian Leopard Working Group of the NCWCD defined a conservation strategy and recognized that *in situ* conservation was the most appropriate means of protec-

ting the species, and *ex situ* captive breeding will provide a genetic backup of the gene pool (Joubert 2001).

Captive breeding

Four individuals are currently kept in NWRC and three have been loaned for breeding purpose to the Breeding Centre for Endangered Arabian Wildlife, Sharjah. In order to develop the captive breeding programme in NWRC, new facilities are under construction with private funds received from Prince Faysal bin Saud bin Mohammed al Saud. Construction of three such breeding units, totalling 9 separate cages, has been planned over 5 years as well as the setting up of a natural enclosure to rear captive-bred young in semi-captivity.

Genetic analyses

Genetic analyses have been initiated in 1998 in KKWRC with the aim of clarifying the taxonomic status of the Arabian subspecies *P. p. nimr* (Hammond *et al.* 1997). In 2000, 101 samples from 13 of the 27 subspecies have been collected, most of them from specimens in the Arabian Peninsula. First analyses focused on DNA sequencing by PCR amplification (Winney *et al.* 1999). Analyses were stopped through technical problems and lack of funding.

Field surveys

NWRC staff promptly visit places where signs of presence are reported. Field surveys and camera-trapping were con-



Fig. 5. Goat killed by a leopard in wadi Khatan. The increasing rarity of typical prey species forces leopards to prey more and more often on livestock, which reinforces conflict with local human populations (Photo J. Judas).

ducted in 2002 and 2003 in Wadi Oshar (down to Biljurashi escarpment, south of Al Baha), where sightings and signs of activity have recently been reported. Two infra-red camera traps, on loan from BCEAW, were installed from April 5 to June 8, 2002 and 3 from March 7 to May 31, 2003, totalling 338 trap nights and allowing us to obtain 396 pictures. Unfortunately, no pictures of leopards were obtained.

Recommendations

Field investigations and ecological study
Updating the status and distribution based on extensive surveys of remaining wild populations needs to be urgently undertaken. All potentially suitable sites have to be investigated. Areas where the presence of leopards has recently been reported should be targeted as priority sites for conservation.

Efficiency of conservation programmes and population management would be greatly improved with accurate knowledge of the ecology of the Arabian subspecies. Field surveys should firstly focus on population assessment using the camera trapping technique, which appears to be efficient for leopard surveys in Oman. A second step would be to gather information on the number of individuals per sub-population, to determine range use pattern, home range size, activity pattern, habitat requirements, food requirement (prey species), prey availability, relation predator-prey (such as seasonal movements of ibex and gazelles), competition with other predators (caracal, hyena, wolf), conflict with man.

The proper organization of ecological studies would require the full time appointment of at least one PhD student and/or one researcher and a team of field workers with appropriate funding. Important material means should be available to capture and mark wild animals, and conduct radio-tracking or satellite-tracking studies.

To assure long term survival of the wild populations, population viability analysis should be developed to project populations trends with regularly updated data. This would require:

- an understanding of population dynamics;
- study of dispersal rates and quantify movements between populations;



Fig. 6. Leopard's accommodation in the National Wildlife Research Center – Taif, Saudi Arabia (Photo O. Coupey - NWRC, Taif).

- establishment of long-term monitoring with regular periodic surveys (camera trapping);
- assessment of the gene pool by determining genetic identity from blood and scats (DNA microsatellite mapping).

Socio-economic survey

Socio-economic surveys should assess the effect of leopard predation on livestock (number, species killed and economic cost). Compensation measures for kills of domestic animals should be examined, including solutions for proper identification of the causes of death, and for regular fundraising. Human activities in areas used by leopards, need to be described and quantified to modify the conservation plan.

In situ conservation: Protected Areas

Presence of leopards has been reported in only 2 protected areas, both too small to provide any efficient conservation. New key sites have to be identified and secured through establishment of new protected areas in order to assure viability of the last remaining populations. In the actual state of knowledge, we suggest concentrating conservation efforts on the Biljurashi escarpment, between Al Mikwah and Nimrah, from where the most recent records come, as well as Al Atifah area. Several areas (Wadi Aleb, Jibal Bani Yub, north of Badr, Himat Al Fiqrah) already mentioned

as potential sites for leopard conservation (Child & Grainger 1990), should receive particular attention. Minimum critical size and management plans of Protected Areas have to be carefully considered (see Judas *et al.* 2004 for suggestions). As a further step, potential sites for reintroduction, population reinforcement or translocation would have to be identified, if requested, according to the updated results of population status and distribution.

Ex situ conservation: Captive breeding

Captive breeding facilities in NWRC are currently too small to develop a captive breeding and reintroduction programme. New facilities with a large enclosed area are on the way to being implemented. This would allow us to capture remaining individuals for captive breeding and release purposes, if the population is thought not to be no longer viable. A structure or company able to help the NWRC has to be identified (Espie & Bertschinger 2001) and financial funding should be planned to assure the construction of facilities and the functioning of the project (food, veterinary care, researchers, technicians and labourers, staff training, materials). The captive breeding structure can generate some funds, through opening to visitors or by stimulating private sponsors. Captive breeding could also contribute to development of a genetic fingerprinting method for individual identification and



Fig. 7. Arabian leopard Rashid from the National Wildlife Research Centre (NWRC) in Ta'if, Saudi Arabia on breeding loan in the Breeding Centre for Endangered Arabian Wildlife, Sharjah, UAE (Photo J. Edmonds).

scat analysis of hairs for prey identification, to collect and freeze semen for genetic management of captive animals and conservation of genetic diversity, and to improve knowledge of reproduction, physiology, pathology, behaviour in captivity (Sutherland 1998, Joubert 2001).

Political support

Numerous efforts should be made at the political level to reinforce legislation, to create mechanisms of policy implementation and fund raising. All national institutions involved in land management or whose activities affect leopard conservation, have to be approached, cooperative actions reinforced and information exchange increased. Leopard conservation in Saudi Arabia also requires the support of international institutions or NGOs to intercede with local communities.

Public awareness

Public awareness programs have to be initiated and developed in "leopard areas", to involve local people in a clearly defined strategy. Brochures mentioning the high conservation profile of the Arabian leopard, its CITES position, hunting laws in force and penalties, could be distributed in schools, police stations, and shops. Development of the captive

breeding programme could be used to make the Saudi public aware of leopard conservation, and to collect funds.

Management plan & long term conservation strategy

A management plan should include benefits for local communities with replacement of activities that disrupt ecological processes by others that preserve habitats or restore them. Trade-off between social, economic and ecological interests is necessary. Protected Area management should involve local people by creating a consultative committee of local representatives for bottom-up regulation in harmony with top-down ones. The socio-economic importance of biodiversity has to be assessed to define a national programme of sustainable rural development (Child 2003). This should include maintenance of ecological productivity, a principle underlying all sustainable management plans. Efficiency of implemented measures has to be controlled (adaptive management).

Animals in captivity

Seven leopards have been acquired by the NWRC during the last 7 years (Table 1). Four are currently kept in NWRC, and three have been loaned to BCEAW in Sharjah (Fig. 7).

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Appendix 1. Leopard records in the last 5 years (1998 – 2003)

Site	Latitude	Longitude	References	Year	Reliability	Information type
Al Atifa	19.317	42.033	Paillat & Khoja 1998	1998	u	reported
Malgocta near Tanumah	18.954	42.156	Rachid Ajaj Pers. comm.	1998	u	reported
Bada	26.850	36.900	Budd 1999	1999	u	reported
Jibal Shada	19.800	41.333	Budd 1999	1999	c	livestock killed
Bada	26.850	36.900	Budd 1999	1999	u	reported
Bada	26.850	36.900	Budd 1999	1999	u	reported
Jibal Shada	19.800	41.333	Budd 1999	1999	u	reported
Jibal Ward	26.483	37.100	Joubert 2001	1999	u	reported
Al Atifa	19.317	42.033	Lagrot and Lagrot 1999	1999	c	tracks & signs
Al Atifa	19.317	42.033	Lagrot and Lagrot 1999	1999	u	reported
Samta	16.592	42.940	Paillat comm pers.	1999	c	killed
Jibal Nis	20.033	41.250	Joubert 2001	2000	u	reported
Wadi Khatayn	19.705	41.671	J. Judas	2002	c	tracks & signs
Marbble village	19.924	41.437	J. Judas	2002	u	reported
Tallan, wadi dava	17.390	43.170	Rachid Ajaj Pers. comm.	2002	u	reported
near Jibal Shada	19.683	41.433	Rachid Ajaj Pers. comm.	2002	u	reported
Jibal Nahr	26.042	38.141	Rachid Ajaj Pers. comm.	2002	u	reported
Wargan	22.584	39.668	Rachid Ajaj Pers. comm.	2002	u	reported
Jibal Kabkab	21.418	40.108	Rachid Ajaj Pers. comm.	2003	u	reported

u: unconfirmed record, c: confirmed record