

STATUS AND DISTRIBUTION OF Ammotragus lervia:
A WORLDWIDE REVIEW

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ABSTRACT

The so-called Barbary sheep or Aoudad, designated by a number of native and European names, is the only member of its genus. Both males and females are distinctive because of their large horns and long chap hair on the forelegs. Fossil remains have been found at a number of locations in North Africa, and similar forms have been recovered in Europe and North America. Rock paintings in Algeria and Egyptian tomb and temple reliefs all suggest an animal of considerable economic and cultural importance. Ammotragus is probably ancestral to the Eurasian sheep, and might also be an ancestor of the goats. The probable phylogenetic relationship of Ammotragus to the other Caprini strongly supports the view that it should be maintained as a full and separate genus. Six subspecies are recognized. Barbary sheep occupy arid mountains or canyons in areas of rugged terrain throughout their endemic and exotic ranges. In North Africa, the species inhabited all the major mountain massifs of North Africa above about 10°N latitude within historic times, although some populations have been extirpated as a consequence of intensive hunting and poaching. In Europe, Barbary sheep were recently released in Spain; earlier introductions in Germany and Italy were unsuccessful. In the United States, there are at least five major free-ranging populations in Texas, New Mexico, and California, and the species is expanding its range. At least four introductions occurred in Mexico, but apparently all of the wild populations have now been extirpated. Populations in North Africa appear to be threatened, but aoudads compete with native wildlife in the southwestern States.

INTRODUCTION

The Barbary sheep (*Ammotragus lervia*) is the sole member of its monotypic genus within the Tribe Caprini of the Subfamily Caprinae and Family Bovidae. The species is sometimes referred to as the Arui, or more commonly as the Aoudad, particularly in Mauritania. Other native names include Arouy in Algeria (Lataste 1885: 288, Hartert 1913: 36); Kebsh el Gebel and Wadden in Egypt (Osborn and Helmy 1980); Drrui in Morocco (Cabrera 1932); Beddan (males only) or Tedal/Teytal in Nubia (Blyth 1839: 76); Naded, Naddan, or Oudad in Tunisia (Schomber and Kock 1960); and Wodad by some Arabian tribes of North Africa (Khushal Habibi, personal communication, 1984). Old males are sometimes called Fischthal (Michel Anciaux de Faveaux, personal communication, 1984). In Europe, the species is known as the Mouflon à manchettes, Mouton Berbère, Mähnenspringer, Mähnenshaf, Muflone Berbère, and Arrui.

The following combination of gross morphological characteristics is diagnostic for *Ammotragus* (Gray and Simpson 1980): the presence of true horns (on females as well as males), subcaudal gland, ventral neck mane, and chap hair on the front legs of adults (particularly evident on males); and the absence of preorbital, interdigital, or inguinal glands, and an inter-ramal chin beard. Although a mane is found on other caprines, chaps are apparently peculiar to aoudads (Figure 1).

The purpose of this paper is to summarize the status and distribution of Barbary sheep throughout the world.

METHODS

My familiarity with the historic status and distribution of Barbary sheep is a result of two efforts: (1) background information I gathered before conducting field research on Barbary sheep biology in Palo Duro Canyon, Texas (Gray 1980); and (2) additional literature sources that were consulted while preparing the species' account for the Mammalian Species series (Gray and Simpson 1980). Information on current status and distribution was solicited in letters sent to over 70 members of the American Society of Mammalogists residing in countries where wild *Ammotragus* populations were known or thought to exist.

FOSSIL RECORD AND ARCHEOLOGICAL EVIDENCE

In North Africa, Barbary sheep remains (*Ovis paleotragus*) were recovered from Villafranchien deposits near Constantine (Joleaud 1918) and at Mansoura in Algeria; they were common in Mousterian and Upper Paleolithic deposits, but rare in the Neolithic (Pomel 1898). Quaternary sediments also yielded remnants of the species (Thomas 1884), and they have been found in caves in the Akouker and Haizer massifs at Djurdjura (Arambourg 1927). *Ammotragus* fossils, called *A. palaeotragus*, were dated to the Pleistocene according to Trouessart (1904-5). More specifically, Vaufrey (1955) noted this species among the Pleistocene fauna in the Maghreb (Atlas massif), and Arambourg et al. (1934) recorded Barbary sheep at Beni Segoual.

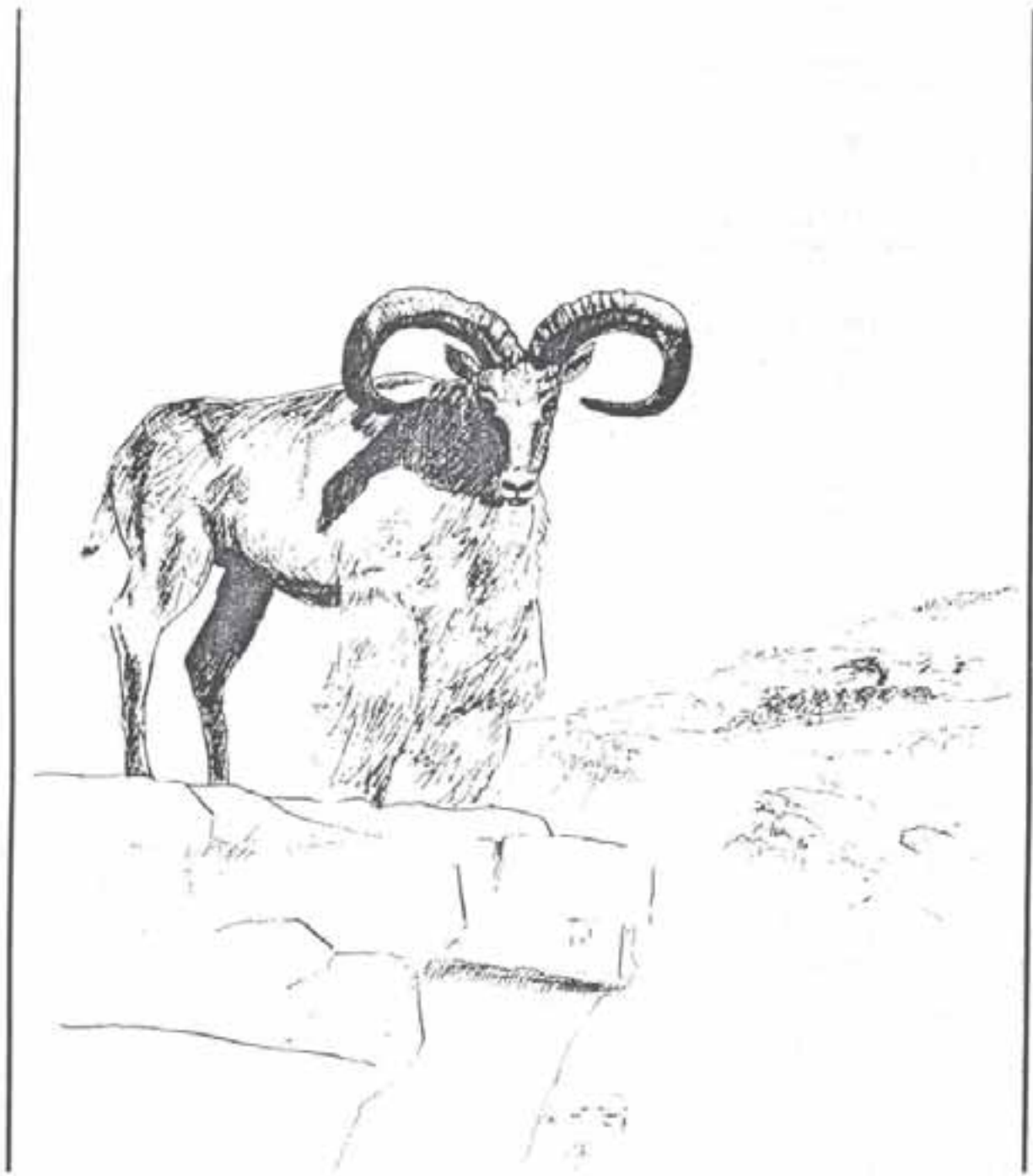


Figure 1. *Ammotragus lervia*, apparently the only caprine with chap hair on the forelegs, occupies arid mountains and canyons within its endemic North African distribution, and in its exotic range in Spain and the southwestern United States. Drawing by J. David Renwald.

McBurney (1967) found Ammotragus remains at Haua Fteah, a large natural cave on the northern coast of Cyrenaican Libya, in a number of deposits that ranged in age from about 85,000 to 2,000 years old. Bate (1955) discussed the vertebrate faunas, including Barbary sheep, from Quaternary deposits in Cyrenaica.

Fossil sheep remains have been recovered from superficial deposits in Europe and were referred to as Ovis tragelaphus fossilis by Seres (1848:149), and O. magna and O. primoeva by Gervais (1852:76). Lydekker (1912:310) commented that these "sheep were akin to the modern arui of North Africa."

Osborn (1910:433) wrote of the Pleistocene in North America and mentioned "a wild sheep (Ovis paleotragus) very similar to the existing Barbary sheep."

B. Brentjes (1980) commented that rock paintings in North Africa and in early Algerian hunting camps indicate that Barbary sheep were more widely distributed in the past than they are now. Thus, he considered their recent distribution to represent a remnant population range.

A Central African subtropical (or tropical) fauna dominates the oldest rock paintings from the North African region. About 2,000 years ago Barbary sheep began to appear with increasing frequency in rock paintings, although Brentjes (1980) remarked that the species was evidently widespread prior to this period.

Barbary sheep are present in hunting scenes on pottery from the Megade culture (late 4th century B.C.) that probably came from the periphery of the Nile Valley (Brentjes 1980). Pictographs of Barbary sheep are less frequent during the transition to the Dynastic Era, and are limited to representations of captive animals. Brentjes further conjectured that human colonization of arable lands might have driven Barbary sheep out of this area, and that they moved both eastward and westward. Meanwhile, the species was used in rituals and sacrifices and had become quite scarce. For this reason, some Barbary sheep may have been maintained in enclosures (Brentjes 1980).

A different view was expressed by Zeuner (1963) who contended that Barbary sheep, unlike other native bovids, were never domesticated. They were hunted by the ancient Egyptians and presented as offerings (Butzer 1959). In any event, Barbary sheep were obviously widespread in ancient North Africa, and their portrayal in Egyptian tomb and temple reliefs suggests an animal of some economic and cultural significance.

PHYLOGENETIC RELATIONSHIPS

Valerius Geist (1971) provided a plausible explanation for the evolutionary relationship of Ammotragus to the other caprines. He arranged the Eurasian mountain sheep in a cline based on external appearance and geographic distributions, and considered Barbary sheep to be ancestral to this Palearctic sheep lineage. This hypothesis was based on the observation that Barbary sheep exhibit more rupricaprine characteristics than any other

caprine. Rupicaprines, of which the chamois (Rupicapra) and Rocky Mountain goat (Oreamnos) are living representatives, are thought to be the progenitors of the Caprinae.

Several studies have been conducted to clarify the phylogenetic relationship of Ammotragus to the other Caprini using techniques from biochemistry, molecular biology, and immunology. Serum protein analyses by Schmitt (1963) and immunoglobulin cross-reactivity studies by Curtain and Fudenburg (1973) indicated a close relationship between Ammotragus and Ovis. The amino acid sequence of various hemoglobin chains examined by Maxwell and Baker (1975) showed that Ammotragus hemoglobin was more nearly similar to that from the domestic goat (Capra hircus) than from the domestic sheep (Ovis aries), but also exhibited some unique characteristics. However, an immunological technique adapted for computer analysis by Hight and Nadler (1976) demonstrated a closer relationship between Ovis and Capra than between either of these and Ammotragus!

Based on chromosome studies, Nadler et al. (1974) suggested the following summary of caprine evolution:

"The cytogenetic evidence suggests there are two main lineages among surviving caprines. Starting from a hypothetical rupicaprine-type ancestor with a primitive $2n = 60$, $FN = 60$ karyotype, one lineage evolved through an intermediate, aoudad-like form to the true sheep, with reductions in diploid number. In the true goat (Capra) lineage, morphological differentiation proceeded while the karyotype remained conservative; in contrast, the thar (Hemitragus) has remained morphologically close to the hypothetical rupicaprine ancestor while its chromosome number has been reduced ($2n = 48$). The 5th member of the tribe Caprini, the bharal (Pseudois nayaur) has a reduced chromosome number ($2n = 54$) but morphologically exhibits convergence toward true sheep."

This supports Geist's (1971) view that: (1) Ammotragus is ancestral to the Eurasian sheep, and more nearly resembles the Armenian urial (Ovis orientalis gemelini) and the Elburs urial (Ovis o. orientalis) than other members of the genus Ovis; and (2) Ammotragus could also be an ancestor of the goats, particularly the round-horned ones, and forms a cline of similarity and geographic distribution through the Caucasian tur (Capra cylindricornis) to the bharal (Pseudois).

TAXONOMIC STATUS

Linnaean binomial nomenclature was first applied to the Barbary sheep by P.S. Pallas, who referred to it as Ant(ilo)pe lervia in 1777. Two synonyms, Ovis tragelaphus (Afzelius 1815:216) and Ovis ornata (Geoffroy Saint-Hilaire 1827:264), were used during the 19th century before the current name combination was applied by Thomas in 1902. The genus name Ammotragus--meaning "sand goat" (Valdez and Bunch 1980)--had first been used by J.E. Gray (1950). A succession of generic or subgeneric reassignments from 1840 to 1902 may have contributed to confusion about the taxonomy of the species. These other name combinations were listed by Gray and Simpson (1980) for the convenience of those interested in the systematics of Barbary sheep.

Ansell (1971), Corbet (1978), and Van Gelder (1977) all included Barbary sheep in the genus *Capra*. Their justification for this assignment was that Barbary sheep will interbreed with goats--sometimes producing live hybrid offspring--and that *Ammotragus* is anatomically closer to *Capra* than to other Caprini. Geist (1971) discounted the ability of Barbary sheep to hybridize with goats as an indicator of a closer phylogenetic or taxonomic relationship. He hypothesized that reproductive barriers between *Ammotragus* and *Ovis* were established during the Pleistocene when they had a sympatric distribution in North Africa. *Ammotragus* and *Capra* were not sympatric and therefore had no cause to develop reproductive barriers.

Based on the evidence I have summarized, Gray and Simpson (1980) maintained *Ammotragus* as a full genus. Nowak and Paradiso (1983:1301) subsequently concurred in this view by listing *Ammotragus* as a separate genus in the most recent edition of Walker's Mammals of the World.

GEOGRAPHIC DISTRIBUTION OF SUBSPECIES

G.M. Allen (1939) recognized six subspecies of *Ammotragus lervia*, and Gray and Simpson (1980) summarized the type locality of each. However, Michel Anciaux de Faveaux (personal communication, 1984) collated detailed geographic distributions of four of these subspecies, and much of the summary that follows is based on his account.

A. l. lervia was described as inhabiting "Africae borealiori propria" by Pallas (1777:12), but the type locality was later restricted to the "Department of Oran, western Algeria" by Harper (1940:327). It is present in the mountains of Morocco and Tunisia, the northern part of Algeria (in the Saharan Atlas Mountains at Bèchar à Gafsa [Le Berre 1983:390]), and in the regions of Air and the Tibesti massif (Lhote 1957:88); but was approaching extinction in Algeria and Tunisia, according to Schomber and Kock (1960:279). This is apparently the subspecies that was imported to European zoological gardens in the late 1800's, and from there to American zoos about 1900 (Ogren 1965:6). Surplus zoo stock was later sold to private individuals and subsequently escaped (or was released) to form the basis of free-ranging populations in the western United States. It has also been introduced in the Sierra de Espuna Mountains of Murcia in Spain (J.R. Vericad, personal communication to M. Anciaux de Faveaux, May 1982).

The type locality of *A. l. ornata* was defined as "pres des portes de la ville du Caire" (= Cairo, Egypt) by I. Geoffroy Saint-Hilaire (1827:264). Its distribution was given by Osborn and Helmy (1980:521) as being the central part of the Eastern Desert in Egypt, as well as central and southwestern parts of the Western Desert. This subspecies was rather rare, and Heinemann (1972:493) indicated it may already be extinct.

The type locality of *A. l. sahariensis* was given as "Oued Mya" (Rothschild 1913:459), which is located between El-Golea and In-Salah, 28°30'N, 3°E, in the Algerian Sahara. This subspecies has a very large geographic distribution that includes parts of southern Morocco, the Sahara of Southern Algeria, southern Tunisia, southeastern Libya, Sudan, Mali (Adrar des Iforas), Niger (Air and Djado), Mauritania, and the Tibesti Mountains. It has been introduced into the "Park for the Preservation of Saharan Fauna" in Almeria, Spain (Cano and Vericad 1983).

The type locality for *A. I. blainei* was listed as the "Border of Dongola Province and Kordofan" in the Anglo-Egyptian Sudan (Rothschild 1913:460). Schomber (1960) called this the Kordofan Barbary sheep and indicated its range was restricted to isolated mountains in the provinces of Darfur, Kordofan, and Nubia. In 1923 this subspecies was introduced into the Sabaloka reserve on the Sixth Cataract of the Nile.

The type locality for *A. I. angusi* was recorded as "Tarrouaji Mt. Asben, 3,100 ft." French West Africa (Rothschild 1921:75); and Heim de Balsac (1934:489) placed it at Adrar des Iforha (18°-20°N and 1° -3°E).

The type locality for *A. I. fassini* is the Garian range of northwestern Libya (Lepri 1930:271). It also occurs in the extreme southern part of Tunisia (Schomber and Kock 1960:280), and has been introduced into the "Park for the Preservation of Saharan Fauna" in Almeria, Spain (Cano and Vericad 1983).

ECOLOGICAL DISTRIBUTION

Perhaps the greatest variation in altitudinal distribution of Barbary sheep was recorded within its endemic North African range in Morocco. There, the species is known to have inhabited desert mountains of the Sahara, ranging from sea level up to the extent of snow-free areas at about 3900 meters (10,694 feet) (Jolead 1928). In this region, Barbary sheep habitat is characterized by rough, rocky slopes covered with loose stones of all sizes, from pebbles to boulders (Rodd 1926). Vegetation is sparse, limited to a thin cover of grasses, scattered shrubs, and a few acacias (Brouin 1950).

Reginald Barrett (1967) distinguished three somewhat different types of Barbary sheep habitat in Africa:

"One is the Atlas Mountain region, straddling the 35°N parallel. Besides being steep and rocky, this habitat is characterized by elevations of up to 13,000 feet (3960 meters), where much of the 10-25 inches (25.4-63.5 centimeters) of precipitation falls as snow. It is not on the lower desert, but up on the mountain slopes that the aoudad lives (Joleaud 1927, Panouse 1957).

"A second habitat is that of the true desert mountains, such as the Tibesti, Ahaggar, and Air massifs, lying between 15° and 25°N latitude. Although these mountains rise as high as 11,000 feet (3351 meters); the climate is dry, averaging one to five inches (2.54 to 12.7 centimeters) annual precipitation.

"The third habitat includes the rugged canyons eroded into the plateaus of much of the Sahara (Brown 1965:44). Many such canons are characterized by steep cliffs which provide good aoudad cover. Areas such as this in north central Libya receive less than five inches (12.7 centimeters) of rainfall a year".

Introduced free-ranging populations in the southwestern United States occupy canyons with gorges to 244 meters (800 feet) in depth at elevations up to 1829 meters (5,015 feet) in Palo Duro Canyon of the Texas Panhandle; mean January and July temperatures are 2.8°C (37.1°F) and 24.3°C (75.5°F), respectively, with an average annual precipitation of 53.6 centimeters (21.1 inches). In the Canadian River gorge of northeastern New Mexico, Barbary sheep habitat is situated in canyons more than 305 meters (1,000 feet) deep at elevations of 1371 to 1828 meters (4,500 to 6,000 feet). This area has mean January and July temperatures of -1.2°C (29.9°F) and 20.7°C (69.3°F), respectively, and a mean annual precipitation of 32 centimeters (12.6 inches). The population in Largo Canyon of northwestern New Mexico lives at an altitude of 1739 to 2040 meters (4,916 to 5,594 feet) (Bird and Upham 1980), whereas most sightings in the Rio Hondo Valley and surrounding vicinity of southeastern New Mexico were between 1219 and 2312 meters (3,342 and 6,340 feet) (Dickinson and Simpson 1980).

Barbary sheep throughout the southwestern United States are found most often in rugged terrain (Ogren 1965, Evans 1967), and habitat utilization is greatest in areas of precipitous topography (Hampy 1978, Simpson and Gray 1983). Typical vegetation at occupied sites in this region includes ponderosa, white, or pinyon pine (*Pinus* spp.) at higher elevations. Juniper (*Juniperus* spp.), mountain mahogany (*Cercocarpus montanus*), and mesquite (*Prosopis glandulosa*) are important components of the shrubby vegetation at lower altitudes. A variety of shortgrass prairie and semiarid grasses and forbs comprise the understory plants in these areas.

The California population on the West Coast of the United States inhabits an area characterized by a Mediterranean climate with wet, cool winters and dry, hot summers. Annual precipitation there is 63.5 to 88.9 centimeters (25 to 35 inches), of which snow may comprise a small fraction (Barrett 1966). Topography in the Santa Lucia Mountains is less rugged than the terrain in most other locations occupied by Barbary sheep, but several fairly distinct herds are each associated with a large rock outcrop surrounded by oak (*Quercus* spp.) woodland (Barrett 1980). The other important plant communities in areas utilized by Barbary sheep are grassland, coastal sage scrub, and introduced pine (*Pinus* spp.) forest (Johnston 1980).

STATUS AND DISTRIBUTION IN NORTH AFRICA

Ammotragus may have shared the epithet "Ophion" with *Ovis ammon* in ancient accounts written by Pliny and others (Cuvier 1827:359). However, "Caio Britannico described a large wild sheep that populated the mountains of North Africa" in 1561 (Scortecchi 1957:492). This is probably the earliest European account we have of Barbary sheep.

Lhote (1957:88) designated the species' range as being all the hills of the Sahara, especially the Hoggar, Tassili, Ayr, and Tibesti mountains. Barrett (1967) summarized the endemic geographic distribution

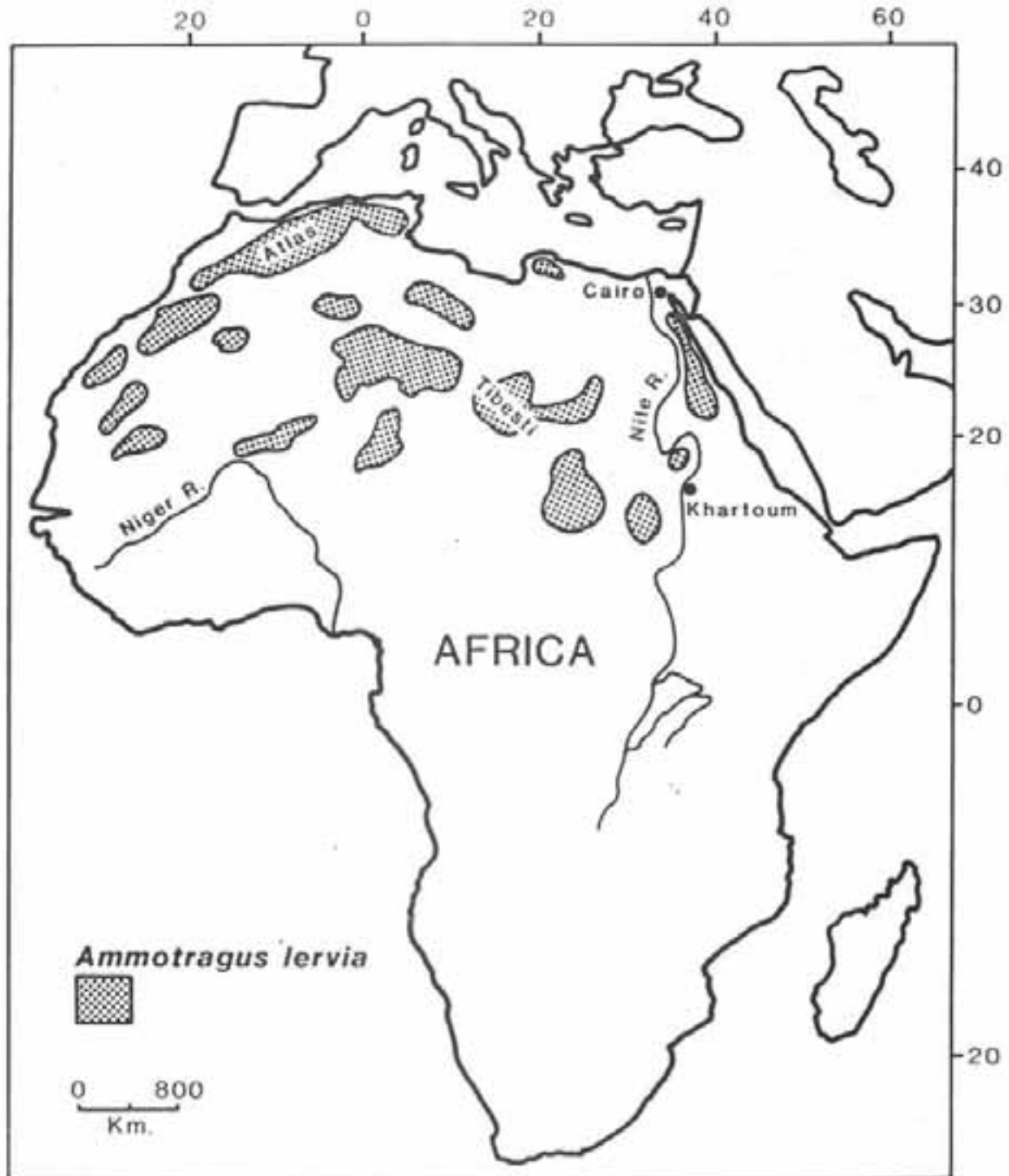


Figure 2. The approximate geographic distribution of *Ammotragus* in North Africa. Adapted from G.B. Schaller, 1977, Mountain Monarchs: wild sheep and goats of the Himalaya, University of Chicago Press, Chicago and London

of Barbary sheep and indicated that the species inhabited all the major mountain massifs of North Africa above 15°N latitude; his sources included Bigourdan and Prunier (1937), Rode (1943), Brouin (1950), Malbrant (1952), and Edmond-Blanc (1957).

Schaller (1977:63) stated: "The aoudad confines itself to Africa north of 10° latitude, being found in many of the ranges and isolated massifs that lie in and around the Sahara--Atlas, Ahaggar, Air, Tibesti, Dar Fur, Adrar des Iforas, and others (see Joleaud 1929)." The approximate distribution of Barbary sheep in North Africa shown in Figure 2 is based on Schaller's (1977:53) range map.

Brentjes (1980) suggested that Barbary sheep may have penetrated into Central Africa at the height of the Pleistocene glacial period. During this time the dunebelts extended southward, and he considered that large parts of North Africa may have been too dry even for Barbary sheep. As a consequence, Brentjes commented that populations in the southern part of the species' range, and those around the Red Sea, should be regarded as remnant populations.

In Algeria, K. De Smet (personal communication, 1984) of the Department of Forestry at the Institut National Agronomique in El Harrach described the status and distribution of Barbary sheep in a recent letter to me. I have paraphrased his account, as follows:

Although the species is fully protected by law, Barbary sheep are subjected to heavy poaching as they occur in areas where law enforcement is very poor. One positive point is that for security reasons (to prevent assassinations), hunting is only allowed by lead pellets: high-powered rifles with telescopic sights are prohibited all over the country. Therefore, hunters have to approach Barbary sheep as closely as 30 meters or so in order to kill them, which is far from easy!

Probably a lot of poaching is done by snares, but the Touaregs are known to kill them by cutting their throats after jumping on them in the early morning or at night in places where they sleep!

The only protected area where the species occurs is the Tassili National Park in the south (Djarnet), but there is a lot of poaching even there because the Libyan border is so close. We intend to introduce them in a 1200-hectare reserve (Mergueb) located 170 kilometers south of Algiers, but law enforcement is still too inadequate to release them at this time. The zoo at Algiers has a little breeding stock and they intend to capture some more animals to avoid inbreeding.

De Smet also enclosed two maps on which he outlined the distribution of Barbary sheep in Algeria. I have consolidated this information into one map shown in Figure 3.

In Egypt, Ralli (1957) said Barbary sheep did not exist in the northern part of the Nile Valley mountains, but were present near the center of that massif close to Assiouh. He further commented that a fair number had been there for 30 years, but that numbers were diminishing. They were said to be easy prey for the Bedouins because they inhabit less rugged terrain--and are less agile--than the ibex, even though they cannot be approached as closely as the ibex.

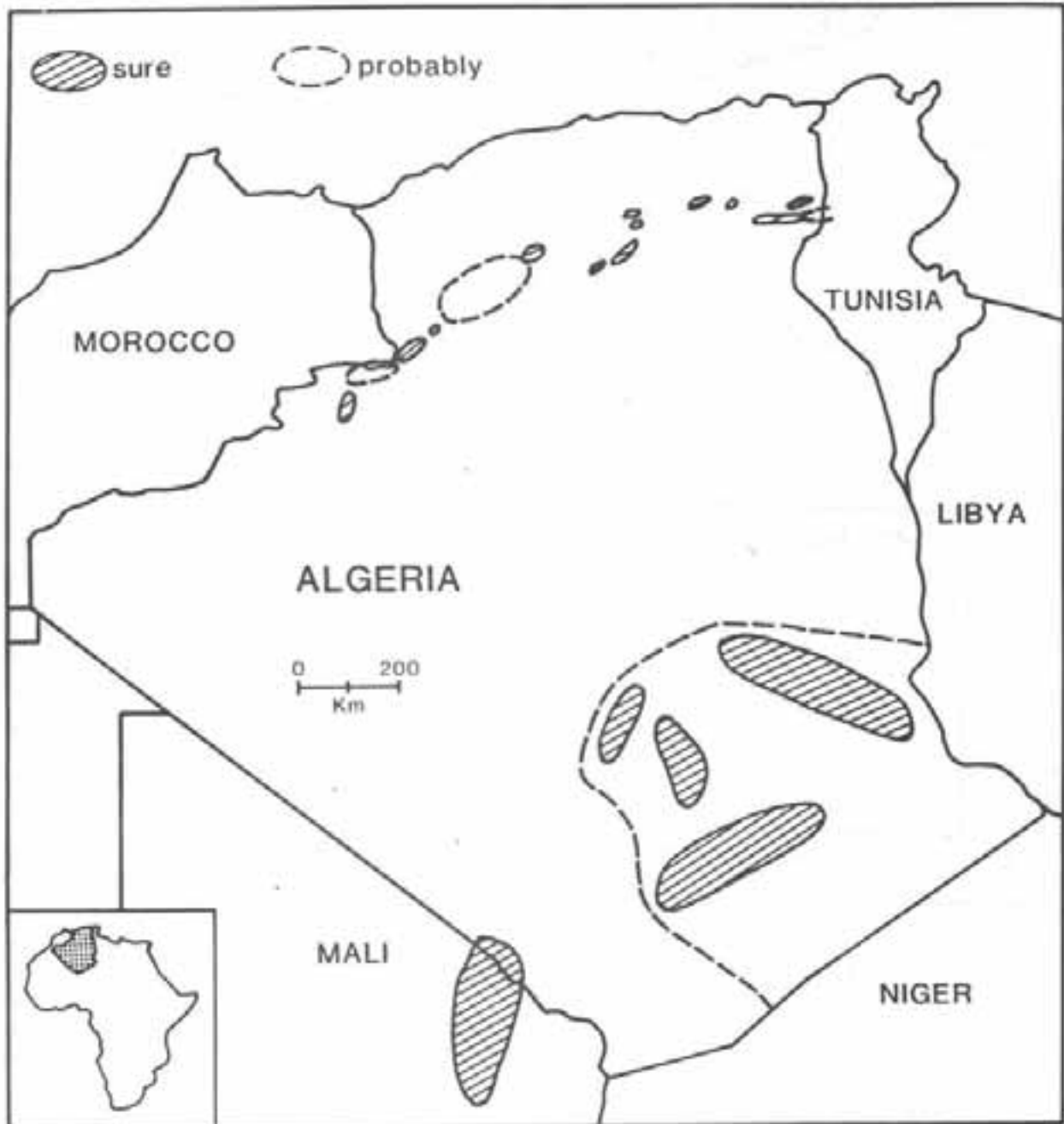


Figure 3. Present distribution of *Ammotragus* in Algeria. Adapted from K. DeSmet (personal communication, 1984), Département de Foresterie, Institut National Agronomique, El Harrach, Algeria.

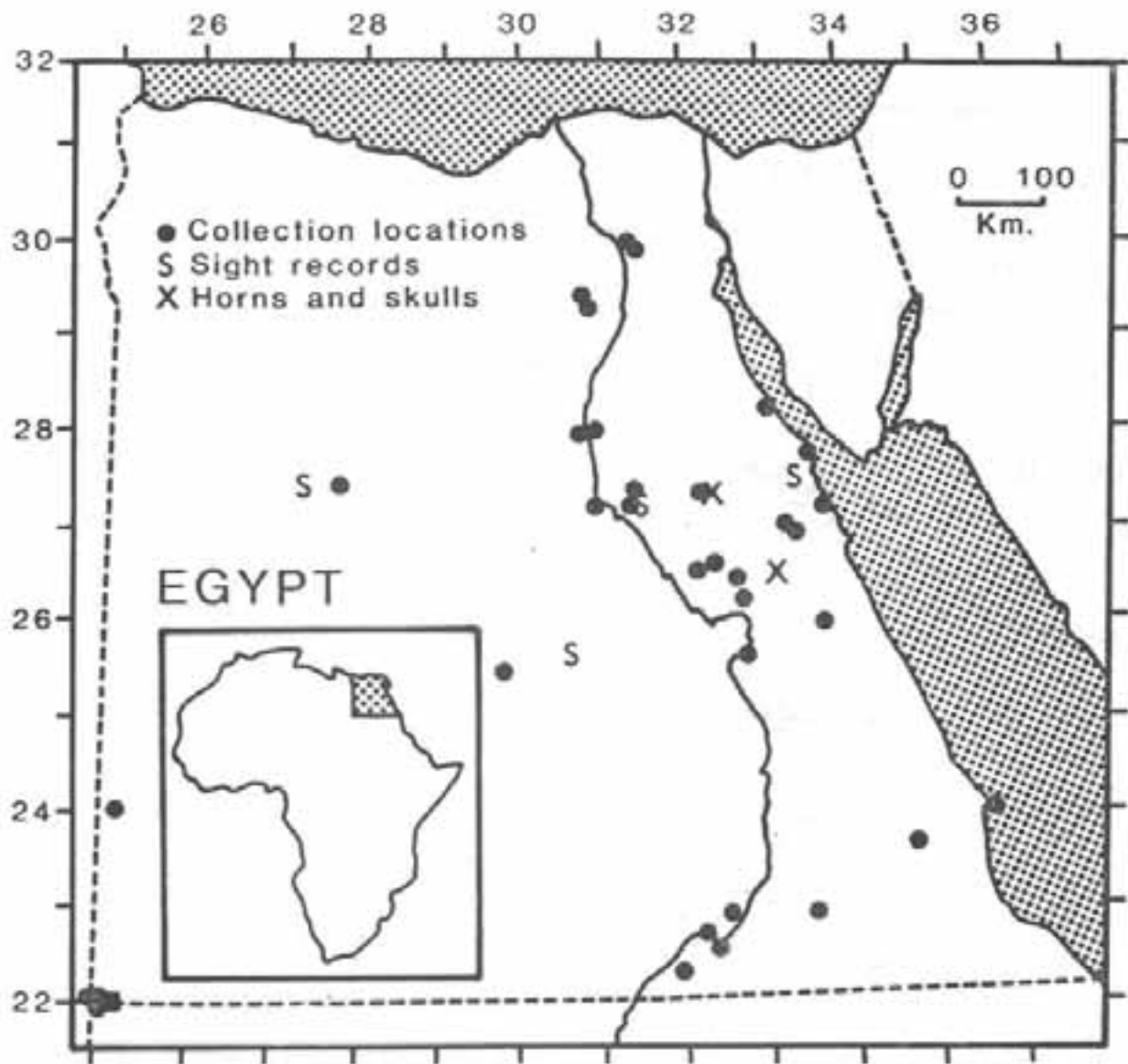


Figure 4. Historic distribution of *Ammotragus* in Egypt, based on collection locations of whole animals, of horns and skulls only, and documented sightings. Adapted from D.J. Osborn and I. Helmy, 1980, The contemporary land mammals of Egypt (including Sinai), *Fieldiana Zool.* No.5 (new series), Publ. 1309

Osborn and Helmy (1980) listed records of kills and observations in Egypt published from 1832 to 1971. Under the heading of "historical notes," Osborn and Helmy indicated that:

"Within historical time, Barbary sheep probably inhabited most of the Eastern Desert and areas of rugged terrain in the Western Desert. In the Eastern Desert, incidentally, a well, a wadi, and a mountain are called Umm Kibash (Mother of wild sheep). The type of *A. I. ornatus* was shot "outside the gates of Cairo" (Rothschild, 1913, p. 459), and Barbary sheep were reported to have existed in the hills east of Cairo in the late 1700's (Anderson, 1898). Russell (1831) commented that sheep lived in the rocky deserts bordering the Nile, but did not occur habitually in the vicinity of Cairo. Numerous explorers since have observed Barbary sheep and their remains and published these, together with reports from guides. Many of these references pertain to Wadi Qena, Wadi Asyuti, and adjacent drainages in the Maaza Plateau. Flower (1932, p. 435) stated that, although the Barbary sheep was said to occur on both sides of the Nile in Upper Egypt during 1900-1909, by 1910, it had become 'really scarce.' Bedan (1928) killed a Barbary sheep in Wadi Asyuti in February 1927. He commented on the hunting pressure during World War I in the Wadi Asyuti area and said that a 1920 expedition had found no game. Some sheep, he thought, took refuge in an inaccessible cliff east of Wadi Asyuti on the west side of Wadi Qena. Russell (1949ab, 1951) recounted the decimation of Barbary sheep and ibex in the Wadi Qena-Wadi Asyuti country by commercial hunters, particularly during the war years when meat was scarce and expensive. He concluded that wild sheep no longer existed north of Gebel Elba.

"Of interest is the comment by Hoogstraal (1964, p. 237) that 'Legends of wild sheep on Gebel Elba are rife among Bishareen, but we obtained no specimens.' We do not know if sheep ever existed in the Elba mountains, although they were known to occur on Gebel Hisse (Isse or Is) 100 km. SW of Elba (Sciater, 1895).

"Recent observations of Barbary sheep in Wadi Asyuti and Wadi Mellaha in the Eastern Desert and Ain Dalla and Gebel Uweinat in the Western Desert (see above) indicate that small populations survive in isolated areas. The most recent record is a specimen killed by a hunter in 1972 near Bir el Obeyid NW of Farafara Oasis. Further indication of the former extent of distribution is the horns found in 1927 in Qattara Depression near Minqar Abu Dweiss (Murray, 1967)."

A map of locations in Egypt where Barbary sheep were killed, where horns and skulls were collected, or where sightings occurred (Figure 4) is adapted from Osborn and Helmy (1980). This indicates the historic distribution of the species in Egypt, but it is clear that only small numbers of the original populations remain in widely scattered groups.

In Libya, Toschi (1957) stated that Barbary sheep were present in the mountains south of Nabut and Garian, near Syrte and Mizda and east to Gebel Soda, at Ouaddan near Aruggi, and particularly in the vicinity of Ghat and mountains to the south. According to Khushal Habibi (personal communication, 1984), they apparently still "occur in viable numbers in the

Tibesti mountains...(that) form a chain between Chad and Libya," but little scientific work has been done on them. Dr. A. Darwash, who worked in Libya for 11 years, reported the presence of about 50 animals in an enclosure, probably near Tripoli. They had been captured by the Italians who worked in Libya before Gaddafi seized control of the country (Khushal Habibi, personal communication, 1984).

In Morocco, Bourgoin (1958) indicated that the population in the southern part of the country was "severely threatened" and that a special reserve for Barbary sheep had been created in French West Africa. Panouse (1957) remarked that the species occurs in the Empire chérifien ("Kingdom of the Shieks") where it is concentrated in the High Atlas and Anti-Atlas mountains. Barbary sheep numbers were said to be highly variable in other areas. At the time Panouse's monograph was published, the Department of Water and Forests had a policy of limiting Ammotragus populations in this region because of their damage to plantations and vineyards.

Panouse (1957:53) included a map of the geographic distribution of Barbary sheep in Morocco, but more recent information has come from Michel Thevenot and Stephane Aulagnier (personal communication, 1984) of the Université Mohamed V in Rabat. They remarked that Barbary sheep are still present in the Middle Atlas, High Atlas, and the Occidental Sahara (where investigations have not been possible since 1974). Thevenot and Aulagnier are working on a Catalog of Moroccan Mammals, and provided a map showing the geographic distribution of Barbary sheep by map quadrangle (54 X 46 kilometers). The Moroccan distribution of Barbary sheep shown in Figure 5 is adapted from their map and is based on information Thevenot and Aulagnier compiled from Brosset (1960), Panouse (1957), Morales Agacino 1949, 1950), and Valverde (1957), as well as their own data.

In Niger, John Grettenberger (a former Peace Corps volunteer in Niger) reported some Barbary sheep were still present in that country (Khushal Habibi, personal communication, 1984).

In the Sudan, Molloy (1957) remarked that Barbary sheep had been common in the hills along the Red Sea, and were still found in the hills around Beja north of the Port Sudan railroad, at Atbare, and west of the Musmar station longitude. Furthermore, they were common in the hills of North Kordofan and North Darfour, near Jebel Meidob, and northeast of Koutoum. A reintroduction in the Shabluka hills 100 kilometers north of Koutoum, where they had been exterminated at the end of the 19th. century, was said to have been successful. Another account, by Schomber (1960), indicated:

"The Barbary Sheep, in several sub-species, is distributed in the Sahara regions from the Atlas Mountains to the Sudan. The number has decreased and is mainly restricted to isolated mountains in the provinces of Darfur, Kordofan and Nubia."

"An estimate of the number in the Sudan is in no way possible. To what extent the population of Barbary Sheep suffers from illegal trapping I am unable to say. The maned sheep is clearly included in Schedule III as a protected species. The possessor of an A or D class licence is, however, allowed to kill up to two animals."

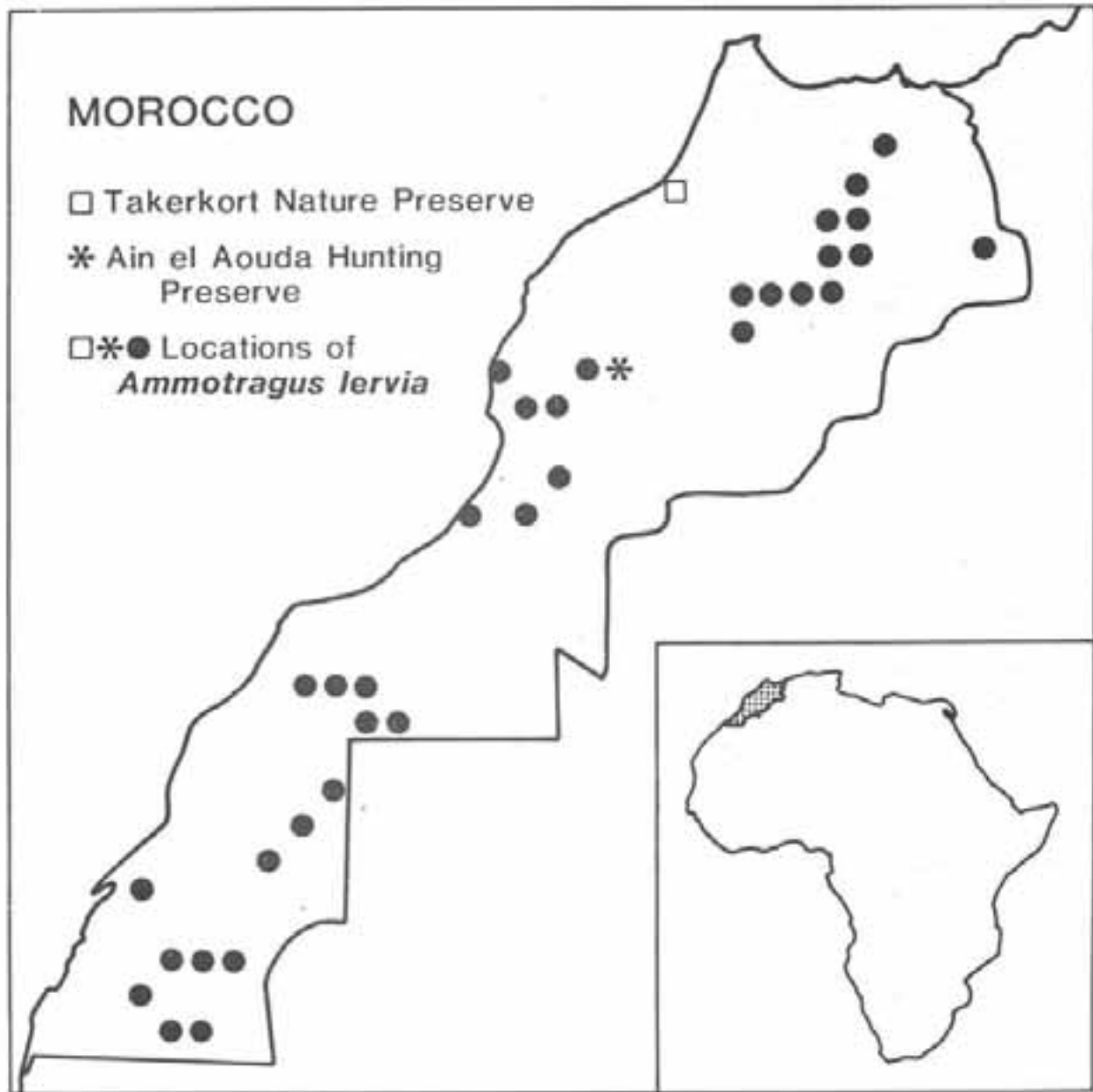


Figure 5. Present distribution of *Ammotragus* in Morocco. Adapted from M. Thevenot and S. Aulagnier (personal communication, 1984), Institut Scientifique, Université Mohamed V, Rabat, Maroc.

In Tunisia, Schomber and Kock (1960) stated:

"This northern sub-species, which is characteristic of Northern African mountain fauna, is found in the Atlas Mountains and the foothills from Morocco to Tunisia. But although the rocky wastes of the largely barren mountains offer the sheep excellent protection, which is enhanced by the similarity in colour of the animal to the rocks, nevertheless its existence is seriously endangered through being hunted continuously. In the uninhabited Atlas Mountains in Morocco it is safe, whereas in Algeria it has already decreased alarmingly and in Central Tunisia there appears to be no chance of saving any of the species. The maned Atlas sheep, as it is called, can be stated with certainty still to exist in small numbers on the Djebel Bou Hedna, at Fom el Khanga near Tamerza, where it alternates between Algeria and Tunisia, according to the fluctuations of the local disturbances, and in a herd of 14 to 15 in the mountains north of Chott Fedjady. Its favoured habitat was in the mountains, carpeted more or less with sparse bush or at least with adequate grazing. With the exception of Morocco it may by now have been completely ousted from this biotope by the herds of the Nomads.

"The Tripoli maned sheep of southern Tunisia does not differ from the northern sub-species in either habitat or normal habits. Its area of distribution starts in the barren mountains south of Remada, whereas fifty years ago it was still to be found near Fom Tatahouine, 100 kilometres further north. Shortly before our arrival a specimen was killed at Djebel Kambout, about 10 km south of Remada. The local Bedouins told us that the maned-sheep was still said to exist between Remada and Bordj Bourgiba. It was observed in small herds in Djebel Segdel and in Merbah Safsaf in the spring of 1959.

"The survival of the Tripoli species in the southern districts is somewhat less in jeopardy since only a few Arabs indulge in this difficult hunting and Europeans only in exceptional cases."

STATUS AND DISTRIBUTION IN EUROPE

In Italy, Zammarano (1930) mentioned that Barbary sheep were introduced onto game preserves. However, I have been unable to determine whether they still exist there.

In Germany, the species was introduced at two locations in the north--near Lopshorn in Lippe in 1883 (Lons 1908), and later in the Teutoburger Wald (Strasson 1916). Both introductions failed, and no further introductions have been attempted in northern Germany (Rolf Schoppe, personal communication, 1984). Information from Ralf Angst (personal communication, 1984) indicates that Ammotragus is a familiar animal in German zoos, that they breed successfully, and the zoos have a problem selling young males. Angst also sent a photocopy of two pages from a book by Niethammer (1963) that gives some details of the Lopshorn release.

According to Niethammer (1963), Prince Waldemar of Lippe released two maned sheep from the Dresden Zoological Garden in his 6600-hectare preserve near the Lopshorn Hunting Lodge in 1883. Eight young were obtained from Antwerp the same year, and were kept confined for six weeks in the abandoned fortress Steinbruch on Stemberg before being released. An early notice (Zool. Garten 31:376, 1890) indicated some success, but Schacht (1904) reported that the project soon failed. Later attempts were also unsuccessful, and the last male was killed in 1902. The explanation for the failure of this venture was that the maned sheep could not find enough nutritious food and therefore had to be kept half-tame so they could be fed.

Blume (1911) mentioned that the brothers von Born kept maned sheep in their animal park at Neumarkt/Krain about the turn of the century, but these were tame and not hunted. Von Turcek commented that maned sheep were hunted for 30 years in Inovec-Gebirge, but these presumably were animals purchased as Mufflons (Niethammer 1963).

In Spain, M. Delibes of the Estacion Biologica de Donana in Sevilla has kindly furnished me with a short manuscript on the status of Ammotragus that will appear in the next volume of the Handbuch der Säugetiere Europas.

According to his account (Delibes in press), there is a single free-living Barbary sheep population in Europe at the present. It is located in the Sierra Espuna near Murcia in southern Spain (37°50'N, 1°35'W), and was established in 1970 using eight animals of each sex from the zoo in Casablanca as well as 8 males and 12 females from the zoo in Frankfurt am Main, Germany. This stock was held in enclosures, after which 9 male and 18 female zoo animals were released along with 2 males and 5 females that were born in the enclosures. When released, they dispersed up to 80 kilometers (50 miles).

By 1973 there were 79 animals, and the population increased at an average annual rate of 30 percent a year to 1982 when numbers totalled approximately 750. The population has been hunted since 1977, and has been reduced to about 500 animals since hunting began. The location of the free-ranging population in Spain is indicated in Figure 6.

There are also private herds of Barbary sheep in fenced enclosures in the provinces of Ciudad Real, Toledo, and Cadiz. An introduction of the species was made on one of the Canary Islands, La Palma, but failed.

STATUS AND DISTRIBUTION IN NORTH AMERICA

In California, on the West Coast of the United States, the history of the Barbary sheep population was recounted by Reginald Barrett (1980). Barbary sheep were apparently among the first ungulates procured when a private zoo was established in 1924 on the estate of William Randolph Hearst near San Simeon in San Luis Obispo County. These animals were probably obtained from the Fleishacker Zoo in San Francisco. Although the Hearst Ranch included about 100,000 hectares (1000 square kilometers; 386 square miles) by 1940, only 810 hectares (about 2,000 acres) were enclosed by a 2.44-meter (8-foot) woven wire fence; this fenced area was subdivided into eight paddocks.



Figure 6. Location of the *Ammotragus* population in Spain. Adapted from M. Delibes. In press. *Ammotragus lervia* (Pallas, 1777)-Mahnenschaft. In *Handbuch der Säugetiere Europas* (G. Niethammer, ed.).

By 1937, Barbary sheep numbered 20 to 30 and the herd was said to have been productive. Records showed a herd size of 98 in 1949. During 1950 and 1951, 81 animals were sold to an animal dealer. Some of these formed the basis for introductions in the Canadian River Gorge of northeastern New Mexico and Palo Duro Canyon of the Texas Panhandle. The Hearst Zoo census noted 58 Barbary sheep in 1950, 55 in 1951, and 67 in 1952. In 1953 the private zoo was disbanded and about 85 Barbary sheep escaped from the deteriorating enclosures. These animals were the foundation of the present free-ranging population.

Soon after their escape Barbary sheep were observed on and around Red Rock, a large basaltic plug 1.5 kilometers east of the Hearst Castle. By 1954, the first animals had moved to Vulture Rock, 14 kilometers south of the Castle. Ten years after the escape there were estimated to have been 172 Barbary sheep in the area between the Hearst Castle and Red Rock. Meanwhile, many sightings of one to six individuals were made as far as 30 kilometers north and 65 kilometers south of the Hearst Castle. A number of sightings were made by deer hunters, who shot aoudads (which are not protected by closed season or bag limit in California).

Barrett's (1980) paper indicated the presence of four major female-young herds in this area. The Red Rock herd is limited to the present confines of the 30,800-hectare (76,106-acre) Hearst Ranch. This herd was composed of a least 258 animals in August 1965 (Barrett 1980), but numbers were reduced to about 154 by 1977 as range conditions deteriorated (David S. Johnston, personal communication to R.H. Barrett, 1979). Thus, the density of the Red Rock herd declined from 0.84 to 0.5 per square kilometer (2.2 to 1.3 per square mile) from 1965 to 1977. The Glazier Ridge herd occupies an area around large rock outcrops on the western slope of the Santa Lucia mountains just east of the Red Rock area. There were at least 143 Barbary sheep in the Glazier Ridge herd in the mid-1960s, but it is thought to have declined to as few as 50 animals. The Cline Peak herd, east of the Santa Lucia crest, was estimated to include over 80 aoudads in the 1960s, but has also declined to about 50. Poaching as well as changing range conditions were probably responsible for reductions in the Cline Peak herd. The Vulture Rock herd was comprised of about 100 animals in 1964, but was reduced to minimize competition with beef cattle for scarce forage. This herd is intensively harvested on a fee hunting basis, and subject to some mountain lion (*Felis concolor*) predation. Several years ago the herd was fluctuating in size from 40 to 60 animals. The approximate location of the population in California is noted in Figure 7.

In New Mexico of the southwestern United States, 12 Barbary sheep--four males and eight females--were released at Old Mills Canyon of the Canadian River gorge by the New Mexico Department of Fish and Game in January 1950 (Ogren 1965:8). These 12 original animals were obtained from the Joe McKnight Ranch in Picacho, New Mexico. McKnight had gotten his stock about 1940 from the St. Louis (Missouri) Zoological Park and the San Diego (California) Zoological Garden. Ogren made a number of inquiries and finally determined that some of the Barbary sheep from the Hearst Ranch that had been sold to animal dealer Louis Goebel were later dispensed to San Diego, and from San Diego to McKnight's Ranch. In November of the same year another 45 animals (26 females including 6 juveniles, and 19 males including 5 juveniles) that had been procured directly from the Hearst Ranch in California were liberated on a state game refuge near the north end of the Canadian River Gorge (Ogren 1965:8).

A second New Mexico population resulted from the unauthorized release of 21 Barbary sheep (also purchased from animal dealer Louis Geobel) in Largo Canyon of the northwestern sector by the San Juan County Wildlife Federation in 1956 (Ogren 1965:8). One 1979 population estimate for this area was 200-250 animals (1-1.5 per square mile; 0.4-0.6 per square kilometer) according to Bird and Upham (1980), although Bruce Morrison (personal communication, 1980) has said that aerial censuses indicated a density of about 4 Barbary sheep per square mile (1.54 per square kilometer).

Two major free-ranging Barbary sheep populations in southeastern New Mexico--in the Hondo Valley and Guadalupe Mountains-- and a number of smaller herds or bands were all derived from seven animals (three males and four females) placed in a 810-hectare (2,000-acre) game enclosure on the McKnight Ranch in 1940. McKnight has estimated that about 10-20 Barbary sheep escaped each year from 1943 to 1979. In addition, approximately 100 animals escaped in 1965 and 50 in 1977. Dickinson and Simpson (1980), who researched the dispersal and establishment of Barbary sheep in this area, ventured a conservative estimate of 510 escapees from the McKnight game enclosure over the last 36 years. Their data suggested a yearly dispersal rate of 0.3-2.4 square kilometers per year, so that Barbary sheep occupied an area of at least 7000 square kilometers (2,700 square miles) in southeastern New Mexico by 1979. Aerial censuses by the New Mexico Department of Fish and Game suggested a population density of 3.85 per square mile (1.5 per square kilometer) in the Hondo Valley (Bruce Morrison, personal communication, 1980).

Another herd, north of the Grants area in northwestern New Mexico, apparently resulted from long-range dispersal (Simpson and Krysl 1981). However, it is not known whether animals in this area came from the Canadian River gorge or moved south along the Continental Divide from Largo Canyon.

Dispersal of Barbary sheep from the Canadian River gorge has been greater toward the north and west, although there has been some emigration in most directions (Simpson and Krysl 1981). Most dispersal from the Hondo Valley population has been northeast, west, and south through the Sacramento and Guadalupe mountains, but some animals have moved northward into the Jecarilla and Capitan mountains. The Largo Canyon population has expanded its range onto adjacent public lands, but there are no confirmed records of long-distance movements.

Apparently, long-distance movements are not unusual for Barbary sheep. One animal was shot illegally 105 kilometers (65 miles) east-northeast of Roswell, and another within 32 kilometers (20 miles) of Hobbs. These records represent distances of about 129 and 113 airline kilometers (80 and 70 miles), respectively, from the closest rough terrain considered suitable for Barbary sheep. The 1979 sighting of a male in the San Francisco River drainage north of Glenwood was almost 200 miles (322 kilometers) from the closest known release site (Simpson and Krysl 1981).

From 1955 through 1978 a total of 1,008 Barbary sheep were legally harvested in New Mexico. A 1980 estimate suggested the species numbered about 2,500 in the state. At present, some estimates range from 1,000 to 3,000, but Bruce Morrison (personal communication, 1985) of the New Mexico Department of Game and Fish believes the total is closer to 5,000. The distribution of Barbary sheep in New Mexico is shown in Figure 7.

Barbary sheep continue to present management problems in New Mexico and the state is beginning to address these problems. Bruce Morrison (personal communication, 1985) recently wrote: "We have abolished our so-called trophy hunt areas and opened the entire state to Barbary hunting. The hunts are concurrent with our deer seasons and during the month of January. The bag limit is any two Barbary sheep. This year, we are proposing to open the southwest quarter of the state to year-round hunting" for Barbary sheep. He also noted that the species does not seem to be confining itself to any specific habitat type, and that there seem to be no barriers to its range expansion.

In Texas of the southwestern United States, 31 Barbary sheep (8 males, 13 females, and 10 juveniles) were released into the Dry Creek branch of Palo Duro Canyon on the Christian and Harrell ranches southwest of Claude in December 1957 (DeArment 1971). This area is situated in Armstrong County at 34°58'N, 101°31'W, approximately 38 kilometers (23.6 miles) southeast of Amarillo. Another 13 animals, 4 males and 9 females, were liberated about 64 kilometers (40 miles) southeast, near Quitaque in Briscoe County in February 1958. Reports by ranchers in the vicinities of these introduction sites indicated that most Barbary sheep remained within 16 kilometers (10 miles) of release points for about two years (Wallace 1959, 1960). However, Wallace documented two sets of sightings from as far away as 32 kilometers (20 miles), and several animals moved from the Armstrong County site on the Christian and Harrell ranches to an area 19.5 airline kilometers (12 miles) south.

Subsequent dispersal to the west and north by animals released in Armstrong County was limited by the canyon head and human activity in Palo Duro State Park. As a consequence, most movement was directed southward down the canyon. Dispersal of Barbary sheep from the more southerly Briscoe County site was toward more precipitous portions of the canyon to the north (Hudgins 1962), so that the two groups converged.

Reliable reports in the late 1970s documented the presence of Barbary sheep along the Caprock escarpment east of Lubbock, an airline distance of about 98 kilometers (60 miles) south of the Briscoe County release area. The species has also been sighted along the Red River north of Vernon, which is about 178 kilometers (110 miles) east of the Briscoe County site (Gray 1980). There is no indication of when Barbary sheep reached these areas or how much further they may have dispersed.

Studies of Barbary sheep in the original Dry creek release area of Palo Duro Canyon 20 years after their introduction showed that group sizes of more than 60 were not unusual where animals were attracted to winter wheat (*Triticum aestivum*) fields along the canyon rim. However, the mean size of groups observed during seven aerial censuses ranged from 6 to 15 animals (Gray and Simpson 1982). The results of these aerial counts also suggested a minimum population density in the Dry Creek area of 0.35-1.57 Barbary sheep per square kilometer (0.9-4.1 per square mile) (Gray and Simpson 1983).

From 1963 through 1979 a total of 1,125 Barbary sheep were legally harvested in Palo Duro Canyon. Some estimates of the Palo Duro Canyon population were as low as 1,400-1,600 in 1979 (Dvorak 1980), but Simpson et al. (1980) thought that as many as 2,500 were present.

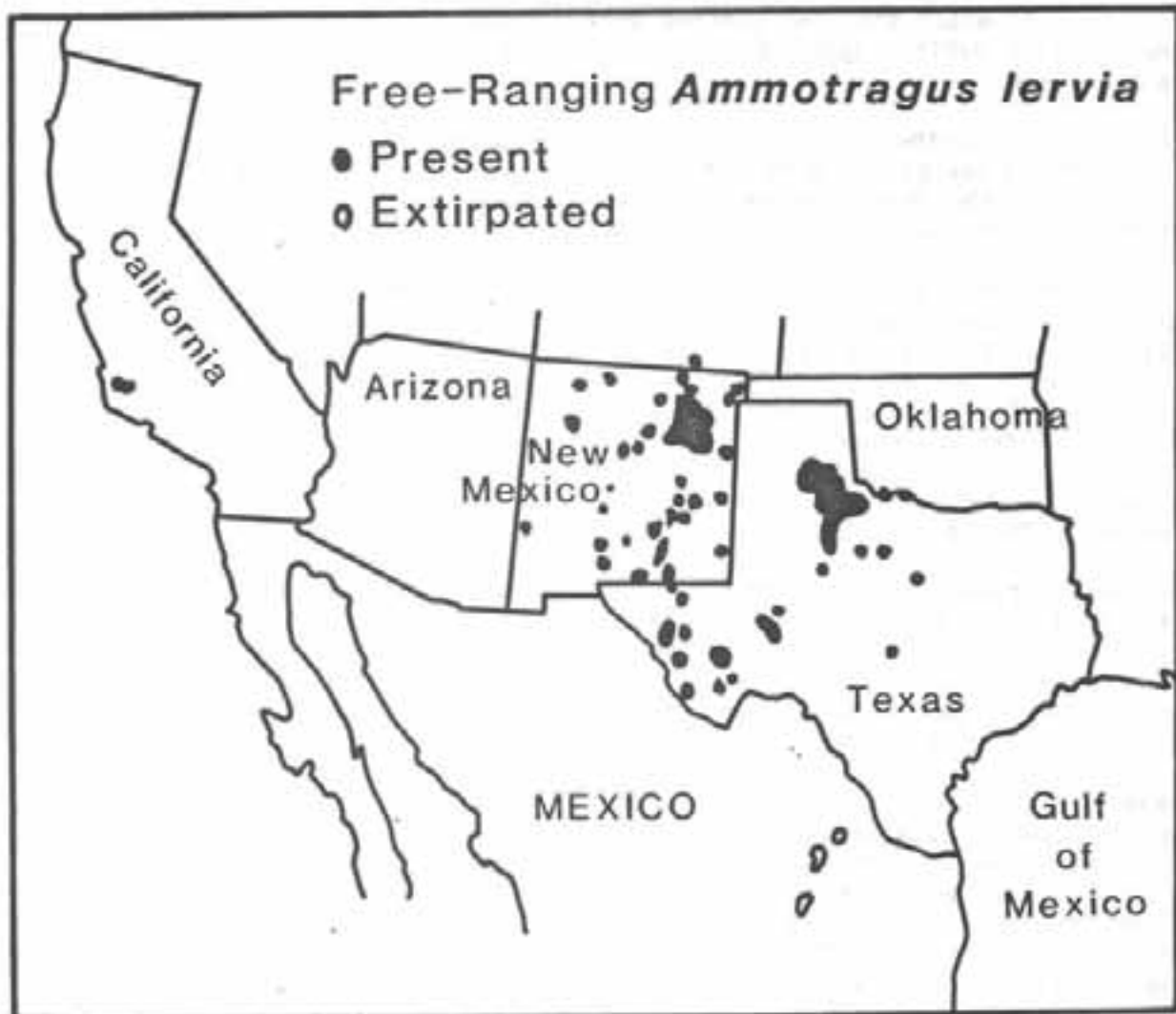


Figure 7. Location of introduced free-ranging *Ammotragus* populations in North America . Adapted from C.D. Simpson and L.J. Krysl , 1981, Status and distribution of Barbary sheep in the Southwest United States, Trans. Desert Bighorn Coun. 25:9-15.

Three other releases of Barbary sheep were made by private landowners in the Trans-Pecos region of southwestern Texas during the 1960s (Decker 1978), but details were not recorded. In addition, four escapes from confined herds in the Edwards Plateau of central Texas and one escape in the Rolling Plains of north-central Texas have resulted in two small free-ranging populations (Simpson and Krysl 1981). Based on information compiled from all sources, Simpson and Krysl (1981) estimated the total number of free-ranging Barbary sheep in Texas at 3,750 in 1980. The distribution of Barbary sheep in Texas is noted in Figure 7.

Other locations in the southwestern United States, have reported Barbary sheep sightings as result of dispersal from the populations already mentioned, or due to releases or escapes that have not been reported. Barbary sheep seen on a ranch in Oklahoma about 32 kilometers (20 miles) north of the Red River probably reached this area by following the rugged terrain along the Prairie Dog Town Fork of the Red River as they dispersed out of Palo Duro Canyon. Simpson and Krysl (1981) speculated that 25-40 animals might be present in southern Oklahoma. Occasional reports of sightings in southern Colorado have probably been animals dispersing northward from the Canadian River gorge. There were three separate records of Barbary sheep in southern Colorado during the early 1960s (Simpson and Krysl 1981), and I heard of one observation in the 1970s; however, it seems doubtful that any populations have become established. Unconfirmed reports indicate that Barbary sheep may have expanded their range into eastern Arizona, but there is still no definitive evidence (Bruce Morrison, personal communication, 1985).

In Mexico, Barbary sheep were released in three places; these introductions were summarized by Rangel-Woodyard and Simpson (1980). One release, probably the first, occurred on the Sierra Morena Ranch, a major cattle operation in northwestern Nuevo Leon. Ownership of the ranch changed several times before it was subdivided to comply with land reform policies. As several species of exotics, including Barbary sheep, were not continued within a suitable enclosure, they moved off the ranch; many of these animals were killed by subsistence hunters from surrounding settlements. However, a group of Barbary sheep escaped into the eastern foothills of the Sierra Madre Mountains. There, the herd became established, increased in numbers, and dispersed along the range resulting in a population in excess of 100 animals.

A second release occurred in the Sierra Pajaros Azules, located along the boundary between the northwestern part of Nuevo Leon and the eastern section of Coahuila. Rangel-Woodyard and Simpson (1980) were unable to obtain any information on this introduction, but they were able to confirm an established population on the east side of the Sierra Madre Oriental.

The third release was on private land in the northwestern part of San Luis Potosí. Twelve animals (2 males, 8 females, and one juvenile of each sex) were liberated in 1975-76. They were not confined by a game-proof fence when released and are said to have remained on the ranch in the general vicinity of the release site.

Each of these releases was apparently prompted by individual interests in having exotic animals rather than to supplement native animals for sport hunting. In two of these cases, Barbary sheep escaped, dispersed into relatively inaccessible mountainous terrain, and became established as free-ranging populations. At the time, both were thought to have increased and dispersed over a relatively large area of suitable habitat (Rangel-Woodyard and Simpson 1980).

Recent information from Bernardo Villa-R (personal communication, 1985), of the Universidad Nacional Autonoma in Mexico, indicated that Barbary sheep were also released on Espiritu Santo Island in the Sea of Cortez. Here, they were heavily hunted and eventually extirpated. According to Villa-R, the other three populations have also been eliminated and there are no longer any free-ranging Barbary sheep anywhere in Mexico. It is possible that some ranchers may still maintain small groups--but if so, Villa-R is not aware of where or how many might exist under these conditions.

NOTES AND COMMENTS

Simpson and Krysl (1981) estimated the total number of all Barbary sheep introduced in the western United States at approximately 400 animals. More than 1,000 Barbary sheep have been killed by hunters in Palo Duro Canyon, Texas, another thousand have been harvested in New Mexico, and an unknown--but undoubtedly much smaller--number slain in California. Still, their survey indicated that the number of free-ranging Barbary sheep in the western United States had increased to about 6,500 by 1980 (Simpson and Krysl 1981).

Clearly, the management of this species poses distinctly different challenges in its exotic range in the southwestern United States than it does within its endemic distribution in North Africa. In the United States, Barbary sheep in some areas are valued for the challenging sport hunting they provide (Christian 1980), whereas populations in other places may be viewed as a nuisance or even a direct threat to native wildlife such as desert bighorn sheep (*Ovis canadensis*) (Simpson et al. 1978). In North Africa, Barbary sheep in many areas seem to be subject to intensive hunting and poaching pressure. Increasing numbers of people, improved transportation, the development of Saharan oil and mineral resources, and continuing political and social strife will probably result in further population declines in many areas. Thus, North American populations are increasing and continuing to disperse, while the species is probably threatened at many places in North Africa. A future paper will discuss management considerations for *Ammotragus* populations under various conditions in different localities throughout the world.

Three publications on *Ammotragus* may be of interest to persons involved with conservation, management, or research on this species. One, entitled "*Ammotragus lervia*" (Gray and Simpson, 1980, *Mammalian Species* 144:1-7), was published by the American Society of Mammalogists. It is available from the author of this status and distribution review. A second is the *Proceedings of the Symposium on Ecology and Management of Barbary Sheep* held at Texas Tech University in 1979. It was edited by C. David Simpson and contains a keynote address, seven agency reports on Barbary sheep,

15 papers on various aspects of Barbary sheep biology and management, two summaries, and appendices. This is available from Dr. Henry A. Wright, Chairman, Department of Range and Wildlife Management, Texas Tech University, P.O. Box 4169, Lubbock, Texas 79409, U.S.A. The third is Herman A. Ogren's classic monograph, Barbary Sheep (New Mexico Department of Game and Fish, Bulletin No. 13, 117 pages, 1965). It is still available from Mr. Bruce L. Morrison, Assistant Chief of Game Management, New Mexico Department of Game and Fish, Villigra Building, Santa Fe, New Mexico 87503, U.S.A. There is no charge for any of these publications. In addition, an international symposium on hunting wildlife was held in Fez in 1983 during which Barbary sheep were discussed. The text of this symposium may be available from: My Y. Alaoui, Service de la Protection de la Nature, Division de la chasse, de la peche et de la protection de la nature, Direction de Eaux et Forets, RABAT, Maroc (Morocco).

I would like to receive reports on Ammotragus status, distribution, introductions, research results, and management from workers throughout the world on a continuing basis. I also would be willing to act as an intermediary and share this information with other interested biologists.

This review of Barbary sheep status and distribution is respectfully dedicated to Dr. Herman A. Ogren in recognition of his pioneering research on the species.

ACKNOWLEDGEMENTS

I thank all the biologists who graciously responded to my request for current information on the status and distribution of the species. Many of their names are noted in the personal communications mentioned in this paper. I also thank J. David Renwald of the U.S. Bureau of Land Management, Farmington, New Mexico, for the original illustration, Carol Garner for drawing the distribution maps, Dr. Malcolm Jollie for assistance with translations and helpful comments on the manuscript, and Paula Propst for typing the paper.

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