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Food habits and population characteristics of dorcas gazelles and distributions and statuses of wild ungulates in Morocco

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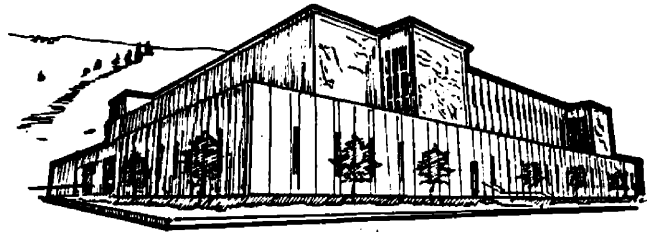# FOOD HABITS AND POPULATION CHARACTERISTICS OF DORCAS GAZELLES, AND DISTRIBUTIONS AND STATUSES OF WILD UNGULATES IN MOROCCO

BY

Chris O. Loggers

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Date

FOOD HABITS AND POPULATION CHARACTERISTICS OF DORCAS GAZELLES, AND
DISTRIBUTIONS AND STATUSES OF WILD UNGULATES IN MOROCCO

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Food habits and population characteristics of dorcas gazelles, and distributions and statuses of wild ungulates in Morocco.

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Historic and current distributions and statuses of Morocco's native and introduced wild ungulates, except the boar *Sus scrofa*, are reported. Conservation suggestions are included. Hartebeest *Alcelaphus buselaphus* have not been reported since 1925. Addax *Addax nasomaculatus* and oryx *Oryx gazella dammah* were probably extirpated by 1960. Habitat destruction and poaching threaten remaining species. Cuvier's gazelles *Gazella cuvieri* survive in the northern Middle Atlas, western High Atlas, and Anti Atlas mountains. Dama gazelle *Gazella dama* might still live south of the Oued Draa. Dorcas gazelles *Gazella dorcas* roam the plains south and east of the Atlas mountains, with 1 wild population remaining in Morocco's interior. Aoudad *Ammotragus lervia* live in all chains of the Atlas mountains. No cervids lived in Morocco in historic times. Red deer *Cervus elaphus bolivari* has been introduced in the Rif mountains. Sika deer *C. nippon* and fallow deer *Dama dama* have been introduced, though free-ranging populations do not exist.

All other information concerns the dorcas gazelle population at M'Sabih Talâa (Sidi Chiker) in Morocco's interior. Availability of vegetation and diets of adult gazelles, measured by microhistological fecal analysis, were estimated during 3 seasons. Diets and availability were compared using Spearman's correlation and t-tests with Bonferroni confidence intervals. Diets between sexes were highly correlated. Available biomass and diets changed between summer (July-Aug.), autumn (Oct.-Nov.), and spring (Mar.-Apr.). During summer, forbs and shrubs constituted 24% of available forage but comprised 93% of the diet (75% forbs, 18% shrubs). In autumn, consumption of shrubs increased to 63%. High consumption of *Zizyphus lotus* (28%) compared with availability (2%) underscored its importance to the gazelles. Grasses in the diet increased to 50% in spring. Fruit from *Z. lotus*, though eaten during summer, did not appear in diet analysis. Close grouping of individual diets for animals that were associated suggests that the scale at which availability was measured should be reduced.

Morphological and behavioral characteristics used to identify sex, age classes, and individual gazelles are described. Data from counts and extended observations were used to estimate the population's size and structure. About 35 territorial males lived on the reserve. Territories of 12 males averaged 30.4 ha and contained 23 dung heaps, with no noticeable concentration of heaps at the territory boundary. Actual territory size and the number of dung heaps/territory were greater than reported due to technique limitations. Territory size may limit the number of breeding males, which reduces the effective population size. Densities were at least 6.9-7.9 animals > 12 months old/km^2 and 9.6-10.4 gazelles of all ages/km^2. Herd composition was about 60% adults, 13% subadults, 25% animals < 12 months old, and 2% unidentified. Fawning occurred mainly during October and March. Predators of adult gazelles were feral dogs and humans. Average age at death of adult animals whose skulls were found on the Reserve, determined by cementum layers of teeth, was 67 months for females and 53 for males. Longevity was 108 months for females and males.

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CHAPTER I

INTRODUCTION

Little is known about the gazelles that inhabit North Africa, much less those in Morocco. Unfortunately, the gaps in knowledge are not rapidly closing. Most international conservation organizations concentrate their African funding in East and Central Africa. Indeed, the African Wildlife Foundation restricts its funding to programs south of the Sahara (AWF, pers. comm.). From a utilitarian standpoint, the lack of studies concerning desert ungulates may be unfortunate for future generations. If predictions for global warming prove correct, gazelles that currently occupy the arid regions, some of which were herded in ancient times (Anderson 1985), could provide domesticated protein sources. The dorcas gazelle (*Gazella dorcas*, Fig. 1a) is one of these animals. The most widespread and abundant of all gazelles, its populations across North Africa and the Middle East, like those of its congenerics, have plummeted in the last half of this century (Dupuy 1972 [Algeria], Mendelssohn 1974 [Israel], Essghaier 1980 [Libya], Furley 1984 [Arabia], Grettenberger 1987 [Niger], Saleh 1987 [Egypt], Yom-Tov and Ilani 1987 [Israel], Loggers et al. in prep. [Morocco]).

Captive dorcas gazelles have been well studied. Carlisle and Ghobrial (1968) and Ghobrial (1974) examined food and water requirements of dorcas gazelles in the Sudan. Essghaier (1981) and Alados (1983, 1985a, 1985b, 1986a, 1986b) reported on behavior. Furley (1986) compiled reproductive parameters from zoos and published records, and Alados (1984) reported similar data for the herd at the Arid Zone Institute in Almeria, Spain. Ralls et al. (1980) and Ballou and Ralls (1982) documented inbreeding depression in a population at the National Zoological Park, Washington, D.C. Furley (1987) compiled a bibliography that contains publications about dorcas gazelles since 1980.

Fig. 1 Adult male dorcas gazelle in leghold trap.

Much less is known about wild populations, which have been quantitatively examined only in Israel and Niger. Baharav (1980) and Grettenberger (1987) contain the only estimates of population structures published. Habitat use and foraging ecology have been studied by Baharav (1980, 1982, 1983), Baharav and Rosenzweig (1985), and Grettenberger (1987). Essghaier and Johnson (1980) examined the distribution and use of dung heaps in Libya. Valverde (1957), Roussel-Gaussen (1975), and Essghaier (1981) include notes on food eaten by dorcas gazelles.

This thesis contains the first known quantitative data on diets and population characteristics of dorcas gazelles in North Africa. One chapter reports the statuses and distributions of wild ungulates in Morocco. Three chapters describe feeding habits, individual identification, population characteristics, and territoriality of dorcas gazelles at the M'Sabih Talâa (Sidi Chiker) reserve in west-central Morocco. Except for this chapter, each chapter is written in publication format, with the style corresponding to the targeted journal. The submitted manuscripts have been shortened in some cases, and include references to the thesis for clarification of methods .

All information presented in Chapters III-V and much from Chapter II was collected from 1985-1987 when I was a Peace Corps Volunteer working for the Moroccan Department of Waters and Forests. I designed and implemented each project, conducted all analyses, and wrote each paper.

Chapter II contains information on the statuses and historic and current distributions of the wild ungulates that existed in Morocco during the 20th century, excluding the wild boar (Sus scrofa barbarus). The project began in 1985 with a survey of Waters and Forests posts. It expanded to include historic literature and interview information shortly thereafter. The literature review was assisted by Dr. M. Thévenot of the Institut Scientifique, Rabat and Mr. S. Aulagnier of the Faculté des Sciences, Agadir. They will be co-authors on the paper.

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Chapter III describes the analysis and presents the results of a study that compared vegetation availability with use. No diet differences between the sexes were found. Vegetation biomass and species composition, and gazelle diets changed by season. The gazelles did not select vegetation in proportion to availability. Estimates of variances for relative biomass were calculated using a bootstrap resampling technique (Efron 1982). (The computer program I wrote, in TRUE BASIC, is included as an appendix.) Annual plant production peaked in April/May and available biomass was least at the end of the dry season in October/November (Fig. 2). Diets of animals associating in the same area were closely matched. Suggestions for further studies are forwarded.

Chapter IV discusses aspects of territoriality in male dorcas gazelles. Only adult males hold territories, and only holders of territories seem to breed. Territory sizes and periodicity are presented for several animals. Territorial males construct and maintain dung heaps by repeatedly defecating in the same place. The location of these heaps in relation to territories is reported. Possible influences on territorial size and management considerations concerning territoriality are discussed.

Chapter V contains information on the population's characteristics and methods used to individually identify animals. Age classes and social groups are presented. The Reserve's population's size and composition are compared with a population in Israel. Subadults constitute a low proportion of the population, and possible reasons are presented. Timing of natality was bimodal. Fawn/adult female ratios are presented, and the limits of using count data to estimate fawn/adult female ratios is discussed. Cause of mortality in adults was nearly restricted to humans and dogs (Fig. 1b). Average and maximum longevity, based on tooth cementum layers, are given. The gazelles carry a low parasite load.

The dorcas gazelle Reserve lies 55 km northwest of Marrakech on the semi-arid Haouz plains of Morocco at longitude 8° 30' W and latitude 31° 48' N (Chapter III, Fig. 1). The hills in the northwest

corner mark the westernmost extension of the northeast-to-southwest oriented Marrakech Jbiletes, the schist foothills of the High Atlas Mountains. Topography slopes from 365 m above sea level to 306 m in the southeast (Rakstad 1974). Gently rolling hills cut by gullies cover most of the area. Soils are poor, consisting of eroded particles from the Jbiletes. Current climatic and vegetative conditions do not favor soil formation. Wind and water erosion have been severe, and most soils are shallow and unstratified. The Reserve contains 2 major vegetation communities, upland savanna and lowland shrubs. Savanna areas can be divided into within and outside plowlines. (See Chapter III, STUDY AREA.) Based on shrub composition, the savanna outside plowlines can be further subdivided (Fig. 3). Herb composition was relatively homogeneous over the entire savanna outside the plowlines.

The Reserve was created by the Moroccan Department of Waters and Forests in 1952 to serve as a sylvo-pastoral perimeter. Between 1952 and 1960 Waters and Forests compartmentalized the perimeter by erecting barbed wire fences. They attempted to decrease erosion by planting forage species and windbreaks within plowlines and by constructing *banquettes* on hillsides.

Debate concerning subspecific classification of dorcas gazelles continues. Panouse (1957) described *G. d. dorcas* as living in all the Moroccan plains to the High Atlas Mountains and *G. d. massaesyla* in the Moulouya Valley and the high plateaus, though did not include a description from the Western Sahara. Groves (1969) described *G. d. massaesyla* as occupying the area from Morocco to Senegal, and included *G. d. neglecta* (from the Algerian Sahara [Lavauden 1926]) in *G. d. osiris*. Later, Groves (1983) redescribed *G. d. osiris* to include the Western Sahara. A cladistic study by Alados (1986/87) suggested that *osiris* be included in *G. d. dorcas*, and *G. d. neglecta* stand alone. No author has determined the taxonomic status of the population at M'Sabih Talâa. D. Koch collected 3 skulls from "the southern end of the Moroccan Meseta," or the region of M'Sabih Talâa, whose premaxillae were longer than other Moroccan dorcas gazelles (Groves, pers. comm.). I

collected and measured skulls from 5 adult female and 13 adult males that were found on the Reserve (Appendix A). The results indicate the animals fall in the range for *G. d. massaesyla* (Groves, pers. comm.).

Dorcas gazelle were once widespread in the Haouz. An old farmer described how he hunted gazelles by walking alongside his camels and shooting between the camels' legs. Gazelle trapping with large, homemade leghold traps was frequent, though large desert "kites" used to corral and slaughter gazelles in Israel (Mendelssohn 1974) have not been found in Morocco. By the late 1960s gazelles had become scarce in the Haouz, and the perimeter was declared a reserve. It is protected under the decree that establishes biological reserves, and though assigned the descriptor "Royal Reserve" to underscore its importance, the Reserve receives no special protection privileges.

Human use of the area was prohibited when the area changed from a sylvo-pastoral perimeter into a gazelle reserve. But human use did not cease. Outside the Reserve, nearly all land is cropped or heavily grazed and few trees remain. Protection of the Reserve's vegetation has increased its density over that outside the fence. This sea of green during the growing season proves an attractive lure to some shepherds. People from the 5 villages located within a few kilometers enter the Reserve to collect firewood. Because of the Reserve's small size, any human activity affects the gazelles. Range and forestry projects for the area outside the Reserve would decrease illegal human use of the Reserve, but outlining range and forestry programs is beyond the scope of this thesis.

Fig. 2. Seasonal changes in vegetation at the M'Sabih Talâa gazelle reserve: March, 1986 (top), and October, 1986.

I	*Haloxylon, Zizyphus, Retama*
II	*Zizyphus, Retama*
III	*Atriplex, Zizyphus, Retama*
IV	*Atriplex, Haloxylon, Zizyphus, Retama*
V	*Atriplex* solid
VI	*Zizyphus, Retama, Acacia*
VII	Shrubless
VIII	*Zizyphus*
IX	Lowland
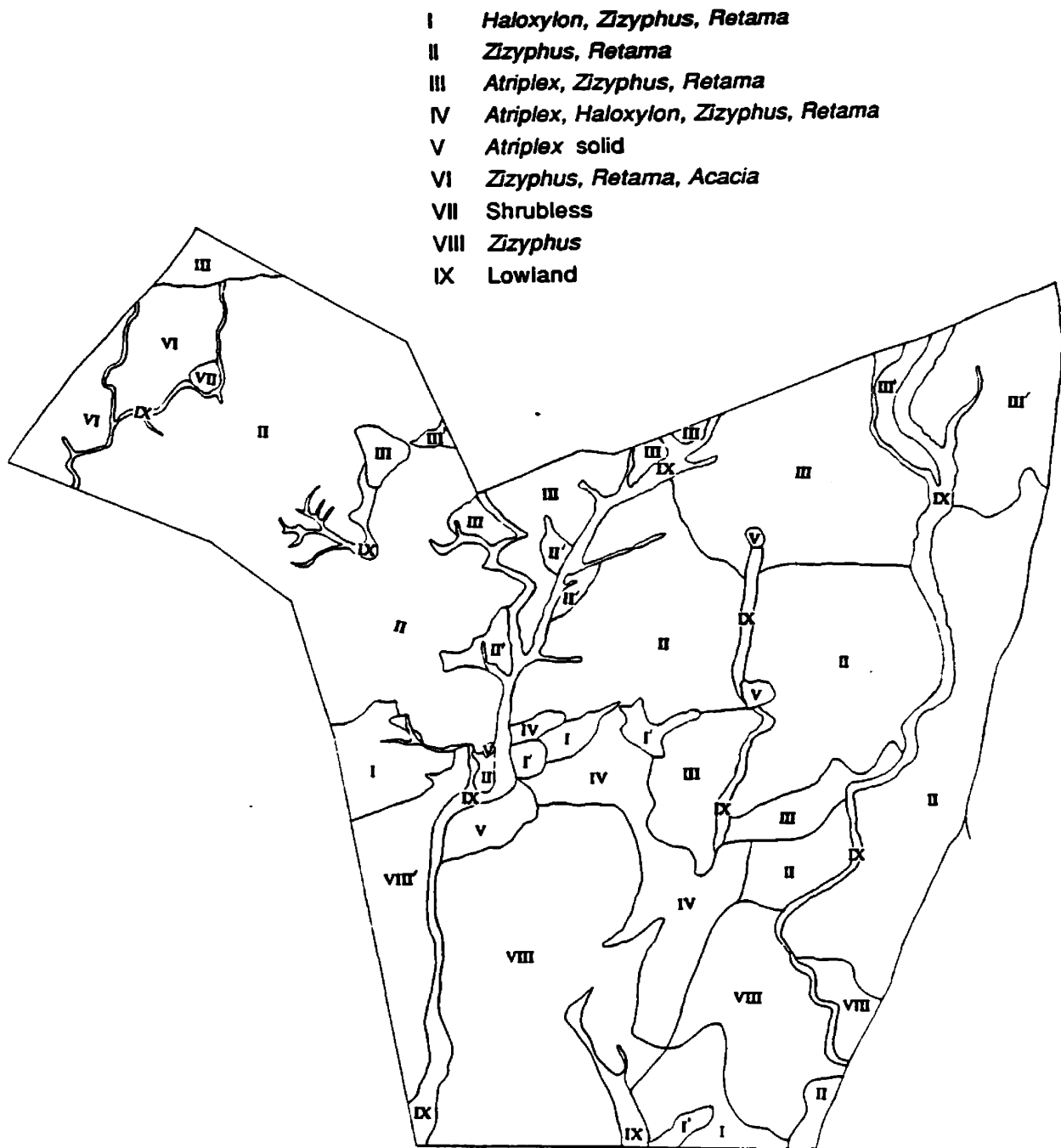
Fig. 3. Plant associations based on shrub species.

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CHAPTER II

STATUSES AND DISTRIBUTIONS OF MOROCCO'S WILD UNGULATES

ABSTRACT

The historic and current distributions and statuses of Morocco's native and introduced wild ungulates, except the boar *Sus scrofa*, are reported. Suggestions for conservation are included.

Three species have been extirpated in Moroccan territory. The last reported hartebeest *Alcelaphus buselaphus* were shot in 1925. Addax *Addax nasomaculatus* and oryx *Oryx gazella dammah* lived south of the Sequiat al Hamra and were probably extirpated by 1960.

Habitat destruction and poaching threaten remaining species. Barbary sheep *Ammotragus lervia* are dispersed in scattered groups in all chains of the Atlas Mountains. Dorcas gazelles *Gazella dorcas* roam east of the Atlas and south of the Anti Atlas Mountains; only 1 wild population exists in Morocco's interior. Cuvier's gazelles *Gazella cuvieri* remain in 3 disjunct areas: the northern Middle Atlas, western High Atlas, and Anti Atlas mountains. Dama gazelle *Gazella dama* might still live south of the Oued Draa. Red deer *Cervus elaphus* did not live in Morocco in historic times. The subspecies *bolivari* has been introduced in the Rif mountains. Both sika deer *C. nippon* and fallow deer *Dama dama* have been introduced, but free-roaming populations do not exist at present.

INTRODUCTION

Morocco, like other North African countries, has a long history of resource exploitation. Neolithic farmers tilled soil and attended flocks. Phoenicians established Lixus (Larache) about 1101 B.C. (Cohen & Hahn, 1966). Romans forged farther inland, exporting grain, lumber, and animals. Arabs invaded in the 7th century. During the 15th and early 16th centuries, Portuguese constructed forts along the Atlantic coast. In the late 19th century colonial thrust, European powers divided the Maghreb. Spain controlled the extreme northern part of Morocco, Sidi Ifni in the south, and the Western Sahara. Shortly after France gained possession of the remainder in 1912, Morocco contained an estimated 2.5 million people (Williamson, 1937). By 1985 the population had grown to over 21 million inhabitants (Direction de la Statistique, 1985). Its expansion rate is 2.5% per year (United Nations, 1988).

North Africa supports a diverse fauna. Its Recent ungulates evolved from stocks in 3 faunal areas. Hartebeest *Alcelaphus buselaphus* arose in the paleotropics. Other bovids originated from Saharo-Sindian representatives. Wild boar *Sus scrofa* and cervids entered North Africa from the Eurasian subregion.

Intermittent descriptions of Morocco's ungulates extend over several millennia. Prehistoric humans' petroglyphs of ungulates dot Morocco. Historic descriptions began with the Greeks and Romans. Pliny the Elder (1942 edition) wrote about elephants *Loxodonta africana* and Strabon (24 in Roget, 1924) mentioned hartebeest. Between the end of the Roman occupation and the 1800s, other than the account of Leo Africanus (1485-1554) from the late 1500s, few wildlife descriptions were written in European languages. By the mid 1800s, ungulate populations had decreased throughout Morocco; large mammals were not common, though still existed in remote regions (Meakin, 1901). The main causes of the decline were habitat destruction for agricultural land and building materials and the introduction of modern firearms (Chernier, 1788; Raethel, 1986).

Morocco's expanding human population, coupled with its colonial, extractive history, has left it with limited wildlands (Chapuis, 1961, 1973). Only 0.05 % of Moroccan territory is legally classified as protected (Cheggar & Derouiche, 1986). Boundaries of protected areas are often inadequately marked, and well-marked boundaries are rarely respected. Morocco's megafauna, which depend on these wildlands, are nearing a critical point. Excluding the wild boar, all 4 of Morocco's wild ungulates are listed as either threatened or endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN, 1988).

This paper examines the current distribution of Morocco's wild ungulates, contains notes on past occurrences and suggests conservation measures. It was initiated to collect records of ungulate distribution and to inform interested persons of the present situation of wild ungulates in Morocco.

AREA DESCRIPTION

Morocco stretches 1835 km along the northwestern coast of Africa (World Resources Institute, 1986). Morocco added 252,120 km^2 to its 710,850 km^2 when it obtained *de facto* jurisdiction over the Western (formerly Spanish) Sahara in 1976 (Direction de la Statistique, 1985). This increased its shoreline by about 750 km. Due to military conflict, little of the Western Sahara is open to travel, and meager current information is available from that region.

Morocco's land area can be divided into 11 geographical regions (Fig. 1). A series of mountain ranges, the Middle, High, and Anti Atlas, bisect the country and separate the interior from the Sahara. The Rif Mountains rim the northern coast. Atlas steppe dominated by *Stipa tenacissima* stretch into Algeria on the northeastern (occidental) side of the mountains. The pre-Sahara region, drier than the grasslands, nestles against the High and Anti Atlas and joins the Sahara proper to the east and south. The country's interior consists of the fertile north Atlantic plains,

the central plateau, and the middle interior plains and plateaus. The fertile Sous valley lies near the Atlantic coast between the High and Anti Atlas mountains.

METHODS

We gathered information by reviewing published and unpublished records, interviewing, and surveying the provincial Department of Waters and Forests offices. Locations were mapped on a 0.5° latitude X 0.5° longitude grid (Scale 1/100,000).

RESULTS

Bovids

Hartebeest

During early European explorations, hartebeest (Fig. 1) were common in Morocco (Aulagnier & Thévenot, 1986a). However, hunting with modern weapons during the 1800s rapidly decimated the populations (Raethel, 1986). In the north, the last reported hartebeest near "Boomer" (probably Boumia) was shot about 1835, though they may have persisted there until 1900 (Hay: 66 in Meakin, 1901). During the 1890s, hartebeest were hunted near Jebel Guettar, 80 km southwest of Mecheria, not far from Chott Tigri. These animals kept to the mountainous areas by day, but at night descended to feed on the plains. Some of the captured animals were sent to the *Jardin des Plantes* in Paris (Heim de Balsac, 1928). Powell-Cotton (1937) interviewed Caid Krit, who had shot 12 from a herd of 15 about 70 km southeast of Outat el Haj in 1917, a comment misinterpreted by Panouse (1957) to be more recent. The last known specimens from Morocco were shot in 1925 in the upper Moulouya River Valley, 1 near Missour and 2 shortly thereafter in the same region, closer to Outat el Haj (Bédé, 1926; Seurat, 1943). Lavauden (1926) believed hartebeest still survived in the east near Missour, which was repeated by Gruvel (1937), long after the last known animal had been shot. Thus, Cabrera (1932) signaled the extirpation of hartebeest in Morocco north of the Oued Draa.

Panouse (1957) mentioned a herd of hartebeest near the Zguid oasis (location unknown) in 1945, though he did not believe the report. The hartebeest was an animal of mountains and hills; the area cited is a plain between the Mhamid oasis and the Draa hammada. For the Western Sahara, Haltenorth and Diller (1980) mentioned the extermination of hartebeest in the Wad ed Dahab (Rio de Oro) by 1950, though no Spanish Saharan authors mention hartebeest as having existed in the region (Morales Agacino, 1949; Valverde, 1957).

Addax

During the 1800s addax *Addax nasomaculatus* (Fig. 1) lived throughout the North African deserts, where they were hunted incessantly (Haltenorth & Diller, 1980). The infrequent Moroccan reports are restricted to the Sequiat el Hamra and Wad ed Dahab in the Western Sahara (Spatz, 1926; Morales Agacino, 1934, 1949, 1950) and southeast of Zagora (Marçais, 1937). This suggests addax may not have been permanent residents. J. L. Herce photographed 12 that had been killed in 1943 at Adam Uerk in Rio de Oro (Morales Agacino, 1949). After extensive work Valverde (1957) concluded addax were extirpated in the Western Sahara.

Oryx

Very few recent records exist for the scimitar-horned oryx *Oryx dammah* (Fig. 1). Oryx once lived in subdesert regions of North Africa and Western Sahara (Aulagnier & Thévenot, 1986b), but intensive hunting radically reduced both numbers and range. All historic locations occur south of the Oued Draa, in the regions of Zemmour, Wad ed Dahab, and Tiris (Chudeau, 1920; Spatz, 1926; Morales Agacino, 1934, 1949, 1950; Heim de Balsac, 1948; Valverde, 1957). Permanent residents probably no longer exist in Morocco.

A: Rif Mountains
B: Rharb
C: Eastern High Plateau
D: Middle Atlas Mountains
E: Interior Plateau
F: Interior Plains
G: High Atlas Mountains
H: Anti Atlas Mountains
I: Sous Valley
J: Pre-Sahara
    and Sahara
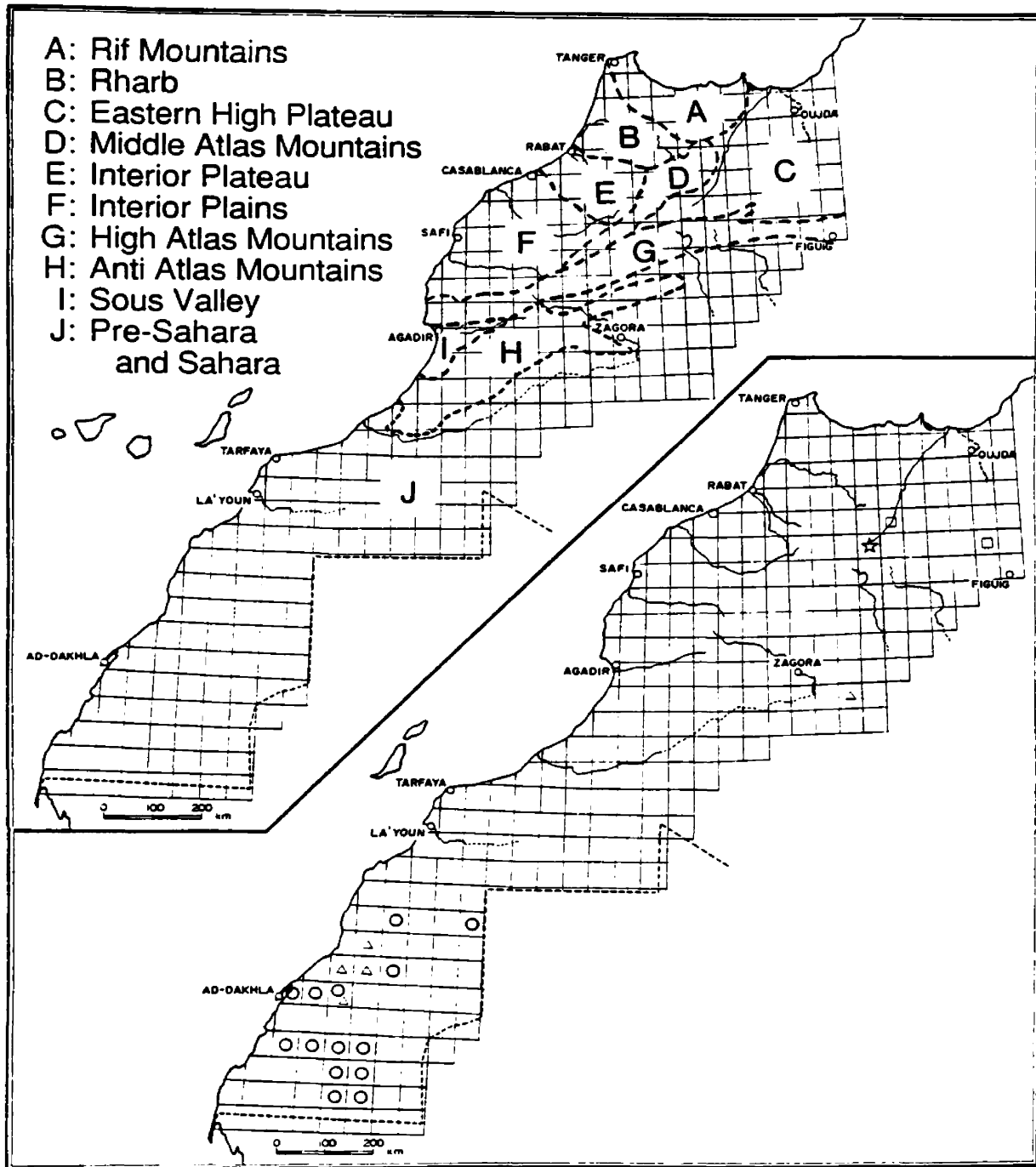
Fig. 1. Geographic regions of Morocco (top); Recorded distribution records of hartebeest (□), addax (△), oryx (○), and Loder's gazelle (☆). All records are from before 1955.

Cuvier's gazelle

The Cuvier's gazelle *Gazella cuvieri* (Fig. 2) is endemic to North Africa (Gentry, 1972; Groves, 1969, 1985), though confusion exists whether to classify it as a subspecies of the mountain gazelle *Gazella gazella* or assign it specific status (Haltenorth & Diller, 1980). In Morocco, it once occurred in all mountainous regions (except the western Rif), on the high plateaux of the High and Middle Atlas Mountains and on the Central Plateau east of Casablanca (Heim de Balsac, 1928; Cabrera, 1932; Panouse, 1957).

Cuvier's gazelles, listed by IUCN as endangered (1988), still survive in three disjunct areas of Morocco: the northern Middle Atlas, western High Atlas, and Anti Atlas mountains. Cuvier's gazelles occupy a variety of short maquis, *S. tenacissima*, and open forest habitats. On the rocky high plateaux of eastern Morocco, their habitat contains *Tetraclinus* scrub, *Rosmarinus officinalis*, and *S. tenacissima*. Mixed scrub containing *Quercus ilex*, *Pinus* spp., *Olea europaea*, and *Pistacia lentiscus* enter this mosaic towards the Middle Atlas. In the Anti Atlas Mountains, their habitat includes *Tetraclinus* spp., *Argania spinosa*, and *Atriplex* spp. Their southern High Atlas habitats resemble those of the Anti Atlas, but often contain *P. lentiscus*. They also live in reforested areas throughout their range. An attempt was made to reintroduce Cuvier's gazelles into Massa National Park, south of Agadir, but dogs killed the animals. The gazelles came from the Estación Experimental de Zonas Aridas in Almeria, Spain.

Cuvier's gazelle populations continue to decrease as human activities expand into more remote mountainous areas. Because Cuvier's gazelles occupy rough terrain, poaching with vehicles and modern weapons constitutes less a threat to them than to the plains-dwelling dorcas. Trapping, as practiced by resident and nomadic humans near Foum al Hassan and Guelmim, can rapidly reduce local populations.
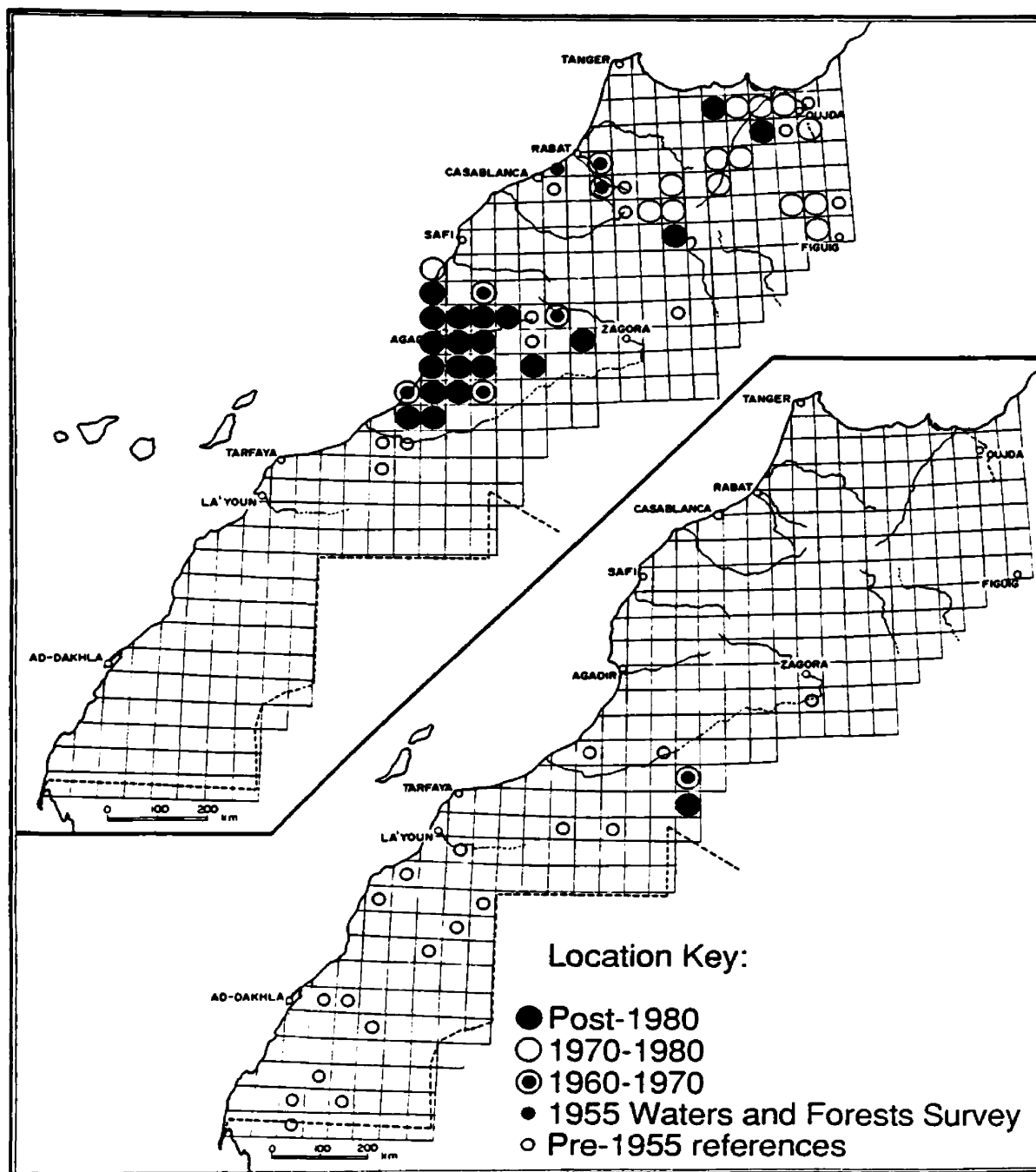
Fig. 2. Distribution records for Cuvier's gazelle (top) and dama gazelle.

Dama gazelle

Dama gazelle *Gazella dama* (Fig. 2) lived near the Oued Nun, north of the Oued Draa (Bennett, 1833; Sclater & Thomas, 1897-1898), but had been extirpated in this area by the early 1900s (Cabrera, 1932). Until the 1950s, dama gazelle were scattered throughout Western Sahara (Valverde, 1957), and reached their northernmost limit along the Oued Draa. They were often seen on the Tindouf hammada, where 3 were captured near Merkala in 1948 (Panouse, 1957).

In 1969, a group was captured near Dawra (Western Sahara) for breeding at the Estación Experimental des Zonas Aridas. This herd provided the nucleus for most captive dama gazelles in zoos around the world (M. Cano, pers. comm.). Dama gazelles were again seen on the Tindouf hammada in 1975 (Tata nomads, pers. comm.). According to De Smet (1989), a small herd was observed in the *Argania* forest near Tindouf in 1985. Two species of gazelles reportedly live in the Wad ed Dahab's acacia maquis (Waters and Forests personnel, pers. comm.). Travel in that area is restricted because of the Western Sahara conflict, and no more information is available. Historically, only dorcas and dama gazelle lived in that area. Though the IUCN (1988) lists dama gazelle as vulnerable, they are extremely rare in Morocco, and may be extirpated.

Dorcas gazelle

The dorcas gazelle *Gazella dorcas* (Fig. 3) is an animal of grasslands and steppes. It is the most widespread of the gazelle species, extending from the Atlantic coast to the Arabian peninsula and into Iraq (Haltenorth & Diller, 1980). In Morocco, Leo Africanus (1896 edition) claimed dorcas gazelles occupied all the plains, including the Rharb and Chaouia. Today, scattered herds inhabit only a portion of their former range. The IUCN (1988) lists the dorcas gazelle as vulnerable.

Local people hunted gazelles on the interior Haouz plain less than 50 years ago (M. Hamdaoui, pers. comm.). Today, only 1 group of about 200 gazelles remains in Morocco's interior, on and around the 1987 ha M'Sabih Talâa (Sidi Chiker) reserve northwest of Marrakech (Loggers in

prep.). This reserve was established in 1952 and fenced by 1960 (Eaux et Forêts, undated).

The habitat consists of *Stipa retorta* grasslands dotted with *Zizyphus lotus* and *Retama monosperma* shrubs. Feral dogs and periodic poaching with leghold traps are the major gazelle mortality factors on the reserve. In 1985 an anomalous sighting was made near Settat. This animal was probably a long-distance migrant from the M'Sabih Talâa population, about 110 km to the south.

East of the Atlas mountains, small groups of dorcas gazelles are widely scattered throughout the Moulouya River valley, along the Moroccan-Algerian border, and on the plains between Zagora and Figuig. Dorcas roam the northeast, where *Z. lotus* steppe at the western edge merges with *S. tenacissima*. Nomadic herdsmen traditionally grazed stock on the grasslands. Changing land use practices that accompany settlement of these pastoralists, especially the establishment of permanent agriculture, are detrimental to the gazelles. Patrolling by Moroccan and Algerian troops may prevent animals from being shot along the undetermined border areas.

Only 3 recent records of small dorcas gazelle groups come from the Sous Valley. French bus drivers near Agadir shot them from the windows of their busses during the 1950s, when gazelles were considered fairly common (B. O'Gara, pers. comm.).

Dorcas gazelles can be found scattered throughout the Oued Draa valley. Dominant perennial vegetation is *Tamarix articulata* trees and shrubs. Gazelles from the valley were, until recently, common household pets in Tata. They still provide a source of protein to some inhabitants. Near the mouth of the Oued Draa and along the Atlantic coast, gazelles can be found inhabiting the *Euphorbia* matorral (U. Hirsch, pers. comm.). In the Western Sahara, gazelles still occupy the *Acacia* maquis. Due to conflict over the region, travel is restricted in areas south of the Sequiat el Hamra. Dorcas gazelles were very common there in the 1950s (Valverde, 1957), but no recent information is available.
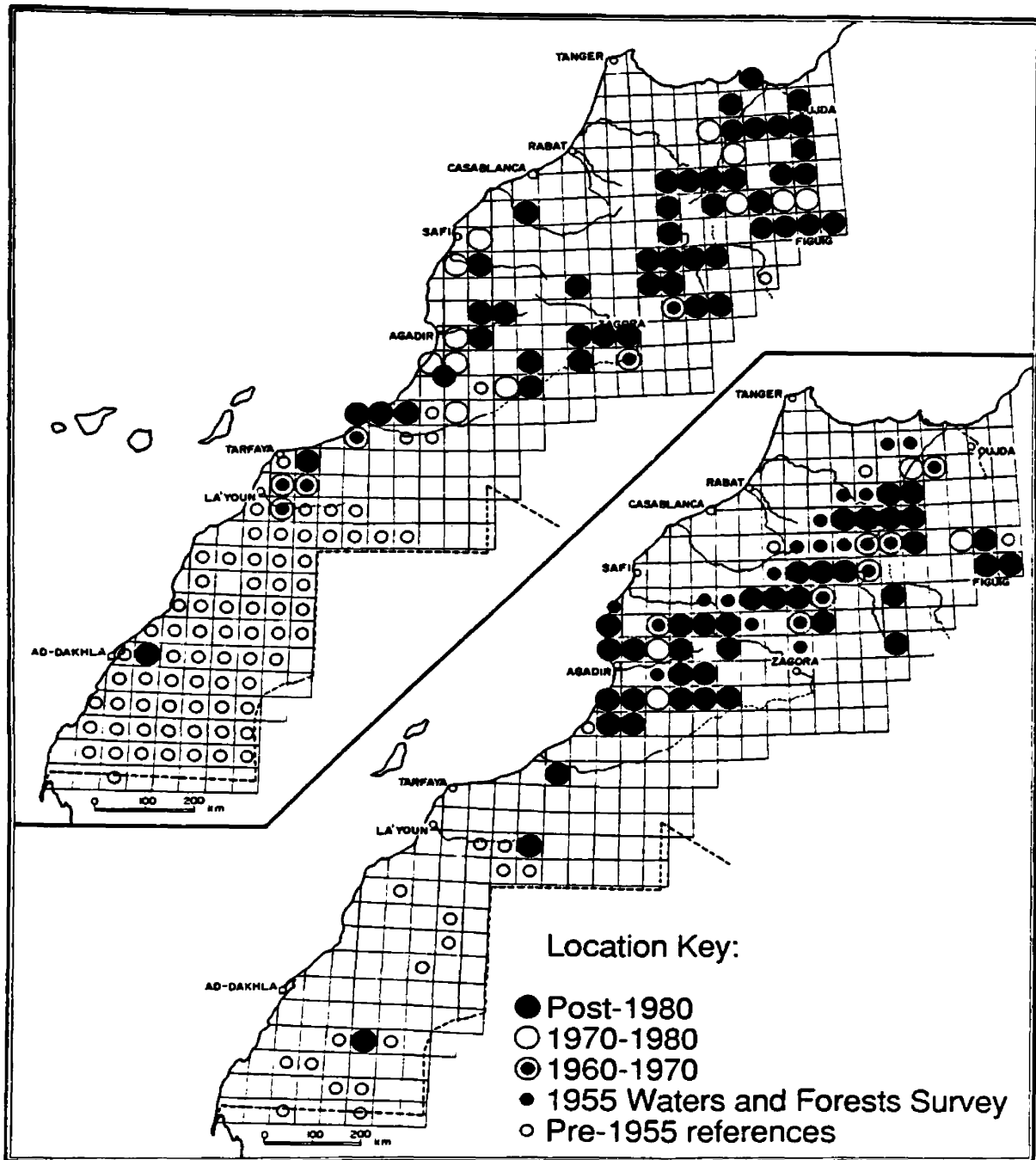
Fig. 3. Distribution records for dorcas gazelle (top) and aoudad (Barbary sheep).

Loder's (Slender-horned) gazelle

Only 1 reference exists on Loder's gazelle *Gazella leptoceros* (Fig. 1) in Morocco. A large male was shot near Boumia in 1954 (O'gara & Groves, in prep.). This animal was accompanying a small herd of either Loder's or Cuvier's gazelles.

Aoudad (Barbary sheep)

The IUCN (1988) classifies aoudad *Ammotragus lervia* (Fig. 3) as vulnerable. Aoudad live in scattered groups throughout all chains of the Atlas Mountains, but they no longer occur in the Rif (Aulagnier & Thévenot, 1986a). In the Middle Atlas and the eastern High Atlas, most habitats that support aoudad contain *Quercus ilex*. Other common overstory woody plants are *Juniperus* spp. and *Cedrus* spp. Habitats in the western High Atlas and Anti Atlas contain *Thuya* spp. and *Argania spinosa*. Adult specimens of these trees are more important for cover than food.

The rising human population's need for more wood and food reduce available habitat as logging, agriculture, and grazing ascend into mountainous areas. Poaching and predation by feral dogs exacerbate the situation. During the 15th century, Leo Africanus (1896 edition) frequently saw aoudad in the western High Atlas and attributed their high numbers to the fact that local people did not hunt them; these aoudad may have been considered property of the local ruler. Caids of the Atlas traditionally hunted aoudad (Meakin, 1901; Naval Staff, 1919; Maxwell, 1966; Collomb, 1980). Hunting by indigenous people did not cease upon prohibition.

Morocco's only established aoudad reserve is the 1230 ha Takkerkhort reserve south of Marrakech. The aoudad population on the reserve, which borders Toubkal National Park, seems to be expanding under protection. However, dogs harass the animals, and kills have been documented (S. Posner, pers. comm.). Young animals are caught for curios (P. Harry, pers. comm.).

Cervids

<u>Red deer</u>

Though red deer *Cervus elaphus* fossils appeared in Moroccan sediments during the Soltanian about 10,000 years ago (Joleaud, 1930; Arambourg, 1938), no records suggest that it occupied Morocco during modern times. The subspecies *C. elaphus barbarus* lives in Algeria (De Smet, 1989) and Tunisia (Kock & Schomber, 1961; Posner, 1988). The Moroccan government wishes to introduce this subspecies in the western Rif Mountains, but fears hybridization with the introduced *C. elaphus bolivari*. A herd of 5 male and 10 female red deer of the *bolivari* subspecies from a park near Madrid, Spain, was introduced near El Ksar es Seghir in the western Rif Mountains near Tetouan in 1952 (von Lehmann, 1969). Von Lehmann (1969) noted that the herd had separated, and the 2 herds contained a total of 50 animals. Benjelloun (1983) estimated that this herd contained 200-250 animals. Another introduction of the *bolivari* subspecies was made in the Ghomara reserve north of Fes in 1981 (Le Matin du Sahara, 29 Nov., 1981).

<u>Fallow deer</u>

Fallow deer *Dama dama* are not native to Morocco, nor ever appeared in the fossil record. A herd was introduced in the same location in the Rif as the red deer, but after 12 years none remained (Benjelloun, 1983). No free-ranging populations exist, though a herd was recently introduced in a reserve near Rabat (Y. Reymond, pers. comm.).

<u>Sika deer</u>

Between 1951 and 1953, attempts were made to introduce sika deer *Cervus nippon* at 3 locations: the forests of Mamora and Ben Slimane and in the remote reforested mountains near Taza. Their introduction seemed successful, particularly near Taza. However, all animals had been killed within 15 years of the introduction (Benjelloun, 1983).

CONCLUSION

Morocco's long history of human exploitation has brought its wild bovid populations to a historical low. Hartebeest were extinct by the 1930s. Addax and oryx have not been sighted since the 1950s and are presumed extirpated. Dama gazelle were seen near the Moroccan border in 1985. Waters and Forests reports that dorcas and another gazelle species live in the acacia maquis in the Wad ed Dahab. Though more exact information is unavailable, historically, only dorcas and dama live in that area. Populations of Cuvier's gazelles, and Barbary sheep outside protected areas, continue to decline, mainly due to loss of habitat. Dorcas gazelles still maintain themselves on the eastern side of the Atlas mountains, though changing land use practices and poaching constitute large threats. Only 1 population exists in the interior of Morocco, on the M'Sabih Talâa reserve. Three species of cervids, none native to Morocco, have been introduced; only red deer maintain a free-ranging population.

The short-term outlook for Morocco's large mammals is grim. The human population is growing rapidly. The concomitant demands on wildlands for agriculture production and domestic animal fodder further fragment wildlands and isolate ungulate populations. Though hunting of wild ungulates (except wild boar) has been completely outlawed since 1958 for Cuvier's gazelles, 1961 for dorcas gazelles, and 1966 for aoudad (Chapuis, 1973), poaching continues. The legal framework of laws concerning nature protection is difficult to decipher, which confuses enforcement of statutes. Management of wildlife is combined with the duties of foresters whose education is silviculture and whose mandate is increased forest production. Funds are insufficient to support an infrastructure for large mammal studies. Therefore, college and university students in ecology concentrate studies on plants or small animals.

Morocco's national debt exceeds US $20 billion (World Bank, in Europa publications, 1989). Morocco can neither initiate nor sustain a rigorous conservation system without either a non-

traditional source of funding or monetary intervention from the international conservation community. Past internationally-assisted programs have met with mixed results.

This very negative scenario has recently been somewhat tempered. In 1986 the Society for Nature Protection was resurrected, with the Crown Prince as Honorary Chairman. In 1986 the government of Morocco elevated the Bureau of Nature Protection from under the Bureau of Hunting's control. The most recent 5-year economic plan increased funding for parks and reserves. In collaboration with Waters and Forests, the American Peace Corps has assisted in wildlife management at 4 sites containing wild ungulates (Massa National Park, M'Sabih Talåa gazelle reserve, Toubkal National Park, and Takkerkhort aoudad reserve). The World Wide Fund for Nature provided funding for the Massa Park project near Agadir, where Cuvier's gazelles may again be reintroduced. Several students are receiving education in wildlife and land management at institutions outside Morocco.

However, the burgeoning human population will absorb these positive changes. Ungulate populations will continue to decline in the near future. Though the results at the gazelle and aoudad biological reserves are encouraging, not all currently extant populations will survive. Because most ungulate populations live in wildlands outside protected area boundaries, the future of Morocco's wild ungulates does not reside in the future of Morocco's protected areas.

OBSERVATIONS AND SUGGESTIONS

The Department of Waters and Forests operates on a limited budget; it cannot afford to address all the conservation needs in the country. Targeting conservation programs might increase the likelihood of success. Successful methods of management in one area might not work in another.

Existing ungulate populations, if correctly managed, could yield a sustained crop of animals in some areas. Bovid populations can rapidly expand, even near human habitation, if afforded a

measure of protection (Yom-Tov & Ilani, 1987). M'Sabih Talâa's dorcas gazelle and Takkerkhort's aoudad populations have increased under protection. Sochatour maintains at least 1 Barbary sheep hunting reserve. Some profits from their closely-monitored hunts could be returned to the local community. Monitored hunting may not prove to be possible in most areas. Indigenous ungulates can offer excellent hunting opportunities, and introducing exotic species usually requires foreign expenditures. Concentrating on the conservation of indigenous ungulates will preserve local biological diversity and decrease costs.

Morocco maintains a system of parks and reserves, most of which receive no funding or protection. At Toubkal National Park, many local villagers are not aware that the park exists (P. DeMaynadier, pers. comm.). The government can establish new protected areas, but without enforcement of their boundaries, these reserves are of little value. Local people legally or illegally utilize resources on many existing reserves and will continue to do so. If communities obtained benefits from the existence of a protected area, they might be more amenable to protect that area. Communities might be given assistance to help identify and develop resources alternate to those currently being exploited within the protected area.

Outside of protected areas, formal laws or informal pressure can curtail individual activities, even in an area legally classified as a commons (Acheson, 1975). If a resource's value were sufficiently high, it might be protected by individual restraint enforced by community norms (McKean, 1982).

Conservation does not necessarily mean complete preservation. Because values held by today's contemporary groups will change, and change cannot be predicted, management should not strive for the single-minded goal of wildlife preservation in areas that prohibit human predation. Though protected areas free of human predation are needed in the western High Atlas, for Cuvier's gazelles, and in the Western Sahara, Morocco will not be able to increase its protected area sizes or numbers to ensure the long-term survival of its wild ungulates. To

conserve these animals, the Moroccan government will need to develop conservation strategies for within and outside of protected areas. Local people could assist in planning strategies tailored to local conditions. Though including local peoples in the planning process increases administrative difficulties, it also increases the probability of success. Ultimately, the future of Morocco's wild ungulates rests in the hands of the local people on whose lands the animals live. It is through education and participation in planning that local people will conserve wild ungulates.

ACKNOWLEDGEMENTS

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CHAPTER III

FORAGE AVAILABILITY VERSUS SEASONAL DIETS, AS DETERMINED BY

FECAL ANALYSIS, OF DORCAS GAZELLES IN MOROCCO.

ABSTRACT

Diets of adult female and territorial adult male dorcas gazelles were compared to availability of vegetation during 3 seasons on a reserve in Morocco. Diets were determined by microhistological fecal analysis. Vegetation was defined as the biomass within 1.2 m of the ground of those species eaten during a season and was measured using reference units. Comparisons between sexes, seasonal diets, and use and availability were made using Spearman's rank correlation. Use and availability for individual species were also compared using *t*-tests that incorporated Bonferroni confidence intervals. Diets of females and males were highly correlated. Available biomass and diets changed between summer (July-Aug.), autumn (Oct.-Nov.), and spring (Mar.-Apr.). No relationship was found between diet and availability within a season. During summer, forbs and shrubs constituted 24% of available forage but comprised 93% of the diet (75% forbs, 18% shrubs). In autumn, consumption of shrubs increased to 63%; the high consumption of *Zizyphus lotus* (28%) relative to availability (2%) underscores its importance to the gazelles. Grasses in the diet increased to 50% in spring, and shrubs dropped to 2%. Fruit from *Z. lotus* did not appear in diet analysis, though it was an important component of summer diets. Close grouping of individual diets for animals that were associated suggests that the scale at which availability is measured must be reduced.

RESUME

L'alimentation des gazelles dorcas adultes femelles et adultes territoriales mâles, mesurée par des micrographiques d'analyse des fèces, et par la disponibilité de la végétation, définis en tant que biomasse dans un rayon de 1,2 m au le sol où ces espèces s'alimentent pendant une saison et mesurée en utilisant des unités de référence, a été mesurée pendant 3 saisons dans une réserve au Maroc. On a comparé en se servant de la corrélation de rang de Spearman les sexes, la nourriture consommée selon les saisons, l'utilisation et la disponibilité. On a aussi comparé l'utilisation et la disponibilité pour les espèces individuelles en se servant de t-tests auxquels on a incorporé des intervalles de confiance de Bonferroni. On a observé une grande correspondance entre l'alimentation des femelles et celle des mâles. La biomasse disponible et la nourriture variaient entre l'été (juillet- août), l'automne (octobre-novembre) et le printemps (mars- avril). Il n'y a pas de relation entre la nourriture et la disponibilité au cours d'une même saison. Pendant l'été, les "forbs" et les arbustes constituaient 24% du fourrage disponible, mais seulement 83% de la nourriture (75% de "forbs", 18% d'arbustes). En automne, la consommation d'arbustes s'est accrue jusqu'à 63%; la consommation élevée de *Zizyphus lotus* (28%) relative à la disponibilité (2%) souligne son importance pour les gazelles. La consommation de graminées dans leur alimentation est montée jusqu'à 50% au printemps, et celle des arbustes a diminué jusqu'à 2%. Les fruits de *Z. lotus* n'apparaissaient pas dans l'analyse de la nourriture, bien qu'étant une composante importante de leur alimentation en été. Le regroupement étroit de l'alimentation individuelle pour les animaux qui ont été associés suggère que l'échelle dont on se sert pour mesurer la disponibilité doit être réduite.

INTRODUCTION

Dietary information is necessary to understand the ecology and management of ruminants. Dietary information is used to determine patch richness in optimal foraging models (Baharav and Rosenzweig 1985), to investigate interactions within and among species and sexes (Shank 1982), to understand animal distribution and diversity (Johnson 1980, Chesson 1983, McNaughton and Georgiadis 1986), to evaluate habitats (Hobbs and Swift 1985), and to devise strategies to manipulate animal populations by vegetation management (Warren et al. 1984). Persons involved in captive maintenance and breeding require this information to maintain healthy captive herds.

Diets of East Africa's Thomson's gazelle (*Gazella thomsoni*) and Grant's gazelle (*G. granti*) have been well-studied in relation to forage availability (Stewart and Stewart 1971, Spinage et al. 1980). Rumen content analysis and observational data indicate that both are mixed feeders, though Grant's gazelle utilizes more shrubs and forbs than Thomson's gazelle (Stewart and Stewart 1970, Hoppe et al. 1977). Less well known are diets of gazelles in North Africa and the Middle East. Mountain gazelle (*G. gazella*) in Palestine mainly graze, but browse more during the dry season (Baharav 1981). Dorcas gazelles, whose diets have been examined in Palestine (Baharav 1980, 1982) and Niger (Grettenberger 1987), primarily browse shrubs but take annual grasses and forbs when available. Valverde (1957), Roussel-Gaussen (1975), and Essghaier (1981) listed plant species eaten by free-ranging dorcas gazelles, and Valverde added that 50% of rumen material of an adult female and 10% of an adult male in the Western Sahara consisted of larval locusts (*Schistocerca*).

The International Union for the Conservation of Nature and Natural Resources lists the dorcas gazelle as an endangered species (1988). One population remains in Morocco's interior, about 220 animals on the 1987 ha M'Sabih Talâa gazelle reserve (Loggers 1990). No systematically collected information has been published on the diet of North African dorcas gazelles. These

data are needed to determine management activities and evaluate reintroduction sites. The purposes of this project were to quantify available vegetation, compare diets of male and female dorcas gazelles, and compare diets to availability during 3 seasons: the middle (July-Aug. 1986) and end of the dry season (Oct.-Nov. 1986), and the peak of the annual plant growth season (Mar.-Apr. 1987).

STUDY AREA

The Reserve is located in the province of Safi on the Haouz plains of Morocco, 55 km northwest of Marrakech (Fig. 1). Summer temperatures frequently exceed 40° C, and winter lows descended to near 0° C. Erratic rainfall averages 150-200 mm/year (Fig. 2, Eaux et Forêts 1976, Bougrine 1982). Elevation averages 330 m above sea level and slopes from the northwestern corner downward to the southeast. The reserve consists of small gullies that cut through gently rolling hills covered by *Stipa retorta* and dotted with shrubs. The gullies merge into 2 dry *oueds* whose 10 m-wide beds lie about 2.5 kms apart. Aside from a few very isolated, small waterholes, the *oueds* contain water for only a few months each year and flow only immediately following a rainstorm. Current climatic conditions do not favor soil formation, and schist bedrock is exposed in many places. Soils in areas with less slope are deeper but mainly unstratified.

The original vegetation of the Haouz is unknown. P. Quezel (pers. comm.) considers the area 'arid Mediterranean'. The reserve's flora contains plant representatives from the Mediterranean, pre-Sahelian and Sahelian zones, which suggests the 3 zones may overlap in the region. It also contains several endemic plant species or varieties whose ranges are restricted to Morocco's interior. Annual herbs dominate the Reserve's biomass, though species' contributions shift seasonally. Herbs begin growing in November or December, depending on rainfall, and seed and die by late April. Densities and robustness of annual plants directly reflect the amount and
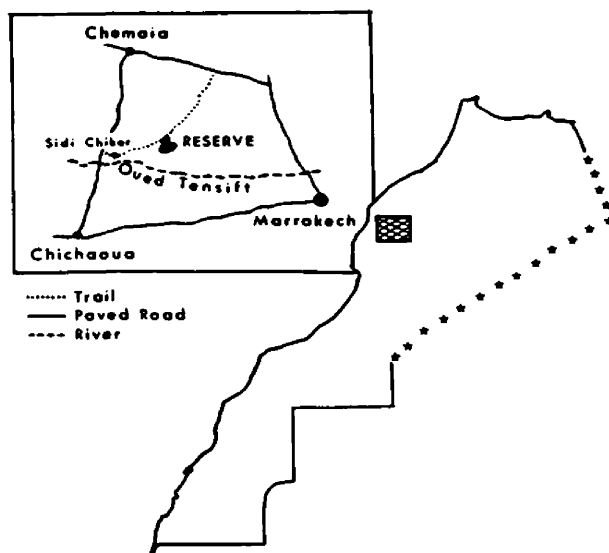
Fig. 1. Location of M'Sabih Talâa (Sidi Chiker) reserve, Morocco.
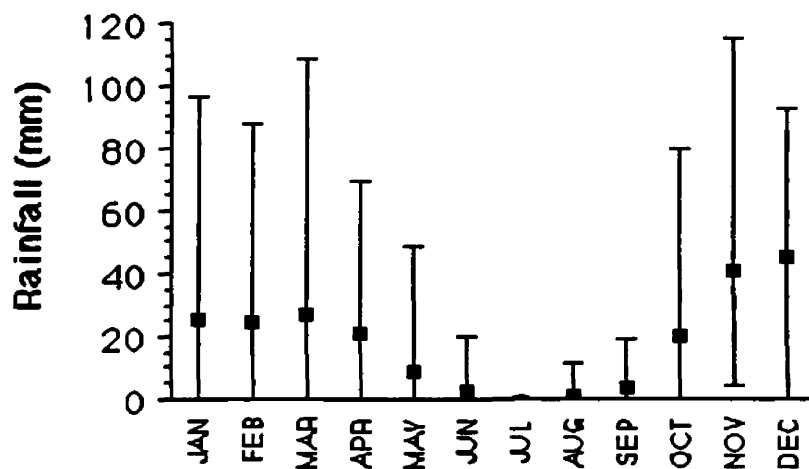
Fig. 2. Average seasonal rainfall and documented ranges (1957-1974) for Chemaia, Morocco.

dispersion of rainfall. Tree and shrub density is low, except for corridors along the *oueds* and in rows of planted trees and shrubs.

Lowlands bordering the *oueds* comprise 7% of the Reserve. Soil moisture in lowlands is much higher than in uplands, and herb and shrub specimens are more robust and have higher densities than their upland conspecifics. Many herb species exist only within the narrow band of higher moisture on either side of the *oueds*. The remaining 93% of the reserve consists of 2 upland types. During the early 1950s, the Moroccan Department of Waters and Forests constructed, every 100 m, parallel 11m-wide strips that traverse the entire length of the reserve. The strips were plowed to a depth of nearly 1m. Within these plowlines, new soil properties and subsequent tree and shrub planting changed the vegetative composition. Dominant shrub species are those planted by Waters and Forests: *Atriplex hamilus, Retama monosperma, Acacia gummifera*, and *Eucalyptus* spp. From 1952 to 1962, they planted more than 195,000 *Eucalyptus* seedlings (Mandouri 1972); less than 20% remain alive. In the second upland type, outside the plowlines, *Zizyphus lotus* is the only frequent shrub. Land outside the reserve is overgrazed or cropped. Little permanent vegetation remains. At the reserve border, tree and shrub densities drop dramatically. Five villages, each containing < 400 people, lie within a few kilometers radius.

METHODS

VEGETATION

Vegetation and feces were sampled 3 times--during the middle (Summer: 16 July-7 Aug. 1986) and end of the dry season (Autumn: 18 Oct.-5 Nov. 1986), and at the peak of production of annual vegetation (Spring: 22 Mar.-14 Apr. 1987). Data do not follow a complete growing season. Available vegetation was defined as that within 1.2 m of the ground, the height an adult gazelle could reach if it browsed by rising off its front legs. Herbs included both forbs and monocots. The sampled area was located in the northwestern 0.25 of the Reserve. The area

sampled was entirely upland, and was stratified into inside (11% of area) and outside plowlines (89%). The same plots were not sampled during subsequent sampling sessions. Species' biomass was estimated using reference units (Andrew et al. 1979). Reference units were oven-dried for 24 hours, and the values used to estimate dry weight.

For herbs, 40 100m-long transects that contained 20 1m^2 plots located 5m apart were randomly located and sampled. During summer and autumn sampling sessions, shrubs were also recorded in the 1m^2 plots. The first 2 plots on each transect were located in the plowline. Plot size was increased to 0.25 ha for shrub sampling because of very low shrub occurrence. During summer and autumn, 221 and 195 randomly located, optimally allocated plots were sampled. During spring, 100 plots were assigned according to stratum area and sampled (Freese 1962).

DIETS

Feces were collected from several adult females and from dung heaps of all known territorial adult males within the study area during each vegetation sampling session. In summer and autumn, I collected feces from 14 and11 females and 9 and 10 males, and during spring from 10 males and no females. Fresh dung was collected except for 3 occasions during summer when dry dung less than 3 days old was used. One pellet from each of 3 samples from an adult male was used for analysis. Pellets were dried and stored in salt. Dung from adult females was gathered within the male territories. Females were observed until they defecated, but during autumn dry dung known to be less than 4 days old was collected on 2 occasions. (If gazelles were "excited", they would often defecate. This could be stimulated by approaching them without causing them to flee.) Because of the difficulty of differentiating among adult females, each defecation constituted 1 sample. The Composition Analysis Laboratory at Colorado State University analyzed the pellets according to methods outlined in Hansen et al. (1976).

ANALYSIS

Variances of mean relative biomass were calculated from a bootstrap sample (Efron 1982). Biomass of only those herbs that were identified from fecal analysis were summed over a transect to form a raw biomass file. If gazelles selectively fed on only a portion of a plant, the biomass for that species was multiplied by the estimated proportion of edible material/plant. Total and relative biomass means were calculated for all species. For each species, the mean biomass of 500 n-1 random samples drawn from the raw biomass file was calculated (n = number of transects for herbs, and number of plots for shrubs). Herb species' biomass for the entire transect were treated as a unit; for shrubs, a plot was the unit (See appendix B for bootstrap program written in BASIC). The resulting shrub matrices were multiplied by the percent of area covered by the corresponding stratum, and the matrices added. Herb and shrub data were tested for independence during summer and autumn, and the herb and shrub matrices were combined to form a 500 x T matrix (T = Number of species). Relative biomass was calculated by row. Distributions were examined, and standard errors of mean relative biomass for each species were estimated by the standard deviation of the bootstrapped data.

Comparisons were made using Spearman's rank order correlation. Spearman's rank correlation is insensitive to large changes in values that do not change rank, and overly sensitive to changes in rank resulting from minor changes in values. Only those species that constituted >5% of either the diet or relative availability were used in correlation tests. Within seasons, t-tests and simultaneous Bonferroni confidence intervals were used to compare mean relative densities from fecal analysis with mean relative biomass of those species identified in the feces. Critical t-values were $[t_{n-1}(\alpha/2p)]$ where $\alpha = 0.05$ and $p = $ the number of species eaten during a season (Johnson and Wichern 1988). During all seasons, n = 39; p for summer, autumn, and spring was 18, 21, and 18.

RESULTS

VEGETATION

Over 160 species of vegetation were identified on the Reserve (Appendix C). Except for

Eryngium spp. and some Asteraceous thistles, the grass *Cynodon dactylon*, and *Asphodelus*

spp. and other irises and lilies, all herb biomass during summer and autumn was dead. Shrub

biomass was green during all seasons. Summer total available biomass of 160 kg/ha had

decreased to 74 kg/ha by fall (Table. 1). The following spring's production of 189 kg/ha was

affected by lower rainfall than the previous year (14 of the 203 kg/ha was dead material from the

previous year). Biomass of those species identified in the gazelles' feces during summer, fall,

and spring were 66, 16, and 164 kg/ha.

Monocots comprised 40% of available biomass during summer, forbs 57%, and shrubs 3%

(Table. 2). During fall, the ratio was 15% grasses, 81% forbs, and 4% shrubs; during spring 27%

grasses, 70% forbs, and 3% shrubs. Summer and spring monocot composition was dominated

by *S. retorta*. This annual rapidly declined and by fall the more persistent perennial grass

Cymbopogon shoenanthus was more abundant.

Forb productivity was highest for *Plantago* spp., *S. retorta*, and *Brassicaceae* spp. Shortly after

they set seed, *Brassicaceae* were disassembled by ants and the brittle stems of *Plantago* broke

from strong winds. During summer, *S. retorta* and the woody forbs *Lavandula multifida* and

Cladanthus arabicus constituted 77% of the total and 85% of the forb biomass. By fall they

composed 72% of the total and 88% of the forb biomass.

R. monosperma and *A. hamilus* dominated shrub composition during summer and fall, and *Z.*

lotus and *A. hamilus* during spring. Neither *Haloxylon scoparium* nor *R. monosperma* were

consumed by gazelles during spring. I estimated that they comprised about 1% of total biomass

and did not measure them. During summer, grasses (99% *S. retorta*) comprised 74% of the

biomass considering only those species identified from fecal analysis. Forbs constituted 19%

Table 1. Mean biomass (kg/ha) and standard deviations (in parentheses) of available vegetation on the M'Sabih Talâa dorcas gazelle reserve, Morocco.

	Jul.-Aug. 1986[a]	Oct.-Nov. 1986	Mar.-Apr. 1987
Monocot biomass	65.8 (39.4)	11.0 (16.8)	55.8 (23.9)
Andropogon hirta	1.8[b] (8.0)	0.2 (1.1)	3.5 (7.8)
Cymbopogon shoenanthus	12.0 (22.7)	5.8 (15.1)	0
Stipa retorta	48.0 (30.7)	4.7 (7.2)	49.3 (22.4)
Other annual grasses	1.5 (4.4)	0.2 (0.6)	2.1 (3.0)
Other perennial grasses	0.4 (2.4)	0.1 (0.4)	0.1 (0.1)
Asphodelus spp.	1.9 (11.1)	0	0.6 (0.7)
Other irises, lilies	0.3 (0.8)	0.1[d] (0.1)	0.2 (0.2)
Forb biomass	89.9 (44.9)	59.9 (35.6)	141.7 (44.2)
Cladanthus arabicus (dead)	36.2 (25.9)	31.6 (25.6)	4.6 (3.7)
Cladanthus arabicus (live)	0	0	12.5 (9.4)
Asteraceous thistles	0.5 (0.8)	0.2 (0.5)	2.0 (1.5)
Asteraceous non-thistles	1.0 (1.5)	0.2 (0.4)	3.6 (2.8)
Brassicaceae species	1.7 (2.7)	1.0 (2.2)	26.5 (23.6)
Notoceras bicorne & *Matthiola parviflora*	0.8 (3.6)	0.7 (1.0)	2.1 (3.6)
Medicago spp.	0.8 (0.8)	0.1 (0.1)	8.2 (6.3)
Astragalus spp. & *Vicia* spp.	0	0	0.03 (0.1)
Erodium spp.	0	0	3.1 (5.4)
Malva spp.	0.1 (0.3)	0.02 (0.1)	4.5 (7.1)
Eryngium spp.	4.2 (7.1)	4.2 (8.7)	1.0 (2.3)
Echium spp.	0.9 (1.5)	0.2 (0.4)	5.2 (7.2)
Lavandula multifida (dead)	40.0 (33.5)	21.2 (23.1)	9.4 (13.2)
Lavandula multifida (live)	0.01 (0.03)	0	5.6 (8.1)
Plantago spp.	2.9 (4.0)	0.3 (0.9)	51.1 (29.2)
Other forbs	0.9 (2.0)	0.3 (0.6)	2.2 (1.8)
Shrub biomass	4.6 (1.2)	2.8 (1.0)	5.2 (1.8)
Acacia gummifera	0.01 (0.02)	0.02 (0.01)	0.2 (0.2)
Atriplex hamilus	1.8 (0.9)	0.7 (0.4)	1.9 (1.6)
Haloxylon scoparium	0.7 (0.7)	0.3 (0.4)	c
Retama monosperma	1.4 (0.5)	1.4 (0.8)	c
Zizyphus lotus (fruit)	0.2 (0.1)	0	0
Zizyphus lotus (leaves)	0.3 (0.1)	0.3 (0.1)	2.7 (0.9)
Other shrubs	0.2 (0.2)	0.1 (0.1)	0.3 (0.2)
Total biomass	160.4 (59.7)	73.8 (39.4)	202.6 (50.2)

[a] Grasses and forbs were sampled on 40 transects. Shrub sampling was stratified; the number of plots sampled per stratum varied by season.

[b] Unless specified, herbaceous vegetation during the Jul.-Aug. and Oct.-Nov. sampling was dead, and that in the April-May session was succulent. Shrub biomass was always succulent.

[c] Plant not sampled.

Table 2. Mean percent relative biomass and 95% Bonferroni confidence intervals (in parentheses) on the M'Sabih Talâa gazelle reserve, Morocco.

	Jul.-Aug. 1986		Oct.-Nov. 1986		Mar.-Apr. 1987	
Total monocots	41.1	(10.26)	15.0	(9.05)	27.5	(10.97)
Andropogon hirta	1.1	(0.53)	0.3	(0.78)	1.7	(4.90)
Cymbopogon shoenanthus	7.5	(7.31)	7.9	(9.51)	0	
Stipa retorta	29.9	(10.58)	6.4	(5.04)	24.3	(10.93)
Other annual grasses	0.9	(1.56)	0.3	(0.43)	1.0	(1.99)
Other perennial grasses	0.2	(0.85)	0.1	(0.32)	0.05	(0.07)
Asphodelus spp.	1.2	(0.78)	0		0.3	(0.46)
Other irises, lilies	0.2	(0.25)	0.1	(0.07)	0.1	(0.18)
Total forbs	56.1	(10.37)	81.3	(8.73)	70.0	(10.37)
Cladanthus arabicus (live)	0		0		6.2	(4.90)
Cladanthus arabicus (dead)	22.6	(7.95)	42.8	(13.31)	2.3	(1.80)
Asteraceous thistles	0.3	(0.25)	0.3	(0.36)	1.0	(0.99)
Asteraceous non-thistles	0.6	(0.46)	0.3	(0.43)	1.8	(2.45)
Brassicaceae species	1.1	(0.99)	1.4	(1.56)	13.1	(16.33)
Notoceras bicorne & *Matthiola parviflora*	0.5	(1.21)	0.9	(0.82)	1.0	(2.59)
Medicago spp.	0.5	(0.28)	0.1	(0.07)	4.0	(3.83)
Astragalus spp.	0		0		0.01	(0.07)
Erodium spp.	0		0		1.5	(3.94)
Malva spp.	0.1	(0.11)	0.03	(0.07)	2.2	(5.22)
Eryngium spp.	2.6	(2.17)	5.7	(5.93)	0.5	(1.70)
Echium spp.	0.6	(0.5)	0.3	(0.28)	2.6	(4.90)
Lavandula multifida (dead)	24.9	(9.3)	28.7	(15.34)	4.6	(11.61)
Lavandula multifida (live)	0.006	(0.003)	0		2.8	(0.00)
Plantago spp.	1.8	(1.24)	0.4	(0.64)	25.2	(26.34)
Other forbs	0.6	(0.89)	0.4	(0.46)	1.1	(1.46)
Total shrubs	2.9	(1.24)	3.8	(1.92)	2.5	(1.21)
Acacia gummifera	0.01	(0)	0.03	(0.04)	0.1	(0.11)
Atriplex hamilus	1.1	(0.75)	0.9	(0.71)	0.9	(0.67)
Haloxylon scoparium	0.4	(0.5)	0.4	(0.67)	a	
Retama monosperma	0.9	(0.5)	1.9	(1.35)	a	
Zizyphus lotus (fruit)	0.1	(0.07)	0		0	
Zizyphus lotus (leaves)	0.2	(0.11)	0.4	(0.25)	1.3	(0.75)
Other shrubs	0.1	(0.18)	0.1	(0.14)	0.1	(0.14)

a. Species biomass not estimated.

and shrubs 7%. By fall, forbs had increased to 53% and shrubs to 17%, while *S. retorta* dropped

to 29%. In spring, forbs had climbed to 67% and shrubs dropped to 3%, while *S. retorta*

remained at 30%.

Shrub and herb biomass on transects was weakly correlated during the summer (r = 0.44). The

number of species/transect were higher for the 10 transects containing the greatest biomass

compared with the 10 transects containing the least biomass during summer and fall.

There was no difference between the number of herb species/transect and the occurrence of

shrubs for the 10 highest and 10 lowest transects during any season. Thus, shrub biomass was

assumed independent of herb biomass, which allowed data from herb and shrub matrices to be

randomly combined.

Table 3 contains percent relative biomass of those forage species identified by fecal analysis.

Gazelles ate only the buds and fruits of dead *L. multifida* and *C. arabicus*, which were 10% and

15% of plant biomass. Cells in columns of the bootstrapped biomass matrices for these species

were multiplied by 0.10 or 0.15. Relative biomass was dominated by *S. retorta* during summer,

which dropped near 30% during fall and spring. Forb and shrub proportions increased due to the

decline of *S. retorta* .

DIET

Twenty-nine plant species were identified in the feces of dorcas gazelles (Table 4). Diets of adult

females and males were strongly associated during summer and autumn when the 9 most

common dietary items were tested (Table 5a.). Therefore, values for females and males were

grouped within a season for further analysis. There were no significant, positive relationships for

diets between seasons, nor between use and availability (Table 5b and c.). During summer,

Table 3. Mean percent relative biomass and 95% Bonferroni confidence intervals (in parentheses) considering only those species identified in feces of dorcas gazelles on the M'Sabih Talâa reserve.

	Jul.-Aug. 1986	Oct.-Nov. 1986	Mar.-Apr. 1987
Stipa retorta (a grass)	73.9^{--} (7.8)	29.4$^-$ (16.1)	30.4$^+$ (13.6)
Cladanthus arabicus (dead)	7.8^{++} (3.4)	29.1^{--}(10.0)	0.4 (0.6)
Cladanthus arabicus (live)	0	0	7.6 (7.5)
Cladanthus arabicus (dead & live)			8.0^{--} (7.4)
Asteraceae species	2.0^{++} (3.4)	0.8 (1.0)	1.7 (2.9)
Astragalus & *Vicia* spp.	0	0	0.04 (0.1)
Brassicaceae species	2.5^{--} (2.2)	6.4^{--} (6.4)	16.2 (17.6)
Notoceras bicorne & *Matthiola parviflora*	1.2 (1.1)	0	1.3 (3.0)
Echium spp.	1.3^{--} (1.2)	0.9 (1.3)	3.1 (5.4)
Lavandula multifida	0	13.5^{--} (8.2)	0
Malva spp.	0	0.1 (0.3)	0
Medicago spp.	1.1 (0.6)	0.3 (0.3)	5.0^{++} (4.7)
Plantago spp.	4.4 (2.9)	1.5 (2.7)	31.3^{--}(29.1)
Total forbs	19.1^{++} (6.2)	53.3^{--}(14.8)	66.7$^-$ (12.9)
Acacia gummifera	0.03 (0.03)	0.1^{++} (0.08)	0.1 (0.1)
Atriplex hamilus	2.8 (1.6)	4.4^{++} (3.1)	1.2 (0.9)
Haloxylon scoparium	1.0 (1.1)	1.8 (2.9)	0
Retama monosperma	2.1^{++} (1.1)	8.8 (5.7)	0
Zizyphus lotus (leaves)	0.5^{++} (0.2)	1.9^{++} (1.1)	1.7 (0.8)
Zizyphus lotus (fruit)	0.4 (0.2)	0	0
Total shrubs	6.8^{++} (2.2)	17.4^{++} (7.2)	3.0 (1.3)

$^{--}$, $^{++}$. Significant negative/positive difference between use and availability (α = .05/2p)

$^-$, $^+$. Significant negative/positive difference between use and availability (α = .15/2p)

Table 4. Mean percent relative density and standard deviations (in parentheses) for plant species identified in fecal samples from dorcas gazelles on the M'Sabih Talâa reserve, Morocco.

	Jul.-Aug. 1986 Both Sexes N = 23		Oct.-Nov. 1986 Both Sexes N = 20		Mar.-Apr. 1987 TAM N = 10	
Total grasses	6.7	(12.0)	13.5	(15.4)	49.3	(22.3)
Stipa retorta	6.6	(12.0)	13.3	(15.6)	49.1	(22.2)
Unknown grass	0.1	(0.3)	0.2	(0.7)	0.2	(0.4)
Total forbs	75.0	(19.0)	23.2	(26.5)	47.9	(22.3)
Cladanthus arabicus	50.0	(17.0)	12.6	(17.9)	0.6	(0.6)
Asteraceae species	16.0	(7.6)	3.5	(4.5)	0.2	(0.4)
Astragalus & *Vicia* spp.	0.1	(0.2)	0		5.4	(10.1)
Brassicaceae species	0	(0.2)	0.1	(0.2)	7.3	(6.4)
Notoceras & *Matthiola* spp.	0.1	(0.3)	0		2.5	(5.7)
Convolvulus sp.	0		0		0.1	(0.3)
Echium spp.	0.1	(0.3)	0.3	(0.9)	0.7	(1.6)
Lavandula multifida	0		0.1	(0.3)	0	
Malva spp.	0		0.1	(0.3)	0	
Medicago spp.	1.8	(2.0)	0.9	(1.9)	29.3	(17.6)
Plantago spp.	0.3	(0.9)	0.2	(0.6)	0.2	(0.7)
Rumex sp.	0.1	(0.2)	0.4	(1.5)	0	
Unknown flowers	5.9	(4.9)	3.0	(4.7)	0.8	(1.8)
Unknown forb	0		0.2	(0.5)	0.1	(0.4)
Unknown monocot	0		0.1	(0.3)	0	
Unknown seed	0.8	(1.0)	1.9	(2.4)	1.5	(1.9)
Lichen	0		0.1	(0.3)	0	
Total shrubs	18.0	(14.0)	63.2	(23.4)	2.0	(2.1)
Acacia gummifera	1.9	(3.6)	0.7	(0.8)	0.1	(0.4)
Atriplex hamilus	1.2	(1.7)	16.3	(13.6)	0.7	(1.2)
Haloxylon scoparium	0.6	(1.5)	8.2	(16.2)	0	
Retama monosperma	6.4	(6.5)	9.8	(7.5)	0	
Zizyphus lotus	7.9	(7.7)	28.2	(19.9)	1.3	(1.6)
Seeds (subset of forbs)	36.0	(11.0)	14.3	(19.5)	2.4	(1.7)

Table 5. Spearman's correlation coefficients for (a) diets between sexes, (b) diets between seasons, and (c) use and availability at the M'Sabih Talâa reserve, Morocco.

a.	r_s	b.	r_s	c.	r_s
Summer	0.91	Summer-Autumn	0.52	Summer	0.07
Autumn	0.97	Summer-Spring	-0.42	Autumn	-0.09
		Autumn-Spring	-0.17	Spring	0.14

C. arabicus and another Asteraceae constituted 66% of the diets. *Stipa retorta* was the only grass commonly eaten, and *Z. lotus* and *R. monosperma* were the most commonly eaten shrubs.

Individual *t*-test results comparing mean density from fecal analysis with mean relative biomass of those species identified from fecal analysis indicated the direction of selection (Table 3). The critical value $t_{n-1}(.05/2p)$ was 2.9 during summer and fall, and 3.2 during spring. The values for p did not change, but n increased. Values for n were: summer, n = 39+23 = 57; fall, n = 39+20 = 59; and spring, n = 39+10 = 49. During summer, the proportions of grasses (t = 19.21), herbs (t = 12.68), and shrubs (t = 3.73) differed in the diet compared with that available. The direction of selection for forbs and shrubs was positive, while that for grasses was negative. *Cladanthus arabicus* showed the highest positive selection value, and *S. retorta* the most negative. The relative abundance of *Z. lotus* in the feces was nearly 16X higher than its relative availability, but its low biomass masks this difference.

As biomass decreased, selection for shrubs increased. During fall, shrubs were 63% of the diets while comprising only 17% of the available biomass of those species eaten. Only *Z. lotus*, *A. gummifera*, and *A. hamilus* were positively selected; other significant values showed negative selection. The relative proportion of *S. retorta* consumed doubled, while that of forbs declined more than 3X. The relative proportion of *C. arabicus* in the diet was 13% and was the only forb whose relative density exceeded 5%.

During the spring annual plant growing season, *S. retorta* and *Medicago* spp. comprised 49% and 29% of the diets. *Medicago* was selected for, though *S. retorta* was not. Plants in the Brassicaceae family, consisting of *Notoceras bicorne*, *Matthiola parviflora*, and others constituted nearly 10% of the diet. Shrubs were rarely consumed. The high biomass values of *C. arabicus* and *Plantago* spp. were negatively selected.

Seeds, mainly from *C. arabicus* and other Asteraceae species, comprised 36.0% of the diet

during summer. The proportion of seeds in the diet fell to 14.3% and 2.4% during fall and spring.

Unknown flowers, presumed to be from forbs, constituted 5.9% of the diet during summer, and

3.0% and 0.8% during fall and spring. Though the sample size was too small to make statistical

inferences, diets of females and males occupying the same area were similar (Fig. 3).
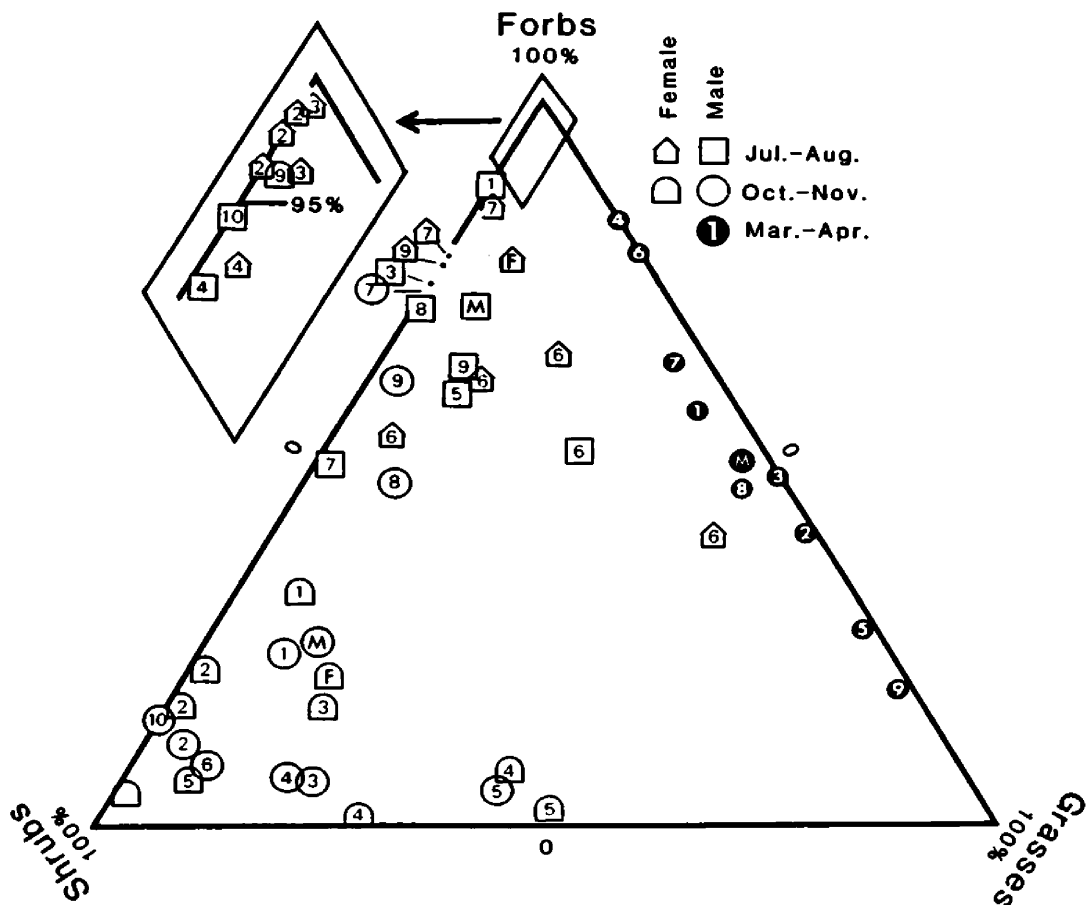
Fig. 3. Seasonal diets of male (M)and female (F) dorcas gazelles on the M'Sabih Talâa reserve, Morocco. Similar numbers indicate animals associating in the same territory. Unnumbered female figure was not associated with any males. Seasonal means for males and females are signified by M and F.

DISCUSSION

This paper presents the first published use of microhistological fecal analysis to estimate dorcas gazelle diets and the first quantiative examination of dorcas gazelle diets in North Africa. Available biomass and diets of adult female and territorial adult male dorcas gazelles changed between summer (July-August), autumn (October-November), and spring (April-May). Dorcas gazelle diets in Palestine changed seasonally and reflected availability of palatable green plant material (Baharav 1980). There was no relationship between diet and availability within a season. The diets of females and males were highly correlated during summer and autumn, which raised 3 possibilities: 1. no significant natural selection for diet differences due to intraspecific competition has occurred (Shank 1982), 2. nutrient requirements for adult females and males are similar, or 3. both sexes attempt to maximize nutrient intake in a poor environment.

During summer, though forbs and shrubs constituted only 26% of available forage, they comprised 93% of the diet (75% forbs, 18% shrubs). Seasonal shifts in dry season diets towards dicots have been demonstrated in mountain gazelle (Baharav 1981), Thomson's gazelle, and Grant's gazelle (Stewart and Stewart 1971, Hoppe et al. 1977, Spinage et al 1980,). Though none of the plant species are the same as those found on the reserve, dorcas gazelle in Palestine (Baharav 1982) and Niger (Grettenberger 1987) also consumed more browse (mainly shrubs) during the dry season. A high proportion of forbs and shrubs in the diets during the dry season might be related to reduced protein and increased fiber in monocots; dicots contain higher dry season levels of protein than grasses (Reed 1983, in Stelfox and Hudson 1986, Stelfox and Hudson 1986). This, however, does not explain decreased utilization of forbs in fall. Consumption of shrubs increased to 63% during autumn. The high proportion of *Zizyphus lotus* utilized (28%) relative to that available (2%) underscores its importance to the dorcas gazelles on the reserve. By late autumn, green leaves of *Z. lotus* provided 1 of the few sources of moisture. Animals were often seen resting in shade afforded by its branches. The only gazelle birth I

observed occurred under a *Z. lotus* . Fawns regularly laid out under the shrub, whose thorny branches may provide protection from avian predators. Baharav (1975, in Baharav 1981) stated that the high productivity of mountain gazelles in the Ramat Yissakhar region of Palestine is a function of the high availability of *Z. lotus*. The percentage of grasses in the diet increased to 50% during spring while that of shrubs dropped to 2%. Dorcas gazelle and mountain gazelle in Palestine (Baharav 1980, 1981), and Thomson's gazelle and Grant's gazelle in East Africa (Hoppe et al. 1977, Spinage et al. 1980, Stewart and Stewart 1971), all showed marked shifts towards grasses when rains caused a flush of new growth.

Other dietary items were observed eaten by the gazelles but were not found in fecal analysis. *Limonium thouini* was taken on 1 occasion. Fruit from *Z. lotus* did not appear in diet analysis, perhaps because the dry, pulpy pericarp is easily digested. The unidentified seeds during summer might have been from *Z. lotus* . When these high-sugar fruits mature during summer, they are voraciously eaten by gazelles. The rumen material of a territorial male that died during summer was dominated by *Z. lotus* fruit.

Benefits and detriments of the microhistological technique have been described by Westoby et al. (1976), Smith and Shandruk (1979), Sanders et al. (1980), Holechek et al. (1982), and Gill et al. (1983). The technique is the only practicable 1 currently available to study shy endangered species. Questions raised against the technique's validity could not be addressed in this study. Spearman's rank order correlation was used because its insensitivity to large changes in percentage, if they do not affect rank, might compensate for some criticisms of microhistological analysis. Only those species that occurred in >5% of the diet were used in calculations because of the insensitivity of Spearman's correlation to changes in rank that result from small changes in proportion. However, the very high and low correlations obtained indicated that differences were either negligible or extremely significant. Individual *t*-tests were used to substantiate Spearman's

correlation for use vs. availability and to determine the direction of selection. The number of individual significant differences needed to state overall significance was not an issue because of the large proportion of individually significant results.

Relative biomass was chosen over relative density as a measure of abundance because the latter is insensitive to differences in plant size. Relative biomass calculated by considering only those forage species identified from fecal analysis during that season was used to obtain a better estimate of selection than relative biomass considering all species. Forage availability is a human concept that is difficult to measure unless availability for a species is defined as a proportion, relative to all species in the area. This definition would have yielded little information because of high proportion of unpalatable biomass. In this study the gazelles defined availability by eating particular species. Those species not eaten during a season were presumed to be structurally or chemically unpalatable. Vegetation management decisions should be based on >1 season's results because seasonal differences in vegetation age or growth form can influence palatability. Scale factors also pose problems for defining availability. Proximity to other food items or other resources can influence availability from the animal's perception. Figure 3 shows close grouping of diets for animals that were associated and suggests that the scale at which availability was measured was too large. Allowing the animal to define the area in which availability were to be measured would provide more accurate results.

Vegetation management for dorcas gazelles in Morocco must stress the establishment of more *Z. lotus* shrubs to provide forage during the dry season and to ensure a food supply in years when rains fail. Because erratic rainfall dictates annual plant productivity, managing for annuals would be difficult. *Cynodon dactylon* is a low-abundance perennial grass that should be increased. It was the only live herb seen eaten during autumn: a single plant was repeatedly grazed by a territorial male. *C. dactylon* provides good forage (Bogdan 1977), and its mat-forming character

inhibits soil erosion. *C.dactylon* is an important forage plant for gazelles in Palestine and East Africa (Baharav 1981, Stewart and Stewart 1971).

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CHAPTER IV

TERRITORY SIZE AND DISTRIBUTION OF DUNG HEAPS OF DORCAS

GAZELLES IN MOROCCO

SUMMARY

The size of territories and distribution of dung heaps were recorded for dorcas gazelles at the M'Sabih Taláa reserve, Morocco. Characteristics used to identify territorial males are described. Data from weekly counts indicate 35 territorial males on the reserve. Fourteen territories from 12 males averaged 30.4 ha. An average of 23 dung heaps were scattered throughout a territory with no noticeable concentration at the territory boundary. Actual territory size and the number of dung heaps/territory were greater than reported due to technique limitations. Territory size may limit the number of breeding males, which reduces the effective population size. Factors affecting the size of territories in dorcas gazelle have not been determined.

INTRODUCTION

Territorial aspects of gazelles have been reviewed by Walther et al. (1983). Studies of marking behavior and territory structure in Grant's gazelle (*Gazella granti*), mountain gazelle (*Gazella gazella*), and Thomson's gazelle (*Gazella thomsoni*) indicate that creation or maintenance of dung heaps by linked urination-defecation occurs in territory holders of all species studied, though the distribution and number of dung heaps varies (Estes 1967; Grau 1974; Walther 1972, 1978; Walther et al. 1983). Likewise, territory size varies among species depending on the location and timing of territory establishment (Walther et al. 1983).

Other than Walther's (in Walther et al. 1983) and Alados' (1984) investigations of the marking behavior of dorcas gazelle (*Gazella dorcas*) and Essghaier's and Johnson's (1981) documentation of the use of dung heaps, no literature is available on the territorial aspects of dorcas gazelles. The purposes of this paper are to describe the location of dung heaps and the size and juxtaposition of territories of dorcas gazelles on a reserve in Morocco, and to comment on a management consideration concerning territory size.

AREA DESCRIPTION

Dorcas gazelles historically roamed the entire plains area of Morocco north and west of the Atlas Mountain chains, but have been reduced to 1 population of about 220 animals on and surrounding the M'Sabih Talâa gazelle reserve, 55 km northwest of Marrakech, near Sidi Chiker (Loggers, Thévenot and Aulagnier, in press). The reserve is an open grassland, dominated by *Stipa retorta* and dotted by the shrubs *Atriplex hamilus, Retama monosperma,* and *Zizyphus lotus.* Annual rainfall (November-April) averages 150-200 mm (Eaux et Forêts 1976, Bougrine 1982). Summer temperatures often exceed 40°C; those in winter can drop to near 0°C. Water is available during the rainy season from 2 *oueds,* and during the dry season from 7 sets of troughs scattered along the roads. Elevation slopes downward from 365 m above sea level in the northwestern corner to 300 m in the southeast section. *De jure* human use of the reserve was

prohibited in 1952, and the reserve was fenced by 1956. Illegal grazing and wood gathering occurs. Land surrounding the reserve is cropped or grazed.

METHODS

Animals could not be physically marked. Thus, 13 territorial males were recognized by morphological and behavioral characteristics. Not all characteristics varied sufficiently to identify an individual animal. The most useful characteristic was site fidelity. Adult males nearly permanently occupied their territories, often restricting movement to small areas. Animals were observed over long periods and their movements marked on small-scale aerial photos. Horn size and shape varied. The rings on the front of the horn were worn in several animals. Horn tips were hooked more severely in some individuals. Horn height at the rearward bend and overall horn length differed. Two animals walked with slight limps. Ear scars and/or notches were noticeable in some animals. Facial patterns, especially the amount of white hair surrounding the horns and eyes, were used to distinguish animals at close range.

Territory size data were gathered between November, 1985, and May, 1986, and again from December, 1986, to February, 1987. Incidental records were maintained June-November, 1986. Each male was located and observed at least weekly. Observations were generally made in the morning and evening, when activity was highest. Location of territory boundaries was determined by observing use of dung heaps, movements unaffected by human or feral dog activity, and encounters with conspecifics. Territory sizes were calculated using the concave polygon method. Locations of activity centers for other territorial males were based on animal locations from weekly counts from December, 1986, to February, 1987. Dung heaps were located by traversing the territories during October and November, 1986, when vegetation height was minimal. Locations were marked on small-scale aerial photographs.

RESULTS

Only adult males held territories. Except for 2 that died during the study, the 13 territorial males that occupied territories at the study's beginning held them until the end. One male was killed by dogs after an illness in August, 1986, and another was poached in January, 1987. An old male, "1-Horn," that occupied a territory near my house decreased his territory size due to agonistic encounters with his neighbor, though 1-Horn occasionally returned to lost portions of his territory. The territory of 1-Horn was assumed non-typical and was not included in size calculations. Territories averaged 30.4 ha (range 18.1-55.3 ha, N = 14, Figs. 1 and 2). Of 2 territories for which data were obtained both years, 1 increased 8%, and the other increased 12%. Because of regular illegal grazing during January, 1987, in area 1, I abandoned attempts to obtain data from that area during the second season. The males observed occupied their territories the entire year. Two territorial males on which incidental records were kept left their territories from August to October. Data from the weekly counts indicated 35 territorial males on the reserve (Fig. 3).

Dung heaps were scattered throughout the territories, with no noticeable concentration near the borders. An average of 23 heaps (range 11-33, N = 8) lay within the boundaries of observed territories. No dung heaps were found outside the reserve within 200 m of the fence. Males were not observed using all dung heaps within their territories. Large heaps associated with prominent topographic features or those located near resting areas received the highest use, >1X/day during peak marking periods. Diameters of dung heap sizes ranged from approximately 0.3 m to >1 m. No systematic records were kept on changes in marking frequency. The gazelles on the reserve did not mark with their preorbital glands. Handled animals had a thick, dark exudate from the preorbital gland, but the gland opening was small.

Fig 1. Territories and dung heap distribution for November, 1985-May 1986 (left) and December, 1986-February, 1987. The sizes of territories for which sufficient observations exist are given in hectares.

Legend:
- ———— Territory boundary
- ·············· 'Temporary' territory
- ▬▬▬▬ Reserve boundary
- — — — — Dirt road

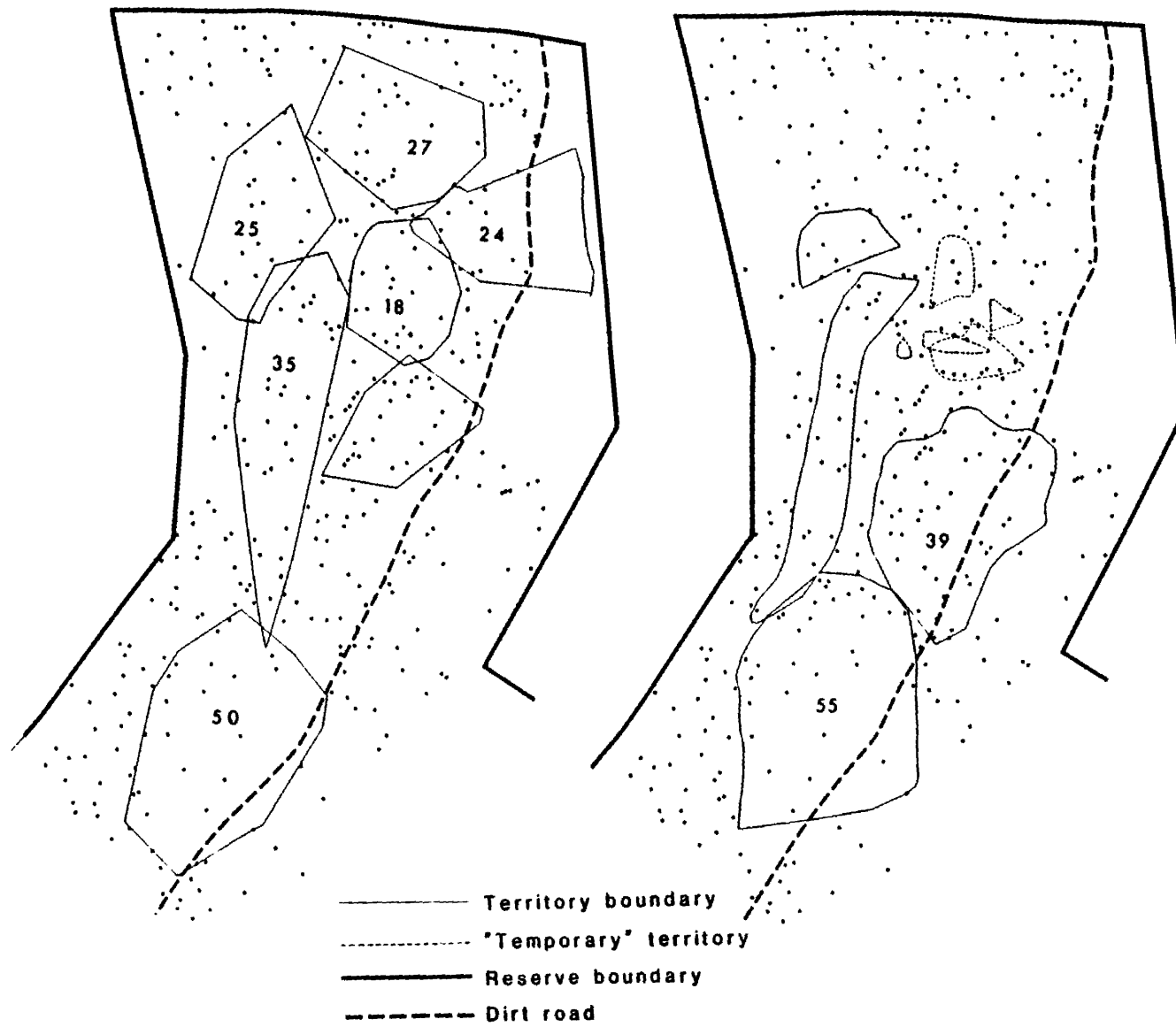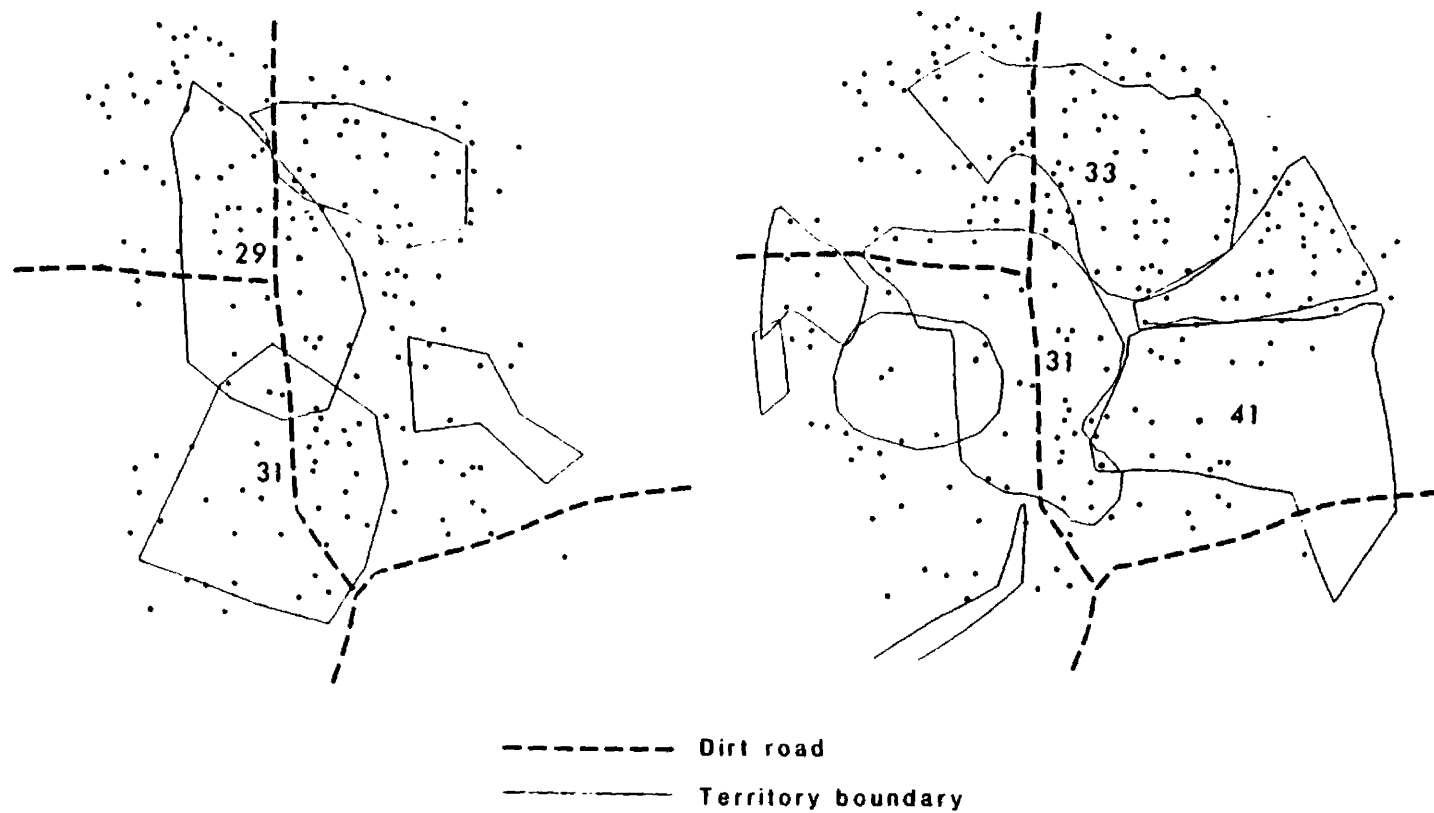Fig 2. Territories and dung heap distribution for November, 1985-May 1986 (left) and December, 1986-February, 1987. The dashed line is a dirt trail; the sizes of territories for which sufficient observations exist are given in hectares.
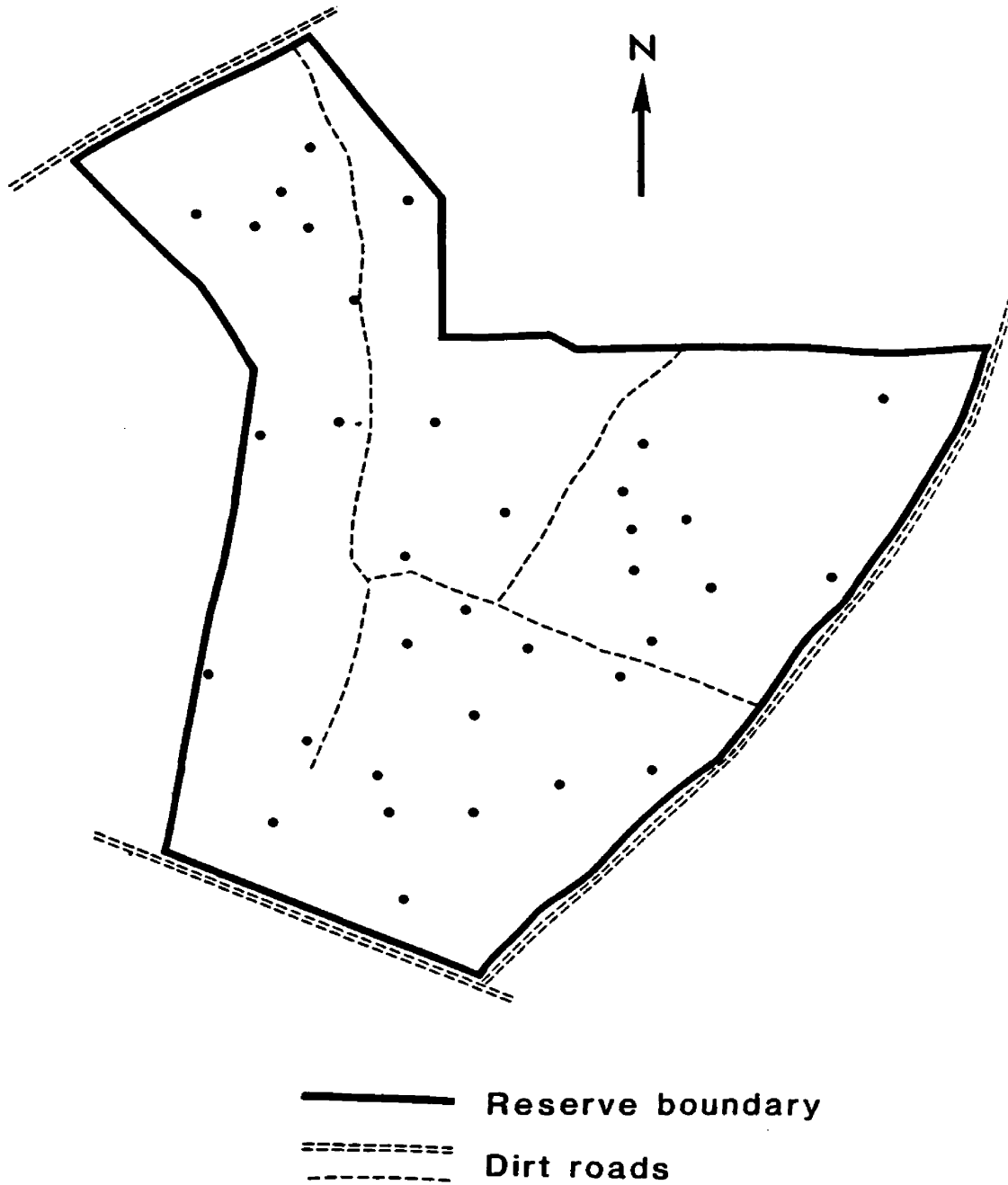
Fig. 3. "Activity centers" of territorial males on the M'Sabih Talâa (Sidi Chiker) reserve, Morocco.

DISCUSSION

All males assumed characteristic postures for urinating and defecating similar among all Antilopinae (Walther 1984) and pronghorn (*Antilocapra americana*, Kitchen and Bromley [1974]). However, the linking of these behaviors was rarely seen in non-territorial males. In pronghorn, the sequence of scrape-paw-urinate-defecate is nearly restricted to territorial adult males (ibid.). Use of dung heaps on the Reserve was almost but not exclusively restricted to the occupying territorial male. "1-Horn" (and the usurper) was seen using his old dung heaps that were in the *de facto* territory of the usurper. Dung from fawns was found in dung heaps on 3 occasions. A donkey defecated in several dung heaps that were located near the house. Three non-territorial adult males were seen serially performing linked urination-defecation in a dung heap of the territorial male that had been poached the previous month. Several of the dung heaps of the other male that died were also used.

Dung heaps are not used to mark territory boundaries. Their wide distribution within a territory suggests that they function to spatially orient the occupying male (Walther 1978). Kitchen and Bromley (1974) noted that pronghorn constructed and maintained scrapes in the territory interior that were marked with feces. Repeated encounters between agonistic, neighboring territorial males generally occurred along the same segment of boundary. Along this segment, these animals restricted their marking to the same 1 or 2 respective dung heaps before or after an encounter, which did not allow a series of dung heaps to build up along the border as in Thomson's gazelle (Walther 1978).

Territory size was larger than that of antelope whose territorial periods are relatively short, but were much smaller than the 100-220 ha reported for the slightly more heavy mountain gazelle, the only other antelope that expresses nearly continuous territoriality and whose territory size has been investigated (Walther et al. 1983). True territory sizes and the number of dung heaps/territory are greater than those recorded because values are based on observation. The

northern boundary of area 1 abuts a road, and was not frequented during daytime. All territorial males in that area were known, and their territories were outlined or labeled. Those dung heaps outside the observed territory boundaries belong to the territorial males indicated. Thus, the average number of dung heaps/territory was nearer 35. Frequent illegal grazing occurs on the east side of the north section of the reserve, which might be why dung heaps are rare in that area. Of the 2 males for which territorial data were obtained for 2 years, both added area from "1-Horn's" territory.

Territorial males did not leave their territories to feed during daytime. No data were collected during the night, though animals were active (Walther 1973), and it is unknown if males left then. If males do not leave at night, their territories must be large enough to sustain them the entire year. The timing of territorial abandonment in the 2 males coincided with the period of lowest vegetation and water availability (Loggers in prep.), and it seems likely that the animals abandoned their territories due to poor resources. The territory of the male that died in August, 1986, was occupied by several adult males between September and December. They maintained the dung heaps and behaved as territorial males, but each abandoned the territory within a few weeks. Poor resource conditions during this period might have discouraged territorial establishment.

Territory boundaries often followed topographic or structural features. Males usurping a territory would probably inherit a relatively fixed territory size because the new male's neighbors would be well-established territory owners. All available space seemed occupied by the territorial males, which precluded the establishment of territories in new areas. Thus, the population of territorial males on the reserve might be relatively static.

Territory size has important management considerations for free-ranging dorcas gazelles in small reserves. The contribution of males to the effective population size (Frankel and Soulé 1981) of

the reserve is much less than the size of the adult male population because mating is virtually

restricted to territorial males. To increase the effective population size of males on the same

amount of land, the territory size must decrease. If territory sizes were based on resource

availability, they might be decreased by vegetation and/or water manipulation. If territories were

delimited by topographic or structural features, management to increase the number of territorial

males would be more difficult.

ACKNOWLEDGEMENTS

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CHAPTER V

**POPULATION CHARACTERISTICS AND INDIVIDUAL IDENTIFICATION   OF
DORCAS GAZELLES IN MOROCCO.**

ABSTRACT

Morphological and behavioral characteristics used to identify sex, age classes, and unmarked

individuals of a dorcas gazelle (*Gazella dorcas*) population in Morocco are described. Total count

and extended observation data were used to estimate the size and structure of the population.

The population fluctuated slightly by season. Densities were at least 7 animals >12 months

old/km^2 and 9.6 gazelles of all ages/km^2. Herd composition was about 60% adults, 13%

subadults, 25% animals <12 months old, and 2% unidentified. Fawning occurred mainly during

October and March. Predators of adult gazelles were feral dogs and humans. Average age at

death of adult animals whose skulls were found on the Reserve, determined by cementum layers

in teeth, was 67 months for females and 53 for males. Longevity was 108 months for females and

males. Limits to using count data to estimate fawn/adult female ratios are discussed.

INTRODUCTION

Dorcas gazelles (*Gazella dorcas*) once roamed all plains areas of Morocco (Loggers et al. in prep.). However, overharvesting and habitat destruction reduced numbers in Morocco's interior to 1 population on and around the M'Sabih Talâa (Sidi Chiker) gazelle reserve. Scant literature is available on densities, composition of, or factors affecting a dorcas gazelle population (Valverde 1957, Mendelssohn 1974, Baharav 1980 and 1982, Essghaier 1980, Yom-Tov and Ilani 1987). The dorcas gazelles on the Reserve were studied from June, 1985 to March, 1987. This paper describes (a) field methods used to distinguish individuals, age classes, and sex in dorcas gazelle, (b) the size and the age and sex structure of the population, and (c) natality, longevity, and causes of mortality of the M'Sabih Talâa gazelles.

STUDY AREA

The Reserve is located in the Haouz plains 55 km northwest of Marrakech (Fig. 1), 320 m above sea level. The Reserve consists of small gullies that cut through gently rolling hills covered by the grass *Stipa retorta* and dotted by shrubs (Loggers in prep.). Gullies merge into 2 *oueds* whose 10 m-wide beds lie about 2.5 kms apart. *Oueds* only contain water during winter. Summer temperatures exceed 40°C; those in winter drop to near 0°C. The Reserve was established in 1952 and by 1956 had been surrounded by barbed wire fence, through which the gazelles passed.

AGE CLASSES

Age classes were based on horn development (Walther 1973), though Brooks (1961, in Robinette and Archer 1971) noted that horn growth can be delayed. Ages cannot be accurately assigned to animals >18 months old.

Fawns. Date of parturition was difficult to establish because fawns "lay out" (Walther 1973, 1984). Neonates were darker than older fawns. Horns could not be seen at viewing distances >100 m until fawns were >6 months and could not be used to consistently distinguish sexes

until animals were >12 months. Sex identification was based on urination position, maternal behavior, and perineum shape. Female dorcas gazelles squat to urinate. If they defecate after urinating, they begin while squatting, rise to a standing position, and often walk. Male dorcas gazelles adopt urination and defecation postures characteristic of Antilopinae (Walther 1984). The male stretches his back to urinate, widening the normal distance between front and hind legs. (Females were observed to stretch in this manner, so urination must be observed.) The back legs are brought forward to defecate, and feces are deposited in a heap, with no trailing line of pellets as in females. No males of any age were seen walking while defecating. The location the maternal female licks the fawn to stimulate passage of wastes can indicate a fawn's sex (Walther 1973). Mother's lick a male fawn's penile region and were never observed licking a female fawn in the same area. Both sexes were licked in the anal region. The size and shape of the black perineum against the white rump patch were used to determine sex of young animals. In males the black anus forms a horizontal bar beneath the tail; in females the black area includes the vulva and appears as a wide "T" (Fig. 2).

Juveniles. At 12 months, the juvenile males' horns began to show prominent rings. Horn tips hooked sharply, a characteristic maintained throughout development. Horns of 12 month-old females remained slim and hooked slightly inward. At 18 months, horns of both sexes were about 1 ear-length, though those of the male are much thicker. Because of the difficulty of separating 12-18 month old animals from 18 month old animals at some distances, the juvenile age group was grouped with the subadults for analyses.

Subadults/adults. Subadult females are 18-24 months old. At 24 months, subadult females sport horns that are difficult to distinguish in the field from those of some adult females, though their bodies remain slightly smaller. Females of 18 months were courted, and some gave birth at 24 months. Two subadult females whose mothers were known remained in their maternal
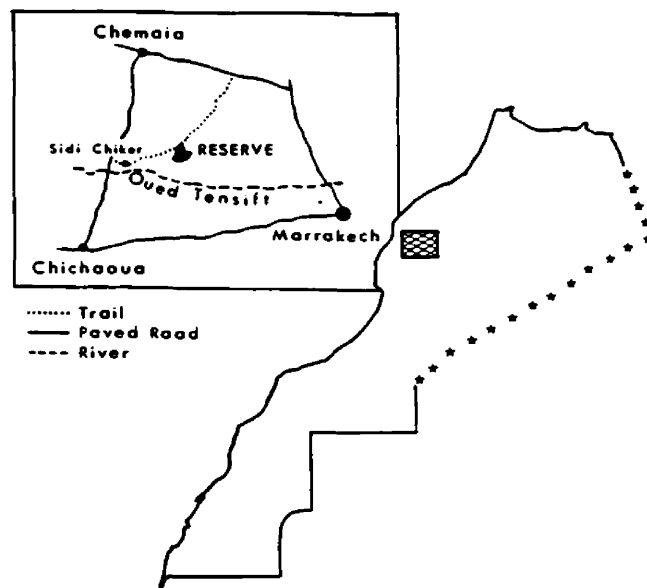
Fig. 1. Location of M'Sabih Talâa (Sidi Chiker) reserve, Morocco.

Fig. 2. Female (left) and male perineum patterns used to determine sex.

group. The male subadult category extended from 18 months until the horns attained the lyrate shape of the adult at 30-36 months of age. After 18 months, subadult males appeared to be forced from the maternal group by the territorial male. Horn shape and perineum pattern differentiates males from females and may stimulate antagonistic behavior from the territorial male. Territorial males of mountain gazelle (*G. gazella*) and Grant's gazelle (*G. granti*) chased adolescent males that accompanied female groups, and may have precipitated departure of the adolescent males (Walther 1972, Grau 1974). For analysis,I grouped the juvenile males of 12-18 months with the subadults.

FIELD IDENTIFICATION OF INDIVIDUALS

Individuals were identified by morphological or behavioral traits. A 15-60X telescope facilitated recognition. Territorial adult males were most easily recognized by their constant residence in a limited area (Loggers in prep.). Gait when walking, horn size and shape, and large scars were the only characteristics useful to identify animals of both sexes at long distances. Females' horns were less robust than males', and non-symmetry was common.

Finer differences were used at closer ranges. Fronts of horns were worn in several males. The amount of white around the eyes and horns and unique notches and scars on and around the ears varied between individuals. Dorcas gazelle do not have the very dark nose spot Walther (1973) used to identify individual Thomson's gazelles (*G. thomsoni*). Differences in facial stripes could not be distinguished at the distances the animals were observed. Non-adults and many adult females could not be consistently recognized. Juvenile females and fawns were identified based on their association with adult females, presumably their mothers.

AGING BY TOOTH CEMENTUM LAYERS

Teeth from skulls found on the Reserve were removed and sectioned. One light/dark tooth ring was assumed to mark the annual wet/dry cycle (Erickson and Seliger 1969). Robinette and

Archer's (1971) data on tooth replacement in Thomson's gazelle indicated that molars erupted at 2-10 months of age and deciduous incisors and premolars were mostly shed at 12-15 months. For age calculations, I added 6 months to the age determined by the number of rings on each sectioned molar and 12 months for each incisor and premolar. Average age for those adult males whose skulls were found was 53 months (n = 12) and for adult females 67 months (n = 5). Oldest specimens were 108 months for both sexes. These data should not be used as estimates of average age at death for adult gazelles, for they do not estimate the ages of animals that die off the Reserve or are removed from the Reserve.

POPULATION DATA

Population size and structure

A count of all animals was attempted each month, but disturbances prevented complete counts during all but the September, 1986 and January/February, 1987 attempts (Table 1). The Reserve was sectioned, and 1 or more sections counted/day to allow disturbed animals time to settle. Additional information was gathered from extended observations of known animals (Loggers in prep.). Openness of and personal familiarity with the terrain allowed high count accuracy. Densities for animals >12 months old were at least $6.9/km^2$ in September and $7.9/km^2$ in January/February. Densities including animals <12 months old were at least $9.6/km^2$ and $10.4/km^2$ for September and January/February.

Sex ratios for animals >12 months old decreased from 1.25 females/male during September to 0.8 females/male during January/February. Observation data reflect a similar trend, from 1.1 females/male (sd = 0.4) in the dry months of June-September to 0.8 males/female (sd = 0.6) from November to February. Adult males might immigrate from nearby forest reserves. Forest guards reported that gazelles left those areas when domestic livestock grazing began in late autumn, and returned after grazing was prohibited in May. This may account for the appearance

of a large bachelor herd in autumn. Likewise, territorial males that had abandoned their territories during summer returned to them in late autumn.

Table 1. Dorcas gazelle population size on the M'Sabih Talâa reserve, Morocco.

Date	Animals < 12 months*	Subadult females	Subadult males	Adult females	All adult males	Territorial males	Other adult males	Animals not identified**	Minimum estimated
09/1986	52	15	11-12	57	(43-46)	25-32	14-18	10	190
01-02/1987	51	9	10	59	(70)	35-37	33-35	8	207

* Calculated number using average animal <12 months old/adult female ratios of 0.9 in September and 0.87 in January/February.
** Contains adult and subadult females, and males about 18 months old. All sported horns.

Table 2. Dorcas gazelle age class proportions for count and daily observation data on the M'Sabih Talâa reserve, Morocco.

Date	Animals <12 months old	Sub-adults	Adults	Unidentified Animals
NOV-JAN 1985/86	0.20	0.20	0.58	0.02
MAY-SEP 1986	0.23	0.18	0.59	0
SEP 1986 CENSUS	0.26	0.12	0.57	0.05
DEC-JAN 1986-87	0.28	0.09	0.62	0.01
JAN/FEB 1987 CENSUS	0.26	0.08	0.62	0.04

A person on a motorcycle shortened flight distance over a person on foot, though an enclosed vehicle was least disturbing. Slow driving is essential, for animals fled from vehicles driven faster than 35 km/hour. Any animal within 50 m crossed in front of the vehicle; females with fawns crossed with the fawn, then re-crossed and headed in the opposite direction.

Ratios of population structure varied little by season or year, and count data reflected observation data (Table 2). The subadult class contained a low proportion of the population

considering the age range it contained was >2X that of animals <12 months old. Whether animals disperse or suffer high mortality prior to or during this period is not known.

Social groups

Females live in groups normally associated with but not restricted to the territory of 1 male. These female groups ("nursery groups", Estes 1967) consist of adult females and their fawns, subadult females, and juveniles of both sexes. When the territorial male was present, female groups averaged 1.4 animals <12 months old (sd = 1.7), 2.1 adult females (sd = 1.6), and 0.4 subadult females (sd = 0.7) for 2.5 females of reproductive age. The largest number of females that associated with a territorial male for >1 month was 8. Females were often seen singly. Males live either as single territorial males or as bachelors. The activity centers of 35 territorial males were identified on the Reserve (Loggers in prep.). Bachelors of all ages were found singly or in small herds of up to 10 males.

Mixed groups consisted of animals >18 months old of both sexes. Mixed groups of females and a territorial male were relatively stable, but those consisting of females and bachelor singles or groups were temporary. Temporary associations formed when bachelors encountered a female group that was not attended by a territorial male. Bachelors attempted to court females in the group, though none successfully mounted. Temporary, mixed-sex herds of up to 40 animals formed in response to disturbance by humans or dogs. The guards used this behavior as an indication of illegal activities on the Reserve. Mountain gazelle also form large groups during disturbances (Grau 1974).

Natality

Single fawns were born mainly during October and March, though neonates were seen in late summer. Births occurred in all months in the dorcas gazelle herd at the National Zoo in Temara (B. Haddane, pers. comm.). Dorcas gazelles do not produce twins (Furley 1986). Ratios of

fawns/adult female obtained by counts rose in months following parturition peaks. Fawns "lay out" (Walther 1984) rather than accompany their mothers, behavior similar to pronghorn fawns (Bromley 1967). Data collected shortly after parturition can underestimate ratios; count accuracy would increase in the few months post parturition. Baharav (1983) attributed reproduction to the availability of free water and suggested that gazelles that depend on water available in plant tissues will reproduce yearly. The count ratio of 0.91 animals <12 months old/adult female in September corresponded with that obtained from observation data (0.92), though the January/February count data, 3 months post-parturition, was slightly lower (0.83) than that obtained from observation data (0.90). A small sample size precluded estimating sex ratios of fawns.

Mortality

The Reserve's adult gazelles have no non-human-related predators. Dogs from nearby villages entered the Reserve regularly and caused 3 of 9 known gazelle deaths during the study period. Another adult male was killed by dogs after an illness. Several homemade leghold traps were found, and 2 deaths were trap-caused. A territorial male killed by dogs had a trap injury which undoubtedly contributed to its death. Leghold traps set in runways and dung heaps could rapidly reduce the population. Exodus from the maternal group is stressful for males. The deaths of 2 18-month-old males may have been stress-related (C. Furley, pers. comm.). One fawn was killed by a golden eagle (*Aquila chrysaetos*). The fawn and its mother exited an area of heavy cover in early morning, and the fawn lay out under a *Zizyphus lotus* shrub. The eagle arrived about 9 AM and perched on a Eucalyptus snag about 6 m above the ground. The mother remained between the eagle and the fawn, with her body oriented toward the eagle. When the eagle made its first pass at the fawn, the mother rushed towards the eagle, which returned to the snag. The mother repeatedly jumped at the eagle, then returned to her position between the eagle and fawn. he eagle made another attempt at the fawn about 12 AM. The fawn was struck

as it lay under the *Z. lotus*, though the mother chased off the eagle, which returned to the snag. Periodic attempts were made by the eagle until late afternoon. Each attempt was repulsed by the mother, which remained between the fawn and the eagle, before the eagle struck the fawn. At no time did the fawn suckle. About 1 hour before dusk, 2 ravens (Corvus corax) arrived and landed near the fawn's position. The mother drove away the ravens, which landed nearby, then again hopped towards the fawn's position. They remained about 5 m from the *Z. lotus*. Shortly before dusk the eagle again flew toward the fawn. The mother made little attempt at defense. The eagle attempted to carry off the fawn, though I intervened and collected the fawn. The fawn was cold, and the fresh opening showed no hemorrhaging, indicating the fawn had died earlier. I was not allowed to skin the animal, so could not determine if the 12 AM attempt by the eagle had been successful.

Parasites

Fresh feces from 11 animals were collected, stored in formalin, and examined to determine parasite egg load levels. *Trichuris* ova, a common intestinal worm infecting desert ungulates, was not found; 6 animals carried light nematode ova levels, and 1 contained *Stragyle* ova (C. Furley unpubl. data).

DISCUSSION

Population densities were near those reported from other areas. Valverde (1957) encountered densities of <20-710 animals/100km in the Western Sahara, though animals were migratory. If all animals within 300m either side of the transect were visible, Valverde's maximum was about 12/km^2. Densities on the 7.2 km^2 Hai-Bar reserve in Palestine fluctuated from 4.6-7.9 animals >12 months old/km^2 (Baharav 1980).

Tables 3a-c. (a) Total dorcas gazelle numbers from the Hai-Bar reserve, Israel, (b) adjusted total numbers, and (c) adjusted ratios (after Baharav 1980).

a.

Year	Female <12 mo.	Male <12 mo.	Total <12 mo.	Adult females	Subadult males	Adult males	Total gazelles	Fawns/ adult female
1972	4	3	7	21	4	8	40	0.34
1973	8	5	13	29	9	13	64	0.43
1974	9	5	13	29	9	13	64	0.45
1975	4	2	6	34	9	8	57	0.18
1976	10	4	14	31	8	7	60	0.45

b.

Year	Fawns	Subadult females	Adult females	Subadult males	Adult males	Total gazelles	Fawns/ adult female
1972	18	4	17	4	8	51	1.06
1973	20	9	20	9	13	71	1.00
1974	18	10	26	10	12	76	0.69
1975	16	9	25	9	8	67	0.64
1976	20	8	23	8	7	66	0.87

c.

Year	Adults	Sub-adults	Animals <12 months old
1972	0.49	0.16	0.35
1973	0.46	0.25	0.28
1974	0.50	0.26	0.24
1975	0.49	0.27	0.24
1976	0.45	0.24	0.30

Data from complete counts of the Hai-Bar gazelles are the only published data on a dorcas gazelle population's structure. However, the data suffer from the difficulty of counting animals <12 months old. The reserve trapped 17 females and 1 male when the fence was completed in 1969. Baharav's age categories were fawns (animals <12 months) separated by sex, adult females (females >12 months), subadult males (12-23 months), and adult males (>24 months). In 1972, 3 male fawns were observed, yet in 1973, 9 subadult males were counted. For each year's count, more subadult males were tallied than the previous year's number of male fawns. Layout periods for captive dorcas gazelles were 2-6 weeks, during which they suckled in 0.5-5

min bouts 3-5X/day (Walther 1968). Laying out periods for wild dorcas gazelles might be longer because fawn/adult female ratios I obtained from observation data didn't show an expected increase due to a parturition peak until several months after fawning. If the counts were made during fawn laying out periods, and it was not done during a suckling bout, the chance of not counting a fawn would be high.

I recalculated the Hai-Bar data and assumed sexual parity at birth, female fawning at 24 months, and no mortality between the subadult males and the previous year's fawns (Tables 3a-c). Resulting data were assigned to age categories previously defined in this paper, except for the 12-23 month range of the subadult male category. My definition of subadults was based on horn development rather than age and therefore covers a wider age range. Over 5 years, the proportion of adults at Hai-Bar averaged 48%, lower than the Reserve. Adult female/male ratios on Hai-Bar were 1.5-3.3, 2X that of the Reserve, though the Hai-Bar data reflected commonly reported skews toward females for other bovids (Dasmann and Mossman 1964, Spinage 1974, Wilson and Hirst 1977). Mendelssohn (1974) noted that the first animals to be seen in areas of range expansion were single females or females with fawns rather than juvenile males. If this pattern holds for dorcas gazelles at M'Sabih Talâa, it could explain part of the female/male parity: there is little habitat into which animals leaving the reserve can disperse.

The adjusted data increased the fawn/adult female ratio from 0.18-0.45 to 0.64-1.06. However, the adjusted ratio was limited by the assumption of no mortality when the number of fawns was estimated by the number of subadult males 1 year later. The Reserve's animal <12 months old/adult female ratio of near 0.90 suggested high survival of fawns or productivity of >1 fawn/year. If females produced >1 fawn/year, fawn survival would be lower than indicated. Mountain gazelles in Israel produce fawns on average every 9.5 months (Mendelssohn 1974).

Pregnancy lasts about 6 months, and fawns are weaned in 3 months. Gestation in dorcas is 5-5.8 months (Furley 1986); loss of a fawn would shorten the cycle if it affected the doe's estrous.

Poaching with leghold traps and predation by feral dogs caused most of the adult mortality, though the extent to which poaching impacted the population could not be determined. When protected from human exploitation, gazelle populations rapidly increase (Baharav 1980, Yom-Tov and Ilani 1987). The time frame in which the animals were studied did not allow the cause of the small proportion of the population in the subadult category to be investigated. Though the subadult category from the Reserve contained a greater age range than that from Hai-Bar, the proportion of the population at Hai-Bar consisting of subadult animals was 76% higher. Dispersal, human-related mortality, or poor reproduction or survival during times of food stress could affect proportions in subsequent years. Guards reported animal die-offs during years of low or no rainfall, when annual vegetation production was minimal. Subsequent population studies on the Reserve should examine fawn survival, dispersal, and mortality, all of which require marking individuals.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix A. Measurements, in centimeters, of dorcas gazelles skulls found on the M'Sabih Talâa reserve, Morocco.

PARAMETER	FEMALES			MALES		
	n	AVE	SD	n	AVE	SD
Short skull length: *basion-premolare* (+)	5	11.60	0.26	7	13.27	0.50
Median *frontal* length: *akrokranion-nasion* (+)	4	8.91	0.13	10	9.90	0.25
Akrokranion-bregma (+)	5	2.04	0.10	13	2.03	0.09
Frontal length: *bregma-nasion* (+)	4	7.96	0.53	10	8.61	0.30
Upper *neurocranium* length: *akrokranion-supraorbitale* (+)	5	7.95	0.16	11	9.05	0.23
Akrokranion-infraorbitale of one side (+)	5	12.58	0.57	7	13.13	0.32
Greatest length of the *nasals: nasion-rhinion*	0	-	-	2	4.89	-
From the aboral border of one *occipital condyle* to the *infraorbitale* of the same side (+)	5	12.09	0.37	7	13.12	0.31
Length of the cheektooth row (measured along the *alveoli*) (+)	5	5.37	0.14	7	5.75	0.11
Length of the molar row (measured along the *alveoli* on the buccal side) (-)	5	3.38	0.08	7	3.57	0.08
Length of the premolar row (measured along the *alveoli* on the buccal side) (-)	5	1.90	0.19	7	2.16	0.07
Greatest inner length of the *orbit: ectorbitale-entorbitale* (+)	5	3.55	0.12	8	3.60	0.08
Greatest inner height of the *orbit* (measured in same way as 24) (+)	5	3.37	0.10	8	3.46	0.09
Greatest *mastoid* breadth: *Otion-otion* (+)	4	6.25	0.05	11	6.66	0.26
Greatest breadth of the *occipital condoyles* (+)	5	3.78	0.06	12	4.06	0.13
Greatest breadth at the bases of the *paraoccipital processes* (+)	3	5.70	0.17	12	5.89	0.20
Greatest breadth of the *foramen magnum* (+)	5	1.86	0.08	12	1.76	0.12
Height of the *foramen magnum: Basion-opisthion* (-)	5	1.67	0.12	12	1.55	0.05
Least breadth of the *parietal* =least breadth between the *temporal lines* (+)	5	2.85	0.24	11	2.91	0.32
Greatest breadth between the lateral borders of the horncore bases (+)	5	5.26	0.09	9	6.14	0.39
Greatest *neurocranium* breadth=greatest breadth of the braincase: *Euryon-euryon* (-)	5	5.65	0.09	11	5.78	0.21
Greatest breadth across the *orbits* =greatest *frontal* breadth=greatest breadth of skull: *Ectorbitale-ectorbitale* (+)	3	7.76	0.10	8	8.18	0.23
Least breadth between the *orbits: entorbitrale-entorbitale* (-)	4	4.68	0.16	7	5.20	0.19
Facial breadth: breadth across the *facial tuberosities* (+)	4	5.29	0.15	7	5.23	0.09
Greatest breadth across the *nasals* (+)	0	-	-	2	2.25	-
Greatest breadth across the *premaxillae* (+)	0	-	-	1	1.21	-
Greatest *palatal* breadth: measured across the outer borders of the *alveoli* (-)	4	4.66	0.05	7	4.77	0.11
Greatest (oro-aboral) diameter of the horncore (+)	4	1.52	0.07	7	3.10	0.14
Least (latero-medial) diameter of the horncore base (+)	4	1.35	0.09	7	2.40	0.10
Length of the horncore on the front margin (tape measure)	3	8.70	0.87	3	19.83	0.70
Length of the horn on the front margin (tape measure) (these were taken from the right horn on the dorcas measurements)	3	13.97	0.45	11	28.17	1.68

Appendix B. Bootstrap computer program to resample vegetation data.

This program is designed to run with True BASIC®. To change the program into normal BASIC language, a few modifications must be made. The program begins underneath the solid line. Comments are to the right of the ** symbols. These comments cannot be included when the program is written. Numbers must be substituted in for the bold variables. Explanations of the bold variables follow:

Y = number of species in the data file (note: due to storage problems on computers, I
    recommend bootstrapping only 4-5 species at a time)
X = number of transects or plots for which you have values (note: For a particular run, the length
    of each column of the data file should be the same.)
Z = number of bootstrap repetitions
A = the incoming text file name that contains X rows and Y columns
Bmat = the name of the resulting bootstrap matrix that contains Z rows and Y columns.

```
dim sum(Y), avg(Y), A(X,Y), newmat(X,Y), Bmat(X,Y)

open #1: name "A", organization text, create newold
open #2: name "sum", organization text, create newold
open #3: name "avg", organization text, create newold
open #4: name "Bmat", organization text, create newold

erase #2
erase #3
erase #4

let noreps = Z          ** "noreps" : the number of bootstrap repetitions
let smplsz = X          ** "smplsz" : the number of independent samples (transects to be
drawn)
let nospec = Y          ** "nospec" : the number of species in your data file
let notrans = X         ** "notrans" : the number of independent values in your data
                             file. In this case, it is the number of transects.

mat input #1: newmat(Y,X)
for reps = 1 to noreps
erase #2

    for x = 1 to nospec
    let sum(x) = 0
    next x

for k = 1 to smplsz
        let i = int(1+rnd*notrans)       **Chooses a random number
            for j = 1 to nospec          **matches the random number with
                let sum(j) = sum(j) + newmat(i,j)   **a row of the data file. This row is
            next j                       **placed in a temporary internal file. In essence, this
                                         **randomly samples your data, keeping the
next k                                   **dependent values together

for a = 1 to nospec
        let avg(a)= sum(a)/smplsz        **This finds the average of the values calculated
    next a                               **in the previous subroutine and prints them to
mat print #4: avg;                       **your final permanent file. The process is repeated
                                         **for the number of times you desire to bootstrap.

next reps
end
```

Appendix C. Plants collected at M'Sabih Talàa reserve, Morocco. Voucher specimens were donated to the New York Botanical Garden. s = shrub, f = forb, g = Poaceae, m = monocot other than Poaceae, t = tree.

s *Acacia gummifera*
s *Acacia horrida*
s *Acacia* sp.
f *Aizoon hispanicum*
f *Ajuga iva*
m *Allium paniculatum*
m *Alyssum parviflorum*
f *Ammi majus*
f *Anacylus rosliata (maroccanus)*
f *Anagallis arvensis*
f *Androcymbium gramineum*
g *Andropogon (Hypparhenia) hirta*
m *Andryla integrifolia*
f *Antirrhinum oruntium*
m *Arisarum vulgare*
g *Arundo donax*
m *Asparagus altissimus*
m *Asparagus stipularis*
m *Asphodelus teniufolius*
f *Asteriscus odorus*
f *Astragalus edulis*
f *Astragalus hamosus*
f *Astragalus maroccanus*
f *Astragalus.* sp.
f *Atractylis cancellata*
  (var. eremophilae)
s *Atriplex hamilus*
s *Atriplex semi-baccata*
g *Avena sterilis*
f *Ballota hirsuta*
f *Biscutella didyma*
f *Brachyapium involucratum*
g *Brachypodium distachyum*
f Unknown Brassicaceae
g *Bromus hordeaceus*
g *Bromus rubens*
f *Bryonia dioica*
f *Calendula stellata*
f *Capsella bursa-pastoris*
f *Carduus pteracanthus*
g *Cenchrus ciliaris*
f *Centaurea maroccana*
f *Centaurea pullata*
  Chamaecystis albidus
f *Chenopodium murale*
f *Chrysanthemum coronarium*
f *Chrysanthemum* sp.
f *Cichorium intybus*
f *Cichorium pumilum*
f *Cladanthus arabicus*
f *Convolvulus althaeoides*
f *Convolvulus arvensis*
f *Convolvulus* sp.
f *Convolvulus tricolor*
f *Cuscuta planiflora*
f *Cyanopsis (Volutaria)*
  crupinoides
f *Cyanopsis (Volutaria) muricata*
g *Cymbopogon shoenanthus*

g *Cynodon dactylon*
m *Dactylis glomerata*
f *Delphinium peregrinum*
m *Dipcadi serotinum*
m *Diplotaxis tenuisiliqua*
m *Diplotaxis vergata*
f *Echinops spinosus*
f *Echium horridum*
f *Echium modestum*
f *Echium* sp.
f *Emex pulcher*
f *Emex spinosus*
f *Ephedra altissima*
f *Erodium chium*
f *Erodium praecox*
f *Eruca sativa*
f *Eruca visicaria*
f *Eryngium ilicifolium*
f *Eryngium tricuspidatum*
t *Eucalyptus* spp.
s Unknown Euphorbiacea
f *Fagonia cretica*
f *Filago germanica*
f *Foeniculum vulgare*
s *Frankenia corymbosa*
f *Fumaria agraria*
f *Fumaria densiflora*
s *Haloxylon scoparium*
m *Hannonia hesperidum*
f *Helianthemum virgatum*
f *Hippocrepis multisiliquosa*
g *Hordeum murinum*
m *Iris sisyrinchium*
f *Jasione corymbosa*
g *Lamarkia aurea*
f *Lavandula multifida*
f *Leontodon hispidulus*
f *Leysera leyseroides*
f *Limonium thouini*
f *Linaria bipartita*
f *Linaria sagittata*
g *Lolium rigidum*
f *Lotus arenarius*
f *Lupinus pilosus*
f *Lycium intricatum*
f *Malva hispanica*
f *Malva nicaensis*
f *Malva parviflora*
f *Malva silvestris*
f *Mantisalca salmantica*
f *Mathhiola parviflora*
f *Matricaria pubescens*
f *Medicago hispida*
f *Medicago lasciniata*
f *Medicago truncatula*
g *Melica ciliata*
f *Mercurialis annua*
f *Mesembryanthemum nodiflorum*
m *Narcissus serotinus*

m *Narcissus tazetta*
f *Notoceras bicorne*
t *Olea europea*
f *Onabrychis peduncularis*
f *Ononis laxiflora*
f *Ononis polysperma*
f *Ornithopus* sp.
g *Oryzopsis miliacea*
f *Pallensis spinosa*
f *Papaver* sp.
t *Parkinsonia aculeata*
f *Paronychia argentea*
f *Peganum harmella*
f *Phagnalon saxatile*
g *Phalaris minor*
t *Picus albida*
f *Plantago amplexicaulis*
f *Plantago coronopus*
f *Plantago ovata*
f *Plantago psylium*
f *Plantago psyllium*
g Unknown Poaceae
f *Pulicaria arabica*
f *Ranunculus bullatus*
f *Reichardia tingitana*
f *Reseda lutea*
s *Retama monosperma*
f *Rumex papilio*
f *Rumex vesicarius*
f *Salvia aegyptiaca*
f *Scandix pecten-veneris*
m *Scirpus holoschoenus*
f *Scorpiurus sulcata*
f *Scorzonera undulata*
f *Scrophularia arguta*
t *Scrophularia canina*
f *Sonchus tererrimus*
f *Spergula flaccida*
f *Spergularia purpurea*
g *Stipa retorta*
f *Tetraclinis articulata*
f *Teucrium decipiens*
f *Thapsia garganica*
t *Tillaea muscosa*
f *Tolpis barbata*
f *Torilis nodosa*
f *Trifolium angustifolium*
f *Trifolium glomeratum*
f *Trifolium subterraneum*
f *Trifolium tomentosum*
f *Urospermum picroides*
f *Vella annua*
f *Vicia (villosa)*
f *Vicia benghalensis*
f *Vicia lutea*
s *Vitex agnus-castus*
g *Vulpia geniculata*
s *Withania frutescens*
s *Zizyphus lotus*