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EXPEDITION REPORT

Expedition dates: 13 - 8 February 2008
Report published: November 2008

Status of the Arabian leopard (*Panthera pardus nimr*) in Dhofar, Sultanate of Oman.

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Author:
Marcelo Mazzolli
Projeto Puma

Matthias Hammer (editor)
Biosphere Expeditions

Abstract

The Arabian leopard *Panthera pardus nimr* has disappeared from much of its former range on the Arabian Peninsula so that today populations are limited to the most remote areas. Previous Biosphere Expeditions studies in 2006 and 2007 have suggested the existence of a remnant population on the Omani side of the Musandam peninsula. The Musandam peninsula is located south of the Strait of Hormus at the entrance of the Arabian Gulf on the northeastern tip of the Arabian Peninsula and as such forms an exclave of Oman bordered by the United Arab Emirates. The leopard population on the peninsula was thought to be very small and the lack of evidence of two important prey species, namely the Arabian tahr *Hemitragus jayakari* and gazelle *Gazella gazella cora*, and of the other top carnivore, the Arabian wolf *Canis lupus arabs*, provided a clear picture of the conditions under which leopard numbers have declined. The killing of animals, habitat degradation and livestock and human disturbance were the main causes of decline.

Following on from this work, this report details the surveys conducted by Biosphere Expeditions in January and February 2008 in the area limited by the wadis Amat and Uyun, located in northwest Dhofar in southern Oman. The location is on the Arabian leopard's northern distribution boundary in the Dhofar mountains, currently the last stronghold of the leopard in Oman. It is also where intensive studies on wild leopards are ongoing under the auspices of the Office for Conservation for the Environment, Diwan of Royal Court, including camera trapping and radio tracking of leopards. There was, however, a gap in the knowledge on the status of the leopard and its prey in the study area, and the mission of Biosphere Expeditions was to remove that information gap.

The expedition surveyed the wadi floors, ledges, and ridges for signs of Arabian leopard, its prey species, and other wildlife that could provide information on habitat quality. Three camera traps were set by the end of the expedition and are still in place. Nine potential signs of leopards in the form of scats were collected resulting in a frequency of 0.067 scats per kilometre, but no recent evidence of the Arabian leopard's presence was recorded. The habitat of the study area was, however, found to be in good condition. It had a rich assemblage of the main prey species and harboured a number of threatened large mammalian fauna. Signs of livestock overgrazing, so prevalent on the Musandam peninsula, were not found. The Nubian ibex *Capra ibex nubiana*, mountain gazelle *Gazella gazella cora*, and rock hyrax *Procavia capensis* were present in more than half of the fifty-one 2 x 2 km cells surveyed. Multiple records of hyaena *Hyaena hyaena sultana*, a predator with large resource requirements, corroborated the good quality of the habitat, as did the presence of caracal *Caracal caracal schmitzi* and Arabian wolf *Canis lupus arabs*. Interviews indicated that leopards were once encountered more frequently by herders and this finding supports the species' loss of range mentioned in the literature and is compatible with the expected higher vulnerability of species' along its distributional edge.

In conclusion the report provides a number of recommendations regarding future research, capacity building, local community involvement, networking, information dissemination and compensation schemes which should be considered in order to provide the Arabian leopard with a chance to not only survive in Oman but to also re-colonise areas of its historical distribution range.

ملخص

انقرض النمر العربي من معظم مناطق عيشه في شبه الجزيرة العربية، وينحصر وجوده حاليًا في الأماكن النائية. وقد أشارت دراسات بيوسفير اكسبيديشنز السابقة في عامي 2006 و2007م إلى بقاء أعداد منها في الجهة العمانية من شبه جزيرة مسندم الواقعة جنوب مضيق هرمز عند المدخل إلى الخليج العربي على رأس شمال شرق شبه الجزيرة العربية. ومسندم محافظة عمانية معزولة ومحاطة بحدود دولة الإمارات العربية المتحدة. وتشير الدلائل إلى وجود أعداد قليلة جداً من النمور في جبال مسندم، كما لم يتم الحصول على أدلة على وجود أهم فرائسه وهما الطهر العربي والغزال بالإضافة إلى عدم وجود حيوانات مفترسة أخرى كالذئب العربي مما يعطي صورة واضحة للأحوال التي تناقصت فيها أعداد النمور. وتعود الأسباب الرئيسة لهذا التناقص إلى صيد الحيوانات ومنافسة قطعان الماشية لمناطق عيشها والاستيطان البشري.

ومتابعة لهذه الدراسات ، يبين هذا التقرير أعمال المسح التي قامت بها بيوسفير أكسبيديشنز في شهري يناير وفبراير 2008م في المنطقة الواقعة بين وادي عمات ووادي عيون في شمال غرب محافظة ظفار في جنوب السلطنة. ويمثل هذا الموقع الحدود الشمالية لمنطقة عيش النمور في جبال ظفار والتي تمثل الموطن الأخير للنمور في السلطنة. كما أنه المكان الذي تجري فيه دراسات مكثفة على النمور برعاية مكتب حفظ البيئة بديوان البلاط السلطاني والذي تم فيه استخدام الكاميرات الفخية وتتبع آثار النمور لاسلكياً عبر الأقمار الاصطناعية. وتساعد حملات بيوسفير أكسبيديشنز في إجراء المسوحات الميدانية للحصول على المعلومات حول وضع النمر وفرائسه.

وقد قامت الحملة بمسح ميدانيا للأودية والمنحدرات والسلاسل الجبلية في المنطقة بحثاً عن مؤشرات للنمر العربي وفرائسه وأحياء برية أخرى والتي قد تساعد في الكشف عن جودة الموائل . وبنهاية الحملة تم وضع ثلاثة آلات تصوير فخية والتي لا تزال منصوبة بمواقعها. كما تم جمع تسع عينات براز محتملة للنمر تم العثور عليها على مسافات تقارب 0,067كم بين كل عينة وأخرى دون تسجيل دلائل حديثة على تواجد النمر العربي. أما موائل المنطقة المدروسة فكانت في حالة جيدة إذ احتوت على الفرائس الرئيسة بما فيها الثدييات الكبيرة, حيث آثار الرعي الجائر التي كانت واضحة في مسندم لم تكن موجودة. وأظهر المسح أن الوعل النوبي والغزال الجبلي والوبر الصخري لزالت موجودة في أكثر من نصف المساحات الممسوحة على شكل مربعات عددها 51 ومساحة كل منها 2×2 كم. كما أن التسجيلات المتعددة للضبع (أحد الحيوانات المفترسة الكبيرة) تؤيد جودة الموائل بالإضافة إلى وجود الوشق والذئب العربي. كذلك أشارت المقابلات إلى أن مواجهات الرعاة مع النمر كانت أكثر في الماضي مما يدعم ما نشر عن فقدان هذا الكائن لنطاق حركته وتعرضه للمخاطر في المناطق التي يجوبها.

وفي خاتمة التقرير قائمة بالتوصيات الأساسية في مجالات البحوث وبناء القدرات ومشاركة السكان المحليين وشبكات التواصل ونشر الوعي وبرامج التعويض التي ينبغي أتباعها لإتاحة الفرصة للنمر العربي للبقاء ليس في عُمان فحسب ولكن ليعود للعيش في المناطق التي كانت مرتعًا له في الماضي والموضحة في التقرير .

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1. Expedition Review

M. Hammer (editor)
Biosphere Expeditions

Marcelo Mazzolli
Projeto Puma

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Expeditions are open to all and there are no special skills (biological or otherwise) required to join. Expedition team members are people from all walks of life and of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

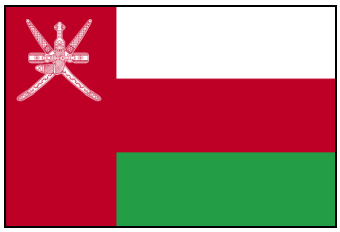
This expedition report deals with an expedition to the Nejd area of Dhofar in southern Oman that ran from 13 January – 8 February 2008. The expedition assisted local scientists from the Office for Conservation of the Environment, Diwan of Royal Court (OCE) in ascertaining the status of the Arabian leopard in parts of the remote and mountainous Dhofar region of Oman. The expedition searched for leopard signs and attempted to camera trap animals in potentially prime leopard habitat, completed a wildlife inventory of the area, strengthened ties with local people and investigated historical records of leopard presence.

The Arabian leopard is a flagship species for Oman's mountain habitats. It once occurred throughout the mountainous regions of Oman, Yemen, Saudi Arabia, the United Arab Emirates, Palestine and Jordan. However, by the 1990s the leopard became locally extinct in most areas of the Arabian Peninsula and if viable populations remain, they are most likely to be found in the high mountains of Oman and Yemen.

The Arabian leopard is the largest surviving cat species of Arabia. Listed as "critically endangered" in the IUCN List of Threatened Species, it is on Appendix 1 of the Convention on International Trade in Endangered Species (CITES), which strictly regulates international trade in listed animals.

In 1997 the OCE began a survey of the Arabian leopard in Jabal Samhan Nature Reserve in Dhofar, where a strong population has been shown to exist. However, the one other area of Oman where the leopard may survive, namely the Musandam peninsula, had not been surveyed until Biosphere Expeditions conducted a study in 2006 and 2007. As the natural prey species in the Musandam region are likely to be at very low numbers, leopards often have to turn to domestic stock, mainly goats, for food. The socio-economic interaction with local people and herders were also investigated during the expedition. With the current project Biosphere Expeditions is helping to fill another gap in knowledge on the distribution of the Arabian leopard and its prey, this time in the western Dhofar moutains between wadis Amat and Uyun, in a region known as Nejd.

1.2. Research Area



Flag and location of Oman and study site.

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations is at Google Maps.

Oman is the third largest country in the Arabian Peninsula, with a population of 2.3 million. It maintained its independency throughout its history except for brief occupations by Persians and the Portuguese (McBrierty & Al Zubair 2004). The Dhofar mountains in southern Oman run eastward from the Republic of Yemen to the southernmost eastern tip of Oman. Salalah is the region's biggest town and of commercial importance thanks to its port. The local economy also benefits from fishing and Frankincense harvesting. In areas along the coastline with good irrigation or rainfalls, fruits such as dates, coconut and bananas are produced, and cattle are farmed.

Geology

Oman is located in the Arabian plate, which includes the Arabian Peninsula, the shallow Arabian Gulf and the Zagros mountains of Iran. For most of its history, it has been part of the larger Afro-Arabian continent until 25-30 million years ago when the Red Sea began to open and separate the Arabian and African plate. Presently the plate is moving at a rate of 2 to 3 cm per year away from the African plate (Vine 1995).

The mountains of Dhofar in the south and the al Hajar mountains in the north have different origins (Clarke & Glennie 2006). Those of Dhofar were uplifted as part of the process of creating the Red Sea and Gulf of Aden, which began about 30 million years ago, whereas the origins of Al Hajar can be traced back 300 million years (Clarke & Glennie 2006).

Natural history

Dromedaries *Camelus dromedarius*, known in the area simply as camels, are found just about everywhere. Although it has been suggested that they never existed in the wild in Arabia, there is some evidence that they were probably once found as a wild animal throughout the Arabian region (Nowak 1999).

Other than dromedaries, Grobler (no year) mentions the following animals, named in accordance with Hellyer & Aspinall (2005).

Common name	Latin name	Main distribution in Oman			
		North coast	South coast	Central coast	Desert of Empty Quarter
Arabian tahr	*Hemitragus jayakari*	X			
Small spotted genet	*Genetta felina*		X		
Honey badger	*Mellivora capensis*		X		
Rock hyrax	*Procavia capensis*		X		
Nubian ibex	*Capra ibex nubiana*		X	X	
Porcupine	*Hystrica indica*		X	X	
Ethiopian hedgehog	*Paraechinus aethiopicus*	X	X		
Brandt's hedgehog	*P. hypomelas*	?	?	?	
Wolf	*Canis lupus arabs*	X	X		
Blanford's fox	*Vulpes cana*	X	X		
White-tailed mongoose	*Ichneumia albicauda albicauda*	X	X		
Striped hyena	*Hyaena hyaena sultana*	X	X		
Arabian leopard	*Panthera pardus nimr*	X	X		
Gordon's wild cat	*Felis silvestris gordoni*	X	X	X	
Caracal	*Caracal caracal schmitzi*	X	X	X	
Arabian red fox	*Vulpes vulpes arabica*	X	X	X	X
Rüppell's sand fox	*Vulpes rüppelli*			X	X
Arabian oryx*	*Oryx leucoryx*			X	X
Arabian or mountain gazelle	*Gazella gazelle cora*	X	X	X	X
Cape hare	*Lepus capensis*	X	X	X	X
Sand gazelle	*Gazella subgutturosa marica*			X	X
Sand cat**	*Felis margarita harrisoni*	?	?	X	X

* Today confined to a single reserve.

** Distribution based on Nowell & Jackson (1996).

Birds

At present 486 species of birds have been recorded for Oman. Many are seen only during migration or are winter or summer visitors. Perhaps for this reason, 150 species are vagrants, which have been seen fewer than ten times (Eriksen & Eriksen 2005).

1.3. Dates

The expedition ran over a period of four weeks divided into two two-week slots, each composed of a team of international research assistants, guides, support personnel and an expedition leader. Expedition slot dates were

13 – 25 January
27 January – 8 February

Winter dates away from the extreme heat of summer were chosen for best weather and working conditions.

1.4. Local Conditions & Support

Expedition base

The expedition base consisted of a Bedu style tent camp (of a Bedu mess tent and more modern one and two person dome tents for sleeping in). An expedition cook complemented the team and vegetarians and other special diets could be catered for. There was very limited electricity at the field base. The circuit was a car battery based 12V DC cigarette lighter plug and socket system.

Field communications

There was an (emergency) satellite telephone at base. Mobile phones did not work in and around camp and around much of the study site. In the field, two-way radios were used for communication between research teams wherever possible. The expedition leader sent an expedition diary to the Biosphere Expeditions HQ every few days (see appendix 4) and this diary appeared on the Biosphere Expeditions website at www.biosphere-expeditions.org/diaries for friends and family to access.

Transport and vehicles

Team members made their own way to the assembly point in Muscat. From there the team boarded a one hour flight to Salalah and then drove about four hours to base in the expedition Land Rovers. From the assembly point onwards and back to the assembly point all transport and vehicles was provided for the expedition team, for expedition support and emergency evacuations. Courtesy of Land Rover Middle East & Africa in Dubai, the expedition had the use of three LR3s and exceptional support from Land Rover Middle East & Africa in Dubai and the local dealers MHD in Muscat and Salalah throughout.

Team members wishing to drive the Land Rovers had to be older than 21, have a full clean driving licence and a new style EU or equivalent credit card sized driving licence document. Off-road driving and safety training was part of the expedition.

Medical support & insurance

The expedition leader was a trained first aider, and the expedition carried a comprehensive medical kit. The standard of medical care in Oman is high and further medical support was available at government health posts in rural areas and a government hospital in Salalah.

All team members were required to carry adequate travel insurance covering emergency medical evacuation and repatriation. Emergency evacuation procedures were in place. There were no serious medical incidents. Some cases of blisters and sore legs after long surveys occurred. One person suffered from a sprained ankle due to a fall. Furthermore there was one case of toothache and some minor stomach problems because of the change of diet.

1.5. Expedition Scientists

The expedition scientists comprise a team from the Office for Conservation of the Environment based in Muscat. The team is headed by Dr Andrew Spalton and assisted by field assistants Hadi al Hikmani and Khalid al Hikmani.

Andrew Spalton came to Oman in 1987 to work on the reintroduction of the Arabian oryx. After six years at the project field headquarters in central Oman he left for Aberdeen (Scotland) to complete his PhD on the ecology of the oryx. Returning to Oman in 1995, Andrew took up a new post in Muscat. While continuing to help oversee the oryx project, he undertook new work with the Arabian leopard and Arabian tahr. He set up the Arabian Leopard Survey which collected the first information on the ecology of the highly endangered Arabian leopards. Using camera traps and later satellite collaring, Andrew and his team have mapped the occurrence and range of the Arabian leopard in southern Oman. Andrew now works as Adviser for Conservation of the Environment and oversees a team of scientists and rangers working on the Arabian oryx project, Arabian tahr project and the Arabian Leopard Survey. His other interests in Oman include whale watching, diving, trekking and camping in the interior.

The expedition's field scientist was Dr. Marcelo Mazzolli. Born in Brazil, he graduated in Biology in 1992, with a master's degree from the University of Durham, UK. His Ph.D. in ecology, obtained in Brazil, was on the effects of human occupation on the extinction of large mammals. He has devoted his career to the study of large mammals, particularly the puma and jaguar, but has had many other outdoors experiences. He was a professional jungle guide in the Amazon forest in 1986 at age 21. He has attended many national and international workshops, and published relevant articles. His studies have made his work well known, and early in his career he was invited to be a member of the International Union for Conservation of Nature (IUCN) Cat Specialist Group with one of his projects listed as a priority in the World Wide Cat Action Plan. He has travelled extensively, living in the United States and Peru, and has surveyed lions in Botswana.

Hadi Musalam al Hikmani, the expedition's field guide, was born near Jabal Samhan, Dhofar. He joined the Office for Conservation of the Environment in 2001, working first as a volunteer and then since 2002 as a full-time field assistant. He quickly became the local expert on Arabian leopard and is today responsible for the field work of the Arabian Leopard Survey. He has also worked on the sand cat and joined expeditions to India where work is ongoing on the snow leopard.

Khalid Mohammed al Hikmani, assistant to Hadi Musalam al Hikmani, was born in the northern mountains of Jabal Samham, Dhofar. He joined the Office for Conservation of the Environment in 2007, working first as a volunteer and then since 2004 working full time.

1.6. Expedition Leader

This expedition was led by Peter Schütte. Peter was born in Germany. He studied geography and cartography at the University of Bremen (Germany) and Göteborg Universitet (Sweden) and geoinformatics in Salzburg (Austria). He has worked on several mapping and remote sensing projects all over the world. In 2004 and 2005 Peter was involved in wildlife conservation projects in Namibia, where he joined Biosphere Expeditions as member of the team of local scientists and was promptly bitten by the wildlife expeditions bug. He has travelled in Scandinavia, Iceland, southern Africa, North America and central Asia. Peter holds First Aid and Off-Road driving certificates and has worked in Namibia, Altai and Oman for Biosphere Expeditions.

1.7. Expedition Team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of all ages, nationalities and backgrounds. They were (with countries of residence):

13 – 25 January 2008

Sigrid Aschenbrenner (Germany), Roger Bunce (UK), Mark Doherty (UK), Guy Kelly (Australia), Robin Little (UK), Christopher Lucy (USA), Marc van Reenen (UAE).

Shell Oman, who kindly supported this expedition with fuel and in-kind support, also sent four of their staff on this first expedition slot as a trial. Their local knowledge, language skills and enthusiasm were a great asset to the expedition and it is hoped that Shell will send more staff in subsequent years on all slots. Shell staff were Ali Aidid, Abdulaziz Al-Abri, Mohammed Al-Farsi and Aziz Al-Rashdi. Also on this slot were guest scientist Gareth Whittington-Jones (South Africa), journalist Klaus Haselböck (Austria), Biosphere Expeditions Vice-President Australia Kate Curnow (Australia) and Biosphere Expeditions Managing Director Matthias Hammer (Germany).

27 January – 8 February 2008

Mark Adlington (UK), Neil Bowman (UK), Guy Kelly (Australia), Neil Mackay (UK), Katharina Mahofsky (Austria), Carole Mahoney (UK), Nicole Munzert (Sweden), Roland Scheiber (Austria), Heike Schlegel (Germany), Felix Schueler (Germany), Frank Stoll (Germany). Also on this slot were journalist Jeta Pillai (Oman).

Throughout the expedition

Biosphere Expeditions trainee expedition leader Ronald Seipold (Germany), rangers Rames Mohammed ali Zabnoot and Bakait Al Shashaay from the Ministry of Environment & Climate Affairs and cook Mohammed Ibrahim Finally there was Mabrook Zabnoot who supported the expedition by providing camels and bringing in water and fuel on his truck.

1.8. Expedition Budget

Each team member paid towards expedition costs a contribution of £1225 per person per two week slot. The contribution covered accommodation and meals, supervision and induction, special non-personal equipment, all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses like telephone bills, souvenirs etc., as well as visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	£
Expedition contributions	25,361
Expenditure	
Base camp and food includes all board & lodging, base camp equipment	3,478
Transport includes fuel & oils, taxis	2,998
Equipment and hardware includes research materials & gear, etc. purchased in UK, Dubai & Oman	2,765
Biosphere Expeditions staff includes salaries, travel and expenses to Dubai & Oman	3,622
Local staff includes cooks, helpers, guides and other locally staffed services	1,877
Administration includes registration fees, visas, sundries etc	1,031
Team recruitment Oman as estimated % of PR costs for Biosphere Expeditions	3,243
Income – Expenditure	**6,347**
Total percentage spent directly on project	**75%**

1.9. Acknowledgements

This study was conducted by Biosphere Expeditions which runs wildlife conservation expeditions all over the globe. Without our expedition team members, who are listed above and who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The support team and staff, also mentioned above, were central to making it all work on the ground. Thank you to all of you and the ones we have not managed to mention by name (you know who you are) for making it all come true.

Biosphere Expeditions would also like to thank Land Rover Middle East & Africa and MHD, local dealers in Muscat and Salalah, for outstanding support in-country in terms of vehicles, support and press conferences, especially from Rob Hales, Wouter Kingma and Marcelle Safar, who all helped well above the call of duty. We would also like to thank Leanne Blanckenberg and her staff from Promoseven in Dubai for organising an excellent press conference and interviews. Thank you also to Shell, and in particular Abdulwahid al Farsi, for their continued and valued support with fuel, logistics and personnel. Further thanks to Motorola, Buff®, Cotswold Outdoor, Globetrotter Ausrüstung and Gerald Arnhold for their sponsorship. Thank you to Roger Bunce and Neil Bowman for working on the bird list. For their help and support in-country we thank the Royal Oman Police, the Royal Air Force of Oman, the Office of the Governor and State of Dhofar and Musandam, the Ministry of Environment & Climate Affairs and the local people who helped with the survey.

1.10. Further Information & Enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Enquires should be addressed to Biosphere Expeditions at the address given below.

2. Arabian Leopard & Prey Survey

Marcelo Mazzolli
Projeto Puma

M. Hammer (editor)
Biosphere Expeditions

2.1. Introduction

It is thought that the total wild population of Arabian leopard *Panthera pardus nimr*, the leopard subspecies inhabiting the Arabian Peninsula, has been reduced to fewer than 250 individuals (Breitenmoser et al. 2006). Accordingly the Arabian leopard is placed in the highest category of threat of Critically Endangered by the World Conservation Union (IUCN) Red Data List (2004), and in the highest level of concern regarding its trade (Appendix 1) by the Convention on International Trade in Endangered Species (CITES).

The Arabian leopard has lost most of its distribution due to habitat modification, direct persecution and prey decline. Qarqaz & Abu Baker (2006) report the use in Jordan of traps made of stone to catch leopards as recently as 1999 and the species has been poached and even commercialised alive in part of its current range. During a three year survey in Jabal Samhan Nature Reserve in eastern Dhofar, Spalton et al. (2006a) observed that goats and young camels were taken by leopards on six occasions and that one leopard was shot in reprisal.

Although there is some debate on the exact extent of the Arabian leopard's current distribution, it is clear that the species has lost most of its historical distribution (Breitenmoser & Breitenmoser- Würsten, 2006). In Saudi Arabia, for example, it is believed to have lost 90% of its former range (Judas et al. 2006), whilst in Oman it is reported no longer to exist in a great extent of its northern range, namely the entire Hajar mountains (Anon 1997) that run alongside the northern coast of Oman. Although Biosphere Expeditions has recently found evidence of leopards on the Musandam peninsula (Hammer et al. 2007), it was also found that the Arabian tahr *Hemitragus jayakari* and mountain gazelle *Gazella gazelle cora*, the leopard's main natural prey in the area, were no longer present or at very low numbers. Stuart and Stuart (2007) corroborated this by not finding evidence of continued occurrence of any wild ungulate in southern Musandam and adjoining areas of United Arab Emirates (UAE). Instead, they found that leopards were feeding mainly on exotic goats and Cape hare, whilst caracals preyed on goats and sheep.

Actions to conserve the leopard have started in several countries of its historical range. The Emirates in 1993 saw the formation of a non-governmental organization, the Arabian Leopard Trust (ALT), which conducted a survey in parts of the UAE and confirmed the presence of the Arabian leopard. After that, the Sharjah Desert Park had facilities built to start a breeding programme of Arabian leopards. Cooperation from Oman, Yemen, Saudi Arabia, and the UAE formed the Arabian Leopard Working Group in 2001, concerned solely with the management of the leopard in captivity (Budd & Ashley-Edmonds 2005). Although Oman also has a captive centre for Arabian leopards (Bait al Barakah Breeding Centre for Omani Mammals), it has focused on the conservation of wild populations, particularly in the southern region of Dhofar..

The Dhofar mountains are considered the best habitat for the Arabian leopard in the country, and it is also where the only large protected area within the range of known Arabian leopard distribution is located, namely the 4,500 square km Jabal Samhan Nature Reserve (Spalton et al. 2006a). Sizeable protected areas have also been established in Jordan, encompassing a total of 1,300 square km, but the status of the species in the country is unknown, as the last confirmed record dates back to 1987 (Qarqaz & Baker 2006). The prey population in Dhofar is also probably the healthiest in the Arabian Peninsula (Stuart & Stuart 2007) and although leopards sometimes kill livestock, the majority of its diet is composed of native species, as shown by Muir-Wrights' (1999) diet study, which lacked evidence of domestic stock in 74 leopard scats found in Dhofar.

Figure 2.1a. Former and current (since 1990) distribution information for the leopard on the Arabian Peninsula. Confirmed records include confirmed evidence such as dead specimens (with body, skin, etc. available), camera trap pictures and genetic analyses. Probable records include those confirmed by any evidence or by a trained person. Possible records include all non-confirmed or not confirmable records including hearsay and direct observations by untrained persons. From Spalton & Hikmani (2006).

It is also in Oman, and mainly in the Dhofar mountains, where the most extensive study on Arabian leopard was conducted by the Office for Conservation of the Environment, Diwan of Royal Court, using amongst other tools camera traps and radio telemetry. This study is still ongoing.

Much of the expedition work of the current study focused on looking for animal sign so that data could be compared to those previously recorded for the species. Previous work in this area has shown that the frequencies of scrapes and scats of Arabian leopard found in the Jebal Samham Nature Reserve is very similar to that given by Jackson and Hunters' (1996) study on snow leopards and as such may be used as a basis for comparison. The frequencies given for the Jebal Samham Nature Reserve were 94 scats and scrapes over a distance of 200 km, i.e. a rate of 0.47 signs per km (Spalton 2000).

The study area for this expedition, located in the western Dhofar mountains, has only been surveyed once previously and the excessive rains at the time hampered field activities (H.M. Hikmani, personal communication). The area is largely uninhabited and was expected to be good habitat for the Arabian leopard and its prey by Spalton et al. (2006b). It was also known to harbour the critically endangered Nubian ibex *Capra ibex nubiana*, the Arabian gazelle *Gazella gazella cora*, the hyrax *Procavia capensis* and top carnivores such as the Arabian wolf *Canis lupus arabs*, the caracal *Caracal caracal schmitzi*, and the striped hyaena *Hyaena hyaena sultana*.

It is also in Oman, and mainly in the Dhofar mountains, where the most extensive study on Arabian leopard was conducted by the Office for Conservation of the Environment, Diwan of Royal Court, using amongst other tools camera traps and radio telemetry. This study is still ongoing.

2.2. Issues in Arabian Leopard Conservation

The first steps towards building a regional network that may provide the foundations of leopard conservation were taken in 2000 at the first of what was to become an annual CAMP (Conservation Action Management Planning) in the Emirate of Sharjah. Here specialists from most countries within the distribution of the Arabian leopard have met, exchanged their experiences, and declared a commitment witnessed by a world-wide audience of experts. The result of these meetings was published in a 2006 special issue of the Cat News, the information vehicle of the World Conservation Unions' Cat Specialist Group (IUCN/CSG). The unfolding of that meeting in terms of leopard conservation in practice are still to be seen, but the expectations should be high.

In Oman the Arabian Leopard Survey has an eleven year history and in that time has acquired considerable knowledge on the distribution, status and biology of the leopard. The work conducted by the Arabian Leopard Survey team has been acknowledged by the international scientific community, and involved collaboration from several Omani organizations including the Sultan Qaboos University and the Ministries of Environment & Climate Affairs and Tourism, and it is also known among the local communities within the leopard range in Oman. The community awareness about the Arabian Leopard Survey was evident when the current expedition team asked a local person for information about the presence of leopards, who informed us that he was aware that there was an ongoing research programme with camera traps to locate leopards.

The assistance of international volunteers from Biosphere Expeditions since 2006 and more recent ideas to develop similar programmes with other partners demonstrate a commitment to embrace local community-oriented conservation as well as a desire to share the responsibility of leopard conservation with the international community. These are definitive steps to promote conservation, but the work has only just begun.

Further networking and partnerships, commitment, research and good planning are necessary to make the conservation of the Arabian leopard a success story.

2.3. Methods

Study area

The expedition base camp was located in Wadi Amat in the northwestern area of the Dhofar mountains, with the villages of Mudday and Aybut to the west and Uyun to the east.

The study site encompassed an area of roughly 30 x 30 km between Wadis Amat and Uyun (Fig. 2.3a). The Dhofar mountains form a narrow girdle with a maximum width of 23 km that extends for 400 km east to west from the Halaaniyat islands to the Yemen border. The highest peak is 2,500 metres. The monsoon rains fall on a 75 km stretch of mountains and an 8 km wide plain surrounding Salalah.

Figure 2.3a. Dhofar mountains in southern Oman, with study area (black square) between Wadis Amat and Uyun.

Wadi Amat, in contrast to Wadi Uyun, does not receive the annual monsoon rainfall, known locally as *al Khareef*. Instead rain falls sparsely after the annual *al Khareef* monsoon event from the end of June to the end of September. During this period, flash floods may occur and the usually dry wadi beds are often transformed into sizeable streams and the dry slopes into green pastures (Barrault 1999).

Umbrella thorn Acacia *Acacia tortilis* dominated the bottom of the wadis (Fig. 2.3b). This species is also found in East Sahel and Nile Valley, the Horn of Africa, Israel, and Jordan (www.fao.org).

Figure 2.3b. Overview of base camp in the bottom of Wadi Amat and among the Acacia trees. Photo: M.V. Reenen.

As mentioned earlier, the area was thought to be largely uninhabited and was expected to be a good habitat for the Arabian leopard and its prey (Spalton et al. 2006b). Indeed, camels were the only livestock found, grazing freely in the wadis. In Wadi Amat camels belonged to a single person, who periodically came down to bring them fodder and water. Goats were said to be brought to graze in Wadi Amat only when rains were sufficient to turn the landscape green, which does not happen every year. Herders tend their livestock during this time and young goats are often kept in small rock pens (Fig. 2.3c).

Figure 2.3c. Goat pen commonly found on wadi ledges. Photo: M. Adlington.

A preliminary camera trap assessment by local scientists during the year 2004 revealed the presence of wolves and wild cats (Fig. 2.3d) in Wadi Amat, and the leopard approximately 20 km south of the study area (Fig. 2.3e).

Figure 2.3d. Wolf and wildcat camera-trapped in 2004 in Wadi Amat. Photo: Diwan of Royal Court.

Figure 2.3e. The nearest Arabian leopard recorded was an individual camera trapped in 2004 approximately 20 km south of the study area, near Dhofar's southern escarpment. Photo: Diwan of Royal Court.

GIS and mapping

The main reference map used was a topographic map called Uyūn, 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 dated from 1993 and field updates by NSA in 1999. Grid data was in Universal Transverse Mercator projection, covering zones 39 and 40, and datum WGS 84.

A GIF image of the area was imported into the GIS program TrackMaker (www.gpstm.com), a freeware program. A grid of 51 2 x 2 km cells with the main wadis was uploaded into the expedition's GPS units (Garmin GPS60) to aid navigation and correct data collection. 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. Added to this were the 2 x 2 km cells grid system, the expedition base, overnight camp and camera trap locations. Narrow wadis within the sampled grids became fragmented during the editing process and needed to be redrawn (Fig. 2.3f).

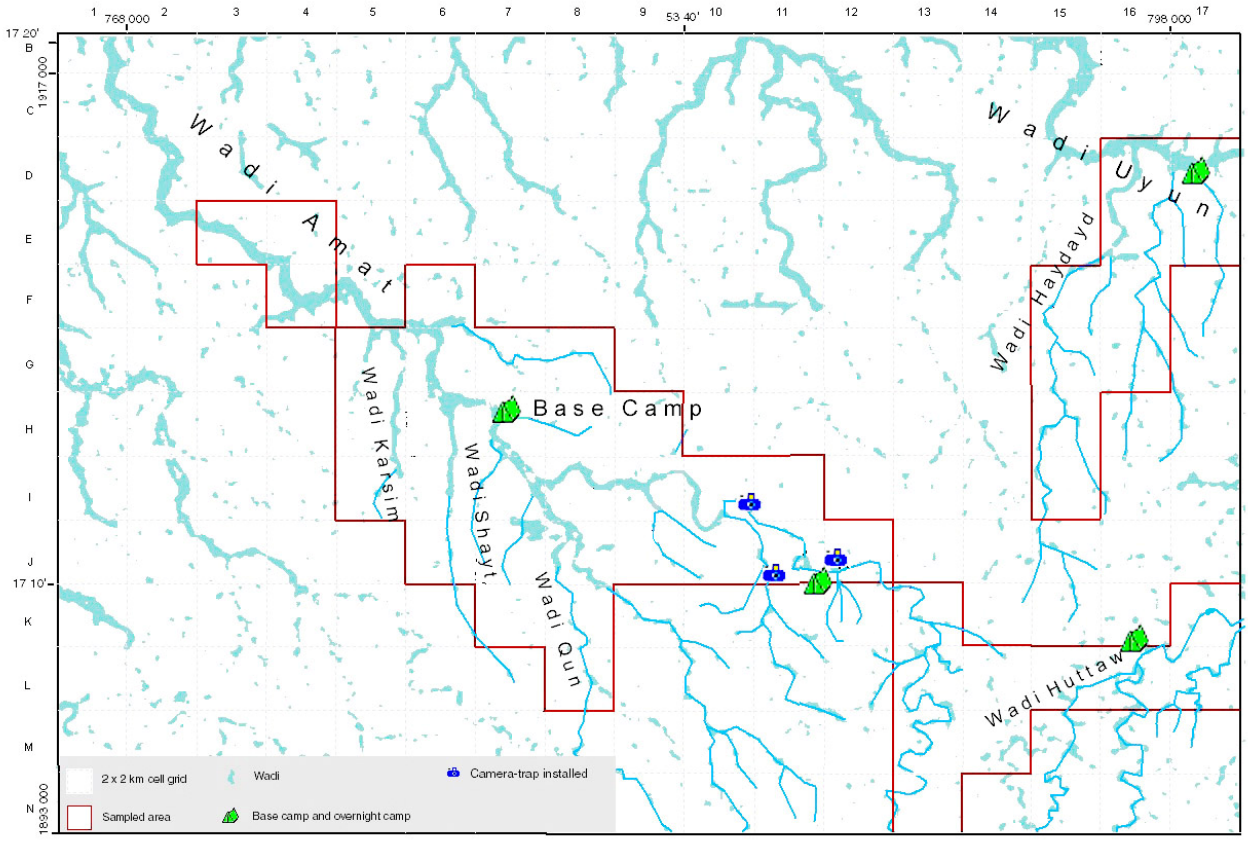


Figure 2.3f. Topographic map modified to show only the wadi system. The 2 x 2 km cells surveyed, expedition base, overnight camp and camera trap locations were added. Coordinates are in UTM datum WGS 84 and Degrees and Minutes. Cell coding is also shown, with numbers in the X axis and letters in the Y axis.

Training

Training included an introduction to leopard conservation issues, the role of Biosphere Expeditions in the Leopard Survey Project and the methods of recording presence of species using GPS and datasheets (Fig. 2.3g). Before team members were split into small groups to perform different tasks, an introductory survey was performed with all of them as part of the training process. During this survey, tracks and scats of known species were shown. To reduce identification errors, team members were instructed to bring scats to base camp whenever they were unable to identify the species, and briefed on how to take photos of tracks for identification later at base.

Figure 2.3g. Training session inside the Bedu tent. Photo: P. Schuette.

Sampling

The 30 x 30 km study area was divided into 2 x 2 km cells and coded by numbers in the X axis and by letters in the Y axis. Except during training or when on overnight surveys with camels, team members were tasked to cover at least two cells during daily survey trips, a sampling practice that provided a good compromise between detailed surveying and inclusion of adequate habitat heterogeneity. Following the presence/absence method of occupancy (MacKenzie et al. 2002), the presence of prey species and large carnivores was recorded using the general location given by a cell code, and once a species or its signs were found in a given cell, it was scored as containing the species. Each sign of leopard had its exact coordinates recorded, thus allowing the team to return to the same exact location if needed, either to check the signs or to install camera traps where judged suitable. The ‘accountancy’ of every leopard sign coupled with the distance surveyed then made possible calculation of rates of sign following the recommendations of the Snow Leopard Information Management System (SLIMS) given by the International Snow Leopard Trust (ISLT) (Jackson & Hunter 1996).

As with any animal able to move, the absence of records of a species in a certain cell does not necessarily mean the species itself is absent. That is why resampling is required to provide a reliable scenario of species' occupancy (McKenzie et al. 2002). During the expedition, however, little resampling was actually done, because signs remained *in situ* for long periods before being erased (unlike in rainy areas) and because multiple simultaneous sampling (groups formed by several team members, spread out in the wadi and over the ledges) compensated for the absence of resampling.

Sampling was designed to provide a scenario of the presence/absence and habitat preferences of leopard, its main prey species, and those whose presence/absence could provide information on habitat integrity. Species that were often recorded, such as gazelle, ibex, hyrax, and hyaena provided sufficient quantitative information for a more complete spatial analysis of presence/absence in the study area. The greater amount of information recorded for these species does not necessarily imply that they were the most abundant or that there were not enough signs of other species. Indeed, issues related to the correct identification of signs of other species may have hampered a broader scope.

Regarding information on habitat preferences, the main landscape features were categorized into wide wadi, narrow wadi, ridge, ledge, slope and escarpment. One feature, wadi bottom, was added to the sheet for future surveys (see appendix 3). Wide wadis were consided to be those of 100 m width or more, such as found in most of the extensions of the main Wadis Amat and Uyun. Secondary wadis (those that branched from the main wadis) were usually where narrow wadis, saddles, and gorges were found.

Sampling was by and large done on foot and usually started at the bottom of the wadi. At least two promising ledges (Fig. 2.3h) (those that were long enough to be used as trails) were also sampled in each cell.

Figure 2.3h. Sampling a ledge on the bottom of an escarpment. Photo: M.V. Reenen. Notice the 'slope' in the bottom right of the photo.

Ridges were reached by climbing up the slopes or by following narrow wadis all the way to their origin. Ridges were sometimes crossed by team members to reach nearby wadis from the top (Fig.2.3h).

Figure 2.3h. Ridge with view to a wadi (top) and top of the ridge, always barren (bottom). Photos: M.V. Reenen.

Teams by and large left in the morning and returned to base in the afternoon when surveying quadrats near base camp. Overnight surveying was required to reach quadrats further away. These overnight surveys were either camel-based (Fig. 2.3i) or Land Rover-based (Fig. 2.3j), meaning that supplies and equipment were carried either by animals or vehicles.

Figure 2.3i. Camel being loaded with water and supplies for overnight survey. Photo: G. Kelly.

Initially overnight survey teams spent one night in the field, but as the number of cells that had already been surveyed near base camp increased, the extent of overnight surveys also increased and up to two nights were spent on the surveys.

In all situations, small teams were assigned for overnight surveys at each location (Fig. 2.3j) so that groups could spread out and survey a large number of cells.

Figure 2.3j. Team overnighting in a remote site. Notice Land Rover in the background. Photo: M.V. Reenen.

Three camera traps (Trailmaster www.trailmaster.com) were set in Wadi Amat during camel overnight surveys at ledges selected by OCE staff (Fig. 2.3k).

Figure 2.3k. Hadi Musalam al Hikmani (left) and Khalid Mohammed al Hikmani from the OCE installing a camera trap in Wadi Amat Photo: M. Mazzolli.

Table 2.3a. Camera trap and camcorder locations and sampling effort. 'End date' refers to the date when last photographs had been taken before this report was published, as cameras were still in the field by the time.

System	Date installed	End date	Cell code	Easting	Northing	Trap nights
Still camera	03/02/08	24/06/08	11i	785786	1903338	142
Still camera	03/02/08	24/06/08	12j	788463	1901499	142
Camcorder	03/02/08	24/06/08	12j	788463	1901499	142
Still camera	04/02/08	24/06/08	11j	786525	1901396	143
Camcorder	04/02/08	24/06/08	11j	786491	1901290	143
Total number of days				**Total trap nights**		**712**

Interviews

Interviews required assignment of a specific group for the task and always included a native Arabic speaker. Interviews were conducted with a structured datasheet (see appendix 2), which was followed loosely and were designed to obtain information on leopard presence, livestock conflicts, and on how the community perceived the presence of leopards and other species.

Quality control procedures

Regular staff meetings were held to discuss data collection, data gathered, results, overnight surveys, logistics, planning and other issues (Fig. 2.3l).

Figure 2.3l. Staff meeting. Photo: M.V. Reenen.

When the survey teams returned from field, data collected was reviewed with staff (Fig. 2.3m) to ensure quality and to stimulate information exchange.

Figure 2.3m. Inspecting animal droppings collected during a survey. Photo: C. Mahoney.

2.4. Results

Wildlife survey

A total of 134 km (in a straight line) covering 51 cells of 2 x 2 km were walked. Old scats likely to be of Arabian leopard were found nine times and were generally associated with narrow wadis (Fig. 2.4a). No fresh tracks or other signs of recent occupancy were found and at the time of writing the camera traps have not produced any pictures of the Arabian leopard.

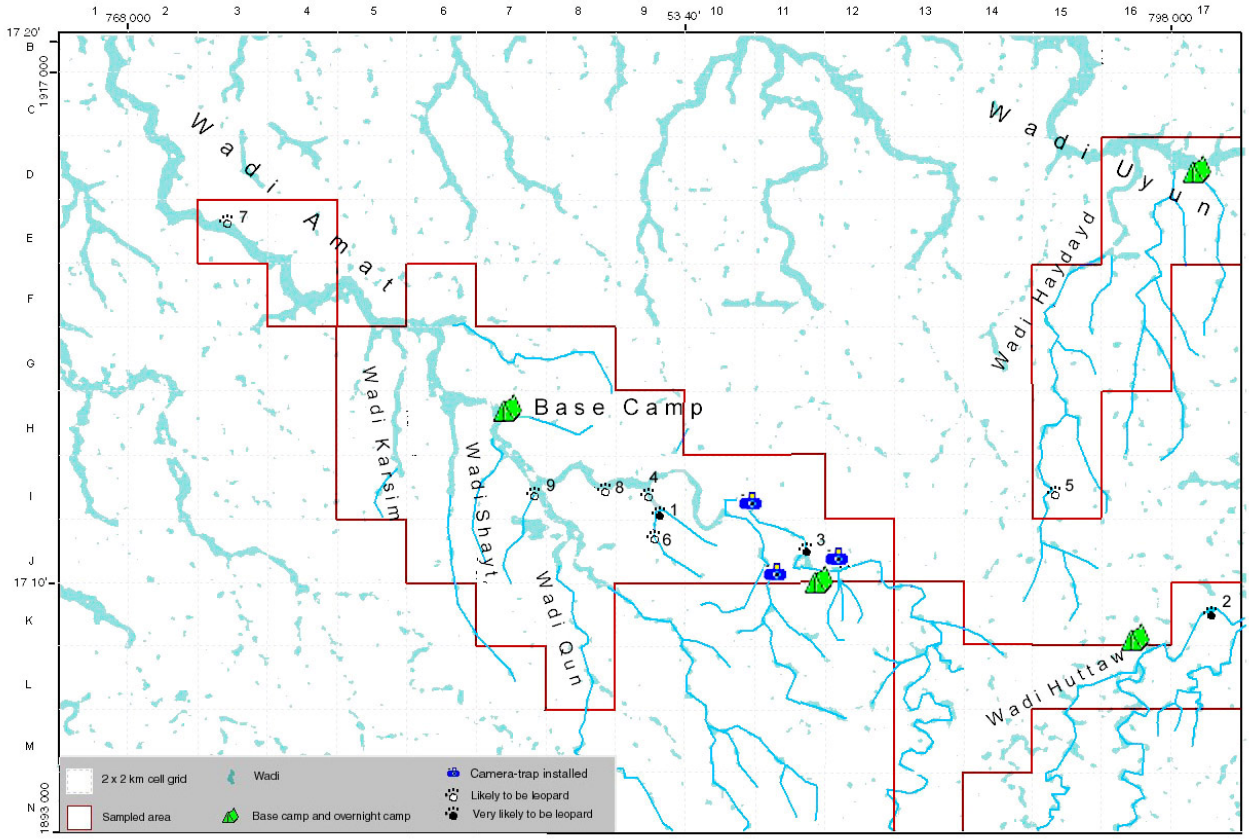


Figure 2.4a. Locations where leopard scats were found in the Wadis Amat, Haydayd, and Huttaw. Numbers refer to the scat bags in which samples were stored for future DNA analysis.

A typical leopard scat is slightly curved and may look somewhat spiralled. It is about 7 cm long and 1.5 cm wide, with segments distributed at every 1.5 cm (Fig. 2.4b). Although some of these characteristics are quite distinctive and may be used to identify leopard scats quite accurately most of the time, there is no 100% accurate way of precise identification in the field (but there is highly accurate laboratory-based DNA fingerprinting), as scats will often assume a variety of shapes and sizes, resembling those of hyaenas and wolves.

Leopard scats were the only indication of the species' presence and the coordinates of their location (Table 2.4a) were recorded so that camera traps can be installed nearby to maximise chances of photographing leopards in 2008. The correct location of every scat was also important for future revision of scat identification with information obtained from DNA analysis. The rate of leopard sign was 0.067 scats per km, much lower than the rate of 0.47 signs per km obtained by Spalton (2000) in Jabal Samhan.

Figure 2.4b. A typical leopard scat, collected in Wadi Amat. Photo: M. Mazzolli.

Table 2.4a. Coordinates of leopard scat.

Bag #	Date	Coordinates		Leopard presence	
		Northing	Easting	Likely	Very likely
01	30/01/08	1903241	0783236		X
02	04/02/08	1900148	0799090		X
03	17/01/08	1902039	0787413		X
04	21/01/08	1903726	0782962	X	
05	31/01/08	1903994	0794832	X	
06	01/02/08	1902415	0783220	X	
07	20/01/08	1912160	0771040	X	
08	29/01/08	1903909	0781621	X	
09	07/02/08	1904021	0779512	X	

Camera-traps and camcorders recorded three species, the wolf, the ibex, and caracals (Fig. 2.4c).

Figure 2.4c. A pair of caracals camera trapped in Wadi Amat. Photo: Diwan of Royal Court.

Although no fresh evidence of leopard was found, there was ample evidence of its most important prey species (Fig. 2.4d). 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 hyaena (23 records in 16 cells), a carnivore with large resource requirements, also suggests that the study site provides suitable habitat for large predators. Since teams were asked to record the presence of a species only once for each cell, a larger number of records per cells reflects the fact that some cells were re-sampled, and that there were also occasions of double recording for the same species in the same cell by multiple teams that happened occasionally to be surveying simultaneously in the same cells.

Other mammal species such as the porcupine (n=6), Cape hare (n=2) and small rodents (n=2) were also found. Tracks of foxes were common, some of them identified as red fox by their (large) size.

The gazelle was one of the species most frequently seen. Data collected show that this species was found in wide wadis 73% of the time (n=17) as opposed to narrow wadis (n=5) (Table 2.4b).

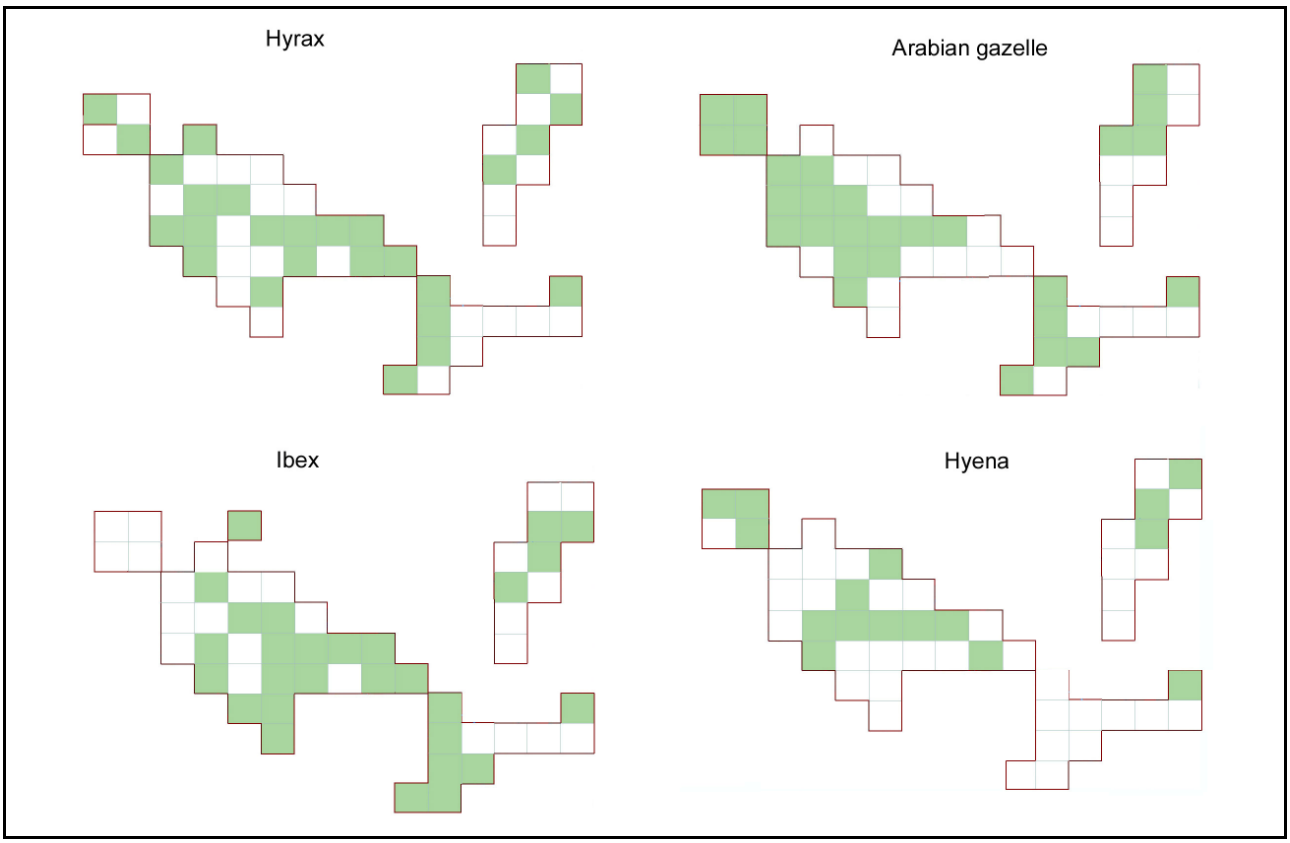


Figure 2.4d. Distribution of species in the 51 2 x 2 km cells of the study area.

Table 2.4b. Distribution of records of most commonly found mammals according to habitat.

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

Gazelles were also found on the ridges (Fig. 2.4e) and climbing up a slope, an indication that they must travel between the bottom of the wadis and the top ridges. There was, however, little evidence of gazelles on the slopes and ledges sampled, suggesting that the journey from the bottom of the wadi to the ridges and back down again is made quickly.

Figure 2.4e. Gazelle in the stony plains of Wadi Uyun's top ridges (left). Photo: M. Adlington.
Gazelle in the bottom of Wadi Amat (right). Photo: R. Bunce

In contrast to the gazelle, the ibex was recorded 88% of the time in narrow wadis (n=15), as opposed to wide wadis (n=2), and was observed only occasionally (Fig. 2.4f). Data also support the suggestion that ledges and escarpments are the preferred habitat for the ibex as the species was only found in the bottom of wadis where they were narrower than 40 m.

Figure 2.4f. Ibex at the top ridge of Wadi Amat. Photo: N. Munzert.

Hyrax colonies were seen frequently and their alarm calls were also heard often. They are peculiar creatures that look like rodents (Fig. 2.4g), but are in fact taxonomically classified in an order of their own.

Data support that hyraxes prefer ledges and escarpments of both narrow and wide wadis.

Figure 2.4g. Hyrax. Photo: M. Adlington.

Tracks and camel bones that had been split and chewed (Fig. 2.4h) were the only signs of striped hyaenas found. Hyaena tracks were found mainly on the bottom of wide wadis and occasionally in narrow wadis and on ledges.

Figure 2.4h. Tracks of hyaena (left). Note the front paw larger than the hind. Photo: S. Aschenbrenner. Camel bone split apart and chewed by a hyaena (right). Photo: M. Mazzolli.

Other mammals recorded included a couple of species of rodents and Cape hare (Fig. 2.4i).

Figure 2.4i. From left to right: Egyptian spiny mouse *Acomys cahirinus* or *A. russatus*. Photo: M. Doherty. Sundevall's jird *Meriones crassus* or *M. arimalius*, visiting the Bedu tent. Identification of both rodents with Hellyer & Aspinall (2005) and Nowak (1999). Photo: R. Bunce. Cape hare. Photo: R. Seipold.

There were issues of misidentification that were a source of some dispute amongst the expedition team. These issues did not, however, compromise results because of stringent post-expedition data processing. Misidentification issues will be minimised in future by more time spent on training, as well as building and maintaining a library of reference material of scats and tracks, such as in Figs. 2.4j and 2.4k below.

Figure 2.4j. Scats of ibex (left), hyrax (top) and gazelle (bottom right). Photo G. Kelly.

Figure 2.4k. From left to right: Track of porcupine. Photo: M. Mazzolli. Tracks of ibex. Photo: N. Munzert. Tracks of gazelle. Photo: M. Adlington.

Human presence

Although there was no indication of hunting of leopards, it was a general consensus during interviews (Fig. 2.4l) that leopards had been a problem in the past for the herders. It was also a consensus that leopards are no longer a problem, even though it was mentioned that herds are still maintained in the same areas as they were in the past. This information corroborates that leopards have lost part of their historical distribution in the area.

Figure 2.4l. Interviews with local people with one of them demonstrating his knowledge of leopards by drawing a track (right). Photos: C. Mahoney.

Both Wadis Amat and Uyun had camels, and signs of hunting of hyrax and ibex (Fig. 2.4m). Bullet cases, pelts and heads of ibex, as well as many hyrax heads that had been severed were found. Vestiges of goats in Wadi Amat were older and less frequent than in Wadi Uyun, indicating higher human activity there when grazing material is more abundant.

Figure 2.4m. Expedition staff finding an ibex pelt hidden by poachers. Photo: Guy Kelly

2.5. Discussion and Conclusion

Leopard presence and habitat condition

No fresh signs of leopards were found and although some of the scats found are leopard beyond any reasonable doubt, the identity of others are more contentious. Conclusive identification will require DNA analysis.

It should be stressed that the area studied is located at the margin of the leopard's distribution and/or where it was believed to have been reduced significantly up to local extinction (see Fig. 2.1a above). The distributional boundaries are located at the confluence of two different habitat conditions, where the monsoon-affected Dhofar mountains meet the arid lands that lead to the deserts of the Empty Quarter. Of course leopard distribution does not end abruptly and there is no hard edge. Instead abundance is gradually diluted towards the distributional boundary as the habitat gradually becomes unsuitable (see also Holt & Keitt 2005).

Besides that, it seems that leopards may favour areas with broken relief, which becomes scarce in the areas from where they may have retreated. Indeed, this study corroborates that inference, as escarpments, and particularly narrow wadis show the greatest concentration of prey species. Indeed, even the gazelle, which prefers the plains, were found to travel across slopes and escarpments.

The margins of the leopard's distribution are therefore not prime habitat for the species and it is thus reasonable to assume that it is more difficult for the leopard to recover from population crashes in these boundary areas. Nevertheless boundary habitats are an important area of research in elucidating the factors determining leopard decline, as they are likely to stand out in such areas. For conservation purposes too, it is important to study these parameters and of course to elucidate with some accuracy the current distribution of the leopard in Dhofar. In a nutshell, only if leopard distribution and suitable habitats can be identified with some accuracy and boundaries delineated, can protected areas be considered.

Although it is too early to state results categorically, initial findings of this study support the view that leopards only occur in low numbers locally. As mentioned above, the frequencies given for the Jebal Samham Nature Reserve were 94 scats and scrapes over a distance of 200 km, i.e. a rate of 0.47 signs per km (Spalton 2000), whereas the current survey resulted in an estimated rate of 0.067 leopard signs (scats) per km. Even assuming that all prospective leopard scats are indeed from leopards, their rate of occurrence would be seven times less frequent than in the Jabal Samhan Nature Reserve.

Interviews corroborated the view that leopards preyed on livestock more often in the past - and as interviewees mentioned that they still graze their livestock in the same wadis they used to in the past, leopards surely did not stop attacking goats and camels because they became tame. The conclusion therefore is that the leopard's distribution has contracted or that its numbers have been reduced, or more likely both. Retaliation to livestock depredation may have been a driving force that resulted in reduced leopard presence in the area.

Having said that, it should be stressed that much of the habitat is still quite preserved, as evidenced by the presence of the whole assemblage of prey species and other relevant species that are absent when habitat has been degraded.

The overgrazing and bark damage resulting from permanent goat herding in the wadis, as recorded by Biosphere Expeditions on the Mudandam peninsula (Hammer et al. 2007), was not observed in Wadis Amat and Uyun. Signs of goat herding were found particularly in the monsoon-affected areas of Wadi Uyun, but the activity is known to be carried out only once a year for a month or two, and there was no sign of feral goats. The only permanent herding was that of camels which, unlike the herding of goats, were left to graze without the constant presence of humans.

The mammalian fauna of interest was found to be largely intact, with the main prey of the Arabian leopard recorded in more than half of the 51 cells surveyed, and the hyaena, an apex predator like the leopard with large resource requirements, was recorded in 16 cells. Moreover, the wolf, a species that has been displaced elsewhere due to habitat modification has been camera trapped, as well as the wild cat, during previous sampling activities conducted by local researchers. Further, the caracal was photographed by camera traps installed during the current study.

Causes of decline

Interviewees were aware that leopards are protected in Oman. Thus although leopards are known to have been killed, trapped and commercialised on the Arabian Peninsula, it is very difficult to obtain information on this issue because understand that it is illegal to kill or capture a leopard. The overriding local culture to be hospitable, please and welcome guests may have led to biased reports on their perception of the leopard, in the sense that it was an unanimous answer that they liked the predator. Indeed when this emerged from the interviews, our translator/guides were clearly pleased with the result; just as they were clearly displeased when somebody mentioned that they did not like the leopard. All this reinforced the impression that interviews were also biased towards opinions of those that held no animosity towards the leopard.

It is good to find that people like the leopard, but more valuable information can be gleaned from those that do no like the predator and are not afraid to say so. They are more likely to have information that will lead to the understanding of local processes and conflicts behind the species' decline, invaluable baseline information for pragmatic and successful leopard conservation.

It is not enough to know that leopards have declined due to human activity, direct persecution or habitat loss – which is the extent of information available so far for the entire Arabian Peninsula (see Breitenmoser & Breitenmoser-Würsten 2006). Leopard populations have doubtless been reduced due to retaliation after livestock depredation, but quantitative information is missing. Elucidating whether depredation and retaliation still occurs frequently is essential to protect leopards in the study area. Ideally, future studies should aim to quantify livestock depredation and number of leopards killed.

As mentioned, there will only be rare occasions in which killing is known to an environmental officer, so opportunities to gather data on retaliation in a systematic way are limited. Only a local environmental officer or someone that spends much time in the

community would have the chance of earning the local people's trust to the extent that details are volunteered. The only other option to gain enough knowledge on livestock depredation would be to establish an experimental pilot project for compensation in case of losses to depredation. To keep costs down, it would have to be established within a circumscribed area and during a limited period. Transparency, adequate funding, training of staff, rapid and accurate verification of damage, and lessons from the private insurance industry are some of the key factors that contribute to the success of such programmes (Nyhus et al. 2005).

Despite the likelyhood of retaliation as the driving factor in leopard decline, the possibility that other environmental variables have contributed concurrently to species' decline cannot be discarded. Therefore conservation of leopards also has to rely on detailed ecological data.

Although no information on the illegal capture and trade of leopard was collected during the survey, poaching of the leopard's prey was recorded in several situations, albeit the extent to which poaching has modified prey availability remains unknown. Recurrent and frequent recording of main prey species suggest, however, that reduced prey availability is not the cause of the leopard's population decline in the study area.

Based on the data collected, the only scenarios that can be built regarding the leopard's decline are those based on human-wildlife conflict:

1. Leopards are shot in retaliation (or for other reasons) at a rate that may or may not result in their decline

2. Leopards have been shot in the past resulting in a reduction of their distribution, but they are not persecuted any longer.

If the second scenario is correct, as our interviews suggest, then there may be a chance that the leopard can make a comeback to its former range, provided that the prey base is still present and that the habit remains suitable. Whatever is the case, it is important that we gain a better idea of the factors that will decide the future the Arabian leopard, if we want to avoid losses of other healthy leopard populations. The importance of detecting the causes of leopard decline in detail cannot be understated. Diagnosing the causes of population decline is the principle component of virtually all projects aimed at saving threatened species from extinction (Norris 2004).

2.6. Recommendations for Action and Further Studies

The expeditions should be continued in order to undertake further studies on the marginal habitats, the conditions that prevail there, elucidate where inside these area the leopard is still present, where it is not and what the differences between these habitats are. In this context all the measures below should be considered:

(1) Increase the number of camera traps

(2) Survey areas at a scale adequate to incorporate home ranges of several individual leopards.

(3) Use double cameras traps to record both sides of the animals for their adequate identification.

(4) Find a reliable laboratory for prompt DNA analysis of scats.

(5) Investigate livestock predation.

As discussed above, it may also be beneficial to set up an experimental pilot project for compensation in case of losses to depredation. However, this is outside Biosphere Expeditions' remit and can only be done with the help of the government. Biosphere Expeditions should raise this topic with the appropriate authorities.

Because leopard conservation requires collaboration of multiple agencies and people, future expeditions should also be used as platforms to increase capacity building and information exchange with local people, organisations and the various government agencies. In this context all the measures below should be considered:

(1) workshops with rangers should be organised in conjunction with the Ministry of Environment & Climate Affairs (MECA) and the Office for the Conservation of the Environment, Diwan of Royal Court (OCE), utilising the expedition base as a training base.

(2) Involving local staff from Shell is also an activity that should be extended within Shell and perhaps other companies, as this is a very good way of disseminating crucial messages throughout Oman.

(3) Further developing this theme, the information disseminating power of press conferences organised by corporate partners such as Land Rover and Shell should not be underestimated. In 2008 two press conferences in Muscat organised by Land Rover and Shell respectively resulted in a large number of articles about leopard conservation in Oman. These kinds of activities should be continued and possibly expanded.

(4) On a more local level, local people should continue to be involved, as they were on this expedition, and gain some modest economic benefit within the tight constraints of the expedition budget, by being paid for services such as guiding, providing camels, bringing in water and fuel, etc. Care must be taken here not to generate jealousies amongst members of different communites and the expedition must be seen not to be favouring a particular person or ethnic group. This requires some significant diplomatic skills and experience, which Biosphere Expeditions lacks, and therefore needs to rely on guidance from local staff and partner organisations such as OCE and MECA.

(5) The intense interest of local people in the expedition, its equipment, vehicles and team members from all over the world should also be harnessed by holding local information workshops about the work it and the OCE does in leopard conservation. This would also help to alleviate fears that may exist and reduce tensions.

(6) Finally, efforts should be undertaken to support and/or reactive societies concerned with Arabian leopard conservation and perhaps give visibility to sponsors and general personnel by creating a group of 'Friends of the Leopard', which could also work to increase networking.

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Appendix 1. Bird inventory generated by the expedition.

Scientific name	Common name
Acridotheres tristis	Common mynah
Alectoris melanocephala	Arabian partridge
Ammomanes deserti	Desert lark
Ammoperdix heyi	Sand partridge
Aquila nipalensis	Steppe eagle
Aquila verreauxii	Verreaux's eagle
Cercomela melanura	Blackstart
Circaetus gallicus	Short-toed eagle
Columba livia	Rock dove
Corvus rhipidurus	Fan-tailed raven
Emberiza striolata	House bunting
Euodice cantans	African silverbill
Falco tinnunculus	Kestrel
Irania gutturalis	White-throated robin
Lanius meridionalis	Southern grey shrike
Merops orientalis	Little Green bee-eater
Nectarinia habessinica	Shining sunbird
Nectarinia osea	Palestine sunbird
Oenanthe lugentoides	South Arabian wheatear
Onychognathus tristramii	Tristram's grackle
Passer domesticus	House sparrow
Pterocles lichtensteinii	Lichtenstein's sandgrouse
Pterocles senegallus	Spotted sandgrouse
Ptyonoprogne fuligula	African rock martin
Pycnonotus xanthopygos	Yellow-vented bulbul
Streptopelia senegalensis	Laughing dove
Sylvia curruca minula	Desert lesser whitethroat
Sylvia nana	Desert warbler
Upupa epops	Hoopoe

Appendix 2: Interview datasheet

GUIDELINES FOR RECORDING INTERVIEWS
OMAN

Objectives of interviews

To learn from local community on the main following topics:

1. Where leopards are present now, and where they were present in the past (possible change in distribution);
2. Attacks of leopard to livestock (goats, camels, etc) now and in the past;
3. Where leopard are most often seen now and where there are more attacks to livestock – If leopards have attacked recently you can plan to visit this location;

Guidelines for Team members

You will be visiting local people to find out about their attitudes to and information on Arabian leopards and other wildlife. These interviews will be conducted in Arabic and will be discussed with you. Give time to the Arabic interviewer to get acquainted and introduce the subject to the interviewee. He should soon get you updated on the conversation, as he has been briefed to do. In practice, role of the team member is to make sure that all topics on this sheet are covered and all questions asked as far as possible. In a broader sense, this component of the project would not be in execution without your presence.

1. Be relaxed, friendly, chatty.
2. Take pictures only after asking for permission and then only a few.
3. Keep the datasheet out of sight as much as possible.
4. You can glance at the datasheet or record the questions in your notebook beforehand to make sure they are all covered.
5. Immediately after the interview and out of sight of the interviewee, discuss the datasheet and record the answers, using judgment.
6. Discuss the datasheet in the evening with scientific staff as part of filling in datasheet activity

Guidelines for the Ranger and OCE staff

It is recommended that you introduce yourself and the team members appropriately. This procedure is to avoid the community to consider your as guide and the group as tourists, which is not true. Make sure the local guide, if present, also understand that the **team members are research volunteers working in cooperation with the Diwan of Royal Court and Ministry of Environment & Climate Affairs**, in the Leopard Survey Project. Introduce yourself as Ranger of the Ministry of Environment or an officer of the OACE, as appropriate. You should avoid such sentences as ‘<u>they</u> want to know about …’, the best way to communicate is to say ‘<u>WE</u> are interested to know about the leopard, as we are in the condition as researcher for the Leopard Survey of the OACE…’. Failure to do so may compromise the interview, as the community will perceive the Biosphere Expedition’s team as foreign tourists and may ask for rewards.

Guidelines for the local guide

The Diwan of Royal Court, the Ministry of Environment & Climate Affairs, and Biosphere Expeditions are interested in the leopard because it is disappearing fast. If we do not help protect it, the desert border and mountains will be emptied, there will be no more leopards in the wild. By helping the leopard, you’ll be helping your community.

You are very important for this research because people from your community will trust you information that would not to visitors. We need to know as much as we can about the presence of the leopard in the past and where it is know to live now. If the leopard is causing damage to livestock (goats, camels) we need to know to help the leopard and the herders.

DATASHEET: RECORDING INTERVIEWS
OMAN

INTERVIEW CONDUCTED BY: **DATE OF THE INTERVIEW:**

PERSONAL INFORMATION ABOUT THE INTERVIEWEE

Sex:

Age:

Place of residence (name of community):

Place of birth (region):

Occupation:

If you are a livestock owner/raiser, what kind of animals do you have?
Camels Goats Cows Horses Other

INFORMATION ABOUT ARABIAN LEOPARDS AND OTHER WILDLIFE

Are there leopards near this area? If there are, when did you have a last evidence?
□ More than 10 year ago □ Between 5 and 10 years ago □ Less than 5 years ago

Where did you find evidence of the leopard (Wadi, Region?) _____

If you have a herd, where do you leave it (Wadi, Region?) _____
(You should insert a general coordinate after the interview) Coordinates: _____

If you have a herd, there are leopards near it? Yes _____ No _____

Livestock losses to <u>leopards</u> (fill number of animals that have been taken)

	Loss this year	Loss last year	Total herd size	Number of herders involved (single herd or multiple herd)	Unit price in OMR
Camel					
Goat					
Cattle					

Livestock losses to <u>other animals</u> (hyenas, wolves, dogs)

	Loss this year	Loss last year	Total herd size	Number of herders involved (single herd or multiple herd)	Unit price in OMR
Camel					
Goat					
Cattle					

DATASHEET: RECORDING INTERVIEWS
OMAN

Livestock losses to <u>other causes</u> (disease, fall from cliff, snake bite, theft, drought)

	Loss this year	Loss last year	Total herd size	Number of herders involved (single herd or multiple herd)	Unit price in OMR
Camel					
Goat					
Cattle					

YOUR OPINION ON THE LEOPARD

Which of the following statements best describes your feelings towards Arabian leopards?

Strongly dislike Dislike Indifferent Like Strongly like

The presence of Arabian leopards for you is
A good thing A bad thing You are indifferent You are scared

If Arabian leopards attracted more tourists to the region, this would be

A good thing A bad thing You are indifferent

Are Arabian leopards protected in Oman? Yes ____ No _____

	Strongly disagree	Dis-agree	Neutral	Agree	Strongly agree
Arabian leopards have a considerable impact on large game (gazelle, ibex, etc)	1	2	3	4	5
Arabian leopards have a considerable impact on small game (hyrax, hedgehogs, etc)	1	2	3	4	5
Arabian leopard attack humans	1	2	3	4	5
In regions where Arabian leopards live in close proximity to livestock, they feed primarily on domestic animals	1	2	3	4	5
We already have enough Arabian leopards in the region	1	2	3	4	5

Comments (record any other useful/interesting information here)

Appendix 3: Survey datasheet

DATASHEET
SPECIES DATA ENTRY – SINGLE SURVEY ROUTE - OMAN

To be use for individual Survey Routes. Use more than one sheet per Route if necessary.

Observer names		Route number/name		Start time	
		Date		End time	
		Extent (linear km)		Entered into computer(tick)	
Threats to Arabian leopard		Damage from livestock or people			

Species/number seen	Time (if sighting)	Quadrat number	Coordinate		Type of record Track, vocalization, sighting, scat, scrape, carcass	Landscape and vegetation Wide or narrow wadi, bottom of wadi, ledge, ridge, slope or escarpment; saddle, water hole, gorge; vegetation cover (example: 10%), grass and or bushes.	Photo name *
			X (East)	Y (North)			

* Name the photographs you've taken of the landscape, animals, and animal signs. Name as follows: your name + sequential number + species + quadrat number. Photos to be stored in a specific folder (IMAGE FOLDER) in Biosphere computer.

Appendix 4: Expedition leader diary by Peter Schuette.

2 January

Happy New Year and hello to all Oman expeditioners and those involved with the expedition to this first entry of our Oman 2008 diary. I am Peter Schuette, your expedition leader this year, and I will be entertaining or boring you (whichever way you see it!) with this diary over the next month or so.

It's freezing in Germany where I am at the moment and I don't know about you, but I am definitely looking forward to the warmth of Arabia! Preparations for the expedition are in full swing. The Land Rovers should be ready and waiting for us in Dubai, we have found a cook, Khalid, our field guide, is ready and waiting in Salalah, Marcelo, the man with the camels is standing by, our scientist is about to arrive in Muscat from Brazil and meet up with Andrew, the Adviser of Conservation of the Diwan of Royal Court (Omani government) to talk things through, your flight tickets to Salalah (and back☺)are booked, we're packing up the equipment here in Europe and flying out on Saturday to Dubai to pick up the vehicles and more equipment. You name it – it's all in place. YEAH RIGHT! "Insha'Allah" is a phrase you are about to become very familiar with… It translates roughly as... 'If Allah wills it' and is a marvelously useful term of complete fatalism and one which has no direct English equivalent. The nearest thing would probably be '...but on the other hand I might get hit by a number 73 bus tomorrow' - uttered in tones of sodden dejection by a clinical depressive with a strong Solihull accent.

First change of plan: It won't be me meeting you in the airport lobby at Muscat, but a representative of NTT Oman, our Muscat travel agency partner. He will be at Costa Coffe (how's that for globalisation!) at 09.00 as described in your dossier, distribute tickets and point you in the general direction to check in for your Salalah flight. I'll then meet you at the airport in Salalah with the camels, sorry, Land Rovers. This is not a big deal, but it's always good to have a plan B in case things go pear-shaped, as they tend to on expedition, so if our friend from NTT is not there by 08.30, please give me a ring on my Oman mobile (see below) or ring Ginu from NTT on +968 92 800281 sounding slightly worried that the man with your tickets has not turned up yet!

I'll send another update from Oman once all the staffers have met up there and we know which shape the pear is going to take this year ☺ But enough of scaring you with expedition lore – we do know what we are doing, honest, and we all look forward to meeting you in Salalah soon. My Oman mobile number (for emergency use only) is +968 92700497.

Safe travels

Peter Schuette
Expedition leader

9 January

It was all smooth sailing. No delayed flights, transfers waiting, Land Rovers ready, uneventful 6-hour drive from Dubai through the desert to Muscat, Marcelo ready and waiting there. Then we went to where our gear had been stored for the past year in Muscat and it had for some reason, by someone been moved outside into the garden for the past few months. Everything valuable was gone. GPSs, compasses, binoculars, books – you name it, it was no longer there. Ever so slightly concerned by this, we spent yesterday on an extreme shopping spree around Muscat and Dubai. Rob, Wouter and Johnny from Land Rover were a godsend and pulled out all the stops to help get everything together in time. Thank you! We've just done our Land Rover press conference and we're now all packed up and heading off to Salalah to set up camp. Perhaps I'll send an update before 13 Jan, but more likely, I will see the first group at Salalah airport.

14 January

The first team has arrived and settled in at base camp. On the way there we saw Arabian gazelle on the hills and tracks of hyrax and hyaena. After a beautiful sunset making the mountains around us glow golden, we spent some time around the camp fire getting to know each other. Then it was talks on the science, GPS, compass, the Land Rover driving course, and a first field walk today. Lots of information, lots to take in, as always. All well here and more soon.

19 January

The first week at base is over and we've had lots of sightings of gazelles & hyrax, some ibex, signs of wolf and hyaena and also our first signs of leopard during the camel overnight survey. We've also been to some communities and talked to local people there. The picture that is emerging from the interviews matches what we find in the field. Gazelles are pretty common, as are hyrax colonies. Hyaenas and wolves are around and even get close to the villages to raid the rubbish dumps. There are fewer ibex higher up in the mountains and leopards are around too.

We think we've found a few good places to put our first camera traps and also a number of wadi valleys that look promising for further surveys. The team are in the full swing of things and even survived a couple of uncharacteristically cold nights of 6 degrees centigrade and cloudy (not blue!) skies.

23 January

We covered a lot of ground in the last few days and have also started to work on a bird inventory of mainly partridges, grouse and some birds of prey. Last Sunday's explorer team discovered lots of tracks and spotted some gazelle close to the car.

On Monday, part of the team went on a two-day overnighter with the Land Rovers, driving 5 hours to start with on day one to set up an advanced research camp and then discovering a lot of human disturbance in the survey area. Those left at base camp, went out to interview local people in the village of Mudday. As it's our first time in the area, quite a lot of time is spent explaining why a bunch of foreigners from all over the world is keen to go walking and camping in the remote wadis ;)

The rest of the week we spent looking for other areas that look promising for more surveys.

1 February

We went through extensive field and animal identification training in the first couple of days of the second slot. On Tuesday we ventured out to track and record signs of animals for the first time with the new group. We entered a promising-looking narrow, green wadi. Everybody did well looking for and identifying tracks and scats and of course, most importantly, filling in datasheets ☺

As reward we got to see two ibex running on a ridge! A hyrax colony was also found, another one is just couple hundred metres far from base camp. What a great start for this team!

Wednesday we split into two groups, one went out for two nights to survey a new area. Setting up a small camp for our overnighters is always hard work but rewarding and so our Land Rovers packed with tents, cooking stuff and water set off to make their way to wadi Uyun. The rest of the team back at base camp went for more interviews with local people in the villages and shorter surveys around base camp.

Our results of the last few days: three possible leopard signs (we have to confirm these with Hadi), a waterhole in one of the wadis, a very exhausted survey team after a strenuous 24 km walk in the heat of more than 35 centigrade and a successful exploratory trip to asses access routes into another wadi that we want to survey next week.

So today we are back at base camp, recovering, entering data and preparing for the days that lie ahead.

6 February

Last Sunday the next survey and exploration chapter started. Again we split into two teams. Team one had the task of setting up camera traps. So they headed out with a camel for two nights. Hadi was with them to help decide where the cameras and video cameras should be placed. After successful placement of the traps and a clear night on a mountain ledge under the stars, Hadi's group investigated another wadi. Worrying signs of poaching activity were found, such as freshly skinned ibex, a fireplace and lots of human footprints.

Team two went out to Wadi Huttaw, sleeping on the plateau with a strong and cold north wind blowing down from the Empty Quarter. This was definitely one of the chilliest nights an expedition ever spent on Oman! On the survey we spotted seven hyrax and lots of tracks and scat. Many of the tracks were quite old and in deep sand, so not identifiable, but there is definitely some movement in this wadi! We found a couple of promising scats, which we will now send off to Sultan Qaboos University in Muscat for identification.

8 February

We spent the last few days of this year's expedition re-sampling some promising areas more intensively and carefully, spending more time on ledges and in caves.

To summarise the last four weeks and our efforts, we found three scats in the study area, which are very likely leopard and five more, which we still have to confirm. We spotted a lot of signs of hyaena, wolf, fox, Arabian gazelle, Nubian ibex, hyrax, porcupine and hare. There is still a lot of human impact in this area, not only camel and goat herders but also poaching activity!

We worked successfully on a first-ever bird list of the Dhofar mountains, identifying 30 species, thanks mainly to Roger, Neil and Carole who put a lot of work into it. Our list includes steppe eagle, Verreaux's eagle, Arabian partridge, sand partridge, hoopoe, and so on…..

We started making contact with the locals, interviewing them to supplement our findings.

All this together was a excellent start to getting more information about the presence of the Arabian leopard and its prey and we will continue this work in the years to come.

Last but not least I would like to thank everybody who joined this expedition or who helped to bring it about. You've all done a great job! I know it's not always easy to be flexible in the face of ever-changing plans or to get up in the morning for another strenuous survey or indeed spending a freezing night in an advanced camp. But never forget that without you, we would not be working here!

Hope to see you all again some day.

Peter Schuette
Expedition Leader

P.S. Don't forget to share your pictures! www.biosphere-expeditions.org/pictureshare