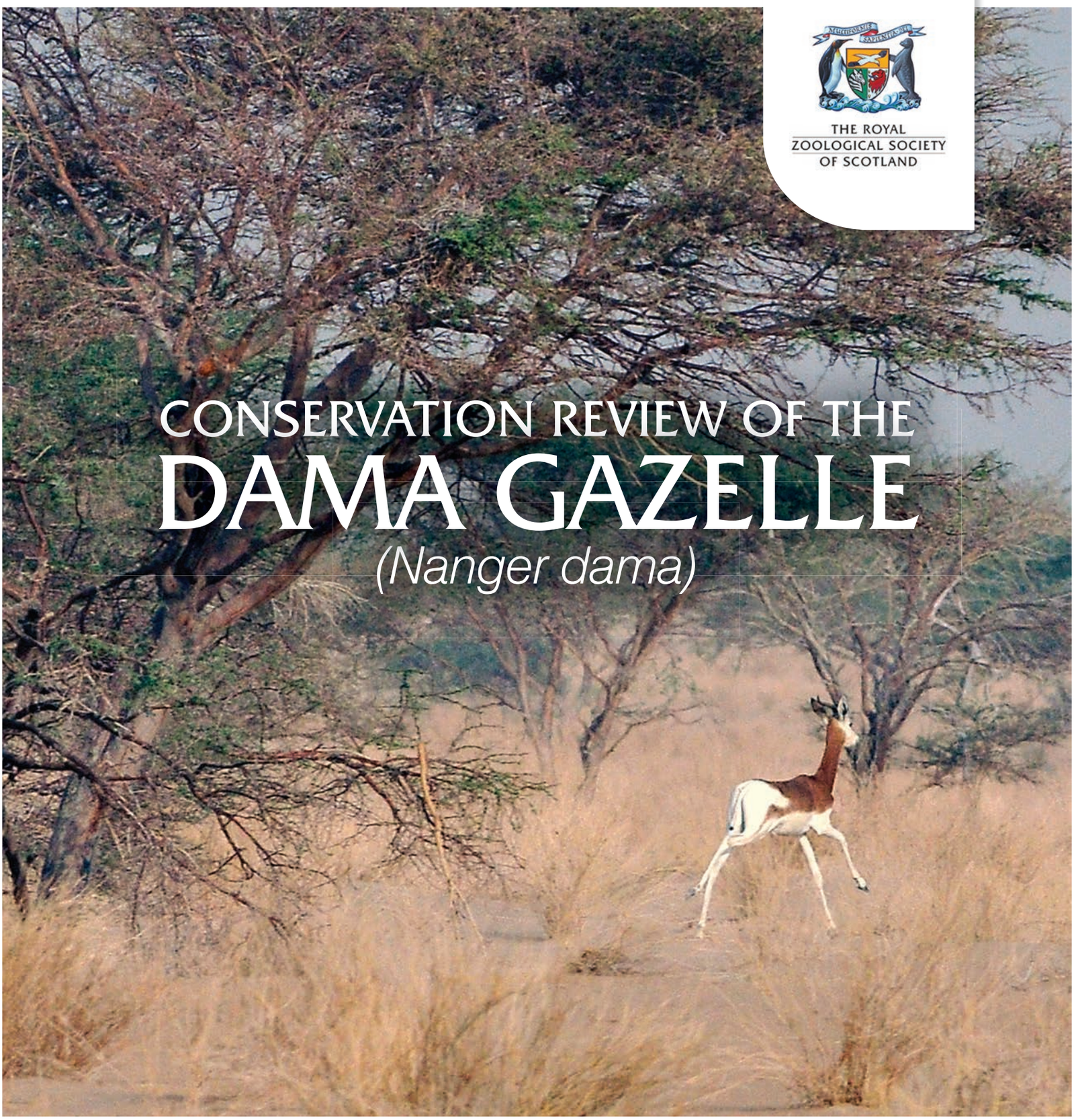

THE ROYAL ZOOLOGICAL SOCIETY OF SCOTLAND

CONSERVATION REVIEW OF THE DAMA GAZELLE

(Nanger dama)

IUCN

SSC Species Survival Commission

Antelope Specialist Group

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Cover photo: Dama gazelle in Manga region of Western Chad Feb 2014 © John Newby/SCF

CONSERVATION REVIEW OF THE DAMA GAZELLE

(Nanger dama)

Report produced following the roundtable workshop for dama gazelle conservation held at the Royal Zoological Society of Scotland, Edinburgh, 19th-21st November 2013

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EUROPEAN ASSOCIATION OF ZOOS AND AQUARIA
EAZA

EXECUTIVE SUMMARY

- The dama gazelle (*Nanger dama*) is one of the three most threatened antelope species.
- Once distributed widely across the Sahelo-Saharan region, it is known to survive in only five small subpopulations in Mali, Chad and Niger and numbers in the wild are estimated to be fewer than 300.
- Approximately 1500 animals exist in captivity worldwide (in zoos and on Texas ranches) which have been bred from around 24 founder individuals, collected from the wild in the second half of the twentieth century.
- Since the 1980s dama gazelles have been released from captivity into fenced reserves in Morocco, Senegal and Tunisia with mixed success.
- The species was historically split into three subspecies (*N.d.mhorr, N.d.dama* and *N.d.ruficollis*) due to variations in coat coloration that are present in successive regions across its range. Current captive management is conducted according to these subspecific delineations although there is some doubt about their validity.
- A workshop was held at RZSS, Edinburgh, in November 2013 to review and discuss key issues for dama gazelle conservation.
- This document represents the culmination of the workshop and outlines the next steps to be taken in order to achieve a vision of "Sustainable and free-living populations of dama gazelle persisting in their indigenous range, supported by well-managed populations elsewhere."
- Some key outputs within the document are:
  1. A review of the biology, ecology, taxonomy and history of dama gazelle.
  2. A comparative assessment of wild dama gazelle populations and the threats that they face.
  3. A history and assessment of captive populations worldwide, both in zoos and on Texas ranches, and of the released populations.
  4. A recommendation that, for conservation purposes, it is most appropriate to view the dama gazelle as a species without subspecies division, which may exhibit local adaptation of pelage coloration along a broad cline.
  5. A recommendation to conduct experimental breeding between captive *ruficollis* and *mhorr* to assess the risks and benefits of merging stock in captivity.
  6. A list of eight possible principal conservation actions that could be conducted in support of dama gazelle and their associated risks and benefits.
  7. A road map for moving conservation actions forward.
- This report is intended to provide the basis for a full dama gazelle conservation strategy, to be developed by the dama gazelle stakeholder community: principally range state agencies, international and local conservation NGOs, zoos and research institutions.

CONTENTS

LIST OF ABBREVIATIONS AND DEFINITIONS

AAZ:	Al Ain Zoo
ASG:	IUCN/SSC Antelope Specialist Group
ASS:	Projet Antilopes-Sahélo-Sahariennes
AZA:	Association of Zoos and Aquariums (USA)
AZAA:	Arabian Zoo and Aquarium Association
CBD-Habitat:	Fundación para la Conservación de la Biodiversidad y su Hábitat
C2S2:	Conservation Centers for Species Survival
CITES:	The Washington Convention on the International Trade in Endangered Species of Wild Fauna and Flora
CMS:	The Convention on the Conservation of Migratory Species of Wild Animals
DFC/AP:	Direction de la Faune, de la Chasse et des Aires Protégées, Ministère de l'Environnement, de la Salubrité Urbaine et du Développement Durable, Niger
EAZA:	The European Association of Zoos and Aquaria
EEP:	European Endangered Species Programme
EEZA:	Estación Experimental de Zonas Aridas Instituto del Consejo Superior de Investigaciones Científicas (CSIC) perteneciente al Área de Recursos Naturales, Almeria. Also referred to in literature as "La Hoya" Experimental Field Station or simply "Almeria".
EWA:	Exotic Wildlife Association
Indigenous range:	The indigenous range of a species is the known or inferred distribution generated from historical (written or verbal) records, or physical evidence of the species' occurrence. Where direct evidence is inadequate to confirm previous occupancy, the existence of suitable habitat within ecologically appropriate proximity to proven range may be taken as adequate evidence of previous occupation.
IUCN:	International Union for Conservation of Nature and Natural Resources
NMS:	National Museums Scotland

NP:	National Park
OROA:	Ouadi Rimé-Ouadi Achim Game Reserve, Chad
PA:	Protected Area
PCBR:	An ongoing project (2013-2015) for the Termit reserve (RNTTT), under the leadership of Noé Conservation and Sahara Conservation Fund. The acronym stands for Partenariat pour la Conservation de la Biodiversité Sahélo-Saharienne de la Réserve Naturelle Nationale de Termit et Tin Toumma au Niger
Phenotype:	An animal's observable characteristics or traits which may be controlled by genetic and/or environmental factors. Used in this report to refer to coat colouration of dama gazelle.
PSWS:	Pan Sahara Wildlife Survey
Range state:	Country within indigenous range
RCP:	Regional Collection Plan
Repatriate:	Return animal to range state (but not necessarily indigenous range)
RFG:	Red-fronted gazelle (*Gazella rufifrons*)
RZSS:	Royal Zoological Society of Scotland
SCF:	Sahara Conservation Fund
SHO:	Scimitar-horned oryx (*Oryx dammah*)
SSC:	Species Survival Commission
SSIG:	Sahelo-Saharan Interest Group
SSP:	Species Survival Plan Program
TWCS:	Tunisia Wildlife Conservation Society
UNESCO:	United Nations Educational, Scientific and Cultural Organization
ZSL:	Zoological Society of London

1. INTRODUCTION

The dama gazelle (*Nanger dama*) is one of the three most threatened antelope species in the world. It is classified on the IUCN Red List of Threatened Species as Critically Endangered and is listed on Appendix I of CITES and CMS. Three subspecies are generally recognised, but the intraspecific taxonomy of the species is not fully resolved and their validity may be questionable (see below).

Dama gazelles were once widely distributed across the whole Sahel zone, parts of the western Sahara and lower valleys of the mountain massifs of the Sahara, but range and numbers have drastically declined (Devillers *et al.* 2005; Newby *et al.* 2008; Scholte 2013). Now only five small and fragmented subpopulations are thought to survive and numbers in the wild are estimated to total less than 300 (Figure 1).

The main threats include unsustainable hunting and loss and degradation of habitat due to competition with and overgrazing by domestic livestock. Prolonged droughts in the Sahel have also had an adverse impact on rangeland quality, while the lack of security across much of the range has hindered effective conservation efforts.

The global captive population numbers ~550 in coordinated breeding programmes in North America, Europe and the Middle East. However, the number of founders is small and genetic diversity within the captive population is low. In addition ~900 dama gazelles are also kept on private Texas ranches with varying degrees of reproductive management practised.

Since the early 1980s dama gazelles have been released into fenced reserves in Morocco, Senegal and Tunisia (Cano *et al.* 1993; Akakpo *et al.* 1995; Abaigar *et al.* 1997; Müller 2002; Jebali 2008), with mixed success (Jebali 2012; Jebali & Zahzah 2013).

A workshop was held to review and openly discuss key issues for dama gazelle conservation and identify priority actions. The workshop was organised by the RZSS in association with the IUCN/SSC ASG and took place between 19th and 21st November 2013 at the RZSS headquarters in Edinburgh, UK. The workshop aimed to review the status of dama gazelles in all four of their current environments (wild, zoo, reintroduced/repatriated, Texas ranches) and so was aligned with a 'One Plan' approach. Intended outputs were: (1) a conservation review with proposed priority actions and draft recommendations; (2) an updated status review; and (3) a road map for developing the plan through further stakeholder input, especially from the range states. Appendix 1 contains a list of participants and Appendix 2 the workshop agenda.

2. NOMENCLATURE & TAXONOMY

Nanger dama (Pallas 1766) belongs to the tribe Antilopini, sub-family Antilopinae, family Bovidae. The other two species in the genus are N. soemmeringii and N. granti.

Common names (Chapman 1921; In Tanoust 1930; Roure, 1956; Devillers et al. 2005)

Arabic:	(ج: لمهار) الممر ، رغ ال الممر, addra, ariel[1], mehara (*pl.* mhor/ mohor), ril
Djerma:	ména
English:	dama gazelle, addra gazelle[2], mhorr gazelle[3]
French:	gazelle dama, biche-Robert, gazelle mhorr, grande gazelle, antilope nanguer (historic use).
Fulani (Peul):	nanguer, jabaré, n'bagaboula, téouda
German:	Damagazelle
Hassania:	mohor
Haussa:	ména
Mandingo:	sinédjé
Manga:	maina, karjou
Sonraï:	sanaï
Spanish:	mohor, antílope mohor, gacela mohor
Tamachek:	enher, tinheri (*pl.* tinheren, tinheran)
Toucouleur:	tevda
Tubu:	grashi (*pl.* grasha)

The dama gazelle has historically been subdivided into a number of species or subspecies based on variability in coat colour. The following scientific names have been given to dama gazelles: *Antilope dama* Pallas (1766); *Antilope nanguer* Bennett (1833); *Antilope dama* var. *occidentalis* Sundevall (1847); *Gazella dama permista* Neumann (1906); *Gazella mhorr reducta* Heller (1907); *Gazella dama damergouensis* Rothschild (1921); *Gazella dama weidholtzi* Zimara (1935); *Antilope ruficollis* Hamilton Smith (1827); *Antilope addra* Bennett (1833); *Antilope dama* var. *orientalis* Sundevall (1847); *Antilope mhorr* Bennett (1833); *Gazella dama lozanoi* Morales Agacino (1934). A review of the taxonomy can be found in Groves and Grubb (2011) and Scholte (2013).

Only three subspecies are usually now distinguished, following Cano (1984[4]): *Nanger d. ruficollis* which is situated east of around 15°E, *N. d. dama* approximately 7°E to 15°E, *N. d. mhorr* west of 7°E. *The N. d. mhorr*/*dama* boundary at 7°E has been debated owing to a misunderstanding and reinterpretation of the type locality of *Antilope dama*, Pallas (1766). Pallas's (1766) description is based on a specimen described and figured by Buffon (1764), which was collected from Senegal[5]. Neumann (1906) suggested that the morphology of this specimen showed that it originated from around Lake Chad. However, Lake Chad was not discovered by Europeans until 60 years after the collection of the specimen. Moreover, Groves and Grubb (2011) confirmed that they have seen other specimens from Senegal that match the morphology of the type. Therefore, the type locality of *Antilope dama*, and hence of the putative subspecies *N. d. dama*, is likely to be Senegal[5]. In contradiction to Cano (1984) the putative subspecies *N. d. mhorr* then extends "no farther S

[1] Ariel is also applied to Soemmerring's gazelle *N. soemmerringii* in parts of its range.
[2] Commonly used to refer to animals from the eastern section of the range.
[3] Commonly used to refer to animals from the north-western section of the range.
[4] Referenced as Cano Perez (1984) by Groves and Grubb (2011).
[5] Assuming that the specimen indeed genuinely originated there as opposed to simply being shipped from Senegal.

[South] than the W [Western] Sahara" (Groves and Grubb 2011) (Figure 1). It should be noted however that the specimen described and illustrated by Buffon (1764) was based on a taxidermal and not a live specimen (Figure 2a). The first drawing from a live specimen was not until 1824 and was of a female brought to France from Senegal where it was painted in the Menagerie du Jardin des Plantes (Natural History Museum of Paris) (Saint-Hilaire & Cuvier 1824) (Figure 2b). This painting shows greater biological accuracy and interestingly looks much more like a *mhorr* gazelle than that of Buffon, therefore supporting the contention of Cano (1984) that animals conforming to the phenotype of *N. d. mhorr* did once occur in Senegal.

Each subspecies is characterised according to the relative amounts of white and chestnut (reddish-brown) in the pelage, with the amount of white being greatest in eastern forms and least in the west (Figure 3). However, this taxonomic arrangement raises several issues: (1) the possibility that the variation simply expresses a cline (see Section 2.1). (2) Several authors have reported observations of differing phenotypes (see Section 2.1) in the same geographical location or even in the same group of gazelles, and captive groups also display considerable variation (Figure 4); and (3) the lack of convincing geographical isolating barriers[6] which could correlate with the development of distinct subspecies.

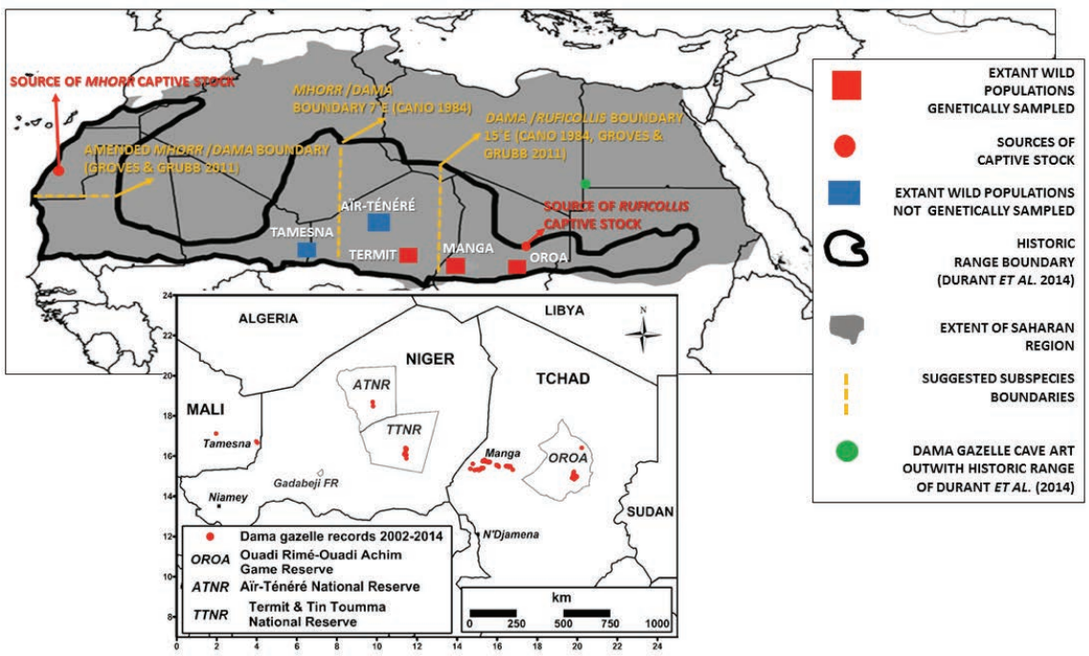


Figure 1: The former range of dama gazelle, including the putative subspecies boundaries following Groves and Grubb (2011) and Cano (1984). The location of current populations and details of sightings since 2001 (inset, Wacher & Newby ZSL/SCF 2014).

[6] Although the shorelines of palaeolake 'Mega-Chad', which covered >400,000 km^2 at its maximum extent (Drake & Bristow 2006) did divide the recent known range of dama gazelle, it could only have served as an isolating mechanism if the habitat types around its shoreline were similar, latitude for latitude, to what they are today. This seems unlikely.

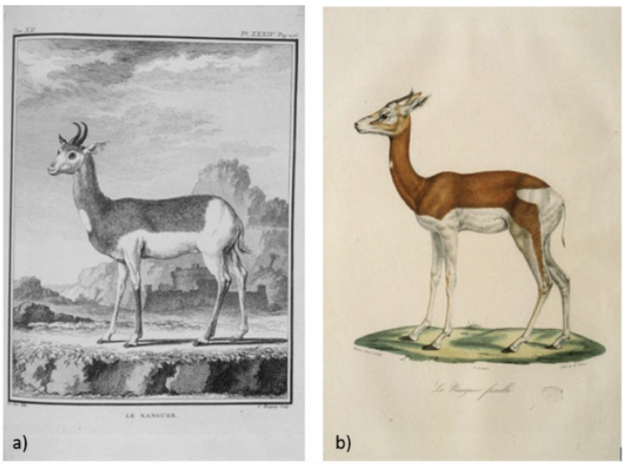


Figure 2: a) Depiction in Buffon (1764) of a dama gazelle, an individual most likely originating from Senegal, based on a taxidermy specimen. b) The first depiction of a live dama gazelle, also from Senegal (Saint-Hilaire & Cuvier 1824).

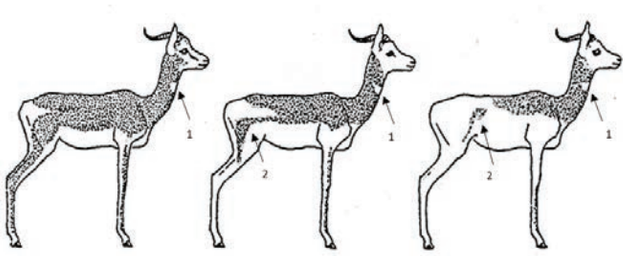


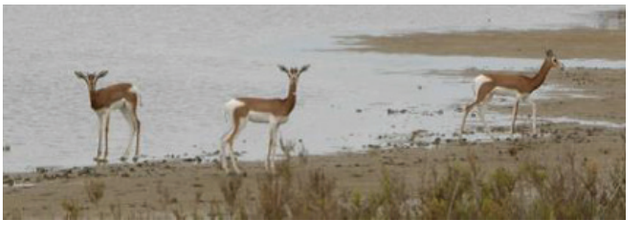
Figure 3: A stylised illustration from Dorst and Dandelot (1972) of the transition in phenotype from a typical N. d. mhorr *(left) to typical* N. d. dama *(centre) and typical* N. d. ruficollis *(right). Highlighted are (1) White patch on ventral neck (2) haunch-mark which can be attached to or separate from the main cape, or absent altogether. For further images see Figure 3 and further description in text below and Cano (1984).*

2.1. Description

The dama gazelle is the largest of the gazelle species. The pelage is white with a chestnut or reddish-brown cape on the neck and/or back. The pelage coloration is variable and is generally accepted to follow a clinal pattern (Cano 1984). From south-east to north-west through the species' range, the extent of the dark cape increases; chestnut may be limited to the neck only on palest forms in the east and extends to include the entire back and most of the legs in the darkest forms from the north-west (Figures 3 & 4). In the north-west, the dorsal body is almost completely chestnut, leaving a white underside and rump (Figure 4 a-c). The vast majority of animals have a small white patch on the ventral neck. Animals with a full or intermediate level of cape coloration exhibit a haunch-mark which can be attached to or separate from the main cape (Figure 4 e-g, j). On animals that have it, this mark may disappear altogether with age. The face of adults has relatively few markings, being completely white in fully mature adults in the southeast but with chestnut cheek patches and thin black stripes running through the eyes to the corners of the mouth in the north-west (Figure 4 a-c compared to i). Cano's (1984) descriptions of the three putative subspecies are given in Table 1.

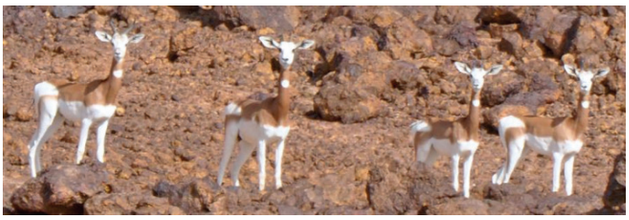
a) Al Ain Zoo, UAE, captive mhorr type

b) Frankfurt Zoo, Germany, captive mhorr type



c) Guembeul, Senegal, repatriated mhorr type

d) Aïr Ténéré, Niger, wild dama type



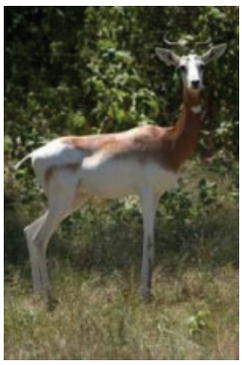
e) Termit, Niger, wild dama type

g) OROA, Chad, wild ruficollis type

f) Manga, Chad, wild ruficollis type

h) Al Ain Zoo, UAE, captive ruficollis type

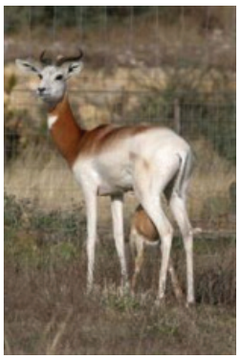
i) White Oak, USA, captive ruficollis type



1)

2)

3)



4)

j) Texas, US, ranched ruficollis type: an example of a family group, where the dam (1) and sire (2) gave rise to two variably coloured offspring (3&4), one of which was particularly light (3).

Figure 4: Variability in coat coloration in the dama gazelle (a-j). A general impression of the transition in phenotype from northwest to southeast and an indication of phenotypic variation within the populations. Individuals in photographs (b) & (c) and in all likelihood (a) originated from stock taken to EEZA from the Hagunia area of western Sahara. Note some variation in amounts of white on the flank and legs. Individuals in photographs (g-j) originated from Ouadi Hawach near Ouadi Rimé-Ouadi Achim, the source of the captive ruficollis-type population. Subspecies designations for the populations have been made based on geographical location according to Groves and Grubb (2011). Note that there is considerable intra- and inter-population variation. For example, within the wild populations at Termit (e) variation in the width of the haunch-mark and the extent to which coloration extends down the leg is present. The animal second from the right is mhorr-like in the extent of its markings. In OROA, Chad (g) the haunch-mark is present (right) and absent (left) in two animals from the same population and social group. Variation is apparent within the captive ruficollis population (h-j) within a Texas ranch population (j), two darker parents (1&2) gave rise to an offspring (3) with conspicuous coloration only on its neck. Although only visible in dull light, the animal did have an extremely light admixture of pigmented hairs over a small portion of the back. It is also interesting to note how dark and mhorr-like in coloration the animal from Aïr Ténéré in Figure d is (Figure 4c acknowledgement: Mar Cano).

All fawns are born with a tan coloration that disappears into the white/chestnut pelage with age. Juveniles can have harlequin-patterned faces and there are marked changes in face pattern as an individual matures; these changes may serve a social function (Figure 5).

The body is supported by thin legs and the neck is long and slender. Horns are found in both sexes, short compared to those of most other gazelles. They are ringed and functional in both sexes whilst being significantly thicker in males. They are S-shaped, slant backwards and then curl upwards distally. The tail is short and white, with a sparse fringe (Mallon & Kingswood 2001).

No traits other than pelage coloration are known to follow a clinal pattern in variation. No marked seasonal variation in coat colouration has been noted either in the wild or captivity, although minor variations may occur due to sun-bleaching prior to moulting.

Figure 5: Illustration of the change in facial marking with age in mhorr type animals from EEZA. From left-right: female - 3 months old, male 5-6 months & adult female > 7 years.

Today, it is hard to assess the extent to which clinal variation in coloration was continuous among historical populations. This is because of severe fragmentation of the current range (Figure 1; Durant 2014) and incomplete historical sampling in the form of museum specimens (Cano 1984). It is most likely that the historical range was continuous, although a number of breaks have been debated (see section 4.1). Although the cline is often stylised (as in Figure 1) and presented as a smooth gradation from northwest to southeast, many authors have noted variation of phenotype within the same population, including Cano (1984), the author of the currently accepted taxonomy, but also Hamilton-Smith (1827), Brouin (1950), Malbrant (1952) and Dragesco-Joffé (1993). These variations are still apparent in the wild today (Figure 4). However, it should be noted that typical *mhorr* colouration has never been found in the far east of the range, nor typical *ruficollis* coloration in the far northwest, although as potentially evidenced by confusion of the type specimen of *Antilope dama* (see Section 2), variation may be considerable.

Table 1. The main distinguishing characteristics for typical western, central, and eastern dama gazelles as determined by Cano (1984) based on examination of 50 skins from animals in European museums and 120 zoo animals from Almeria, Osnabrück and Rotterdam (living animals and skins) . Cano also states *"In any representation of the test results on the basis of the available material, the large variability in colouring must be strongly stressed. This holds true for the whole species generally as well as for each of the three subspecies. This (variation) is linked to a gradation with a tendency for the coloration to lighten from northwest to south and east, although without an unbroken continuity, such that it is possible to define mhorr from dama and dama from ruficollis."* See main body of text for discussion and comment. Brigitta Richardson is thanked for assistance with translation.

Nanger dama mhorr, N. d. mhorr* west of 7oE
"..show a uniformly red-brown coloration (Havana brown No. 131 on the Segui color scale) on the upper part of the body, which begins at the head – although becoming weaker as the colour expands onto the cheeks – and continues until reaching the centre of the croup. The white colour of the lower body is separated along a line running horizontally from the (tip of the) breast bone to the inguinal region[1]. This line, which runs beneath the centre of the body forms a downward pointing projection at the upper fore leg. The coloration of the back runs on over the (upper) thighs and forms a ham-shaped mark, the shape of which is curved smoothly at the rear, while in front two clearly demarcated lobules[2] emerge. This mark carries on to the tarsal articulation which, depending on the specimen, varies in colour intensity and size. Between these colorations and the overlying red of the croup, the white penetrates forward in the characteristic wedge-shape. Just as characteristic is a small white patch lying somewhat above the centre of the ventral neck, its extent and shape differing from one individual to another. It can even be asymmetrical or split. A red line runs from each forefoot to the upper forearm and varying in width and length. The length of this line can extend to only a tenth of the distance to the red body mantle or join with it. On the distal part of the four extremities, the red presents itself only on the front, forming a more or less broad line of varying colour intensity, which extends close to the dew claws. A further characteristic for this subspecies is a clearly defined eye stripe. This line is black in the proximal part and dark red in the distal part. From above the eye, it crosses straight to shortly before the edges of the mouth where it dissipates. From the evaluation of the above, a substantial range of colour variability which characterizes the subspecies becomes clear. This variability also applies to the other subspecies. However, one can still specify the limits within which one finds the range of characteristics that apply to *Gazella dama mhorr.*"

** See in text for disagreement with other classifications.*
[1]Probably actually referring to the flank.
[2]Or "lobes".

***Nanger dama dama, N. d. dama* approximately 7oE to 15oE**

"…not as evenly coloured on the upper body as the aforementioned subspecies *mhorr*, having intensified coloration on the neck. The encroachment of the red coloration onto the face is less pronounced, although it is greater in extent and hue than on some of the lighter versions of the *mhorr* gazelle skins examined.

On the body, the dividing line between red and white runs somewhat higher, while the projection which it forms at the upper fore leg remains present, albeit a little less pronounced. The pigmented stripe on the forearm can reach at the most to within 1/5 of the distance to the coloured part of the body, although normally the stripe does not come this far, and the forearm area is then perfectly white. The white patch on the front of the (ventral) neck is somewhat larger than on *mhorr.* The coloured zone on the lower legs is somewhat thinner. The actual distinction between these two subspecies, however, is in the markings on the (upper) thigh, which are substantially narrower on *dama* and whose margins run parallel without forming lobules[2]. This marking also does not reach the heel tendon, or it if does, it reaches it only weakly and without colouring it completely. As a consequence of this, the white wedge on the croup extends further forward over the body. In addition, the eye line is shorter and weaker and does not extend above the eye in its proximal part. In most individuals of this subspecies, the white is pure. However, on some (..), it possesses a yellowish tone (..)."

***Nanger dama ruficollis*, east of around 15oE**

"The subspecies *ruficollis* is lighter than *mhorr* and *dama*. It is characteristic that the coat colour on the upper body does not completely reach as far as the head and appears only rarely on the face. The pigmentation reaches its greatest density in the neck region, weakens on the back, and finally disappears completely. On the darker individuals (..) the reddish coat color extends over the croup region to the same place as in *mhorr* and *dama*, but in this case with a markedly lighter and more diffuse tone, and the dividing line with the white of the belly does not run horizontally as in the other two subspecies, but diagonally over the sides from the breastbone to the croup area.

On these animals (regardless of the coloration of the back) there is a tendency for the development of a large light patch with indistinct edges behind the withers. This, however, is not seen in all of the skins examined. The (upper) thigh mark appears only in a few cases in darkly colored individuals, but is never complete and takes at most the form of a small appendage which is separate from the main coat color. The front legs are white, but exceptionally rudimentary marks of the characteristic line running up this zone can show. The distal part of the feet shows a similar coloration as the other two subspecies but, however, is generally lighter. The neck mark is larger than in *dama*."

2.2. Taxonomy, genetics & recommendations

2.2.1. The difficulty and importance of taxonomy

Despite assumptions about the clinal variation in pelage coloration in dama gazelles throughout their range (Figure 4), individual variation within geographical areas may include forms which match the phenotypes of more than one putative subspecies. Therefore, although Cano's (1984) classification into three subspecies is the most widely accepted, there is still considerable uncertainty and discussion surrounding the dama gazelle's intraspecific taxonomy (see Section 2.1).

Taxonomic uncertainty is common in many species and most often reflects poor sampling and the historic naming of taxa, which is generally not based on scientific study, but instead on descriptions of single specimens. Comparison between wild variation and current captive phenotypes is further complicated by the very small founder base of the captive populations (see section 4.2); this may by chance have exaggerated apparent phenotypic differences or reduced variability in ways that are now undetectable. It is crucial from a conservation perspective that a species' taxonomy is based on its evolutionary history, and is coherent and workable (Frankham *et al.* 2012; Zachos *et al.* 2013).

Current uncertainty over the dama gazelle's intraspecific taxonomy creates particular problems when deciding how to manage populations in the wild and captivity. Although the current captive management programmes may seem sensible, regardless of eventual taxonomic decisions (two phenotypically distinct and geographically distant populations managed separately (Figure

4 a-c versus h-j, and details in section 4.2)), the continuing uncertainty surrounding taxonomy leaves a number of questions unanswered: (1) which captive populations would be suitable to provide donors for reintroductions? (2) And should this vary across the range? (3) To what extent can individuals in the wild be translocated between populations? (4) If new wild animals can be brought into captivity, which populations could they be bred with? (5) Is it feasible to exchange animals between captive populations? (6) Can animals from one wild population be translocated to supplement another wild population?

2.2.2. Genetic evidence

Studies of karyotype (chromosomal number and arrangement) have found differences in Robertsonian translocations both within *mhorr* and between the captive populations of *mhorr* and *ruficollis* (Effron *et al.* 1976; Arroyo Nombela *et al.* 1990; Vassart *et al.* 1993). Although Robertsonian translocations[7] may be the cause of reproductive isolation, they are also commonly found within ungulate species (Effron et al. 1976; Vassart et al. 1994), so it is unlikely that there would be chromosomal incompatibilities between populations of dama gazelles. Given the low founder base of captive populations, care must be taken in over-interpreting apparent differences between populations.

The only way to gain a clearer understanding of the level of differentiation between the putative subspecies is to conduct an extensive genetic and morphological survey of wild (contemporary and historic) populations. The technical challenges to this sort of study are considerable, not least because many populations are simply no longer in existence (see Figure 1), but also because of the difficulty of gathering a sufficient number of high quality samples. A genetic study of 36 faecal samples collected across three of the remaining wild populations and blood and tissue samples collected from captive populations represents the most extensive study to date (Senn *et al.* 2014). This study assessed the genetic structure and relatedness of populations using sequencing of the mitochondrial cytochrome b and control region.

The key findings were (Figure 6):

1. The genetic structure in the data was not clearly associated with geographical location (i.e. no phylogeographic structure).
2. The wild sample population now living in a small area of Chad (Manga & OROA) shows some evidence of polyphyly with respect to wild samples from Termit in Niger and captive animals originating in southern Morocco. Translated to the traditional subspecies view, this implies that the putative *ruficollis* may be polyphyletic with respect to both *dama* and *mhorr*.

These data suggest that the current subspecies definitions may not be valid.

Some level of genetic structure is present as evidenced by the transition in pelage colouration across the Sahara. However, it is unclear whether this is adaptively neutral, occurring as a result of genetic drift, or whether it is adaptive, for example against predation or reflection of solar radiation. No concurrent cline in habitat or predator presence

[7] A type of chromosome rearrangement that is formed by fusion of the whole long arms of two acrocentric chromosomes (chromosomes with the centromere near the end).

has been documented to support the latter. The most conservative approach for conserving the species is to assume that phenotype has some adaptive value and to take this into consideration when managing different populations and reintroductions. Critically it is not the phenotype per se that is important, but the genetic variation that underpins it. Although phenotypic match to the environment may be important, no attempt should be made to breed individuals for a particular phenotype as this will result in inbreeding, loss of genetic variation, loss of adaptability and possibly unforeseen fitness consequences due to a pleiotropic effect of coat coloration genes, as has been observed in domestic animals (Cieslak et al. 2011).These reasons underpin why selective (artificial) breeding for phenotype contravenes the IUCN technical guidelines on the management of ex-situ populations for conservation (IUCN 2002) and the EAZA Code of Practice (EAZA 2004).

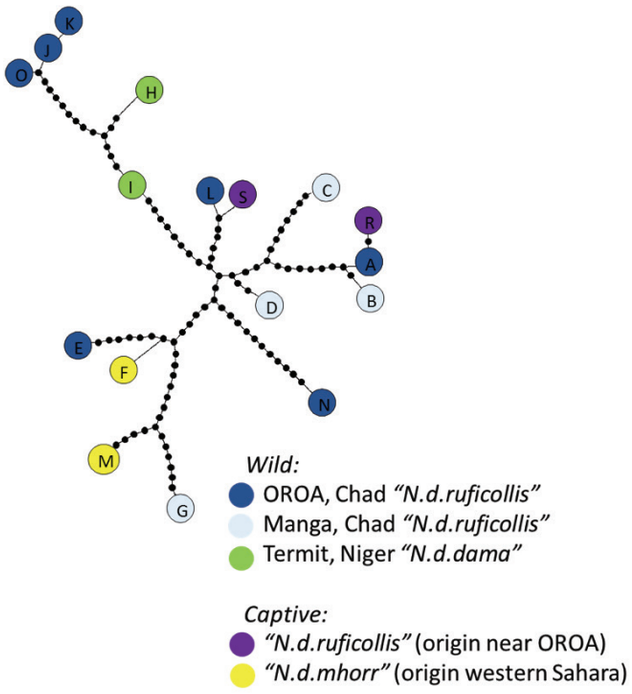


Figure 6: A mitochondrial DNA haplotype network (560bp of control region) illustrating the relationship between maternal lineages found in the wild and captivity. Each of the coloured circles represents a haplotype sampled at a given location, small black circles represent mutational differences between them. Haplotypes found in one geographical location are often closely related to those from another geographical location (see E&F, M&G).

2.2.3. Recommendations

To the best available knowledge phenotypic variation was broadly clinal across sub-Saharan Africa. Today we see phenotypic variation between populations and within populations. The division of the historical phenotypic cline into three subspecies is inconsistent with the available genetic results, where a lack of any phylogeographical structure has been revealed.

It is most appropriate to view the dama gazelle as a monotypic species (i.e. without subdivision into subspecies), which may exhibit local adaptation of pelage coloration along a broad cline. Under this "no subspecies view" there is a continuum of suitability of donors to a population, where **all else being equal**, the geographically most proximate population is the most suitable. However, there are no *a priori* barriers to exchange between any populations provided the risks and benefits have been evaluated properly and there are good conservation justifications for doing so.

With respect to potentially augmenting populations in the wild, we suggest that either the closest neighbouring wild population or the geographically most proximate captive source (in terms of its origin, not current location) are considered as first choice candidates.

Mixing of the captive *mhorr* and *ruficollis* stocks (see section 4.2 for full history) should also be considered as a captive management option. Since the source of the two captive stocks come from geographically distant sources, this should not be done comprehensively until the risk and benefits have been evaluated fully. These are summarised in Table 2.

Table 2. Possible risks and benefits of mixing captive stocks of "*N .d .ruficollis*" and "*N. d. mhorr*"

For mixing	Against mixing
• Lack of genetic support for the three 'forms' or 'subspecies'. • Considerable phenotypic variability evident within 'subspecies' in wild and captivity. • Phenotype appears to follow a cline in wild, phenotypic differences in captivity possibly exaggerated due to small founder group sampling effect. • Enabling some level of gene flow between 'subspecies' reflects historic natural process. • Restricted gene pools of captive *mhorr* and *ruficollis* resulting from very small numbers of founders (captive, Texas, release sites) suggests mixing may lead to more viable herds (captive and released). • Reduction in risk of inbreeding depression. • Keeping *ruficollis* and *mhorr* separate increases population extinction risk. • No "*N. d. dama*" available in captivity, so decision to mix putative subspecies may have to take place in the wild anyhow.	• Once mixed, cannot go back. • Phenotype may have adaptive value and mixing may remove naturally existing locally adaptive variation. • Phenotype shows variation and follows a cline, but nevertheless shows clear differences at the extremes of the distribution. • Possible risk of outbreeding depression or sterility. • Mixing *ruficollis* and *mhorr* will result in loss of phenotypic distinctiveness of captive populations. • Risk that holders might feel permitted to mix captive stock *ad libitum* and concurrent danger of lack of official reporting or record-keeping. • Danger of deliberate generation of phenotypic curiosities for hunting/spectating as opposed to conservation. • Risk that mixed stock may be created that will later be rejected by captive community. • Promotes public perception that related forms need not be valued as separate entities.

As a first step we recommend carrying out an experimental breeding between *mhorr* and *ruficollis* to evaluate potential negative impacts and to see whether there is any reduction in viability of resulting offspring. This should be followed by a population viability analysis of mixed and unmixed options for captive populations.

2.2.4 Nomenclature used in this report

The names of the three described 'forms' or 'subspecies' are retained in this report for ease of reference and are used as follows: *mhorr* for putative '*N. d. mhorr*'; *ruficollis* for '*N. d. ruficollis*'; To avoid confusion '*N. d. dama*' is only ever used to refer to the subspecies '*N. d. dama*' and '*dama gazelle*' refers to the species *Nanger dama* as a whole.

3. ECOLOGY AND HABITAT

3.1. Habitat and diet (adapted from Devillers *et al.* 2005)

Characteristically the dama gazelle has a mixed diet of grazing graminoid or non-graminoid herbaceous plants, and of browsing the foliage of woody species, which play a particularly important role in its ecological requirements (Newby 1974). In the Sahel it browses leaves, flowers and pods of *Acacia* spp., *Balanites aegyptiaca, Maerua crassifolia* and other trees and shrubs, and sometimes grazes on grasses during the wet season (Scholte 2013). The presence and density of trees appear to influence the distribution of the dama gazelle (Grettenberger and Newby 1986). Its close association with acacia woodlands and their accompanying flora has been noted by numerous observers in various parts of the range (Sclater and Thomas 1898; Lhote 1946; Brouin 1950; Morales Agacino 1950; Malbrant 1952; Valverde 1957; Kowalski & Rzebik-Kowalska 1991; Dragesco-Joffé 1993). In the Aïr Mountains of Niger, Grettenberger and Newby (1986) documented its strong preference for the major wadis and their flood plains, environments in which trees remain in better condition during the dry season and provide both shade and fodder in the hot season. In the Atlantic Sahara, *N. d. mhorr* mainly occupied wadis dotted with acacia at variable densities (Morales Agacino 1950; Valverde 1957). In the north-western part of its range, in areas lying some 10-50 km from the Atlantic Ocean, *Nanger dama* was found in dense shrubby steppes without Acacia spp. and it may have fed on *Argania spinosa* foliage, as do *Gazella dorcas* and *G. cuvieri* (Cuzin 1998, 2003).

Dama gazelles occur in rockier habitats in the Aïr Mountains, Termit Massif and formerly in other localities such as the Hoggar. It is likely that these are atypical habitats within the former range (In Tanoust, 1930; Roure, 1956; Dekeyser, 1950), where they remain due to lower levels of persecution. They may also occasionally occur in open desert (Dragesco-Joffé 1993).

In one of the last strongholds of the dama gazelle (Termit, Niger) micro-habitat seems to be important during their resting periods. Juveniles and adults have been observed resting on the Termit Massif in a rocky plateau or along slopes on small clay-sandy patches (Figure 7). Therefore suitable habitat for dama gazelles in Termit could be a combination of well-treed valleys separated by rocky relief where at some point clay-sandy patches are available (Rabeil *et al.* 2010).

The dama gazelle is drought resistant. Though detailed field studies on the most important sources of water for dama are lacking, most of its water is obtained from its plant food, including the wild melon *Citrullus colocynthis* (Dragesco-Joffé 1993) and it undertakes nomadic movements in response to food availability. Monitoring of the dama gazelle population, reintroduced into Ferlo North, Senegal, showed that the gazelles are mainly encountered in densely vegetated areas during the dry season and in clear and open areas during the rainy season (Jebali 2008).

Figure 7: Dama gazelles in the Termit massif have been observed to make use of small clay-sandy patches (Rabeil et al. 2010).

3.2. Social organisation

The limited available information indicates that social groups consist of harems (one male with several females), pairs with young, females and young, mixed groups, male groups and individual males (Scholte 2013). Group size in the 1980s in Aïr and Ténéré NNR was 1.92 ± 1.20 (Grettenberger & Newby 1986). In the western Sahara, according to data provided by Morales-Agacino (1949) and Valverde (1957), most social groups consisted of 1–4 individuals, with some groups of 13 and 15 *mhorrr* gazelles accompanied by dorcas gazelles.

Large herds of 100-200 have been observed in the late dry season and early wet season (In Tanoust 1930, Newby 1978, Dragesco-Joffé 1993). Gestation is reported to be 6.5 months and a single young is born. In the wild, births are seasonal and probably linked to food availability (Scholte 2013). Mean group sizes reported recently are shown in Table 3.

Table 3. Mean group sizes reported by SCF/SSIG teams 2001-2013

(with additional thanks to Abdoulaye Harouna, Issaka Houdou, Christian Noirard & Alkabouss Matchano)

Site	Sightings	Mean group size	95% CI	Max group
Manga	14	2.1	1.57-3.57	8
Termit	79*	3.3	2.73-4.13	15
OROA	15	2.6	1.60-4.20	9

** to 2012 only – 19 observations in 2013 not included.*

4. DISTRIBUTION AND STATUS

4.1. Distribution in the wild

4.1.1. Historical distribution

Dama gazelles formerly occurred across the Sahelian zone from Mauritania to Sudan, west of the Nile, extending north up the Atlantic Sahara to the Anti-Atlas mountains in Morocco, and around some Saharan mountain massifs (e.g. Hoggar, Tassili, Aïr, Adrar des Ifoghas and Tibesti). There are records from a few other locations in southern Algeria (Kowalski & Rzebik-Kowalska 1991) and reports from extreme southern Libya (Hufnagl 1972) that may represent movements of animals northwards from the Hoggar and Tibesti mountains, respectively. There are older records, some relatively ancient and circumstantial, of occurrence in NW Algeria, Tunisia and Egypt's Western Desert (Scholte 2013), but no recent evidence of established populations of dama gazelles in the sub-desert steppes north of the Sahara (Devillers et al. 2005). Some old records may derive from depictions on mosaics and thus are not reliable indicators of indigenous wild populations in the vicinity. Cave paintings of dama gazelle have been found in the Hoggar region, Algeria near Eherene and Immidir (Timesigan, N 25o 24', E 04o 14'). They have also been found in Ennedi (NE Chad), Manga (W Chad), Jebel Uweinat (on the Egypt-Libya-Sudan border), and Western Gilf Kebir ('Cave of Beasts', Wadi Sora North, SW Egypt). These last two sites fall outside the historical range given by Durant *et al.* (2014) (Figure 1). For some examples of rock art see Figure 8.

A massive decline in both range and numbers has occurred, beginning in the late 19th century and accelerating since around 1950. This decline has taken place in the context of a massive overall decline in the large vertebrate fauna of the region (Durant *et al.* 2014; Jebali 2008). Further details of former distribution are available in CMS (2006), East (1990 and chapters therein), In Tanoust (1930) and Scholte (2013).

(a)

(b)

(c)

(d)

Figure 8) Some examples of cave paintings of dama gazelle. a) A dama gazelle hunting-scene from the 'Cave of Beasts', Wadi Sora North, western Gilf Kebir, SW Egypt. b) A dama gazelle that appears to be on a noose or a leash in Gebel Uweinat (Egypt-Libya-Sudan border). c) A section from a hunting scene depicting five dama gazelle in Gebel Uweinat d) Paintings from Manga (W Chad). Cape colouration on all depictions is fairly extensive, with haunch-marks possibly indicated in some animals (d&c). It is interesting to note that none of the Egyptian depictions (a-c) show the extremely light variation of ruficollis that have been seen in captivity (e.g. Figure 4j.3), perhaps in contradiction with the idea that coat-coloration had a clinal trend towards being much lighter in the far east of the range. Photographs [a-c] by András Zboray, [d] by Ursula Steiner.

The range is assumed to have been continuous or largely continuous. Although, Lake Chad, when at its maximum historical extent of c.400,000 km^2 around 7000 years ago ('Lake Megachad'; Drake & Bristow 2006) may have formed a partial barrier between western and eastern parts of the range, even then interpopulation connectivity may have been maintained, especially around its northern region. A break in the range in southern Mauritania has also been debated (Cano 1984; Devillers *et al.* 2005; Jebali 2008).

4.1.2. Current distribution

Only five confirmed populations are known since the year 2000: South Tamesna (eastern Mali/ western Niger), Aïr Mountains (northern Niger), Termit (eastern Niger), Manga (western Chad) and Ouadi Rimé-Ouadi Achim (north-central Chad) (Figure 1). In total, 116 sightings of dama gazelles were reported, 2001-2014 (Table 4).

Table 4. Summary of known dama ranges at remaining wild sites 2001-2014

Site	Known extent of occurrence* of dama gazelles (km^2) at each site	Basis of estimated sightings
Tamesna (Mali)	3000km^2	3 groups seen at two widely separate locations 2005 & 2006 (reports from Niger side of frontier in 2010 not included)
Aïr and Ténéré (Niger)	600km^2	5 groups and associated signs
Termit and Tin Toumma (Niger)	900 km^2	98 groups recorded during regular monitoring 2007-2012
Manga (Chad)	6000-7000 km^2	16 groups and associated signs, 2001, 2010 & 2014
OROA (Chad)	1100 km^2+	15 groups and associated signs 2010, 2011, 2012,2013

** IUCN. (2012). IUCN Redlist Categories and Criteria; Version 3.1. Second edition. Gland. Switzerland and Cambridge, UK: IUCN iv+32 pp.*

South Tamesna
Surveys of two areas, covering 1775 km2 and conducted in February 2005, observed seven dama gazelles and found evidence of another 18. The population was estimated at 170 (Lamarque et al. 2005, 2006, 2007). The habitat consisted of uneven relief with large grass tussocks where vehicle access was difficult and there were no signs of pastoral activity. Some local reports were received in 2010 of sightings in adjacent areas of western Niger. No subsequent surveys have been carried out because of the security situation and no information on current status is available.

Aïr and Ténéré National Nature Reserve
Total area of 77,360 km2. The population was estimated at 150-250 individuals in 1983-1984 (Grettenberger & Newby 1986). Two dama were seen in 2002 and a small number of reports confirming continued presence in low numbers have been received from reliable local observers since then, but there have been no recent surveys due to the uncertain security situation.

Termit and Tin Toumma
The area was declared a National Nature Reserve (97,000 km2) in March 2012. Dama gazelle numbers are currently estimated at 50-60 with the population being monitored over the last 5-6 years by SCF and the former Antilopes Sahélo-Sahariennes Project. Through these surveys dama gazelles have been monitored, camera-trapped and their locations mapped. They were found in rocky areas in the core where they are safer or less vulnerable to hunting and may have been forced to occupy sub-optimal habitat. Further details in Rabeil et al. (2013).

Chadian Manga
This region of fixed, vegetated dunes lies north of Lake Chad, spreading east from the Niger border and covers 4000-7000 km2. Dama gazelles were seen thinly scattered in wet seasons of 2001 (maximum group size 3) and 2010 (maximum group size 8) during SSIG & Pan-Sahara Wildlife Surveys. Currently, the area is not formally protected but habitat condition is good. Some local reports have also been received from across the border in East Niger. A dry season survey by SCF in January 2014 observed dama gazelles twice, but found tracks and received local reports of their presence in small numbers over a wide area, demonstrating that dama also use an extensive region of *Acacia*/*Panicum* grassland plains to the north and east of Manga; however the population is considered to be very small and threatened by significant and increasing incursion of human hunting as shown by the presence of vehicle tracks and trails. For further details of this area see Wacher & Newby (2010).

Ouadi Rimé-Ouadi Achim Game Reserve (OROA)
Covers 77,950 km2 in north-central Chad. Dama gazelles were once abundant here; 6000-8000 were estimated in the mid-late 1970s (Newby 1978; Thomassey & Newby 1990). Now only an estimated 30-50 remain concentrated in a 1100 km2 area in the central part of the reserve, where there are relatively few wells and low human presence. Within this small focal area, encounter rate approximated 1 dama gazelle/20 km over four surveys conducted between 2011 and 2013. This compares with an encounter rate of 1/5 km across a much larger region of the reserve generally in 1975-1977, indicating a dramatic reduction in both range and relative abundance. This remnant population is living 160km SSE of the Ouadi Hawach which is well known as the location where in 1967 van den Brink caught the founder animals of the captive population now attributed to *N. d. ruficollis*. Ouadi Hawach lies within the northern part of the OROA game

reserve; the carcass of a female dama gazelle was found there in 2011 while a local report of live animals was obtained there in 2013 (see Wacher & Newby 2012). OROA has been designated as a reintroduction site for scimitar-horned oryx. This operation will be accompanied by work to rehabilitate the reserve and increase protection that will benefit the dama gazelle population there too.

Other sites

Unconfirmed local reports suggest that a small group of dama gazelles occurs in dense acacia woodland south of Ati (in the Batha region, c.450 km north-east of N'Djamena and south of OROA).

Additionally there are unconfirmed local reports of dama gazelles in the Tassili de Tin Gherghor, an area of the SW of Tammanrasset, Hoggar Mountains, Algeria.

Many areas of former range have not been surveyed in recent years/decades due to political instability and lack of security. So there remains a slight possibility of small groups persisting elsewhere, e.g. Western Sudan. However, dama gazelles have the potential to make long-distance movements, like all desert antelopes, so any 'new' small groups discovered may represent wanderers and not new subpopulations.

The species previously occurred in the Darfur and Kordofan regions of Sudan, but internal conflicts and lack of security have prevented field surveys for several years. Wilson (1980) said that only very small numbers of dama gazelles remained in Northern Darfur, but East (1999) reported anecdotal information from local people indicating that dama gazelles survived at low densities in North Darfur and North Kordofan in the 1990s. One likely location for an overlooked relict population is the Wadi Howar area in North Darfur. Dama gazelles were reported to be extinct in Mauritania (Sournia & Verschuren 1990; Wilson & Reeder 1993), but there have been some tentative local reports recently, although no recent surveys have been conducted.

The five relict subpopulations are situated a long way apart from one another and the possibility of migration or movement between them is thought to be low or non-existent, rendering them more or less isolated. Measured from the central part of dama gazelle range in the Chadian Manga, Termit in Niger lies 400 km westwards and OROA 480 km to the east. Contiguous natural habitat between Manga and OROA suggests that dama gazelles were probably once continuously distributed. However, recent increases in settlement and well development throughout the region, and particularly an increase in international trading and road traffic along the growing complex of trackways of the Bahr al Ghazal in Chad (an extensive braided wadi system running diagonally across the terrain between these two sites) probably strongly discourage dama gazelle movement. Although as its name indicates, the Bahr al Ghazal was once a notable area for gazelles generally, even the dorcas gazelle, relatively abundant in the Manga and at OROA, is today only occasionally observed within its margins.

4.1.3. Population

There is no reliable estimate of former population size, but there is no doubt that current numbers are only a small fraction of the original. East (1999) surmised that numbers were in the low thousands and continuing to decline. The current population is estimated to contain $<$ 250 mature individuals (i.e. those capable of reproduction) (Newby *et al.* 2008).

4.1.4. Site suitability assessment

During the course of the workshop at the Royal Zoological Society of Scotland, Edinburgh, a comparative assessment of the wild sites was conducted with scores from 1-3 given to a number of considered individual elements of suitability (e.g. security, biological suitability etc.) (see Table 5). These scores are essentially qualitative and were reached during a group discussion of each element. Summation across all scores gives an approximate indication of the suitability of each site. However care should be taken when interpreting the scores because they represent a snapshot of the current situation and not necessarily its future potential. Some elements may be more or less immutable (perhaps biological suitability), whereas others could change or could actively be changed over time (such as security). In addition to this, summation across all elements of the suitability assessment assumes equal weighting of each element. In reality this may not be the case and there may be certain elements (e.g. security) which might negate all others. A number of elements are also likely to be strongly interrelated (e.g. security and local capacity).

With these caveats in mind, the assessment recognised that currently OROA and Termit represent the most favourable sites for taking conservation action. By and large the scores for both sites were at parity. OROA scored poorly on human land use with respect to Termit and Termit scored poorly on biological suitability with respect to OROA (recognising that the Termit region is historically atypical dama gazelle habitat). The lower scoring of Manga with respect to these two sites was arguably due to factors interrelating to its lack of protected area status (lower government commitment, financial resourcing and local capacity) and a higher human land use threat. Aïr and Tamesna scored low on a large number of factors although some of these are interrelated e.g. poor security and concurrent lack of accessibility of these regions.

4.2. Zoos and breeding centres

Dama gazelles are held in 44 institutions in North America, Europe, Africa, and Asia. The global registered ISIS (International Species Information System) captive population numbered 550 (231.318.1) in 2013. Since institutions do not always comply with registration this is a general estimate. Only *N. d. mhorr* and *N. d. ruficollis* are kept and there are no individuals of *N. d. dama* in captivity. North American zoos focus on breeding *ruficollis* (through an AZA SSP) and European Zoos on *mhorr* (through an EAZA EEP).

The captive *N. d. mhorr* population started with 4 (1.3) founders, originating from animals taken from the Dora-Hagunia and Tichla-Bir Ganduz areas of Western Sahara in 1958, which were transferred to the EEZA breeding station between 1970 and 1975 (Cano 1991). There are currently 293 (119.174) in 20 collections; most of these are in EAZA member institutions: 216 (91.125) in 13 institutions in Europe and 66 (24.42) in the Middle East. There were over 32 births in the year 2013/14. Genetic analysis based on the studbook has shown that the fraction of original genetic diversity (GD) retained relative to the founding population of the studbook is 73% and average inbreeding coefficient (F) is 0.273.

The known history of captive *N. d. ruficollis* is as follows: all current animals descend from a single capture that was carried out near Ouadi Hawach, Chad, by Frans van den Brink in 1967. Either 22 or 23 individuals were taken from the wild and transported onwards to the USA. It seems most likely that 20 of them survived and that 12 were given to San Antonio Zoo (3.9) and 8 to Catskill Game Reserve (2.6), although there is some uncertainty surrounding the exact numbers and division (Petric 2012). According

to studbook records it seems mostly likely that the AZA captive population is descended, in the main, from the initial founder population at San Antonio Zoo. However subsequent transfers of descendants from the original Catskill group into the AZA breeding programme have occurred. Transfers from AZA into private collections (that may have also been supplied by Catskill) are also documented. In both private collections and the AZA studbook the extent of mixing of the two gene pools is unknown. Thus whilst all *ruficollis* individuals in North America (and indeed the world) are descended from the original capture, there may be different genetic variation present in different captive populations and investigation of this should be a priority as it is likely to be a useful resource for future conservation breeding programmes.

In ISIS registered collections there are now 220 (103.117) *ruficollis* in 18 facilities in North America and 89 (42.46.1) in four institutions in the Middle East. There were 45 births in the last 12 months. The GD of the North American population is 85.77% of the 20 founders (which may have been related). The 2009 regional collection plan target was 200, but it is estimated that 700 are needed for long-term viability.

Table 5. Assessment of existing wild sites for future conservation action; scored from 1 (worst) to 3 (best). Summation across all scores gives an approximate indication of the suitability of each site, although each element should be considered individually as they may be interdependent and not of equal importance (see text).

	Security	Government commitment	Local capacity	Financial Resources	Knowledge	Biological suitability	Population Viability	Human land use threat	Protected Area	Poaching	Area Occupancy	Score
Tamesna	1	1	1	1	1	2	1	3	3	1	2	**17.0**
Aïr	2	2	2	1	1	1	1	3	3	1	2	**19.0**
Termit	2	3	3	3	3	1	3	2	3	1	2	**26.0**
Manga	3	2	2	1	2	3	2	1	1	1	3	**21.0**
OROA	3	3	2.5	2.5	3	3	2.5	1	3	1	2	**26.5**

4.3. Released populations

Dama gazelles (from the *mhorr* captive population) have been released into six fenced-protected areas located within or close to their former range: Morocco (3), Senegal (2) and Tunisia (1). The sites range in character from breeding facilities to attempted reintroductions and success has been variable. All the sites are fenced, and water and/or food are provided (release site summary in Table 6).

4.3.1 Senegal

Guembeul Faunal Reserve (720 ha)
This reserve was established in 1983 as an acclimatisation and reintroduction site. In 1984, seven (2.5) dama gazelles were transferred there from EEZA. From the Guembeul reserve, several individuals were then transferred to the privately-owned Bandia reserve (3 animals some time before 1997; East 1999) and possibly Fathala reserve (no further details available). None are now present in either reserve. Five were also transferred to the Katané enclosure in Ferlo Nord Faunal Reserve in 2003 (see below) and two were reportedly sent to Mauritania in 2009-2010. The population at Guembeul reached a maximum (32 animals) in 2002. Since then there has been a declining trend. Aside from the animals sent to other reserves, five dama gazelles in Guembeul were killed by stray dogs in 2008. In 2013, 13-15 animals were present. Moreno *et al.* (2012) cited changes in habitat structure as the most likely cause for the decline in numbers.

Ferlo Nord Faunal Reserve (450 ha, recently enlarged to 1200 ha)
The Katané enclosure was constructed within the reserve as an acclimatisation/pre-release site for dama gazelles and other species. Five (2.3) animals from Guembeul were released there in 2003. The group now numbers 16-18 animals.

4.3.2 Morocco

R'Mila Royal Reserve (465 ha)
This reserve near Marrakech (the furthest reserve in Morocco from the former natural range) was established in 1982, mainly as a breeding facility. In 1992 six (3.3) dama gazelles were brought from EEZA and Munich Zoo, followed by more from German zoos in 1992-1996 (Wiesner & Müller 1998). Under intensive management, with fully artificial provision of feed and water, the population has increased steadily and now numbers 158.

Souss-Massa National Park (33,800 ha)
The park was established in 1991 and is situated on the coast of SW Morocco, south of the city of Agadir, outside the known former dama gazelle range. Twenty-one dama gazelles from Berlin, Frankfurt and Munich Zoos were released between 1994 and 1998 into the fenced Rokkein enclosure (2000 ha). Captive-bred addax (*Addax nasomaculatus*) were also released along with dorcas gazelles (*Gazella dorcas*) at Rokkein. The dama gazelles have since died out, in contrast to the other species which are thriving[8]. The factors preventing dama gazelles from establishing here have not been identified.

Safia Reserve (600+ ha)
Established in 2006 in the far south of Morocco and within the former range in the Atlantic Sahara. Sixteen (7.9) dama gazelles were transferred from R'Mila reserve in April 2008 and the population has increased to 41.

[8] In the case of addax, sufficient to survive a serious population crash following a period at unnaturally high density.

Table 6. Characteristics of release sites

Site	Country	Proxim. to native range	Area (km2)	Founder Nos.	Date	Current No's.	Supplem. feeding	Water	Compe-tition	Predation	Poaching	Manage-ment plan?	Manage -ment intensity
Bou – Hedma	Tunisia	?	24	18 (5.13)	1990-1994	3 males	X	Natural	Addax SHO Dorcas gazelle	Caracal Jackal	✓	X	Low
Souss – Massa:	Maroc	Out	10	21 (13.8)	1994-98	0	✓	Supplem.	SHO Addax Dorcas gazelle Wild boar	Wild boar	X	X	Low
Safia	Maroc	In	5.59	16 (7.9)	2008	41 Increasing	✓ (not used)	Supplem.	Addax	No	X	X	Medium-High?
R'Mila	Maroc	Out	4.65	6 (3.3) +??	1992 1992-96	158 Increasing	✓	Supplem.	Dorcas gazelle	??	X	X	High
Guem-beul	Senegal	Out	7.24	7 (2.5)	1984	13-15 Decreas-ing	✓	Supplem. in dry season	SHO	Feral dogs	X	X	High
Ferlo Nord (Katané)	Senegal	In	12	5 (2.3)	2003	16-18 Increasing	X	Supplem.	SHO, RFG Dorcas gazelle Warthog	Jackal Caracal	X	X	Low

4.3.3 Tunisia

Bou Hedma Biosphere Reserve and National Park (16,988 ha, including an 8,814 ha core zone) was established in 1980. In 1990, five (2.3) dama gazelles were brought from different German zoos, followed by a female in 1991 and two females in 1992 but mortality due to manual handling and the transfer conditions was high. In 1993, there were only four (1.3) gazelles that were reinforced by 14 more (4.10) from EEZA in 1994 (Jebali & Zahzah 2013). The last group spent five months in a 10 ha acclimatisation enclosure before being released into a 2000 ha total protection zone (Abaigar *et al.* 1997; Wiesner & Müller 1998). The dama gazelle population never became fully established, numbers dwindled and only three males now remain, rendering the effective population size zero. The causes of this failure are not known, but poaching is suspected to be a significant factor, and predation by jackals (*Canis aureus*) on young animals has also reportedly been a problem (Jebali and Zahzah 2013).

4.3.4 Reasons for success and failure

It would be an extremely valuable exercise to identify the reasons underlying the mixed record of success and failure of these operations; firstly to improve management and increase population sizes at existing sites, and secondly to inform the planning of similar operations in the future. Whilst such an evaluation is beyond the scope of this document, we briefly suggest possible factors here. These include small size of the founder populations, unsuitable habitat, competition with other species, herbivore density exceeding carrying capacity and predation by jackals and stray dogs or other predators. Sites within the former range (Safia, Ferlo) appear to be doing better than those outside, but the sample size of sites is too small to draw firm conclusions; and management practices may not be comparable (Table 6).

Out of the six transfers to date, two were essentially to breeding centres or holding facilities (Guembeul and R'Mila), and four have aimed, to some extent, at reintroductions; although two of these have already failed (Bou Hedma and Rokkein). The small size of the current enclosures (which are smaller than holdings on some Texas ranches – see Section 4.4) and the provision of water and/or forage make it difficult for them to qualify fully as 'reintroductions'; for example, none of these populations would normally be considered 'wild' for inclusion on the IUCN Red List. A second question concerns the location of the release site in relation to indigenous range – i.e. whether they are reintroductions (inside) or 'introductions' (outside). In view of these considerations, it may be more appropriate to refer to them as 'repatriated' populations. In this document we refer to 'repatriation' as transfer to former or current range states.

Future release sites: There are currently no known plans for new releases/reintroductions. The habitat around the Safia site is in good condition and release of animals from the reserve into the surrounding area appears to have potential, subject to the outcomes of an ecological survey and assuming protection could be established. Other potential sites within the former range include Banc d'Arguin Biosphere Reserve (Mauritania), and Gadabeji Reserve (Niger).

4.4. Texas populations

Dama gazelles are kept widely on Texas ranches for hunting, conservation and personal interest. The animals originated from the 20 animals obtained from Frans van den Brink in 1967 and most are considered to be descended from the (3.9) van den Brink founders placed in San Antonio Zoo (see section 4.2). Numbers on private ranches grew to 369 by 2003 and an estimated 894[9] in 2010. There may be more animals in unreported collections. At least 27 herds are known to exist, all consisting

of *N. d. ruficollis* except for one small group of *N. d. mhorr* which has recently been split over two properties. The size of these *ruficollis* herds varies: eight ranches have group sizes of 21-40 and one has a group size of 41-50 (Table 7). Presently, two of the largest ranch populations include approximately 90 individuals (divided across three pastures) on a Central Texas ranch and a herd of as many as 125 is kept on approximately 8907 ha of West Texas rangeland. Pasture/enclosure sizes range from 0.4 ha to 8907 ha (Table 8). Thus some ranches are considerably larger than the areas holding repatriated populations (see Section 4.3).

Table 7. Group size distribution for dama gazelle on Texas ranches (2003 survey)

Group size	No. of ranches
1-10	14
11-20	3
21-40	8
41-50	1
TOTAL	**26**

In the Hill Country of Central Texas dama gazelles are mainly held on grassland, dotted with clumps of juniper bushes (*Juniperus ashei*) and oak trees (*Quercus* spp.) and in West Texas on thorny scrub, sometimes much denser than in the indigenous range. When kept continuously on limited Hill Country pastures of 24 ha or less, the dama gazelles may strip bushes, and a clear browse line is visible on many Central Texas ranches. They often stand on their hind legs to reach browse. There are also dama gazelles in Central Texas, in large pastures of nearly 500 ha that have browse at all levels (Further discussion of data in Tables 7-8 and Figure 9) (see Mungall 2003 and Mungall 2004 for further discussion.)

Table 8. Pasture size distribution for dama gazelle ranches in Texas (2003 survey plus 2006 addition)

Pasture Size	No. of enclosures/ pastures
0.4-2 ha (1-5 acres)	3
4-20 ha (10-50 acres)	6
40-202 ha (100-500 acres)	12
243-364 ha (600-900 acres)	1
405-1,012 ha (1,000-2,500 acres)	4
8,907 ha (22,000 acres)	1
TOTAL	**27**

Dama gazelles have proved more difficult to establish on ranches than certain other aridland species, namely scimitar-horned oryx (*Oryx dammah*) and addax (*Addax nasomaculatus*) (Mungall & Sheffield 1994). Population growth tends to be slow until a 'critical mass' is reached and in Texas, numbers have typically increased more rapidly from seven years after herd establishment (Figure 9). Experience suggests that attempting to start a dama gazelle herd with a trio (1.2 animals) is likely to give poor results. The largest Hill Country population failed twice to get established with a founding base of three animals in a small pasture but finally succeeded with 1.6 animals to start the breeding herd. Because of fighting among males when females are present, ranch herds in Texas are typically comprised of one adult male with females and young. Except in the largest pastures where youngsters can withdraw from persecution, maturing males are removed. Males not needed for the ranches' breeding program are sold, hunted, or put with other males in bachelor pastures.

[9] Extrapolated from a total of 502 known animals held by 567 potential owners, of which 247 were not contactable.

A study of births (n=61) on a single ranch located in the Hill Country of Central Texas over a six year period revealed that they occurred from March to December with a peak (42.6%) in July-August and a secondary peak (16%) in April (Mungall *et al.* 2011). The spread of births through the year increased as herd size increased from its initial size of 1.6 and after the number of mature males increased. Splitting the growing number of females to set up a second breeding group within sight but separated by fences appeared to spur breeding competition. A study of mortality (n=23) on the same Texas ranch during the same period revealed that: 35% of all deaths were attributed to predation, mainly by coyote (*Canis latrans*), and only on young animals. Other cases of mortality included the weather (22%; extreme cold and one case of extreme heat in a neonate), hitting fences when panicked (17%), aggression involving adult males killing subadult males (9%) and, in one adult male, overeating acorns (Mungall *et al.* 2009).

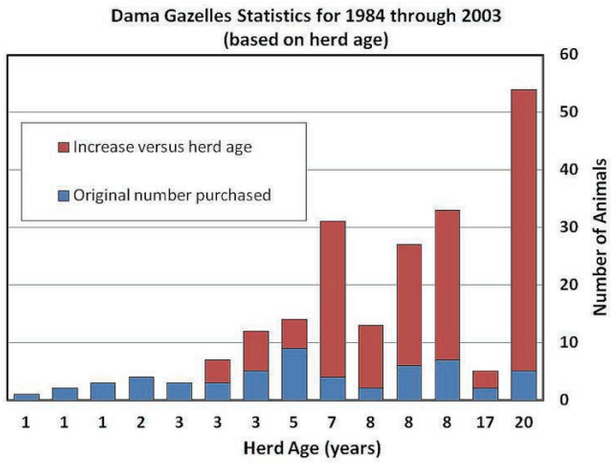


Figure 9: Herd age and founder numbers for herds found in Texas.

4.5. Other captive animals

Dama gazelles are kept as pets and as potential gifts in Chad and Niger. While the number of such animals is likely to be low, they would contain unique genetic material since they will originate from populations not currently represented in captivity. There is a small possibility that a few captive animals, not descended from the original two collections from the wild, may also be found in Sudan or in private collections in the Middle East. A wild animal caught on the Chad-Sudan border in the 1980s was present at Al Wabra Zoo, Qatar in 1993 (pers. comm. Faris al Tamimi to Tim Wacher). At least one captive male gazelle is known of in Libya (pers. com. Ahmed Elkesh of the Libyan Wildlife to Trust to Amina Fellous, Figure 10).

Figure 10: A 3-4 yr old male dama gazelle in Libya brought as a young animal from Niger to Ghat-Libya (SW) and originally intended for the wildlife trade. A female was also captured with the male but died later (Pers. com. Ahmed Elkesh of the Libyan Wildlife Trust to Amina Fellous).

5. THREATS

5.1. Wild populations

5.1.1. Poaching and persecution

Uncontrolled hunting is the major factor behind the catastrophic decline in dama gazelle numbers and range, especially owing to the combination of all-terrain vehicles and readily available modern weapons (Sournia & Dupuy 1990 and chapters therein, Cuzin 2003, Devillers *et al.* 2005; Scholte 2013). Dama gazelle gallstones were also highly sought-after, at least in the western part of the species' range, as a talisman (Cuzin 2003). Poaching remains a threat, especially in sites that are not formally protected and where enforcement of laws protecting wildlife is weak.

5.1.2. Habitat destruction and degradation

Several factors have contributed to the degradation of natural habitats; overgrazing by livestock, cutting of trees and shrubs for fuel and charcoal, droughts and shifts in climate patterns. Sinking bore wells in new areas can alter traditional transhumance patterns, opening areas up, and extending the potential period of use and associated severity of offtake by domestic grazing animals, thereby reducing undisturbed 'cores'.

5.1.3. Small population size

The remaining subpopulations are likely to suffer from the inherent effects of small population size, namely genetic, demographic and environmental stochasticity. This may be further compounded by Allee effects (positive correlations between population size/density and mean individual fitness) which could be suppressing population establishment or recovery at low numbers, although this has not been demonstrated experimentally for dama gazelles. The slow rate of establishment on Texas ranches, until a critical herd size is reached (see Section 4.4), may show a threshold effect that inhibits population growth and contributes to the lack of success of some release programmes.

5.1.4. Inbreeding

As wild populations shrink in size, they become at risk of inbreeding. The issues surrounding inbreeding are discussed in Section 5.2.1. Genetic data suggest that inbreeding in the wild, on the whole, is not at the levels that have been reached in captivity (Senn *et al.* 2014). However, it remains a long-term concern if populations continue to diminish. Worries surrounding inbreeding could be alleviated through population augmentation (although some captive stock may contribute limited genetic diversity) or the creation of corridors to link isolated populations. Currently inbreeding ranks lower than threats such as habitat loss and hunting.

5.2. Zoos and breeding centres

5.2.1. Inbreeding and adaptation to captivity

Inbreeding is a serious issue in captive dama gazelle populations. Populations are inbred due to the small founder numbers (4 for *mhorr,* ~20 for *ruficollis*). Inbreeding is highly likely to result in inbreeding depression (loss of fitness). This has been demonstrated in numerous studies of wild and captive mammals (reviewed in Frankham 2010). Studies have already shown that inbreeding in the captive *mhorr* population is causing decline in semen quality (Ruiz-López *et al.* 2012). Two other studies have failed to find evidence of the effect of inbreeding, in the same population, on juvenile mortality and body weight (Ibáñez *et al.* 2013), although see earlier study by Alados & Escós (1991). However, this is possibly a consequence of the way inbreeding was measured (Ruiz-López

et al. 2012) or due to a lack of opportunity for expression of inbreeding consequences in the benign captive environment. No studies have been conducted on the effect of inbreeding in the captive *ruficollis* population but it is highly likely that inbreeding is currently, or will in the future, cause an adverse effect on fitness in this population as well.

It is crucial to note that although declines in fitness as a result of inbreeding may not be apparent in the benign conditions of captivity, it may result in maladaptation to wild conditions. Measures of fitness in captivity do not necessarily correspond to measures of fitness in the wild.

Inbreeding is not just detrimental because of its immediate fitness consequences, it also results in the loss of genetic variation. Lack of genetic variation means that the population has less capacity to adapt or evolve to new challenges, such as disease, climate change or simply being released into the wild. Loss of genetic variation as a result of inbreeding is a serious issue for the long-term conservation of the species. Captive breeding may also cause unintentional selection on traits such as behaviour or disease resistance (Araki *et al.* 2007; Frankham 2008; Christie *et al.* 2012).

5.3. Released (repatriated) populations

5.3.1. Inbreeding and adaptation to captivity

Repatriated populations face the same problems of inbreeding as captive populations. The levels of inbreeding in these populations are likely to be higher than in the captive programmes, as a result of subsampling from the captive population and absence of active inbreeding avoidance due to the (necessarily) unmanaged nature of the populations.

Since the environmental conditions are closer to the wild than most zoo populations, and enclosures are larger, this should mitigate some of the risk of unintentional selection for maladaptive traits (i.e. the animals may be subject to more natural selection).

5.3.2. Carrying capacity

A further issue arising from the use of release enclosures is that of carrying capacity and the risk of density-dependent mortality once that has been exceeded. It is advisable to develop contingency plans to address the issue of population size exceeding capacity at each release site. Experience has shown that it is important to take action before carrying capacity is reached (see Islam *et al.* 2012 for a case study involving heavy mortality of Arabian oryx (*Oryx leucoryx*) and Arabian sand gazelle (*Gazella [subgutturosa] marica*) in Saudi Arabia; this occurred in a fenced protected area of 2244 km2, so even very large enclosed areas may encounter this problem).

5.4. Texas populations

5.4.1. Inbreeding and adaptation to captivity

The same problems are faced by the Texas populations as the other captive populations. Inbreeding levels are likely to be highest in populations that have no active management to avoid inbreeding and that have been subsampled from small numbers of founders. In an attempt to minimise inbreeding, Texas ranchers may source founders from different ranches, rotate their breeding male (typically every three to four years) and will periodically exchange females. The relatively large numbers of individuals typically held on each ranch may also alleviate some of the extent of inbreeding[10].

[10] The level of inbreeding will also be influenced by growth rate of the population and relatedness of the founders.

It could be argued that despite their geographical distance from North Africa, the Texas ranch pastures are more similar to the wild habitat due to their size, and the presence of natural foraging and predation, and that individuals from the populations are more suitable for reintroduction than individuals that have been kept in zoos or smaller breeding centres. The downside is that, in comparison to the zoo studbook managed programmes, breeding has been largely unrecorded and so the extent of inbreeding within ranch populations relative to other captive populations is unknown; however genetic screening could provide some resolution on this issue.

5.4.2. Legal issues

One problem faced by private property owners in Texas, and elsewhere in the U.S., wanting to work with dama gazelles has been the consequences of the U.S. Endangered Species Act. Although intended to safeguard vanishing species from threats which would decrease numbers, this legislation has had the opposite effect for wildlife native to other countries (often called exotics) bred in the USA by private owners. Recognising this problem, the U.S. Fish and Wildlife Service, which administers the act, initially granted dama gazelles, as well as scimitar-horned oryx and addax, a captive-bred exemption in 2005 when these three species were listed under the act. However, challenges in the courts subsequently resulted in the exemption being removed.

Owners then had to negotiate the full form of a permitting system that is formulated more for zoos than for ranches and that can cause uncertainty and delays for the kinds of management practices (capturing and moving animals, etc.) needed for routine husbandry. For the ranches that depend on hunting to pay animal upkeep expenses such as personnel, maintenance of fences, and taxes, the act requires additional permitting that can also be difficult. With more than eighty other kinds of exotic animals available for ranch owners who want to raise species of foreign wildlife, some ranchers opted not to continue keeping these three species. Nevertheless, reduction in numbers were less for dama gazelles than for the other two because of the dama gazelle's lower initial numbers as ranch exotics and, thus, less reliance on them in hunting programmes. As of March 19th 2014 a new legislation was passed which reinstated the captive-bred exemption for all three species. Numbers are now expected to resume their upward trend.

6. CURRENT CONSERVATION ACTION

6.1. International status

The dama gazelle is classified as Critically Endangered on the IUCN Red List (Newby et al. 2008). This assessment is based on a total wild population numbering less than 250 mature individuals; a number that continues to decline. They are listed on CITES Appendix 1 and CMS Appendix I and are included in the CMS Concerted Action Plan for North African Antelopes (Beudels *et al.* 2005).

6.2. National status

The species is legally protected in all existing range countries (details in Devillers *et al.* 2005).

6.3. Protected areas (PAs)

Three of the five existing wild populations occur in designated protected areas (PA) (Figure 1). Several other PAs lie within the former species range and some held dama gazelles until recently. These include: Ansongo-Menaka Elephant Reserve (Mali); Hoggar NP (Algeria); Banc d'Arguin (Mauritania); Ferlo Nord Fauna Reserve (Senegal) and Gadabeji Game Reserve (Niger). The effectivieness of PAs is variable, mainly as a consequence of under-resourcing.

6.4. In situ conservation measures

Two organisations, SCF and PCBR, are active in Termit & Tin Toumma and are conducting monitoring, site management etc. Al Ain Zoo is supporting the next phase of ecological research in this area to begin in 2014.

In addition SCF has completed a number of field surveys across the range of the dama gazelle as part of its Pan-Saharan Wildlife Survey (www.saharaconservation.org).

The proposed reintroduction of scimitar-horned oryx to OROA (scheduled for 2015) will have several concomitant benefits for dama gazelles. These include:

- aerial surveys and monitoring
- enhanced ranger presence
- reserve infrastructure
- rehabilitation of the reserve

The *mhorr* gazelle population reintroduced in the Safia enclosure benefits from the anti-poaching control that three institutions (the local NGO, Nature Initiative; the CBD-Habitat foundation (Spanish foundation); the Haut Commissari at des Eaux et Forêts et de la Lutte contre la Desertification (Moroccan Ministry of Agriculture)) have been carrying out in the Oued Eddahab-Lagouira region since 2008.

6.5. Flagship status

Although the dama gazelle is largely unknown by the general public outside range states, in Niger the national football team is known as the *Ména*, the Hausa name for the dama gazelle. The dama gazelle also appears on their badge in the colours of the national flag (Figure 11).

Figure 11: Badge of the Niger national football team.

6.6. Texas

Owing to the free-ranging nature and accessibility of the Texas populations, there are a large number of potential study opportunities available on ranging, diet, behaviour etc. A current Second Ark project on the Stevens Forest Ranch in West Texas, led by Dr E.C. Mungall, has radio-collared five males to investigate home range size and spacing patterns. A continuing Second Ark Foundation-Exotic Wildlife Association project by Dr E.C. Mungall started in 2005, with a Central Hill Country Texas breeding herd of individually known animals, is charting behaviour and general biology on Texas rangeland.

6.7. Zoos and breeding centres

Most ISIS registered collections and some additional institutions with captive dama gazelles participate in regional collaborative breeding programmes led by AZA and EAZA (described in section 4.2, above).

The Conservation Centers for Species Survival (C2S2) is a consortium of six centres in the USA that collectively manage more than 10,000 ha devoted to endangered species study, management and recovery. Five of the six centres manage dama gazelles and collectively hold 46.3% of the AZA population. Dama gazelles are a C2S2 focal species, and the group invests in innovative approaches to managing large populations of ungulates as a precursor to reintroductions. Future plans envisage expanding the consortium and including Texas ranches holding dama gazelles. A report summarises the breeding programmes at Fossil Rim Wildlife Center and White Oak Conservation, focusing on animal husbandry methods and lessons learnt as a guide for repatriation programs (Speeg *et al.* 2013).

Within the captive collection of *mhorr* gazelle, the EEZA in Almeria Spain keeps almost 50% of studbook-managed gazelles. The others are distributed among 13 European institutions.

There are currently five known populations of dama gazelles in Arabia (the United Arab Emirates and Qatar), in both government and private collections, with a total of 116 *N. d. ruficollis* and 76 *N. d. mhorr*. In contrast to collections in the USA and Europe three of these institutions hold both subspecies and therefore have potential for research that could be more difficult to carry out elsewhere.

Collectively these captive programmes (zoos and ranches) have great potential (with physical capacity in Arabia and the USA) to increase breeding of dama gazelles to provide animals for research and for reintroduction and reinforcement.

6.8. Research

A number of institutions around the world are undertaking research to support dama gazelle breeding and conservation. The following list briefly describes the current projects.

Al Ain Zoo, UAE
Genetic analysis of its captive *ruficollis* and *mhorr* populations in collaboration with the Royal Zoological Society of Scotland.

Estación Experimental de Zonas Aridas, Spain
Reproductive biology of *mhorr* gazelles, including semen cryopreservation and assisted reproduction. A genetic resource bank (semen, oocytes and embryos) is kept for future research and application. Research is also conducted into parasitology, behaviour and effect of inbreeding on the captive population. There is a collection of skulls and skins that represent almost the entire history of captive *mhorr* gazelles in the EEZA.

Royal Zoological Society of Scotland, UK
Population connectivity of wild populations in collaboration with Sahara Conservation Fund and genetic diversity of captive populations in collaboration with Al Ain Zoo. Partial (RAD) genome sequencing of samples from around the world as part of C2S2 programme on 'Big Herds' in collaboration with Smithsonian Conservation Biology Institute and other AZA partners.

Second Ark Foundation in collaboration with the Exotic Wildlife Association, USA
Behaviour, development, reproduction, mortality (including predation), diet and other basic biology issues for dama gazelles in rangeland pastures of varying size. GPS radio collar investigation on movement patters and space use in large expanses of fenced rangeland. Conservation focus on captive husbandry to secure the future of dama gazelle as well as on improving reintroduction possibilities for the future.

Smithsonian Conservation Biology Institute, USA
Semen cryopreservation and assisted reproduction of *ruficollis*. Whole genome sequencing of *ruficollis* as part of the C2S2 programme on 'Big Herds'.

7. STRATEGY FOR DAMA GAZELLE CONSERVATION

7.1. Vision

As a starting point for future dama gazelle conservation action planning, participants at the Edinburgh workshop first agreed on a Vision for the dama gazelle that encapsulated the ideal future situation for the species.

Vision: *Sustainable, free-living populations of dama gazelle living in their indigenous range, supported by well-managed populations elsewhere.*

Subsequently an initial evaluation of the principal options to achieve this Vision was conducted (Section 7.2). A set of more concrete Objectives were then developed (Section 7.3), corresponding to the main identified strategic directions, that represent the first stage in attaining the Vision, along with an initial set of actions needed to attain each Objective.

7.2. Principal options

The serious situation that continues to face dama gazelles provided the motivation for the workshop. It was recognised throughout that the immediate threat of extinction in the wild, the difficulty in establishing repatriated and reintroduced populations, and the small number of founders of the captive population demanded full consideration of all the available options, however extreme they might appear. A flow chart of these options can be found in Figure 12. A discussion of the eight (#1-8) most likely options for dama gazelle conservation, together with their advantages and disadvantages as discussed during the workshop and in subsequent correspondence, are listed in Table 9. These can be linked to the flowchart in Figure 12. Option #9 (maintaining/increasing captive populations that are present outside of the indigenous range) is a priority within the captive conservation community already and this is not discussed further. We recommend its continued prioritisation.

The eight options presented here should be viewed as interdependent and not necessarily mutually exclusive (see Figure 12).

One decision relevant to all of these possible options is the question of how to handle the management of the putative subspecies – jointly or separately. The issues surrounding this have been discussed in detail in Section 2 of this report, and recommendations made.

Additionally although cryopreservation of material from wild dama gazelle is currently logistically very unlikely, we also recommend that the options surrounding cryo-banking of wild gametes (and tissue) in the event of an intervention in the wild are investigated fully. Ongoing research into reproduction and cryopreservation in captive populations forms an important baseline in this respect (Section 6.8). Some possible future options might include using semen collection from wild-caught animals as an insurance policy against their accidental death in transit, conducting semen transfer instead of animal translocation, collection of material from dead animals and the establishment of projects to gather material from captive animals from unusual sources (Section 4.5).

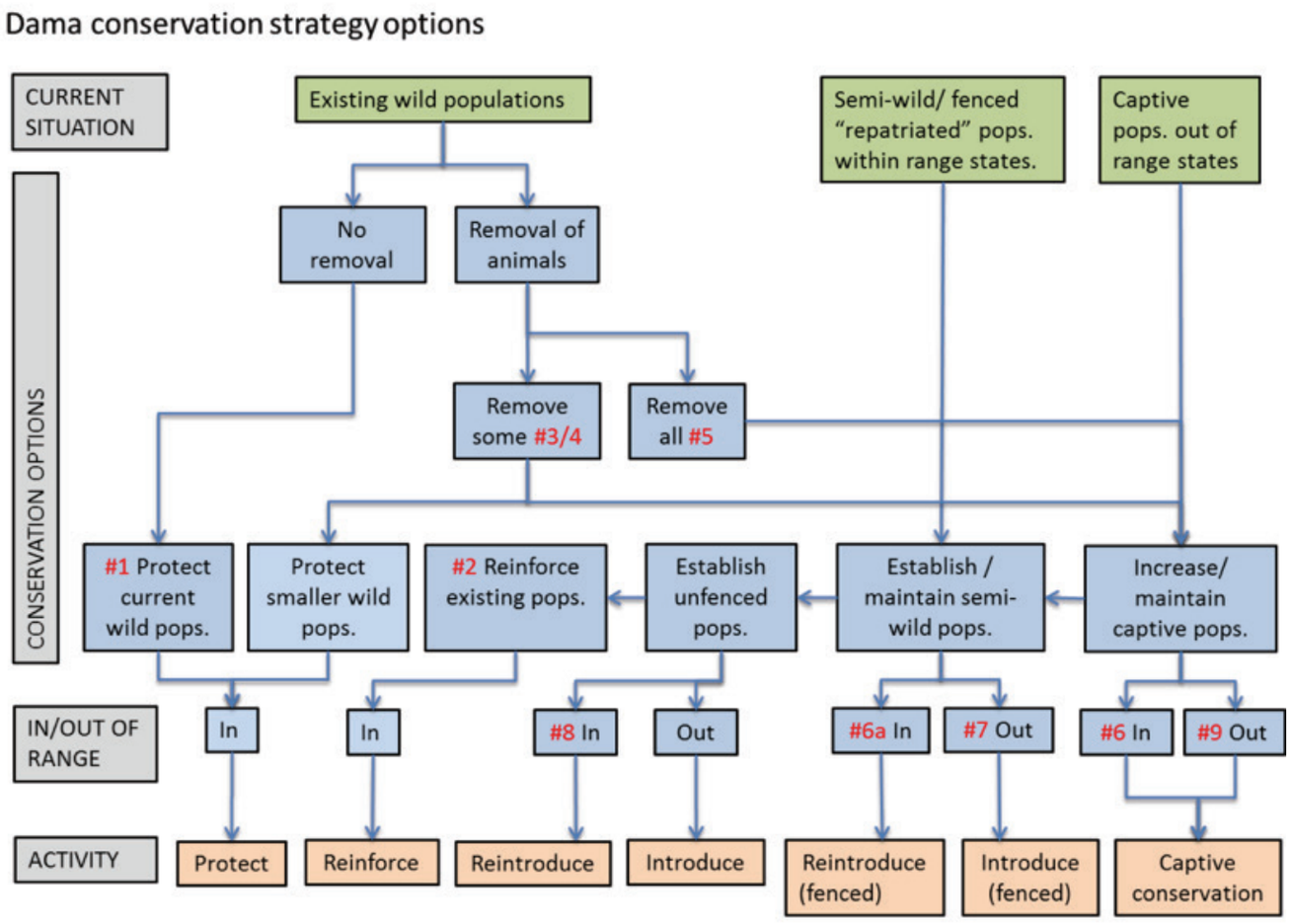


Figure 12: A summary of the conservation options available for the dama gazelle. The arguments for and against eight of the most likely options are evaluated in Table 9. These should now undergo a systematic review by the full stakeholder community. Option #9 (maintaining / increase captive populations that are present outside of the indigenous range) is already a priority within the captive conservation community and this is not discussed further.

Table 9. Dama gazelle – principal conservation options

Option #1: Prioritize in-situ conservation efforts (e.g. increase number of rangers/ vehicles/patrols; raise local awareness; secure protected areas and corridors)

For	Against
• Long-term aim is wild populations in natural habitat/dynamic ecosystems. • Once gone, difficult to bring back into wild. • May lose the species from local memory. • More cost-effective than e.g. reintroduction.	• Wild populations may be non-viable due to risk of stochastic events and very small numbers. • Field projects on some populations not feasible at this time.

Option #2: Augment wild populations with repatriated/semi-wild/captive animals

For	Against
• Increasing the viability of remaining subpopulations reduces extinction risk.	• Choice of captive stock for augmentation not obvious for some sites e.g. within *N. d. dama* range. • Remaining populations are declining. • Threats are not removed. • Possible introduction of disease. • Disruption of existing social systems. • Risk of outbreeding depression as yet unevaluated if sourcing from geographically distant populations.

Option #3: Capture some remaining wild animals to bolster captive populations and/or acquire wild-caught animals currently in captivity in range states.

For	Against
• Improves long-term viability of *ex situ* population. • Makes use of animals from populations which may otherwise become extinct.	• Increases extinction risk of remaining populations. • Difficulty of obtaining government export permits (if intended to move animals outside range country). • Difficult to obtain import permits to USA and EU. • Limited choice of source sites. • Risk of mortality during capture, transport, and transfer. • Negative public/officials perception of removal from range country. • May negate public awareness raised to date at local, national, regional levels. • No wild *mhorr* available.

Option #4: Capture those entire relict populations most likely to become extinct

For	Against
• Makes use/secures animals from populations which may otherwise, or are likely to, become extinct. • Improves long-term prospects of the captive population.	• Ensures extinction of some remaining wild populations. • No guarantee that attempts to captive breed, reintroduce or integrate populations will be successful. • Potential political difficulties (as above). • Animals may die during capture or transport. • Capturing all animals is unfeasible. • Potentially expensive.

Option #5: Take all remaining dama gazelles into captivity

For	Against
• Safeguards remnant populations (all threatened by poaching). • Improves long-term viability of the species in captivity. • Avoids the 'Northern White Rhino situation' (action too little, too late).	• Too scattered over a vast range to be feasible. • No guarantee that captive herds will thrive/ survive. • Need separate facilities for the 'subspecies' (unless these are merged). • Very high costs of capture, facility establishment and management. • Identifying the optimal time to intervene (when conservation in wild is certainly failing, but before too late). • Risk of mortality during capture, transport, and transfer. • Negative public/officials perception of removal from range country. • May encourage some governments to view *ex-situ* as the best option for 'difficult' species. • Removes incentive for government to conserve wildlife and protected areas

Option #6a/b: Establish further captive breeding facilities and/or fenced semi-wild populations in range country (perhaps especially with respect to N. d. ruficollis/dama)

For	Against
• Increases range country focus, with diverse benefits. • Natural conditions (climate, vegetation). • Eventual release into wild requires less acclimatization. • Less extraneous disease risk. • More cost-effective than transporting animals long distances outside range countries. • Lower risk of injury/ mortality during transport. • Could act as a legitimate refuge for animals held in captivity by people in range states.	• Cost of establishing a facility. • Cost of husbandry training. • Long-term viability. • Security of facility. • Lack of local expertise and resources in captive husbandry and veterinary care of dama gazelles.

Option #7: Establish viable fenced semi-wild population[s] outside range states in appropriate habitat for example in USA, Australia.

For	Against
• Safer environment (from poaching). • Land-use planning may prioritize dama gazelle. • May allow large herds to build up. • Could be a last resort in certain circumstances	• Non-indigenous biotic environment (vegetation, competitors, predators). • Lose natural ecosystem role. • Adaptation to different conditions may reduce utility for ultimate re-establishment within indigenous range. • Potential conflict of interest of 'ownership' of animals.

Option #8: Establish populations within indigenous range

For	Against
• Reduces fragmentation & increases metapopulation viability. • Contributes to restoration of Sahel ecosystem. • Can provide national focus for dama gazelle conservation.	• Few remaining areas with intact habitat and low human pressure. • Widespread lack of effective site protection. • Small size of available stock for release (especially if three separate forms are considered). • Known difficulties in establishing populations. • Very high cost of each operation.

7.3. Objectives

The immediate objectives that will enable the dama gazelle conservation community to work towards the Vision, are outlined in Table 10.

Table 10. Dama gazelle outline conservation strategy

Vision - Sustainable and free-living populations of dama gazelle in indigenous range, supported by well- managed populations elsewhere

Objective	Element	Responsible parties*	Timeline*
Objective 1. Secure and expand wild populations	1.1. Support local NGO in monitoring in Aïr and Ténéré NNR and Field survey in March 2014 (funded by UNESCO, WHC)	SCF/UNESCO, DFC/ AP	
	1.2. Continue monitoring in Termit and Tin Toumma NNR	SCF, PCBR Project	
	1.3. Re-survey Manga area in dry season	SCF/ZSL	Jan 2014 (Done)
	1.4. Investigate reports of dama gazelles near Ati	SCF/ZSL	
	1.5 Investigate reports of dama gazelles in Tassili de Tin Gherghor		
	1.6. Follow up local reports from E Niger		
	1.7. Identify sources of local information in Sudan	SCF/PCBR	
	1.8. Enhance protection in OROA		
	1.9. Carry out corridor assessments and feasibility	SHO project	
	1.10. Promote value of the Bahr al Ghazal corridor to the government		

Objective	Element	Responsible parties*	Timeline*
Objective 2. Maximise the effectiveness of captive population management	2.1. Develop a globally integrated population management plan.	AZA, EAZA, EWA, C2S2, AAZA	
	2.2. Develop best practice husbandry / management guidelines	C2S2, AZA TAG, EAZA TAG	Ongoing
	2.3. Expand C2S2 consortium	C2S2, EWA	Ongoing
	2.4 Investigate reports of additional captive sources in Middle East and North Africa		

Objective	Element	Responsible parties*	Timeline*
Objective 3. Enhance the role and potential of reintroductions/ repatriations	3.1. Review operations to date and ID reasons for success and failure	EEZA	
	3.2. Identify and evaluate options for future releases	EEZA	
	3.3. Assist in developing management plans for each site (to include contingency plan to deal with carrying capacity issues)	EEZA	
	3.4. Assess feasibility of establishing a captive breeding/ repatriation site within the range (e.g. Bahr al Ghazal, OROA)		
	3.5. Carry out Population Viability Analysis for all current populations in Table 3 above		

Objective	Element	Responsible parties*	Timeline*
Objective 4. Raise the profile of the dama gazelle and its plight	4.1. Publish and distribute the conservation strategy	RZSS, ASG, all	
	4.2. Translate strategy into French	RZSS	Done
	4.3. Publish popular book on dama gazelle	E Cary Mungall	
	4.4. Initiate an education and awareness programme on dama gazelle and ecosystem in range countries (schools, media, public)		

** Organisations listed are those that have made a commitment to that area of work, but are not exclusive. It is envisaged that more will be added, and the time lines completed as part of the wider stakeholder engagement process, referred to in Section 7.4 below.*

Objective	Element	Responsible parties*	Timeline*
Objective 5. Conduct research critical for the conservation of dama gazelle	5.1. Compile plan of in-situ and ex-situ research needs		
	5.2. Continue radio-collaring and biological research in Texas	Second Ark Foundation, EWA	Ongoing
	5.3. Assess the role of cryo-banking as part of future conservation action(s) in relation to wild dama gazelle and compile research needs		

Objective	Element	Responsible parties*	Timeline*
Objective 6. Continue to clarify taxonomy and subspecies structure	6.1. Record morphological data and take genetic samples from all museum specimens with locality data	NMS, RZSS	
	6.2. Continue genome sequencing	RZSS, C2S2 Smithsonian,	Ongoing
	6.3. Continue genetic research and morphological research into connectivity and subspecies structure	RZSS, SCF, AZZ, NMS	Ongoing
	6.4. Experimental breeding of *mhorr* and *ruficollis* to assess reproductive isolation, phenotypic variation and future management options.	Al Ain Zoo, NMS	Mid-2014

Objective	Element	Responsible parties*	Timeline*
Objective 7. Secure the resources necessary for dama gazelle conservation	7.1. Develop budget for each action	All	
	7.2. Develop business plan	All	

Objective	Element	Responsible parties*	Timeline*
Objective 8. Ensure effective implementation	8.1. Undertake a systematic review to assess the feasibility and appropriateness of the options in Table 9, specifically: population viability analysis, long-term stability/prospects, financial implications, and cost/benefit analysis	All	
	8.2. Set up contact group of key stakeholders ('Dama team') to take the process forward	Workshop participants	Ongoing
	8.3. Set up 'Dama-library' of key reports and publications (Google Groups etc)	RZSS	Ongoing
	8.4. Develop Monitoring & Evaluation Plan involving all stakeholders.	All	

7.4. Recommendations and next steps

Given the critical situation of the dama gazelle, which faces a real possibility of becoming extinct in the wild, some key decisions have to be made. Two of the most crucial decisions involve managing the species as a single unit or separately as three 'subspecies' (Section 2) and whether to capture some or all of the remaining wild animals to bolster captive breeding programmes (Options #3-5 in Table 9). The latter will need a realistic assessment of the full impact on source and sink populations, as well as the impact on perception and support of conservation efforts in the range states and their policy positions on alternative strategies.

This report is intended to form the basis for a comprehensive dama gazelle conservation strategy to be developed by the full dama gazelle stakeholder community: principally range state agencies, and international and local conservation NGOs, zoos and research institutions.

As part of this process, all options in Table 9 should undergo a systematic review to assess their feasibility and relevance, specifically with respect to the following aspects: population viability, long-term stability/prospects, financial implications, and cost/benefit analysis, and the Objectives in Table 10 require further refinement. The preferred options and recommendations can then be planned and costed in detail and built into an integrated conservation plan. The review should be carried out urgently so that groundwork is completed before an emergency intervention is needed.

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10. APPENDICES

Appendix 1a. List of Participants

Organisation	Representative/Person	Position	Country	Contact
Al Ain Zoo	Hessa Al Qahtani	Conservation Officer	UAE	Hessa.AlQahtani@alainzoo ae
Al Ain Zoo	Lisa Banfield	Conservation Officer	UAE	lisa.banfield@alainzoo.ae
International Foundation for Wildlife Management	Philippe Chardonnet	Director; Co-Chair, IUCN SSC Antelope Specialist Group	FR	p.chardonnet@fondation-igf.fr
Al Ain Zoo	Mark Craig	Director Life Sciences	UAE	mark.craig@alainzoo.ae
Fossil Rim Wildlife Center	Adam Eyres	Hoofstock Curator; Vice Chair AZA Antelope and Giraffe Taxon Advisory Group—Aridland antelope, gazelle and pronghorn.	USA	adame@fossilrim.org
Marwell Wildlife	Tania Gilbert	Conservation Biologist; Vice-chair, EAZA Antelope and Giraffe Taxon Advisory Group	UK	TaniaG@marwell.org.uk
Tunisia Wildlife Conservation Society	Abdelkader Jebali	Vice-President	TU	jebali2004@yahoo.fr
NMS	Andrew Kitchener	Principal Curator of Vertebrates, Department of Natural Sciences	UK	a.kitchener@nms.ac.uk
IUCN	David Mallon	Co-Chair, IUCN SSC Antelope Specialist Group	UK	d.mallon@zoo.co.uk, dmallon7@gmail.com
Second Ark Foundation (SAF)/Exotic Wildlife Association (EWA)	Elizabeth Cary Mungall	SAF Science Officer/EWA Technical Advisor	USA	emungall@gmail.com
Sahara Conservation Fund	John Newby	CEO	CH	john.newby@bluewin.ch
RZSS	Rob Ogden	Director of Conservation	UK	rogden@rzss.org.uk
RZSS	Helen Senn	Research Scientist (conservation genetics)	UK	hsenn@rzss.org.uk
White Oak Conservation Holdings LLC	Brandon Speeg	Director of Conservation Education	USA	bspeeg@wogilman.com
Wildlife Conservation Research Unit, University of Oxford	Mark Stanley Price	Senior Research Fellow	UK	mark.stanleyprice@zoo.ox.ac.uk
ZSL	Tim Wacher	Senior Wildlife Biologist, Conservation Programmes	UK	tim.wacher@zsl.org
RZSS	Caroline Whitson	Conservation Administrator	UK	cwhitson@rzss.org.uk

Appendix 1b. Additional Contributors

Organisation	Representative/Person	Position	Country	Contact
EEZA/CSIC	Teresa Abaigar	Research Scientist, Estación Experimental de Zonas Aridas (CSIC)	SP	abaigar@eeza.csic.es
IRSNB/CMS	Roseline C. Beudels-Jamar	IRSNB, Conservation biology unit; chair of CMS ScC Terrestrial Mammals Working Group	BE	roseline.beudels@naturalsciences.be
Smithsonian Conservation Biology Institute	Pierre Comizzoli	Research Biologist	USA	comizzolip@si.edu
Sahara Conservation Fund	Koen de Smet	Secretary of the Board	BE	koenraad.desmet@gmail.com
Agence Nationale pour la Conservation de la Nature, Algeria	Amina Fellous	Conservation -biologist	DZ	Fellousa2000@yahoo.fr
Saint Louis Zoo	Martha Fischer	Curator of Mammals, Ungulates and Elephants; Director, WildCare Institute Center for Conservation in the Horn of Africa; Chair, AZA Antelope and Giraffe Taxon Advisory Group (TAG)	USA	fischer@stlzoo.org
Smithsonian Conservation Biology Institute	Steve Monfort	Director	USA	monforts@si.edu
Sahara Conservation Fund	Thomas Rabeil	Regional Program Officer	FR	thomas.rabeil@saharaconservation.org

Appendix 2. Meeting Agenda

Tuesday 19th
12:00
Arrival and Welcome Lunch at RZSS
13:00
Introduction by Rob Ogden and David Mallon (chair)
Aims of the meeting discussed
Presentations Given – each presentation followed by discussion
• Tim Wacher & John Newby: Current Status of Wild Populations
• Al Ain Zoo: Status of dama in Arabia
• Elizabeth Cary Mungall: Status of dama in Texas
• Brandon Speeg: Status of dama in Texas
15:00
Coffee and tea
• Abdelkader Jebali: Pattern of decline of dama in Sahara - Sahel
• Teresa Abaigar: Dama reintroductions - presented by Abdelkader Jebali
• Andrew Kitchener - Historical Taxonomy and range
• Helen Senn: Status of genetic findings
• Adam Eyres: Status of captive populations
• Tania Gilbert: Status of captive populations
17:00
Workshop finishes for the day
19:30
Dinner at Hampton Hotel

Wednesday 20th

12:00

Workshop starts at RZSS

Discussion introduced by David Mallon (chair)

- **Problems in wild populations**

What are the characteristics of each group that are important?

Drones – is it feasible to use these to spot antelope and collect data.

11:00

Coffee and Tea

- Continuation of discussion on wild populations

Matrix table compiled to assess each sites sustainability.

If you got rid of all the threats in all of the areas – where would you choose to put a population?

Why have numbers not recovered?

13:00

Lunch at RZSS

- **Reintroduced Populations**

Indigenous or historical range?

Characteristics of each reintroduction site discussed – matrix table compiled.

Why are some succeeding and others failing?

- **Captive Populations**

Are these populations sustainable?

Integrated Population Management plan discussed

- **Texas Populations**

Total numbers present

Habitat differences to range states

Benefits of Texas population

Could Texas populations be reintroduced into range states?

15:00

Coffee and Tea

- **Genetics and phylogenetics**

Are the current three sub species valid?

Is there a selective advantage for different phenotypes across the range?

Experimental mixing of phenotypes

- **Summary of discussion**

What outputs do we want to produce?

Updated status review

Actions for each site

Create a wildlife corridor?

What about unknown sites?

- **Plan made for next day of meeting**

17:00

Workshop finishes for the day

19:30

Dinner in Edinburgh City Centre

Thursday 21st
08:30
• **Discussion Starts at RZSS**
Actions for Captive breeding decided
Repatriated populations
What went wrong/right - an evaluation
Lessons Learned
Critical review of current populations
10:30 - 11:00
Coffee and tea
11:00
• **A Vision statement of the group was decided**
Goals created for dama gazelle populations
One plan approach was discussed
Output of meeting discussed
Actions decided
13:00
Lunch
14:00
End of workshop

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