The Biology, Husbandry and Conservation of Scimitar-horned Oryx (*Oryx dammah*)

Edited by
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Front Cover: Scimitar-horned oryx in Bou Hedma National Park, Tunisia. Photograph by Tim Woodfine

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Foreword

This updated publication fulfils an obligation to produce husbandry guidelines for member institutions of the European Association of Zoos & Aquaria (EAZA) that participate in the European Endangered Species Programme (EEP) for scimitar-horned oryx. However, we have also taken the opportunity to draw together available knowledge on the biology and conservation of scimitar-horned oryx and hope that this will be of interest to EEP institutions and others concerned with the conservation and management of this species. We have taken the unusual step of including all references to scimitar-horned oryx that we are aware of in the bibliography, even if not specifically mentioned in the text. We hope that this will be a useful resource in its own right as many papers are unpublished and consequently not available through standard literature searches.

Readers will note that a select number of authors and publications are referenced frequently throughout. We would therefore like to acknowledge the importance of this body of work to our current knowledge of scimitar-horned oryx. Observations of the species prior to its extinction in the wild are a particularly precious and rare resource. Hence, there are gaps in knowledge and the need for research on many topics is obvious.

This is the second edition of this volume on scimitar-horned oryx and contains small but significant changes from the previous publication. To assist us in improving later editions, we will be grateful for any comments or criticisms. We would also be pleased to receive information on any other publications on scimitar-horned oryx to include in the species bibliography that we may have missed.

The great aim of those of us involved in the management of scimitar-horned oryx is to see herds return to their former ranges in North Africa. Where this process has begun, knowledge gained from the experience of keeping scimitar-horned oryx in captivity has been invaluable in assisting range states with animal management during acclimatisation and post-release monitoring phases of release projects. We are hopeful that reintroduction efforts will gain momentum and recognise the need for the zoo community to offer further assistance in the process. To this end we have produced an adapted and translated version of this publication for distribution among range states.

Tania Gilbert & Tim Woodfine, September 2004

Acronyms

AAZPA	American Association of Zoological Parks and Aquaria
ARAZPA	Australasian Regional Association of Zoological Parks and Aquaria
ASMP	Australasian Species Management Program
AZA	American Zoo and Aquarium Association
BVDV	Bovine Viral Diarrhoea Virus
CCN	Cerebro-cortical Necrosis
DNA	Deoxyribonucleic Acid
EAZA	European Association of Zoos and Aquaria
EDTA	Ethylenediaminetetracetic Acid
EEP	Europäisches Erhaltungszucht Programm
ELISA	Enzyme-linked Immuno-sorbent Assay
ESS	Evolutionarily Stable Strategy
GPS	Global Positioning System
GTZ	Gesellschaft für Technische Zusammenarbeit
IATA	International Air Transport Association
IUCN	The World Conservation Union
MCF	Malignant Catarrhal Fever
NGO	Non Government Organisation
NP	National Park
PCR	Polymerase Chain Reaction
PPR	Peste des Petits Ruminants
RSG	Reintroduction Specialist Group
SSC	Species Survival Commission
SSIG	Sahelo-Saharan Interest Group
SSP	Species Survival Plan
TAG	Taxon Advisory Group
TPZ	Total Protection Zone
UNEP	United Nations Environment Program
ZSL	Zoological Society of London

Contents

PART ONE

Biology and Conservation

Photograph: Scimitar-horned oryx at the Arrouais Reserve, Souss Massa National Park, Morocco. Photograph by Heiner Engel

1
Taxonomy & Nomenclature

JUERGEN ENGEL

Order:	Artiodactyla
Suborder:	Ruminantia
Family:	Bovidae
Subfamily:	Hippotraginae
Genus:	*Oryx*
Species:	*Oryx dammah* (Cretzschmar 1826)
Common name:	Scimitar-horned oryx

Taxonomy

It is possible to crossbreed all species of oryx and for that reason some systematists previously recognised only one species with several subspecies including the scimitar-horned oryx (Walther, 1968, 1988; Huth, 1976, 1980). However, current taxonomy regards the scimitar-horned oryx and its four close relatives as evolutionary isolates (Devillers & Devillers-Terschuren, 2003).

There is some debate over whether different subspecies of scimitar-horned oryx once existed in the east and the west of their natural range (Sausman, 1992). Antonius (1931) and Flower (1932) believe that this was not the case, whereas Schomber (1963) distinguishes a subspecies of '*Oryx gazella dammah'* east of the Nile. A second hypothesis is that the isolated populations of scimitar-horned oryx north and south of the Sahara (Newby, 1988) may have represented two distinct subspecies.

Examining only scimitar-horned oryx in Chad, two separate populations existed which apparently differed in phenotype and behaviour. The individuals of the northern population were smaller, more stoutly built and had somewhat finer horns. Their pelage was almost white and showed very little contrast. Individuals of southern populations lived in smaller groups and undertook more pronounced seasonal movements. The nomads recognised these differences and used different names for the northern and southern oryx (Gillet 1965, 1966a; Newby, 1974).

Nomenclature

Since the first description of the scimitar-horned oryx in 1816 the nomenclature has changed numerous times. Several different names can be found in the literature including: *Oryx algazel, O. dammah, O. damma, O. tao, O. bezoarticus, O. ensicornis, and O. leucoryx* (Dolan, 1973), and up until 1950, some authors used the genus name of *Aegoryx* (Pocock, 1918; Rode, 1943; Harper, 1945; Brouin, 1950).

The use of the name '*oryx'* for this genus of antelope was introduced by De Blainville in 1816 (Hemprich & Ehrenberg, 1828; Rode, 1943). The scimitar-horned oryx was subsequently described by Oken (1816) who named it *Oryx algazel*. A decade later in 1826, Cretzschmar also described the scimitar-horned oryx, but chose to name the species *Oryx dammah.*

In 1827, the species name *leucoryx* came into use for scimitar-horned oryx (Hemprich & Ehrenberg, 1828; Johnston, 1898; Sclater & Thomas, 1899/1900; Brehm, 1927). However, this synonym had previously been assigned to the Arabian oryx (formerly *Oryx beatrix*) (Schomber, 1963; Dolan, 1973). When it was recognised that the name *leucoryx* was not available (Hamilton, 1918/21), many authors reverted to the original name of *Oryx algazel* (Pocock, 1910, 1918; Brehm, 1920; Antonius, 1931; Flower, 1931, 1932; Shortridge, 1934; Rode, 1943; Harper, 1945; Brouin, 1950; Zuckermanm 1952/53). However, in 1951 Ellerman & Morrison-Scott (1951) realised that this name was also not available at the time and for that reason, on the first of January 1956, the International Trust for Zoological Nomenclature settled on the second oldest name, *Oryx dammah* (Cretzschmar, 1826) for the scimitar-horned oryx (Setzer, 1956; Haltennorth, 1963; Dolan, 1966).

To confuse the issue further, many papers published after 1956 used other names. This includes: *O. gazella tao* in Schomber, 1963, *tao* in Stewart, 1963, Dittrich, 1969, Huth, 1970, Kock, 1970 and Wurster, 1972, *algazel* in Andrae & Krumbiegel, 1976, and *damma* in Durrant, 1995. However, *Oryx dammah* (Cretzschmar, 1826) remains as the accepted convention in modern taxonomy.

Oryx dammah is known as Wach or Begar al Ouach in Arabic, Algazelle in Dutch, Säbelantilope or Nordafrikanischer Spieβbock in German, Oryx de Cimitarra in Spanish, and Oryx algazelle, Algazel, Agazelle, Antilope oryx, and Oryx blanc in French. In English, the species is most commonly referred to as scimitar-horned oryx, but sometimes abbreviated to scimitar oryx (Devillers & Devillers-Terschuren, 2003).

The Latin word O*ryx* means gazelle, and the species name *dammah* comes from ‘dama’ or ‘damma’ (Latin for antelope, gazelle) or from ‘dammar’ (Arabic for sheep) (Gotch, 1995).

2
Morphology & Genetics

JUERGEN ENGEL

Morphology

The scimitar-horned oryx takes its common name from its horns which curve backward in an arc or scimitar form, which are distinct from those of its close relatives. Maximum horn length is approximately 150cm (Newby, 1978a) and both genders carry these weapons.

Scimitar-horned oryx are about the size of a medium-sized deer (Brouin, 1950), but males tend to be larger than females. Adult males may attain a shoulder height of 126cm and weigh up to 165kg. In comparison, females grow to 120cm at the shoulder and weigh up to 150kg (Brouin, 1950).

Both sexes are whitish to light brown with the neck being the only part, except for a white spot of variable size on the throat, which is ruddy brown. A similar cast may be found on the anterior shoulder region, the chest, the croup, and the posterior parts of the flanks, however, there are great individual variations. This is also true for the brownish-grey facial markings. There is often a dark patch at the base of the horns and on the nose, and a dark stripe on each cheek through the eyes, but as scimitar-horned oryx mature, they usually lose the lines between the face patches (Mungall & Sheffield, 1994). The tail is long with a terminal tuft.

The coat is short and thick, growing longer during the winter (Haltenorth, 1963; Dolan, 1966; Gordon & Wacher, 1986). While the pale pelage reflects sunlight, the black skin and tip of the tongue protects against sunburn (Mungall & Sheffield, 1994). These characteristics, along with the enlarged hooves, which enable the oryx to walk easily on sand, are adaptations to the arid environment that the animals inhabit.

Scimitar-horned oryx calves are light brown, with a white abdomen and a black-tipped tail. Their pelage changes to adult coloration when the animals are three to twelve months old (Dolan, 1966; Nishiki, 1992).

Genetics

Very little information is available on the genetics of *Oryx dammah*, and much research is required to improve current knowledge of this species. The karyotype of the scimitar-horned oryx is similar to that of the Arabian oryx *Oryx leucoryx*. There is a diploid number (2n) of 58 chromosomes: 56 autosomes (two metacentric, 54 acrocentric) and the usual XY-type of sex chromosomes (Wurster, 1972).

All oryx species will interbreed readily with each other or with addax *Addax nasomaculatus*, and oryx hybrids are usually fertile. Scimitar-horned oryx / addax hybrids resemble addax and have been sold as such (Grimwood, 1967/68; Dolan, 1976; Ruhe, 1993; Mungall & Sheffield, 1994). One such example is of a female addax-scimitar hybrid being mated with an Arabian oryx and producing offspring at Berlin Tierpark (S. Wakefield, *pers comm*.).

3
Behavioural Ecology

JUERGEN ENGEL

Prior to its extinction in the wild, the scimitar-horned oryx inhabited the arid grasslands surrounding the Sahara (Newby, 1988). Living in this environment explains the behaviour of the species that is characterised by crepuscular activity patterns, migratory tendencies and the ability to adopt flexible strategies for foraging and social organisation.

Behavioural Ecology

Scimitar-horned oryx are primarily grazers, feeding on grasses and forbs when available, but shifting to other food sources including browse when required (section 4). In its Sahelian range, the species was noted to migrate over large distances in pursuit of adequate food and water resources. Migrations of up to 1300km per year have been observed in the Republic of Chad (Gillet, 1965, 1966b). The basic pattern was repeated every year: in the dry season (March to May) the animals travelled southward, and after the first heavy rainfalls in June and July, they moved back to the north (Brouin, 1950; Haltenorth, 1963; Schomber, 1963; Gillet, 1965, 1966b, 1971; Dolan, 1966; Newby, 1974), travelling mainly at dusk and dawn (Brouin, 1950; Gillet, 1965, 1966b, 1971). Scimitar-horned oryx are thought to have the ability to respond to variations in air humidity over large distances, moving to areas where rainfall is due (Gillet, 1965, 1966b; Newby, 1974).

Even when not migrating, scimitar-horned oryx were active early in the morning and late in the afternoon, and frequently also into the night (Brouin, 1950; Dolan, 1966; Newby, 1974; Gordon, 1991; Gordon & Gill, 1993). During the hottest hours of the day, from around 09.00 to 16.00, animals rested in the shade (Haltenorth, 1963; Kranz & Ralls, 1979; Gordon & Wacher, 1986; Wacher, 1986a). If there were no suitable trees and shrubs offering shade, scimitar-horned oryx excavated hollows in the soil with their front hooves (Gillet, 1965, 1966b).

These activity patterns no doubt help to minimise water loss (Newby, 1975a, 1978a; Wakefield, 1996a; Dolan, 1966; Anon, 1987a). However, the scimitar-horned oryx is also physiologically adapted to arid environments and may go for long periods without drinking (Dolan, 1966). During such times moisture is attained from food plants with bitter wild melons *Colocynthis vulgaris* being an essential and staple water-food (Barzdo, 1982; Newby, 1988). Animals also search for plants like *Indigofera viscosa* late at night and in the early morning that are densely covered with glandular hairs and produce a hygroscopic secretion, further contributing to their water requirements (Gillet, 1965, 1966a).

A healthy adult scimitar-horned oryx has no natural enemies in its arid environment. However, young and weak oryx may fall victim to lappet-faced vultures *Torgos tracheliotus*, golden jackals *Canis aureus*, wild dogs *Lycaon pictus*, striped hyenas *Hyaena hyaena*, spotted hyenas *Crocuta crocuta*, cheetah *Acinonyx jubatus*, and in former times, lions *Panthera leo* (Gillet, 1965, 1966a; Newby, 1974, 1988).

Social Organisation & Behaviour

Before their extinction in the wild, scimitar-horned oryx herds are reported to have been relatively small (Bonnet, 1909; Brouin, 1950), ranging between 10-30 animals (Rode, 1943; Dolan, 1966; Gillet, 1971; Newby, 1974, 1975a, 1978a, 1988; Kranz & Ralls, 1979; Newby,

1984; Spinage, 1986; IUCN, 1987; Nowak, 1991). However, during their migrations, numerous herds joined together creating aggregations of hundreds, and in former times, even thousands, of individuals (Brouin, 1950; Edmond-Blanc, 1955; Haltenorth, 1963; Gillet, 1965, 1966a, 1971; Dolan, 1966; Newby, 1974, 1978a, 1988; Bassett, 1975/76; Kranz & Ralls, 1979, Barzdo, 1982, Walther, 1988; Stanley Price, 1989; Nowark, 1991). Once food became scarce the aggregations would break up, and the oryx would reform smaller herds (Newby, 1974). Scimitar-horned oryx have also been observed associating with dorcas gazelle (*Gazella dorcas*) or dama gazelle (*Gazella dama*) (Gillet, 1965, 1966; Druwa, 1985; Wacher, 1988).

According to Newby (1974), an older female takes the lead in scimitar-horned oryx herds, but Kranz and Ralls (1979) report that an adult male is the group leader. It is likely that the structure is similar to that of the fringe-eared oryx *Oryx beisa callotis*. A high-ranking female is in front of the group, however the dominant male directs all the group's movements from the rear (Walther, 1978, 1984, 1992, 1995; Estes, 1991a).

Conflicting observations of the behaviour of mature males suggest that they may adopt herd-living or territoriality depending on conditions and the distribution of females. Low population density (approximately 0.05 to three animals per km²) (Gillet, 1971; Stanley Price, 1989) and unpredictable food resources to which female oryx are particularly sensitive, favour herd-living, with males roaming together with the females throughout an extensive home range. However, males may temporarily defend territories at times when localised, sedentary aggregations occurred and reproductive success could be improved through a 'sit and wait' strategy. Several researchers have observed solitary males that were estimated to be older than the herd males offering some evidence of territoriality (Rode, 1943; Haltenorth, 1963; Schomber, 1963; Gillet, 1965, 1966a; Brown, 1966; Dolan, 1966; Estes, 1974, 1991b; Newby, 1974; IUCN, 1987; Wacher, 1988; C. Muller*, pers.comm*.). Consequently, this evidence suggests that male scimitar-horned oryx developed a mixed evolutionary stable strategy (ESS) which has been described in closely related species such as fringe-eared oryx (*Oryx beisa callotis*) (Gosling, 1986; Wacher, 1988; Stanley Price, 1989; Estes, 1991a, Feuerriegel, 1995a, 1995b), gemsbok (*Oryx gazella*) (Estes, 1974, 1991a; Wacher, 1988, Stanley Price, 1989) and Arabian oryx (Oryx leucoryx) (Spalton, 1993, *pers. comm*., T. Wacher, *pers. comm*.).

Although never reported, it is likely that non-breeding male scimitar-horned oryx formed bachelor groups (section 8). Observations of semi-free ranging populations of scimitar-horned oryx in Tunisia, Morocco and Senegal would help to verify this theory.

4
Wild Diet

TANIA GILBERT

Scimitar-horned oryx are primarily grazers. However, as an arid land specialist, the species demonstrates a flexible foraging strategy (Newby, 1975b; Wakefield, 1996a), exploiting a range of additional plant materials including browse, seedpods of legumes, bulbs, tubers, and succulents depending on season and availability (table 1.)(Macdonald, 2001; Kingdon, 1997; Dolan, 1966). Hence, previous authors describe the importance of these different food plants throughout the course of the year (Newby, 1975b; Devillers & Devillers-Terschuren, 2003). Information on the diet of wild scimitar-horned oryx is available from observations from Chad (Gillet, 1966a, 1966b; Newby, 1975b) prior to the species' disappearance in the wild. More recently, this has been supplemented with knowledge gained from the reintroduction of scimitar-horned oryx to protected areas in Tunisia (Bertram, 1988; Gordon, 1991; Wacher, 1986b; Davey, 1999; di Crocio, 2003).

There are three distinct seasons within the natural range of the scimitar-horned oryx: the rainy season; a cold, drier season; and, a hot dry season. The rainy season lasts from July to September in the Sahelian range (Devillers & Devillers-Terschuren, 2003), but begins in September in the northern Sahara fringe countries (E. Flach & S. Wakefield *pers. comm.*). During this period, scimitar-horned oryx in the Sahel fed on temporary pastures formed by the emergence of annuals and the green shoots of shrubs such as *Indigofera* sp. and *Cordia sinensis*. Tuft grasses including *Cymbopogon schoenanthus* provided grazing immediately after the rains, but oryx abandoned this species and the browses in favour of more palatable grasses such as *Cenchrus biflora*, *Panicum laetum* and *Dactyloctenium aegyptium* as soon as they became available (Newby, 1975b). Scimitar-horned oryx migrated northwards following the rains and the formation of these temporary pastures (Gillet, 1965; Newby, 1974).

Many plants remain green and thus provided continued grazing for oryx over the subsequent colder months between November to February. At the end of the cold season and the beginning of the hot season, scimitar-horned oryx ate large amounts the newly fallen *Acacia* seedpods of *Acacia raddiana* (Newby, 1975b). However, by the hot dry season from March to June, scimitar-horned oryx became reliant on perennial grasses, notably *Panicum turgidum* and *Aristida sp.*, and browse species including *Leptadenia sp*., *Cassia italica* and *Cornulaca monacantha* also formed an important part of the diet (Newby, 1975b; Devillers & Devillers-Terschuren, 2003).

In areas with low, sporadic rainfall and high rates of evaporation, the environment may be waterless for ten months of the year, but scimitar-horned oryx are perfectly adapted to cope with these conditions (Bremen & de Wit, 1983; Newby, 1981a; Davey, 1999; Dolan, 1966). The species can cope without free water for several months at a time, and it is reasonable to assume that they do not drink from the end of the rainy season until the first rains fall, a period of at least eight to ten months (Newby, 1975b, 1978a, 1978b; Anon, 1987a). However, when free water is available, the oryx will take considerable risks to get it and will gorge themselves, making it difficult for them to travel quickly over any distance (Newby, 1975b).

At other times of the year, scimitar-horned oryx gained most of their annual water requirements from the succulent plants that grow along wadis (Newby, 1975b; Davey, 1999). Of these, the wild melon *Citrullus colocynthis* is considered an important forage with its leaves and stems staying green well into the hot season (Newby, 1975b, 1978b; Wakefield, 1996a; Dolan, 1966; Anon, 1987a; Devillers & Devillers-Terschuren, 2003). The leafless twigs and shoots of *Capparis decidua* and *Indigofera oblongifolia* are also eaten in quantity due to their high water content (Newby, 1975b).

Despite the need to exploit a varied and seasonally changing diet, previously naïve scimitar-horned oryx released at Bou Hedma National Park in Tunisia were noted to be cautious about unfamiliar plants (Bertram, 1988; Wacher, 1986b). Individuals investigated novel food plants by sniffing them and thrashing them with their horns before tentatively nibbling the leaves. This behaviour differs from the confident feeding behaviour observed when oryx encountered a familiar plant species. The same animals were also noted to avoid feeding on two toxic species of plants following initial olfactory investigation (Wacher, 1986b; Gordon, 1991).

Table 1. Species known to be eaten by the scimitar-horned oryx in the wild and at release sites for reintroduction programmes. This is not intended to be a comprehensive list, but a guide to their wild diet, and includes plant species from both the Sahelian and North of the Sahara zones.

Group	Species	Notes
Trees	*Acacia raddiana*	Seed pods are eaten. Important part of the diet especially for females suckling young as the pods have a high nutritious value.
	Capparis decidua	Leafless twigs and shoots are eaten in quantity due to their high moisture content.
	Cordia sinensis	It is eaten as it is one of the first plants to green after the rains, but is disregarded when more palatable grasses emerge.
Shrubs	*Amarantaceae (Aerva sp.)*	
	Cassia italica (C. obovata)	Shrub that persists in good quantities into the hot season
	Chrozophora senegalensis	Shrub that persists in good quantities into the hot season
	Cornulaca monacantha	Persistent shrub
	Indigofera oblongifolia	Leafless twigs and shoots are eaten in quantity due to their high moisture content.
	Leptadenia pyrotechnica	Browsed on during the hot season.
	Maerua crassifolia	Browsed on during the hot season.
	Nyctaginaceae (Boerhavia sp.)	
Herbs	*Artemisia sp.*	Compositae
	Blepharis linariifolia	
	Boerhavia repens	
	Citrullus colocynthis (Colocynthis vulgaris)	Most important water nutritive plant species. The leaves, stems and fruit are all eaten and are very moist and bitter, and stay green well into the hot/dry season.
	Chascanum marrubiifolium	
	Cyperus jeminicus	
	Farsetia aegyptiaca	Crucifer with strong mustard flavoured leaves. Popular with the oryx.
	Fimbristylis hispidula	
	Heliotropium strigosum	Herb that persists in good quantities into the hot season
	Indigofera aspera	Leguminous annual. Stems and leaves are eaten.
	Indigofera colutea	Leguminous annual. Stems and leaves are eaten.

Table 1. Continued…

Group	Species	Notes
Herbs Cont.	*Indigofera hochstetterii*	Leguminous annual. Stems and leaves are eaten.
	Inula sp.	Compositae
	Moricandia arvensis	Crucifer with strong mustard flavoured leaves. Popular with the oryx.
	Rhanterium sp.	Compositae
	Tamarix gallica	
	Tephrosia linearis	Leguminous annual. Stems and leaves are eaten in cold season when less succulent plants die out.
	Tephrosia obcordata	Leguminous annual. Stems and leaves are eaten in cold season when less succulent plants die out.
	Tephrosia nubica	Leguminous annual. Stems and leaves are eaten in cold season when less succulent plants die out.
Grasses	*Artistida sp.*	
	Artistida mutabilis	Dry perennial grass. Major part of the oryx's diet in the rainy season and important in the hot season.
	Artistida pallida	Perennial grass. Major part of the oryx's diet in the rainy season.
	Cenchrus biflorus (Cram-cram)	Annual grass on temporary pastures. Important component of the diet in the rainy season.
	Cenchrus ciliaris	Major component of the oryx's diet.
	Cymbopogon schoenanthus	Tuft grass. One of the first to green after the rains. It is disregarded when more palatable grasses emerge.
	Dactyloctenium aegyptium	Annual grass on temporary pasture.
	Echinochloa colona	Annual grass on temporary pasture.
	Limeum viscosum	Annual grass on temporary pasture.
	Panicum laetum	
	Panicum turgidum	Perennial grass that is an important component of the diet in the rainy season. Also offers cover to new born calves.
Fruits	*Acacia raddiana*	Seed pods are eaten. Important part of the diet especially for females suckling young as the pods have a high nutritive value.
	Acacia tortis	Seed pods eaten
	Citrullus colocynthis (Colocynthis vulgaris)	Most important water nutritive plant species especially in the cold season where it forms a large part of the oryx's diet. The leaves, stems and fruit are all eaten and are very moist and bitter, and stay green well into the hot/dry season.

Anon, 1987a; Devillers & Devillers-Terschuren, 2003; Gordon, 1991; Newby, 1975b, 1978b; Wacher, 1986b; Wakefield, 1996a.

5
Reproduction

JUERGEN ENGEL

In the dry region inhabited by the scimitar-horned oryx, the availability of food depends heavily on the irregular rainfall. From the reports available on free-living scimitar-horned oryx, it is known that most of the young are born in a short period of time (approximately two months) when environmental conditions are good (Gillet, 1965, 1966a; Newby, 1974; IUCN, 1987). However, these months may vary from year to year, and after a drought only a few young antelope may be born (Newby, 1974). If environmental conditions are favourable, reproduction may take place all year round (Brouin, 1950; Zuckerman, 1952/53; International Zoo Year Book, 1961; Dittrich, 1970; Kranz & Ralls, 1979; Kirkwood *et al*., 1987; Nishiki, 1992; Volf, 1994). Although the reproductive traits in male scimitar-horned oryx do not appear affected by season (Roth *et al*., 1997), zoo males are somewhat more active in autumn. Consequently, in captivity, most of the young are born in summer (Volf, 1994).

Female scimitar-horned oryx have a partially divided cervix (Kanagawa & Hafez, 1973) and a mean cycle length of 21-26 days (Durrant, 1983; Loskutoff *et al*., 1983; Shaw *et al*., 1995). In some animals a break of 38-96 days between two consecutive cycles has been observed (C. Morrow, *pers. comm*.). Sexual receptivity in female scimitar-horned oryx has been reported to be as short as 30 minutes (Schiewe *et al*., 1991). Theoretically this very short span of time may take place at any time in a period of several months, which makes it extremely difficult for males to find a female in oestrus. Only the postpartum oestrus a few days after parturition can be predicted because it is linked to an externally visible event (Stanley Price, 1989; Volf, 1994).

The mean gestation length is eight to eight and a half months with a range of 242 to 300 days (Brehm, 1920; Brouin, 1950; Dolan, 1966; Dittrich, 1970, 1972; Newby, 1974; Knowles & Oliver, 1975; Kranz & Ralls, 1979; Gill & Cave- Browne, 1988; Walther, 1988; Puschmann, 1989; Nishiki, 1992; Volf, 1994). Due to the postpartum oestrus the minimum birth interval is 261 days. Under the favourable environmental conditions maintained in zoos, most females could easily produce a calf every year (S. Wakefield, *pers comm*.).

Pregnant females leave the herd for approximately one week (Gordon, 1988a), and during that time, give birth to their calf and re-conceive during their post-partum oestrus. Approximately one percent of births are twins, but single offspring are more usual (Brouin, 1950; Haltenorth, 1963; Dolan, 1966; Nishiki, 1992; Mungall & Sheffield, 1994). However, Gillet (1965, 1966a) states that there is a higher incidence of twins being born after a poor year. Gill and Cave-Browne (1988) reported the following description of an oryx giving birth at Edinburgh Zoo:

"The foetal membranes and first hoof became visible 20 minutes before parturition. From this time, contractions occurred every two seconds as the dam alternately stood and sat down. While recumbent, the dam passed faeces twice before the head appeared and five minutes later she stood up, dropping the calf to the ground. She immediately ate the membranes as the neonate struggled to free itself. The dam's intense licking of the calf was interrupted only to allow her to drink the birth fluids lying on the ground. The calf made five attempts to stand, before succeeding after 20

minutes. This particular calf suckled 80 minutes after parturition, though others have taken over two hours. The placenta was passed 168 minutes after parturition and was later eaten."

At birth young scimitar-horned oryx weigh nine to 14 kg (Dittrich, 1969, 1979; Puschmann, 1989; Volf, 1994) and possess two to five centimetre horn stumps (Haltenorth, 1963; Mungall & Sheffield, 1994). The baseline biomedical values for neonatal scimitar-horned oryx are listed in table 2.

Table 2. Baseline biomedical values for neonatal scimitar-horned oryx (Kock & Hawkey, 1988; Ferrell *et al.,* 2001).

Parameter	Median	Minimum	Maximum
Body weight [kg]	9.3 male: 9 female: 10	6.4	11.9
Temperature [°C]	39.0	38.0	40.3
Pulse rate	155	104	256
Respiratory rate	29	18	52
Packed cell volume [%]	34.0	23	50
Total plasma protein [g/dl]	5.6	4.3	6.7
Glucose [mg/dl]	143.5	73	230
WBC [cells/µl]	5900	4350	10600
Neutrophils [cells/µl]	3658	2126	7632
Bands [cells/µl]	0	0	147
Lymphocytes [cells/µl]	1558	696	3584
Monocytes [cells/µl]	215	0	649
Eosinophils [cells/µl]	0	0	87
Basophils [cells/µl]	0	0	87

Scimitar-horned oryx calves lie hidden in vegetation at a distance from their mothers for the first three weeks of their life (IUCN 1987; Gill & Cave-Browne, 1988). Thereafter, they join a nursery crèche with calves of similar age and are then weaned from their mothers at five to ten months (Newby, 1974, 1984; Gill & Cave-Browne, 1988). For the first 15 months of their life young males (there is no data available for females) gain weight according to the following formula: $y=0{,}201x+9{,}961$; $R^2=0{,}984$; $p<0{,}0001$ (Engel, 1997). Males are sexually mature at 10-22 (maximum 30) months, females at 11-27 (maximum 30) months (Dittrich, 1970, 1972; Newby, 1974; Dolan, 1976; Durrant, 1983; Gill & Cave-Browne, 1988; Puschmann, 1989; Nishiki, 1992; Wakefield, 1993a; Volf, 1994).

Several studies on the hormone cycle and artificial insemination have been conducted in scimitar-horned oryx. The oestrus cycle has been monitored by urinary and faecal hormone analysis (Shaw *et al*., 1992, 1995; Durrant, 1983; Morrow & Montfort, 1998), and ovulation has been successfully induced by hormone treatment (Durrant, 1983; Schiewe *et al*., 1988a). Research on artificial insemination with cryo-preserved semen has been carried out (Durrant, 1995; Morrow *et al*., 1997), and last but not least intra-species embryo transfer was studied with fresh (Pope *et al*., 1991), and cryo-preserved embryos (Schmitt, 1986), as well as interspecies embryo transfer with cryo-preserved embryos (Durrant, 1983).

6
Cultural History

JUERGEN ENGEL

The oldest known references to the scimitar-horned oryx are numerous rock paintings and engravings found in the Saharan massifs (Aïr, Hoggar, Ténéré, Tibesti). These very realistic depictions of scimitar-horned oryx were created up to 8500 years ago (Gillet, 1971; Newby, 1974, 1978, 1980, 1988).

In Ancient Egypt scimitar-horned oryx were called 'rãn' (Andrae & Krumbiegel, 1976), and were bred in captivity (Brehm, 1920) and tamed (if not domesticated), at least to the extent that it was possible to keep them on a lead (Bonnet, 1909). A fresco from the tomb of Khnumhotep (about 1000 BC) shows Nubian slaves tending a herd of scimitar-horned oryx (Boessneck, 1988; Newby, 1988). However, the reason for keeping these animals is disputed. Haltenorth (1963) suggests, that they were kept as an offering for religious ceremonies, whereas Bonnet (1909) stated that the primary reason was to provide the people with meat. After studying many reliefs and frescoes Boessneck (1988) concluded that the animals were fattened for oblation in a religious sacrifice. In either case, the wealth of the overlords at their death, was judged by the number of addax (*Addax nasomaculatus*) and scimitar-horned oryx they possessed (Gillet, 1965, 1966a).

There are many reliefs and frescoes depicting scimitar-horned oryx from the period of the 4th to the 6th Dynasty (Boessneck, 1988; Newby, 1988). During the 6th Dynasty (approximately 2320 – 2150 BC), according to the inscription in his tomb, a certain Sabu of Sakkarah (or Saquâra) owned 1308 oryx (Gillet, 1971; Boessneck, 1988; Newby, 1988).

Herodotus (about 484-428 BC) referred to (in IV.192) an oryx the size of a cow, which lived in the north-eastern part of Africa and did not require any water. He also stated that the Phoenician lyres were made from the horns of scimitar-horned oryx.

In the Roman culture, scimitar-horned oryx are depicted on frescoes and mosaics in the Bardo Museum (Johnston, 1898), and in a villa near Tunis (Sclater & Thomas, 1899/1900). A 1600 year old mosaic in the villa Romana del Casale in Sicily shows scimitar-horned oryx which were shipped together with other African animals (Giubelli, 1990). In Rome, the antelopes were kept in paddocks and used for coursings (Hemprich & Ehrenberg, 1828), and Juvenal (Satire XI.140) stated that the species was part of the buffet of wealthy Romans. Consequently, poets like Martial (Epigram XIII.95) or Oppianus from Apameia (Kynegetika II.445) were aware of some of the behavioural patterns of these animals. In his masterpiece 'Naturalis Historia' Pliny the Elder mentions scimitar-horned oryx several times (II.107; VIII.214; X.201; XI.255).

From the neolithic to the late 20th century, scimitar-horned oryx have always been a favourite animal of the hunt (Newby, 1978a), and much of the culture and the livelihood of a number of Sahelo-Saharan tribes have been derived from oryx hunting. The Nedmadi of Mali and Mauritania, the Aza and Mahalbi of Niger, and the Haddat of Chad and Sudan all incorporated hunting as a major activity and integral part of their cultural history (Newby, 1988).

Oryx hide is generally regarded as being of superior quality. The hide of the neck and shoulder was prized by the Berber peoples for making the shields with which they went into battle (Newby, 1988). During the middle ages, the king of Rio de Oro sent 1,000 shields made of scimitar-horned oryx hide as a gift to a contemporary (Dolan, 1966). The oryx has supplied a lucrative commercial trade in leather goods since at least the 16th century, when Leo Africanus recorded that 600 skins were sent from the 'Land of the Negroes' to Fez, and that each skin was recorded as being worth eight ducates, approximately half the price of a male slave. Since that time, oryx hide has been used for ropes, harnesses, storage sacks, saddlery, cords and even shoeing horses (Newby, 1988).

7
Conservation

SIMON WAKEFIELD, JUERGEN ENGEL & TANIA GILBERT

Former & Current Distribution of Scimitar-horned Oryx in North Africa

Red Data Book listing: **Extinct in the Wild** (IUCN, 2002).

In former times scimitar-horned oryx were common in large areas of northern Africa (figure 1). The species' range extended from the Atlantic Ocean almost up to the Red Sea and from the Mediterranean Sea to the 15th degree of northern latitude (Haltenorth, 1963; Schomber, 1963; Wilson, 1980). Only the eastern boundary of their former distribution is a subject of controversy. Some authors (e.g. Bonnet, 1909; Brehm, 1920; Flower, 1932; Harper, 1945; Dolan, 1966; Kock, 1970; Newby, 1988) state that the river Nile represented the limit of the species range, however others (Haltenorth, 1963; Schomber, 1963; Gillet, 1965, 1966a; Mungall & Sheffield, 1994), believe that the oryx occupied additional areas east of the river.

Being a sub- or semi-desert species, the actual distribution would have been dictated by available habitat, and therefore the described range was never uniformly occupied (Newby, 1978, 1988). Typically, the perennial grassland formations, dry acacia woodlands and flushes of annual herbs and grasses, which the oryx utilise, occur where annual precipitation is between 75 and 400mm. During the arid conditions of the last three thousand years, this has meant that the potential distribution has been largely the northern and southern sub-desert fringes of the Sahara, and potentially in areas such as the fringes of central Saharan mountains where local run-off supports these vegetation communities (Devillers & Devillers-Terschuren, 2003).

The range of the scimitar-horned oryx is thought to have declined since Roman times, due to habitat loss and hunting (Newby, 1988; Gordon, 1991). All the populations on the northern fringe of the Sahara had certainly disappeared by the beginning of the 20th century. The southern Sahelian range remained almost continuous until the 1960's, became fragmented into several larger portions during the 1970's, persisted as two fragments in Niger and Chad during the 1980's, until finally the species was only thought to occur in Chad (Newby, 1988).

In 1976, scimitar-horned oryx were classified as vulnerable by IUCN. By then resident populations had already disappeared from Algeria, Burkino Faso, Egypt, Libya, Mauritania, Morocco, Senegal, Tunisia, and Western Sahara, leaving only four countries (Chad, Mali, Niger and Sudan) with extant populations. Soon afterwards the oryx in Sudan, which had already been reduced to a few isolated herds in the Darfur region, become extinct (Newby, 1982). The formerly widespread population of Mali is believed to have become extinct in 1981 (Lamarche – in Newby, 1988), and by this time the population of Niger was reduced to probably less than 200. The last oryx seen in Niger was a herd of four animals located between the Aïr mountains and Termit in 1983, and scimitar-horned oryx are believed to have become extinct in Niger that year (Newby, 1988).

The only population of scimitar-horned oryx that was thought to have had a reasonable chance of survival at this time was in the Sahelian regions of Chad south of the Ennedi, in the Ouadi Rimé-Ouadi Achim region (Newby, 1988). In 1977, the population of this reserve was estimated to be 4000-6000. However, in 1978 civil war in Chad disrupted protective measures in the reserve and the population was reduced to a handful of scattered groups (Anon, 1987a).

During the last two years there have been unconfirmed sightings of oryx in the eastern part of Niger and western Chad (Newby*, pers. comm.*) However, it is quite likely that another species, perhaps dama gazelle, have been mistaken for oryx, as very few people would now have any familiarity with the species in the wild.

Causes of Decline

There is no single reason for the decline, and then the extinction of scimitar-horned oryx across its natural range (Newby, 1988). A number of factors have contributed including over-hunting, war, development, drought and competition with domestic livestock (Dixon *et al.*, 1991; Wakefield, 1992).

Hunting

Newby (1980) attributes hunting as being the greatest single cause of the Sahelo-Saharan fauna's rapid decline. Oryx have been hunted for millennia for meat, and for their valuable hides that have supplied a prestigious trade in leather goods. Traditional hunting of oryx using spears, throwing sticks, bows, nets and dogs had little effect on the wild populations (Barzdo, 1982; Newby, 1980, 1981a, 1988). However, this changed with the introduction of firearms and the motorcar. These vehicles opened up the waterless deserts and the slow-running oryx were easily chased down (Newby, 1980, 1981).

During World War II, much aridland fauna was shot by the occupying armies (Wakefield, 1992), and after that time motorcars, particularly four wheel drive vehicles, became commonplace. The military and expatriate mining, mineral, petro-chemical and administrative personnel took advantage of easy sport (Barzdo, 1982; Newby, 1980), and this resulted in an unsustainable level of hunting (Dixon *et al.,* 1991). Tourists have also played an unwitting role in the decline of wild oryx numbers. They have chased after oryx to get that perfect picture often resulting in the oryx dying from heat exhaustion, calves being abandoned and unborn young being aborted (Newby, 1988).

Habitat Loss, Development & Competition with Domestic Livestock

The reasons for the increased aridity and desertification of North Africa are both natural and man-made. Since the Neolithic, the Saharan and sub-Saharan climate has been getting drier (Newby, 1980), but the effects of this have been exaggerated by human impact. Over the past few decades, the marginal aridlands of the Sahel have come under ever-increasing pressure.

In the past, the nomads would move their livestock seasonally to different pastures to ensure enough food and water for their animals. However, international aid programmes have helped sink boreholes, cement deep wells and install pumping stations to ensure a continuous supply of water. Consequently, nomads have become sedentary herdsmen who do not move their livestock around and exploit all the grazing in the areas where they have settled (Newby, 1988). This has resulted in three effects:

1. Burgeoning livestock numbers has resulted in overgrazing. Subsequent soil erosion and desertification has caused the loss of large tracts of formerly rich pastures. Equally serious is

2. the destruction of tree cover as an important resource for oryx, as they spend much of their day lying in the shade in a bid to conserve water (Newby, 1980).

3. Direct competition with livestock. Domestic animals tend to remain close to the waterholes, and deprive wild ungulates of their traditional dry-season pastures. The oryx are forced out of the best pastures and onto poor or marginal lands (Newby, 1980).

4. Proximity to human settlements. The permanent presence of nomads brought the oryx into much closer contact with people, and so increased the opportunities for hunting (Newby, 1988).

Drought

Drought has serious biological consequences and recent episodes resulted in the disappearance of ephemeral pastures that scimitar-horned oryx relied on. Without them, they cannot build sufficient fat reserves to see them through the hot, dry months (Wakefield, 1992). In addition to the risk of starvation, drought weakens the immune system making animals more susceptible to disease and parasites, as well as causing them to abandon new-born calves (Newby, 1978a, 1980). The worst impact on numbers can be observed when drought is coupled with hunting. The animals, already weakened by the drought, tire faster and are more susceptible to heat exhaustion (Newby, 1980). Chronic droughts will either kill the animals outright, or force them to adopt their traditional coping mechanism of migration. However, this forced scimitar-horned oryx into areas where they came into conflict with humans (Dixon *et al.,* 1991; Newby, 1978a).

War and Political Instability

Political instability and war have contributed to the decline of scimitar-horned oryx in the wild (Barzdo, 1982; Gordon, 1991). The most notable example of this was seen in Chad, when the conservation work at the Ouadi Rimé-Ouadi Achim Faunal Reserve, the world's last stronghold of scimitar-horned oryx, had to be abandoned in 1978 (Wakefield, 1995b). Subsequently, the scimitar-horned oryx became extinct in the wild.

Measures to Conserve Scimitar-horned Oryx

International protection

- Scimitar-horned oryx are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), also referred to as the Washington Convention. This means that commercial trade in this species is strictly prohibited, however trade may occur for scientific research (CITES, 2002).

- Scimitar-horned oryx are protected under the Convention on the Conservation of Migratory Species of Wild Animals, otherwise known as the Bonn Convention or CMS. The Convention came into force on the 1st of November 1983, and as of September 2002, it had 80 signatories. Scimitar-horned oryx are listed under Appendix I, Resolution 3.2, paragraph four, and are given strict protection by the convention (UNEP, 2002).

- Scimitar-horned oryx are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (1968). Under the convention scimitar-horned oryx are totally protected, but may be hunted, killed or captured or collected under special authorisation granted by the 'Competent Authority' (UNEP, 2003).

National protection
The species is totally protected in Algeria, Tunisia, Mauritania, Mali, Niger, and partially in Sudan.

Ex situ Conservation of Scimitar-horned Oryx

History in captivity
Records of scimitar-horned oryx in captivity go back to the 1940s and '50s, but the majority held in the captive population descend from wild-caught animals from Chad in the mid 1960's (Rost, 1985; Dixon *et al.*, 1991). These animals, and their offspring, were distributed from European zoos to Great Britain, North America, and more recently Australasia (Dixon *et al.*, 1991). Records of these early captures and the subsequent transfers and births are incomplete, and consequently the ancestry of many animals is not entirely known. However, assuming the worst-case scenario, 30 founders of the North American and 12 of the British population have been identified (Dixon *et al.*, 1991; Gill & Cave-Browne, 1988; Knowles & Oliver, 1975). In total, the number of wild-caught founders of the global population is estimated to be less than 40 – 50 (Dixon *et al.*, 1991; Mace, 1986).

It is probable that bloodlines from other founders, not represented in the European, North American and Australasian co-ordinated captive management programmes, are present in the captive global population of scimitar-horned oryx. Certainly institutions in North and South Africa, Indonesia, the Middle East and Europe hold oryx that are not part of any such programme. Nishiki (1992) reported that oryx held in Tama Zoo, Tokyo are descended from a wild-caught pair which arrived at the zoo in November 1967. By 1989, 25 oryx had been sent to other institutions including other Japanese zoos and zoos in Cuba and Beijing.

Co-ordinated breeding programmes
On an international level, Europe, North America and Australasia have co-ordinated captive breeding programmes for scimitar-horned oryx. The International Studbook for scimitar-horned oryx is held by Marwell Preservation Trust.

The European captive breeding programme
In 1985, a captive breeding programme for scimitar-horned oryx was established in Great Britain, and in 1989, this programme was incorporated into the European captive breeding programme, the Europäisches Erhaltungszucht Programm (EEP) (Dixon *et al.,* 1991). The EEP is a programme of the European Association of Zoos and Aquaria (EAZA), and is designed to collate data and co-ordinate breeding of certain species at a European (EAZA member) level.

The studbook for the European captive population of scimitar-horned oryx, states that the population on the 31st of December 2003 was 148.298.3 (449) in 51 EEP institutions and 40.43.0 (83) in 13 non-EEP European institutions (Gilbert, 2004). It is likely that the figures are notably higher due to non-returns of questionnaires and oryx held in private collections.

North American captive breeding programme
The North American population of scimitar-horned oryx appears to descend from 30+ wild-born founders caught in Chad in 1967. However, there were three earlier imports of wild-caught animals from the same area in Chad (Rost, 1985). In 1981, the American Association of Zoological Parks and Aquaria (formerly AAZPA but now known as AZA) set up the species survival plan (SSP) for scimitar-horned oryx (Dixon *et al.*, 1991; Anon, 1989), and development of the North American regional studbook began in 1984 (Anon, 1989). Part of the SSP involved

the development of supporting ranch programmes (Rost, 1985), and in 1983, the Texas Ranch Project began (Anon, 1989). There are now several ranches in Texas with oryx, but the largest herd is held at the Bamberger Ranch near Johnson City, Texas (J.Baccus, *pers. comm*.).

The Australasian captive breeding programme
The Australasian Species Management Program (ASMP) was established by the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA) in 1993. The first animals to be brought into the region were originally shipped into New Zealand from Marwell Zoological Park (UK) in 1978. These animals bred and their offspring were dispersed to institutions in Australia. Further oryx were imported from Marwell in 1986 and 1987. The population of scimitar-horned oryx in the Australasian region as of the 30th June 2002 was 24.47.0 (71) (R Wilkins, *pers comm*.).

The global overview
In the 1990s, the Conservation Breeding Specialist Group (of the IUCN Species Survival Commission) established that the scimitar-horned oryx was the second most commonly found antelope species in 'managed' populations around the world with over 1,200 individuals in zoological institutions. This figure excluded the oryx held on the Texas ranches which total more than 2000 animals (Lankard, 2001). Current estimates of the global captive population from the international studbook put the number of captive oryx at 913.1124.25 (2062). This may be an overestimate, but it is certain that oryx breed well in captivity and readily adapt to captive conditions (Dixon *et al.*, 1991).

In situ Conservation Activities
While scimitar-horned oryx continue to rely on responsible *ex-situ* management, efforts are now being made to return this species to the wild.

Release projects
A number of projects have been initiated, or proposed, to reintroduce scimitar-horned oryx to the Sahelo-Saharan region. In 1985, Bou Hedma, Tunisia, became the first National Park (NP) to receive captive oryx for release back into the wild. Since then, projects have been initiated in Sidi Toui NP, Tunisia; Souss Massa NP, Morocco, and the Guembeul Fauna Reserve and the Ferlo NP and Biosphere Reserve, Senegal. Wildlife surveys have taken place in Chad and Niger to establish if suitable sites exist for the reintroduction of oryx, and other countries have initiated and participated in activities to return this species to their natural range. Further details of some of these activities can be found in Appendices A to E.

The rationale for current release projects tend to follow formal planning processes including the provisions in the Djerba Action Plan, and efforts are being co-ordinated via the Sahelo-Saharan Interest Group (see below).

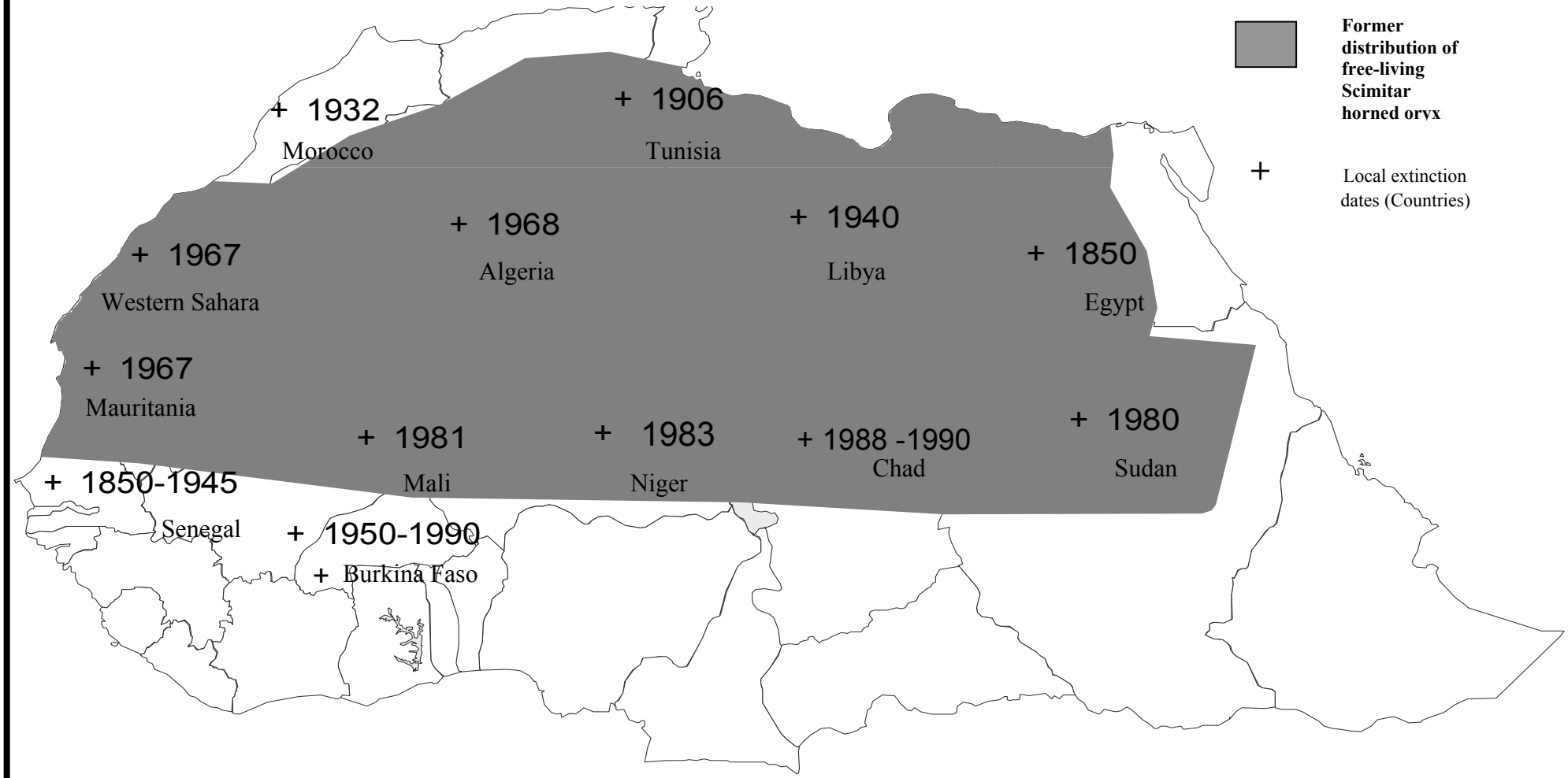
The Djerba Action Plan
In February 1998, a workshop on the 'Restoration and Conservation of Sahelo-Saharan Antelopes' was held at Djerba, Tunisia, under the auspices of the United Nations Environmental Programs (UNEP) Convention on Migratory Species. The workshop attracted delegates from Sahelo-Saharan states, as well as antelope experts from around the globe. The workshop addressed six issues; desert habitats, research and monitoring, capacity building and training, sustainable use and economic development, development and funding of national projects, and captive breeding and re-introduction. In 1999, as a result of this workshop, the previously written

draft Action Plan was approved and distributed as the final Djerba Action Plan (Monfort, 2000; S Wakefield, *pers comm*.).

The Sahelo-Saharan Interest Group

In May 1999, a meeting was held at Marwell Zoological Park in the UK that included captive managers of scimitar-horned oryx and representatives of non-government organisations (NGOs). Delegates from North America and Europe discussed how progress could be made to implement some of the provisions of the Djerba Action Plan, namely the reintroduction and restoration of aridland antelopes. As a result of the meeting, an informal Sahelo-Saharan Interest Group (SSIG) was formed which agreed to work towards the implementation of aridland antelope restoration and reintroduction programmes by working, and co-ordinating efforts with the range state's governments (Monfort, 2000). Since that first meeting, the SSIG has met four more times, and continues to work towards implementing effective *in situ* conservation projects in Sahelo-Saharan range states.

Figure 1. Distribution map of the past population of scimitar-horned oryx in North Africa



Map based on Sclater & Thomas 1899/1900; Bonnet 1909; Brehm, 1920; Maydon, 1923; Flower, 1932; Rode, 1943; Harper, 1945; Haltenorth, 1963; Schomber, 1963; Gillet, 1965, 1966a, 1971; Dolan, 1966; Newby, 1975c, 1984, 1988; Wilson, 1980; Barzdo, 1982; Wacher, 1986b; IUCN, 1987; Heringa, 1989; Stanley Price, 1989; Dixon *et al*, 1991; Gordon, 1991; Sausman, 1992; Gordon & Gill, 1993; H.Brahim, *pers comm*.

PART TWO

Husbandry Guidelines

Photograph: scimitar-horned oryx and Grevy's zebra at Marwell Zoological Park, UK. Photograph by Tania Gilbert.

8
Social Organisation of Scimitar-horned Oryx in Captivity

JUERGEN ENGEL

The social organisation of captive ungulates is dictated by the institutions in which they are held. This section reviews the various social systems for managing herd animals with special reference to available knowledge on the social behaviour of scimitar-horned oryx prior to extinction in the wild (section 3) and experiences gained from maintaining the species in zoos (appendix F). As scimitar-horned oryx are gregarious in nature, I begin by discussing the various ways in which a herd may be constituted. Thereafter, I address questions regarding the formation of bachelor groups, and managing animals in pairs or singly.

Herds

One male, several females (harem group)
Harem groups, consisting of a dominant male, several females and their offspring is the most common system for managing scimitar-horned oryx in zoos throughout the world, and is recommended by previous authors writing on the subject (Kock and Hawkey, 1988; Puschmann, 1989).

An important issue is the timing of the removal of young males from the breeding herd. Male scimitar-horned oryx become sexually mature at ten to 22 (maximum 30) months of age (Dittrich, 1970, 1972; Newby, 1974; Gill & Cave-Browne, 1988; Wakefield 1993b; Volf, 1994). However, to breed successfully, males have to be dominant over their mate, and they are unlikely to exert dominance over all females until they are four years old (Engel, 1997a). Observations made at Paris Zoo suggest that some young oryx (less than four years old) will mate with females, but this tends to depend on the rank of the female concerned (C. Renvoise, *pers comm*.). Males facing competition with other among multi-male breeding groups (see below) will not reproduce until 28 to 42 months of age (Nishiki, 1992). Therefore, if the enclosure is sufficiently large and well structured, young males do not need be removed from the breeding herd (if ever) until they are two years old at the earliest.

As there is an almost balanced sex ratio at birth in the captive population with an equal number of male and female scimitar-horned oryx, the question remains what to do with the surplus male animals. Possible solutions, including groups with more than one adult male or bachelor groups are discussed below.

Several males, one female
This grouping is definitely not recommended, as every adult male will try to monopolise the female. Consequently, there will be a large number of severe aggressive encounters between the males and a lot of distress caused for the female, which will be permanently herded, courted or mated without any time for rest.

Several males, several females (multi-male group)
In the wild, scimitar-horned oryx formed groups with an almost equal sex ratio of 1:1 (Newby, 1974; Estes, 1974, 1991a, 1991b; Kranz & Ralls, 1979; Macdonald, 1984; IUCN, 1987; Stanley Price, 1989; Gordon, 1991). In contrast, zoo animals are almost exclusively kept in one-male to several females groups with only a few institutions going against this convention by keeping several males and females in the same herd.

Essential requirements for this type of group are a large and well-structured enclosure, as well as one male whose dominant position is unchallenged. The latter is easily accomplished if the prime male is considerably older (though not senile) than the other males. The subdominant males will form a subgroup within the herd, but not an independent bachelor group (Engel, 1997a).

Problems will occur when there is only one other adult male in addition to the dominant breeding male. If there are several bachelors, the attention of the alpha male is not focused on a single competitor. As a result, there are no long-lasting agonistic interactions and the whole group is much more stable.

If a specific male is recommended for breeding, the other males have to be removed from the group for about one month. On their return, the breeding male will prevent them from getting close to any females in oestrus. If a bachelor tries to usurp the dominant male when returned to the herd, he should be removed from the group for another two to three weeks. This should protect the alpha position of the desired breeding male (S. McKeown, *pers. comm*.).

Single sex groups: several males (bachelor group)
All male or bachelor groups were not recorded in wild scimitar-horned oryx, but are a common phenomenon in ungulates. Engel (1997a) addressed this question for scimitar-horned oryx statistically by comparing the social systems of 147 bovid (sub-) species. The study concluded that there was a high probability (99.75%) that all-male groups of scimitar-horned oryx would occur naturally. Moreover, bachelor groups can be expected to include males of varying ages and to be formed throughout the year.

Bachelor groups of scimitar-horned oryx have been formed in zoos with varying degrees of success. However, this approach may offer a viable solution to problems of surplus males and opportunities for their social development provided lessons from previous experiences are taken into consideration.

According to Engel (1997a), 60% of zoos maintaining scimitar-horned oryx bachelor groups, experienced problems including aggressive interactions between animals that resulted in death. In other cases, individuals had to be separated with many males losing one or both of their horns. Horn loss presents a problem if an individual is needed for breeding at a later date because females will not tolerate males that are unable to become dominant in the herd.

The Fossil Rim Wildlife Center in Texas has attempted to control aggression in bachelor groups with the aid of hormonal implants (Blumer *et al*., 1992). Similar experiments using a synthetic progestogen given with feed were carried out with all-male groups of fringe-eared oryx *Oryx gazella callotis* at the San Diego Wild Animal Park (Patton *et al*., 2001). All treatments successfully reduced aggression for some time, but little is known about possible side effects or long-term impacts. Consequently, it is uncertain if medication is really a practical solution for the problem. In some cases, castration of the most aggressive animals has led to a

more peaceful bachelor group. However, this is not an appropriate method because it is not possible for the animals to contribute to the captive breeding programme after the operation.

The key factors dictating levels of aggression in bachelor groups appear to be available space, group size, and age of individuals:

Problems tend to occur when space is limited and the group size is small. If the enclosure is large, the animals are able to avoid one another. If there are many animals in the group, the attention of the dominant male is directed towards many opponents, and so attacks are not concentrated on any particular individual (Krebs and Davies, 1993). This is analogous to several bachelors entering the territory of a conspecific dominant male and creating a situation in which the energy expenditure needed to repel those incursions is too great (Geist, 1968; Gosling, 1986).

In addition, problems will tend to occur when all males are greater than 22.5 months in age and are sexually mature. Conversely, an obvious stratification of ages should produce a mostly peaceful group. If one animal is about two years older than its group members, it is able to hold the alpha position unchallenged. Moreover, this animal will act as peacemaker and prevent aggression amongst other members of the group (Mungall & Sheffield, 1994; Engel, 1997a).

In bachelor groups, there is no behavioural difference between individuals that have already produced offspring and those that have not been used for breeding. Neither the presence of females of other bovid species, nor a lack of linearity in the rank order affects the bachelor group negatively (Engel, 1997a).

Assuming the above points are taken into consideration, the formation of bachelor groups is highly recommended, particularly as all-male group may play an important role in the socialisation of young males. In mixed herds, the lower ranking male adopts the female role in mating behaviour between two males. In bachelor groups there is no such correlation between rank and role. This supports the hypothesis that young male scimitar-horned oryx in a bachelor herd perfect their sexual behaviour through practical training. Young subdominant males in mixed groups do not have this opportunity. Furthermore, it is evident that learning is more important in all-male groups than the demonstration of dominance (Engel, 1997a).

A final observation is that the level of aggression reported in all-male groups of scimitar-horned oryx may be a particular phenomenon of artificially well-fed zoo populations. In the wild, scimitar-horned oryx live in semi-arid and desert habitats where they spend most of their time searching for food, and by the end of the hot season they are usually in very poor condition (Gillet, 1966a; Newby, 1974). Bachelor groups in particular are forced to live in the least favourable habitats (Bigalke, 1974; Gosling, 1974; Montfort-Braham, 1975; Attwell, 1982). Although the mechanisms by which diet modulates gonadotrophin secretion are unclear, there is substantial evidence for a positive correlation between nutrition and testosterone levels (Setchell *et al*., 1965; Millar & Fairall, 1976; Gauthier & Couland, 1986). Furthermore, there is a positive correlation between testosterone and social aggressive behaviour (Illius *et al*., 1976, 1983; Sapolsky, 1982, 1993; Bouissou, 1983; Sachser & Pröve, 1986). It may be possible to reduce aggression in zoo-based bachelor groups by modifying the diet. This would be in perfect accordance with what is known about the ultimate and proximate factors of all-male groups (Engel, 1997a).

Single sex groups: several females
There are no reports of female scimitar-horned oryx adopting this social system naturally and the long-term consequences are not known. All-female herds of scimitar-horned oryx may be useful for temporary suspension of breeding when needed and there are no reports of the levels of aggression seen in bachelor groups. Observations of all-female groups in zoos reveal a distinct hierarchy with the highest ranked female adopting the role of a dominant male and displaying elements of male behaviour including herding, courtship, defecating in a deep squatted posture, and conciliation of horn fights between subdominant herd members (Engel, 1997a).

Herds: additional comments
Scimitar-horned oryx have a strong social structure with a well-defined social hierarchy. The removal of individuals from the group for any length of time may result in the change in the social hierarchy of the group, making it difficult to re-integrate an animal back into the herd. Observations made at Paris Zoo suggest that females should only be segregated for a maximum period of one week. Separating them for longer could result in a change of their social status and rank (C Renvoise, *pers comm*.).

Pairs
Although male-female pairings have been reported in the wild during the last stage of pregnancy, birth and the period of postpartum oestrous when a female and a dominant male separate from the herd, it is only a temporary occurrence (Gordon, 1988b). In terms of captive husbandry, pairing animals is not recommended as a long-term solution. Without the distraction of other animals, a male may seriously molest a single female.

Solitary Animals
Scimitar-horned oryx are gregarious in nature and individuals were unlikely to have spent much, if any, time separated from the herd. Exceptional cases of solitary males have been recorded, but these may have been animals temporarily defending territories when conditions allowed (Wacher, 1988).

Although some zoos keep surplus males in isolation (Nishiki, 1992), this should only be done for short periods and if no other option is available. In the long term, there are risks that singly housed animals may not become socially competent and could develop aberrant or stereotypic behaviour. In males, this may even result in impotence as observed in Przewalski's horses *Equus ferus przewalskii* (Boyd, 1988 & 1991; Tilson *et al.,* 1988).

Recommendations from the EEP Coordinator
The following social groupings are recommended by the EEP Coordinator for scimitar-horned oryx in captivity with due consideration of advice set out above:

- Harem groups (one male, several females)
- Multi-male groups (more than one mature male)
- Bachelor groups
- All female groups (if necessary for husbandry reasons)

In context, housing single animals, pairs and groups with more males than females should be avoided.

9
Reproduction & Breeding Management

SIMON WAKEFIELD & JUERGEN ENGEL

Scimitar-horned oryx breed well in captivity. Although there are no records on the longevity of free-ranging scimitar-horned oryx, they will live for 18-20 years in captivity (Spinage, 1986; Jones, 1993).

For breeding programmes attention should be focused on attaining the required calf production to meet the needs of the captive breeding programme. Without any form of birth regulation, a female oryx could easily produce a calf every year. In the past this has lead to a policy of temporarily 'freezing' breeding in some EEP zoos to prevent an unmanageable surplus of animals. This approach has the advantage of controlling the number of offspring per annum, and obtaining offspring from under-represented founder lineages. However, some zoos are unwilling to implement such a strategy due to the public appeal of young animals.

Another important consideration in the captive breeding of oryx is the climatic zone of the collection keeping the species. Where animals may spend prolonged periods inside due to unfavourable weather conditions, such as winter in the northern regions, it is best to avoid calves being born at this time. Under these conditions, mother-calf contact in indoor stalls is abnormally high compared to natural conditions, or during the summer, when a new-born calf may be left alone for periods while the mother is feeding nearby. As a result, calves tend to over-feed, and this has resulted in high calf mortality due to digestive ailments such as *E. coli* infections.

Where winter calves are likely to suffer, it is better to regulate the breeding season by only introducing the breeding male at the appropriate time. For example, in Northern Europe, putting the male into the group in late summer or early autumn will result in calves being born in late Spring, at a time when the herd should have free access to a sufficiently large outdoor enclosure or paddock. This will ensure that mother-calf contact is more normally distributed through the daily activity cycle. The breeding male should then be removed again in the Spring just before the first calves are expected, to avoid pregnancies arising from mating during post-partum oestrus.

If the herd is kept in a smaller yard over the winter for paddock protection or parasite control, it is better to release the breeding male into the group while it still has access to a larger summer paddock. This is because during the first few days after the introduction of the male there will be frequent bouts of chasing behaviour as the group settles down to accept the new social structure. It should also be noted that during the period of removal from the group, the male should have an adequate enclosure.

Typically, it is easier to tag and give a veterinary check to a calf within the first few days of birth. One system that can be employed is to isolate mothers from the rest of the herd a few days before the expected birth and to keep mother and calf together for a few days before releasing them back into the group. A sudden swelling of the udder with milk indicates an

imminent birth. During these first few days the calf can be tagged and it also ensures correct identification of the dam of each calf (section 14).

When all births are co-ordinated to fall within a relatively short space of time, the calves will often all crèche together during resting periods. A favoured place for this is a sand pit, which should be provided where possible.

Where the climate permits, oryx should have access to a large outside enclosure at all times of the year. However, the needs of the programme in terms of numbers of births and priority individuals for breeding should also be borne in mind.

It is known from the studbook data that a young male of only 15 months is already sufficiently mature to successfully mate and produce offspring. There is some debate over when the males should be removed from the breeding group, but to ensure that young males will not mate with the group, they should be taken out of the breeding group before they reach 15 months. Females are also sexually mature between 18 months and two years.

The ratio of male to female oryx born in EEP institutions is approximately equal. However, due to the social (harem) structure of the scimitar-horned oryx in most zoos, the equal ratio of births will result in a surplus of males. This is a potential problem for institutions that do not have the facilities to hold male oryx separately from the breeding group. There are several options for the management of the surplus male oryx population and they are listed below (section 8):

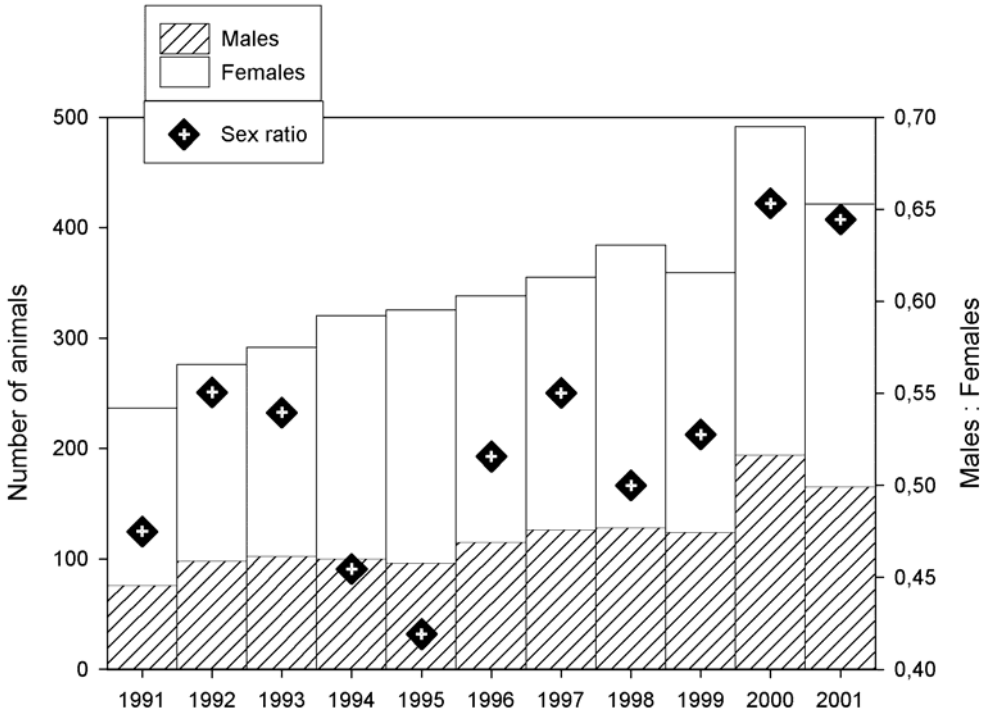
1. Surplus males can be held in bachelor herds either alongside a breeding group at an institution, if such facilities are available, or at an institution that only holds male oryx. The advantage of this strategy is that males can be rotated relatively frequently between breeding and bachelor groups to ensure that there is an equal contribution of founder genes to the captive gene pool.

2. Males from well-represented founder lineages may be castrated and held with female oryx. This scenario is rare and there are risks associated with any surgical procedure.

3. Males from well-represented founder lineages may be euthanased if the animal cannot be appropriately placed with a herd of oryx.

Before any of these options are considered, the regional breeding programme coordinator or studbook keeper must be consulted, so they can advise on which course of action is the most appropriate for the individual animal, and the captive population as a whole. It would be detrimental to the genetic diversity of the captive population if a genetically important animal were prevented from contributing its genes to the captive gene pool. Data available on the captive population indicates that the reported number of male and female oryx held in EEP institutions over a ten year period, is disproportional in favour of females (Figure 2). This suggests that given the approximately equal male to female birth ratio, that male scimitar-horned oryx have a higher level of mortality in captivity.

Figure 2. The ratio of male to female scimitar-horned oryx in the EEP from 1991 to 2001. The number of male and female oryx in the EEP is indicated on the left vertical axis, and the proportion (ratio) of male to female oryx in the EEP is indicated along the right vertical axis.



10
Zoo Diet & Nutrition

TANIA GILBERT

There is a lack of data on the dietary needs of scimitar-horned oryx, either in the wild, or based on experiences of captive husbandry (Lechner-Doll *et al.*, 2000). While some information is available on plants consumed by the species, apparently no chemical analyses have been carried out, without which comparisons of nutritional composition between natural and captive diets are not possible (Oftedal *et al.*, 1996). However, given the diversity of the reported scimitar-horned oryx diet in the wild, and apparent ability of the animals to switch between monocotyledon to dicotyledon resources, it is unlikely that this has been, or can be, readily duplicated. Seasonal changes are likely to be significant but are not addressed in captivity (Lechner-Doll *et al.*, 2000).

In captivity, scimitar-horned oryx diets are based on the requirements of their domestic ruminant counterparts. Extensive information is available on domestic ruminant diet and nutrition, and this at least provides a foundation for the formation of diets for exotic species (Oftedal *et al.*, 1996). The summary of captive scimitar-horned oryx diet presented here is based on questionnaire returns from 22 EEP institutions. This represents approximately 42% of EEP scimitar-horned oryx holders in Europe and offers a reasonable overview of captive diets for the species.

Bulk forage is provided in the form of grass hay and Lucerne (Dittrich, 1979; Gill & Cave-Browne, 1988), although other forages, such as peanut hay, have been fed to oryx reintroduced to Senegal (B Clark, *pers comm*.). Concentrated feed or pellets usually form a major component of the diet, and this is supplemented with a range of other foodstuffs, most commonly vegetables, fruit and freshly cut browse. Approximately 88% of captive herds have access to pasture, though for many, this is seasonally dependent (see tables 3 & 4, and Appendix G).

In the majority of cases, grass or Lucerne hay is provisioned on an *ad libitum* basis. EEP zoos have revealed a preference for providing oryx with grass hay rather than Lucerne hay, although some make both readily available to the oryx. If sufficient hay is not available, scimitar-horned oryx are reported to eat their own straw bedding. Dividing hay rations into several piles on the floor or in a number of racks should ensure all animals have access to the resource (Dittrich, 1976).

Pellet feeds offer a convenient method for ensuring that the oryx's nutritional requirements are met (Gill & Cave-Browne, 1988; Oftedal *et al.*, 1996). Zoos traditionally use cattle concentrates, but problems associated with high protein levels have been reported and new formulas available from commercial feed companies have become more popular.

Traditional high protein feed can lead to overweight animals, especially if the oryx do not have the opportunity to get sufficient exercise, as well as overgrown hooves and diarrhoea. Moreover, when commercial concentrates are fed in large quantities, acidosis develops

resulting in chronic rumenitis (Lechner-Doll *et al.*, 2000). Pellets should be fed to lactating females with young offspring, but the amount should be reduced if scouring is observed in the calves (E. Flach, *pers comm*.). Some concentrated feeds are reported to contain too little copper leading to symptoms synonymous with copper deficiency (Allen & Oftedal, 1996). This is discussed further in section 15.

Table 3. The number of EEP zoos which provide each food item in the summer diet for captive scimitar-horned oryx. *The data is derived from the 22 returned questionnaires sent to all EEP institutions holding scimitar-horned oryx*.

Food stuff	Total number of EEP zoos which feed the food stuff to scimitar-horned oryx
Pellets	19
Grass/grazing	18
Hay	22
Lucerne hay	8
Mineral salts	22
Maize	5
Oats	8
Barley	4
Fruit	8
Vegetables	10
Browse	8
Dried sugar beet pulp	1
Acacia fruit	1
Sugar beet	1
Bran carrubba	1

Table 4. The number of EEP zoos which provide each food item in the winter diet for captive scimitar-horned oryx. *The data is derived from the 22 returned questionnaires sent to all EEP institutions holding scimitar-horned oryx*. *However only 18 institutions provided data on the winter diet for the oryx. See Appendix H for a nutritional breakdown of some of the food items.*

Food stuff	Total number of EEP zoos which feed the food stuff to scimitar-horned oryx
Pellets	15
Grass/grazing	11
Hay	18
Lucerne hay	6
Mineral salts	12
Maize	4
Oats	5
Barley	4
Fruit	7
Vegetables	8
Browse	4
Bran molasses	1

The pellets themselves are made of a variety of constituents, which vary according to the brand manufacturer. No manufactured pellet should contain meat meal due to the concerns over Bovine Spongiform Encephalopathy (BSE) in ungulates.

Some EEP institutions report seasonal adjustment to diet to maintain condition of animals in the winter when pasture access is limited, and energy requirements are higher to cope with thermal stress. At Marwell, scimitar-horned oryx have daily access to grazing during the summer months (Knowles & Oliver, 1975), and are provided with *ad libitum* hay and one kilogram of formulated pellets per animal. During the winter months the animals are maintained off paddock, and oats are added to the diet together with rations of flaked maize if there is a noticeable loss of body condition (Appendix G).

Feeding fruit and vegetables should be unnecessary given adequate provision of hay and concentrates. Domestic fruits grown for human consumption are unlikely to match the nutritional composition of wild fruits that the oryx encounter in their natural habitat. These foodstuffs should not be harmful if occasionally offered in small quantities, but should not comprise a significant proportion of the daily diet.

Provision of browse is likely to be more suitable as a supplement to hay and concentrates given reports of natural utilisation of woody plants by scimitar-horned oryx. However, as the species is primarily a grazer, browse should be offered in moderation. There may be behavioural benefits to provisioning oryx with browse as it may increase time spent feeding and enable animals to exhibit a greater range of their feeding behavioural repertoire, especially if they are restricted to hard stands. If feeding browse, it is always preferable to offer a range of species rather than just one.

Specific vitamin and mineral requirements for scimitar-horned oryx have not been established. Until further information becomes available, it is sensible to base requirements on those for domestic ruminants and to supplement the diet accordingly. Beyond this, it is difficult to be prescriptive as requirements will vary depending on overall dietary husbandry, access to pasture, soil type, and other factors including behavioural stress. While commercially available feed concentrates contain added vitamins and minerals, most EEP institutions provide mineralised salt licks and offer some further vitamin supplement in the diet, with an emphasis on vitamin E to meet anti-oxidant requirements.

Despite the scimitar-horned oryx being an arid adapted species which may not drink for several months at a time, in captivity a continuous supply of fresh, clean water should be available at several places in the enclosure.

Summary of Dietary Problems Reported in Captive Scimitar-horned Oryx

- By far the most prevalent dietary problem associated with captive scimitar-horned oryx is obesity due to overfeeding. Additionally, body reserves accumulated in the autumn are not mobilised in the winter as the animals are maintained on full rations (as opposed to the conditions that their wild conspecifics encounter) (Lechner-Doll *et al.*, 2000).

- When commercial concentrates are fed in large quantities, acidosis develops resulting in chronic rumenitis (Lechner-Doll *et al.*, 2000).

- Pellets should be fed to lactating females with very young offspring, however, the amount should be reduced if the calves start scouring (E. Flach *pers comm*.).

- High protein levels in feed concentrates have been associated with excessive hoof growth and diarrhoea. The latter has also been reported in animals returned to pasture following prolonged periods without grazing.

- The occasional case of copper and magnesium deficiency have been reported, but otherwise mineral imbalances do not appear to be widespread.

See section 15, this volume for further information on nutritional causes of disease.

Summary of Dietary Recommendations for Scimitar-horned Oryx
With no available information on the composition of the natural diet for the scimitar-horned oryx, current dietary recommendations are based on apparently successful feeding regimes in EEP institutions and requirements for domestic grazing ruminants:

- Bulk diet should consist of grass hay *ad libitum* with provision of appropriate feed concentrates to meet additional nutritional requirements (Oftedal *et al.*, 1996). Quantities depend on access to pasture and should be adjusted if the animals become overweight. While some mobilisation of body stores is desirable in winter to duplicate natural seasonal trends, body condition should be monitored and diet adjusted if necessary.

- Use of browse in moderation may be beneficial, but should not be a major component of the diet.

- Feeding of fruit and vegetables should not be necessary, but if included in the diet should be used sparingly.

- Supplementing the diet with additional vitamins and minerals should be in line with the requirements for domestic livestock. Salt licks should be available at all times.

- Fresh, clean water should be provided at all times.

Hand-rearing Scimitar-horned Oryx Calves
Hand rearing of scimitar-horned oryx calves should only occur in exceptional circumstances when it is absolutely clear that the calf will not survive without human intervention. Only seven (out of 22) EEP zoos that replied to the husbandry questionnaire reported that their institution had experience of hand-rearing oryx calves. Given the limited experience of EEP institutions, and reports on hand rearing oryx, it is difficult to make precise recommendations, and the following information should serve only as a guide.

EEP zoos have reported feeding scimitar-horned oryx calves on goat, cow and sheep's milk. At Marwell, hand reared calves were originally fed on cow's milk, but this frequently resulted in bouts of diarrhoea. As a result, any orphaned or rejected calves are now fed on goat's milk which appears to be more suitable for their digestive system. See table 5 for a nutritional comparison of different milks. Both raw eggs and vitamin powder can be added to the milk,

but this should not be common practice. In the initial stages post-partum, colostrum may be included in the feed.

Mayor (1984) provides a detailed account on the hand-rearing of an orphaned female scimitar-horned oryx calf at Orana Park, New Zealand. She states that the oryx originally consumed 1000cc of milk formula in three feeds per day, but after 18 weeks had lost interest in the bottle and was easily weaned. Gill and Cave-Browne (1988) report that mother-reared calves are weaned at five to ten months, but the calf will start eating grass and supplemental food at three weeks of age. Whilst the calf at Orana Park was being hand-reared, it remained within group in the hope that it would successfully develop the necessary social skills and integrate well into the herd. From the report, it would appear as if this were mostly successfully (Mayor, 1984).

Table 5. The following nutritional data is given as a percentage on an as fed basis.

Component	Scimitar-horned oryx milk %	Goat's milk %	Cow's milk %	Sheep's milk %
Fat	12.7	-	-	-
Crude fat	-	4.14	3.34	7
(Saturated fat)	-	(2.67)	(2.08)	(4.60)
Protein	5.4	-	-	-
Crude protein	-	3.56	3.29	5.98
Non-fat solids	24.5	-	-	-

(Mayor, 1984; WCS, 1999)

11
Enclosure Design

RENATA MOLCANOVA AND MARTINA HORVATHOVA

There is a long history of keeping animals in captivity, and the holding and breeding facilities have been continuously improved over the years to achieve the most suitable conditions for the animals. The environment should be consistent with the needs of the species. This includes shelter from adverse weather, use of suitable substrates, sufficient space to escape other animals (section 8) and the public. The enclosure should also allow the animals the opportunity to express normal behaviour. All these requirements must be balanced with the need for hygiene and husbandry (DETR, 2000). In this section we review various aspects of enclosure design for scimitar-horned oryx.

Accommodation

Facilities available in zoos vary considerably and while some may not be so limited by space, others face greater restrictions. This can be taken into account with appropriate herd size and social structure. However, accommodation for scimitar-horned oryx should comprise: an indoor shelter or stable that provides protection and a means of separating or handling animals when required and, an outside exercise enclosure. For the latter, some EEP institutions maintain oryx solely on a hardstanding area of varying size. Others are able to offer an additional grazing paddock.

Indoors

Shelter or stable design

Scimitar-horned oryx have a strong social structure (sections 3 & 8) and so the herd should be able to stay together inside the stable or shelter, hence a large enough area is required. However, additional stalls or partitioned areas with doors that can be operated from outside the facility are recommended so that animals can be separated if needed. If animals are separated, it is important that they remain aware of each other by sound and scent. Visual gaps in the partitions may, however, provoke fighting between individuals, and are therefore not recommended (E Flach, *pers comm*.).

Flooring and bedding

The floor should be flat with a non-slippery, slightly rough surface, which is easy to clean and dry. It should be hard but not cold or porous. Concrete is frequently used, but asphalt may be a good alternative, or a water tight and seamless rubber flooring with granular elements. This type of rubber flooring is very soft, warm and slip resistant. It is also easy to clean and more hygienic than other substrates. A double layer of bedding is recommended. The first layer needs to possess good absorbing qualities, so sawdust or bark should be appropriate. Some collections use sand to minimise dust. A suitable material for the top layer is straw. The amount used of both materials depends on the number and density of the animals in the indoor space. It is not necessary to change the bedding every day to keep it clean. It is sufficient to remove just the wet areas to reduce the risk of mould. It may also be helpful to have a slight slope on the floor, to prevent water and urine accumulating.

Environmental conditions
The building should be sufficiently insulated to prevent heat loss in winter and overheating in summer. Scimitar-horned oryx can cope with cold, but not continually freezing temperatures. However, the species is intolerant of cold and wet conditions, and care should be taken to maintain a draft-free environment, but the shelter must be well ventilated.

Natural lighting is preferable, but if windows are incorporated into the indoor shelter, they should be placed high up or in the roof as skylights. This avoids the risk of the animals accidentally breaking windows or seeing them as a potential escape route. Animals should not be able to come into contact with any artificial lighting.

Outdoor Enclosure
An outdoor exercise enclosure should comprise a hardstanding area and if possible a grazing paddock. The size of these areas depends on the number of animals and social organisation of the herd.

Substrate for hardstands
EEP institutions use a range of substrates including concrete and compacted gravel or sand. However, the use of substrate should consider the need for cleaning and drainage. Hard and rough surfaces help reduce the need for hoof trimming.

Grazing paddocks
It is beneficial for scimitar-horned oryx to have access to a grazing paddock. However, problems can occur if animals stand in wet or muddy areas for long periods and the herd should be restricted to the hardstand if these conditions prevail.

Barriers
Scimitar-horned oryx enclosures may be surrounded by fencing or other barriers such as ditches. Height of fences in EEP institutions ranges from 1.4 to 2.1m. If chainlink or weldmesh fences are used, mesh size should be small enough to prevent animals pushing their heads or legs through, but large enough that horns cannot become stuck.

Ditches may be used as a less obtrusive barrier than fences. The height of the ditch and the angle of ditch sides need to be considered, and, if necessary, a ‘psychological’ barrier such as a hedge, wall or small fence should be placed on the top of the outer ditch side.

Additional features
An open shelter that offers shade and provides protection from the wind and rain should be incorporated into outdoor enclosures for scimitar-horned oryx. A stand of overhanging trees or a simple wooden construct are both suitable for these purposes. Sand pits are another valuable feature that are used regularly for resting and as crèches for calves.

Feeding and Watering Sites
Water should be available for animals in their shelter or stable and in the outdoor enclosures. Hayracks may be placed inside or outdoors. It is important not to place hayracks too high as dust inhalation can lead to respiratory problems. It is also recommended that hayracks are placed in a position that allows easy access for animal management staff. Do not place the rack on the floor due to the risk of injury from panic behaviour. If hayracks are available in the outside enclosure, they should be protected from the rain with a roof.

12
Handling

EDMUND FLACH

In order to safely handle scimitar-horned oryx, they need to be restrained. This can be achieved through either physical or chemical immobilisation.

Physical Immobilisation
Calves up to about four to five months of age can be caught manually and restrained for examination, sampling and/or treatment, but this should only be done by trained personnel, and in a confined, well-padded box. There is a real risk of injury to the catching personnel, mainly minor traumatic injuries from the feet and horns, but potentially severe horn pokes, and there is also a risk of damage to the animal, especially to the horns which are easily bent at this age. The author knows of one calf which jumped vertically, fell on its hind-quarters and fractured it's sixth lumbar vertebra.

For older animals it is possible to train them to pass through raceways where they may be held in a confined space for observation and weighing, and then restrained in a hydraulic crush for examination, sampling and treatments. These systems were originally designed for deer farming (Fowler, 1995), but have been adapted successfully for scimitar-horned oryx (Atkinson *et al.*, 1999).

Chemical Immobilisation
In most collections, and for most procedures it is necessary to use chemical restraint.

a) The commonest, and still most reliable, drug combination is a mixture of etorphine (M99) with xylazine. The etorphine is often used with acepromazine in the commercial preparation Large Animal Immobilon (Vericore), and there appears to be little difference in effect. Typical doses are 1.7 – 2.5ml Immobilon plus 20-30mg xylazine for an adult, and 1.2-1.5ml Immobilon plus 20mg xylazine for a yearling. It is important to use a dose which will cause deep sedation and recumbency within ten minutes, because under-dosed animals continue to pace around their enclosure and become hyperthermic and acidotic, and may subsequently succumb to capture myopathy. The etorphine is reversed with diprenorphine (Revivon, Vericore, 1ml [3.26mg] to reverse 1ml Immobilon) and the xylazine with yohimbine, RX821002A (1mg) or atipamezole (1/10 dose of xylazine). Scimitar-horned oryx are prone to re-cycling, or re-narcotization, and may become sedated and unresponsive to external stimuli anything up to 24 hours after reversal and recovery from sedation. For this reason it is worth giving an extra half-dose of diprenorphine sub-cutaneously when the full dose is administered intra-venously at the end of the procedure. Using the lowest effective dose of etorphine for the sedation will reduce the likelihood of re-cycling, and it may not be a good idea to reverse an animal too soon after induction, in case the etorphine is still being absorbed and distributed. If the clinical procedure only takes a short time it is advisable to wait until 25-30 minutes after the initial darting before reversal.

Etorphine typically gives 45-60 minutes of immobilisation, but with muscle tremors, respiratory depression and tachycardia. Xylazine helps by reducing the muscle activity and heart rate and, by reducing the amount of etorphine required, may improve respiration. If the animal is too light for the procedure a low dose (50-100mg) of ketamine can be injected intra-muscularly, or preferably intra-venously. This is preferred to further doses of etorphine by the author because of the potential for fatal respiratory depression. Minor surgery can be performed under etorphine and xylazine if local analgesia is used, but for longer procedures, and for major surgery, it is recommended that the animal is intubated and maintained on isofluorane, or halothane, in oxygen. Physiological effects of the combination are described by Pearce and Kock (1989).

b) Carfentanil has been used instead of etorphine at 2.5mg total dose for an adult female, and 3mg with 10mg xylazine for an adult male (Allen *et al.,* 1991).

c) Xylazine and ketamine. A dose of 2ml of the Hellabrun mixture, containing 125mg/ml xylazine and 100mg/ml ketamine, has been used for adult scimitar-horned oryx.

d) Medetomidine and ketamine. Arabian oryx have been successfully immobilised with 50µg/kg medetomidine and 1.5mg/kg ketamine. After the procedure the medetomidine can be reversed with atipamezole (Schaftenaar, 1996).

e) Tiletamine and zolazepam (Zoletil/Telazol) doses of between 1.5 and 2 mg/kg of the combined drugs with 0.1-0.3mg/kg xylazine have been used by Bush *et al.* (1992).

An important factor for successful immobilisation, whatever the drug combination, is reducing the amount of stress on the animal at the time of darting. A stressed animal will need a higher dose of drug for the same degree of sedation, and is more likely to suffer later from capture myopathy. On a practical level stress can be reduced by keeping to a routine as much as possible, and so it helps if oryx are used to being shut in races or yards as part of their daily routine. It is also useful, if an animal has to be confined for darting, if one or two other animals can be kept with it, and then released when the drugs start to take effect. Animals should not be immobilised in very hot weather, except in emergencies when they should be moved quickly into the shade and cooled down.

Once recumbent and sufficiently deeply sedated, the animal can be positioned for the procedure. If at all possible it should be kept in sternal recumbency with the head raised and the muzzle lower than the pharynx. If this is not possible an endotracheal tube should be placed so that, in the event of regurgitation, rumen contents will not pass down the trachea. An endotracheal tube will also be required for gaseous anaesthesia. Oryx have narrow jaws and placement of the tube can be difficult. It may be possible to place the tube without visualisation of the larynx, with a hand introduced into the pharynx guiding the tube. Alternatively a long laryngoscope can be used to illuminate the larynx, but once the tube is introduced alongside it the field of view can be obliterated! One solution is to introduce a stomach tube into the larynx first, and then pass the endotracheal tube over it. Bush (1996) describes another, similar, technique using a human endotracheal tube exchanger.

Anaesthetic monitoring should include, as a minimum, regular measurement and assessment of the pulse rate, respiratory rate, rectal temperature, mucous membrane colour and capillary refill time. Respiratory and cardiac monitors can assist, but should not replace, a trained member of staff with responsibility for the care of the animal whilst immobilised. Pulse

oximetry can give valuable information about the oxygen saturation of capillary blood, provided that the probe can be reliably attached to a suitable site, such as the tongue or nasal septum. Likewise, a portable blood gas analyser (iStat, Heska) will give useful information about the physiological state of the animal and, if acidosis is suspected whether it is respiratory or metabolic. The base excess will then indicate the amount of bicarbonate required to reverse the acidosis. For prophylactic treatment of acidosis, following a stressful induction for example, I have safely given 1ml of 8.4% sodium bicarbonate (=1mmol) per kg body-weight intravenously without access to blood gas values.

Long-acting neuroleptic drugs used to treat anti-depression in humans have proved useful for calming oryx for transportation, acclimatisation to new surroundings, mixing with unfamiliar animals and confinement/isolation for veterinary treatment. A dose of 100mg zuclopenthixol acetate (Clopixol-acuphase, Lundbeck) has an initial effect after one to two hours and lasts three to five days, 100mg perphenazine (Trilafon LA, Sherag) doesn't produce any effect for 12-24 hours, but may last for seven to ten days. Both have been used successfully for scimitar-horned oryx. Side-effects include sedation, tremors and star-gazing, but these can be treated with 10mg biperiden (Akineton, Knoll), repeated if necessary.

13
Transport

RENATA MOLCANOVA & TANIA GILBERT

This section aims to provide recommendations for the transport of scimitar-horned oryx between zoological institutions, and for reintroduction programmes. Different institutions have different experiences of transporting oryx, and the information provided is designed only as a guide.

Single Animal and Group Transports
Scimitar-horned oryx can be transported individually or in social groups depending on the purpose of the translocation, the number, the sex, and the age of the oryx and the strength of the social bond of the group. Many transports between institutions will involve only one oryx, and so the animal will be individually crated.

During the reintroduction of oryx to Bou Hedma National Park, Tunisia, in 1985, several oryx were transported per crate. The animals were five to seven months old (and therefore small) and had been allowed to establish a social structure prior to transport to North Africa. The advantage of this approach is that the transport costs are reduced, and it was thought that the young animals would integrate better once they were introduced to their new environment (Gordon, 1991).

Similarly, the reintroduction of oryx from Hai-Bar, Israel to Guembeul, Senegal in 1999, involved the transportation of eight oryx in a single container. It was assumed that due to the strong social nature of oryx, the stress factor associated with such a long journey (50 hours) would be reduced if the oryx could remain in a social group. The project managers certainly believe that this was achieved as the journey proceeded without incident (B. Clark, *pers. comm*.).

In both examples the oryx were held in a social group prior to transport and had established a social hierarchy. This is an important consideration to prevent, or at least reduce, the possibility of fighting or increased stress levels during transport. It is also important that IATA guidelines are met, regardless of whether oryx are being transported individually, or in a group.

Other considerations include emergency access to the oryx during long transports for veterinary reasons. It is easier to control and give veterinary treatment to an individually crated animal, than it is for a group of animals in a crate.

Additionally, the facilities for unloading crates at the destination need to be taken into account. Problems were encountered with unloading individually crated oryx during the 1999 reintroduction to Sidi Toui National Park, Tunisia due to the difficulties in manoeuvring the forklift truck on the sandy substrate. A larger crate, containing several animals, would have been even more difficult to unload under such conditions (S. Wakefield, *pers comm*.).

As a general rule, younger animals are more suited to being transported in a group than adults due to their size and ability to establish a strong social hierarchy prior to transport. Additionally, thought should be given to the sex ratio of the animals, to ensure that aggression is kept to a minimum.

There are advantages and disadvantages for transporting oryx in individual crates and in multi-animal crates, and the pros and cons of the method of transport need to be carefully weighed in each individual case.

The remainder of the section provides summarised information from the IATA guidelines on crate construction and basic principles for transporting oryx. For more detailed information, please refer to the IATA Guidelines on the Transport of Live Animals (IATA, 2000).

Container Construction

Material
The container or crate should be made of wood or metal and rubber, burlap or canvas for padding and light reduction, if required.

Dimension
The height and width of the container must allow the animals to stand erect with head extended. The size of container must sufficiently restrict movement so that the animal cannot turn round and in doing so trap or injure itself. Additionally, it should not have the space to kick or damage the container. However, the animal must have enough space to lie down, lie comfortable and stand up. The dimension will vary according to the age and sex of the animal being shipped.

Frame
The frame must be made of a minimum of 2.5cm solid wood or metal parts, bolted or screwed together. When the weight of the container plus the animal exceed 60 kg, additional metal bracing must be present around the whole container.

Sides
Suitable plywood or similar material need to closely line the frame to a level slightly above the animal's eye over which there must be a louvered or slatted area for ventilation extending to the roof. The interior must be completely smooth.

Floor
The base must be solid and leak-proof, there must be either pegboard or slats bolted to the solid base to give a firm foothold. A dropping tray must be provided under the pegboard or slats to prevent excreta escaping.

Roof
The roof must be slatted at a width that horns cannot become trapped between the slats. If padding is required, soft material such as shavings can be stuffed under the rubber, canvas, or burlap covering.

Ventilation
Ventilation louvers or slots, with 2.5cm spacing between the louvers/slats or holes, with a minimum diameter of 2.5cm, must be present, above eye level, on all four sides and the roof

of close boarded containers. Slots and holes must be covered with a fine wire mesh that will not allow any part of the animal, including horns, to protrude. If the mesh is on the inside of the container all edges must be protected to prevent injury.

Spacer bars/handles
Handles must be made to a depth of 2.5cm, and formed from the framework of the container.

Feeding and watering in the containers
Food and water containers must be provided with outside access from a hinged bolted flap that must be large enough for the entry of a large water dish and /or quantities of appropriate food such as grass hay, roots, vegetable, etc.

Special requirements
Plastic or rubber piping can be placed over the horns, and the roof of the container must be padded with rubber or other suitable material in order to prevent the animals from hurting themselves. For a diagram of a suitable transport crate, please see page 273 of the IATA live animal regulation guidelines (IATA, 2000).

Preparations before Transport
The condition of container (interior and exterior) must be checked before the shipment. Any defects must be corrected to prevent any injury of the animal while it is being transported. For the comfort of the animal during the long/short-term shipment, it is important to provide the right bedding inside the container. Good absorption of excrement is necessary. For this purpose it is recommended to staple polythene sheeting to the sides of the container to prevent spillage of excreta, and an absorbent such as wood shavings be placed underneath the container. Additionally, straw and hay should be placed on top to help to keep the animal sufficiently dry. Normal rations should be fed before transport, but care should be taken not to overfeed the animals. The oryx should be watered not less than two hours prior to loading in the container. In case of immobilisation, veterinary instructions must be followed (IATA, 2000).

General Care, Loading, Transport
Animals do not normally require additional feeding or watering during 24 hours following the time of dispatch. However, the shipper's watering instruction must be followed. If feeding is required due to an unforeseen delay, fodder must be provided but care must be taken not to overfeed the animals.

Some of the animals may require tranquillising for transportation. The name of the medication and time of administration must be provided to the shipper and affixed to the container, the information must also be accompanied by the shipper's certification. The transport contractor must be instructed about the general care during the shipment.

During the transport the container with the animal must be placed in the freight space (lorry, train, ship, aeroplane) on a horizontal plain, strictly avoid placing the contained at an angle. The container must be located in an area with good air ventilation, to ensure a good supply of oxygen to the animal. Animals must be checked regularly while in the container (IATA, 2000).

14
Marking & Identification

TANIA GILBERT

Introduction

Identification of individual herd animals is necessary to facilitate routine animal management, captive breeding programmes and scientific studies. Furthermore, it is important that each animal can be positively identified for the duration of its life and *post mortem* (Jarvis, 1968; Reuther, 1968; Ogilvie, 1968). There are a number of methods available for identifying individual animals. These include: use of natural markings; ear tagging; ear notching; implanting sub-cutaneous or muscular transponders or microchips; tattooing; and freeze branding. These techniques vary in their suitability for use with scimitar-horned oryx, and this section sets out recommendations for the most appropriate methods for this species based on practical considerations and experience of EEP zoos.

Factors to Consider

Rice & Kalk (1996) suggest the following criteria for marking animals:

- Markings should be permanent and last the lifetime of the animal to which it is applied (see also Reuther, 1968; Jarvis, 1968).
- The technique should be inexpensive so that it can be applied to the entire collection without incurring excessive costs.
- Visible markings should be legible at a distance so that animals can be identified without the need for restraint.
- Markings should be humane, and it should be possible to apply them quickly and easily to prevent the animals from becoming unduly stressed

Ideally, the animals should be marked using an established technique, so that anyone who is unfamiliar with the collection can identify the individuals. In some circumstances, it may also be desirable to use marking techniques that are inconspicuous.

Marking Techniques

Natural markings

Identifying individuals using natural marks such as pelage pattern, horn structure and permanent scars (Rice & Kalk, 1996) is suitable for scimitar-horned oryx. This approach is non-invasive, inexpensive, permanent, and can be used to identify animals at a distance.

The use of naturally occurring features is reliant on detailed and accurate records and must take into account the fact that differences between individual oryx may be very subtle. This can be achieved with the aid of photographs, drawings and written descriptions of the animal. However, each identifying traits or combination of features must be unique to that animal and must be permanent. Features such as the animal's size and small wounds are subject to change, and are therefore not suitable as identifying marks (Rice & Kalk, 1996). Care must be taken to update records if other physical characteristics change (e.g. horn loss).

Animal keepers who are familiar with their oryx will be able to identify some individuals visually without the need for an applied marking technique. However, identification using individual characteristics of the animal is susceptible to human error (Jarvis, 1968), and a person who is unfamiliar with the animals is likely to have difficulty in telling individuals apart. Hence, use of natural markings should be complemented with an additional method of identification.

Ear tags
Ear tagging is one of the most common methods for marking ungulates in general (Ashton, 1978; Dietlein, 1968; Griner, 1968) and scimitar-horned oryx in EEP zoos. Ear tags are inexpensive, quick and easy to apply, relatively inconspicuous (Ulmer, 1968; Rice & Kalk, 1996), and facilitate identification without the need for animal restraint (Rice & Kalk 1996). Identifying animals with tags is quicker and easier than relying on natural markings to distinguish individuals (Ashton, 1978).

Plastic ear tags are readily available in a variety of sizes, shapes and colours, and can have numbers printed on them (Rice & Kalk, 1996). Consequently, they can be used to distinguish individuals, their age and sex according to the marking protocol. Common approaches include:

- Use of numbers for individual identification.
- Use of different coloured tags to identify year of birth (Davis, 1968; Rice & Kalk, 1996).
- Tagging of different ears to distinguish between sexes i.e. right ear for males, left for females or vice versa (Ulmer, 1968; Deitlein, 1968; Rice & Kalk, 1996).

More complex systems can be devised to convey additional information by tagging both ears. However, loss of one tag may lead to confusion. Coloured tags that fade to the same or similar colours (e.g. red and orange) should not be used for any of these tagging strategies (Rice & Kalk, 1996).

Tags are applied using a special tool that can be obtained from the tag manufacturer. For both adult and young animals, tags should be placed in the thick cartilage on the anterior edge of the ear where it is less likely to tear out (Ulmer, 1968; Rice & Kalk, 1996). With mature oryx this may be difficult to pierce and so it may be necessary to either pre-cut the puncture site or attach the tag to a thinner section of the ear. Care should be taken to avoid any major blood vessels (Rice & Kalk, 1996). For a more detailed description of ear tags and application methods, see Griner (1968) and Rice and Kalk (1996).

Different institutions tag animals at different ages from infants on the day of birth to adults that have been recently transferred to that institution or are restrained for veterinary care (Griner, 1968; Davis, 1968). Oryx can be tagged on the day of birth, however there is a risk of rejection by its mother. Ulmer (1968) recommends waiting for four days after the birth, so the mother can develop a bond with the infant, whereas Rice and Kalk (1996) state that the tagging should be applied between 24 – 48h after birth, but can be delayed for six to eight weeks.

The main disadvantage of using ear tags is their lack of permanency. Plastic tags swing freely on a perforating pin, but they can still be caught on fences or branches and be either ripped from the ear, or fall apart when the animal pulls away (Davis, 1968; Griner, 1968; Ulmer,

1968; Rice & Kalk, 1996). Dirt and fading may reduce the effectiveness of ear tags over time (Ashton, 1978) and numbers on some tags are difficult to read at a distance (Ulmer, 1968).

Transponders
The use of transponders for marking individual animals is increasing in popularity amongst EEP zoos. Transponders are quick and easy to apply, permanent and inconspicuous.

Transponders are small, rod-shaped and encased in a glass capsule. They range in size from 2mm x 10mm to 3.5mm x 30mm with the smaller transponders having a range of less than 8cm and the larger transponders having a range of 16cm. Each transponder is programmed with a unique code during manufacture and this code can then be read when a reader wand is waved over it (Rice & Kalk, 1996). Transponders are implanted under the skin or in the muscle, and once the implant site is cleaned with alcohol, infection is unlikely. However, due to the limited range of the transponder, implantation sites should be recorded and / or standardised for each animal (Rice & Kalk, 1996).

However, the method may not be completely reliable and is usually used in conjunction with another, more visible, method of marking such as ear tags or notches.

The disadvantages of using transponders for identification is that they are relatively expensive compared to other methods of marking, the performance is not always reliable and they need to be read in close proximity to the animal which usually entails physical restraint. Transponder systems are manufactured by different companies and are not all compatible with one another. When individual animals are transferred between institutions, the signal may not be detectable by the reader wand at the new institution. This lack of compatibility compromises the permanency of this marking technique (Rice & Kalk, 1996).

With advances in technology it is likely that some of the concerns regarding the use of transponders such as the detectable distance will be overcome. For the time being the use of transponders offers a suitable backup to visual markings such as ear tags.

Tattooing
Tattooing is a traditional method for marking ungulates and is still used to identify individual oryx in some EEP zoos. Tattoos are inexpensive to apply (Rice & Kalk, 1996), should be permanent if applied correctly (Ashton, 1978; Rice & Kalk, 1996) and are inconspicuous, especially if the tattoo is applied to the inside lip or ear (Rice & Kalk, 1996).

Numbered or lettered tattoos are applied using an electronic needle or tattoo pliers (Rice & Kalk, 1996; Ashton, 1978; Reuther, 1968; Ogilvie, 1968), and indelible green ink is preferable to black or red, as it contrasts well with the surrounding flesh colour (Ashton, 1978; Reuther, 1968; Ogilvie, 1968). Tattoos should be applied to areas of skin with little hair where the number will be easy to read. This is commonly the ear (Rice & Kalk, 1996), but can include the axilla, medial thigh, ventral abdomen or chest, foot, inside the lip and inside the ear (Ulmer, 1968; Ogilvie, 1968; Reuther, 1968; Ashton, 1978).

Tattoos can be applied shortly after birth as the animals are not difficult to capture and handle at this time (Reuther, 1968). However, a delay of 24 – 48 hours may be advisable to give time for the mother-infant bond to develop (Rice & Kalk, 1996).

Tattoos cannot be read from a distance (Rice & Kalk, 1996) and require restraint of the animal, especially if the tattoo is located discreetly on the inside of the lip, ear or thigh (Davis, 1968). Marks may also fade after a time (Ashton, 1978; Rice & Kalk, 1996) and can be obscured by hair depending on location (Ulmer, 1968).

Freeze branding
Freeze branding is a permanent marking technique that is gaining acceptance for use on cattle and horses (Rice & Kalk, 1996), including Przewalski horses in zoos (Ashton, 1978; Zimmermann & Kolter, 2000). Freeze branding is permanent (Rice & Kalk, 1996) and may be visible from a distance, or made inconspicuous depending on requirements. It is thought to be painless as the rapid freezing of the skin acts as an anaesthetic and inactivates local nerve endings for approximately one month (Rice & Kalk, 1996).

Freeze branding is however, most appropriate for dark skinned animals as the branding is accomplished by cooling the skin to such a degree that the melanocytes in the hair follicles are permanently destroyed. When the hair grows back it lacks pigmentation and appears white (Ashton, 1978; Rice & Kalk, 1996). This is a problem with scimitar-horned oryx because the branded white hairs do not stand out against the pale coats (Ashton, 1978). Furthermore, freeze branding is more expensive than other identification methods such as ear tagging, the equipment is cumbersome and the animal has to be properly restrained for the duration of the branding process to achieve a good mark (Rice & Kalk, 1996; Zimmermann, 2000). Consequently, the application of freeze branding as an identification method for scimitar-horned oryx has not been reported by EEP zoos.

Ear notching
This is a permanent marking technique that is useful for all large-eared ungulates (Ashton, 1978). It is a permanent method, it inexpensive to apply and can be inconspicuous (Rice & Kalk, 1996) if notches do not stand out from natural tears in the ears.

The process involves cutting one to four 'U' or wedge shaped notches using special pliers at any of four pre-determined coded sites on the ear margins. Using this method, up to 99 animals can be distinguished (Ashton, 1978; Rice & Kalk, 1996). Bleeding may occur but can usually be controlled by applying direct pressure, clips or hemostats to the wound site (Rice & Kalk, 1996; Ashton, 1978). Ear notching can be difficult and time consuming, may be objectionable on humane grounds, and there is a risk of infection (Rice & Kalk, 1996).

The notch pattern must follow a standard system for all animals (Ashton, 1978). Individuals may be difficult to discern if the notches are not applied carefully or notch sites overlap. This marking technique may also be compromised if injuries, infection or growth obscure the notch sites (Ashton, 1978; Rice & Kalk, 1996). Unless notches are very clear, individuals cannot always be identified at a distance (Rice & Kalk, 1996).

Despite the incumbent problems, ear notching has been used successfully with scimitar-horned oryx. However, it is not a widely used technique for the species and other methods appear to be preferred by zoos.

Identification techniques currently used by EEP zoos
A questionnaire was sent to all zoos participating in the scimitar-horned oryx EEP to establish what marking techniques are currently being used for animal identification. Although there were only 24 respondents this was sufficient to establish that a range of methods are used

(Table 6). Furthermore, a number of zoos combine two techniques to ensure permanence of marking and a system of verification in case one of the methods fails. The single most popular approach amongst the zoos surveyed is to combine ear tags with the use of transponders. However, use of natural markings was also favoured. More invasive techniques including tattoos and ear notching were only used by two of the 24 zoos.

Table 6. Methods used for marking scimitar-horned oryx in EEP zoos.

Technique	Number of EEP zoos which use the technique	Age of oryx at which the technique is used in EEP zoos
Ear Tags	3	Ranges from 24 hours to six weeks after birth
Ear Tags & Tattoos	1	Ear tags: Ranges from 24 hours to six weeks after birth. Tattoos: No data.
Ear Tags & Transponders	8	Ear tags: Ranges from 24 hours to six weeks after birth. Transponders: Ranges from 24 hours to one year after birth/adult.
Transponders only	6	Ranges from 24 hours to one year after birth/adult.
Transponders & Ear notches	1	Transponders: Ranges from 24 hours to one year after birth/adult. Ear notches: one to three days old
None / Natural markings	5	N/A

Recommendations

None of the available marking methods fulfil all of the ideal criteria for animal identification. As a result, it is advisable to combine two techniques to ensure that the scimitar-horned oryx are permanently marked in an appropriate manner. Freeze branding is the only technique that is not recommended for use with scimitar-horned oryx because the resulting white hairs are not readily discernible on the oryx's pale coat. The most appropriate approach is probably a combination of natural markings, coloured and numbered ear tags, and transponders, which together fulfil all the criteria for the ideal marking method.

15
Veterinary guidelines

EDMUND FLACH

Introduction

These guidelines are not intended to be a comprehensive review of all diseases to which scimitar-horned oryx are susceptible, or in which they have been reported. Instead I have tried to cover a range of conditions under aetiological and organ system classifications, and concentrated on diseases which have occurred at Whipsnade. I acknowledge with gratitude all of the efforts of my colleagues and predecessors in the veterinary department of the Institute of Zoology, Zoological Society of London. I hope that these notes may stimulate further investigation of diseases of oryx, and would welcome comments and reports which I can incorporate in the future.

Investigation of Disease or Ill-health

Signs of ill health may be reported by keepers or found during routine health checks. Initial signs may include changes in behaviour, separation from the herd and anorexia, or external signs of disease, such as poor body condition, hair loss, over-grown or cracked hooves, ocular or nasal discharges, swellings etc.

The animal records for the collection should be consulted to compare the clinical signs and differential diagnosis with previous cases. Certain diseases may show a strong seasonal pattern, for instance parasitic gastro-enteritis, or they may manifest when the herd is at too high a stocking density. Plant poisoning, copper deficiency and liver fluke are all examples of diseases which may be associated with particular paddocks.

Once the affected animal, or animals, and the rest of the herd have been observed by the veterinarian it may be appropriate to submit faecal samples for parasitological and bacteriological examination, and it may also be possible to collect discharges and hairs without handling the animal(s). If the clinical signs suggest a recurrent disease then, under certain circumstances, treatment may be started and the provisional diagnosis reviewed depending on the response to treatment. Further investigation requires a full clinical examination and sampling which must be undertaken with the animals physically or chemically restrained (section 12).

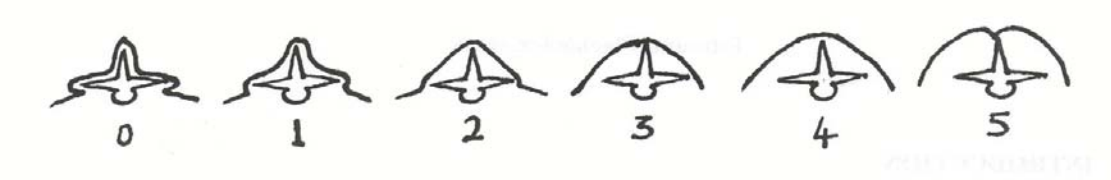
The **clinical examination** follows the same pattern as for domestic hoofstock, paying particular attention to the following:

Body condition;

a) Ideally animals should be weighed whenever they are examined, using either a purpose-built weigh-bridge, or commercial scales capable of weighing up to 200kg. At Whipsnade we use two weigh bars (made for industrial use; to weigh pallets of goods) and place the immobilised animal on a human stretcher or a large sheet of wood between the bars. Alternatively it is possible to use two human bathroom scales and add the two weights.

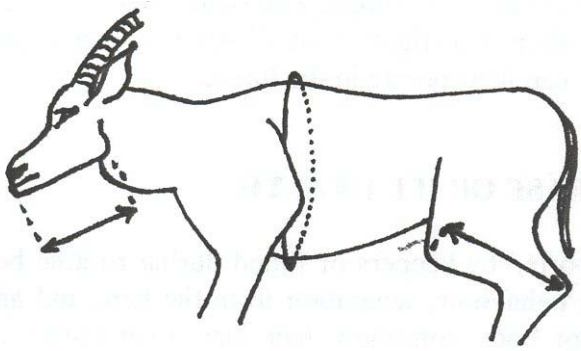
b) The body condition is assessed over the lumbar spine using a scoring system similar to those for cattle and sheep which subjectively estimates the degree of muscle and fat covering the lumbar vertebrae. See Figure 3.

Figure 3.



c) Morphological measurements can also be used as a guide to growth and condition. We routinely measure the length of the horizontal ramus of the left mandible and the length from the dorsal aspect of the flexed left stifle to the plantar aspect of the flexed hock (stifle-hock) as indicators of skeletal size, and the thoracic circumference immediately caudal to the elbows (girth) as indicator of body condition. See Figure 4.

Figure 4.



The head should be carefully examined for lesions of the skin, eyes, ears, nostrils, mouth and horns, and any asymmetry between the sides. The tongue should be extended and pulled to one side to allow a visual examination of the teeth, palate and pharynx. A larygoscope or endoscope is invaluable for close examination of deep structures. The lateral aspect of the molar teeth can also be palpated digitally.

The trunk, limbs and external genitalia should be examined and palpated for wounds, swellings and signs of dermatitis. The hooves should be carefully examined after cleaning, and trimmed if necessary. The respiratory, cardiovascular, gastrointestinal, urinary, genital and lymphoreticular systems are examined routinely.

Pathological samples taken for diagnostic purposes will depend on the history and clinical signs, but the following routine samples are used for health screening:

Venous blood collected;

a) in EDTA for routine haematology and fibrinogen concentration (a non-specific indicator of inflammation);
b) in plain tubes to allow clotting and separation of serum for routine biochemical tests, for serological assays, and to store in a serum bank for future investigations, and;

c) in heparin for whole blood copper (normal range in cattle 12-19µmol/l), or after centrifugation the plasma for biochemical tests, for example plasma pepsinogen concentration (an indicator of abomasal damage usually due to nematodiasis; normal is <2U/l @ 37°C).

Normal ranges established at the Zoological Society of London are given in Appendix I, but each collection should establish their own normal values, based on local husbandry, nutrition and the laboratory performing the analyses.

Blood in EDTA or heparin can be a source of peripheral blood leucocytes for DNA, both of the oryx itself and also of any viral infections of white blood cells, particularly gamma herpesviruses.

Fresh faecal samples should be examined;

a) by a concentration technique, such as the modified McMaster method, for the presence of parasitic ova, and;
b) by bacteriological culture for the presence of pathogenic bacteria, particularly *Salmonella* species. Faecal smears may also be stained and examined microscopically for the presence of *Cryptosporidium* species, especially in neonates, or *Mycobacterium avium paratuberculosis* (Johne's disease).

All animals which die must be subjected to a full *post mortem examination*. In addition to any diagnostic samples for bacteriological, virological and other investigations, it is recommended that;

a) a full range of tissues, including the brain and sections of spinal cord, are stored in 10% formal saline for later histopathological examination;
b) the abomasum is washed in a bucket and the contents made up to 10 litres and a sample (e.g. 200ml) removed, mixed with an equal volume of 10% formal saline and stored for later worm count +/- identification, and;
c) a range of tissues, especially liver, kidney, skin and muscle, are stored deep-frozen. Liver and kidney samples can be submitted for copper, and other trace element, analysis. The skin and muscle are good sources of DNA for genetic studies.

Diseases: Causative Agents

Viral and prion diseases
It can probably be assumed that scimitar-horned oryx are susceptible to most viruses which affect domestic cattle and sheep, but there have been few studies.

Most captive scimitar-horned oryx have antibodies to malignant catarrhal fever (MCF) virus because they carry their own gamma herpesvirus which is related to both wildebeest (Alcelaphine herpesvirus-1) and sheep (Ovine herpesvirus-2) viruses. DNA from this virus can be found in newborn calves, suggesting that it is transmitted *in utero*, and the virus itself has now been isolated from four to five month-old calves (Flach *et al.*, 1999). Despite this, clinical MCF has been suspected in scimitar-horned oryx.

Antibodies to Bovine Viral Diarrhoea virus (BVDV) have also been found in captive scimitar-horned oryx, and may have been associated with diarrhoea and loss of body condition (Frolich & Flach, 1998). In the same study individuals were also found which had antibodies to bovine adenovirus-3, bovine herpesvirus-1 (Infectious bovine rhinotracheitis) and caprine herpesvirus-1, but none had antibodies to enzootic bovine leukosis, cervid herpesvirus-1, bovine respiratory syncytial virus or epizootic haemorrhagic disease of deer.

Foot-and-mouth disease, blue-tongue, rinderpest and peste des petits ruminants (PPR) have all been recorded in related members of the Hippotraginae, although virus isolation has not generally been carried out (Kock & Hawkey, 1988). Arabian oryx (*Oryx leucoryx*) in several captive and wild herds were found to have antibodies against blue-tongue, rinderpest and PPR without having shown signs of the diseases (Greth *et al.*, 1992), and, in addition, there were healthy individuals which were seropositive to parainfluenza-3, lumpy skin virus and akabane.

Scimitar-horned oryx are one of the species which have been affected by the bovine spongiform encephalopathy outbreak in the UK (Kirkwood & Cunningham, 1999).

Bacterial diseases
Tuberculosis was responsible for weight loss in Beisa oryx (Lomme *et al.*, 1978), but only one of two animals reacted to the tuberculin skin test. Other chronic debilitating infections recorded in oryx include nocardiosis and yersiniosis (Kock & Hawkey, 1988). The latter infection, probably transmitted by wild birds and rodents, and free-ranging mara (*Dolichotis patagonum*), has affected four to six month-old scimitar-horned oryx calves at Whipsnade, but usually in combination with parasitic infections and at the onset of cold, wet weather.

Staphylococcus, *Streptococcus*, *Corynebacterium* and *Fusobacterium* species may all be found in abscesses and skin lesions. The first three genera, plus others like *Pasteurella*, may be the causes of respiratory infections and septicaemia.

Clostridial diseases are more likely to occur with over-crowding, causing an increase in contamination of the enclosure and an increase in stress and fighting (Blackleg, gas gangrene, tetanus), or following a sudden change in feeding (enterotoxaemia). Multi-valent vaccines are available for prophylaxis, and tetanus anti-toxin should be used if tetanus is suspected.

Johnes disease (infection with *Mycobacterium avium paratuberculosis*) is becoming more prevalent in the USA and should be considered if oryx have chronic diarrhoea or loss of body condition. Diagnosis can be difficult, but should include the examination of several faecal samples stained with Zeihl-Neelsen, serological testing by ELISA and, if available, use of specific PCR tests on faeces. Brucellosis is another disease which is not recorded in oryx as far as I am aware, but should be tested for when animals are moved between collections.

Chlamydia and Q fever antibodies were present in a survey of Arabian oryx (Greth *et al.*, 1992), but their significance is unknown.

Fungal diseases
An *Absidia* species was isolated from the brain of an Arabian oryx suffering from mycosis (Kock & Hawkey, 1988), but in general oryx do not appear to be particularly susceptible to fungal infections.

Parasitic diseases
Scimitar-horned oryx can harbour a range of gastro-intestinal helminths, but the species will not necessarily be the same in different climatic regions. In zoos in the temperate climate of the United Kingdom *Camelostrongylus mentulatus* is the predominant abomasal nematode, *Trichostrongylus*, *Nematodirus* and *Capillaria* species are commonly found in the small intestine, and *Moniezia* species cestodes are occasionally encountered. *Trichuris* species may be found in the caecum and proximal colon (Flach, 1986; Ohira *et al.*, 1997). *C. mentulatus* is a close relative of the *Ostertagia* nematodes of domestic cattle and sheep, and causes similar pathological lesions in the abomasum. The two classical forms of ostertagiasis may be seen in oryx, firstly diarrhoea and loss of body condition in calves (Type I ostertagiasis), and secondly acute, severe abomasitis and collapse in juveniles and sub-adults at a time of stress, usually late winter in the UK (Type II ostertagiasis). Commonly, parasitism is one of several factors which may cause animals to lose body condition and become susceptible to other infections during late winter. Other factors include exposure to inclement weather, negative energy balance due to reduced appetite (which can be one effect of parasitism) and physiological needs of pregnancy or lactation.

Oocysts of a *Cryptosporidium* species were found in the faeces of juvenile scimitar-horned oryx in captivity (van Winkle, 1985), and coccidial oocysts have occasionally been seen during routine faecal examinations at the Zoological Society of London. Haemoparasites, such as *Babesia*, *Theileria* and *Anaplasma* species, are reported from other hippotragine antelope in southern Africa, and cattle, sheep and camels in North Africa harbour a variety of species so it is likely that scimitar-horned oryx which lived in the region previously became infected at the time of feeding of the various tick vectors (*Hyalomma* species for *Theileria*, *Rhipicephalus* species for *Babesia* and *Boophilus* species for *Anaplasma*). In the endemic situation, animals infected as calves are resistant to disease and become immune, but also carry low numbers of the parasites for life. Animals reintroduced to their former range from captivity will not have this immunity, so it is vital to monitor for signs of heavy tick infestation, and haemoparasitism. Apart from ticks, oryx may be infested with mites and lice, and are susceptible to biting flies and fly-strike.

Physical Causes of Disease
Oryx are often injured during fights, particularly if adult males are kept together in close proximity to females. They may also be wounded by poorly maintained fencing, sharp objects on the ground etc. One of our females required treatment of bilateral sub-cutaneous haematomas on her back where the tips of her horns rubbed when she put her head up.

Scimitar-horned oryx are well-adapted to withstand heat provided they have shade and access to water, and can survive cold and dry weather. However, in temperate climates they need dry housing to withstand cold and wet conditions, and calf survival is poor if there is a lot of rain shortly after birth.

Nutritional and Toxic Causes of Disease
Feeding has been described in section 10, this volume. Scimitar-horned oryx will lose condition if fed an energy-deficient diet, but will also become obese if over-fed. If allowed access to *ad libitum* high-energy concentrates or cereals, they are likely to suffer from acidosis and will require emergency treatment with sodium bicarbonate and a rumenotomy to remove the offending foodstuffs. Any sudden change of diet, particularly to a higher-plane of nutrition, should be avoided because of the risk of multiplication of *Clostridium perfringens* in the intestines and the production of fatal enterotoxins.

There are few reports of specific nutritional deficiencies, but copper deficiency has been reported in gemsbok (Gillespie *et al.*, 1995), and at Whipsnade we have seen copper deficiency in adult male scimitar-horned oryx, associated with loss of body condition and secondary infections. The diet was thought to provide sufficient copper, but the affected individuals were not getting sufficient concentrates. Copper deficiency and parasitism were thought to be responsible for poor neonatal survival because treatment of pregnant females resulted in improved survival. Vitamin E and/or selenium deficiency may cause white muscle disease in calves (Griner, 1978).

Neoplasia
A number of tumours have been reported in oryx, for example a lymphosarcoma in a fringe-eared oryx (Griner, 1983). At Whipsnade an adult female was found to have a bile duct carcinoma.

Diseases: Systems Affected
Investigation of body systems follows the procedures used for domestic ruminants, and the range of conditions is much the same. The following systems are more commonly involved in disease conditions in scimitar-horned oryx.

Skin and associated structures
Traumatic skin lesions are common, especially if there is fighting within the group. Labial avulsion has been seen in scimitar-horned oryx and other antelope which run into fences when disturbed. If mild it can be left to heal by secondary intention, but if severe the mandible and skin should be cleaned, debrided and reattached surgically. A stab incision in the skin ventral to the mandible will allow drainage from the contaminated submandibular area whilst healing takes place. Alopecia may occur with heavy ectoparasitic infections or dermatophytosis. The skin and hair condition may also reflect the general body condition of the animals.

Oryx horns are susceptible to trauma, and if this occurs as a calf the horn may get distorted. This distortion will remain at the end of the horn as it grows out. Horns get knocked off quite frequently in captivity and, provided that the horn bed doesn't suffer further trauma, no treatment is necessary. In many cases there will be little, or no, regrowth. Cracked or split horns can sometimes be repaired with hoof cement, such as methyl-methacrylate. The horn base can get infected with bacteria, such as *Staphylococcus aureus*. This results in necrotic material around the base, and weakening of the horn. Treatment is with local and systemic antibiotics, local cleaning and debridement and, in severe cases, removal of the horn.

It is sometimes necessary to protect the horns during transport, and rubber hosepipe is often used for this. However, if the pipes do not wear down and fall off, the horns will eventually become very soft. Therefore, they should be removed within one or two months, even if this requires immobilisation.

Hoof problems are common in captivity, particularly when oryx are maintained on high levels of nutrition and kept on soft ground. Typically there is over-growth at the toe and on the lateral (abaxial) hoof walls, with subsequent cracking or separation of the hoof wall from the sole at the toe, allowing entry of bacteria, and the formation of a false sole over the front half to two thirds of the foot, again trapping soil and faeces, and predisposing to solar abscess formation. Treatment is based on similar conditions in cattle and sheep. Following radical removal of hoof wall it has sometimes been necessary to dress the foot and keep the animal confined, but alternatively a modified hoof block can be attached to the sound digit to keep the affected digit off the ground.

Reproductive
Infertility does not appear to be a major problem in scimitar-horned oryx, but neonatal losses may be high. A case of dystocia and subsequent caesarian section has been recorded (Kock & Hawkey, 1988), and we have seen endometritis with retained placenta/foetal membranes occasionally.

Central nervous
Bovine spongiform encephalopathy should always be considered if an animal shows neurological signs of central origin, although there are many other causes such as cerebro-cortical necrosis (CCN) and listeriosis.

Treatment
Drugs formulated for domestic cattle and sheep have been found to be satisfactory for use in oryx. Long-acting formulations of antibiotics have been particularly useful, allowing a single injection at the time of immobilisation to last for two to three days (e.g. amoxycillin trihydrate 150mg/ml in an oily suspension or oxytetracycline dihydrate 200mg/ml). One product is claimed to give four to five days of therapeutic effect (Oxytetracycline dihydrate at 300mg/kg, Duphacycline XL, Fort Dodge Animal Health). Further doses can be delivered by darting, provided that the viscous drugs can be injected by the darts and needles used. Unfortunately this often needs two darts, and can be quite stressful unless the animal has been given a long-acting neuroleptic drug beforehand.

Non-steroidal drugs such as flunixin meglumine, ketoprofen and carprofen have all been used in oryx, usually by intra-muscular or intra-venous injection. Individuals with parasitic gastro-enteritis are usually darted with ivermectin (Ivomec), but group treatment is normally achieved by treating the feed (see below).

Preventative Medicine
Good husbandry, with appropriate housing, nutrition and group structure are vital for prevention of disease.

The need for vaccination will depend on local circumstances, but may include clostridial diseases, pasteurellosis and pathogenic *E.coli*.

Regular monitoring for, and prophylactic treatment against, nematodiasis is essential, particularly if animals have access to grass enclosures. A group faecal sample (comprising pellets from at least four to five different faecal piles) should be submitted for a parasitological examination on a regular basis throughout the year. For close monitoring this may need to be done every month. Routine treatments should be given at appropriate times to reduce the main periods of build-up of infection, and egg output by calves. In the temperate climate, with calves born during early summer, this will be mid-summer and autumn, with additional treatment(s) of pregnant females to reduce any peri-parturient rise in egg output. Treatment is most easily given in the food, either as a supplement or included in the concentrate pellet (e.g. fenbendazole at 750g/tonne, ivermectin at 20g/tonne) and fed for two to three consecutive days to ensure treatment of all individuals. Calves may not eat sufficient concentrates to receive effective medication, so we have found it useful to treat them individually by darting or injecting with ivermectin when three to four months of age, and again one month later.

Annual hoof trimming should be considered if hoof disease is a persistent and severe problem.

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APPENDIX A
The Reintroduction of Scimitar-horned Oryx to Bou Hedma National Park, Tunisia

TANIA GILBERT

Introduction

In 1980, the Zoological Society of London, the Direction Générale des Forêts in Tunisia and La Fondation Internationale pour la Sauvengarde du Gibier in Paris started discussions on the possibility of reintroducing a group of scimitar-horned oryx from the UK to Bou-Hedma National Park in Tunisia. Bou-Hedma was designated as a National Park in the 1920s, and covers an area of 120km² at the northern edge of the scimitar-horned oryx's natural range (Gordon, 1991). Approximately one quarter to one third of the Park is mountainous forming the northern part if the Orbata-Bou-Hedma range with a maximum elevation of 840m above sea level. The rest of the Park is relatively flat with sandy or rocky terrain (Gordon, 1991; Abaigar, 1997).

In 1977, 2400ha of the National Park were designated a Total Protection Zone (TPZ I), and agreements were made between the Direction Général des Forêts and the local people that they and their livestock would not enter the TPZ in return for 20 year leases to the rest of the Park. Subsequently a habitat rehabilitation programme was initiated, and the vegetation in the TPZ regenerated remarkably well. Exclusion of the livestock from the area, and exclusion of tree-cutting activities were probably the key factors which led to the regeneration of the vegetation. However, habitat restoration efforts may have added to this effect as well (Smith *et al.*, 1997).

Given the notable improvement in the Park's vegetation, plans were implemented to reintroduce the large indigenous animals which originally inhabited the area; scimitar-horned oryx, addax, dorcas gazelle and ostriches (Gordon, 1991).

The Animals

The following five paragraphs are adapted from a summary paper on the Bou Hedma reintroduction by Gordon (1991).

In December 1985, five male and five female scimitar-horned oryx, all between five and seven months old, were sent from Marwell and Edinburgh Zoos in the UK to Bou Hedma (Wacher, 1986b). Such young animals were selected for the following reasons; several animals could be transported in one crate thereby reducing transport costs, as the animals came from two sources, it was thought that young animals would integrate better and develop a graded social structure. Additionally, young animals were expected to adapt more quickly to their new environment than adult animals.

The chosen animals all had a known ancestry, but despite attempts to select the most genetically diverse animals from those available, one male sired seven of the ten oryx, and the remaining three were sired by a second male. Additionally, the maternal lines

were also interrelated. Consequently the inbreeding co-efficients for the F1 generation would be reasonably high.

The Reintroduction
A 'soft-release' approach was adopted, and the ten animals were released into small reception paddocks in the middle of the National Park. The feeding regime remained the same as when the animals were in the UK, and hay was given morning and afternoon, with a pelleted feed given in the morning only. Water was available *ad libitum* throughout the day. The oryx also had access to native plants growing in the pens, but initially approached many plants cautiously.

Four and a half months after arriving at Bou-Hedma, the oryx were released into a ten hectare enclosure. Supplementary hay continued to be fed, but the oryx also had access to the plants which were common in the TPZ. The oryx spent the next 16 months in this ten hectare enclosure, until the perimeter fence on the 2400ha TPZ was erected.

The animals appeared to acclimatise quickly to the Tunisian environment and most retained good health. However, several of the females were observed to be in a poorer condition and were slow to breed. The animals ranged as a group and co-ordinated their movement, feeding and resting bouts. By the time the oryx were released from the ten hectare enclosure into the TPZ in July 1987, they had developed a stable social structure with a clear dominant male. In the days following the release, the oryx returned to the feeding pens for their usual supplementary concentrates.

Progress
The work at Bou-Hedma has progressed since the first reintroduction in 1985. Two more Total Protection Zones have been designated (TPZ II & III) (Smith *et al.*, 1997), and in 1999, one male adult oryx was added to the population at Bou-Hedma. This animal was shipped out to Tunisia from Europe with the other oryx for the 1999 Sidi Toui reintroduction. This was the first non-birth addition since the original reintroduction in 1985, and had the aim of increasing genetic diversity of the population at Bou-Hedma (S. Wakefield, *per comm*.). The population of scimitar-horned oryx in May 2002, at Bou-Hedma National Park stood at 100 on 25km² of land (four oryx per km²) (de Smet, 2002). By the beginning of 2004, the population in the National Park was approximately 120 (Lazah, 2004, *pers .comm*.).

Monitoring
Smith *et al.'*s (1997) report stated that large antelopes (oryx, addax and dama gazelle) were monitored daily by ten guards on foot, primarily to identify birth, mortalities and any unusual events. Each month a total census of antelopes in the TPZs is made, although the monitoring is limited mainly to population numbers as the animals are not individually marked, making more comprehensive monitoring difficult. A need for a degree of veterinary involvement in the post-release phase to monitor the health and well being of the animals, has been identified (Gordon, 1991), but since the post-release phase, no regular veterinary care inspections have been carried out at Bou-Hedma. The vegetation in the TPZs are monitored through the use of line transects to estimate biomass, and assess the impact of the herbivores on the vegetation (Smith *et al.*, 1997).

The Future

Given the existing size and growth rates of the populations, the carrying capacity of the area will be reached in the near future. Animals may be moved to TPZ II and III, but the carrying capacity of these areas (± 2,500ha total) will also be reached relatively quickly. It is likely that antelopes cannot be successfully released into the surrounding Park in the foreseeable future. It may be possible for surplus oryx to be transported to Sidi Toui National Park, but there are no current plans for this to occur (Smith *et al.*, 1997). Given this situation, it is important that a cohesive metapopulation management plan is produced for the oryx across Tunisia. This should address the issue of the carrying capacity of the environment, maintenance of the genetic diversity of the existing, and any future oryx in Tunisia, and the role that individual National Parks can play in the conservation of scimitar-horned oryx.

APPENDIX B
The Reintroduction of Scimitar-horned Oryx to Sidi Toui National Park, Tunisia

RENATA MOLCANOVA

Introduction

The reintroduction of scimitar-horned oryx to Sidi Toui National Park, Tunisia was carried out under the umbrella of the Bonn Convention, with funding from the Flemish Ministry of the Environment. The project was co-ordinated by Simon Wakefield and Renata Molcanova, with Marwell Zoological Park (UK) and the Zoological Garden of Bratislava (Slovakia) as the executing agencies and representatives of EAZA/EEP. The Tunisian co-partner was the Direction Générale des Forêts. This international project brought together 14 oryx from six zoos in five countries, and an additional two female slender-horned gazelle (*Gazella leptoceros*) from a seventh zoo to establish an *in-situ* captive breeding group for the gazelles.

In Spring 1999, the oryx and gazelles were transported to Sidi Toui National Park. The park, 6135ha of desert steppe in the south of Tunisia, had no other ungulates other than a small free-ranging population of dorcas gazelle (*Gazella dorcas*), and had previously been assessed as suitable to support an expanding population of oryx. The planning, preparation and release stages followed *the IUCN Guidelines for Reintroductions* laid down by the IUCN/SSC Reintroduction Specialist Group.

General/Primary Aims of the Project

1. To establish a free-ranging breeding group of scimitar-horned oryx in the Sidi Toui National Park, Tunisia.
2. To monitor the behavioural, ecological and veterinary aspects of the released oryx group during their first six months after their arrival in Tunisia.
3. To assess the effectiveness of the techniques employed to future reintroduction strategies for the species.
4. Exchange of skills and knowledge with Tunisian counterparts.

Associated/Secondary Aims

1. To provide one male and two female scimitar-horned oryx, *Oryx dammah* for Parc National de Oued Dekouk and an adult male of *Oryx dammah* for Parc National de Bou Hedma.
2. With the donation of two female slender-horned gazelle*, Gazellaleptoceros,* to establish a breeding pair with the existing hand-reared male in Sidi Toui.
3. Veterinary care for existing captive stock.

Selection of the Animals

The oryx were chosen:

i) As a genetically separate line to the existing population in Bou Hedma National Park.

ii) To be as genetically diverse within the release group as possible. The group included three adult females which were pregnant on the transport to Tunisia by a male unrelated to the other members of the release group.
iii) To have an age and sex structure which will maximise the early development of group cohesion, which is essential to a successful release.

Origin of Animals
The animals originated from the following EEP institutions:

Parc Zoologique de Paris, France	(0.3)
ZOO La Palmyre, France	(2.0)
Bratislava ZOO, Slovak Republic	(1.3)
Leipzig ZOO, Germany	(0.2)
VCZOO Dvur Kralove, Czeck Republic	(0.2)
Parco Faunistico Le Cornelle, Italy	(0.1)
Planckendael Animal Park , Belgium	(0.2 gazelle)

Preparation for Transport; Arrival in Tunisia
Before transport each animal was ear-tagged with unique combinations of coloured tags to allow future identification of individuals. They also underwent a comprehensive veterinary assessment to satisfy the Tunisian import health requirements. Veterinary examinations established baseline data for each animal for routine biochemistry, haematology and body condition. These results provided valuable comparisons with samples taken from the same animals after their arrival in Tunisia.

In March 1999, the animals were transported from their respective countries to Oostende in Belgium, and then onto Tunisia. The oryx were observed regularly throughout the transport and appeared calm at all times.

On arrival at Sidi Toui, the oryx were released into several small reception pens and exhibited very little aggression toward each other. Within minutes of their release they had started to pick at the natural vegetation in the enclosure. All of the animals quickly adapted to seeking shade during the heat of the day and eating at cooler times of the day, and at night.

Few veterinary problems were encountered, however, one of the adult females had a vaginal discharge one week after arrival which started bloody, became mucoid and cleared up within two days without any other clinical signs. She was thought to be two months pregnant so it may have been an early abortion. All of the other animals showed no clinical signs of disease throughout the quarantine period. The oryx were vaccinated on the second day after their arrival against A, O and C strains of foot and mouth disease by remote injection using blow darts.

Acclimatisation and Release
During the initial acclimatisation phase, the females for the Sidi Toui group (six young females and three adult females) were mixed (day 15 post-arrival), allowed to settle and establish a hierarchy. During this time, observations were made of the oryx's social behaviour, daily activities and water consumption. On day 29, the female oryx were introduced to the breeding male in one of the five hectares pre-release enclosures.

After the herd was mixed, the group's social structure began to stabilise, and each animal established its own position in the social order resulting in a clear social structure. The male demonstrated a protective role toward the herd and kept the group together. A few days after the herd had been released to this area, the gate between the first and second five hectare enclosures was left open and the animals had the opportunity to use the whole ten hectare enclosure. Despite having a larger space available to them they preferred to stay in the second five hectare area feeding on the fresh vegetation.

During this time, two water troughs were built and situated outside the fence of the five hectare area right next to the existing water troughs inside the enclosure. This was to ensure that the oryx would have access to water in the early period after the release. After a 30-day quarantine period, during which the oryx were monitored under the supervision of ZSL veterinarians (E. Flach, *pers comm*.), the additional four oryx brought to Tunisia were transported to the other two parks (Oued Dekouk (1.2) and Bou-Hedma (1.0)).

The establishment of a stable group had been the most important goal before the final release of the oryx. They were considered to have a stable herd structure 49 days after their arrival and so were released into the National Park. Monitoring took place for five months after their release, and the oryx were observed to adapt extremely well to their desert home. All the adults remained healthy and one calf was born into the herd. A soft-release approach continued to be adopted, where the animals are offered supplementary food and water during their first year.

Prior to their release two females (one young and one adult) were fitted with radio-collars to enable researchers to locate the animals after their release into the Park. Their principal activity pattern for the first month was not related to seeking water or shade at set times. However, their activity pattern changed when they returned to the enclosures to drink for the first time from the water troughs provided at the beginning of June 1999. They then returned for water every two to three days and made daily use of the three artificial shelters built near the release site. Two shelters were built near to Bir Turki, and were used in the middle of the day, when the temperature was approximately 35 - 40 °C.

From June until the end of August, the oryx's activity was controlled by their need for shade, and water to drink. However, in the Park these resources were all provided artificially and so they spent a significant portion of their time near Bir Turki. The artificial shelters were used four to seven hours per day (from 08:00-09:00 in the morning, until 16:00-17:00 in the evening) for sleeping and ruminating.

Their home range did not change significantly during the four month monitoring period. They used approximately one quarter of the total available area, staying in the North/West part of the Park. The first month was spent more or less in one location near the perimeter fence of the Park. They then developed a looser association with the fence line, but still remained in close proximity to it. They remained habituated to human presence and at times strayed very close to human activities without appearing scared.

Breeding

The three adult females were pregnant before their transport to Tunisia, one of the oryx miscarried, and two of them gave birth in December 1999, but only one calf

survived (see table B1). In order to minimise the risk of loss by jackals, the park staff decided to isolate the females in the acclimatisation pens a few weeks prior to birth, and kept the mother and calf there until the calf was at least two to three weeks old. With such a small release group and the importance of the genetic contribution of each founder individual, this was considered to be a useful precaution, even though it limited the natural movements, and impacted on the social structure, of the group. This resulted in regular visits by the other members of the herd, and the subsequent splitting of the original herd into several groups. The 'nursery herd', which comprised of all the mothers and their offspring, was protected by the breeding male. The other females, which were either not pregnant or in the early stages of pregnancy, were running between the nursery group and the acclimatisation pens where the two oldest pregnant females had been placed. This raised the issue of increased social stress experienced by the group as a whole.

Table B1. The composition of scimitar-horned oryx in Sidi Toui National Park in May 2002

Current status	Subgroup total	Subgroup composition
24	16 (3.8.5)	Original breeding male 3 original females 2 adult females* 1 male juvenile* 3 sub-adult females* 1 sub-adult male* 5 calves*
	1	Solitary male*
	7 (1.6)	Adult male* 6 original females (5 pregnant)

Predators

It is clear that predation can pose a significant risk to very small populations or groups, even when predators are relatively uncommon. Dunham (1997), monitoring mountain gazelle (*Gazella gazella*) reintroduced in Saudi Arabia, reported that 32% of the mortality of released gazelles was accounted for by predators, either wolves or feral dogs. Interestingly, older released gazelles (>three years) were more likely to be killed than younger ones. By May 2002, 18 calves had been born and four were lost to jackals. The deaths of all animals of the Sidi Toui population from the release in April 1999 until May 2002 is summarised in table B2.

Table B2. Deaths of all animals in Sidi Toui National Park, Tunisia since April 1999

Birth Date	Sex	Death Date	Cause of death
27.12.99	F	2.1.00	Lack of milk
16..8.00	?	19..8.00	Jackal
2001	?	2001	Jackal
19..2.02	?	?.2.02	Jackal
19..2.02	?	26.2.02	Jackal

This relates to a juvenile mortality of approximately 25%. To date, none of the original animals re-introduced have been lost.

Current Living Conditions
Due to a lack of rainfall (100mm in 1999, and 65mm in 2000), supplementary feed (hay) was provided to the oryx in autumn 2000. Water continues to be supplied in water troughs beside the pre-release area. The regular use by the animals of this part of the park makes it possible to check their body condition and the status of the herd. This strategy also retained contact between the oryx and humans which was important during the first stages of post-release observation. Apart from the new calves, most animals have retained their ear tags allowing individual identification and ensuring accurate records were kept of the breeding history of the herd. However, due to the loss of several ear tags, there have been several mistakes in identification already. Later, when the population further increases, it will be more difficult to keep accurate studbook data. Faecal pellets were evident in all parts of the park that were visited, demonstrating that the oryx use the whole area available to them (Molcanova, 2002).

Present Situation
By May 2002, the scimitar-horned population in Sidi Toui had increased to 24 animals; one solitary male, one group of seven (1.6, with five of the females being pregnant), and one group of 16 (3.8.5) (Mertah, *pers. comm*.). Generally, the oryx had a high body condition score, and appeared to be good health. At the beginning of 2004 the population at Sidi Toui was estimated to be 28 (Wakefield, 2004, *pers. comm*.).

An additional enclosure has been built to allow the entire group to be confined easily when required. It is intended to isolate the entire group at the birth of new calves to ensure that the calves are protected from predation, and that the social bonds within the group are maintained.

APPENDIX C
The Reintroduction of Herbivores to Souss Massa National Park, Morocco

HANS PETER MÜLLER & HEINER ENGEL

Introduction
The reintroduction of scimitar-horned oryx (*Oryx dammah*) to the Kingdom of Morocco is part of the Moroccan National Management Plan of the Conservation of Nature, which is the responsibility of the Ministère des Eaux et Forêts. This case study aims to discuss the reintroduction of all the animals, including scimitar-horned oryx, to the Souss-Massa National Park in Morocco, and give an overview of a multi-species reintroduction programme.

Project Description
The Moroccon Government has highlighted the rehabilitation of the habitats within the current National Parks, and the management of the existing National Parks, as a conservation priority. An important component of the rehabilitation of Morocco's wild animal life is the protection of the remaining animals, and the reintroduction of the species which became extinct before the country gained independence. Financial support for some of this work, including reintroductions, has been obtained from the Federal Republic of Germany (BMZ, Federal Ministry for Collaboration and Development), and the Gesellschaft für Technische Zusammenarbeit (GTZ) has been engaged in a project since 1993 supporting the proposed measures.

The Reintroduced Species
To fulfil some of these aims, the following species have been reintroduced to the Moroccan Sahara zone:

- Scimitar-horned oryx, *Oryx dammah* (Cretzschmar, 1826)
- Addax, *Addax nasomaculatus* (de Blainville, 1816)
- Mhorr gazelle, *Gazella dama mhorr* (Bennet, 1832)
- Edmi gazelle, *Gazella cuvieri* (Ogilby, 1840)
- Dorcas gazelle, *Gazella dorcas* (Linné, 1758)
- Barbary sheep, *Ammotragus lervia* (Pallas, 1777)
- Red-necked ostrich, *Struthio camelus camelus* (Linné, 1758)

The following chronological procedure has been set out for the reintroduction of these species:

1. Procuring the animals:
   a) from the wild (ostriches from Chad, edmi gazelles from Morocco)
   b) from breeding programmes in Morocco (edmi gazelles, dorcas gazelles)
   c) from breeding programmes in international zoos (scimitar-horned oryx, addax, mhorr gazelles)
2. Acclimatising the animals in the Souss-Massa National Park and founding core herds

3. Reintroducing the offspring herds to the planned Sahara National Parks (Iriki, Bas Draa, Dakhla)
4. Migration of wild animals from the Sahara national parks into the open Sahara zone.

Characteristics of the Souss-Massa National Park

The Souss-Massa National Park (33,800ha) was established in 1991 and is located in the oceanic Sahara region of Morocco, 30 km to the south of the city of Agadir. It stretches over 70 km along the Atlantic coast to the city of Tiznit, and has a width of between seven and ten kilometres. It includes two river deltas (Souss and Massa) which are important wetlands for migrating birds. The habitats in these areas consists of rocky and sandy coast, consolidated and migrating sand dunes, sand-covered limestone and rocky sandstone crusts, and gently rolling bush and tree savannah which changes into a pseudo savannah after favourable rainfalls.

The natural vegetation in this area consists of Mediterranean and oceanic Saharan flora influenced by the Atlantic and the Sahara. The dominant vegetation consists of plant associations of the Argana tree (iron tree) (*Argania spinosa*) and bush and cactus euphorbias with sweet grasses, herbs and shrubs which provide the basic nutrition for antelopes, gazelles and ostriches. The steep coast supports nesting colonies of the Northern bald ibis (*Geronticus eremita*{Linné, 1758}), whilst the deltas support populations of dorcas gazelles, edmi gazelles, ground squirrels, and porcupines. A large number of reptiles can be found including, chameleons (*Chamaeleo chamaeleo chamaeleo*{Linné, 1758}), helmet geckos (*Gecko spp.*), berber skinks, agame (*Agama bibronii*{A. Dumeril, 1851}), tortoises (*Testudo graeca* {Linné, 1758}), cobras, levant adders and puff adders. This region as well as the southern ocean coast, was formerly the habitat of large herds of gazelles (edmi gazelles until 1983, and dorcas gazelles until 1987) and probably Saharan zone antelopes. It is also the former habitat of ostriches, and ostrich eggs and egg shells are frequently discovered.

The region has a moderate climate influenced by the Atlantic and the Sahara, and the temperatures rarely drop below 15° C in winter. In summer when the Chergui blows in from the Sahara, temperatures can rise up to 50° C in the shade. The rainy season is from November to March and it rarely rains in the summer. The average annual rainfall lies between 240mm in the north of the park and 180mm in the south. The prevailing winds blow out of the west from the Atlantic and carries moist air from June to September, which is often visible as fog in the early hours, guaranteeing moisture for plant growth in the arid zones.

The areas of the national park with sand dunes and sandy surfaces are only accessible with four-wheel drive vehicles.

Reintroduction of Addax, Mhorr Gazelles, Dorcas Gazelles and Red-necked Ostriches

The Rokein reserve (2000ha) was established within the Souss-Massa National Park, to support core herds of addax, mhorr gazelles, dorcas gazelles and red-necked ostriches. The reserve is surrounded by a 1.6m high game fence, which extends 60 cm into the ground. Additionally, a thick barrier of horny branches was erected to prevent the entry of wild dogs, or other predators into the reserve. The acclimatisation station for addax is located within the Rokein Reserve and consists of:

2 enclosures each measuring	20 m x 12 m	=	480 m²
2 enclosures each measuring	30 m x 20 m	=	1200 m²
2 enclosures each measuring	20 m x 10 m	=	400 m²
			2080 m²

These interconnected enclosures form one large enclosure with an area of ten hectares containing tree savannah and sand dune habitats. They are connected to the Rokein reserve by two fenced game gates.

There are drinking places in all of the acclimatisation enclosures and the reserve, and a feeding station with vetch hay, Lucerne hay and food concentrate pellets has also been erected. Each of the enclosures in the acclimatisation station has covered shelters to protect the animals against the wind, sun and rain.

In addition to the Rokein Reserve, a 2000ha fenced-in reserve belonging to the King, and another 1000ha, will be made available to the animals at a later date (total 45 km²).

Reintroduction of Scimitar-horned Oryx to the Arrouais Reserve
In 1995, a new reserve (Arrouais, 1500 ha), within the Souss-Massa National Park, was established 10km to the south of the Rokein Reserve. The habitats in the Arrouais reserve consist of bush and tree savannah, stony and sandy ground, and migrating dunes. This reserve was designed for the purpose of establishing core herds of scimitar-horned oryx, dorcas gazelles and red-necked ostriches. The forestry station in this area also contains an acclimatisation area, which consists of two enclosures each measuring 20m x 30m. These enclosures are connected to a five hectare enclosure, which in turn are connected to the Arrouais reserve. The reserve is surrounded by a two metre high game fence, which extends 60 cm below ground.

The Reintroduction and Research Activities
In November 1995 the first scimitar-horned oryx were brought, together with addax and mhorr gazelles, to the Souss-Massa National Park. The scimitar-horned oryx were transported to the Arrouais acclimatisation station by truck (40 km), and the addax and mhorr gazelles were transported in the same way to the Rokein acclimatisation station in the Souss-Massa National Park (30 km). The addax adapted to their environment without any particular difficulties, and the first addax calf was born in May 1996. Another two calves were born in July and October 1996 which have survived to adulthood.

The six male scimitar-horned oryx were released into a 30m x 30m acclimatisation enclosure. After two to three weeks it was possible to release the animals into the five hectare enclosure to allow them to acclimatise slowly to the larger area. The time at which the animals were released into the 1500 ha reserve was dependent upon the behaviour of each of the animals.

Since the initial reintroduction more animals have been repatriated to Morocco. In 1997 a total of 29 scimitar-horned oryx had been reintroduced (see table C1).

Current Situation
In March 2000 the number of addax was estimated to be at least 150, and by April 2002, approximately 170 addax existed in the Souss Massa National Park (Műller, 2002). Another interesting observation, was that none of the >70 addax born in the

national park had deformed horns. In April 2002, the number of mhorr gazelles in the reserves is estimated at around 11 animals, and there are less than 200 dorcas gazelles (Műller, 2002).

Although the project seems unsuccessful with regard to the released red-necked ostriches (by 1998, 27 of the 37 released animals died), they did produce offspring for the first time in 2002. Two hens and one cock have been observed accompanying 21 young ostriches, and current estimates stand at 75 individuals (Műller, 2002).

By March 2000, the number of scimitar-horned oryx in the Arrouais reserve had risen to 50, by April 2002 to approximately 65 (Műller, 2002), on the 6th May 2004 the reported population at Souss Massa National Park was 35.45.11 (91) (Haddane, *pers. comm*.).

It is reasonable to assume that the number of addax and dorcas gazelle are probably higher than the numbers stated in the report due to the rapid growth of the vegetation in the national park providing cover for the animals.

According to the observations of the forestry officials as well as the national park management, the behaviour of the animals fully reflects the natural repertoire of behaviour in the wild. This is also confirmed by direct observations by the authors.

Table C1. The list of animals provides an insight into origin, age and the sex of animals reintroduced to Morocco (for further details, please see Engel & Brunsing, 1999).

Species	Number of reintroduced individuals (male, female) timespan of releases	Observed births	Observed mortalities
Addax nasomaculatus	70 (42.28) from 1994 to 1997	More than 40	7 (3.4)
Oryx dammah	5 (5.0) on 16 November 1995	4 in 1997	1 (1.0) in 1997
	10 (4.6) on 13 November 1996	9 in 1998	This was an adult male that was blind.
	14 (8.6) on 12 November 1997		1 (1.0) in 1998. Death after 9 days post-natal.
	29 (17.12)	13	2 (2.0)
Gazella dama mhorr	21 (13.8) from 1994 to 1998	6	7 (2.5)
Gazella dorcas	152 (74.78) from 1995 to 1996	-	Only estimated number
Struthio camelus camelus	37 1996	21	27

Conclusion

It can be concluded that the numbers of animals in the Souss-Massa National Park make a vital contribution to the wild populations for the respective species. The relocation of young animals from Souss-Massa into the Bas Draa National Park now depends on the progress of the project. Two Total Protection Areas have already been selected, near Torkoz for scimitar-horned oryx and near M'sseied for the addax. Fund raising for the erection of the fence line has already begun and is progressing well.

APPENDIX D
The Reintroduction of Scimitar-horned Oryx to Senegal

TANIA GILBERT

Introduction

The scimitar-horned oryx's natural range in Northern Senegal, once extended from the Louga region in the west to the Bakel region in the east (Devillers & Devillers-Terchuren, 2003). However, they are thought to have become extinct in Senegal between the 1850s (Newby, 1988) and 1914 (Sournia & Dupy, 1990 in Devillers and Devillers-Terchuren, 2003).

In 1996, work began on a project to reintroduce scimitar-horned oryx to the Ferlo National Park and Biosphere Reserve (Devillers and Devillers-Terchuren, 2003), and in February 1999, the first part of this project was carried out when Israel donated eight scimitar-horned oryx to Senegal for a reintroduction programme in the Guembeul Fauna Reserve, near the Atlantic coast of north-west Senegal (AZA Antelope TAG, 2002). The Guembeul Fauna Reserve contains an enclosure of approximately eight hectares of natural habitat into which the oryx were released (B. Clark, 2003 *pers comm*.). The oryx were mixed with a herd of 49 mhorr gazelle (*Gazella dama mhorr)*, and the two species appeared to mix well, with no obvious signs of conflict (Clark, 2002).

By 2003, a 500ha enclosure in the Ferlo National Park and Biosphere Reserve had been fenced, and smaller internal enclosures for acclimatisation and management purposes had been constructed. This has resulted in the enclosure being totally protected from livestock, which had previously degraded the habitat. Along with livestock exclusion measures, habitat restoration plans have been implemented. A natural pond, the Vendou Katane, was excavated to provide free-standing water throughout the year. This pond historically provided a natural water supply for the area, but decades of overgrazing and wind erosion resulted in it being filled in. With its excavation, it should once again provide an ample water supply for the local fauna (Clark, 2002).

In addition to habitat restoration measures, Park amenities and infrastructure have been constructed, and four Park Officers have been assigned, on a full time basis, to the Ferlo (Clark, 2002).

Current Status

By 2001, the number of oryx in the enclosure had increased to 14, with seven new births and two additional animals imported from Paris Zoo, and by 2003 the population had grown to 26 animals (Clark, 2002, Clark, 2003 *pers.comm*.). In January 2003 a group of eight oryx (3.5) were transported from the Guembeul Reserve to a 500ha fenced enclosure in the Ferlo National Park to establish a new herd. All eight oryx were Senegal born (F1 generation), and four of these oryx have since produced calves (F2 generation). The current population in Senegal now stands at 30 oryx, 18 at the Guembeul Reserve and 12 at the Ferlo National Park (Mamadou Ba & Clark, 2003; Holne, 2004, *pers.comm*.). There are currently plans to import more oryx to increase both the herd size and the genetic diversity of the population in Senegal (Clark, 2002; B Clark, 2003, *pers comm*.).

Future Plans

Although much has been accomplished, there is still a long way to go before a self-sustaining population of scimitar-horned oryx are established in Senegal. There are plans to increase the 500ha enclosure in the Ferlo, to 1200ha, so other habitats such as Acacia grove will be included. Also, the importation of additional oryx would increase the genetic diversity of the extant population. There is also a proposal to initiate aerial surveillance and increase the number of rangers at the Ferlo. On an infrastructure level, there are plans for a small community centre with an amphitheatre and meeting rooms, the creation of an arid ecosystem garden in the 'buffer zone' around the biosphere reserve to help the local populace reduce their reliance on livestock (B. Clark, 2003 *pers comm*.), and a water tower at Vendou Katane. Other development projects include health and education programmes for the local Peul people to encourage greater participation in the programme, and training for Malians, to facilitate the initiation of a similar project in Mali. All these proposed activities require funding, and future plans depend on whether and when, this funding is received (Clark, 2002; B. Clark, 2003 *pers comm*.).

APPENDIX E
Other Conservation Activities for Scimitar-horned Oryx in the Sahelo-Saharan Region

TANIA GILBERT

Introduction
The case-studies cited in this appendix are examples of some of the other field conservation work for scimitar-horned oryx, but by no means includes all the work which is progressing for the species.

The 2001 Wildlife Survey in Chad
There is no current reintroduction programme for scimitar-horned oryx in Chad, however, there is potential for such a programme, and a recent survey by Djadou Moksia, John Newby, Tim Wacher, Steven L. Monfort and Jerome Tubiana, make Chad an important example of potential conservation activities in the Sahelo-Saharan region.

Wildlife survey
Between the fifth of September and fifth October 2001, the survey team made an inventory of Chad's indigenous aridland fauna (dorcas gazelle, dama gazelle, scimitar-horned oryx, addax, red-fronted gazelle, carnivores, bustards and other birds), as well as the conservation status of the fauna, habitats and potential conservation opportunities. No systematic survey has been conducted in potential aridland antelope areas in the last two decades, and new surveys were required not only to determine the above points, but also to assess the potential for *in-situ* conservation and possible reintroduction programmes. The aim of the survey was to fulfil some of the requirements of the Djerba Action Plan on the conservation of Sahelo-Saharan antelopes (Monfort *et al.*, 2001).

The areas surveyed were located in the central region of Chad, and were selected due to their historical importance for antelope e.g. the Ouadi Rimé-Ouadi Achim Reserve, the Manga, Egeuï and Bodélé. However, routes were adjusted due to logistical considerations such as the need to refuel and replenish water supplies. In addition to vehicle surveys, interviews were conducted with local people to establish whether recent observations had been made of any of the species of interest. The survey recorded wildlife and ecological categories, including the location and number of all large mammal sightings, as well as habitat and vegetation status, the occurrence of natural standing water, land use categories and miscellaneous features such as old oryx horns. All data was recorded as GPS waypoints (Monfort *et al.*, 2001).

Scimitar-horned oryx survey
The survey route for scimitar-horned oryx crossed the Ouadi Rimé-Ouadi Achim Reserve which is a gazetted protected area with a few park rangers (Newby & Wacher, 2002). The Reserve was created in 1969 to protect cheetah, addax, scimitar-horned oryx and ostrich (Bassett, 1975). John Newby counted up to 1000 oryx in a day in the Reserve in the 1970s, but since that time all indications suggest that scimitar-horned oryx have become extinct in Chad. The survey team travelled extensively in the oryx's former habitat and interviewed local people, however few positive reports were received about oryx. There were suggestions from

some people that oryx may still exist in Niger, others believed that a small group of scimitar-horned oryx had been seen in the vicinity of Lake Chad. The team also received a report of small herds of oryx in the Ouadi Kharma and Al Guffayley regions of the Ouadi Rimé-Ouadi Achim Reserve. All these reports are unconfirmed and it is probable that the observers observed a herd of dama gazelle and not *Oryx dammah* (Monfort *et al.*, 2001).

No evidence was found of any living scimitar-horned oryx on any part of the survey route. Five old oryx horn fragments were found in the desert, and this along with rotting horn sheaths provided the only indication of their previous abundance (Monfort *et al.*, 2001).

Current status
The larger species of Chad's aridland fauna have virtually disappeared. Historically this was caused by unrest and civil war coupled with prolonged droughts in the 1980s, however, these factors no longer apply (Monfort *et al.*, 2001). Signs of recent hunting are abundant with foreign falconers having a huge impact on the fauna when hunting in protected areas (Newby & Wacher, 2002). Well-digging, livestock and habitat encroachment continue to pose a threat (Monfort *et al.*, 2001), and new roads and tracks cross key wildlife habitat (Newby & Wacher, 2002).

The vegetation and rangeland conditions in Ouadi Rimé-Ouadi Achim are good, and the area is not notably affected by drought or desertification. With protection and support from local people, the present rangeland of the Reserve could support reintroduced oryx (Monfort *et al.*, 2001). However, the area needs an increased level of support, but this could only be obtained from the International Community if Chad could demonstrate its commitment. There are still a number of measures that need to be taken, including banning foreign falconers from protected areas, and supporting local conservation NGOs (Newby & Wacher, 2002), but the Ouadi Rimé-Ouadi Achim Reserve has potential as a site for returning scimitar-horned oryx to Chad.

Other Conservation Activities
In February to March 2002, the Chad survey team visited Niger to survey the aridland fauna (Monfort *et al.*, 2001). Niger hosts one of the region's largest protected areas (the Aïr Ténéré National Nature Reserve (77,360 km²)) (Dixon *et al.*, 1991), which was one of the last strongholds for scimitar-horned oryx prior to their extinction in the wild. At the time of writing, the final report from the survey team had not yet been circulated, and so it is not possible to comment to the current situation for scimitar-horned oryx in Niger.

Other countries in the Sahelo-Saharan region are involved in oryx conservation; Egypt has plans for a captive breeding centre with the aim to reintroduce oryx to the area. Current draw-backs to this project include the viability of the habitat to support indigenous aridlands fauna (Monfort, 2000). In October 2002, it was reported that work began to transfer scimitar-horned oryx from UEA to Libya (Monfort, 2000; Anon, 2002a & 2002b), and by the beginning of 2004 approximately eight oryx were held in an enclosure at Oued Dekouk National Park, Tunisia (Zahzah, 2004, *pers comm*.). Conservation efforts for scimitar-horned oryx remain a priority for many organisations, but there is still much work that needs to be done before they are re-established in their natural range.

APPENDIX F
Captive and Wild Behaviour of *Oryx dammah*: Behavioural Categories

JUERGEN ENGEL

Ten functional categories have been observed for scimitar-horned oryx in European zoos and safari parks with the frequencies detailed in table F1 (Engel, 1997a):

1. ***Standing***

- bout length at least three seconds (including ruminating while standing)

2. ***Lying***

- including lying down, standing up, and ruminating while lying

3. Locomotion

- bout length at least three seconds
    - walking
    - style-trot
    - gallop: scimitar-horned oryx can easily maintain a canter at 30 km/h for half an hour (Gillet, 1965, 1966a)
    - jumping

4. Feeding and Exploration

From some distance away it is difficult to distinguish between actual feeding and some explorative behavioural elements. Therefore all relevant behaviour patterns have been combined in one functional category.

- head down (including food intake such as grazing and drinking)
- licking salt
- breaking off branches with the horns
- feeding while "kneeling"
- chewing while standing (part of the food is still visible outside the mouth, contrary to ruminating)
- head in trough (if available in the enclosure)
- licking/nibbling/sniffing
- scraping the ground

5. Hygiene

- autogrooming with tongue/teeth
- autogrooming with horns
- autogrooming with hooves
- stretching

6. ***Elimination***

- urinating
- defecating (including defecating while walking): normally the strenuous deep squatted posture will only be used by adult males

7. ***Interaction (with conspecifics)***

- sniffing at a conspecific (not sexually orientated)
- allogrooming
- play fighting: usually all movements are slower than in agonistic encounters; none of the participants leaves quickly after the end of the interaction (contrary to agonistic encounters)

8. ***Agonistic Behaviour***

Fighting cows use the same manoeuvres as bulls, but fights are likely to be shorter.

- foreleg kick: mostly used to make a lying conspecific stand up
- biting
- low presentation of horns: The horns are directed towards another animal by quickly lowering head and neck while drawing up the chin towards the chest. However, there is no physical contact between the opponents.
- high presentation of horns: The horns are directed towards another animal by a quick nodding of the head. However, there is no physical contact between the opponents.
- horn blow
- horn fight (one of the opponents leaves quickly at the end of the fight, contrary to play fighting): including the stab-over-the-(own)-shoulder which may be lethal for the opponent. Even in the wild the horns of scimitar-horned oryx may break during an extremely violent horn fight (Brouin, 1950).
- agonistic circling (tail of both opponents is erected, contrary to mating whirl-around)
- horn blow against object
- rubbing horns against object
- ground horning

9. ***Reproduction***

Normally, any bull is dominant over any cow, but a high-ranking cow may take precedence over a subadult or a young adult male. Since the beginning of courtship is comparable with a dominance encounter, with the cow adopting the subordinate role, a young bull may be unable to mate such a cow.

In all-male groups every male may act as a female, whereas in mixed herds, only a lower ranking male may do so. In all-female groups a higher ranking female may act as a male.

- herding (male tries to keep several females together)
- pursue (one male) and being pursued (one female)
- staying behind another oryx (a male behind a female): there is less than one metre distance between the croup of the female and the muzzle of the male; both animals look in the same direction
- mating whirl-around (only the tail of the male is erected, contrary to agonistic circling); both animals round an imaginary pivot in the same direction
- standing in a reverse parallel position: often only a break in the mating whirl-around
- Laufschlag=foreleg kick
- mounting
- sniffing at a conspecific (sexually orientated)
- Flehmen; may be observed in males and females

10. ***Mother – Calf – Behaviour***

- sucking attempt (from a calf)
- nursing (mother) and sucking (calf)
- mother licking her calf

Table F1. Frequencies of scimitar-horned oryx behaviour observed by Engel (1997a) in European zoos and safari parks.

Functional category	**Frequency**
Standing	36.1%
Lying	13.5%
Locomotion	12.9%
Feeding and Exploration	30.8%
Hygiene	2.0%
Elimination	0.4%
Interaction	1.3%
Agnostic Behaviour	1.2%
Reproduction	1.9%
Mother-Child Behaviour	0.1%

In addition to the functional categories, six types of vocalisations have been distinguished: adult contact call, juvenile contact call, calf contact call, adult snorts, calf moans and dam purr calls (Gill & Cave-Browne, 1988).

APPENDIX G
Food Items Fed to Scimitar-horned Oryx in the EEP

TANIA GILBERT

Table G1. The number of EEP zoos which use each food item in the summer diet for the scimitar-horned oryx. The weights are for food items per individual oryx. *The data is derived from 22 returned questionnaire sent to all EEP institutions holding Scimitar horned oryx*.

	Number of EEP zoos who feed each food item to scimitar-horned oryx by weight														
Food Item	**Weight in kg**														
	0.01	**0.2**	**0.3**	**0.5**	**0.6**	**0.8**	**1**	**2**	**3**	**4**	**5**	**6**	**Ad lib**	**Yes**	**Total**
Lucerne		1		1			1				2	1	1	1	**8**
Grass											1	1	10	6	**18**
Fruit				1			3	1						3	**8**
Vegetables							5							5	**10**
Pellets		2		1		2	5	1						8	**19**
Maize		1					2							2	**5**
Oats		1		1	1	1	1							3	**8**
Mineral salts	1							1					8	12	**22**
Browse											1		1	6	**8**
Dried sugar beet pulp		1													**1**
Barley			1				1							2	**4**
Hay							1		2		1		10	8	**22**
Acacia fruit		1													**1**
Sugar beet														1	**1**
Bran carrubba														1	**1**

Table G2. The number of EEP zoos which use each food item in the winter diet for the scimitar-horned oryx. The weights are for food items per individual oryx. *The data is derived from 22 returned questionnaire sent to all EEP institutions holding Scimitar horned oryx. However only 18 provided information on the winter diets for the oryx.*

	Number of EEP zoos who feed each food item to scimitar-horned oryx by weight																
Food Item	**Weight in kg**																
	0.2	**0.3**	**0.5**	**0.6**	**1**	**1.2**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**10**	**15**	**Ad lib**	**Yes**	**Total**
Lucerne	1		1									2			1	1	**6**
Grass										1					5	5	**11**
Fruit					2		1	1								3	**7**
Vegetables					3	1										4	**8**
Pellets	1				5		2	1								7	**15**
Maize					1			1								2	**4**
Oats		1		1	1											2	**5**
Mineral salts									1						5	6	**12**
Browse																4	**4**
Barley			1				1									2	**4**
Hay										2	1		1	1	6	7	**18**
Bran molasses																1	**1**

APPENDIX H
Nutritional Content of Some Food Items Fed to Scimitar-horned Oryx

TANIA GILBERT

Table H1. The nutritional content of different food items which are fed to scimitar-horned oryx in EEP zoos.

Item	Water %	Fat %	Protein %	T.D.F %	Ash %	Starch %	Sugar %
Flaked Maize	15.30	3.54	8.89	13.72	1.43	55.30	1.83
Crushed Oats	15.50	4.62	10.94	26.12	5.73	34.38	2.71
Wheat Bran	14.90	4.52	14.69	33.50	7.11	23.33	1.86
Wheat Germ	12.30	7.13	24.07	10.92	4.33	38.49	2.76
Crushed Barley	15.10	1.46	9.98	14.96	3.88	51.54	2.89
Oatfeed	12.30	1.22	3.64	67.60	2.16	9.91	3.17
Oatmeal	10.20	6.62	15.44	1.72	1.99	64.04	5.15
Exp. Linseed	8.20	6.17	34.38	30.17	6.32	8.41	6.35
Sugar Beet Pulp	15.60	0.44	9.45	41.25	7.68	-	25.59

Data provided by Mazuri™ Zoo Foods.

APPENDIX I
Reference Ranges for Scimitar-horned Oryx at the Zoological Society of London

EDMUND FLACH

Table I1. (LYNX Reference database, Bennett *et al.*, 1991)

Variable N	Units	Range
Total haemoglobin 71	g/dl	9.94 - 16.29
Red blood cell count 70	10^{12}/l	6.07 - 9.97
Packed cell volume 70	l/l	26.76 - 45.67
Mean cell volume 70	fl	38.15 - 52.33
Mean cell haemoglobin 70	pg	14.06 - 18.75
Mean cell haemoglobin conc. 70	g/dl	33.90 - 38.71
Reticulocytes 71	% RBC	0.0 - 0.6
Heinz bodies 24	% RBC	0.0 - 3.0
White blood cell count 71	10^9/l	1.39 - 7.26
Neutrophil count 68	10^9/l	1.08 - 5.13
Lymphocyte count 68	10^9/l	0.00 - 2.35
Monocyte count 68	10^9/l	0.00 - 0.23
Eosinophil count 68	10^9/l	0.00 - 1.08
Basophil count 68	10^9/l	0.00 - 0.12
Platelet count 42	10^9/l	139.2 - 484.1
Fibrinogen conc. 61	g/l	1.59 - 3.77
Sodium 41	mmol/l	133.5 - 151.6

Table I1. continued**…**

Variable	Units	Range
Potassium 35	mmol/l	2.99 - 5.33
Calcium 39	mmol/l	2.06 - 2.70
Inorganic phosphate 36	mmol/l	1.17 - 2.39
Chloride 41	mmol/l	88.5 - 109.3
Bicarbonate 40	mmol/l	20.42 - 36.88
Iron 33	µmol/l	5.78 - 48.30
Total protein 40	g/l	53.31 - 71.49
Albumin 40	g/l	32.85 - 46.85
Globulin 40	g/l	13.03 - 32.57
Urea 40	mmol/l	3.21 - 13.18
Creatinine 41	µmol/l	97.47 - 193.8
Cholesterol 3	mmol/l	0.70 - 1.80
Total bilirubin 41	µmol/l	0.40 - 41.0
Conjugate bilirubin 41	µmol/l	0.0 - 7.0
Alkaline phosphatase 41	iu/l	21.0 - 153.0
Alanine transaminase 38	iu/l	15.0 - 55.0
Gamma-glutamyl transferase 33	iu/l	5.0 - 27.0
Aspartate transaminase 39	iu/l	37.0 - 710.0
Creatinine kinase 14	iu/l	75.0 - 586.0

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