THE CYPRUS MOUFLON

Ovis gmelini ophion

Management, conservation and evolution

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ABSTRACT

The Cyprus mouflon Ovis gmelini ophion is an endangered species of wild sheep found in the Paphos Forest of Cyprus, a mountainous area dominated by pine (Pinus brutia) and golden oak (Quercus alnifolia). Population and reproductive ecology of mouflon was studied in two main habitats; at the centre of the Paphos Forest and at the forest-agriculture interface. The purpose was to provide data that could assist in the management of the species. The population at the edge of the forest had a longer lambing season, produced more lambs, lambs suckled for a longer period of time, and fewer females were barren. Predation was not found to be a factor limiting the population. Mouflon suffered from a wide range of diseases and bone lesions affecting domestic animals. The hemoglobin phenotype of the Cyprus mouflon was Type B, not Type A which is characteristic of domestic sheep or Type M characteristic of the European mouflon. Skeletal measurements revealed that the Cyprus mouflon is 15-18% smaller than the 8000 year old Neolithic sheep of Khirokitia. The captive breeding programme of mouflon at the Limassol Zoo was examined and was considered unsatisfactory for the preservation of this endangered species. Finally, a two -line electric fence was found to be effective in preventing agriculture damage, when properly maintained.

RESUME

Le mouflon de Chypre Ovis gmelini ophion est une espèce en danger d'extinction. Ce mouton sauvage habite la forêt de Paphos, à Chypre, région montagneuse dominée par du pin (Pinus brutia) et du chêne doré (Quercus alnifolia). La population et l'écologie de reproduction ont été étudiées dans deux habitats principaux: au centre de la forêt de Paphos et à l'interface forêt-milieu agricole. Le but de cette étude était d'obtenir des données pouvant aider à la gestion de l'espèce. La population habitant à la limite de la forêt présente des périodes d'agnelage et d'allaitement plus longues. De plus, la production d'agneaux par femelle est plus élevée avec un nombre de femelles non parturientes plus réduit. La prédation n'a pas été trouvée comme étant un facteur limitant la population. Les mouflons souffraient d'une grande variété de maladies et de lésions osseuses qui sont connues chez les animaux domestiques. Le phénotype de l'hémoglobine du mouflon de Chypre était de type B et non du type A, qui caractérise le mouton domestique, ou du type M, qui caractérise le mouflon Européen. Des mesures du squelette ont révélé que le mouflon de Chypre est 15 à 18% plus petit que le mouton Néolithique de Khirokitia vieux de 8000 ans. Un programme de reproduction en captivité du mouflon au Zoo de Limassol a été étudié et considéré comme non satisfaisant pour la conservation d'une espèce en danger

d'extinction. Finalement, dans le cadre d'une étude de prévention des dégâts agricoles causés par le mouflon, la clôture électrique à deux fils s'est avérée le plus efficace des moyens étudiés.

STATEMENT OF ORIGINAL CONTRIBUTION

This is the first population study of the Cyprus mouflon, an island population isolated for 8000 years. This sheep of unknown origin inhabits a forested mountain area of 620 km, and is on the I.U.C.N list of endangered species. It differs from other mouflon of the world in its small size with supracervical horns and slight differences in coloration.

Preliminary observations indicated (1) that this endangered population was growing to nuisance levels in the agricultural areas adjacent to the forest; (2) mouflon were seen in the interior of the forest all year; and (3) there were lambing grounds both in the forest and at the edge of the forest. Since mouflon appear to be loyal to their home ranges it seemed plausible that even in such a small area there might be distinct genetically isolated subpopulations.

Demographic characteristics of the population as well as habitat use of forest and forest edge groups were compared. The results of these comparisons eventually led to

the conclusion that it is possible to manage the subpopulation at the forest edge without compromising the future of the population. This approach, considering ecological isolation of the two subpopulations, provided a unique management plan contributing to the preservation of an endangered species. Bothh biological and political factors (sociobiological) play important roles in mouflon management.

This study was the first to examine diseases and bone pathology of the mouflon and to analyze whether the diseases of domestic animals were affecting wild sheep.

The study for the first time presents a large reference collection of bone measurements to meet the needs of faunal analysts working with excavated sheep bones. It studies the evolutionary history of the Cyprus mouflon by comparing it with the 8000 year old Neolithic sheep of Khirokitia, and examines the effect of island dwarfism on the Cyprus mouflon.

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INTRODUCTION

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1.1.1 The origin of the mouflon of Cyprus

Cyprus, is the third largest island in the Mediterranean (Fig. 1.1), with an area of 9,251 km^2. It is situated at the North-eastern end of the East Mediterranean basin. Is a 15 million year old island of oceanic origin which has never been connected to the mainland. In the Pleistocene glacial episodes the minimum distance to the mainland would have been 30 km (Swiny, 1988). As a result, all endemic terrestrial mammals of the Pleistocene or later date would have had to reach the island by swimming, or to have been imported by humans.

Records prior to man's arrival on the island do not include any representatives of the ancestors of domestic animals, but do include a few bones of a genet (Geneta plesictoides) (Bate, 1903a), pygmy hippopotamus (Phanourios minutus) (Forsyth Major, 1902; Bate, 1906) pygmy elephant (Elephas cypriotes) (Bate, 1903b; 1904; Boekschoten and Sondaar, 1972; Swiny, 1988; Simmons, 1988; Reese, 1989), unspecified murid mice species (Boekschonten and Sondaar, 1972) and a shrew (Crocidura russula) (Boekschoten and Sondaar, 1972; Davis, 1984).

The oldest known human presence in Cyprus is dated at about 8230 B.C. (Reese, 1989). This presence was discov-

ered at Akrotiri-Aetokremmos (Eagle's cliff), and is one of the earliest archaeological sites in any of the Mediterranean Islands. At this site there is a strong association of the extinct fauna of Cyprus with cultural remains, such as flint and burnt bones, but there is no evidence of the presence of caprins (Simmons, 1988). The fossil record of the second oldest neolithic human settlement on the island (6000 years BC), khirokitia, did not include any of the mammalian species found at Aetokremmos, but it did include components of a new fauna such as fallow deer (Dama dama mesopotamica), mouflon/sheep (Ovis sp.) goat (Capra sp.), pig (Sus sp.), and fox (Vulpes vulpes).

The wild mammals found on the island today are: mouflon (Ovis gmelini ophion), which is the largest wild mammal and the only wild caprin, fox, hare (Lepus europaeus) the long-eared hedgehog (Hemiechinus auritus dorotheae) ship rat (Rattus rattus), house mouse (Mus musculus), Cyprus shrew (Crocidura cypria), pygmy white-toothed shrew (Suncus etruscus), and spiny mouse (Acomys nesiotes), one species of Megachiroptera and 11 species of Microchiroptera (Spitzenberger, 1978, 1979).

According to Ryder (1987), around 6000 years BC there were no wool-bearing sheep but only those with a wild-type coat such that of the mouflon. Since there are records of captive sheep in the Zagros mountains on the border between Iran and Iraq, that date back to 9,000 B.C. (loc. cit.), it is quite likely that the mouflon brought

to Cyprus by man were a domesticated wild strain of sheep. It is assumed that it is a feral domesticate from those early times which formed the ancestry of the present population (Davis, 1984) .

1.1.2 The modern record

Records of Cyprus mouflon through the early Greek (2000 B.C. - 57 B.C.) and the Roman times (58 B.C. - 330 A.D.) are only reflected in art. However, the following account of the history of the mouflon from the Middle Ages to 1969 has been taken from the accounts of J. Biddulph, High Commissioner of Cyprus (1884), and the files and/or undated pamphlets obtained from the Department of Forestry of Cyprus. Although the accuracy and precision of the reported population estimates are impossible to evaluate, the general tendencies are probably reflected and thus used to outline the history.

In the Middle Ages, the mouflon was plentiful in nearly all parts of Cyprus and was hunted by the aristocracy using hounds and by coursing them with cheetahs.

By 1878 the mouflon was only found in the Troodos mountains in the western portion of the island (Fig. 1.1), where they were disturbed only by occasional woodcutters and peasants herding goats and sheep. Biddulph (1884) claims that at the time of the British occupation mouflon had been exterminated with the exception of a single flock

of 25 members and a ban was placed on their hunting. By 1884 their numbers were thought to be increasing. In 1930 there was a flock of 20 or more in the Troodos Forest and a similar number in the Paphos Forest. By 1937 the population of the Paphos Forest was thought to have been reduced to 15 animals through persistent poaching.

In 1938 the Game law was amended and strengthened to provide better protection for the mouflon. Special forest staff and police were assigned full-time in order to reduce poaching. From 1938 to 1940 all goats were removed from the forest to eliminate competition with mouflon. Furthermore it eliminated from the forest the goatherders who were thought to be extensively involved with poaching. In 1939, the Paphos forest (620 sq. Km) was declared a Game Reserve, thus eliminating all forms of hunting from the area.

In 1950, a captive breeding stock was established at Stavros tis Psokas Forest Station with one male and two females. In 1955 a similar stock was established at the Limassol Zoological Garden from animals that originated from the captive stock from Stavros tis Psokas.

In 1967, Cyprus signed the International Union for the Conservation of Nature (I.U.C.N.) Form of Acceptance of Ultimate Responsibility of Rare Wildlife Species.

In 1970, Dr. Van Haaften (1974), estimated the population to be 200 animals. He believed that there was no food shortage, and he recommended the planting of lure

crops near the forest to protect agricultural crops from mouflon depredation.

In 1978, the mouflon was placed on the list of endangered species of I.U.C.N. (Goodwin and Holloway, 1978).

In 1983, the Department of Forestry estimated the mouflon population to be 500-600 animals. This estimate was based on the animals seen by employees of Stavros tis Psokas forest station when travelling the roads.

In 1984, 823 hectares of Paphos forest around mount Tripilos, the highest point of the forest (1407 m asl) which included all the indigenous Cyprus cedar (Cedrus brevifolia) was declared a Nature reserve.

In 1990, Law No. 158/90 was approved which gave more powers to the Game Wardens. This latest law allows to game wardens to search people and cars if they have reason to suspect that they broke the game laws, and to prosecute those that did.

In 1992, under the direction of Dr. R. Bider, using a helicopter count we estimated the population to be 900 - 1500 animal.

1.1.3 Recent studies

There have been few studies on Mediterranean caprins living in natural habitats (Pfeffer, 1967; Van Haaften, 1971; Valdez, 1976; Valdez et al., 1978). However, only one study (Maisels, 1988) has focussed on the Cyprus mou-

flon and that addressed questions related to feeding ecology. This paucity of knowledge has made it difficult if not impossible to manage these animals.

1.1.4 The objectives of this study

Faced with desperate need for a management programme which would safeguard the population, this investigation was undertaken with four objectives in mind. The primary objective of the study was to provide basic population data which would be compared with those of other studies. Because there seemed to be two subpopulations of mouflon, one forest dwelling and the other living at the interface of forest and agriculture regions, it was deemed important to understand any possible differences. Two study areas were chosen. The areas were 10 km apart.

The first study area is located nearly at the centre of Paphos Forest in a habitat similar to the original Mediterranean vegetation before it was altered by humans. The second study area is near the edge of the forest in a habitat altered by humans for agricultural purpose. The investigation included movements of the animals, feeding habits based on rumen analyses, chemical analyses of selected forage species for nutrient content, aspects of reproduction, lamb survival, natural mortality factors including diseases and predation, and man-caused mortality.

Because a captive breeding programme might be important at some time in the management program, a secondary objective was to analyze the captive breeding program of mouflon in Cyprus which has been underway for the last 30 years to see if it was suitable for a conservation programme. Sheep are very vulnerable to inbreeding (Wiener and Hayter, 1974; Wiener and Wooliams, 1980). Uncontrolled inbreeding is almost certain to lead to extinction (Soulé, 1980; Frankel and Soulé, 1981). In the special case that an organism is already very homozygous, further inbreeding might do little harm, but assuming the unlikely result of survival without serious depression in viability and fecundity, is the relinquishing of future adaptive options as well as the appearance of random changes in the phenotype (Frankel and Soulé, 1981).

A third objective was to collect data that could contribute towards clarifying the taxonomy of the Cyprus mouflon. The literature contains conflicting information on the taxonomy of Cyprus mouflon (Von Brandt and Ratzeburg Erwahnt, 1827; Blyth, 1841; Pfeffer, 1967; Van Haaften, 1971). As long as this confusion exists it will be difficult to implement the legal application of international treaties to protect endangered species. At the symposium on wild sheep of the commission "Big Game of Europe/Asia, Holarctic Region" of the International Council for Game and Wildlife Conservation (C.I.C.) held in June 1989 at Prague, it was made clear that taxonomy and the zoological

denomination of several wild sheep species and subspecies is still a matter of discussion, whereas their distribution and abundance is still unclear (Franco, personal correspondence, 1989). Because of international treaties for endangered species, taxonomy has become a legal problem; species and subspecies have become legal entities. The lack of clear descriptions of species along with exhaustive distribution maps renders the task of authorities responsible for wildlife protection very difficult.

Data that could contribute to the taxonomy of the species were haematological and bone size measurements.

A fourth objective was to find ways to prevent or minimize damage caused by mouflon to crops. As long as mouflon depredate farm crops, humans will retaliate. The effectiveness of electric fencing used by sheep and cattle breeders as mouflon repellent was investigated.

1.2 THE HABITAT

1.2.1 Geology and soil

The entire Paphos forest is a mountainous area of 620 sq. Km, located in the northwestern part of Troodos massif (Fig 1.1). The central point of Paphos forest is the most elevated area and includes mount Tripilos, a mountain rising to 1407 m above sea level. Because the area has never had the smoothing effect of glaciation, the

topography is dissected by the action of the many winter streams that eroded the hills deeply. This, combined with a long period of tectonic uplift of the Troodos range 10-15 million years ago (Swiny, 1988), has produced steep slopes, sharp-edged ridges and narrow, twisting valleys. The rocks consist of diabasic, basaltic and ultramafic dykes with subordinate gabbro and plagiogranite screens (Geological Survey of Cyprus, 1979).

On the edges of the forest, in the foothills from Argaka village up to Panayia village, basaltic and spilitic Pillow Lavas and Basaltic Dykes are found. This section is at the leading (southern) edge of the Troodos ophiolite complex. It involves lavas characteristic of either the upper or lower lava sequences of the Troodos ophiolite. The lower lavas are characteristically green-weathering pillows which range in size from large one meter pillows to small bun-shaped forms. The upper lavas weather typically a pink brown colour and commonly occur as 0.5 to 1 m size pillows and are associated with volcanic breccia zones (Malpas and Xenophontos, 1987). At the south side of the above lava formations Bentonitic Clays and Tuffaceous Sandstones are found (Lapierre, 1971; Pantazis, 1979).

1.2.2 Vegetation

The dominant upland tree species of the Paphos forest

are pine (Pinus brutia) and golden oak (Quercus alnifolia) along with occasional strawberry trees (Arbutus andrachne), turbentine tree (Pistacia terebinthus) and sumach (Rhus coriaria). The understory brush consist of Rock roses (Cistus monspeliensis and C. villosus creticus), Asphodelus aestivus, Astragalus lusitanicus, Teucrium kotschyanum, Smilax asperea, Lathyrus aphaca, Bromus sp., Dactylis glomerata and Echinops spinosissimus. The riparian vegetation consists of plane trees (Platanus orientalis), with a dense understory of storax (Styrax officinalis), bramble (Rubus sanctus), myrtle (Myrtus communis), laurel (Laurus nobilis), oleander (Nerium oleander), green-brier (Smilax asperea) and braken fern (Pteridium aquilinum).

At the edge of the forest (forest-agriculture interface area) the land is characterized by undulating hills, meadows and flat cultivated areas. Uncultivated areas are covered with thorny broom (Calicotome villosa), buckthorn (Rhamnus oleoides) thorny burnet (Poterium spinosum), and rockrose (C. v. criticus and C. monspeliensis). The fields are cultivated with olive trees (Olea europea) carob (Ceratonia siliqua), almonds (Prunus amygdalus), grapes (Vitis vinifera) wheat (Triticum sp.), barley (Hordeum sp.), and broad beans (Vicia faba). In the valley between Anadhiou village (Fig. 1.1) and the forest, several fields were left uncultivated resulting in grassy meadows. These meadows provided rich forage in the summer and early fall

when all the other fields in the area were ploughed.

1.3 THE STUDY AREAS.

1.3.1 The study area and lambing ground in the forest.

The study area inside the forest centred around the Stavros tis Psokas Forest Station. The lambing ground was located at Kremmos tou Aphoriti (Aphoritis cliff) 2 Km south of Stavros tis Psokas Forest Station, next to the road connecting the Station with the city of Paphos (Fig. 1.1). It is an area of 7,000 sq. m of bare rock (50-80 degrees), at an altitude of 880-792 m. Plants for chemical analysis were collected from within a 2 Km radius from the forest station.

1.3.2 The study area and the lambing ground at the forest-agriculture interface.

The adjacent area on the periphery of the forest was located near the villages of Asproyia, Kannaviou, Anadhiou, Sarama and Instinjo (Fig. 1.1). Plants for chemical analysis were collected from the valley between Anadhiou and Paphos Forest. The lambing ground is located at kremmos tou Pakhniouti near the village of Kannaviou 300 m from the Premixco quarry, where almost every afternoon

there were powerful explosions. The altitude is 400-512 m, and the cliffs rise from 60 to 90 degrees. The area of the cliffs is about 7,500 sq. m of bare rock. A road at the base of the cliff connects Stavros tis Psokas Forest Station with the city of Paphos. Carcasses were collected from all over the forest.

2.4 CLIMATE

The climate in both areas is "Mediterranean" with an emphatic, seasonal rhythm in temperature, precipitation and weather conditions (Robinson, 1973). The ecological summers (June to August) are hot and dry, the winters (December to February) are wet. Spring (March to May) and fall (September to November) are short and mild seasons. During summer, the annual vegetation (shrubs grasses and forbs) withers with startling rapidity; only the drought-resisting trees and shrubs lend green colour to the landscape. Usually by June all grasses are dead. The capacity of the vegetation to survive the prolonged drought of summer depends upon drought-resisting adaptations designed to reduce loss of moisture and to help secure water. For example, the leaves of bushes and shrubs which remain in summer are small, hard, leathery and coated with wax and other aromatic substances such as ladanum and essential oils (which in some cases also makes them toxic to some ruminants), or covered with hair. Fig. 1.2 shows the mean

distribution of rainfall from 1951-1980, and the mean monthly distribution of maximum and minimum temperature for Stavros tis Psokas forest Station, located 700-800 m asl. Fig. 1.3 shows the mean monthly rainfall at Kannaviou village from January 1985 up to July 1988. The normal annual precipitation for Stavros tis Psokas is 844 mm.

Figure 1.1 Map of Cyprus and the study areas.

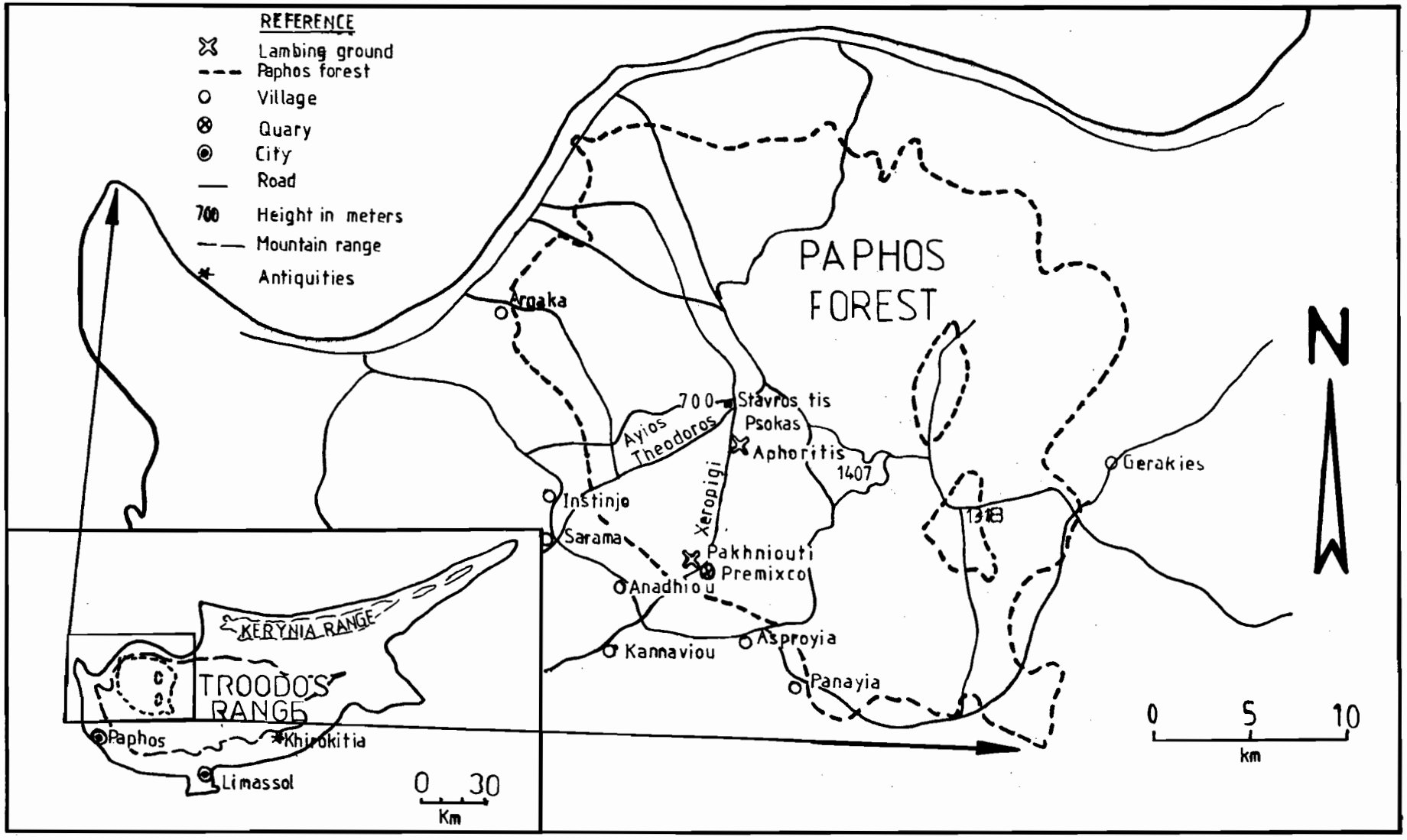

REFERENCE
Lambing ground
Paphos forest
Village
Quary
City
Road
700 Height in meters
Mountain range
Antiquities
PAPHOS FOREST
Arnaka
700
Stavros tis Psokas
Ayios Theodoros
Aphroritis
1407
Xeropigi
Instinjo
Sarama
Pakhniouti
Premixco
Anadhiou
Kannaviou
Asproyia
Panayia
Gerakies
N
0 5 10
km
KERYNIA RANGE
TROODOS RANGE
Paphos
Khirokitia
Limassol
0 30
Km

Figure 1.2 Mean distribution of rainfall from 1951-1980, and the mean monthly distribution of maximum and minimum temperature for Stavros tis Psokas Forest Station.

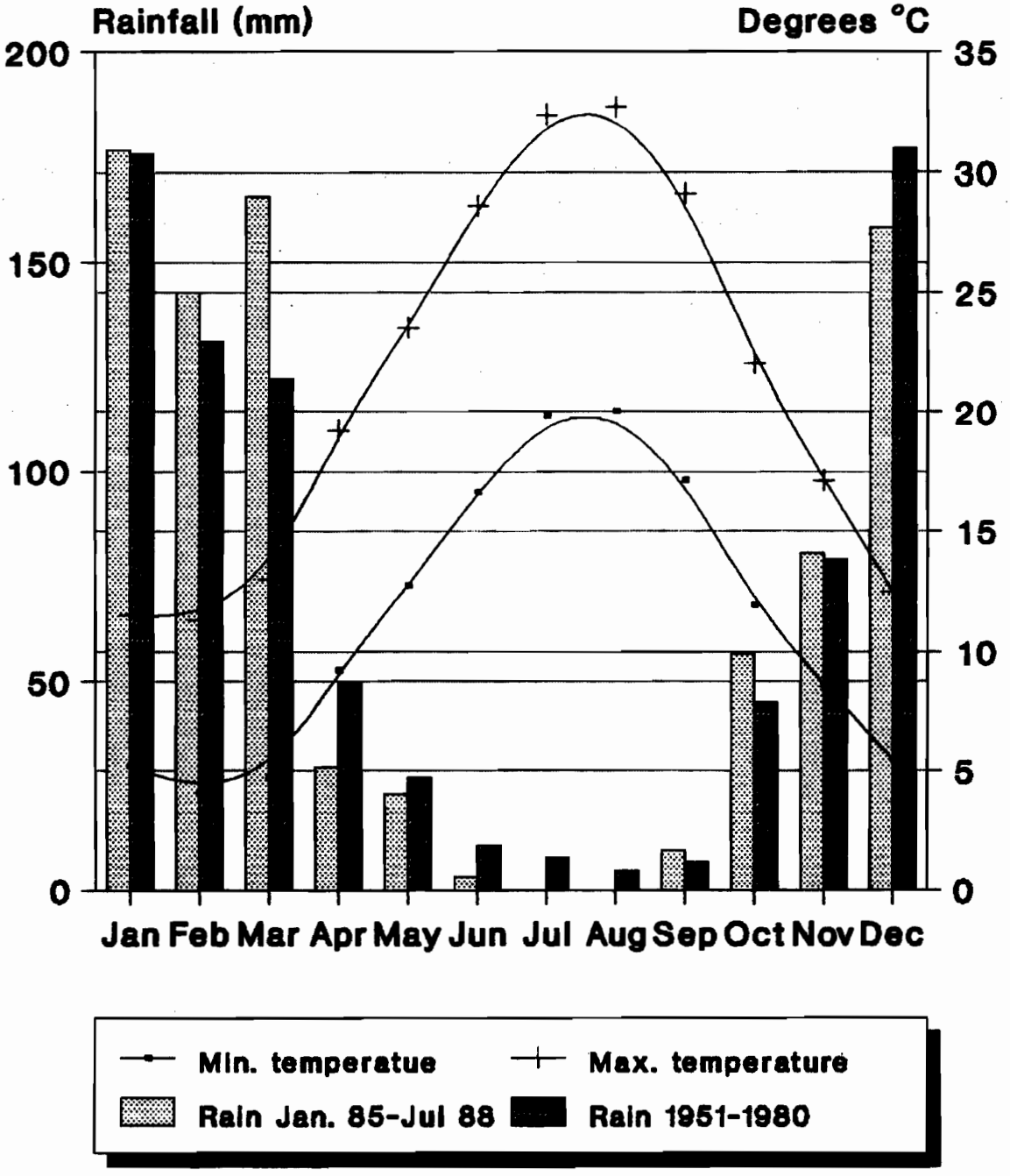
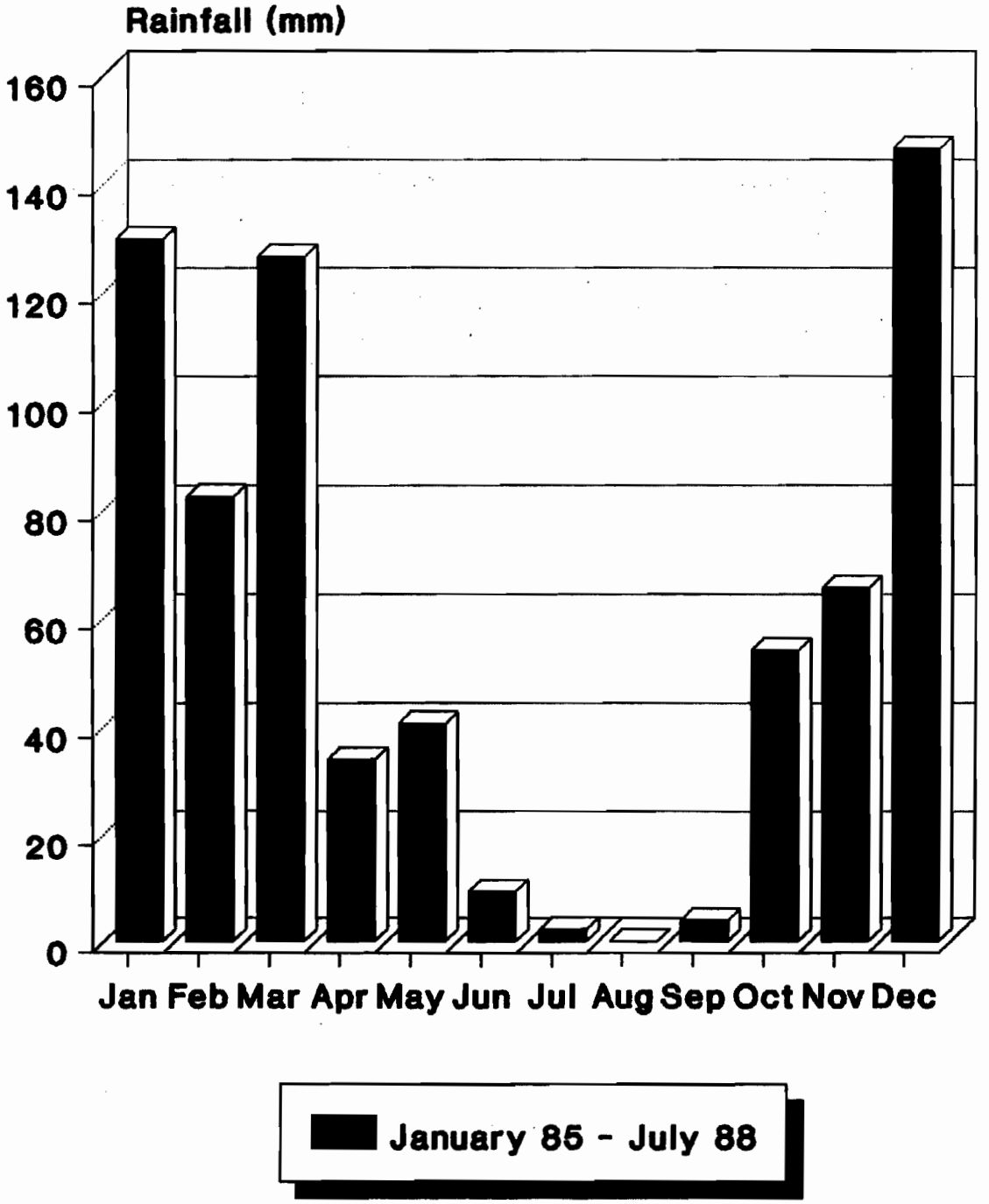

Rainfall (mm)
Degrees °C
200
150
100
50
0
35
30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Min. temperatue
Max. temperature
Rain Jan. 85-Jul 88
Rain 1951-1980

Figure 1.3 Mean monthly rainfall at Kannaviou village from January 1985-July 1988.


Rainfall (mm)
160
140
120
100
80
60
40
20
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
January 85 - July 88

CHAPTER 2. THE POPULATION ECOLOGY AND HABITAT RELATIONSHIPS OF CYPRUS MOUFLON

2.A Home range

A major consideration in the management of mouflon is that sheep are members of a social group which collectively adopt a home range (Grubb, 1974). Mountain sheep are very loyal to their home ranges; their movements between seasonal home ranges are orderly and predictable (Geist, 1971). The European mouflon (Ovis gmelini musimon) remains the year round within an area of 1 to 2 sq. km (Pfeffer, 1967). Its home range is similar to that of the feral sheep of Santa Cruz island of Southern California (Van Vuren and Coblentz, 1989), but smaller than the sheep of Hawaii ($\bar{X}$=627 ha) (Griffin, 1976). It is larger though than that of Hirta sheep (range 5 to 24 ha) (Grubb and Jewell, 1974). Ewes of the Hirta sheep accept the small range of their social group and remain sedentary throughout their lifetime. Rams have a somewhat larger home range than ewes and they might wander farther afield only when rutting. Based on the above evidence, the Cyprus mouflon should be expected to have small distinct home ranges and not travel from the interior of the forest to its edge. The objective of this section was to evaluate home ranges and the movements of the Cyprus mouflon and to see if the animals near the centre of the forest had any asso-

ciation with the animals at the edge of the forest.

2.A.1 Methods and materials

2.A.1.1. Observations of marked animals inside the forest

Home ranges were evaluated at Stavros tis Psokas by affixing radio collars to a female (2 years old), and two males (5 months and 8 years old). In order to identify the ram in the case of a failure of the radio collar, his horns were painted red. An attempt was made to locate each radiocollared sheep at least once a week. Observations were not feasible in the months of April and October. In addition to radio-monitoring, one lamb (a 5 month old male) was ear-tagged in September 1986. Two adult females were colour marked with light reflecting fluorescent collars for easy observation at night with a spotlight. The first one was marked on 8 September, 1987 with a yellow collar and the second on 16 September, 1988 with a yellow-green collar. Eartags were clearly visible 200 m away and collars at 500 m. In the same area two rams could be identified based on natural markings.

2.A.1.2 Arrival and departure of rams at Stavros Forest Station.

The movements of the animals were also studied by noting the dates of arrival and departure of the rams at the feeders at Stavros tis Psokas Forest Station. Two of these rams were observed from 1986 to 1989 because they could be identified based on natural markings.

2.A.1.3 Observations of animals at the edge of the forest

At Anadhiou, one ram could be identified on sight by its peculiar horns. In the same area a female with twins could be identified.

2.A.1.4 Observation of females at the lambing grounds

The home range movements were also registered for the females at the lambing grounds. This was based on animals observed for 140 days from blinds at the lambing grounds of Kremmos tou Pakhniouti and Kremmos tou Aphoriti. At Kremmos tou Pakhniouti, the blind was located on Premixco quarry between 300-400 m from the sheep. At the other lambing ground it was 250 m from the cliff. A pair of 10x50 binoculars was used to locate the animals and a pair of 20x60 binoculars utilized to observe them more closely. Observations were recorded on a portable tape recorder, and supplemented with drawings on topographic maps.

2.A.1.5 Method of capture

All marked animals were captured in two box traps. The first trap was constructed using exactly the same design and materials described by Clover (1956), for a double-gate, portable, collapsible deer trap. The mouflon were reluctant to enter this trap and a new one, the same design, but approximately twice as large (1.5X2X3 meters) was constructed. It was built by using 10X10 cm timber, except for the sliding doors of the entrance which were made out of 1/2 inch galvanized pipe. The sides and top were covered with netting wire.

2.A.1.6 Estimation of home range

Simple estimates of home range as a bounded area were done by joining the peripheral sightings of a sheep in a given month with straight lines on a topographic map 1:50000 so that the maximum area was enclosed (Grubb and Jewell, 1974). The home range area was determined by using a Tamaya digital planimeter (Mosby, 1980).

2.A.2 RESULTS AND DISCUSSION

2.A.2.1 Observations of marked animals inside the forest.

The first radiomarked animal, a 2 year old female, was observed from 8 March, 1986 up to 4 April, 1987, at which point she died from a miscarriage. Its home range in winter (14 locations) was 75 hectares at an altitude of 640-880 m. In late spring and summer (22 locations) her home range averaged 105 hectares at the altitude of 800-1200 m. (Fig. 2.1). Although she was not observed during lambing, prior to lambing she was in the area of Ayios Theodoros valley. Every attempt to locate this animal was successful. The second radiomarked animal was a male lamb which was observed only for a month (4 observations, September 1987) because it died from acidosis after consuming large quantities of barley. It remained within a 70 hectare area around Stavros Forest Station following its mother.

The 8 year old radiocollared ram was observed from 8 October 1987, to 15 November (6 observations), and then was lost. It was seen four times at night, pursuing females within the Forest Station. This ram was found dead by foresters near Stavros tis Psokas Forest Station in the early fall 1991. The radiotransmitter had been lost, however, the animal was recognized by the red paint on his horns.

The 5 month old eartagged male was trapped in September 1986. It was seen occasionally near the feeder of Stavros tis Psokas and at Xeropigi, about 1200 m from the

feeder for about 3 months (15 observations). It was never seen again after 10 December. The ewe marked with a yellow light-reflecting colour on 12 September 1987, was seen occasionally near the feeder. It was found dead on 9 December 1988 at the bottom of Stavros valley 2 km from Stavros Forest Station.

The female with the yellow green collar marked in 15 September, 1988 was also seen near the feeder occasionally, until I left the Forest Station in February 1989. During my last visit to the Station in February 1992, á forester told me that he saw this female near the Station in February of the same year.

All marked mouflon had overlapping home ranges particularly during fall, when all were attracted to the feeding troughs provided at Stavros tis Psokas Forest Station.

2.A.2.2 Arrivals and departures of rams at Stavros tis Psokas Forest Station

Winter 1986-1987: In October to December 1986, there were six rams visiting the feeder of Stavros Forest Station usually at 07.00 hrs (42 observations), including two marked with peculiar cuts on their horns. By the end of January all had left the area except one, which was seen there until 15 February, 1987.

Summer 1987: On 12 July of the same year, the two

identifiable rams were seen on the Zacharou mountain 1.5 km from the feeder, at an altitude of 1120 m. During July and August the same rams were seen five times, visiting a water pool in the afternoon, 500 m north of Stavros Forest Station, at the altitude of 1000 m.

Winter 1987-1988: All rams including the latter two males reappeared at the feeders in October 1987 (20 observations). They left the area by the end of January 1987, for unknown destinations. However, none of the recognizable ones was ever seen at the study area at the edge of the forest.

Summer 1988: In August 1988 the latter two rams, with a third one, were seen visiting the same spring as in 1987.

Winter 1988-1989: In 1988, two old rams appeared at the feeder beginning on the first of September. A third ram appeared on 19 September, and a fourth in October with one of the two identifiable rams. The other one was not seen that winter. By late January 1988, all rams had left from the forest station.

It is not clear if the actual reason for the rams returning to Stavros Forest Station was because they were in the need of food after the long period of the summer drought, or because the area is their breeding home range. The breeding season, as is mentioned later, is in October-November. Since a number of animals arrived at the area during the breeding time it is possible that it might

be a combination of both factors. Even when there was no food in the feeding trough the rams were seen sitting patiently next to it waiting for the game keeper to arrive with the food. During the breeding season they were seen chasing females around the Forest Station.

2.A.2.3 Observations of animals at the edge of the forest.

The forest-edge ram with the peculiar horns was seen only in Semioros near Anadhiou village. It was seen six times during the breeding season in November 1986, 10 times in October and November 1987, and once in November 1988. From May until October 1987 an identifiable female with twins was observed at the edge of the forest at Semieros Valley. Observations stop with the commencement of the rut when harassment from the rams caused her separation from the lambs. Her home range (Fig. 2.2) was smaller than the winter home range of the radiocollared female at Stavros tis Psokas (61 ha) and revealed that at least during the spring and summer she had no contact with the animals at the centre of the forest.

2.A.2.4. Observations of females at the lambing grounds.

The females giving birth at the lambing grounds

stayed in the area for about a month. During the first 3 days of the newborn's life movements were restricted to within the boundaries of the cliffs. Gradually ewes with the lambs moved away from the cliffs to browse, but never farther than 500 m from the cliffs. In the afternoon or in the evening they returned to the cliffs and usually left after 0700 hrs in the morning. None of the Stavros females had any association with those using the Apforitis lambing ground, nor did the latter associate with the females at Paknioutis. All the ewes giving birth at Aphoritis, came from Koufoplatanos valley, whereas the ewes leaving Paknioutis oriented towards the periphery of the forest.

Based on the evidence presented by all the above animals it is suggested that the mouflon might occupy a summer home range, a winter home range, possibly a breeding home range, and a spring lambing home range for the females. The fact that a number of animals from a group were seen occupying a different home range at a different season from other members of the same group suggests the existence of home range groups. Group home ranges have also been observed in other populations of wild sheep. In mountain sheep of North America, one normally observes on a given mountain, different sheep at different years (Geist, 1971). The number of seasonal home ranges for North American sheep may be as high as six or seven if it is a ram, or a maximum of four if it is a ewe.

Van Vuren and Coblentz (1989) proposed that the seasonal variation in home range size is associated with forage availability. Such variation was found for the feral sheep on Hirta which expanded their home range during fall and winter when vegetation was scarce (Grubb and Jewel, 1974). The same might be true for the Cyprus mouflon since in summer and early fall when vegetation is most rare and has the lowest protein content (see chapter 2.C). In the case of the radiocollared female her summer home range had increased which adds support to the hypothesis. The hypothesis is also supported by the female at the edge of the forest since during summer she had a smaller home range than the female inside the forest. It seems that the home range of the Cyprus mouflon is similar to the European mouflon (O. g. musimon) on the island of Corsica which may remain the year round within an area of 1 to 2 km (Pfeffer, 1967). It is also similar to that of the feral sheep of Santa Cruz Island off Southern California ($\bar{X}$=207±30 ha for males, 148±80.7 for females) (Van Vuren and Coblentz, 1989), but smaller than the sheep of Hawaii ($\bar{X}$=627 ha) (Griffin, 1976). Compared to the Hirta sheep (range 5-24 ha) (Grubb and Jewell, 1974) it is larger. Although the number of animals observed was rather small, the existence of home ranges similar to the size of other races of wild sheep, and the overwhelming evidence from other studies that sheep are faithful to their seasonal home range, indicates that

there should not be any association of the animals living at the centre of Paphos forest with the animals at the edge because the distance between the two areas is larger than their home range areas. To confirm this, radiotracking using a helicopter would be necessary.

Figure 2.1 Home range of a two year old female at Stavros tis Psokas Forest Station.

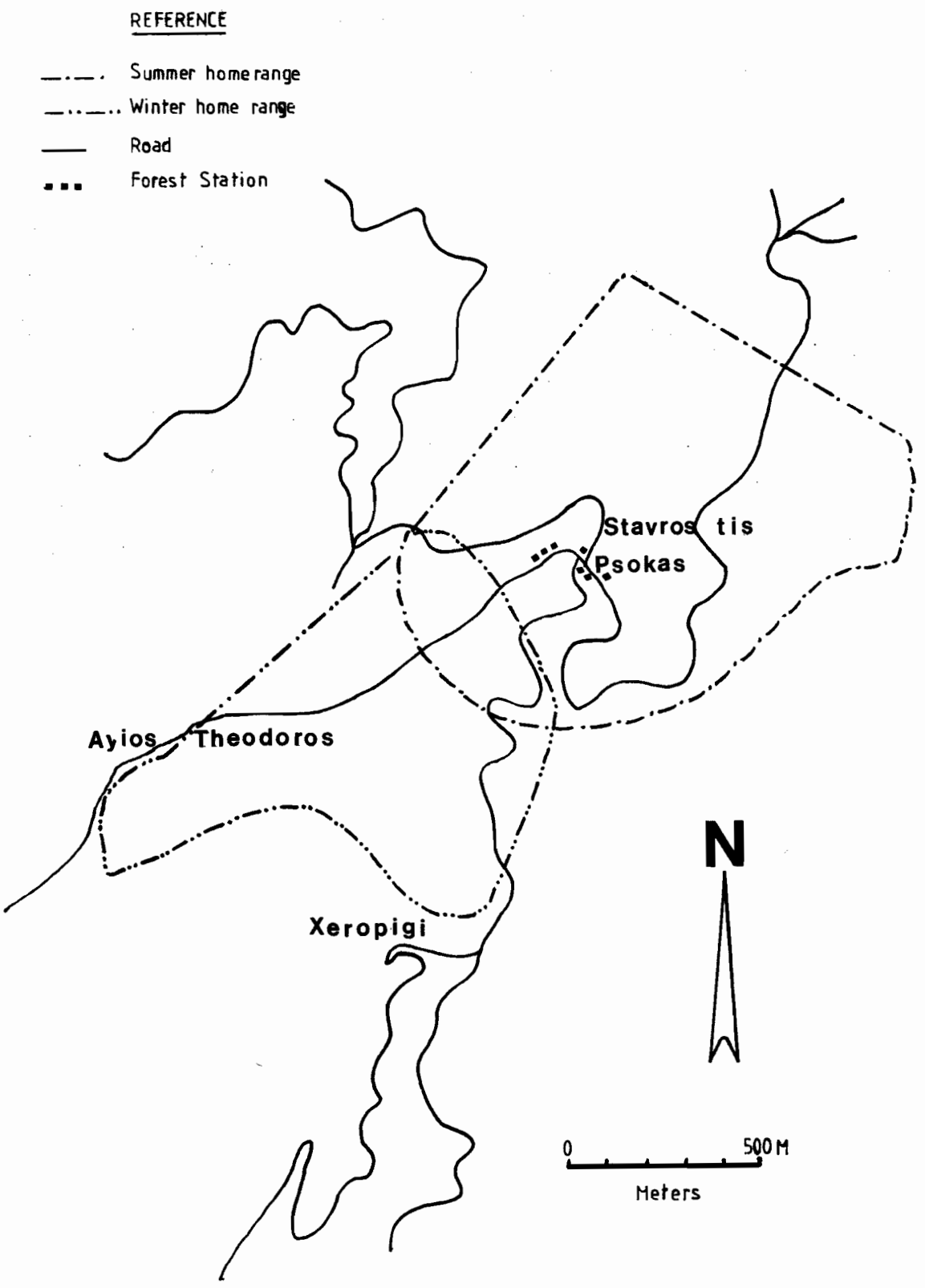
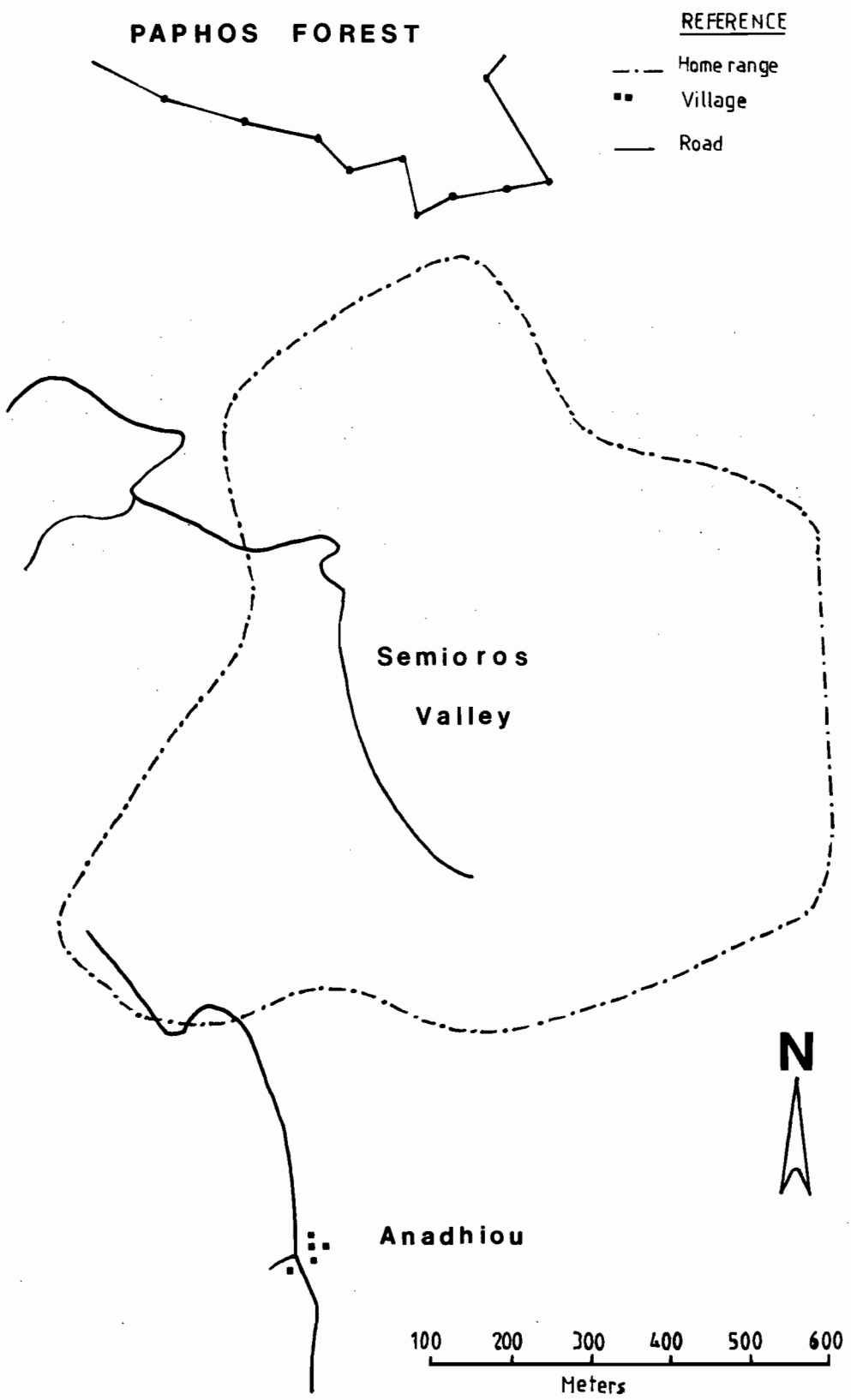

REFERENCE
Summer home range
Winter home range
Road
Forest Station
Stavros tis Psokas
Ayios Theodoros
Xeropigi
N
0
500 M
Meters

Figure 2.2 Home range of a female mouflon near the village of Anadhiou during summer 1988.


PAPHOS FOREST
REFERENCE
Home range
Village
Road
Semioros
Valley
N
Anadhiou
100
200
300
400
500
600
Meters

2.B. FOOD HABITS

2.B.1 INTRODUCTION

Wild sheep prefer to feed on grass and forbs when they are available but they may also consume a wide variety of leaves from shrubs and trees (Blood, 1967; Pfeffer, 1967; Hoefs, 1974: Schaller, 1977; Shank, 1982; Shackleton, 1985; Maisels, 1988). Most sheep however, live in the open steppe or low scrub country (Geist, 1977; Schaller, 1977). The Corsican and Sardinian mouflon on the other hand are considered to be forest species and their diet consists mainly of shrubs and leaves of trees (Pfeffer, 1967). The Cyprus mouflon unlike others of its species live in one of two habitats, forest or forest-agriculture interface. The objective of this section was to determine if the habitat differences of the 2 areas was reflected in diet differences. I predicted that proportionately more woody material and fruit would be found in the diet of the forest dwellers (FD) than in the diets of those animals of the forest edge (FE).

2.B.2 METHODS AND MATERIALS

Food habits have been studied by observing feeding animals, by checking sites at which animals foraged and by analyzing rumen or faeces samples (Schaller, 1977). Faeces analysis is known to underestimate the intake of highly

digestible species and to overestimate less digestible species (Stewart, 1967; Todd and Hansen, 1973; Mclnnis et al. 1983; Bullock, 1985). Faeces analysis was used by Maisels (1988) to study the diet of the woodland Cyprus mouflon. However, since a large number of rumen samples were available from animals killed by poachers, dogs, accidents and other causes, feeding habits of both populations were studied by analyzing their rumen content. In addition, mouflon were observed while feeding and the sites where animals had foraged were examined.

The contents of 24 rumens were examined. The larger, easily identified items were extracted before the smaller well masticated ones. Tiny seeds such as those of Cistus spp. and small species of plants were collected by adding water to the stomach contents and agitating it until the small lighter pieces floated to the top. The portion of the remaining rumen content which was retained by a 2 mm mesh screen was used for analysis. After segregation, the materials were air dried, packed with a plunger and the volumes measured in graduated cylinders (Korschgen, 1980). All items were identified by comparing them with reference material collected from the Paphos forest.

Stomachs were collected from all seasons. Data on feeding habits at the lambing grounds were also collected during spring by watching feeding sheep with 20x60 binoculars. Each animal was watched for 15 minutes or until it was lost from view (Altmann, 1973). The plants selected

and the number of seconds fed on each plant were noted.

2.B.3 RESULTS AND DISCUSSION

Data could be compared between the two study areas only during fall and winter (Fig. 2.3) since no stomachs were collected from the FE during spring (Table 2.1) and from the FD during Summer (Table 2.2). The only food items which account for more than 5% of the diet of the FE mouflon during the fall are grasses, forbs and grape leaves whereas in winter they are grasses and forbs. The diet of the FD consists of grasses and forbs and a broader variety of items in both seasons. During fall their diet includes storax (Styrax officinalis), asphodel (Asphodelus aestivus), moss and fruits and in winter, fruits, sumach (Rhus coriaria), rock rose (Cistus monspeliensis and C. villosus creticus), and green-brier (Smilax asperea). This greater variety possibly reflects the forested habitat in which mouflon lives, or a lack of grass in the forest. The most common fruit in the diet of the FD are acorns. However, the volumes presented for acorns in my analysis are underestimated because usually only peels were measured since the flesh of the fruit was digested.

Considering the data for the FE animals which I supplemented with visual data, it appears that the wild sheep of Cyprus eat more tree leaves in the spring, but decrease

their consumption through summer, winter and fall.

Inside the forest, edible plants with high protein content such as the Smilax asperea, were eaten wherever the sheep could reach in some areas. However, considerable amounts were eaten only in winter (6.4% of the diet). The low percentage in the diet might be due to the fact that since this plant was already overbrowsed, it was not readily available. The same plant at the edge of the forest was eaten occasionally, mainly during fall (3.3% of the diet), but, was never overbrowsed. The spring diet of the FD consists of grasses and forbs along with 20.2% leaves of strawberry trees (Arbutus andrachne).

Since there were no rumens available from the FE during spring, I had the opportunity to collect data on feeding habits by observing females feeding for four hours and 37 seconds at the lambing ground of Kremmos tou Pakhniouti (Table 2.3). The main item in their diet consisted of forbs and grasses (72.2%), followed by leaves from storax (6.1%).

The females on Kremmos tou Aphoriti fed primarily on forbs and grasses, using also strawberry trees occasionally.

Pfeffer (1967) examined the feeding habits of mouflon on Corsican maquis habitat that had been burned seven years earlier. He quantified his results by recording the number of occasions that sheep were seen feeding on particular plants. Pfeffer states that there was snow cover

during part of the winter, forcing the animals to feed on broadleaves (mostly strawberry tree Arbutus unedo) which he estimated comprised 52% of their diet. My results support Pfeffers observations that mouflon feeds on strawberry trees particularly in the spring, but not in winter as he had found. Maisels (1988) states that mouflon in Cyprus were never observed to feed on Arbutus, however, this was a plant that could not be specifically identified in the faeces (Maisels, loc. sit.).

As an interesting side note, Maisels did not report any fruit being in the diet of the Cyprus mouflon. Since faeces analysis is known to underestimate the intake of highly digestible species and to overestimate less digestible species (Stewart, 1967; Todd and Hansen, 1973; Mclnnis et al. 1983; Bullock, 1985) it is possible that fruit being highly digestible, might not appear in her results.

Other quantitative published results of mouflon (Ovis gmelini musimon) diet are those of Mottl (1960) and Pfeffer (1967) (Fig. 2.4). Mottl examined the stomachs of 67 Corsican mouflon which had been introduced into Czechoslovakia in a habitat combining areas of pasture, conifer belts and deciduous woodland. He found that their main food consisted of forbs and grasses. Both Maisels (1988) and my study conclude that mouflon in Cyprus ate more grasses and forbs than the sheep of Europe. Cyprus mouflon also ate fewer shrubs except in winter. Trees com-

posed about 33% of the diet of the Czechoslovakian mouflon in the winter, 18% in spring, and 7-11% in summer and fall.

The findings in this section confirm the hypotheses that in the diet of the FD mouflon one would expect to find a greater variety of woody materials and fruit than in the diet of the FE mouflon.

Table 2.1. Principal Foods of Cyprus mouflon at the edge of Paphos Forest, by Season From November 1985 -December 1988, based on rumen analysis.

Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	0	1	2	3
	%	%	%	%
Mushrooms (*Polypore* spp.) pileus	--	0.0	tr	0.0
Puff balls (*Lycoperdon* spp.)	--	0.0	tr	0.0
Lichen	--	0.0	0.0	tr
Moss	--	0.0	0.0	tr
Horse-tails (*Equisitum* sp.) leaves	--	5.2	0.0	0.0
Bracken fern (*Pteridium aquilinum*) fronts	--	0.0	0.0	tr
Pine (*Pinus brutia*) needles, bark, roten wood	--	0.0	0.5	0.0
Rock rose (*cistus* spp.) leaves	--	0.0	tr	0.0
Thorny broom (*Calycotome infesta*) leaves	--	tr	tr	0.2
Common vine (*Vitis vinifera*) fruit	--	0.0	5.5	0.0

Table 2.1 continued

Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	0	1	2	3
	%	%	%	%
Alfalfa (*Medicaggo arborea*) leaves	--	0.0	1.7	0.0
VIcia sp.	--	0.0	0.0	0.2
Turbentine tree (*Pistacia terebinthus*): fruit	--	0.0	0.0	tr
leaves	--	0.0	tr	0.0
Brumble (*Rubus sanctus*)	--	0.0	tr	0.0
Myrtle (*Myrtus communis*) leaves	--	0.0	tr	0.0
Rubia tenuifolia leaves	--	tr	0.6	0.2
Thistle (*Carthamus* spp.) leaves	--	0.5	0.0	0.0
Strawberry tree (*Arbutus andrachne*) leaves	--	0.0	0.0	tr
Storax (*Styrax officinalis*): leaves	--	tr	0.0	0.0
fruit	--	5.2	2.8	0.0
Lithodora hispitula leaves	--	tr	tr	tr
Teucrium kotschyanum	--	0.0	0.0	0.1

tr=trace

Table 2.1 continued

Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	0	1	2	3
	%	%	%	%
Sumach (*Rhus coriaria*) seeds	--	0.0	0.0	0.0
Hermes oak (*Quercus coccifera*): leaves	--	tr	0.0	0.0
acorns	--	0.0	0.0	tr
Olive (*Olea europea*): leaves and twigs	--	10.5	tr	3.9
fruit	--	0.7	0.0	0.4
Carob (*Ceratonia siliqua*) fruit	--	5.2	0.0	0.0
Smilax (*Smilax asperea*) leaves	--	tr	3.3	tr
Seeds, unclassified	--	tr	0.0	0.0
Asphodel (*Asphodellus aestivus*) leaves	--	0.0	tr	0.3
Grass and/or sedge leaves plants	--	73.3	82.6	92.5
Stones (migrogabrons)	--	0.0	0.0	0.5
Total	--	99.9%	99.3%	99.5%

tr=trace

Table 2.2. Principal Foods of Cyprus mouflon at Paphos Forest, by Season From November 1985 -December 1988, based on rumen analysis.

Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	4	0	7	7
	%	%	%	%
Mushrooms (*Polypore* spp.) pileus	0.0	--	0.2	0.4
Lichen	0.0	--	0.0	tr
Moss	0.0	--	5.6	0.9
Bracken fern (*Pteridium aquilinum*) fronds	0.0	--	0.5	tr
Fern, unclassified-fronds	0.0	--	0.0	tr
Pine (*Pinus brutia*) needles	0.0	--	0.6	2.1
Rock rose (*Cistus* spp.):				
leaves	0.0	--	4.0	28.7
dry fruit	0.0	--	4.5	0.3
Sumach (*Rhus coriaria*) seeds	0.0	--	1.3	0.7
Hawthorn (*Crataegus azarolus*) Leaves	0.0	--	0.0	tr

tr=trace

Table 2.2 continued

Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	4	0	7	7
	%	%	%	%
Bramble (*Rubus sanctus*)	0.0	--	tr	tr
Myrtle (*Myrtus communis*) leaves	0.0	--	0.0	tr
Rubia tenuifolia leaves	tr	--	0.0	tr
Thistle (*Carthamus* spp.) leaves	0.0	--	0.2	tr
Strawberry tree (*Arbutus andrachne*) leaves	20.2	--	1.0	0.4
Climatis spp.	0.0	--	0.0	3.3
Storax (*Styrax officinalis*):				
leaves	0.0	--	5.5	1.9
seeds	0.0	--	0.0	2.3
Lithodora hispitula leaves	tr	--	tr	0.3
Teucrium ktschyanum	2.4	--	0.0	1.7
Golden oak (*Quercus alnifolia*) acorns	0.0	--	5.0	7.6

tr=trace

Table 2.2 continued

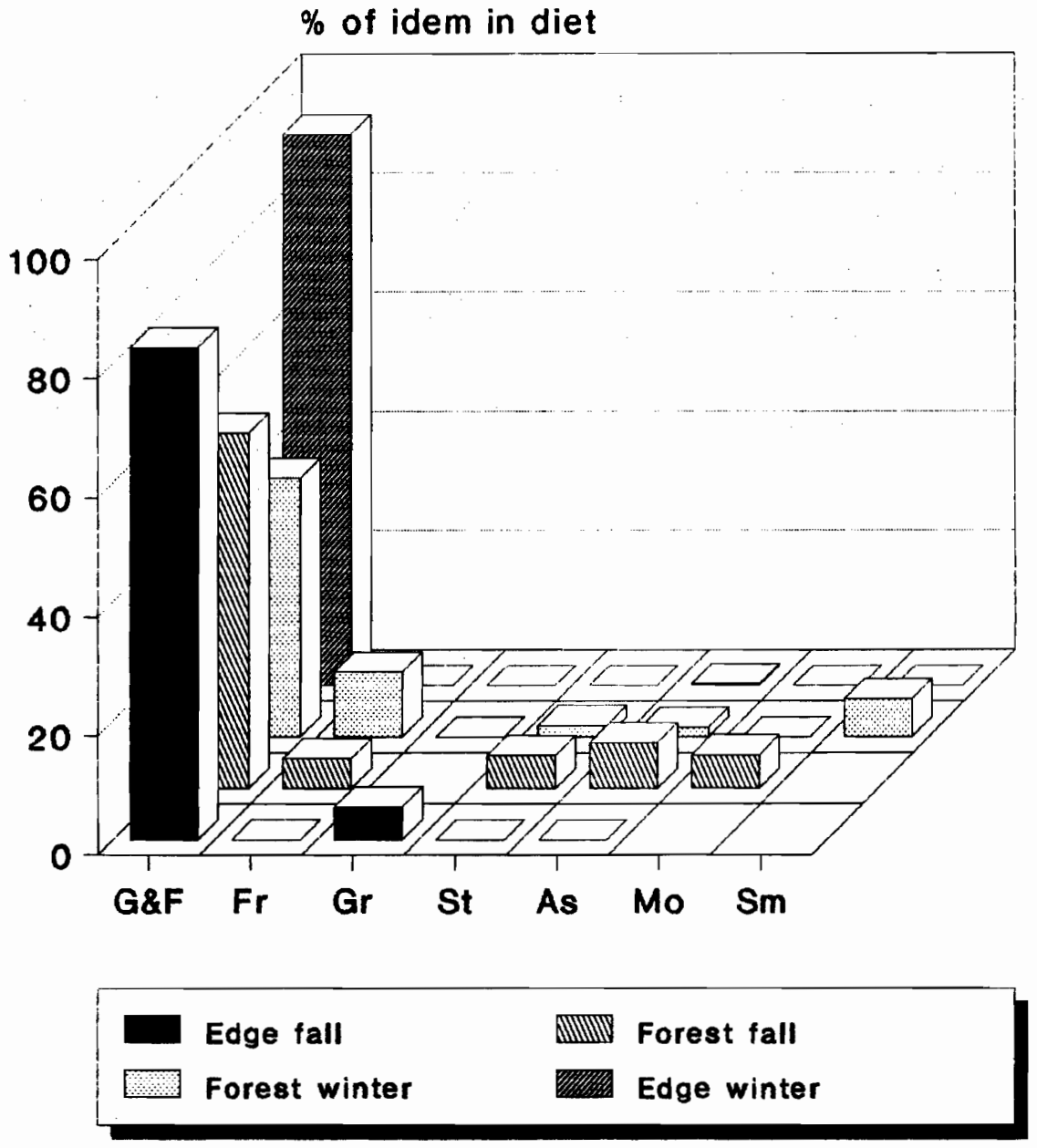
Food items and parts eaten	Spring	Summer	Fall	Winter
No. of samples:	4	0	7	7
	%	%	%	%
Smilax (*Smilax asperea*) leaves	1.1	--	1.2	6.4
Asphodel (*Asphodellus aestivus*) leaves	0.0	--	7.7	1.6
Grass and/or sedge leaves-plants	68.2	--	40.2	37.6
Forbs, unclassified-plant	1.2	--	19.4	5.8
seeds, unclassified	0.0	--	tr	0.0
Stones (migrogabrons)	0.3	--	1.3	0.0
snails	0.0	--	tr	tr
Beetles	0.0	--	tr	tr
Total	99.0	--	98.0	99.0

tr=trace

Table 2.3. Principal foods of Cyprus mouflon females at the lambing ground of Kremmos tou Pakhniouti during April, based on visual observations (number of minutes spent feeding on each plant species).

Forage species	Minutes	%
Pinus brutia (flowers)	6.00	2.2
Olea europea (leaves)	5.00	1.8
Styrax oficinalis	17.00	6.1
Pistacia terebinthus	11.40	4.1
Poterium spinosum	9.20	3.3
Grass and forbs	200.15	72.2
Kalikoton sp.	11.05	4.1
Asphodellus aestivus	0.10	1.0
Bush - not classified	9.30	3.3
Total number of minutes	277.35 (4h. 37min.)	

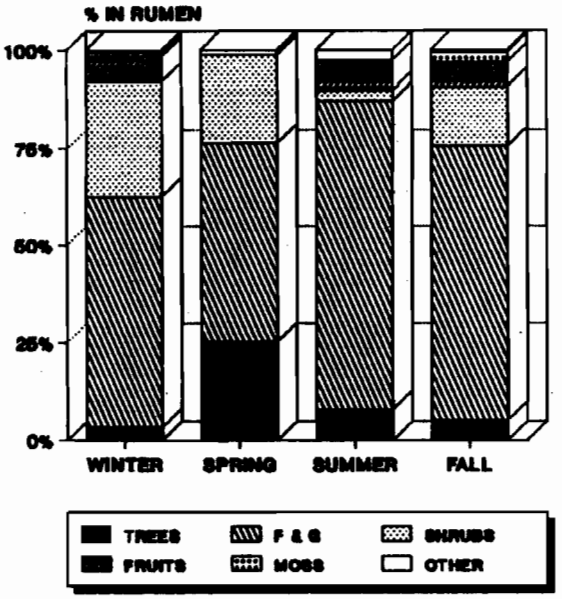
Figure 2.3. Principal foods of Cyprus mouflon inside and at the edge of Paphos Forest during fall and winter as determined from analyses of 24 rumens 1985 -1989.



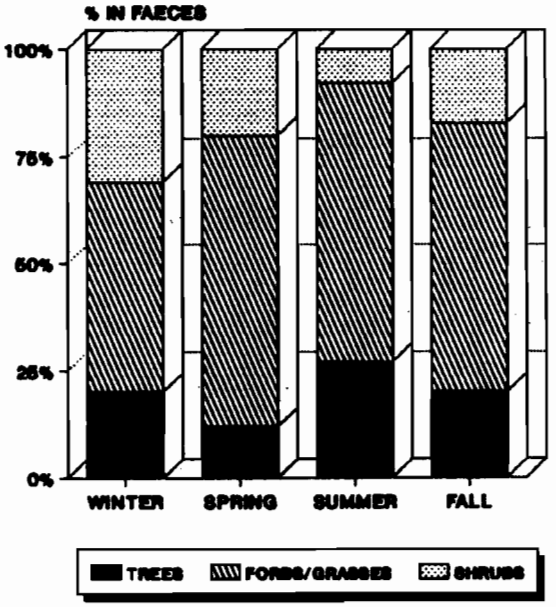
G&F:grass & forbs; Fr:fruit; Gr:grape
St:storax; As:asphodellus; Mo:moss;
Sm:smilax

Figure 2.4 Principal foods in the diet of mouflon from Cyprus (this study; Maisels 1988), Corsica (Pfeffer, 1967) and Chechoslovakia (Mottl, 1960).

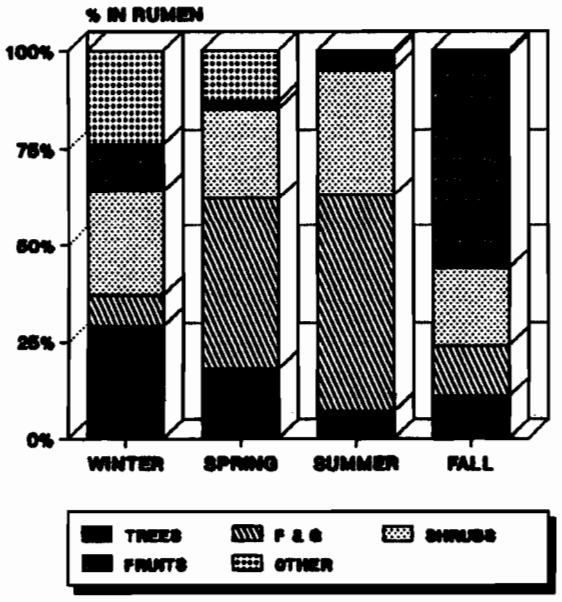
CYPRUS
(This study)



CYPRUS
(Maisels,1988)

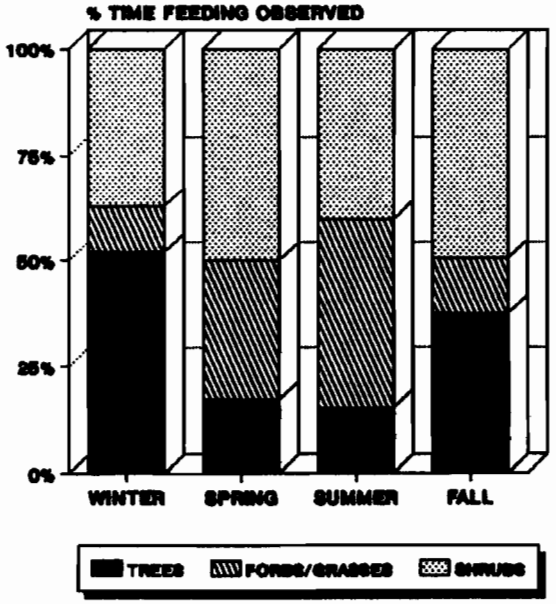


CZECHOSLOVAKIA
(Mottl, 1960)



F & G: FORBS AND GRASSES

CORSICA
(Pfeffer, 1967)



2.C NUTRIENT CONSTITUENTS OF FOODS CONSUMED BY CYPRUS MOUFLON

2.C.1 INTRODUCTION

As pasture forage matures, the protein content declines, fiber increases, and both forage intake and digestibility decline (NRC, 1985). Type and composition of plants at any location in pastures or ranges is dependent on type and composition of the parent soil, as well as moisture, radiant energy available for growth, and previous and present management of the area. Soils inherently low in a given element often will produce plants low in that element, and thus, a deficiency of the element may occur in the diet of animals. Maisels (1988) examined a number of plants in Paphos forest for moisture, digestible and crude protein, phosphorus and potassium. According to her findings mouflon may not have found enough digestible protein for maintenance during late summer, and may be deficient in phosphorus in August. Potassium did not appear to be a limiting nutrient at any time of the year.

Although the body contains many mineral elements, only 15 have been demonstrated to be essential for sheep (NRC, 1985). Seven are major mineral constituents: sodium, chlorine, calcium, phosphorus, magnesium, potassium, and sulfur. The other eight are trace elements: iodine, iron, molybdenum, copper, cobalt, manganese,

zinc, and selenium. Possible macromineral and/or micromineral deficiencies in the diet can cause health problems, reduce growth, or cause infertility (Moustgaard, 1959; NRC, 1985).

The objective of this section was to determine if there were nutrient or mineral deficiencies of the forage plants in either area based on the requirements recommended for sheep by NRC (1985).

2.C.2 METHODS AND MATERIALS

In the summer and fall of 1988, and in the winter, spring and summer of 1989, 85 samples of forage species were collected and analyzed for nutrient content. Selection for analyses was based on plants which occurred in the rumen and on visual observations of mouflon while feeding in the wild. Samples were collected from the valley of Ayios Theodoros, an area of 2 sq. km adjacent to Stavros tis Psokas Forest Station. Samples were also collected in the valley of Semioros near the village of Anadhiou. Leaves and fruit of styrax and turpentine tree (terebinth) were collected from the area near Kremmos tou Pakhniouti because they were not present in Semioros valley. All species collected were seasonally important in the diet. Plant material collected mimicked plant parts selected by mouflon sheep. Plant collections were made over a one to two day period. At least 100 g (fresh

weight) of plant material was harvested from a minimum of 25 individuals of each species, with the exception of Mediterranean medlar (Crataegus azarolus) fruit, which had a very bad crop year. In this case Fruit was collected from only 3 trees. Efforts were also made to collect plants from different slopes and aspects.

Samples were kept for about two days at ambient temperature until received at the Chemical Laboratory at the Ministry of Agriculture in Nicosia. Plant material was frozen and stored at -20 C until analyzed. Dry matter was determined by heating samples to a constant weight in a convection oven at 60 C for 24 hours. Dried material was then ground to a powder with a laboratory mill for further analytical procedures. Zinc, Copper, Iron, Molybdenum, Manganese, (ppm, mg/kg of diet dry matter)and Calcium (Ca percentage of dry matter) were determined with a Perkin Elmer atomic absorption spectrophotometer, after a 1g sample was "wet digested" with a mixture of 10 ml of Nitric-percloric acid. In the case of Ca, Lathanum oxide (La2O3 10%) was added to the sample. Sodium, potassium, and phosphorus, (percentage of diet dry matter) were determined by using a Corning-EEI flame photometer. Nitrogen content was determined by using the Kjeldahl method. Crude Protein content (CP) was estimated by multiplying the Nitrogen content by 6.25 (percentage of diet dry matter, Horwitz, 1960). Sulfur (percentage of dry matter) was determined by using the "dry ashing-barium

sulfate method". Due to technical difficulties, the microminerals Iodine, Cobalt, Selenium and Fluorine were not examined.

To determine if there were any macromineral or micromineral deficiencies or intolerable levels in the samples analyzed, the results were compared with the values presented by NRC (1985, Tables 6 and 7).

2.C.3 RESULTS AND DISCUSSION

The data for the chemical analyses of crude protein and macrominerals at the edge of the forest are presented in Table 2.4, and those for inside the forest are in Table 2.5. The data for micromineral analysis are presented in Table 2.6 for the edge of the forest and in Table 2.7 for inside the forest.

2.C.3.1 Protein

The minimum crude protein, levels for sheep maintenance are 5-7% (Agric. Res. Council, 1965; Mould and Robbins, 1981; Robins et al. 1975). Grass in winter has the highest protein content, but drops in spring and again in fall. In winter, no green grass was available inside the forest therefore dry grass from the previous year was analyzed. Grasses as well as forbs and non-graminaceous monocots (including Asphodellus) have their maximum

digestibility in the wettest part of the year (November, January and February) (Torgerson and Pfander, 1971; Drozdz, 1979; Hobbs et al. 1981; Maisels, 1988), which is also the time when they contain the highest protein levels. Toward the end of the spring at the forest edge, grass protein levels fell to just above the minimum requirements, whereas inside the forest the levels were below the minimum requirements. In September, grass protein levels were below the maintenance requirement levels in both areas.

During late summer and early fall mouflon must rely on other plants to supplement their protein needs. During late summer, the only plants with more than 7% crude protein were broadleaved trees. However, the maintenance threshold for digestibility requirements is 50% and all trees selected by mouflon in Paphos forest in Summer and fall were below the requirement level (Maisels, 1988). Because trees are of low digestibility mouflon may not have found enough digestible protein for maintenance during late summer and early fall. During this time all animals observed were in poor condition. From 32 animals collected dead none had any back-fat or kidney fat (Personal observation).

Some of the trees (Pistacia terebinthus, Prunus amygdalus and Styrax officinalis) had their highest CP levels in spring, with only a minor increase in October or November, when the rain starts. Fruits of trees and

shrubs did not contain more than 7% crude protein.

The energy cost of vertical travel is approximately 10 times the energy cost for horizontal travel (6.86 cal/m/kg body weight versus 0.59 cal/m/kg body weight; Clapperton, 1964). Also, as density of grazeable forage decreases or distance to water increases, the energy needed to satisfy daily requirements increases. During summer many springs inside the forest dry up. In the agriculture are however, besides natural springs and water holes, mouflon make regular use of water troughs set by shepherds for domestic sheep, or water reservoirs for watering gardens, decreasing the need for great travel to find water. Starvation involving severely restricted intake involves both protein and energy deficiencies, since under such circumstances available protein is utilized to provide energy (Jubb et. al., 1985). The animals inside the forest, living on steeper slopes therefore need much more energy than the animals at the edge of the forest. Therefore, during the season when there is possible protein shortage the stress might be higher for the animals inside the forest living on steep slopes.

2.C.3.2 Calcium

The minimum requirements for Ca is 0.20-0.82% of diet dry matter (N.R.C., 1985). Grasses and forbs were above the minimum requirements for calcium at both study

areas. In addition most plants at both study areas, particularly the leaves of trees were within or above the normal requirements of calcium for sheep therefore, mouflon are not expected to have Ca deficiency.

2.C.3.3 Phosphorus

The minimum requirements for P is 0.16-0.38% of diet dry matter (N.R.C., 1985). The phosphorous levels for grasses and forbs, as well as all the other plants examined in both areas during winter and spring were above the minimum requirement. However, in late summer and early fall grasses and forbs were below the minimum requirement levels. With the exception of the fruit of Rhus coriaria (which was present only inside the forest) and Cistus sp. no other plant selected by mouflon was above the requirement level for sheep maintenance from August to September. When all the plants were low in P some animals inside the forest ate some of the Rhus and Cistus seeds. It is unknown how much this diet could make up for the possible deficiency observed in the other forage species.

Grasses and forbs do not start growing until the first rains, usually in September or October, and sometimes in November. Growth inside the forest is much slower than at forest edge. New growth is rich in phosphorous, so it is possible that a phosphorous deficiency

during late summer and early fall might depend on the time and amount of the first rainfall.

There are no clear-cut symptoms which can be ascribed to phosphorus deficiency in grazing sheep (Cole, 1966). Approximately 80% of the phosphorus in the body of a sheep is present in the bones and teeth, indicating the importance of an adequate supply for sound bone and teeth development. Therefore, retarded growth as well as poor bone and teeth development are symptoms to be expected. In Australia most soils and pastures are deficient in phosphorus, but there is no evidence that phosphorus deficiency occurs in grazing sheep in Australia (Cole, 1966). It was thought that provision of a phosphorus lick to sheep grazing on phosphate-deficient country would produce beneficial results in the form of better growth of the sheep and better bone structure but this has not been demonstrated in the trials that have been carried out. However, it has been shown that top dressing deficient soils with superphosphate benefits grazing sheep but this does so by promoting better growth of pasture, thus improving the diet of sheep as a whole. Dietary calcium and phosphorus are absorbed according to the nutritional needs of the animal, and on a low phosphorus diet the efficiency of absorption is increased and the salivary secretion is reduced (Care et al., 1980). Differences have been observed in absorption of phosphorus within and between breeds of sheep. These differences appear to be

partly inheritable and vary as much as twofold (Field et al., 1983; Field, 1984). Since no work was done on the phosphorus absorption in Cyprus mouflon its efficiency is unknown and the extent that its physiology can overcome a phosphorus shortage during summer and fall still needs to be examined.

2.C.3.4 Sodium

The minimum requirement for Na is 0.09-0.18% of diet dry matter (NRC, 1985). Mouflon might be deficient in sodium, particularly at the edge of the forest during late Summer and early Fall. This is because grasses were within or above the requirement level for maintenance in winter and spring but not in late summer and early fall.

Some plants have a higher content of sodium probably because diabase, the main rock formations inside the forest, is richer in sodium than pentonites which form a big part of the area near Anadhiou village (Table 2.8). For example, Asphodellus aestivus, Teucrium kotchyanum and Pteridium aquilinum at the edge of the forest have concentrations above the required Sodium level in winter and spring but not in September. Inside the forest however, the Sodium content of these plants is above the maintenance requirement throughout the year. It is possible that mouflon might be able to reduce their shortage of sodium by feeding on plants rich in this mineral such

as ferns which are the main cover plants in the river beds inside the forest. In some animals up to 10% of their rumen content were found to be ferns (Chapter 2, section B).

All tree leaves, fruits and shrubs analyzed , with the exception of almond (Prunus amygdalus) in May, were below the requirement maintenance level for sheep at both study areas all year. Sodium serves many functions in the body (NRC, 1985). With chlorine (Cl) it maintains osmotic pressure, regulates the acid-base balance and controls water metabolism in tissues. Sodium occurs primarily in extracellular fluids and bones. Several dietary and metabolism studies have been conducted to determine the sodium and /or salt requirements of sheep. McClymont et al. (1957) reported that the addition of 1.2 to 2.6 g of sodium per day (as sodium chloride) to the diet of very thin wethers fed on low sodium grain diet increased growth rate.

2.C.3.5 Potassium

Potassium was above the required levels for sheep (0.50-0.80% of diet dry matter, NRC, 1985) throughout the year in all plants with the exception of grasses and pine tree needles in early fall. All fruits were within the required levels. During fall when grasses were low in K mouflon is known to feed on an increased percentage of

fruits. In this way a possible K deficiency is reduced.

2.C.3.6 Magnesium

Most plants were within or above the required levels for magnesium (0.12-0.18% of diet dry matter, NCR, 1985) throughout the year with the exception of grasses which were just below the minimum in summer and early fall. During early summer and early fall most of the other plants such as moss, storax, sumach seeds, and Teucrium kotschyanum at both study areas were above or within the required level for mouflon. It is possible that the deficiency seen in grasses might be reduced from foraging on other species. Interestingly after examining 30 mouflon carcasses from both study areas, none was found to suffer from tetanus, which is a classic sign of magnesium deficiency (NRC, 1985).

2.C.3.7 Sulfur

The minimum requirements of sheep for sulfur are 0.14-0.26% of diet dry matter (NRC, 1985). Grasses were analyzed for sulfur in winter, summer and fall. Most of the grasses analyzed inside the forest, with the exception of Polypogon sp. were below the minimum maintenance level for sheep. At the edge of the forest green grass in December and February are above the minimum requirement

for sheep.

Grasses seemed to be higher in sulfur content at the edge of the forest than inside the forest and most of them were above the required level for sheep. The rest of the plants analyzed at the edge of the forest were were deficient in early fall. Inside the forest most plants were deficient in all seasons examined, with the exception of Styrax officinallis in spring and Smilax asperea and Teucrium kotchyanum in late Summer and early fall. It seems that the population at the edge of the forest should have fewer problems with a possible deficiency since the plants there contain more sulfur than those inside the forest. The fact that the mouflon at the centre of the forest make extensive use of Smilax asperea and Teucrium kotchyanum to the extent of occasionally overbrowsing it, and that these plants are usually ignored at the forest agriculture interface, might indicate that the animals inside the forest get their sulfur by selecting plants high in sulfur.

The signs of sulfur deficiency are similar to the signs of protein deficiency (loss of appetite, reduced weight gain or weight loss, and reduced wool growth). In addition to the signs of protein deficiency, they include excessive salivation, lacrimation, and shedding of wool. In extreme cases, emaciation and death may occur (Goodrich et al. 1978). Because sulfur is necessary for the synthesis of the sulfur-containing amino acids (methionine

and cysteine) and B-vitamins during microbial digestion in the rumen, rumen microorganisms that are deficient in sulfur do not function normally. Addition of sulfur in such cases increases feed intake, digestibility, and nitrogen retention (Bray and Hemsley, 1969; Bird 1974; Guardiola et al. 1983).

2.C.3.8 Iron

The iron requirement of sheep is 30-50 ppm of diet dry matter (NRC, 1985). Grasses and forbs as well as all other plants were above the minimum requirements for iron.

2.C.3.9 Copper

The minimum requirement of sheep for copper is 7-11 mg/kg of diet dry matter. Grasses and forbs were above the minimum requirement levels for copper in winter and spring with the exception of Asphodellus aestivus and Avina sterilis in May. In September grasses were above the minimum requirements

At the edge of the forest most of the plants analyzed were just above the requirement levels. Lithodora hispitula analyzed in August, and grasses were below the requirement level in September. At the Stavros tis Psokas area most of the plants were high in copper in spring and winter and low in late summer and fall with the exception

of mosses, and Teucrium kotchyanum which were within the requirement levels. The fruits of Styrax asperea and the fruits of Cistus were also within the requirement levels. As was mentioned earlier mouflon feed on considerable amounts of mosses (up to 10% was found in some rumens) and also fruits of Styrax asperea in the fall. This might help the animals meet their copper requirements.

2.C.3.10 Manganese

The minimum requirement of sheep for manganese is 20-40 ppm of diet dry matter (NRC, 1985). Grasses and forbs were above the minimum requirements for manganese throughout the year. Fruits generally were below the requirement levels but leaves from trees were above. Therefore mouflon should not have any manganese deficiencies.

2.C.3.11 Zinc

The minimum requirements of sheep for zinc is 20-33 ppm of diet dry matter (NRC, 1985). Grasses with the exception of dry Hordeum vulgare in winter are above the minimum requirement levels for sheep at the edge of the forest. Inside the forest all grasses examined were above the minimum. With the exception of Smilax asperea, Pistacia terebinthus, and Asphodellus aestivus in late

summer and early fall, the rest of the plants examined at Stavros tis Psokas areas met the minimum requirement levels for sheep throughout the year. However, the plants at the edge of the forest were also low in zinc in May.

Black grapes (Vitis vinifera) were below the minimum requirements for sheep while white grapes (V. vinifera) were above. From personal conversations with grape producers I was told that mouflon usually prefer to eat white grapes.

In summary although the grasses and forbs could provide most necessary protein and mineral nutrients there were notable seasonal shortages. The animals were probably deficient in protein, and some nutrients because they did not eat considerable amounts of the other plants which could have increased their intake over the minimum level. There were cases during the season of the highest protein and mineral shortage when mouflon increased their intake of specific plants with higher content of the needed minerals. However, it must be understood that mouflon might have had some limiting factors that prevented them from increasing their intake of other plants such as ferns, and rock rose. The factors affecting the edibility of the plants of Paphos are discussed in the section 2.E.

Many wild animals are attracted to salt and mineral supplement blocks and it is thought that this is because they have a mineral need (i.e. their diet does not contain the minimum requirements). In the section 2.D I present the results of tests using mineral supplements.

Table 2.4a Crude protein and macromineral content of plant species by season, at the edge of Paphos near Anadhiou village (percentage of diet dry matter).

Species	Month	Mineral				
		C.P.	Na	K	Ca	Mg
Pinus brutia						
flowers	March	8.8	0.052	1.25	0.30	0.26
Cistus monspeliensis						
flowers	March	6.3	0.064	1.30	0.62	0.43
flowers	March	7.9	0.078	1.30	0.62	0.45
leaves	December	8.4	0.076	0.56	0.65	0.27
Pistacia terebinthus	March	23.1	0.034	2.45	0.44	0.27
	May	11.5	0.080	0.93	0.80	0.17
	July			0.58	1.84	0.31
	September	9.5	0.050	0.95	0.14	0.06
Vitis Vinifera						
	May	17.1	0.140	1.97	1.47	0.16
	September	9.2	0.150	0.53	1.87	0.45
fruit black	September	3.0	0.005	0.95	0.14	0.06
fruit white	September	3.2	0.006	0.91	0.14	0.05
Genista sp.						
leaves	December	8.8	0.044	0.60	1.81	0.32
Crataegus azarolus fruit	December	1.2	0.088	1.16	0.27	0.10

Table 2.4a continued

Species	Month	C.P	Na	K	Ca	Mg
Prunus amygdalus						
	March	18.9	0.058	2.25	1.60	0.56
	May	13.3	0.160	1.67	2.40	0.35
	September	12.2	0.090	0.39	2.09	3.75
Trifolium stellatum						
	March	13.8	0.166	2.20	1.37	0.53
Trifolium uniflorum						
leaves, flowers	March	13.3	0.950	3.60	2.50	0.72
Styrax						
Officinalis	March	16.3	0.048	1.70	0.69	0.49
	May	11.5	0.160	0.83	0.76	0.21
	July		0.580	1.00	0.03	
	August	7.0	0.037	2.06	0.60	0.24
	August	1.9	0.037	1.44	0.49	0.19
Lithodora						
hispitula						
twigs	August	3.9	0.042	0.87	1.42	0.13
leaves	August	5.2	0.030	1.25	3.04	0.23
Olea europea						
leaves	August	7.2	0.030	1.19	1.21	0.20
fruit green	August	4.0	0.020	1.93	0.25	0.08
leaves	December	8.8	0.024	0.76	1.40	1.69
fruit black	December	2.5	0.028	2.08	0.10	0.04

Table 2.4a continued

Species	Month	C.P	Na	K	Ca	Mg
Quercus coccifera						
fruit	December	1.6	0.012	0.84	0.18	0.08
Quercus alnifolia						
fruit	December	3.0	0.014	0.64	0.12	0.06
Asphodellus aestivus						
	May	2.3	1.18	1.67	2.35	0.30
	September	2.2	0.30	0.70	1.38	0.38
Bromus madridensis						
leaves, seeds	March	13.8	0.052	2.10	0.46	0.25
Grass mix	February	14.0	0.160	2.72	0.35	0.12
	May	7.4	0.11	0.83	0.55	0.15
	July	2.4	0.64	0.10		
	September	2.3	0.050	0.20	0.27	0.10
	December	21.5	0.134	3.72	0.37	0.24
Hordeum vulgare						
	December	20.0	0.086	3.12	0.35	0.12
Avina sterilis						
	May	5.6	0.16	0.83	0.31	0.09
	September	2.5	0.060	0.20	0.19	0.06
Aegilops ovata						
	May	7.1			1.75	

Table 2.4b Crude protein and macromineral content of plant species (Cl, P, and S) by season, at the edge of Paphos forest near Anadhiou village (percentage of diet dry matter).

Species	Month	Mineral		
		Cl	P	S
Pinus brutia				
flowers	March	0.21	0.198	0.22
Cistus monspeliensis				
flowers	March	0.35	0.145	0.09
flowers	March	0.32	0.161	0.09
flowers	December	0.49	0.175	0.19
Pistacia terebinthus				
	March	0.10	0.511	0.22
	May	0.06	0.115	
	July	0.13		
	September	0.02	0.255	0.12
	December			
Vitis Vinifera				
	May	0.035	0.356	
	September	0.191	0.085	0.07
fr black	September	0.043	0.099	0.07
fruit white	September	0.064	0.099	0.06
Genista sp.				
leaves	December	0. 07	0.080	0.22

Table 2.4b Continued

	Month	Mineral		
		Cl	P	S
Crataegus azarolus				
fruit	December	0.10	0.093	0.09
Prunus amygdalus				
	March	0.07	0.341	0.16
	May	0.11	0.127	
	September	0.04	0.128	0.13
Trifolium stellatum				
	March	0.35	0.178	0.08
Trifolium uniflorum				
leaves, flowers	March	0.67	0.172	0.21
Styrax officinallis				
	March	0.07	0.330	0.22
	May	0.04	0.048	
	July	0.22		
	August	0.42	0.078	0.18
	August	0.04	0.074	0.10
Lithodora hispitula				
twigs	August	0.12	0.079	0.08
leaves	August	0.38	0.074	0.11

Table 2.4b Continued

Species	Month	Mineral		
		Cl	P	S
Olea europea				
leaves	August	0.35	0.110	0.15
fruit green	August	0.142	0.083	0.09
leaves	December	0.07	0.122	0.13
fruit black	December	0.21	0.135	0.06
Quercus coccifera				
fruit	December	0.03	0.080	0.04
Quercus alnifolia				
	December	0.10	0.063	0.10
Asphodellus aestivus				
	May	0.440	0.080	
	September	0.290	0.002	0.001
Bromus madridensis				
leaves, seeds	March	0.53	0.169	0.14
Grass mix	February	0.16	0.299	0.32
	May	0.305	0.048	
	July	0.53		
	September	0.92	0.021	0.08
	December	0.88	0.367	0.28
Hordeum vulgare	December	0.16	0.299	0.32
	May	0.411	0.035	
	September	0.099	0.005	0.07
Aegilops ovata	May	0.148		

Table 2.5a Crude protein and macromineral content of plant species by season, at stavros tis Psokas Forest Station (percentage of diet dry matter).

Species	M onth	C.P.	Macromineral Na	K	Ca	Mg
Moss	September	5.1	0.050	0.33	0.50	0.24
Pteridium aquilinum	September	3.4	0.120	1.14	0.37	0.37
Pinus brutia dry needles	August	6.0	0.027	0.37	0.84	0.21
Cistus sp. leaves	July			1.24	1.47	0.34
fruit	December	5.6	0.036	0.36	0.75	0.18
Cistus Villosus creticus flowers	May	8.3			0.74	
Pistacia terebinthus	March	23.6	0.036	2.40	0.64	0.35
	May	11.6			0.85	
	August	8.6	0.030	0.94	1.65	0.29

Table 2.5a Continued

Species	Month	C.P.	Macromineral Na	K	Ca	Mg
Rhus coriaria						
fruit	August	5.2	0.030	1.06	3.81	0.14
Arbutus Andrachne						
	September	6.4	0.022	0.60	0.75	0.26
	December	7.4	0.016	0.48	1.11	0.32
Styrax officinallis						
leaves	March	21.0	0.036	1.95	0.40	0.41
fruit	May	13.8			0.48	
leaves	September	8.1	0.020	0.65	0.45	0.33
fruit	September	1.9	0.022	1.27	0.24	0.14
Teucrium kotschyanum						
	May	9.0	1.730		1.25	0.28
	July			1.73	1.59	0.26
	September	7.1	0.030	1.06	0.87	0.21
Asphodellus aestivus						
	September	2.6	0.160	0.31	2.63	0.12

Table 2.5a Continued

Species	Month	C.P.	Macromineral Na	K	Ca	Mg
Smilax asperea						
	May	12.8			0.51	
	August	7.4	0.030	1.62	1.07	0.19
Grass mix						
	May	4.3			0.24	
	August	3.5	0.038	0.63	0.53	0.13
	September	1.6	0.100	0.39	0.17	0.09
dry inflorescence						
	December	2.8	0.091	0.80	0.32	0.14
Polypogon spp.						
	Decemer	1.6	0.046	0.48	0.18	0.16
Avina sterilis						
	December	2.3	0.168	0.84	0.36	0.15
Gynosurus echinatus	May	5.6			0.43	

Table 2.5b Macromineral content (Cl, P, S) of plant species by season, at Stavros tis Psokas Forest Station (percentage of diet dry matter).

Species	Month	Macromineral Cl	P	S
Moss	September	0.05	0.085	0.09
Pteridium aquilinum				
	September	0.78	0.013	0.17
Pinus brutia dry	August	0.42	0.140	0.11
Cistus sp. leaves	July		0.36	
fruit	December	0.07	0.154	0.08
Cistus villosus				
creticus flowers	May		0.208	
Pistacia terebinthus	March	0.14	0.572	0.09
	May		0.165	
	August	0.48	0.078	0.11
Rhus coriaria fruit	August	0.02	0.157	0.08
Arbutus andrachne	September	0.02	0.077	0.09
	December	0.03	0.134	0.08
Styrax officinallis				
leaves	March	0.07	0.410	0.24
fruit	May		0.136	
fruit	September	0.35	0.051	0.14
fruit	September	0.53	0.013	0.10

Table 2.5b continued

Species	Month	Macromineral		
		Cl	P	S
Teucrium kotschyanum				
	May		0.265	
	July		0.32	
	September	0.14	0.084	0.15
Asphodellus aestivus	September	0.02	0.038	0.09
Smilax asperea	May		0.180	
	August	0.070	0.064	0.17
Grass mix	May		0.103	
	August	0.120	0.097	0.09
	September	0.170	0.017	0.08
dry inflorescence	December	0.46	0.075	0.10
Polypogon sp.	December	0.03	0.056	0.10
Avina sterilis	December	0.64	0.087	0.09
Gynosurus echinatus	May		0.166	

Table 2.6. Micromineral content of plant species by season, at the edge of Paphos forest near Anadiou village (mg/kg of diet dry matter).

Species	Month	Micromineral Fe	Cu	Mn	Zn
Pinus brutia					
flowers	March	88	7	19	19
Cistus monspeliensis					
flowers	March	151	7	46	20
flowers buts	March	143	8	38	18
leaves	December	1625	12	65	48
Pistacia terebinthus					
	March	139	20	20	50
	May	60	8	23	18
	July	86			
	September	28	9	6	17
Vitis vinifera					
	May	115	17	51	28
	September	119	5	65	21
fruit black	September	20	10	5	13
fruit white	September	25	11	5	21
Genista sp. leaves	December	150	5	60	23
Crataegus azarolus					
fruit	December	29		4	5

Table 2.6 continued

Species	Month	Micromineral Fe	Cu	Mn	Zn
Prunus amygdalus					
	March	145	9	21	43
	May	215	8	47	28
	September	120	5	75	26
Trifolium stellatum					
	March	875	13	30	27
Trifolium uniflorum					
leaves, flowers	March	250	12	51	30
Styrax officinalis					
	March	337	13	71	54
	May	325	12	54	18
	July	729			
	August	337	5	43	24
fruit	August	259	4	16	9
Lithodora hispitula					
twigs	August	1000	4	46	34
leaves	August	737	3	25	19
Olea europea					
fruit green (unripen)	August	65	4	7	13
	December	150	5	27	18
fruit black (ripen)	December	23	6	5	18

Table 2.6 continued

Species	Month	Micromineral Fe	Cu	Mn	Zn
Quercus coccifera					
fruit	December	25	5	16	13
Quercus alnifolia					
	December	312	5	93	10
Asphodellus aestivus					
	May	212	4	23	14
	September	250	4	28	31
Bromus madritensis	March	313	7	53	21
Grass mix	May	190	6	58	33
	July	119			
	September	167	4	21	32
	December	862	12	95	30
Hordeum vulgare					
	December	120	8	85	18
Avina sterilis					
	May	170	5	41	20
	September	192	3	21	23

Table 2.7. Micromineral analysis of plant species at Stavros tis Psokas forest Station, mg/kg.

Species	Month	Mineral			
		Fe	Cu	Mn	Zn
Moss	September	4125	13	98	48
Pteridium aquilinum					
	September	242	4	50	34
Pinus brutia					
dry needles	August	450	2	86	20
Cistus sp. fruit	December	1750	15	48	47
Pistacia terebinthus					
	March	123	15	17	48
	August	75	5	16	10
Rhus coriaria					
fruit	August	300	6	11	16
Arbutus andracne	September	137	6	17	37
	December	207	5	23	100
Styrax officinallis					
leaves	March	339	19	44	106
leaves	September	235	7	19	54
fruit	September	38	7	11	21
Teucrium kotschyanum	Septembeer	450	11	63	64
Asphodellus aestivus					
dry leaves	September	637	3	54	16
Smilax asperea	August	123	16		

Table 2.7 continued

Species	Month	Mineral			
		Fe	Cu	Mn	Zn
Grass mix	August	912	3	38	36
	September	345	5	32	28
dry inflorescence	December	943	10	57	59
Polypogon sp.	December	1112	12	38	80
Avina sterilis	December	550	8	56	43

2.D MINERAL CONSUMPTION

2.D.1 INTRODUCTION

Animals occasionally eat small rocks or soil impregnated with natural salts to rectify possible mineral deficiencies (Schaller, 1977). Geist (1971) found that bighorn sheep (Ovis canadensis) with diets deficient in salt would accept block salt and would "chase" him for a long distance to get this mineral. Schaller (1977) threw a little salt on a knoll at Lapche, and a herd of bharal sheep visited the site for three consecutive days. During rumen analysis of Cyprus mouflon it was found that a number of animals ate small stones of gabbro, which suggests that they might take soil or rocks as a nutrient supplement. The captive mouflon at Stavros tis Psokas Forest Station make regular use of mineral blocks.

I provided the free ranging Cyprus mouflon with mineral salt blocks in order to test whethher they would use them. It would be expected that if the Cyprus mouflon have mineral deficiencies they might make use of these mineral blocks.

2.D.2 METHODS AND MATERIALS

In December 1985, six stations inside the forest were provided with mineral blocks (salt and Limestone-phoshate) used for live-stock. The stations were spread over a distance of 10 km. Four stations were also located in the forest agriculture interface area, spread over a distance of 8 km. To protect the blocks from rain, a shed open on all sides and about 2 m high was built at each station in 1986. The presence of mouflon pellets and tracks near the stations were used to determine if the sheds were a factor in scaring mouflon away from the mineral blocks. A belt of sand about 50 cm wide was spread around each shed to register tracks. Each feeding station was examined at least once a week. An attempt was also made to discover natural mineral licks by watching mouflon eating soil or rocks. When the animals were seen eating particular mineral deposits, a sample was analyzed at the Department of Geological survey of Cyprus. In addition the small rocks found in the rumen of some of the animals were analyzed for mineral content.

2.D.3 RESULTS AND DISCUSSION

Wild mouflon never licked any of the mineral blocks, although there was evidence that they often bedded next to them. However, a free ranging tame mouflon at Stavros

tis Psokas was seen licking a red mineral on a rock which was imported as building material. The chemical analysis of this mineral is seen in Table 2.8, as well as the chemical analysis of the microgabbro found in the rumen of mouflon. This type of stone has higher phosphorus and potassium content than diabase (Table 2.8). It also has higher soundness value (i.e. it breaks up much more than the usual diabase especially in the right environment such as that of the stomach) (A. Charalambides, 1987 and E. Marissau, 1991, Geologists at the Cyprus Department of Geology, Pers. commun.)

Gordon et al. (1954) found that phosphate-deficient sheep and cattle, when offered a phosphate supplement in the form of a ground limestone-phosphate mix, failed to rectify the deficiency. However, this could be because the animals failed to "recognize" the supplement as such, since it is an unnatural food (Gordon, 1970). Therefore based on the above evidence the Cyprus mouflon eat rocks and soil possibly to correct possible mineral deficiencies, but failed to recognize an unnatural supplement.

In terms of a management practice these results indicate that supplying mouflon with salt blocks is not worth while.

Table 2.8. Chemical analysis of microgabbro found in the rumen of mouflon and the other rocks found in Paphos Forest.

Unit Rockbody	mg	c	p*	d*	s*
SiO2	56.48	67.20	53.08	53.36	58.0
Al2O3	13.75	9.32	16.13	15.81	15.57
CaO	10.10	5.17	11.57	12.42	7.98
MgO	4.96	2.99	7.62	7.84	3.56
Na2O	0.86		2.14	2.05	2.81
K2O	0.48		0.16	0.11	0.22
P2O5	0.07		0.02	0.03	
TiO2	0.64		0.67	0.71	1.25
Fe2O3	7.70	6.25	1.47	0.68	
FeO			7.01	6.88	12.29
MnO			0.17	0.14	0.21
H2O		9.07	3.18	1.97	6.96
Loss of ignition	5.25				
Total	100.29	100.00			

* Data from Rautenschlein et al. (1985) and Rautenschhlein (1987). Abbreviations: mg=microgabbro p=pillow d=dike s=sheet c=cedimentary petrifaction licked by mouflon.

2.E. The production of toxic substances in the shrubs and trees of Paphos Forest.

In order to properly manage a population of domestic or wild angulates it is necessary to understand the chemical properties of the plants that grow on pastures and range areas, since many of them contain a class of chemical substance referred to as volatile oils (Nagy and Regelin, 1977). These chemicals which are metabolic waste products are used by those plants that posses them as protection against overgrazing. In addition many plants are poisonous. The objective of this section was to provide information about the nature of the plants in Paphos forest which might be toxic or poisonous to mouflon. The purpose was to stimulate farther research in this area, and to provide a better understanding why some plants in the forest are partly or completely avoided by mouflon.

Most of the trees and shrubs inside the forest contain anti-herbivore substances. Pine needles containing monoterpenes which may deter herbivores (Robinson, 1979). Bacterial action in deer rumen can be inhibited by volatile monoterpenes (Mabry and Gill, 1979). The conifers in Cyprus also have low digestibility, but it is not known whether this is due to the levels of anti-herbivore compounds or to their lignin content (Maisels, 1988; Rhoades, 1979). In addition, conifers like the broad leaved trees and shrubs of Paphos Forest, are poor quality food, as

they are usually less than 50% digestible, with the exception of Teucrium Kotschyanum which is 55-60% digestible except in late summer and early fall (Maisels, 1988). The maintenance threshold for digestibility for ruminants is 50% (loc. cit.)

Myrtus is rich in volatile oils (Ganitsa, 1967; Davis, 1988; Georgiades, 1987). These oils inhibit activities of many different organisms including those found in the rumen (Nagy and Tengerdy, 1967; Longhurts et al., 1968; Nagy and Tengerdy, 1968; Nagy and Regelin, 1977). In small concentrations, these oils have no or very little, impact on rumen microorganisms. At higher concentrations their inhibitory action accelerates (Nagy and Tengerdy, 1968).

The bracken fern (Pteridium sp.) which is the most common fern of Paphos forest is also known to cause illness to sheep, but only after it has been consumed in large quantities for several months (Jones and Hunt, 1983).

Beside the above plants most of the shrubs and trees of Paphos Forest contain some kind of antiherbivore substance, which might force mouflon to avoid them or to eat small quantities and feed mainly on grasses and annuals. Such plants are the terpentine tree Pistacia terebinthus, (Ganitsa, 1967), laurel or sweet bay (Laurus nobilis), bramble (Rubus sanctus), and the rock rose (Cistus spp.) which are rich in essential oils (Georgiades, 1984, 1985).

The Golden oak (Quercus alnifolia) and the holy oak (Quercus coccifera), might contain high tannin (gallotanins) levels similar to many other known members of this genus. These tanins break down into gallic acid and pyrogallol, both of which are toxic for sheep, and are known to cause kidney failure (Jones and Hunt, 1983). In postmortem studies of nine mouflon over two years old, eight had kidney lesions from unknown causes (see chapter four). The leaves and bark of the strawberry tree (Arbutus andrachne) are rich in tannic and gallic acids, resinous compounds and pectins, while the leafs of sumach (Rhus coriaria) are rich in tanins (Georgiades, 1985). Locoweed (Astragalus lusitanicus), which usually grows in open areas and road sides, can cause osteoporosis (Jubb et al., 1985) and only one or two leaves of oleander (Nerium oleander) may result in heart failure of sheep (Novana, 1958; Jones and Hunt, 1983).

The leaves of pine produce volatile terpenes (a class of organic compounds that include camphor), which are known to prevent the growth of other plants, particularly grasses by affecting them directly through the atmosphere, a phenomenon frequently referred to as allelopathy (Collier et al., 1973; Ricklefs, 1979). This might be a reason why grass cover in the forest was 2.6% compared with 21.7% at the edge of the forest where there were no pines. The difference in coverage occurred despite the presence of several hundred domestic sheep and goats for-

aging at the edge of the forest in addition to mouflon.

All pine needles, myrtus leaves and fern fronds in the stomachs were dry. As mentioned earlier, fresh pine needles contain monoterpenes which may deter herbivores from feeding on them in any quantity (Robinson, 1979). The fact that mouflon eat pine needles when dry may suggest that the monoterpenes are leached out. Nearly all rumens had between one or two percent dry needles. It is possible that a number of needles were picked accidentally while feeding on other plants, but I have observed animals selecting only individual needles. Pine flowers may be free from such toxins and were eaten by mouflon. Since these flowers are high above the ground, sheep (particularly the females at the lambing ground) were helped in reaching them by climbing the vertical cliffs and by standing upright on their hind legs. Mouflon often stand upright with one leg propped against the tree or branch for balance and the other used to hook and bend twigs similar to goats. European mouflon may rear up briefly to reach a branch (Pfeffer, 1967), but American sheep which resemble goat in appearance and habitat preferences are not known to feed in this manner (Geist, 1971; Schaller, 1977).

2.F LAMBING

2.F.1 INTRODUCTION

Weather, nutrition, and population density may have a profound effect on reproduction and survival of newborn lambs (Schaller, 1977). High or low air temperatures shortly after fertilization reduce pregnancy rates in domestic ewes, and high temperatures may also cause young to be born weak and small. Nutrition is critical to both mother and offspring. Poor nutrition decreases ovulation rates and also causes loss of ova, especially in those sheep with twins (Sadleir, 1969).

The date of birth depends directly on the onset of oestrus. Consequently an early rut will produce an early lambing season. Work on domestic sheep has shown that good food may advance oestrus by a mean of 20 days (Jewell and Grubb, 1974). Nievergelt (1966) noted that well-fed Alpine ibex rut earlier, and Pleticha (1972) observed that ibex in zoos give birth 20-30 days before those in nearby mountains.

Breeding periods tend to shorten as conditions become more extreme (Schaller, 1977). The breeding season in animals native to the temperate zones is almost invariably timed for the young to be born at a time of the year most favourable to their survival (Clegg and Gannong, 1959). Since the Cyprus mouflon lives in two distinct habitats, at the forest-agriculture interface, and inside

the forest on Paphos mountains, it offered a great opportunity to test whether the reproduction of mouflon was affected in a similar fashion.

Theoretically, since the area at the edge of the forest is considered to produce more forage, it would be expected that the females at the edge of the forest would have a longer lambing season, lamb earlier, produce more lambs, and their lambs would have a higher survival rate than the animals inside the forest. Differences found between the two areas would certainly be caused by environmental conditions rather than by genetics.

2.F.2 METHODS AND MATERIALS

The annual distribution of births, number of lambs per female and lamb survival was based on animals observed from blinds at the lambing grounds of Kremmos tou Pakhniouti (edge of the forest) and Kremmos tou Aphoriti (inside the forest). At Kremmos tou Pakhniouti, the blind was located on Premixco quarry 300-400 m from the sheep. At the other lambing ground it was 250 m from the cliff. A pair of 10x50 binoculars was used to locate the animals and a pair of 20x60 utilized to observe them more closely. Observations were recorded on a portable tape recorder, and supplemented with drawings on record cards. Female arrivals and pregnancy were recorded. If the genitals were excessively swollen labour was expected within one or two

days. Individual females could be distinguished by the size of the face mask, configuration of the head, pelage colour, natural markings, and sometimes by the presence of seasonal shedding and pelage renewal which usually commences at the end of April.

If a female known to have a lamb was seen alone for more than one day it was assumed the lamb was lost.

A Z, one tail test at the level of 5% was used to test differences between the two populations.

2.F.3 RESULTS AND DISCUSSION

2.F.3.1 Reproductive period

The lambing season lasted 20 to 30 days. The first lambs appeared 10-17 days earlier at Kremmos tou Pakhniouti than at Aphoritis. At Kremmos tou Pakhniouti, in 1986, lambing took place from 31 March to 23 April. In 1987 it was from 24 March to 25 April, and in 1988, from 1 April till the end of the month.

On Aphoritis lambing ground the first lambs were seen on 10 April, and lambing lasted 20 days in 1986 compared to 23 days at Pakhnioutis. In 1987 it took place from 8 April to 3 May lasting 25 days compared to 35 at Pakhnioutis, and in 1988, from 17 April to 5 May lasting 18 days in comparison to 30 days at Pakhnioutis. The annual distribution of births for each lambing ground for the

years 1985-1988, at five days intervals are shown in Figure 2.5.

Although lambing started late at Aphoritis, the season was shorter. This seems to supports the hypothesis that the forest population lives in an environment not as favourable to the survival of their young as that at the edge of the forest.

2.F.3.2 Fecundity

At Pakhnioutis between 1986 and 1988, a total of 34 females was observed with 1.3 lambs per female (Table 2.9). Twenty six percent of these had twins and 10.5% were barren. For the same years at Aphoritis 33 females were observed with 1.1 lambs per female. Nine percent of the females had twins and 26.6% were barren. The difference between the two populations in the number of twins and single lambs produced was significant. Also significant was the difference in the number of barren females. This might indicate that conditions prior to the rutting season were more favourable at thhe edge of the forest than inside the forest.

Twins are exceptional in the Corsican mouflon but in an expanding population in the Crimea there were 1.5 young per female (Pfeffer, 1967). Of 152 urial ewes tallied by Decker and Kowalski (1972) in Kopet Doagh, 55% were accompanied by single young, 42% had twins, and the rest trip-

lets. Valdez (1976) collected 57 pregnant Laristan urial near Shiraz in Iran. All 7 yearlings in his sample were pregnant and all had one fetus. The average number of fetuses in 2-year-olds was 1.00, in 3-year-olds 1.25, and in ewes older than 3 years 1.53. Among 66 Tie Shan argali ewes there were 65% with single young, 33% with twins, and possibly one set of triplets (Heptner et al. 1966). American sheep rarely have twins and seldom conceive as yearlings (Geist, 1971).

The incidence of multiple births can be attributed to several selection pressures. According to Schaller (1977) species whose food supply is fairly predictable from year to year tend to have single young. In contrast, desert forms compensate for their high and irregular losses in droughts by adjusting the fecundity of yearling females, and producing twins when conditions prior to the rut are favourable. Also, the average lifespan may have an influence on the number of young born in that long-lived species generally have fewer young. Ibex, bharal, and American sheep survive, on the average longer than do argalis, which produce more lambs per female than the first three species. Furthermore, predation pressure may be more persistent on argalis, which inhabit open terrain, than on those species that can escape to the safety of cliffs.

2.F.3.3 Survival of newborn lambs at the lambing grounds.

At Pakhnioutis none of the 34 females observed lost their 43 lambs as long as they used the cliffs for refuge. Even two newborn lambs that spent the first night of their lives at temperatures as low as 4 degrees Centigrade, in rain and strong winds, survived.

At Aphoritis, of 33 females with 36 lambs only a pair of twins were lost, after rolling down the cliffs for about 10 meters. Although they got up and walked, they were not seen with their mother the following day.

The difference in the number of lambs lost between the two areas (only 2), was not high enough to support a statistical test.

Lamb survival similar to Cypriot sheep was also observed in other populations of wild sheep. Van Vuren and Coblentz (1989) on Santa Cruz island off Southern California found that lamb survival from birth was close to 100%. Schaller and Mizra (1974) observed 75 young per 100 adult females for Punjub urial, indicating good reproduction and survival up to 6 months.

In conclusion all the parameters of lambing seems to indicate that the forest animals had to deal with a harsher environment, and that genetics did not play a part in these differences.

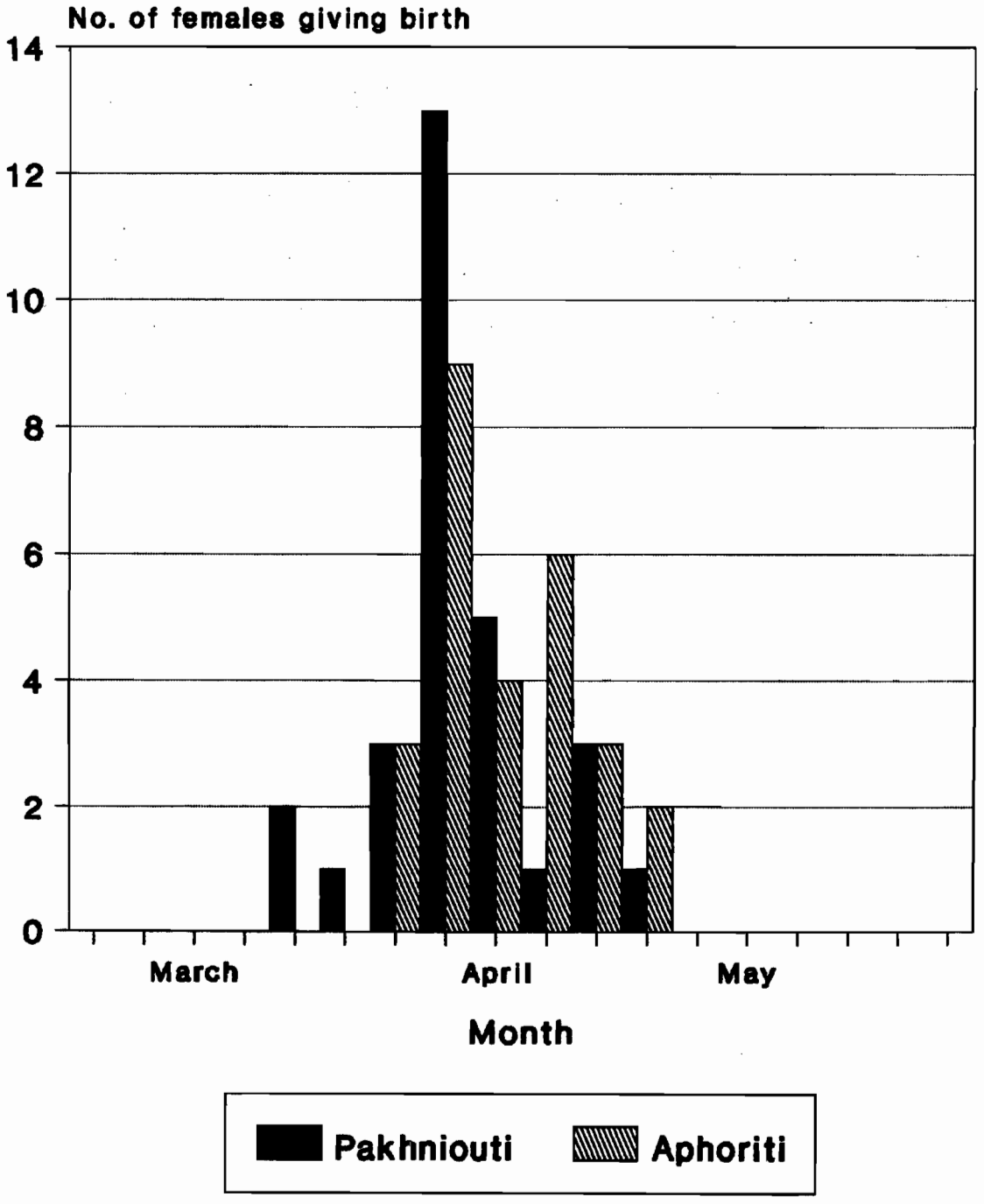
Table 2.9. Fecundity and Survival of lambs up ot one year of age at the lambing grounds of Pakhniouti and Aphhoriti.

FECUNDITY	Pakhniouti			
	1986	1987	1988	$\bar{X}$
Females with twins	2	3	4	3*
Females with single	8	7	10	8.3*
Barren females	1	2	1	1.3*
Total femeles	11	12	15	12.6
Total lambs	12	13	18	14.3*
Lambs / 100 females	109	108	120	112.3*

	Aphoriti			
	1986	1987	1988	$\bar{X}$
Females with twins	1	0	2	1*
Females with single	10	8	12	10*
Barren females	4	4	4	4*
Total femeles	15	12	18	12
Total lambs	12	8	16	12*
Lambs / 100 females	80	66.6	88.8	78.5*

* Significant difference between the populations at the edge of the forest (Pakhniouti) and inside the forest (Aphoriti) at the level of 5%.

Figure 2.5. Annual distribution of births for the lambing grounds of Aphoriti and Pakhniouti for the years 1985-1988.



Each column represents the total for 5 days.

2.G SUCKLING OF LAMBS

2.G.1 INTRODUCTION

About four days after lambing, ewes on a good diet produced 48 ml of milk per hour whereas undernourished ones gave only 14 ml (Alexander and Davis, 1959). Unable to control their body temperature, newborns born from undernourished ewes may succumb to cold weather or to heat above 38 ℃. Geist (1971) found that Stone's ewes suckle their lambs longer at comparable ages than did the lower quality bighorn ewes from Bare Mountain. In addition better quality ewes will interrupt their suckling lambs less frequently than lower quality ewes.

It is known that milk production is affected by the level of maternal nutrition in summer (Brody, 1945) as well as by the size of the udder, which in turn is affected by the level of maternal nutrition during pregnancy (Wallace, 1948).

The purpose of this section was to determine if the feeding time of lambs was lower for animals in the forest than those at the forest edge where habitat is more productive. It would be expected that the lambs at the edge of the forest would suckle more adequately, and interrupt less during suckling compared to lambs inside the forest.

2.G.2. METHODS AND MATERIALS

The time of suckling and the number of times that lambs were interrupted was based on lambs of approximately the same age observed from blinds at the lambing grounds of Kremmos tou Pakhniouti (edge) and Kremmos tou Aphoriti (forest). At Kremmos tou Pakhniouti, the blind was located on Premixco quarry 300-400 m from the sheep. At the other lambing ground it was 250m from the cliff. A pair of 10x50 binoculars was used to locate the animals and a pair of 20x60 utilized to observe them more closely. Observations were recorded on a portable tape recorder. I tested the hypothesis that the average suckling times for the two regions were equal against the alternative that they were different, using a t test (Steel and Torrie, 1980. A Z test was used to test whether there was any significant difference in the number of interruptions during suckling at the two lambing grounds.

2.G.3 RESULTS AND DISCUSSION

The t test showed that the two population means were different at the 5% level, i.e. there is evidence that the mean suckling time of the Pakhniouti area (35.6±29 seconds) is significally longer (34%) than that of the Aphoriti's area (23.5±19 seconds). This supports the hypothesis that the ewes in better habitats suckle their

young longer. However, the Z test found no significant difference in the number of interruption during suckling between the two areas. Of 92 observations at Pakhnioutis the lambs were interrupted 53 times whereas from 27 observations at Aphoritis the lambs were interrupted 13 times.

2.H PREDATION

2.H.1 INTRODUCTION

The only wild predator on the island of Cyprus is the red fox (Vulpes vulpes). Fox tracks are common within the limits of Paphos Forest although the animals themselves are rarely seen. The foresters at Stavros tis Psokas Forest Station believe that fox kill a large number of lambs and limit increases in the population. Avian predators in Paphos Forest are rare and are not considered by the Forestry Department as important mouflon predators.

The objective of this section was to study the effect that predators might have on mouflon, particularly at lambing sites where fox could have a great impact while the lambs were small.

2.H.2 METHODS AND MATERIALS

Data on fox and other predators were collected (i) by direct observation for 140 days of red foxes attempting to capture lambs at the two lambing grounds (ii) by asking all the foresters and others working at Paphos forest if they had ever seen a fox or eagle chasing or killing a mouflon, and (iii) by searching the files of Stavros tis Psokas Forest Station for information as far back as 1958. Prior to this date files had been destroyed by a fire.

2.H.3 RESULTS AND DISCUSSION

In 140 days of observations at the two lambing grounds red fox made three attempts to capture lambs at Pakhniouti and two attempts at Aphoriti. All attempts failed because the ewes protected their lambs by moving them to steeper parts of the cliffs, and by standing between the lambs and the fox, kicking and butting.

Four other cases were reported to me by foresters who observed foxes entering lambing grounds but in all cases the foxes failed to capture lambs.

Away from the lambing grounds employees of the Forestry Department noticed foxes following adult rams on 2 occasions. In the first case no interaction took place, but in the second a ram attacked the fox injuring it fatally. In a third case a fox approached a ewe and its 2-3 month-old lamb while they were foraging. At a distance of 5 m the fox charged toward the lamb. The lamb began to run while the mother attacked the fox managing to chase it away.

There was one report in the files of Stavros tis Psokas Forest Station, in which the lamb did not survive. It noted that labourers cutting wood observed a fox killing a 15 day old mouflon. It did not mention how the lamb was aged.

It seems that the red fox is rather small to attack an adult animal the size of a mouflon although it seems

capable of killing a lamb. As long as the animals are seeking the protection of the cliffs on the lambing grounds the fox has no impact on the population. However, more research is necessary to clarify the impact of fox on lambs after they leave the cliffs.

Ravens (Corvus corax) were often seen raiding the nests of rock doves (Columba livia) at Kremmos tou Pakhniouti. In one case a ewe with newborn twins was resting under a nearby pine. When the ravens were several meters from her she was standing alert facing them but no attempt was made by the birds to capture either of the lambs.

One of the employees of the Forestry Department reported that many years ago an eagle of unknown identity captured a lamb. Eagles can and do take lambs of wild sheep, but since the period when sheep are vulnerable to eagle predation is short, this predation is believed, in most instances, to have little effect on populations (Kelly, 1983). Excessive shooting and the use of pesticides have had deleterious effects on the breeding capabilities of these birds (Hieraaetus fasciatus and Aquila heliaca), and their numbers in Cyprus have become reduced to near extinction. Eagles that are seen occasionally are the Imperial eagle and the Bonellis eagle.

To summarize, potential natural predators seem to have little impact on the survival of lambs or adult Cypriot mouflon.

CHAPTER 3. DOG PREDATION ON CYPRUS MOUFLON

3.1 INTRODUCTION

In Cyprus local authorities in the Department of Forestry believe that free-roaming dogs (Canis familiaris) are the direct cause of many deaths of mouflon to the extent that many consider dogs as a "menace" to the population.

This concern might be justified since Pfeffer (1967) working to Corsica and Sardinia found that stray dogs, sheep dogs, and hunting dogs kill more European mouflon than foxes do, and Mottl (1960) in a study of European mouflon in Chechoslovakia said that dogs chase pregnant mouflon in winter when their movements are impeded by snow.

To try to control the losses of sheep from predation the government in 1958 assigned full time patrols armed with shotguns to kill dogs seen roaming unattended in the forest. In addition meat injected with strychnine was used as a control agent until the late 70's.

The objective of this study was to determine whether dogs were an important factor in the mortality of mouflon and to estimate the efficiency of the dog control program.

3.2 METHODS AND MATERIALS

The evaluation is based on data from the Forestry Department files, a questionnaire, and the examination of sheep carcasses. The files of Stavros tis Psokas Forest Station were searched for information as far back as 1958. Prior to that date the files had been destroyed by a forest fire.

Data for the period 1985-1989 were also gathered through a questionnaire distributed to foresters, the police stations, people working or who had worked at Paphos forest, as well as to shepherds and farmers working near the forest. The questionnaire requested information on the number of chases seen, the outcome of each chase, the condition of the killed animals and their sex and age. Female mouflon over one year of age are difficult to age except by the sequence of teeth eruption and wear, or the extent of the white face mask for each age class. Therefore females were separated into only two age classes, < 1 year, > 1 year. Rams were aged based on horn size and horn rings (Geist, 1971; Valdez, 1976). Pictures of animals of different sex and age classes were made available to people to help them in sex and age determinations.

In December 1985 the Forestry Department requested its employees and the police to inform me about any dead mouflon they found. Each carcass was examined for signs

of predation, and the site, the carcass, and wounds were photographed. Wounds with subcutaneous hemorrhaging indicated that wild sheep were alive when wounds were inflicted (Rowley, 1970; Davenport et al., 1973; O'Gara, 1978; O'Gara et. al., 1983).

3.3. RESULTS AND DISCUSSION

A total of 38 reports were collected. Nine dog chases (24%) resulted in kills. The kills consisted of three males > than 4 years, two females <1 year and 4 females >4 years one of which had a visible crippling abnormality prior to cupture. Eleven (29%) chases ran out of sight and their outcome was unknown. Five chases (13%) were interrupted by foresters. In nine cases (24%) the sheep escaped. In three cases the dogs stopped chasing and four ran to the cliffs where the dogs could not follow. Two rams which hid in the cliffs were found by a dog but the dogs were subsequently chased away. On four occasions (10%) sheep attacked dogs and in one case the ram broke the dog's ribs. Although 41% of the chases whose outcome was known ended in kills, an equal number escaped and in 18% of the cases the dogs were the losers. The antipredator strategies used by the mouflon were; attacking the dogs, hiding among large rocks, retreating to cliffs, and outrunning the dogs.

The search for dead animals resulted in collecting 33

carcasses. Three (9.1%) of them, including two rams (age 4 and 7 yrs) and a ewe (> 4 yrs) were killed by dogs. During necropsy it was found that the two rams had severe cases of grass seed imbedded between the gums and teeth, suggesting they were ill. No other data on their condition were available, because all viscera were eaten by dogs. Possible severe pain from the grass seed lesions may have reduced their alertness and made them vulnerable to predators. The female was pregnant with twins and had a trauma of the left rear leg apparently caused by chronic purulent arthritis. After a histological examination of the lungs it was found that this female was also suffering from mild parasitic pneumonia.

Over the period of 1985 to 1989 there were 15 reports of dogs in the forest. Of 22 dogs actually seen by foresters seven (32%) were shot.

Dogs can and do kill mouflon, however, more chases end in either the sheep escaping or the dogs being chased by sheep. Of the three postmortems done on sheep known to be killed by dogs all three had pathological handicaps. This was also found in the case of one other female reported killed by dogs. All the evidence indicates that dog predation is not a serious problem. There were only 22 dogs reported on the area over a period of 4 years. Dog predation is not selective of either sex although rams can kill dogs. The limited data could support the hypothesis that the dogs do a certain amount of culling of diseased,

parasitized or otherwise handicapped animals.

CHAPTER 4. DISEASES AND PARASITES OF CYPRUS MOUFLON AS DETERMMINED BY STANDARD GROSS AND HISTOPATHOLOGICAL METHODS

4.1 INTRODUCTION

Extensive pathological surveys based on necropsies have been made on populations of wild sheep (Allen, 1983), but no such published information in the literature exist for the Cyprus mouflon. The objective of this investigation was to determine the diseases and parasites found in the Cyprus mouflon. The study included the wild sheep from Paphos forest and animals from the breeding unit of Stavros tis Psokas Forest Station.

4.2 MATERIALS AND METHODS

Since the Cyprus mouflon is protected the only way to collect animals for autopsy is to collect carcasses from the wild or from captive breeding programs. The District Forest Officer of Stavros tis Psokas Forest Station requested all Forest Officers and employees of the Department of Forestry working in Paphos Forest to report all dead mouflon found. In addition at least once a week I carried out an extensive search of individual valleys at Paphos Forest. When a dead animal was found, signs of struggle, of paroxysm at death, any accumulation of

faeces, and signs of predation such as wounds, track and blood, were recorded. In the case of predation, wounds with subcutaneous haemorrhaging indicated that sheep were alive when wounds were inflicted (Rowley, 1970; Daveport et al., 1973; O'Gara, 1973). When possible the sex and age of each animal were recorded. Age was based on horn rings for the males (Geist, 1971; Valdez, 1976) and on tooth eruption and the face mask for the females (personal observation). Carcasses were transferred to the Veterinary Department of Nicosia, where they were examined using gross methods (Cowan and Karstad, 1971) and histopathological methods (Luna, 1968). The latter method included histopathological examination of major organs including liver, lungs, kidneys, heart and spleen as well as muscle tissue. The brain, spinal cord, intestine, testis, epidydimis, skin and lymph nodes were examined in some carcasses. During standard gross examination if a disease of microbial or parasitological origin was suspected pieces of infected tissue were taken for further examination. For coccidiosis the flotation method was used whereas a Baerman apparatus was used to find lungworm larvae (Skerman and Hillard, 1966). Species determination of the coccidia were not performed. When gross examination of the whole carcass was not possible because carrion feeders had discovered the carcass before we did, the tissues selected for histopathological examination were collected on the spot and fixed in 10% formol saline solution.

Representative samples of tissue 0.5 cm thick were processed for histopathological examination. Serial paraffin sections 6-7 mm were stained by haemotoxylin and eosin (Luna, 1968). Permanent slides of all the sections taken are stored at the histopathology laboratory of the Central Veterinary Department of Athalassa.

4.3 RESULTS

4.3.1 Standard gross examinations and visual observations

A total of 44 animals were examined 11 captive and 33 wild (Table 4.1). Six of 9 captive mouflon examined were less than 4 months old. The other 3 were adult females. Of the 8 captive lambs, 2 died from dystokia. Of the 6 remaining 1 died from coccidiosis, one from enteritis of unidentified origin, one from coccidiosis and enterotoxaemia, one from fractured cranium and septicaemia and one from colibacillosis.

Five out of the 33 free-ranging mouflon were lambs. From these lambs one died from unknown aetiology, one from acidosis; one by colliding against the fence in an attempt to escape from captivity after it had been captured by foresters. The remaining two were killed by cars.

One of the 3 adult captive mouflon examined died from tympanism caused by intestinal obstruction from a large

mass of string and plastic fibers. Another tame but free ranging female mouflon at Stavros tis Psokas was observed to have symptoms of polyuria, chronic tympanism and diarrhea. The second adult captive mouflon examined was a female which was killed by colliding against the fence in its attempt to escape from captivity. It was transferred from the large enclosure to the smaller enclosure for public viewing, in December 1988 after all the animals in the small enclosure had escaped. This animal kept jumping on the fence and broke both of it's back legs near the pelvis. The broken bones penetrated it's leg muscles causing internal and external bleeding. It was treated at the Veterinary Department of Paphos but it did not survive. The third captive mouflon died from unknown aetiology.

From the free-ranging sheep, 2 females 4-5 years old, and 3 rams 6, 7, and 8 years old were killed by dogs. A 3 year old ewe died after abortion of unknown aetiology. Two females over 6 years old and a male 11 years old died after falling from cliffs. Five rams over 8 years old, 3 of unknown age, a two year old female and 2 ewes of unknown age were killed by poachers. One was snared, 9 were shot and 1 was hit by a car intentionally. One female was poisoned after feeding in a vineyard sprayed with parathion.

Two types of parasitic larvae were identified in the faecal samples of the wild sheep. These were Mullerius sp. and Protostrongylus sp.

4.3.2 Histopathological examination (Tables 4.2-4.4).

4.3.2.1 Brain:

A total of 14 animals were examined for lesions of the brain (Table 4.2) (8 captive and 6 wild). Of the 8 captive mouflon 7 were lambs, 5 of which had moderate circulatory lesions (ie. congestion and/or haemorrhages), 1 had a severe circulatory lesion and the other had a mild inflammatory lesion of an unidentifiable aetiology. The only adult captive female examined revealed several sarcocysts. No tissue reaction associated with these sarcocysts was found. Similarly one of the 6 wild mouflon, an adult female which was examined also had parasitic cysts of this type in the brain. Of the wild mouflon, 1 female had moderate subacute to chronic meningitis; 3 had moderate to severe circulatory problems and 3 had no pathological findings. No lesions suggestible of scrapie were found in the brains of the animals examined.

4.3.2.2 Epididymis:

One epididymis was examined from a captive lamb. Nothing abnormal was detected.

4.3.2.3 Heart:

Circulatory lesions in the lambs and parasitic lesions in the adults were the main histopathological findings in the heart of the specimens examined. Five out of 7 captive lambs had moderate to severe circulatory lesions. Escherichia coli was isolated from one of the lambs. The other 2 lambs had no pathological findings. From the 11 wild mouflon examined, 9 had Sarcocystosis. Sarcocysts were also observed in the heart muscle of the only one adult captive female examined.

4.3.2.4 Intestines:

Intestines were examined from 4 captive lambs and 4 free ranging adult mouflon. All lambs had moderate to severe inflammatory lesions. Two of 4 adult wild mouflon had inflammatory lesions while in 2 no pathological lesions were recorded. The cause of the inflammation in 1 of the 2 adult mouflon, a four year old male, was parasitic.

4.3.2.5 Kidney:

Eighteen out of 20 animals examined had some kind of problem with their kidneys, degenerative, inflammatory or circulatory (Table 4.1). In some lambs lesions were associated with enterotoxaemia.

4.3.2.6 Liver:

Seven captive mouflon, 6 lambs and 1 adult, and 11 free ranging sheep, 2 lambs and 9 adults were examined for liver lesions. All captive lambs examined had moderate to severe circulatory liver problems. The captive adult females had moderate inflammatory lesions similar to 2 of the wild sheep. Two wild specimens had severe degenerative lesions, 4 had moderate to severe circulatory lesions and 2 had no pathological lesions.

4.3.2.7 Lungs:

Sixteen of the 18 mouflon examined had some type of lung lesion. Five of the 6 captive lambs examined had moderate to severe circulatory problems while the remaining 1 had moderate inflammatory lesions of unknown aetiology. Eight out of 11 wild mouflon, including 1 adult captive female had moderate to severe parasitic pneumonia. Some sheep lungs were studded with many hundreds of nodules. Others were free from nodules although they did have parasites. Only 2 males aged 1 and 11 were free from any kind of lung lesions. The only wild mouflon with circulatory lesions congestion and haemorrhages was a 4 month old female in captivity. Its' lesions were possibly traumatic and had been caused by its collision against the fence in

an attempt to escape from captivity. No lesions suggestive of Pulmonary Adenomatosis were found in the lung specimens examined.

4.3.2.8 Lymph nodes:

Lymph nodes were examined from 3 adult free mouflon, 2 old rams and 1 adult female. The first ram had mild inflammatory lesions and the second one severe circulatory lesions both from unknown aetiology. The only female examined was free of pathological findings.

4.3.2.9 Muscle:

Five captive lambs which were examined had no pathological conditions in the muscles. Two wild lambs indicated sarcosystosis similar to the other 17 adult mouflon examined, (1 captive and 16 wild).

4.3.2.10 Placenta:

The placenta of a female which was killed by dogs was examined. Nothing abnormal was detected. This female was about 4 months pregnant, carrying twins.

4.3.2.11 Skin:

The skin of the nasals of two rams 9 and 11-12 years old were examined histologically. Because they were damaged possibly from fighting during the rut, their skin was cut and the animals were bleeding. The first ram had severe dermatitis and hyperkeratosis of the nasals and the second had chronic dermatitis.

4.3.2.12 Spinal Cord:

Only one spinal cord from a male captive lamb was examined histologically. Spongy changes were present in the cervical part of the spinal cord but the pathognomotic lesions of Scrapie were not observed.

4.3.2.13 Spleen:

The spleen of 9 mouflon were examined, 3 captive lambs and 6 free-ranging adults. Two of the 3 captive lambs and 3 of the 6 wild adults had no pathological lesions in the spleen. Three wild animals had circulatory problems of unknown aetiology. One old male 11 years of age, had nodular hyperplasia of the spleen.

4.3.2.14 Testis:

Two testes and 1 epididymis were examined from captive lambs. Nothing abnormal was detected.

4.4. DISCUSSION

Most of the diseases recorded in this survey as occurring in the wild and captive Cyprus mouflon are the same as those found in domestic sheep and goat (Cole, 1966; Simmons, 1976; Curtis and Lautenslager, 1983a and b; Jubb et. al., 1985; Polydorou, 1967-1987). My findings support those of Jessup (1985) that wild sheep are extremely susceptible to livestock-born diseases. At Paphos forest mouflon were always in contact with domestic sheep. Until 1938 a large number of goat herds were allowed to graze in the forest, but were later removed when the area was declared a game reserve. Today the mouflon range overlaps with the area in which flocks of domestic sheep and goats forage near the periphery of the forest. Therefore it is possible that some livestock born diseases will continue to affect mouflon.

Dystokia is a common obstetrical problem in all farm animals which, unless relieved, leads to death of the fetus and sometimes death of the ewe (Roberts, 1971; Arthur et al., 1982; Majeed and Taha 1989). Occurrence of dystokia is related to several factors including postural abnormalities, number and size of fetuses, fetal anasarca or embhysema, nutritional status of dam, number of kidding and breed (Roberts, 1971; Smith, 1980; Arthur et al., 1982; Adams, 1986; Majeed and Taha, 1989). It was never

possible to observe a wild mouflon during lambing, and therefore it is not known if the problem is as severe in the wild population as it seems to be in the captive flock.

The strings and plastic fibers that obstructed the rumen of the female adult captive mouflon originated from bags used for carrying their grain and pellet food. Materials of the same sort were also found in smaller quantities in the stomachs of 2 other captive mouflon which were decomposed and unsuitable for postmortem examinations. Strings and plastic fibers were rarely found in the stomachs of any free wild mouflon; of 26 stomachs examined, a few were found in a 3 year old female which had escaped from captivity in 1985, and another female which might have been one of the captive mouflon released recently from captivity.

The tame but free ranging mouflon at Stavros tis Psokas which had symptoms of chronic tympanism, polyuria and diarrhea was observed feeding on cigarette stubs, pieces of plastic from a car's running board and fibers saturated with petroleum products including lubricating grease and motor oil, used by the car mechanics at Stavros tis Psokas garage. Sometimes it was observed eating 10 to 20 cigarette stubs per day. According to Mahon (1969) animals eat things completely foreign to their normal diets when they have mineral deficiencies. It is not known if mineral deficiency is a causative factor in mouflon eating

string, cigarette butts and other items which can be harmful to their health.

The lamb with the fractured skull had been butted by a ram. Rams butting lambs or yearling males are normal phenomenon, particularly in the small enclosure where all the animals are forced to remain together because of space limitations. In nature, the newborn lambs and their mothers are separate from rams at the lambing grounds.

Coccidiosis caused the death of at least 2 captive lambs up to 3 months old. Coccidiosis is a disease causing a heavy loss of domestic sheep up to 3 months old. (Cole, 1966; Simmons, 1976; Curtis and Lautenslager, 1983b; Jubb et al., 1985). Coccidia are microscopic protozoa parasites, carried and spread by most of the adult sheep which seldom experience harmful effects, because they maintain a resistance to the infection (Simmons, 1976; Curtis and Lautenslager, 1983b). Although no wild mouflon lambs were found affected by coccidioses, it is possible that this disease affects them. In domestic sheep outbreaks are mainly in feedlot lambs that are raised in crowded conditions and seldom in pastures of a farm flock (Simmons, 1976).

Enterotoxaemia was also found in one lamb of the captive flock. Enterotoxaemia, enteritis and colibacillosis in domestic sheep are mainly diseases of young lambs, affecting them soon after birth, though contamination of the environment (Cole, 1976; Curtis and Lauteslager,

1983a; Jubb et al., 1985). Compared to captive lambs, lambs of wild mouflon probably rarely become affected by these diseases because of their free living conditions.

The effect of sarcosystosis in the brain is not known but there have been cases in domestic sheep where sarcocystosis in vital organs such as the spinal cord caused symptoms of lameness, emaciation and paralysis (Cole, 1966). It does not appear to affect the general health of sheep when present in the muscles (Cole, 1966). Where it was once thought that the muscle phase of infection was asymptomatic and safe for the intermediate host, it is now known that particularly the Schizogenous phase may cause severe clinical disease and death under both natural and experimental conditions (Jubb et. al.,1985).

Fights between mouflon rams during the rut are an every day phenomenon. Broken horns and damaged nasals with symptoms of hyperkeratosis are often seen. A similar situation exists in the desert bighorn of North America (Allen, 1981).

The effect of meningitis on mouflon is also unknown. It can be caused by virus or bacteria responsible for pneumonia or tuberculosis.

Scrapie, a disease found in domestic sheep and goats in Cyprus (Toumazos, 1988;1989), was not recorded in brains examined.

Nodular hyperplacia was never reported on sheep or goats in Cyprus. According to Jolly (1967) nodular hyper-

placia of the spleen was found in 0.75% of old domestic ewes in New Zealand cast-for age at an abattoir. Observations indicated that prevalence of these lesions increase with advancing age. Jolly does not provide figures on sex specific patterns but has noted lesions in males and castrates.

The lungworms affecting the wild sheep in Cyprus, are also found in domestic sheep and goats in Cyprus (Anonymous, 1973). Mullerius causes the shot-like nodules in sheep (Cole, 1966). Protostrongylus often contribute to the development of bronchopneumonia in mountain sheep (Ovis canadensis) (Hibler et al., 1982), and has been associated with elevated mortality in young and adult animals (Miller and Hobbs, 1988), limiting the abundance of these sheep (Miller et al., 1987).

Pulmonary adenomatosis was not found in mouflon, but is found in domestic sheep in Cyprus (Toumazos, 1988), and in mouflon X sheep hyprids bred at the Experimental Farm of the Institute of Agriculture of Cyprus (personal observation

4.5 CONCLUSION

Although mouflon are susceptible to most of the diseases and parasites of the domestic caprins they do not seem to be seriously affected by them. Far more important as mortality factors are predators, road kills, poaching

and accidental deaths from falling.

In the case of captive or newly released animals there are many avoidable deaths. A simple collection of the plastic bags and strings from the enclosure could avoid intestinal obstructions of the animals. Effective prevention of enterotoxaemia can be achieved by vaccination with enterotoxaemia vaccine (Coles, 1966). Heavy concentrations of small lambs on small areas, which favors the spreading of coccidiosis should be avoided. Construction of food troughs which will prevent lambs from standing inside the trough to feed will prevent contamination of their food and the spreading of parasites. Small pens or high densities could be the primary cause of mortality.

Table 4.1 Gross Pathological findings recorded in captive and wild Cyprus mouflon.

Age	Sex and no. of animals	Gross Pathological Changes	Cause of death (or disease)
1 hour	1F*	Severe head oedema	Dystokia
2 days	1F*	Head oedema	Dystokia, starvation
2 days	1M*	Fracture of cranium	Septicaemia
2 days	2M*	Enteritis	Colibacillosis
50 days	2M*	Enteritis	Coccidiosis
92 days	1F*	Enteritis	coccidiosis and enterotoxaemia
4-5 years	1F*	Aetiology unknown	
>4 years	1F*	Broken hind legs	Bleeding
>4 years	1F*	Intestinal obstruction	Tympanism
~30 days	1?	Aetiology unknown	
~30 days	1M	Fracture of cranium	Road killed
~90 days	1F	Traumatic injuries	Internal bleeding
~240 days	1M	Rumen overload	Acidosis
~270 days	1M	Taumatic injuries	Road killed
2 years	1F	Traumatic injuries	Shot by poachers
3 years	1F	Lung consolidation, pneumonia Pneumonia.	Abortion

Table 4.1 continued

Age	Sex and no. of animals	Gross Pathological Changes	Cause of death (or disease)
>4 years	1F	Intoxication	Parathion poisoning
>4 years	2F	Traumatic injuries	Shot by poachers
>4 years	2F	Traumatic injuries	Fell from cliffs
>4 years	2F		Aetiology unknown
4-5 years	2F	Traumatic injuries	Killed by stray dogs
6, 7, and 8 years	3M	Traumatic injuries	Killed by stray dogs
6-8 years	2M	Aetiology unknown	
8 years	1M	Tetraplygia	Heart failure
8 years	1M	Traumatic injuries	Snared
>4 years	2M	Traumatic injuries	Shot by poachers
8-10 years	1M	Traumatic injuries	Shot by poachers
9 years	1M	Paralysis, severe diarrhea	Enteritis
10 years	1M	Traumatic injuries	Road killed
11 years	1M	Traumatic injuries	Fell from cliffs
11-12 years	1M	Aetiology unknown	

Total 6F*, 5M* 12F, 20M and 1? =44 animals.

* captive, F= Females, M= Males, ?= Sex not identified.

Table 4.2a Histopathological lesions recorded

Tissue	Age Years	Degenerative			Inflamatory			Circulatory			P	N	A	B	C	D
		Mo	Mi	Se	Mi	Mo	Se	Mi	Mo	Se						
Brain	0-1	-	-	-	1	-	-	-	5	1	-	1	8		7	
	2-5	-	-	-	1	-	-	-	1	-	-	1	3		2	
	>6	-	-	-	-	-	-	-	-	1	1	1	1	14	1	11
Epidy-																
dymis	0-1	-	-	-	-	-	-	-	-	-	-	1	1	1	-	
Heart	0-1	-	-	-	-	-	-	-	2	3	1	-	6		6	
	2-5	-	-	-	-	-	-	-	-	-	3	1	4		3	
	>6	-	-	-	-	-	-	-	-	-	6	-	6		6	
	?	-	-	-	-	-	-	-	-	-	1	-	1	17	1	16
Inte-	0-1	-	-	-	-	-	2	2	-	-	-	-	4		4	
stine	2-5	-	-	-	1	-	-	-	-	-	1	1	3		2	
	>6	-	-	-	-	-	1	-	-	-	1	-	2	9	2	9
Kidney	0-1	-	2	1	-	2	-	3	1	1	-	1	11		10	
	2-5	-	-	-	-	-	-	-	1	1	-	1	3		2	
	>6	-	-	2	1	-	-	-	-	2	-	-	5		5	
	?	1	-	-	-	-	-	-	-	1	-	-	1	20	1	18
Liver	0-1	-	-	-	-	-	-	1	4	2	-	1	8		7	
	2-5	-	-	1	-	1	-	-	1	1	-	-	3		3	
	>6	-	-	1	2	-	-	1	1	1	-	1	7		6	
	?	-	-	-	-	-	-	1	-	-	-	-	1	19	1	17
Total		1	2	5	6	3	3	8	16	14	14	10	80	80	70	70

Table 4.2b Histopathological lesions recorded

Tissue	Age Years	Degenerative			Inflamatory			Circulatory			P	N	A	B	C	D
		Mo	Mi	Se	Mi	Mo	Se	Mi	Mo	Se						
Lungs	0-1	-	-	-	-	1	-	-	3	3	-	1	8		7	
	2-5	-	-	-	1	-	1	-	-	-	3	-	4		4	
	>6	-	-	-	-	1	3	-	1	-	5	-	7		7	
	?	-	-	-	-	-	-	-	-	-	-	-	1	20	1	19
Lymph-nodes	>6	-	-	-	1	-	-	-	-	1	1	-	3	3	3	3
Muscle	0-1	-	-	-	-	-	-	-	-	-	2	5	7		2	
	2-5	-	-	-	-	-	-	-	-	-	6	-	6		6	
	>6	-	-	-	-	-	-	-	-	-	8	-	8		8	
	?	-	-	-	-	-	-	-	-	-	1	-	1	22	1	17
Pla-centa	2-5	-	-	-	-	-	-	-	-	-	-	1	1	1		
Skin	>6	-	-	-	-	1	1	-	-	-	-	-	2	2	2	2
Spinal cord	0-1	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-
Spleen	0-1	-	-	-	-	-	-	-	1	-	-	2	3		1	
	2-5	-	-	-	-	-	-	1	1	-	-	2	4		2	
	>6	-	-	-	-	-	-	-	-	3	-	1	4	11	3	6
Testis	0-1	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-
Total		-	-	-	2	3	5	1	6	8	24	15	61	61	46	46

Table 4.2c Histopathological lesions recorded

	Degene-rative			Inflama-tory			Circula-tory			P	N	A	B	C	D
	Mo	Mi	Se	Mi	Mo	Se	Mi	Mo	Se						
Total Tables a, and b:	1	2	5	8	6	8	9	22	22	38	25	141	141	116	

P=Parasitic. N=No pathological finding. A=Total number examined per age group. B=Total examined. C=Total with lesions per age group. D=Total with lesions. Mi=Mild. Mo=Moderate. ?=age unknown.

CHAPTER 5

BONE PATHOLOGY OF THE WILD SHEEP OF CYPRUS

5.1 INTRODUCTION

Although there is considerable literature on the bone pathology of domestic mammals (Jubb et al., 1985) there is no published information on the bone pathology of the wild sheep of Cyprus. There are many factors which can cause bone diseases in mammals, causing major problems for the health and survival of the animals. The objective of this investigation was to find if the mortality and physical fitness of the wild sheep of Cyprus are affected by pathological lesions in their skeletons. I attempted to determine the cause of these lesions, and make management suggestions based on these findings.

5.2 METHODS AND MATERIAL

Since the Cyprus mouflon is protected, carcasses were collected from dead animals in the wild or from the captive breeding flock of Stavros Forest Station. Since the number of lamb skeletons from wild animals was small, those of captive animals were also examined. From November 1985 to December 1988 an extensive search for carcasses was carried out in individual valleys of Paphos

Forest on foot and by car at least once a week. Some were also found by foresters and people working in the forest. A total of 69 carcasses were collected most of which were decomposed. A number of captive animals, two adult females, six male and four female lambs ranging from one day to four months old, were also examined. All the animals found freshly dead were transferred the same day to the Central Veterinary Department of Nicosia for postmortem examination. An assessment of the status of the skeleton was made during the autopsy of each animal. The ribs were examined when the thoracic viscera were exposed and the cranium was examined after the removal of the brain. The femur and its articulations were dissected, followed by a lengthwise bisection using a steel blade. Examination of the sawn bone included appraisal of articular cartilages, epiphyses, physes (growth plates) metaphysis and diaphysis with attention given to thickness density and amount of metaphyseal and diaphyseal bone. When the gross appearance of the carcass suggested the need, a more detailed study was made. In some special cases radiography was used to examine areas of special interest. Care was taken to avoid slicing articular cartilage during dissection. Articular cartilages and synovial membranes were examined before they became dry. When confronted with questionable anatomical features comparisons were made with domestic sheep and other domestic mammals (Sisson and Grossman, 1953; Michael, 1973, 1975). The pathological

lesions were compared with those of domestic animals or humans, presented in medical and veterinary literature (Cole, 1966; Matzen and Matzen, 1985; Jubb et al. 1985). These bones were also compared with a controlateral one and an equivalent from all other mouflon skeletons collected. After necropsy, the skeletons were cleaned. Not all skeletons were found complete. Many bones especially the thin and fragile ribs, had been broken or eaten by scavengers after the animal's death. To avoid confusion between old and postmortem fractures only bones which showed signs of healing, or those that were associated with muscle damage and hemorrhage caused by broken bone were used in the study.

A bone was considered osteoporotic when it was brittle and porous (Jubb et al., 1985).

To find if there was any association between the weight of the skull and the occurrence of the asymetry of the articular facets of cervical vertebrae in males and not in females, the average weight of the skull was measured in 20 males and 28 females.

The age of the animals was determined based on horn segment count for the rams and on dental criteria for the females Geist, (1966) and Valdez (1976) established that horn segment counts were reliable for aging North American bighorn rams (Ovis canadensis) and Armenian wild sheep (Ovis gmelini gmelini). Pfeffer (1967) and Valdez (1976) established that permanent incisors for Armenian wild

sheep and the European mouflon (O.g. musimon) erupted in the sequence of I1, I2, I3, C1 at approximately yearly intervals. Observations on captive and free ranging but tame mouflon, revealed that the above age criteria could also be applied to the Cypriot wild sheep. Based on the above information, the ewes are separated in three age classes: Class 1, lambs and yearlings with no permanent incisors of I1 present, Class II, animals two to four years old, with I2, I3 present C1 just erupting, and Class III with animals over four years old with all permanent teeth fully developed. The rams were separated in five age classes. Class one up to one year old, class two, two to four years old, class three, five to seven years old, Class four over eight years old and class five all the animals over four years old of unknown age. Class five included all rams whose heads were not found and could be aged only up to four years, based on bone size and epiphyseal fusion by visual appraisal. In both domestic sheep and mouflon the epiphyses of different skeletal parts generally fuse at different ages, but by the age four yrs, all are fused (Silver, 1969). Thus animals with small (lamb size) bones were considered in class one, animals with unfused bones were placed in class two, and all other skeletons were with fused epiphyses (both male and female), were considered to be over four years old.

The sex of freshly dead animals was easily recorded based on secondary sex characteristics, which included

black throat ruff, horns and white saddle patch in winter for males and hornless females. If the carcass was decomposed and the head taken away, the sex was distinguished based on the presence of suspensory tuberosities on the pelvis for the attachment of the ligaments of the penis (Taber, 1956). In the absence of the above criteria, the sex was considered unknown.

5.3 RESULTS

None of the 10 captive lambs examined right after their death had any bone lesions. From the two adult captive females examined one was free from lesions and the other had a deformation of the Sternum.

The wild animals had a considerable number of lesions. The number of vertebrae and long bones collected are presented in Tables 5.1 and 5.2 respectively. Table 5.3 presents the type of lesions observed for each sex and age class in vertebrae, while Table 5.4 presents those of the long bones.

The following results refer to free ranging mouflon except where it is noted.

5.3.1 Cervical Vertebrae

Asymmetry of the articular facets, stenosis of the vertebral canal, and holes on the transverse processes

were the vertebral malformations observed in the cervical vertebrae. Malformations were observed only in cervical vertebrae six and seven of four males, over eight years old, but never in females. Thi was caused by an asymmetry of the articular facets on the left side associated with degenerative changes (Fig. 5.1).

At the articulation of the atlas and the occipital condyle stenosis of the vertebral canal and the foramen magnum of the two males over eight years old, out of 18 atlases and 35 male skulls collected, was caused by degenerative changes. The bone leading to the stenosis was osteophytic in origin.

A round hole, approximately 6.9 mm wide (Fig. 5.2) was seen on the transverse process of the C6 vertebra on both sides of one eight year old male (N=24 males), and on the left side of the same vertebra of a female over four years old (N=24 females) (Tables 5.1 and 5.3).

5.3.2 Weight of the heads

The average weight of 28 female mouflon heads was 133.14 g and that of 20 male heads 1792.69g. On average a male's head including horns is 13 times heavier than that of females.

5.3.3 Thoracic vertebrae

The abnormalities of the thoracic vertebrae were degenerative changes (Fig. 5.3) and spondylosis, also known as spondylosis deformans or ankylosing spondylosis (Fig. 5.4). At the articular processes and facets, degenerative arthropathy was present and the reactionary osteophytes produced ankylosis of the articulations between vertebral bodies (intervertebral parts) and between the costal facets and the head of the ribs (costovertebral parts). In some cases two vertebrae joined and it was impossible to separate them without breaking the ankylosing bone.

Spondylosis was observed in rams over eight years old, mainly at T11, T12, and T13, although the initial degenerative changes in one were present at the age of four (Table 5.3). From 16 T13 collected, 11 had this lesion. Thirteen T12 were examined and nine had spondylosis, whereas only one out of 14 T4 had this abnormality (Table 5.3). One of the 14 class three females out of a total of 25 females (T12 and T13 were not collected from five of these females) had mild ankylosis at T12 and T13.

Disc damage with osteophytosis, and sometimes degenerative changes of the vertebral body (Fig 5.3) were also observed mainly in males throughout the thoracic vertebra (Table 5.3). Such changes were observed only in one female of the four different animals previously mentioned as having spondylosis.

Twenty seven male skeletons were examined with 295

thoracic vertebrae. In 16 (59%) skeletons, 82 (27.7%) vertebrae had lesions and 13 of these skeletons had at least one vertebrae with spondylosis. However out of 33 females (269 vertebrae collected) only two (7%) skeletons were affected. One of these had seven (2.6%) vertebrae with degenerative changes and the other two (0.7%) vertebrae with spondylosis.

5.3.4 Lumbar vertebra

Spondylosis of the Lumbar vertebrae of males was observed between T13 and Lumbar 1 (L1), creating a Lumbrothoracic articulation, and between L1 and L2. Out of 24 male L1, two both over nine years old, were affected. From 26 L2, one eight and two 11 years old were affected. Degenerative changes in males were observed in 3 skeletons out of 26 collected. These changes were at L1 in an 11 year old, at L3 and L4 in one over 4 years old, and at L2 of another 11 year old.

Of 33 females only an old one had spondylosis between L1 and L2. Five other females over 4 years old had degenerative changes at the lumbrosacral articulation whereas no male had such changes.

A slight bend of the neutral spine to the left or right was observed in five females and in three males.

5.3.5 Sacrum

No pathological signs were detected from the sacrums of 15 males whereas five out of 26 females, had a pathological change of the promontorium. Three of these, (all over four years old) had degenerative changes with osteophytosis (Fig. 5.5). One 3 year old, and one over four years old had mild osteophytosis. As it was noted earlier all the above five females had degenerative changes with osteophytosis at the body of the L5 vertebra, creating a lumbrosacral articulation

5.3.6 Sternum

A total of 26 sternums were collected, 14 from males and 12 from females (Table 5.2). Ankylosis between sternebrae and degenerative lesions of unknown aetiology were seen in nine males. Eight of them were over four years old. A bony bridge fusing adjacent sternebrae was observed affecting the manubrium sterni and the second sternebra in nine rams while the 3rd and the 4th sternebrae were affected in two rams and 4th and 5th in one ram. In two of the above rams the ankylosing bone of the first two sternebrae failed to fuse and moved 2 cm upwards into the thoracic cavity (Fig. 5.6). One nine year old ram had only degenerative changes, and another younger one had upward retraction of the last three caudal sternebrae and

the xiphoid. Three other rams, two four and five years old had no pathological changes. The incidence of bridges and osteophytes were noted on the dorsal side of the sternum in seven rams, on the ventral side of an eighth ram and in both sides of a ninth ram.

Six females, five over four years old and one 2-3 years old had mild to severe exostosis and degenerative changes between the first and second sternebrae. One of them had the exostosis and degenerative changes between sternebrae three and four and another between six and seven.

A captive adult female had scoliosis of the xiphoid and dislocation of a rib attached to the sixth sternebra.

A free ranging female lamb, less than a year old, had a cleft between sternebrae five and six.

5.3.7 Pelvic bone

Degenerative changes were seen in the pelvic bones of both sexes. Two females over 4 year old out of 29 female pelvic bones collected, had osteophytes at the symphysis and between the ischii, about 1.5 cm long. Of 32 pelvic bones collected from rams, six of them aged four, nine and the rest over four years old had a malformation of the tuber coxae area. A bridge of bone, uniting the epiphysis and metaphysis, extended 2.5 cm down to the ischium (Fig. 5.7). At the point of attachment, the epiphysis was

pulled towards the metaphysis or bent upwards.

5.3.8 Fractures

Three of 24 males and four out of 21 females collected from the wild had broken ribs. Of 30 male skulls, the nasal bone of one was broken and four others had one horn broken off near the base. The front leg of an old ram was broken off near the proximal end of the metacarpus and in one female over four years old the tibia was broken in the middle.

Fractures from lead shots were seen in three cases. In the first two bullets were half embedded in the pelvic bones of a nine year old ram and in one ram over four years old. In the third case they penetrated the distal end of the right radius and ulna of a nine year old ram, causing severe osteophytosis (Fig. 5.8). The lead shots in the latter bones were discovered after an x-ray was taken.

5.3.9 Osteoporosis

The above radius and ulna mentioned in the fracture section as well as the tibia and scapula of the same leg had osteoporosis. The skull of six rams of 30 collected, including the four mentioned earlier with broken horns, had osteoporosis. The bone mass of the skulls was reduced

and the horn cores became porus and brittle, sometimes breaking under the pressure of the fingers.

5.3.10 Cysts

Two male mouflon were found to have cysts: one five year old had two, 0.5x1.0 cm apart from the shaft of the left radius (Fig. 5.9). The other, an adult of unknown age, had one at the shaft near the proximal end of the radius and one on the right femur by the vascular groove, 1 cm above the medial epicondyle.

5.3.11 Arthritis

Degenerative ulceration of opposing articular plates between the carpals and metacarpals and/or tarsals and metatarsals caused erosion of the facets. Two nine year old rams had degenerative changes with a hole, 5mm wide, at the facets of the proximal end of the metacarpals. The same was seen at the metatarsals of another eleven year old. Another two, eleven to twelve years old as well as two females over five years old had degenerative changes, without holes. One of these females, collected right after having been killed by free-roaming dogs, had monoarticular purulent arthritis on the rear left leg. The articular region was greatly enlarged and the empyema of the joint ruptured and fistulated to the skin.

Two nine-to-ten year old rams and the above two females had degenerative changes of the proximal ends of the metacarpals and the corresponding carpals.

5.4 DISCUSSION

Gross examination of the skeleton can be sufficient for demonstrating and recording lesions. In some instances though there may be limitations to the accuracy of the diagnosis because special techniques, such as determination of bone ash, bone specific gravity and bone biopsy were not used. The first two techniques are used when metabolic or developmental disease is suspected, but the problem with applying them is the lack of normal values (Jubb et al., 1985). The interpretation of the third technique is often difficult and may be impossible without a precise history and details of surgical site. Many biopsies yield periosteal new bone and little else, and the temptation to overinterpret must be resisted (loc. cit.). Since most of my specimens were putrified the details usually necessary for the interpretation of this technique were lost. Bone biopsies have not been used in Cyprus for veterinary purposes and the means for such study were not available (Toumazos P., Central Veterinary Department of Nicosia, Pers. commun.).

Considering the above difficulties and limitations of these techniques, it was decided to use only methods that

could be easily duplicated by the pathologists in Cyprus i.e. gross examination and radiography.

Comparing the captive and free ranging animals, it can be seen that the lambs of the former were free from lesions, whereas one of the three free ranging lambs had a cleft of the sternum. All the captive lambs were less than four months old. The above probably reveals that lambs in their first few months of life are free from bone lesions. It is admitted though that the number of free ranging lambs examined was limited.

The number of adult captive sheep examined was also small, since only two were examined. The retraction of the caudal sternebra and the xiphoid, seen in one of them was not observed in any of the sternums of the free ranging sheep. This defect is seen in domestic lambs and calves and apparently is due to shortness of the tendious portion of the diaphragm (Jubb et al., 1985).

Different factors such as nutrition and parasites can affect the health and development of bones. These factors differ between the captive and free mouflon, since the captive are provided with a balanced diet ad libitum and are treated with antihelminthic drugs (data in the files of Stavros tis Psokas Forest Station). I now focus the discussion on the free ranging animals.

5.4.1 Asymmetry of articular facets

The effect of this on mouflon is unknown. It is present in horses and it is of variable significance, since many "normal" animals have similar changes. Nonetheless in some horses it causes a spinal cord injury due to vertebral malformation (Fraser and Palmer, 1967; Mason, 1979; Jubb et al., 1985). In mild cases this causes errors of movement and disturbances of balance. The onset is insidious, but vague signs are often exacerbated following episodes of strenuous activity.

An association between fast-growing and abnormal development of cervical vertebrae was established for both horses and dogs (Jubb et al., 1985). It was suggested that the rapidly growing and remodelling bones become deformed by forces related to the weight of the head and length of the neck. Such bone tissue area has a low mineral content (loc. cit). It is relatively soft with a high remodeling rate, and therefore susceptible to mechanical influences.

It is possible that the above factor can be responsible for the asymmetry of the articular facets of the cervical vertebrae of mouflon. This is supported by the fact that it was seen only in rams, which grow faster and larger than the ewes (Geist, 1971) and their skulls are 13 times heavier than those of the female.

5.4.2 Stenosis of vertebral canal

The symptoms of Stenosis of the atlas neural canal and the foramen magnum in two male mouflon are unknown, but are probably similar to those of cervical vertebral stenotic myelopathy. This is a disease that affects horses, dogs and domestic sheep (Palms et al., 1981; Jones and Hunt, 1983; Jubb et al., 1985). The naming of this disease is somewhat arbitrary. There are several lesions associated with it, which are only present in some cases, and a few of which are secondary degenerative changes. However, the common significant factor is morphologic or functional stenosis of the vertebral canal, thus justifying its name.

The clinical syndrome is attributable to compression of the cervical spinal cord because of deformities in the cervical vertebrae. It produces clinical signs similar to those seen in asymmetry of articular facets of the cervical vertebrae.

5.4.3 Developmental errors

The cause of the holes observed on the transverse process of the C6 is unknown. To my knowledge no such holes are described by the atlasses referring to the anatomy of domestic animals (Sisson and Grossman, 1953; Michael, 1973, 1975), or by veterinary books referring to the pathology of bones of domestic animals including sheep (Smith et al., 1972 Jones and Hunt, 1983; Jubb et al.,

1985) It is suspected though that the cause may be developmental error. According to Jubb et al. (1985) developmental errors of the skeleton might be genetic or conditioned by the environment, and may be local or systemic. Since the complexity of the processes by which the skeleton is formed provides ample opportunities for errors, the classification of these errors may cause confusion (loc. cit).

5.4.4 Spondylosis

This is a common condition in bulls, pigs, and dogs but less frequent in other species (Jubb et. al., 1985; Jones Hunt, 1983). The disease is important to bulls in artificial breeding studs and is to be expected in any animal exceeding middle age. The cause is, no doubt, related to their duties, but immediate pathogenesis is not clear (Smith et al., 1972; Jubb et al., 1985). In horses, ankylosing arthritis is usually due to trauma, often from repeated strains and concussions resulting from severe work on hard surfaces (Smith et al., 1972; Jones and Hunt, 1983).

In case of bulls, the initial degenerative changes may be present at the age of two, compared to four in wild sheep, and develop gradually. Osteophytes appear mainly on the posterior of the thoracic and anterior end of the lumbar vertebrae. Their incidence and size tends to

decrease in either direction from the thoracolumbar junction, which is the area of greatest spinal curvature, and maximum pressure on the disc would be expected. Compared to wild rams, as previously noted, T11, T12, and T13 are the most affected, but sometimes create thoracolumbar articulations as well.

The incidence of osteophytes, in dogs, increases with age after about the fifth year. Most lesions occur at L2 L3 and lumbrosacral articulation is often involved, as observed in the female wild sheep of Cyprus. The result in horses is similar to that in other species, although the evolution of the osteophytes has not been studied in detail.

The actual effects of spondyloankylosis on mouflon are unknown. Bulls with spondyloankylosis show posterior weakness and ataxia, or paralysis, after dismounting from service (Jubb et al., 1985). They may continue to be mildly ataxic or recover clinically to be affected again later. The onset of clinical signs is usually associated with fracture of the vertebral bodies and ankylosing new bone. Trauma of the spinal cord is usually mild and paralysis is often an accompaniment of haemorrhage or the result of repeated trauma.

According to Jubb et al. (1985), any factor permitting abnormal mobility of intervertebral articulations has the potential to stimulate osteophyte formation and spondylosis. If this suggestion is applicable to mouflon,

then rams should have a higher occurrence of osteophyte formations at the area of the vertebra, with a greater spinal curvature than ewes. This is because their spinal cord is induced to much greater strain than that of females, as is in fights, which form an important part of their rutting behaviour.

Schaffer (1968) estimates the closing velocity of domestic rams Ovis aries and the European mouflon Ovis gmelini musimon to be about 61 km/h. One would expect a similar figure for those of Cyprus mouflon. Although the horns absorb much of the force from a clash, small rams are compressed forcibly by the collision considerably straining the vertebral column (Geist, 1971, see plate 52 and page 146). The Cyprus female mouflon is hornless (Clark, 1964; Valdez, 1982; personal observation) and therefore lacks the ability to deliver forceful blows, since horns act as weapons (Geist, 1971).

The above is supported with the result that 59% of the rams had spondylosis compared to 7% of the ewes, or 27.7% of the male vertebrae examined were affected compared to 0.7% of the female vertebrae.

The higher occurrence of degenerative changes with osteophytosis, but not ankylosis, in the lumbar vertebrae of the ewes, compared to rams (Table 5.3), suggests that these were subjected to pathological factors other than traumatic.

The pathological degenerative changes of the promon-

torium might be caused by the same factors as those affecting the sixth lumbar vertebra such as the extra weight which the females carry during the five months of pregnancy. This is supported by the fact that, out of the fifteen sacra collected from males, none had such lesions. According to the Obstetrician-Gynaecologist Dr. M. Solomon (pers. commun. 1989) similar degenerative changes are seen in the lumbar and sacral area of pregnant human females, and apparently are caused by the weight and kicking of the embryo, and the affect of the hormone relaxine. This hormone relaxes the connective tissues of the body during pregnancy making the arthroses vulnerable to traumatic injuries.

5.4.5 Sternum

Based on Table 5.2, the degenerative changes seen in sternebrae seemed to be a characteristic of old age since all animals with lesions were over 4 years old. The real problem with these lesions would arise when the ankylosing bone pushes into the thoracic cavity, as was observed in two cases.

Cleft of the sternum may occur as isolated defects in other domestic species, but are usually accompanied by ectopia cordis, or form part of the defect schistosomus reflexus (Jubb et al., 1985).

5.4.6 Pelvic bone

Formation of osteophytes at the symphysis of the pelvic bone is seen in women and is associated with hormonal changes during labour (Matzen and Matzen, 1982). The fact that none of the 27 male pelvic bones had such lesions suggests that the factors contributing to human osteophytosis might affect mouflon too.

5.4.7 Bridges

Traumatic or septic disruption of the physis is followed by formation of a bridge of bone which unites the epiphysis with the metaphysis, acting as an anchor. Sometimes, these bridges are persistent and become effective inhibitors of growth, in which event, continued physical growth on the opposite aspect leads to angulation of the end of the bone (Jubb et al., 1985). Such lesions occur in all species but particularly in young horses and dogs (loc. cit.).

The bridge between spines nine and ten of a four year old ram, and the bridge uniting the epiphysis with the metaphysis of the pelvis were possibly traumatic in origin from unknown causes. However, a possible cause of these traumas could be the forceful, sometimes unexpected, clashes of the rams that can lift the opponent off the ground.

5.4.8 Fractures

The number of animals with rib fractures may be highly underestimated. Sometimes scavengers ate the thin and fragile bones of the ribs as far as 2 cm from the vertebrae, therefore some fractures could not be seen. Also fractures that possibly took place just before the animal died or even those that might had caused its death, were not recorded since the animal did not have the chance to show signs of healing.

Reasons, such as intraspecific fights between males, and rolling stones could have been the cause for the fractures in mouflon. Females are exposed to rolling stones since they spend several weeks, during lambing, in cliffs of fragile volcanic diabase rocks whereas rams usually stay in adjacent areas or in cliffs rich in grass (Hadjisterkotis, unpubl.).

5.4.9 Bone cysts

A cyst has been defined as a collection of gas or fluid enclosed by a capsule (Jubb et al., 1985). Since the bones with cysts were found free from membranes, blood or any other substance, it was difficult to identify their nature.

5.4.10 Osteoporosis

Osteoporosis signifies a pathological loss of part of a bone leaving the rest structurally normal (Wu and Frost, 1969). It results from an imbalance between formation and resorption, in favour of the latter.

This disease is especially common in farm animals, and is often nutritional in origin. In grazing animals it is likely to be overlooked, unless a high incidence of lameness or fracture occurs (Jubb et. al., 1985).

There is no simple way of determining when a skeleton is significantly osteoporotic. Arbitrarily, a reduction in bone mass can be regarded as pathological when the skeleton cannot serve the needs of muscular activity (Jubb et al, 1985).

There are several well accepted causes of osteoporosis, some of which are known to be pathogenetically different in terms of the rate and extent of deposition and resorption. These are starvation, senility, disuse, atrophy, intestinal parasitism, calcium and phosphorus deficiency, and locoweed (Astragalus spp.) poisoning (loc. cit.).

Starvation involving severely restricted intake of a balanced diet, may includes protein and energy deffiiciency since, under such circumstances, available protein is utilized to provide energy (Jubb et al., 1985). The effect of protein level in skeletons is complex, for

example, in sheep the availability of dietary calcium is reduced by low protein intake. Forage with less than 7.0% crude protein is generally of too low a quality to maintain the body weight of sheep (NRC, 1985; Hadjipanayiotou et al., 1975). The calcium levels in grass, which are the main food item of mouflon during late summer and autumn, are below this requirement (see Chapter two) which according to the NRC (1985) are 0.20-0.82% on a dry matter basis, whereas some other plants are just above the required levels. When a mixture of grass from Anadhiou and Stavros tis Psokas areas was analyzed, (loc. cit.) it were found to be just above the minimum requirements. It is, however, possible that the low protein may have a negative effect on the availability of calcium (Jubb et. al., 1985).

The reasons why phosphorus deficiency can cause osteoporosis under such circumstances is not clear but if is perhaps related to anorexia, often accompanying phosphorus deficiency, age and growth rate of the animals, severity and duration (loc. cit.).

In summer and fall, all forage species available to mouflon, except Asphodellus aestivus, have a phosphorus content below normal (Chapter two).

Although these results present some evidence for protein and nutrient deficiencies they are arbitrary, since the most representative method for collecting such information is by using a rumen or oesophageal fistula.

Severely parasitized sheep are frequently osteoporotic, and the lesions are usually considered to be the result of malabsorption (Jubb et. al., 1985). An examination of 26 faecal samples taken from free-ranging mouflon for intestinal parasites, revealed the presence of strongyle and moniezia eggs. For strongyle eggs 12 had no infection, 11 had low infection, and 2 were heavily infected. For moniezia eggs 24 had no infection, and 2 had low infection.

Sheep suffering from energy deficiency have less resistance to infection from intestinal parasites, and this combination increases their chances to become osteoporotic.

5.4.11 Degenerative diseases of joints

Such diseases are common in domestic animals and mainly affect the articulation of limbs (Jubb et. al., 1985). They are known as degenerative arthritis and osteoarthritis, but the term arthropathy is usually used to separate what is primarily a degenerative change from arthritis, which is mainly inflammatory. Nevertheless, because of the limited range of reactions inherent in articular and synovial tissues, changes seen in chronic arthritis and, in the end stage, the differentiation of primary inflammatory disease from the degenerative one may be arbitrary (Jubb et. al., 1985).

The basic factors influencing the development of degenerative arthropathy are the inability of mature articular cartilage to repair itself effectively and the constant mechanical stresses to which it is exposed during normal use. An increased susceptibility to injury, perhaps inherent weakness or a secondary change increases the possibility of arthropathy. To determine the actual causes of mouflon arthropathy more research is needed.

5.4.12 Conclusion

The Cyprus mouflon suffers from a large range of bone problems similar to those of domestic animals. These problems could possibly affect the fitness of individuals to varying degrees, from slowing them down and making them less competitive during the rutting season, to rendering them susceptible to predation. Possibly the most important defect, which affects mainly old males, is spondylosis. Therefore, it is suggested that in the case of hunting, old rams over 9 years old could be removed from the population without affecting it.

Geist (1971) suggested the removal of old rams from a herd by hunting may be harmful, because younger rams would then engage in excessive fighting and harassment of the ewes, possibly resulting in lower reproduction as well as the causing scattering of the herd. This should not be the case in the Cyprus mouflon as these old rams, being

spondylotic no longer would play an important role in the hierarchy of the flock. Pfeffer (1967) stated that mouflon rams younger than 8 years old should not be hunted because, up to 10 years old, they are reproductively efficient but he had no measure of physical deterioration by spondylosis. Pfeffer (1967) also pointed out that European mouflon ewes should not be hunted at all, as old ewes are important in guiding the flock.

Table 5.1 Number of Vertebrae of free ranging mouflon examined

Age class	I		II		III	IV	V		Total		Number	
Age	0-1		2-4		5-7	8	<4		Number of vertebrae examined		of animal with lesions	
Sex	M	F	M	F	M	M	M	F	M	F	M	F
Atlas C1	1	2	4	5	1	8	4	13	18	20	2	
Axis C2	1	2	3	3	2	12	4	14	22	19	2	1
C3	1	2	3	6	2	10	4	18	20	26		
C4	1	2	3	6	2	11	4	16	21	24	1	
C5	1	2	3	4	2	11	4	14	23	20	1	
C6	1	2	3	4	2	13	4	15	24	24	4	2
C7	1	2	4	6	2	13	3	14	23	22	4	1
TOTAL CERVICAL	7	14	24	37	13	78	27	104	151	155	6	3
Thoracic												
T1	1	2	4	3	1	12	3	15	21	22	6	
T2	1	2	4	4	1	13	3	15	22	21	5	
T3	1	2	4	5	1	13	3	13	22	20	4	
T4	1	2	4	4	1	14	3	14	23	20	5	
T5	1	2	4	3	1	11	3	14	20	19	4	
T6	1	2	4	4	1	12	4	12	22	18	5	1
T7	1	2	4	4	1	14	3	15	23	21	5	1
T8	1	2	4	4	1	15	4	15	25	21	6	1
T9	1	2	4	5	1	15	3	16	24	21	7	1
T10	1	2	4	5	1	12	3	15	21	22	6	1
T11	1	2	4	5	1	14	3	15	23	22	10	
T12	1	2	4	3	1	13	4	15	23	20	10	1
T13	1	2	4	3	1	16	4	15	26	21	11	1
TOTAL THORACIC	13	26	52	52	13	174	43	189	295	269	16	2
LUMBAR												
L1	1	2	3	5	3	14	4	20	24	27	4	2
L2	1	2	4	6	3	15	4	20	26	28	5	4
L3	1	2	4	6	3	15	4	20	26	28	2	5
L4	1	2	4	7	3	14	4	22	25	31	2	4
L5	1	2	4	7	3	14	4	21	25	30	1	4
L6	1	2	4	8	3	15	4	23	26	33	1	9
TOTAL LUMBAR	6	12	23	39	18	87	24	126	152	165	9	13
SACRUM	1	2	2	5	1	9	2	19	15	26		5

Table 5.2 Number of long bones examined from free ranging wild sheep

	Age class of individual animals											
	I 0-1		II 2-4		III 5-7	IV >8	V >4		Minimum Number of individuals		Total Number of bones	
	M	F	M	F	M	M	M	F	M	F	M	F
Humerus	1	2	4	2		11	6	17	22	21	27	30
Radius	1	2	4	2	2	12	8	14	28	18	40	30
Ulna	1	2	2		2	12	6	11	23	13	28	20
Metacarpus	1		1	2	3	13	4	10	22	12	28	19
Femur	1	2	4	2	3	12	12	27	32	31	43	41
Tibia	1	3	2	3	5	11	8	24	27	30	38	40
Metatarsal	1		2	1	3	12	12	22	29	24	43	38
Sternum	1	2	2	3	1	8	3	7	15	12	14	12
Pelvis	1	1	6	1	4	12	9	27	32	29	31	29
Ribs	1	3	3	5	3	15	3	16	25	21	24	?
Total	10	17	30	23	26	118	71	175			316	259

Table 5.3. Number of vertebrae with lesions and type of lesions per age class.

	Age class per sex.												
	I		II		III	IV	V		Total		
	0-1		2-4		5-7	>8	>4				
	M	F	M	F	M	M	M	F	M	F	
Cervical											
C1						2S			2S		
C2											
C3											
C4											
C5											
C6						4M,1E		1E	4M,1E	1E	
C7						4M			4M		
Total						11		1	11	1	12
Thoracic											
T1						6X			6X		
T2			5X			5X					
T3			1X			4X			5X		
T4			1X			1A,4X		1X	1A,1X	1X	
T5						2A,2X		1X	2A,3X	1X	
T6						1A,4X		1X	1A,1X	1X	
T7						4X	1X	1X	6X	1X	
T8						5x	1X	1X	7X	1X	
T9			1X		1X	4x	1X		7X		
T10					1X	4X	1X		6X		
T11						6A,3X	1X		6A,4X		
T12						9A,4X	1X	1A	10A,1X	1A	
T13						11A,2X	1X	1A	12A,3X	1A	
Total			3		2	81	7	7	87	7	94
Lumbar											
L1						2A,1X		1A	2A,1X	1A	
L2						3A,1X	1B	1A,1B	3A,1X,1B	1A,1B	
L3				2B		1X	2B	3B	1X,2B	5B	
L4				1B		1X	1B	1B	1X,1B	2B	
L5				1B				5X,1B	1B	2B	
L6				1B						5X,2B	
Total				5		9	5	14	14	19	33
Sacrum								5X			5

A = Ankylosis
B = Bend spine
E = Developmental Error
S = Stenosis
X = Degenerative changes, osteoporosis
M = Malformation

Table 5.4. Number of bones with lesions per sex and age class

Age class	I		II		III	IV	V		Total	
Age	0-1		2-4		5-7	>8	>4			
Sex	M	F	M	F	F	M	M	F	M	F
Humerus										
Radius					1C	1L 1X	1C		2C 1L 1X	
Ulnas						1L 1X			1L 1X	
Metacarpus						2A	1F 2A	 2A	2A 1F	2A
Femur							1C		1c	
Tibia								1F		1F
Metatarsal						3A		2A	3A	2A
Sternum						9D	2D	6D	11D	6D
Pelvis			1D			1D 1L	4D 1L	2D	6D 2L	2D
Ribs			1F	1F	1F	1F		3F	6F	2F
Skulls				1X	1X	5F 4X			5F 5X	1X

F= Fructures
A= Arthritis
L= Shot
X= Ostoporosis
C= Cyst
B= Bridge
D= Degenerative changes, osteophytosis
M= Male
F= Female

Figure 5.1. Vertebral malformation; asymmetry of articular facets.

5.1

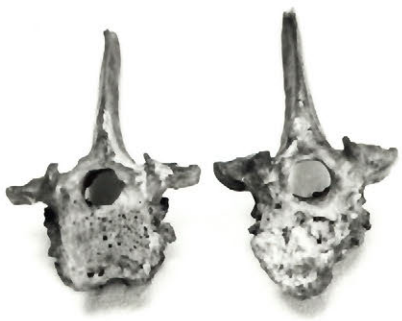
Figure 5.2. Cervical vertebrae number six.

Left: with a hole on the transverse process.

Right: normal.

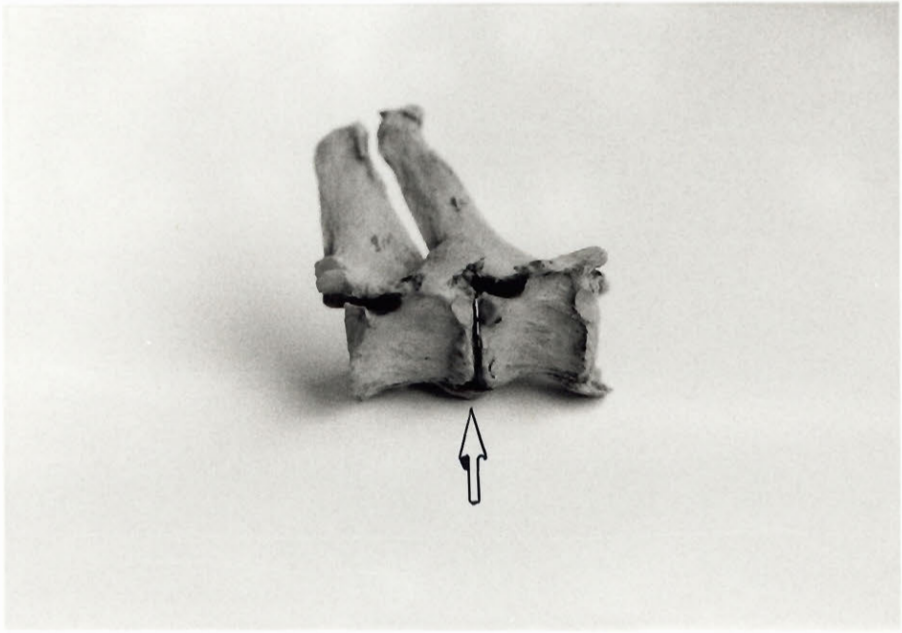
5.2

Figure 5.3. Degenerative changes of the vertebral body.



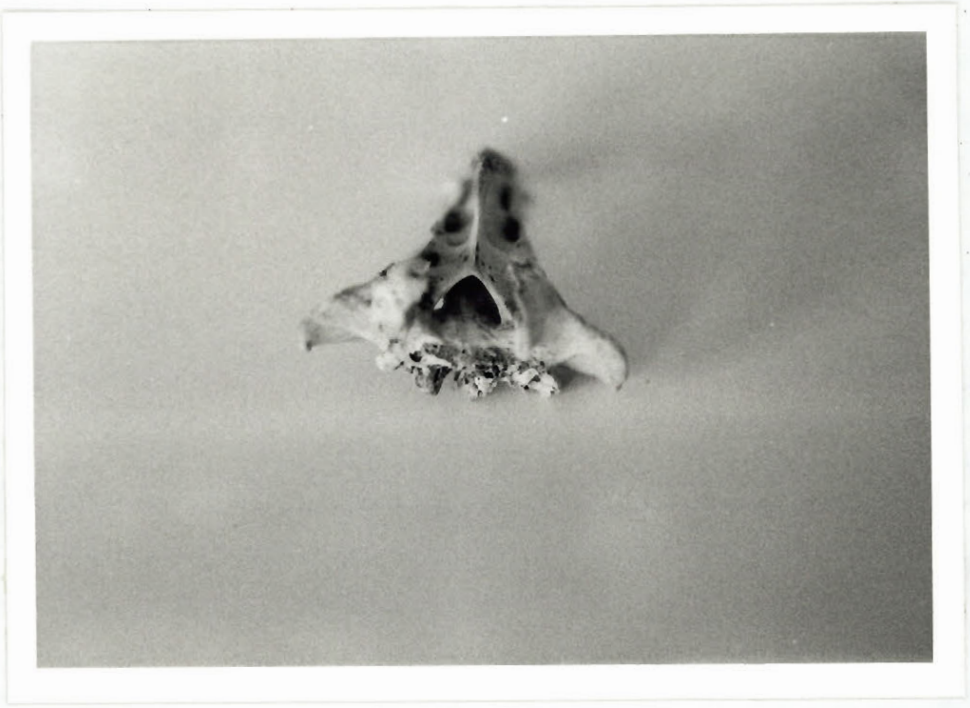
5.3

Figure 5.4. Ankylosing spondylosis; showing ankylosing bone between vertebrae. Arrows show the bridge of bone which unites the epiphysis with the metaphysis.



5.4

Figure 5.5. Degenerative changes of the promontorium with osteophytosis.

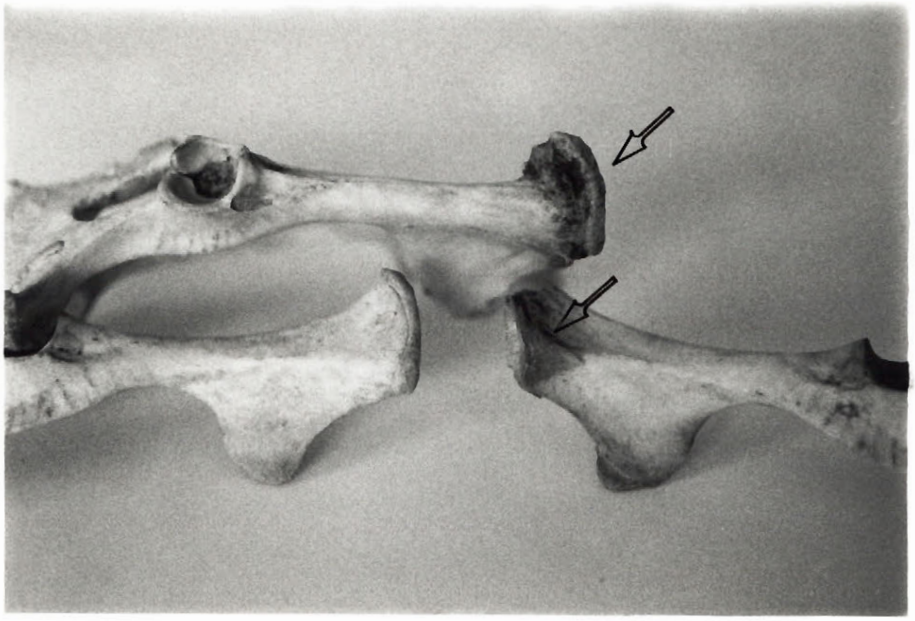


5.5

Figure 5.6 Malformation of the sternum, between manubrium sterni and second sternebra.

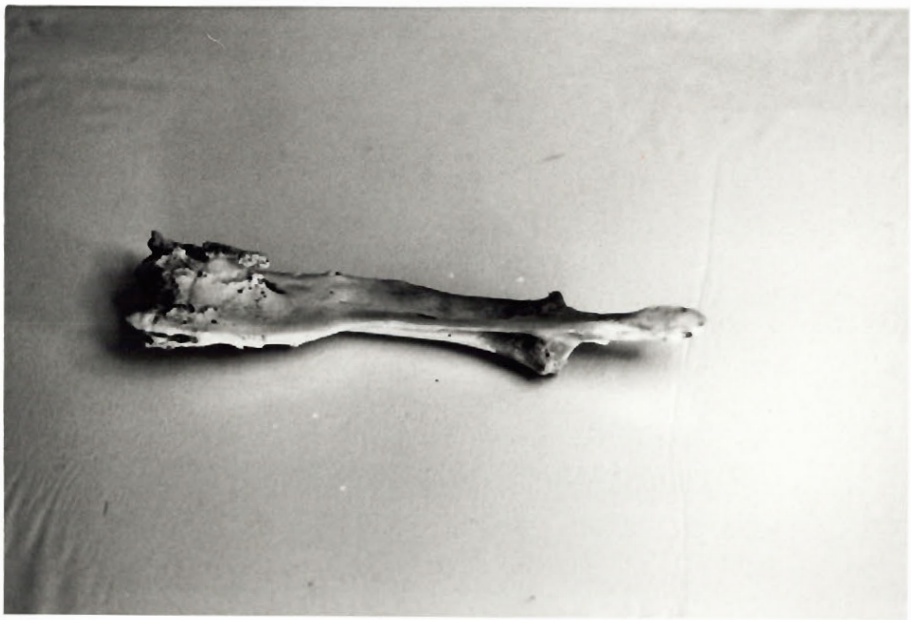
5.6

Figure 5.7. Malformation of the physis of the tuber coxae.



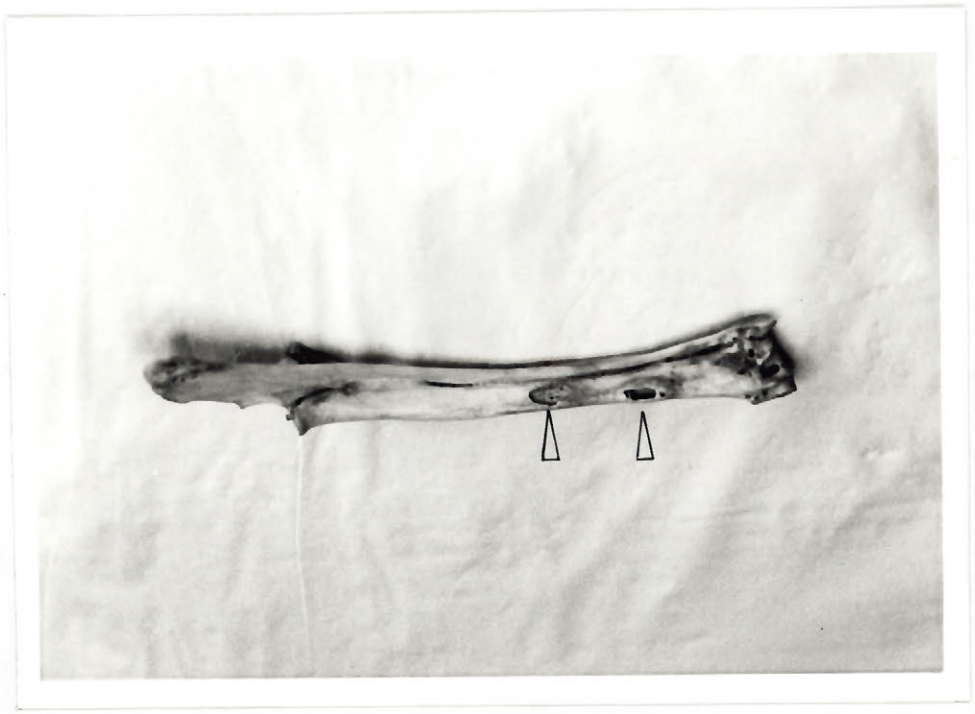
5.7

Figure 5.8. Osteophytosis of the distal end of the right radius (left side) caused by lead shots.



5.8

Figure 5.9. Bone cysts.



5.9

CHAPTER 6

MONTHLY DISTRIBUTION OF DEATHS

6.1. INTRODUCTION

After the detailed examination of the mortality factors (in Chapters 4 and 5) it appeared that there was a seasonal pattern in mortality. The purpose of this chapter was to compare the seasonal mortality of the Cyprus mouflon and to examine the dates of death of animals at the edge of the forest and inside the forest.

6.2. METHODS AND MATERIALS

Carcasses were collected from dead animals in the wild. From November 1985 to December 1988 an extensive search for carcasses was carried out in individual valleys of Paphos Forest on foot and by car at least once a week. Some were also found by foresters and people working in the forest. The study was based on fresh carcasses for which the date of death could be identified.

6.3. RESULTS AND DISCUSSION

Sixty two mouflon were identified as freshly dead in the forest, and 14 at the forest edge (Fig. 6.1). In the

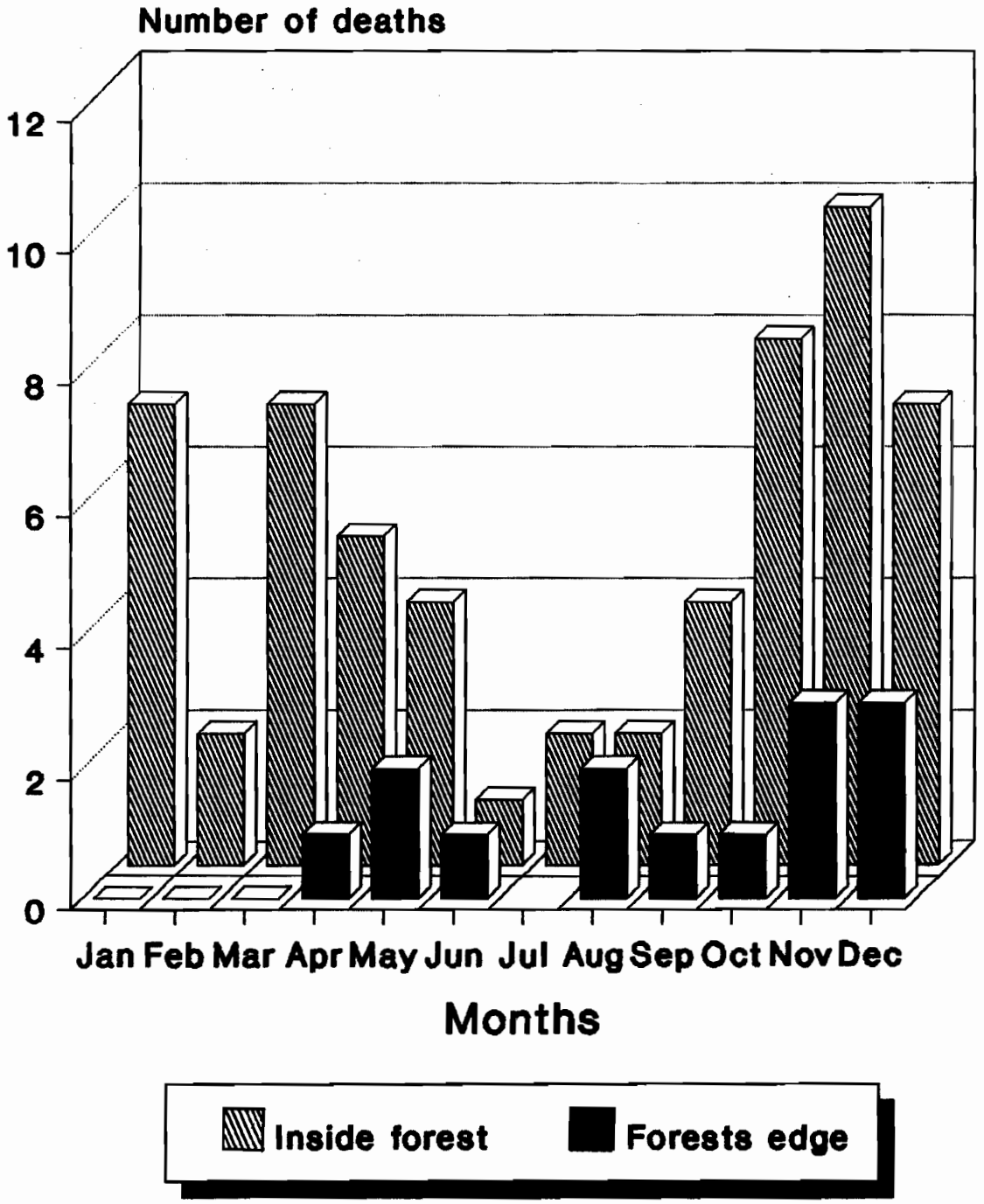
forest, November was the month with the highest mortality rate, while February, June and July were the lowest. Fall was the season with the highest mortality rate with 22 dead animals followed by 17 in winter, 16 in spring, and eight in summer.

At the forest-agriculture interface mortality ranges between 0 and 2 per month. The highest mortality occurred in November and December, followed by August and May.

The comparison of the monthly distribution of the mortality in the two areas, tends to reflect the harsher environmental conditions of the forest. Although a detailed discussion of the mortality factors is presented in the two previous chapters, there are some factors that might predispose the animals to disease such as starvation, lack of nutrients and cold. Immediately following the rut in Cyprus, unlike in temperate habitats, the vegetation begins to grow, providing young, easily digestible material, especially forbs and grasses. Thus the nutritional crisis experienced by other wild sheep does not occur in winter for Cyprus mouflon. In addition, the winter temperatures were milder than those in temperate climates, snowfall being light and infrequent and rarely lying for more than a day or two in the Paphos Forest during the period 1985-1992. However, male ruminants such as sheep and many deer species, have their highest energy cost during the rut. Many lose body weight during the rut, because the time that would be spent grazing is taken up

with activities such as following oestrus females and fighting rival males (Geist, 1971). In temperate climates in addition to loss of condition, there is a high post-rut mortality (Clutton-Brock et al. 1982; Grubb, 1974). According to Maisels (1988) because of the climatic conditions this should not happen in Cyprus. However the highest mortality for Cyprus mouflon is during the rut and immediately following for one or two months. The low quality food of the late summer and early fall with reduced protein and other nutrients (see chapter 2C) in combination with high loss of energy during the rut, the drop in temperature which increases the need for higher energy, and possibly a combination of diseases leads to a loss of condition and eventually death. Depending on the rains fresh grass might not appear particularly inside the forest until a month after the rut and this might lead to the high losses.

Figure 6.1 Monthly distribution of deaths at the edge and inside Paphos Forest from November 1985 to December 1988.


Number of deaths
12
10
8
6
4
2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months
Inside forest
Forests edge

CHAPTER 7.

REPRODUCTION OF CYPRUS MOUFLON IN CAPTIVITY AT THE ZOOLOGICAL GARDEN OF LIMASSOL.

7.1 INTRODUCTION

The Cyprus mouflon is considered an endangered species mainly because it is restricted to an area of about 600 Km in the Paphos mountains and no one is sure of the size of the population or its susceptibility to extinction. In the sense that it is better to be safe than sorry, it is wise to maintain some isolated captive populations, but this must be done well or not at all. The main concern is that the captive populations maintain a heterozygotic genetic stock which could if necessary reinforce a dwindling native wild population at some later date. If this is not done the captive animals will become less productive than their wild congeners and their reproductive capacity would be wasted.

The Cyprus mouflon has been bred in captivity at the Zoological Garden of Limassol in Cyprus, since 1955. The object of this chapter is to review the history and management of the Limassol animals, and evaluate the captive breeding program in view of the needs of an endangered species population.

A major genetic problem which is almost certain to

lead to extinction is inbreeding (Soulé, 1980; Frankel & Soulé, 1981). Wiener & Hayten (1974) and Wiener & Wooliams (1980) suggested that sheep are vulnerable to this problem. Characteristic indicators of inbreeding effects include excessive mortality particularly in juveniles (O'Brien et. al.,1986), and reduced fecundity (Soulé, 1980; Frankel & Soulé, 1981). Other apparently genetic phenotypic changes brought out in captivity are early sexual maturity and lengthening of the lambing season (Volf, 1975; Frankel and Soulé, 1981). To avoid loss of fitness or even extinction, Frankel and Soulé (1981) suggested that on a short term basis, there should be a minimum effective size (Ne) of 50 animals, not all of which have to be at the same institution. The performance of this captive flock is compared with that of the free ranging mouflon of Paphos Forest (from which the captive animals originated) and other related wild sheep from other countries.

7.2 METHODS AND MATERIALS

This study is based on the unpublished data accumulated in the files of Stavros tis Psokas Forest Station, (Stavros), the Zoological Garden of (Limassol) and the Cyprus Veterinary Department. The staff of Limassol reported the sex and date of birth or death of every mouflon between 1955 and 1969. From 1970 to 1973, records at

the Zoological Garden were lost. However, during those four years the files of Stavros tis Psokas Forest Station provided information on the interchange of mouflon between Stavros and Limassol.

Since 1974 the total number of male and female animals present was recorded. Records were usually taken in January when lambs were about 9-10 months old and their secondary sexual characteristics were distinguishable from a distance. In addition, the total number of newborn including those born dead was kept.

The lamb per ewe ratio was based on females that reached sexual maturity, i.e. 2 years of age, with the exception of yearlings that gave birth.

The genetically effective population size (Ne), for each year from 1955-1970 was calculated according to Kimura and Crow (1963) and Frankel and Soulé (1981). Using the formula:

$$Ne = \frac{4Nm\ Nf}{Nm + Nf}$$

Where Nf is the number of females and Nm is the number of males in the founder population.

The paddock for the Cyprus mouflon at the Limassol Zoological Garden is located at sea level about 200 m from the beach. It is a small enclosure (17 X 19 m). The sur-

face of the paddock yard consists of a hard smooth surface of limestone. A separate closed brick stable (3 x 6 m) provided protection for their food from rain. The daily feeding ration for 4 adult animals consisted of 5 Kg of barley, 0.5-0.75 Kg of wheat bran, 1.5 Kg of domestic sheep pellets and alfalfa hay ad libitum. Sometimes they were fed on leaves from various trees, such as acacia (Acacia cyanophylla) carob (Ceratonia siliqua) and Peruvian mastic trees (Schinus molle). All animals were kept in the same pen throughout the year and were allowed to breed freely.

The annual distribution of births of the "wild" population of Paphos forest was based on animals observed from blinds at the lambing grounds of Kremmos tou Pakhniouti and Kremmos tou Aphoriti (Fig. 1.1). At Kremmos tou Pakhniouti, the blind was located on Premixco quarry between 300-400 m from the sheep. At the other lambing ground it was 250m from the cliff. A pair of 10x50 binoculars was used to locate the animals and a pair of 20x60 utilized to observe them more closely. Observations were recorded on a portable tape recorder, and supplemented with drawings on record cards. Female arrivals and pregnancy were recorded. Individual females could be distinguished by the size of the face mask, configuration of the head, pelage colour, natural markings, and sometimes by the presence of seasonal shedding and pelage renewal which usually commences at the end of April.

7.3 RESULTS

A reconstruction of the breeding program of the sheep of Limassol and its effective population size (Ne as low as 2 and as high as 6) is seen in Table 7.1. Between 1955 and 1969, 18 (56%) of 32 lambs died within nine months. Nine died within the first two days of their life, two within the first five days and seven within the first nine months. From 1974 to 1988, 34 lambs were born and 24 (71%) died within eight months: Ten died right after birth, five within the first month of their life, and nine other lambs died before reaching the age of 8 months. The highest mortality occurred between 1978 and 1988, with 13 deaths of 16 lambs born (81%). No dates of death were recorded, but according to the zoo keeper most of them died right after birth. The cause of death for a number of animals examined postmortem is seen in Table 7.2. Three yearling females were recorded giving birth. The lamb per ewe ratio was 0.88 lambs per female for the first 14 years of the programme (1956-1969). For the years 1979 to 1988 was 0.61 lambs per female. By 1988, 16 animals had been sent back to Stavros tis Psokas Forest Station for reintroduction to the wild.

The distribution of dates of birth at Limassol and Paphos forest are given in Fig. 7.1. In Limassol lambing commenced and peaked 10 days later than at Paphos and

ended 30 days later.

7.4 DISCUSSION

All the signs of increased homozygosity were present. Juvenile mortality increased from 58% in the first 14 years to 71% in the last 14 years. The number of lambs per ewe declined and was consistently lower than the wild populations of Paphos or other populations. (Table 7.3).

Early sexual maturity of animals in captivity has been found frequently. Hediger (1942) reviewed the subject and gave instances of early maturity for ibex (Capra spp.), lions (Panthera leo), Indian black buck (Antilope cervicapra), Indian elephant (Elephas maximus) and others. More recently the Przewalski horse (Equus przewalskii) kept at the Zoological Garden of Praque (Volf, 1975) exhibited an early reproductive season, as well as the European Bison (Bison bonasus) in several Zoological Gardens (Raczynsk, 1975). Animals exhibiting early sexual maturity might produce young when temperature and forage conditions are not favourable for the survival of their young.

In wild sheep a small percentage of Punjab urials and Corsican mouflon conceived as yearlings (Schaller, 1977; Pfeffer, 1967). Seven yearlings among 57 urials were found pregnant (Valdez, 1976). No yearling females were observed giving birth or being followed by a lamb in

the wild or at Paphos forest station captive flock.

Though a newborn animal should have a better chance of survival if born in captivity (Jeffkins, 1990), juvenile mortality was much higher at Limassol compared to that of Paphos forest. Of 79 lambs observed from 1985 to 1988 in the Paphos forest, only two (2.53%) were lost during the first month of their life. High lamb survival in the wild during the first months of life was also observed in other populations of wild sheep. Van Vuren and Coblentz (1989), on Santa Cruz island offshore from Southern California found that the postnatal lamb survival of a feral domestic sheep population was close to 100%.

7.4.1 Conclusions

The wild sheep of Cyprus is one of the most endangered Mediterranean races (Cassola, 1976) and captive breeding can be used as a conservation strategy to ward off extinction.

The Limassol Zoological Garden did not maintain a captive population which would be of any use to a conservation program. Had the animals been left in the wild at Paphos rather than being brought to the zoo a larger number of progeny of better genetic quality would have been added to the population.

Although the breeding programme of the Cyprus mouflon at Limassol has been a failure the Zoological Garden of

Limassol should continue the captive propagation of this wild sheep based on a new breeding program. The guidelines for management of small populations in captivity provided by Soulé (1980), Frankel & Soulé (1981), Foose (1983), Allendorf & Leary (1986) should be followed.

7.4.2 Suggestions for management

1. Captive breeding should continue.

2. All captive mouflon of Limassol Zoo and the other captive centres in Cyprus should be ear-taged and a geneological record should be kept for each animal. In each generation there should be a reciprocal transfer of one animal between institutions insuring effective panmixis.

3. Ne must be kept at the minimum recommended size of 50. This must be maximized by having all males to mate with an equal number of females that is keeping a sex ratio of 1:1.

4. All captive animals should be examined yearly for the diseases noted in Table 7.2 and a vaccine for enterotoxaemia might be administered. Any measures to maintain a clear dry environment which prevents faecal contamination of food and water will minimize parasitic infections, including coccidiosis and also protect the captive animals

from enterotoxaemia and colibacilosis.

5. All animals must be examined for diseases before reintroduction. Sick animals with infectious diseases such as tuberculosis should not be returned to the wild.

6. To avoid hypersexuality, a second enclosure should be built to keep sexes apart during the non breeding season.

Table 7.1. Reconstruction of the breeding programme of the mouflon of Limassol.

	1	2	3	4	5	Ne
1955-1970	1.3M 2.9F	32	18(56%)	5	1	2.0-6.5
1971-1973	?	?	?	?	?	?
1974-1981	3.0M 4.1F 3.2?	23	15(78%)	6	9	?
1982-1989	1.5M 1.8F	11	9(81%)	4	0	2.0-4.8

1=No. of breeding animals

2=No of lambs born

3=Mortality of lambs

4=mortality of adults

5=No of animals sent away

M=Males, ?=Number of animals or sex unknown

F=Females

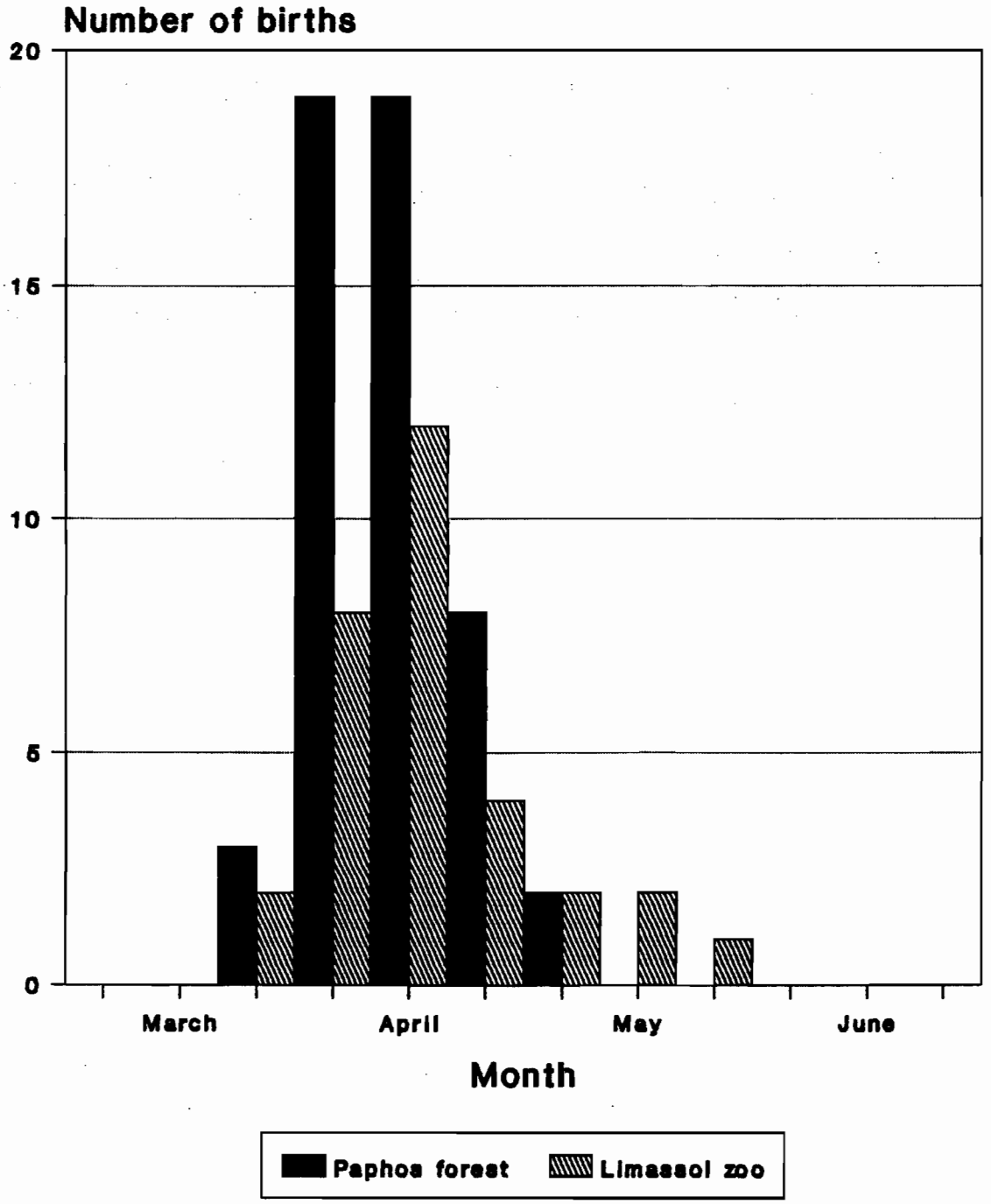
Table 7.2 Diseases of the Cyprus mouflon at the Zoological Garden of Limassol(From the files of the Veterinary Department of Limassol, Unpubl.)

Disease	Number of cases	% of cases
Abortion	2	8.7
Catarhall enteritis	1	4.3
Coccidiosis	6.0	26.6
Dystokia	1.0	4.3
Enterotoxaemia	3.0	13.0
Gastroenteritis	2.0	8.7
Lung hemorrhage	1.0	4.3
Metritis	1.0	4.3
Paraplegia	1.0	4.3
Paratuberculosis	1.0	4.3
Rahitis	1.0	4.3
Septicaemia	1.0	4.3
Tuberculosis	1.0	4.3

Table 7.3. Ewe - lamb ratios in wild and captive sheep.

Sheep	Number of lambs	Locality
European mouflon	1.5	Crimea (Pfeffer, 1967)
Urial	2.0	Kopet Dagh (Decker and Kowalski, 1972)
Argali	1.4	Tien Shan (Heptner et al. 1966)
Punjab Urial	1.1	Punjab (Schaller, 1977)
Cyprus mouflon	1.1	Paphos forest near Stavros Forest Station (this study)
Cyprus mouflon	1.3	Paphos forest near Kannaviou vilage (this study)
Cyprus mouflon	0.9	Limassol captive flock from 1956-1969 (this study)
Cyprus mouflon	0.6	Limassol captive flock from 1970-1989 (this study)

Figure 7.1 Annual distribution of births of mouflon at Paphos Forest and at the Zoological Garden of Limassol.



Each column represents a total of 10 days.

CHAPTER 8

HEMOGLOBIN AS EVIDENCE CONCERNING THE ORIGIN AND TAXONOMY STATUS OF THE CYPRUS MOUFLON.

8.1 INTRODUCTION

Studies of the hemoglobin of domestic sheep resulted in six electroforetically separable protein zones (Harris and Warren, 1955; Evans et al., 1958; Vaskov and Efremov, 1967; Stormont et al., 1968; Lay et al., 1971; Naitana et al. 1990; Masala et al. 1991). The common adult hemoglobins occur in the form of Hb A, Hb B, and the heterozygote Hb AB. These alleles vary among different breeds. Hb C appears in anemic sheep and apparently replaces Hb A (Van Vliet and Huisman, 1964), and Hb B (Naitana et al., 1990; Masala et al. 1991). Hb D is a rare adult type found in some Yugoslavian sheep. Hb F is fetal, while Hb M was found only in the European mouflon of Sardenia (Naitana et al., 1990; Masala et al., 1991). A number of wild sheep examined, including the Rocky mountain Bighorn (Ovis canadensis), Dall's sheep (Ovis dalli dalli) Altai argali (Ovis ammon ammon), European mouflon (Ovis gmelini musimon), and Alborz Red sheep hyprid (Ovis gmelini gmelini X Ovis gmelini arkal), all possess Hb B (Lay et al., 1971; Nadler et al., 1971; Spillet et al., 1975; Bunch and Valdez, 1976; Stratil and Bobak, 1988; Naitana,

et al., 1990; Masala et al., 1991). One exception is the European mouflon of the isle of Isola de Giglio off the Argentario headland in Tyrrhynean sea. This mouflon which originated from Sardinia has Hb B and Hb X (Roberto pers. comm. 1989). The latter is not known to exist in domestic sheep, however according to Masala (Pers. comm. 1993) Hb X might be the same as Hb M.

A second exception is the European mouflon kept captive in France but which originated from the islands of Corsica and Sardinia. These animals were found to posses Hb A as well as Hb b (Bunch at al., 1978). The origin of the Hb A allele in the gene pool of these animals is open to conjecture (Bunch et al. 1978). Hemoglobin A has been considered to have originated with a mutation that took place during the domestication of sheep (Nadler et al. 1971, 1973). One possible hypothesis is that these animals are hybrids between domestic sheep and mouflon.

No hemoglobin studies had been done on wild sheep of Cyprus, which were considered as feral domesticates (Bunch et al. 19878; Valdez, 1982; Davis, 1984). If the latter sheep originated from introduction of a recent domesticated strain, it should possibly posses Hb A, which is characteristic of domestic sheep. In this report the hemoglobin of eight Cyprus mouflon from Paphos Forest is described.

8.2. MATERIALS AND METHODS

Specimens were examined from the following localities:

Milikouri village, 1 female; Kremmos tis Pelis, 1 female; Livadi valley, 1 female; Phinokli valley 1 male; Stavros tis Psokas Forest Station captive breeding stock, 2 females and 2 males. All animals were live trapped and blood was collected from the external jugular vein using a hypodermic syringe. Five ml of the blood were placed in a vial containing lithium heparin. The vials were placed in an ice box and transferred immediately to the lab where they were kept at 5 degrees Centigrade and analyzed within 24 to 48 hours. Hemolysales were prepared by washing the heparinized blood 3 times in physiological saline, then lysing the red blood cells by adding 1,0-1,5 parts (by volume) volume of distilled water to 1 part of packed cells and stirring for a few minutes (Antonini et al., 1981). Serum or plasma were obtained by centrifugation. Cellulose acetate electrophoresis was used to separate the hymolysates (Sargent, 1969). The voltage used was 250v, the strip gap 7.5 cm, the volume of serum analyzed was 2 ml, the concentration of Hb-Lysate was 12 g%, and the time run was 30 minutes. The buffer used was 84,9% w/w Tromethemine (tris) 0.6% w/w EDTA, 14.5%, W/W Glysine at PH 9.2. Hemoglobins were identified against AB, B and A

standards.

8.3. RESULTS

All animals had only Hb B.

8.4. DISCUSSION

Cytological studies by Vorotsov et al. (1972) Nadler et al. (1973) Valdez et al. (1978), and Mavrogenis and Herzog (In Press) have confirmed that the European mouflon (Ovis gmelini musimon), the Armenian mouflon (Ovis gmelini gmelini), the Esfahan mouflon (Ovis gmelini isphanica), the Laristan mouflon (Ovis gmelini laristanica), and the Cyprus mouflon, have a diploid chromosome number of 54 and a karyotype consisting of 3 pairs of biarmed chromosomes, 23 pairs of acrocentric chromosomes, a large acrocentric X and a minute biarmed Y, similar to that of domestic sheep (Ovis aries). Consequently the mouflons or mouflon like sheep (Ovis gmelini) have been reported to be ancestral to domestic sheep (Nadler et al., 1973; Bunch et al., 1978).

The remains of sheep, goats and humans appear simultaneously in lower Neolithic times in Cyprus (6.000 B.C.) (Davis, 1984), which suggests that sheep were introduced by humans. Since the Cyprus mouflon does not posses Hb A, a human introduction of a wild domesticated wild strain of sheep is much more probable than the introduction of a

more recently domesticated strain or hybrids of the two as it was suggested for the European wild sheep.

The presence of Hb B and the absence of Hb M in the Cyprus mouflon, in combination with the occurrence of supracervical horns (Clark, 1964, Valdez, 1982; Personal observation, 1985-1992) support the existing opinion that the Cyprus mouflon is a distinctive Cypriot variety (Ellerman and Morrison-Scott, 1951; Schaller, 1977; Valdez, 1982; Geist, 1986) under the name Ovis gmelini ophion (Hadjisterkotis, 1992).

CHAPTER 9

CRANIAL AND POST-CRANIAL BONE MEASUREMENTS OF THE CYPRUS MOUFLON

9.1 INTRODUCTION

On the island of Cyprus the remains of several species of mammals, both wild and domesticated, were excavated from prehistoric and more recent sites. These mammals include the endemic species of Cyprus mouflon (Ovis gmelini ophion) which is still present on the island (King, 1953; Murrilles, 1978; Davis, 1984). The Cyprus mouflon was probably introduced onto the island about 8000 years ago and quantities of Ovis bones were found at the neolithic village of Khirokitia. Bones of the modern mouflon appear to be morphologically indistinct from the fossil sheep remains of Khirokitia except for a possible difference insize. The remains from Khirokitia are thought to be the closest relatives to the original founding population of the extant "wild" mouflon (Davis, 1984).

Until now Zooarchaeologists working in Cyprus have only had small and scattered collections of mouflon bones with which to compare their archaeological material (king, 1951; Davis, 1984). The need for a larger reference collection of mouflon bones was noted by Davis (1984) and David Reese (Pers. commun. 1988).

A collection of bones of modern species is essential for Zooarchaeological work (Coy, 1978), and the general lack of comparative skeletal materials from many parts of the world has been a source of erroneous interpretations (Reed, 1963). Working with a limited number of specimens, there is a danger of carrying out comparative studies with "radical variants" as Cowan (1940) calls them. Unaccountably dwarfed individuals of wild sheep have been taken on several occasions and have found their way into museums (loc. cit.).

Cyprus, is a 15 million year old island of oceanic origin which has never been connected to the mainland (Swiny, 1988). Ungulates on oceanic islands tend to become smaller (island dwarfism), whereas rodents become larger (Davis, 1984). The discovery of the Khirokitia mouflon/sheep bones provides the opportunity to compare possible size reduction of the modern mouflon. The aim of this endeavor is to present cranial and postcranial measurements taken on a collection of 36 adult male and 34 adult female specimens (most are incomplete) of modern wild Cyprus mouflon. These have been taken to meet the needs of faunal analyst working with excavated sheep bones and reflect changes in the size and proportions of sheep. A comparison of some of these measurements with those from Neolithic remains of Ovis from Khirokitia reveals the extent of changes which have occurred in this species during the last 8.000 years. The collection of modern mou-

flon skeletons is presently housed by the Game and Fauna Service, Ministry of Interior, Nicosia , Cyprus.

9.2 METHODS AND STUDY AREA

All mouflon bones were collected between 1985 and 1989 from animals found dead in their natural habitat in the Paphos forest, located on the Northwestern part of Troodos massif (Fig. 1.1). It is an area of 632 sq. km covered mainly with pine (Pinus brutia) and golden oak (Quercus alnifolia).

The measurements taken are those defined by Duerst (1926) and Driesch (1976), and for the width of trochlea are those defined by Payne (1969) and Davis (1984). Measurements were taken only from bones with fused epiphyses, and skulls from animals that reached the age of complete permanent dentition and so would have shown no more growth. Cranial illustrations are presented in Figures 9.1 and 9.2, and postcranial illustrations in Figures 9.3 to 9.16. As is the normal procedure in zooarchaeology the sign "+" is given for dimensions which are precisely measurable and the "-" for dimensions which are less precisely measurable (Driesch, 1976). All measurements were taken with a vernier slide gauge to the nearest 0.1 mm, except measurements 6, 40 and 43 (Table 9.2; Appendix 1, Tables 1a and 1f) of the cranium. Measurement 6 was taken with curved calibers, and 40 and 43 with a steel

tape measure. Measurements 40 and 43 were taken to the nearest 1.0 mm.

All measurements from Khirokitia are from Davis (1984). These are: the breadth, the diameter (or height) of condyles, the width of condyles and trochlea of the distal metacarpus, the width of metatarsus and the greatest length of metatarsus. Bones with unfused (juvenile) epiphyses in Davis data are not included in this study. Mouflon skeletons in which some epiphyses are fused were not included. The bones from Khirokitia were not sexed, therefore, the sample includes bones from both sexes (loc. cit.). Equal numbers of mouflon bones from both sexes were used in the comparison with the sheep from Khirokitia. Since the collection of mouflon bones contains more males than females, males were selected randomly using a table of random numbers (Dunstan et al. 1988).

Cypriot mouflon are easy to sex because males have horns and females are hornless. In the case of specimens lacking a head, sex was determined by coat colour (Male are darker and in winter possess a white saddle patch). Occasionally both head and skin were missing and it was necessary to determine sex from the skeleton. Taber (1956) found that it is possible to sex white tailed deer (Cervus odocoileus) over two years of age, by the presence of suspensory tuberosities on the ischium, where the ligaments which support the penis are attached in the male. Observations on specimens of Cyprus mouflon of known

sex revealed that this distinction can also be made among Cypriot wild sheep. All bones from the right side are designated with R, and from the left side with L.

t tests (=0.01) were used to determine differences in the size of bones from Khirokitia and those of modern mouflon and sexual dimorphism in modern mouflon (Steel and Torrie, 1980).

9.2.1 MEASUREMENTS

9.2.1.1. Cranial skeleton

Definitions of cranial measuring points of the modern wild Cypriot mouflon skeleton are presented in Tables 9.1 and 9.3, and the measuring points in Tables 9.2 and 9.4. Cranial measurements are presented in appendix 1, tables 1-18.

Table 9.1: Definitions of measuring points of the cranium.

A -Akrokranion, the most aboral point on the vertex of the cranium in the median plane.

B -Basion, the orobasal border of the foramen magnum in the median plane.

Br -Bregma, the median point of the parieto-frontal suture.

Ect -Ectorbitale, the most lateral point of the frontal bone on the occipital side of the orbit.

Ent -Entorbitale, the naso-medial indentation of the orbit that corresponds with the inner angle of the eye in the living animal.

Eu -Eureon, the most lateral point of the braincase.

If -Infraorbitale, the (dorso) aboral point of the foramen infraorbitale.

N -Nasion, the median point of the naso-frontal suture.

Ni -Nasointermaxillare, the most aboral point of the premaxilla on the facial surface.

O -Opisthion, the nuchodorsal border of the foramen magnum in the median plane.

Ot -Otion, the most lateral point of the mastoid region (it is occipital to the meatus).

P -Prosthion, the median point of the line joining the most oral points of the premaxillae.

Table 9.1 continues

Pd -Postdentale, the median point of the line joining the aboral points of the alveoli of the hindmost cheek-teeth.

Pm -Premolare, the median point of the line joining the oral points of the alveoli of the foremost cheekteeth.

Po -Palatinoorale, the median point of the palatine-maxillary suture.

Rh -Rhinion, the median point of the line joining the most oral points of the nasals.

Sp -Supraorbitale, the median point of the line joining the aboral borders of the supraorbital foramina.

Table 9.2: Measurements of the cranium of O. g. ophion (Fig. 9.1a, b, c, d, and e; Appendix 1, Tables 1a-f and 2a-f).

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1. Profile length: Akrokranion-Prosthion (+).

2. Condylobasal length: aboral border of occipital condyles-Prosthion (+).

3. Basal length: Basion - Prosthion (+).

4. Short skull length: Basion - Premolare (+).

5. Premolare-Prosthion (+).

6. Neurocranium length: Basion - Nasion. Can be taken only with curved callipers (+).

7. Viscerocranium length: Nasion - Prosthion (+).

8. Mesian frontal length: Akrokranion - Nasion (+).

9. Akrokranion - Bregma (+).

10. Frontal length: Bregma - Nasion (+).

11. Upper neurocranium length: Akrokranion -Supraorbitale (+).

12. Facial length: Supraorbitale - Prosthion (+).

13. Akrokranion - Infraorbitale of one side (+).

14. Greatest length of the lacrimal: most lateral point of the lacrimal - the most oral point of the lacrimo - maxillary suture (+).

15. Greatest length of the nasals: Nasion - Rhinion.

16. Short lateral facial length: Entorbitale - Prosthion (+).

Table 9.2 continues

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17. From the aboral border of one occipital condyle to the infraorbitale of the same side (+).

18. Dental length: Postdentale - Prosthion (-).

19. Oral palatal length: Palatinoorale - Prostion (-).

20. Lateral length of the premaxilla: Nasointermaxillare -Prosthion (+).

21. Length of the cheektooth row (measured along the alveoli) (+).

22. Length of the molar row (measured along the alveoli on the buccal side (-).

23. Length of the premolar row (measured along the alveoli on the buccal side) (-).

24. Greatest inner length of the orbit: Ectorbitale -Entorbitale (+).

25. Greatest inner height of the orbit. Measured in the same way as M 24 (+).

26. Greatest mastoid breadth: Otion - Otion (+).

27. Greatest breadth of the occipital condyles (+).

28. Greatest breadth at the bases of the paraoccipital processes (+).

29. Greatest breadth of the foramen magnum (+).

30. Height of the foramen magnum: Basion - Opisthion (-).

Table 9.2 continues

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31. Least breadth of parietal = least breadth between the temporal lines (+).

32. Greatest breadth between the lateral borders of the horncore bases (+).

33. Greatest neurocranium breadth = greatest breadth of the braincase: Euryon - Euryon (-).

34. Greatest breadth across the orbits = greatest frontal breadth = greatest bredth of skull: Ectorbitale -Ectorbitale (+).

35. Least breadth between the orbits: Entorbitale -Entorbitale (-).

36. Facial breadth: breadth across the facial tuberosities (+).

37. Greatest breadth across the nasals (+).

38. Greatest breadth across the premaxillae (+).

39. Greatest palatal breadth: measured across the outer borders of the alveoli (-).

40. Horncore basal circumference (+).

41. Greatest (oro-aboral) diameter of the horncore base (+).

42. Least (latero-medial) diameter of the horncore base (+).

43. length of the horncore on the front margin (tape measure) (+).

Table 9.3: Measuring points of the mandible (Duerst, 1926; Driesch, 1976).

Cr -Coronion - the highest point of the coronoid process.

Goc -Gonion caudale - the most aboral point of the angle of mandible.

Gol -Gonion laterale - the most lateral point of the angle.

Gov -Gonion ventrale - the most basal point of the angle.

Id -Infradentale - the most prominent median point at the oral border of the alveoli of the incisors (corresponds to the Prosthion of Maxilla).

Note that all length and height measurements for the mandible refer to only one-half of the jaw.

Table 9.4: Measurements of the mandible of O. g. ophion (Fig. 9.2a and 9.2b; Appendix 1, Tables 3a–c, 4a-c).

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1. Length from the angle: Gonion caudale - Infradentale (+).

2. Length from the condyle: aboral border of the condyle process - Infradentale (+).

3. Length: Godion caudale - aboral border of the alveolus of M3 (-).

4. Length of the horizontal ramus: aboral border of the alveolus of M3 - Infradentale (+).

5. Length: Gonion caudale - oral border of the alveolus of P2 (+).

6. Length Gonion caudale - the most aboral indentation of the mental foramen (+).

7. Length of the cheektooth row, measured along the alveoli on the buccal side (+).

8. Length of the molar row, measured along the alveoli on the buccal side (-).

9. Length of the premolar row, measured along the alveoli on the buccal side (-).

10. Length and breadth of M3, measured near the biting surface (Fig. 3b) (-).

11. Length of the diastema: oral border of the alveolus of P2 -aboral border of the alveolus of I4 (=C) (+).

Table 9.4 continued

12. Aboral height of the vertical ramus: Gonion ventrale -highest point of the condyle process. Usually measured in projection. Best measured by placing one arm of slide gauge along the basal border of the mandible and measuring the distance in projection (see Duerst 1926, p.333) (+).

13. Middle height of the vertical ramus: Gonion ventrale -deepest point of the mandibular notch. Not to be measured in projection but directly from the Gonion ventrale (see Duerst 1926, p. 333) (+).

14. Oral height of the vertical ramus: Gonion ventrale - Coronion. Not to be measured in projection, but like measurement no. 13 directly from the Gonion ventrale (see Duerst 1926, p. 334) (+).

15a. Height of the mandible M3 from the most aboral point of the alveolus on the buccal side (-).

15b. Height of the mandible in front of M1. Measured at right angles to the basal border (-).

15c. Height of the mandible in front of P2. Measured at right angles to the basal border (-).

9.2.1.2. Postcranial skeleton.

Abbreviations instead of numbers are used for designating the measurements of bones of the mouflon postcranial skeleton, following Driesch (1976). Nouns are abbreviated with capital letters (e.g., C = proximal; F = facies; L = length) and adjectives with lower case letters (e.g., d = distal; p = proximal) except when they are at the beginning of an abbreviation (e.g. greatest length = GL). Generally one word is abbreviated to only one letter, but this was not possible with all words (e.g., pe = peripher because p = proximal, or cr = cranial and cd = caudal). Words like diaphysis and depth which begin with the same letter unavoidably are in the same way, but from the position of the letter in the abbreviation or from the abbreviation combination it can be perceived which noun is meant.

Abbreviations of postcranial measurements follow Driesch (1976) and are presented in Tables 9.5-9.18. Postcranial measurements are presented in Appendix 1, Tables 19-35. Table 36 show the difference between Neolithic Ovis from Khirokitia and those of the modern mouflon. No sex determination was done for the bones of Khirokitia (Davis, 1984) however, is believed that bones from both male and female animals are included. Equal numbers of bones from modern male and female mouflon were used for each measurement, to estimate the average bone sizes used

to compared with Khirokitia.

Table 9.5: Atlas (Fig. 9.3a and 9.3b; Appendix,1 Tables 5 and 7).

GB -Greatest breadth over the wings (+).

GL -Greatest length (+).

BFcr -(Greatest) breadth of the Facies articularis cranialis (=cranial articular surface) (+).

BFcd -(Greatest) breadth of the Facies articularis cranialis (=caudal articular surface) (+).

GLF -Greatest length from the facies articularis cranialis to the Facies articularis caudalis (-).

Table 9.6: Axis (Fig. 9.4a, b and c; Appendix 1, Tables 6 and 8).

LCDe -(Greatest) length in the region of the corbus (=body) including the dens (+).

LAPa -(Greatest) length of the arch including the Processus articulares caudales (+).

BFcr -(Greatest) breadth of the Facies articularis cranialis (=cranial articular surface) (+).

Bpacd -(Greatest) breadth across the Processus articulares caudales (+).

BPtr -(Greatest) breadth across the Processus transversi (+).

SBV -Smallest breadth of the vertebra (+).

BFcd -(Greatest) breadth of the Facies terminalis caudalis (=caudal articular surface) (+).

H -(Greatest) height. Measured by placing the 2 basal prominent points of the body of the vertebra on one of the arms of the slide gauge and closing the other arm over the spinous process. (This can be done only if a large vernier slide gauge is available. If not a measuring box can be used) (+).

Table 9.7: Sacrum (Fig. 9.5; Appendix 1, Tables 9 and 10).

GL -Greatest length on the ventral side: from the cranial borders of the wings to the caudoventral border of the body of the last vertebra (+).

PL -Physiological length, measured between the centers of the bodies of the most cranial and most caudal vertebrae (+).

GB -Greatest breadth across the wings (+).

NOTE: The number of segments in the sacrum of mouflon range from 3 to 4. In the results sacrums with 4 segments are marked with: *

Table 9.8: Thoracic, cervical and lumbar vertebrae (Fig. 9.6a, b and c; Appendix 1, Tables 11a-e, 12a-d, 13a-g, 14a-g, 15a-c and 16a-c).

PL -Physiological length of the body. Measured between the centers of the Facies terminalis cranialis and Facies terminalis caudalis (+).

GLPa -Greatest length from the Processus articulares craniales to the Processus articulares caudales (in cervical vertebrae) (+).

BPacr -(Greatest) breadth across the Processus articulares cranialis (in cervical vertebrae) (+).

BPacd -(Greatest) breadth across the Processus articulares caudales (in cervical verterae) (+).

BPtr -(Greatest breadth across the Processus transversi (+).

H -(Greatest) height (+).

Table 9.9: Scapula (Fig. 9.7a and b; Appendix 1, Tables 17 and 18)

Hs -Height along the spine (+).

DHA -Diagonal height from the most distal point of the scapula to the thoracic angle (+).

Ld -(Greatest) dorsal length.

SLC -Smallest length of the Collum scapulae (neck of the scapula) (-).

GLP -Greatest length of the Processus articularis (glenoid process) (+).

LG -Length of the glenoid cavity. Measured to include the cranial lip of the glenoid cavity, paralel to the GLP (-).

BG -Breadth of the glenoid cavity - Greatest breath of the glenoid angle (+).

Table 9.10: Humerus (Fig. 9.8a and b; Appendix 1, Tables 19 and 20)

GL -Greatest length (+).

GLC -Greatest length from caput (head) (+).

Bp -(Greatest) breadth of the proximal end (-).

SD -Smallest breadth of the diaphysis (+).

BT -(Greatest) breadth of the trochlea which is measured in the middle from the cranial side, including the outer borders of both the lateral and medial condyles (-).

Table 9.11: Radius and ulna (Fig. 9.9a, b, c, d, and e; Appendix 1, Tables 21a-b and 22a-b).

Radius and Ulna:

GL -Greatest length (+).

BP -(Greatest) breadth of the proximal end (+).

BFp -(Greatest) breadth of the Facies articularis proximalis (humeral articular surface). Measured in the same plane as Bp (+).

SD -Smallest breadth of diaphysis.

Bd -(Greatest) breadth of the distal end (+).

BFd -(Greatest) breadth of the Facies articularis distalis Measured in the same plane as Bd. (+).

Ulna:

GL -Greatest length (+).

LO -Length of the olecranon (-).

DPA -Depth across the Processus anconaeus. The shortest distance from the Processus anconaeus to the caudal border of ulna (-).

SDO -Smallest depth of the olecranon (+).

BPC -(Greatest) breadth across the coronoid process = greatest breadth of the proximal articular surface (+).

Table 9.12: Pelvis (Fig. 9.10; Appendix 1, Tables 23a, 23b, 24a and 24b).

GL -Greatest length of one half. (Only if epiphysial parts of the Tuber coxae and Tuber ischiadicum have fused) (+).

LS -Length of the symphysis. Only when the two halves have fused.

SH -Smallest height of the shaft of ilium (+).

SB -Smallest breadth of the shaft of ilium (+).

LFo -Inner length of the foramen obturatum (+).

GBTc -Greatest breadth across the Tubera coxarum -greatest breadth across the lateral angle (+).

GBA -Greatest breadth across the acetabula (+).

GBTi -Greatest breadth across the Tubera ishiadica (+).

SBI -Smallest breadth across the bodies of the ischia (+).

Table 9.13: Femur (Fig. 9.11a and b; Appendix 1, Tables 25 and 26).

GL	-Greatest length = lateral length (+).
GLC	-Greatest length from caput femoris (head) (+).
Bp	-(Greatest) breadth of the proximal end (+).
DC	-(Greatest) depth of the Caput femoris (+).
SD	-Smallest breadth of diaphysis (+).
Bd	-(Greatest) breadth of the distal end (+).

Table 9.14: Patella (Fig. 9.12; Appendix 1, Table 29).

GL	-Greatest length (+).
GB	-Greatest breadth (+).

Table 9.15: Tibia (Fig. 9.13a,b and c; Appendix 1, Tables 30 and 31).

GL	_Greatest length (+).
Bp	-(Greatest) breadth of the proximal end (+).
SD	-Smallest breadth of the diaphysis (+).
Bd	-(Greatest) breadth of the distal end.

Table 9.16: Astragalus (Fig. 9.14a, b and c; Appendix 1, Tables 27 and 28).

GLI	-(Greatest) length of the lateral half (+).
GLm	-(Greatest) length of the medial half (+).
DI	-(Greatest) depth of the lateral half (+).
Dm	-(Greatest) depth of the medial half (-).
Bd	-(Greatest) breadth of the distal end.

Note: In Ovis, there is a projection on the medial side in the middle between the proximal and the distal part of the astragalus. This makes it impossible to measure the Dm accurately.

Table 9.17: Calcaneus (Fig. 9.15; Appendix 1, Table 32).

GL	-Greatest length (+).
GB	-Greatest breadth. Measured in a measuring box or with a slide gauge callibers with broad arms (+).

Table 9.18: Metapodials (Fig. 9.16a, b, c, and d; Appendix 1, Tables 33a-b, 34a-b, 35 and 36).

Bp	-(Greatest) breadth of the proximal end.
SD	-Smallest breadth of the diaphysis (+).
DD	-(Smallest) depth of the diaphysis.
Bd	-(Greatest) breadth of the distal end (+).
W. troch.	_Width of trochlea (as in Payne, 1969).
HT	-Diameter or height of condyles (Davis, 1984).

9.3 RESULTS

9.3.1 Metrical data of the Cyprus mouflon

Metrical data for the modern wild sheep of Cyprus are presented in Appendix 1, Tables 1 to 3 for the cranial measurements, and for the postcranial measurements in Tables 4 to 36. In order to make measurements available to other analyst as clear as possible the unprocessed metrical data is presented. According to Driesch (1976), "only the least abstracted type of documentation can guarantee the use by others of the basic data in ways not envisioned or not pursued by the original analyst". Also in order to make it easier for other analysts to utilize the data, I present the total number of measurements (N), the largest (MAX) and the smallest (MIN) measurements, the mean (AVG), the sample standard deviation (STDS), and the variance (VARS) for each set of measurements. In addition, in Appendix 1, Tables 37a-c I present the ratio of the mean female bone mesurements divided by the mean male measurements.

9.3.2 Differences between the sheep of Khirokitia and modern mouflon.

The mean (Bd) breadth of the distal end of the metatarsus of the sheep from Khirokitia was 28.05 mm, N = 23,

and was significantly larger (18.4%) than that of modern mouflon ($\bar{X}$ = 23.76, N = 24, α = 0.01, t calculated =11.47 > 2.42.

The mean (HT) diameter or height of condyle of the metacarpus of the sheep from Khirokitia was 18.176 mm, (N = 33) and was significantly larger (18.2%) than that of the mouflon of Paphos forest ($\bar{X}$ =15.38 mm, N = 34), α = 0.01%, t calculated = 12.77 > 2.39.

The mean (W. troch.) width of trochlea of the metacarpus of the sheep from Khirokitia was 12.35 mm, N = 71 and was significantly larger (17.0%) than the modern mouflon ($\bar{X}$ = 10.58 mm, N = 34), α = 0.01%, t calculated = 12.177 > t tabulated = 2.35).

The comparative data between the mouflon remains of Khirokitia and the modern sheep are seen in Figures 9.17 -9.19.

9.3.3 Differences between modern male and female mouflon.

The mean Bd of the metatarsus of the male mouflon is 24.8 mm, N = 18, and is significantly larger (8.00%) than that of females ($\bar{X}$ = 22.9, N = 12, α = 0.01, t calculated =19.69 > t tabulated = 2.46). However, since the Neolithic specimens were not sexed, perhaps the sample is arbitrary.

The mean HT of the metacarpus of the male sheep was 15.9 mm, N = 28, and was significantly larger (6.8%) than

that of the female mouflon ($\bar{X}$ =14.8 mm, N = 17, α = 0.01%, t calculated = 12.77 > t tabulated = 2.42).

The mean W. troch. of the metacarpus of the male sheep was 10.99 mm, N = 28, and was significantly larger (6.11%) than the female mouflon ($\bar{X}$ = 10.31 mm, N = 17, α = 0.01, t calculated 3.09 > t tabulated = 2.42).

From Tables 37a, 37b and 37c in Appendix 1, it can be seen that the largest mean difference between male and female mouflon bones exist between the vertebrae. The highest difference between sample means is 43.56% and is at the BFcr of the sacrum (significant at α = 0.01, t calculated 15.14 > t tabulated 2.60). From the thoracic vertebrae the largest difference is at the H of T1, males being larger by 37.97%. However, data were not considered sufficient for a statistical test. The atlas of males is larger at its GL than that of females by 34.69% (significant at α = 0.01, t calculated = 13.95 > t tabulated = 2.54). The difference between male and female sample means of the H of the axis was 26.00% (significant at α =0.01, t calculated 13.35 > t tabulated 2.55.

9.4 DISCUSSION

The measurements in this study confirm Davis's findings that the modern Cyprus mouflon is smaller than the sheep from Khirokitia dated approximately 6,000 B.C. Davis suggested that the diminution of mouflon may be an example

of island dwarfing. Island dwarfism of large mammals on oceanic islands probably arises in the absence of predation (Azzaroli, 1982). The largest predator known to have existed in Cyprus is the red fox and there is evidence that they might kill lambs (see Chapter two). The antipredator tactic seems to have evolved in sheep by lambing on cliffs where fox are at a disadvantage in trying to outrun the sheep. Finally there is no evidence that the predation on lambs would affect the size of adults.

Dwarfism gives greater mobility to the once-large mammals in mountainous island environments. It also enables them to utilize their food sources more efficiently (Reese, 1989). Poor forage conditions, possible phosphorus shortage limited living space and the forested mountainous habitat (see chapter two) are valid reasons to lead towards island dwarfism since predation seems to be limited.

Major differences in size between male and female sheep are also seen in other species of wild sheep (Geist, 1971; Schaller, 1977, Tables 10 and 11). According to Geist (loc. cit.) female bighorn sheep are considered paedogenic, or paedomorphic, a condition in which the females are considered to be frozen in their development at the stage of a young ram. The female and yearling male so greatly resemble each other that it is often difficult to separate these classes. The ram continues to grow and develop towards his ultimate, mature body form at 8 to 9

years of age. Male and female sheep pass through the same developmental stages, but whereas the female's development is stopped at sexual maturity, the male's development continues. There is evidence that the Cyprus female mouflon may also be peadomorphic, something that might explain their smaller size. Their colour resembles that of yearling males and they are hornless, something which is characteristic of the juveniles.

The development of larger vertebrae in male sheep compared to females, is probably because the spinal cord of male mouflon is induced to much greater strain than that of females, due to intraspecific fights. Although the horns absorb much of the force from a clash, small rams are compressed forcibly by the collision considerably straining and sometimes causing traumatic injuries to the vertebral column (see chapter 5). A vertebral column with larger bones could absorb much greater force, and support greater muscle mass. These could permit less abnormal mobility of intervertebral articulations during clashes, reducing the risk of vertebral damage.

Figure 9.1A. Cranium, dorsal view.

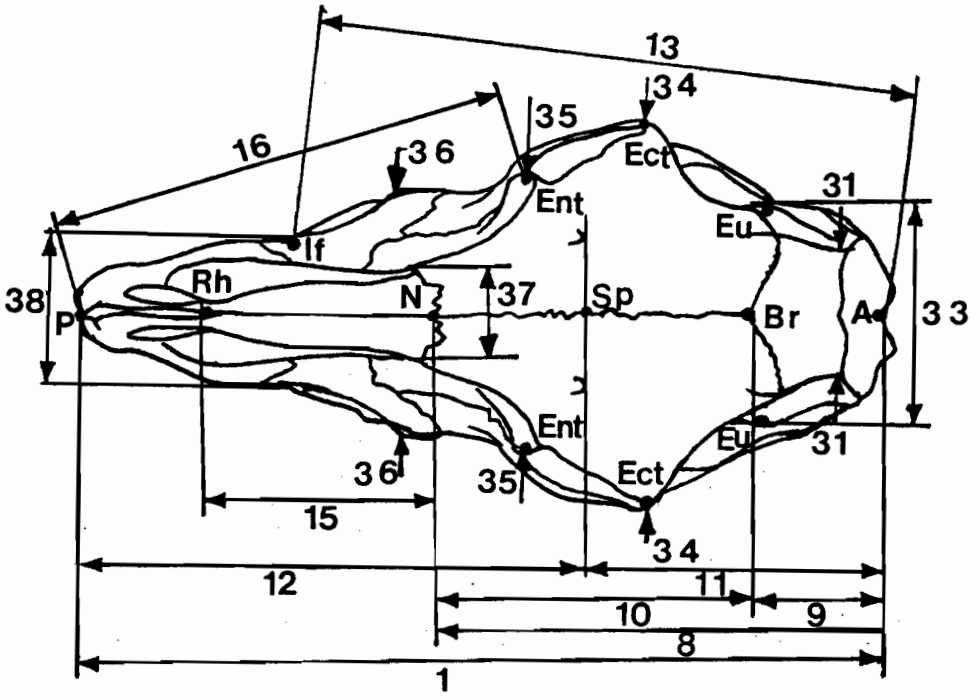
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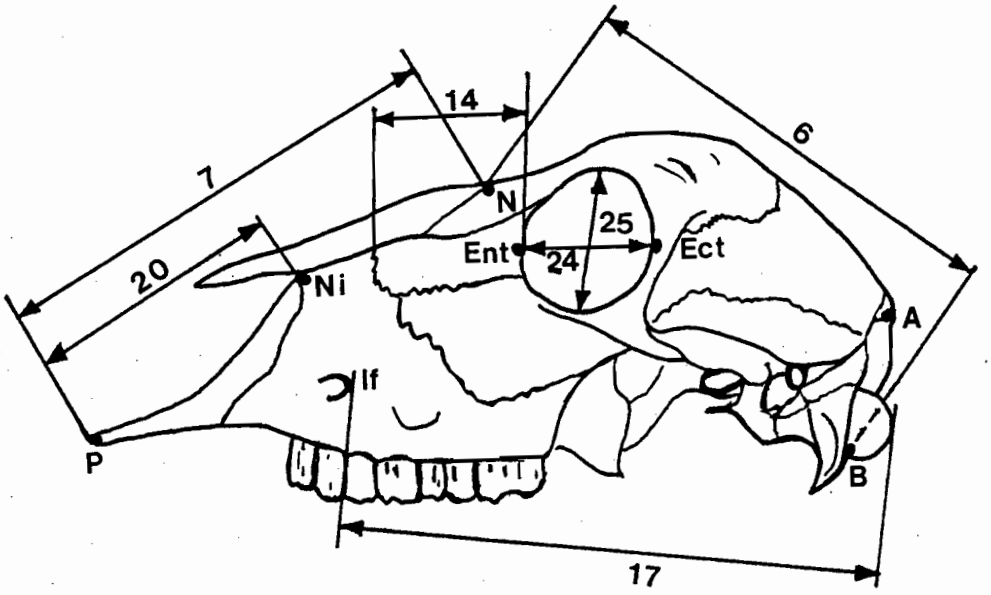
Figure 9.1B. Cranium, left side view.

Figure 9.1C. Cranium, basal view.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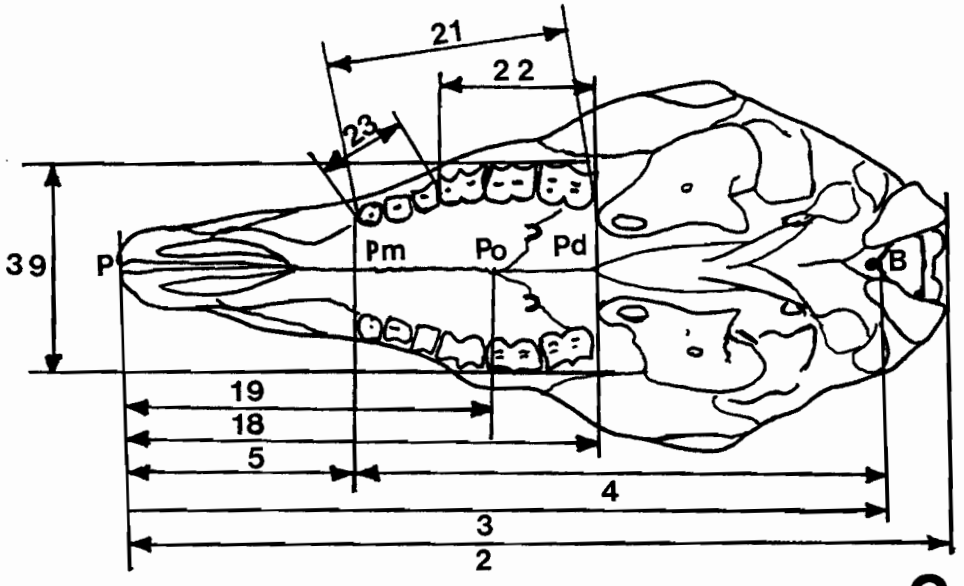
A
If
P
B
17

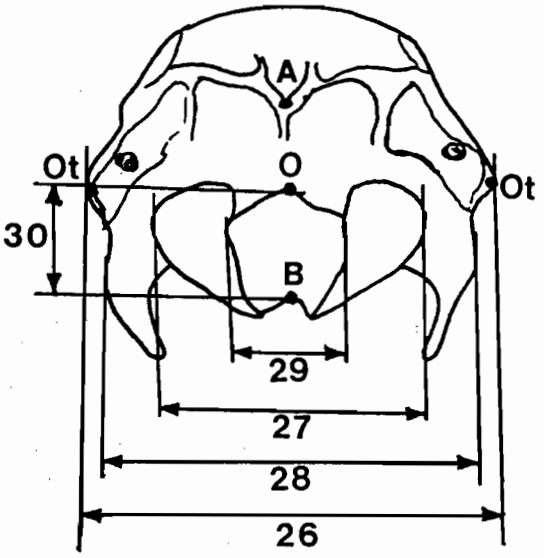
B


21
22
23
39
P
Pm
Po
Pd
B
19
18
5
4
3
2

C

Figure 9.1D. Cranium, nuchal view.

Figure 9.1E. Cranium (male), dorsal view.



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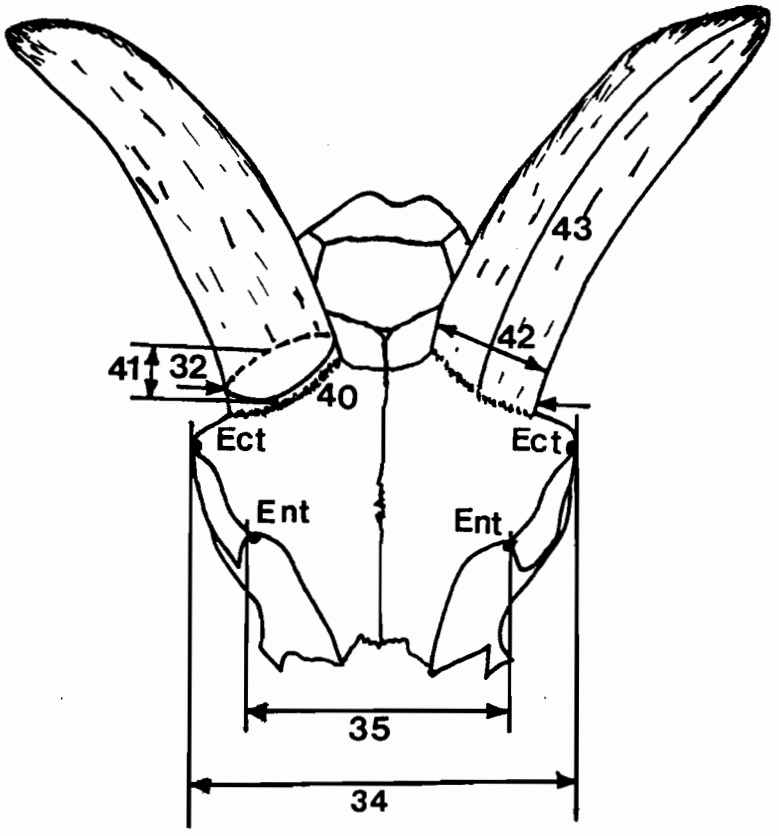
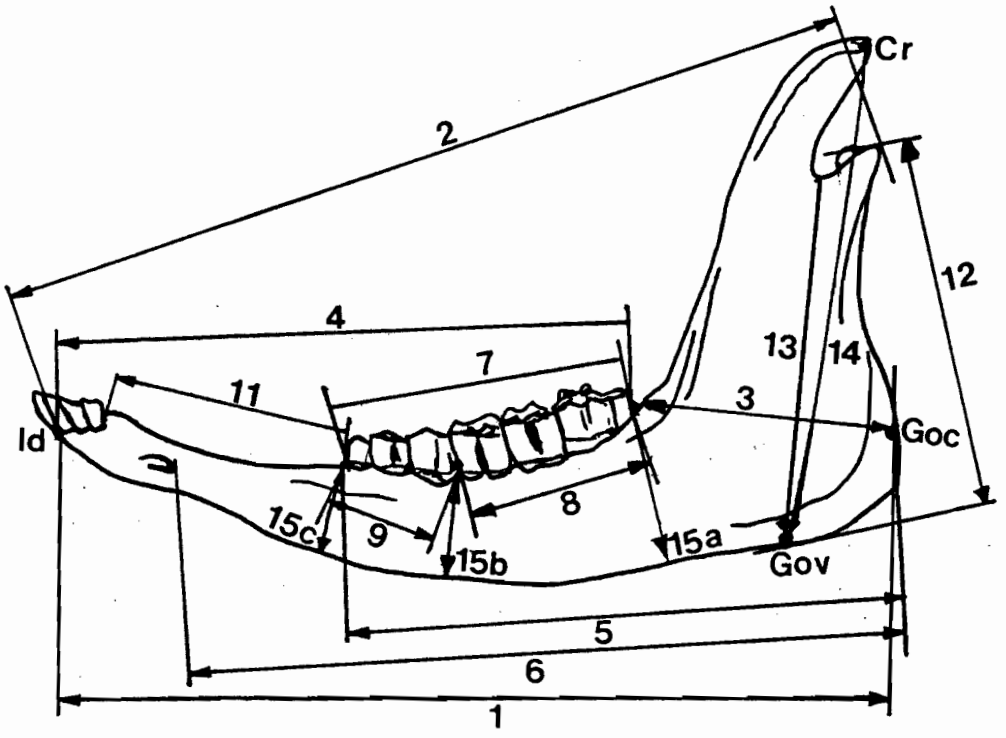


E

Figure 9.2A. Mandible, left side, lateral view.

Figure 9.2B. M3, Length (L) and breadth (B) at the biting surface (see M 10)



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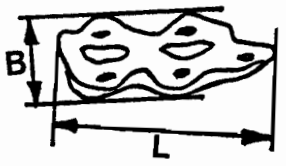
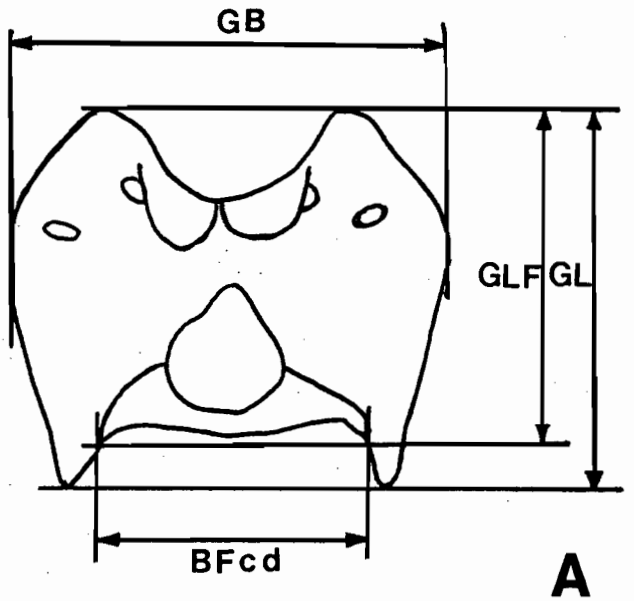


B

Figure 9.3A. Atlas, caudodorsal view.

Figure 9.3B. Atlas, cranial view.



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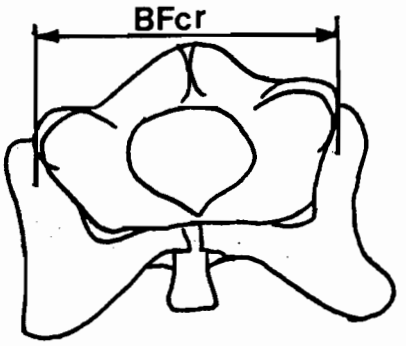
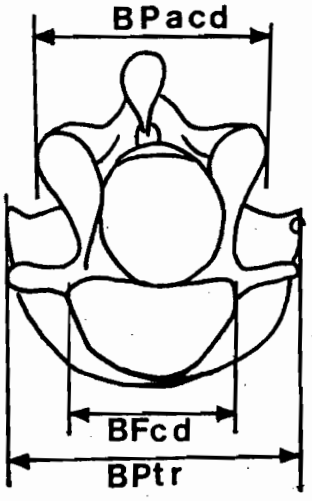


B

Figure 9.4A. Axis caudal view.

Figure 9.4B. Axis, ventral view.

Figure 9.4C. Axis. left side view.



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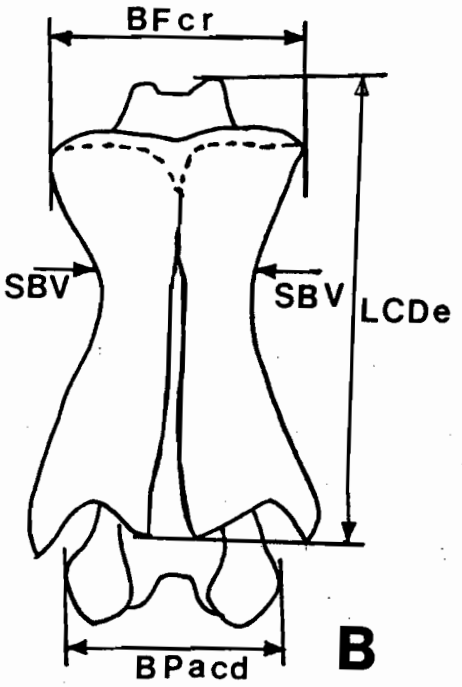

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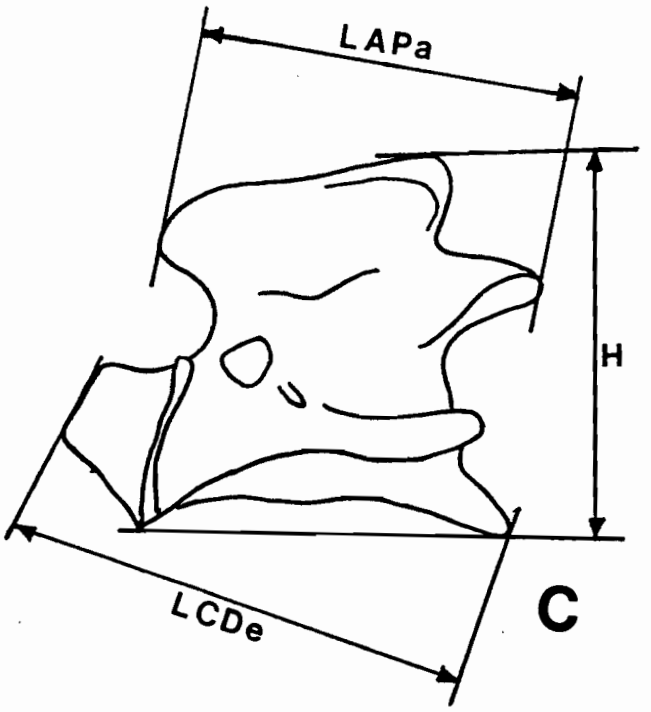
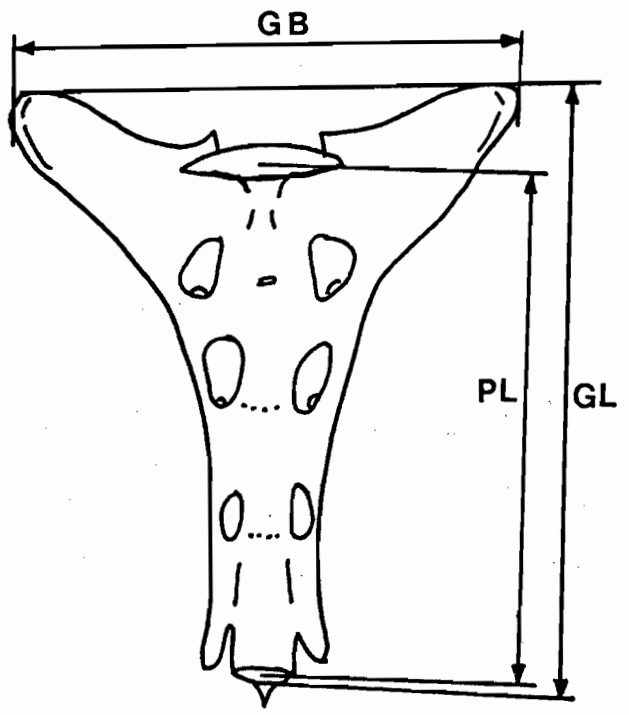


C

Figure 9.5. Sacrum, ventral view.

Figure 9.6A. Thoracic vertebra, left side view.



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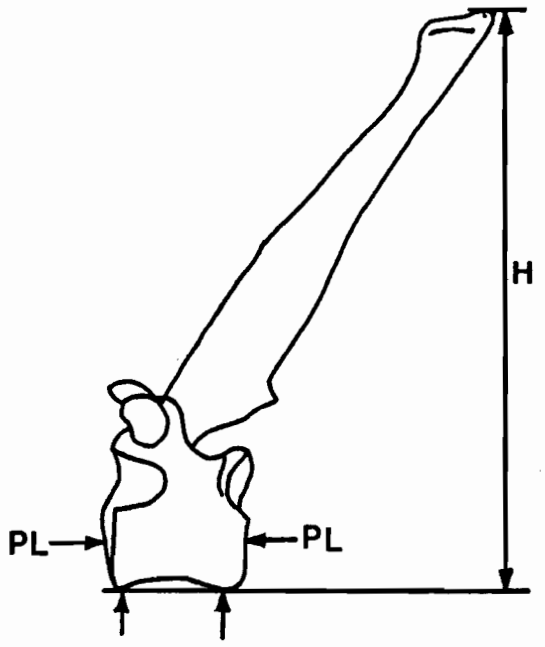
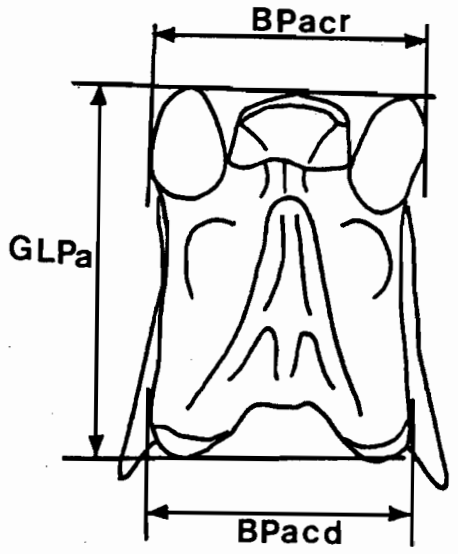


6A

Figure 9.6B. Cervical vertebra, dorsal view.

Figure 9.6C. Lumbar vertebra, cranial view.



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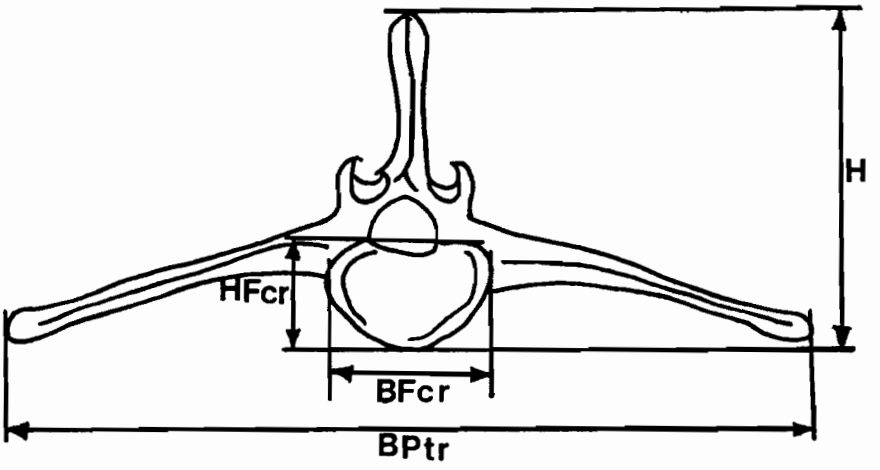
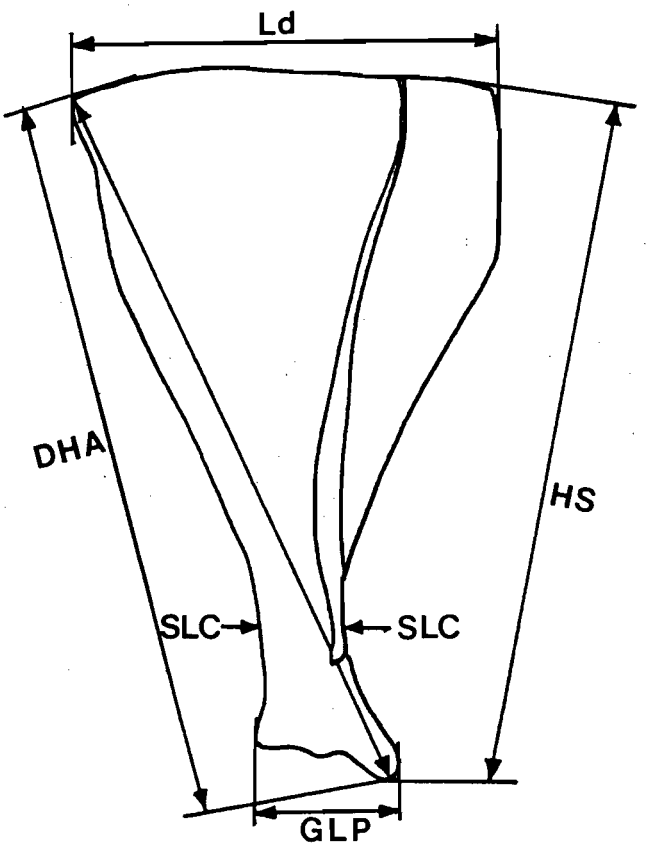


C

Figure 9.7A. Scapula, lateral view.

Figure 9.7B. Scapula, distal view.



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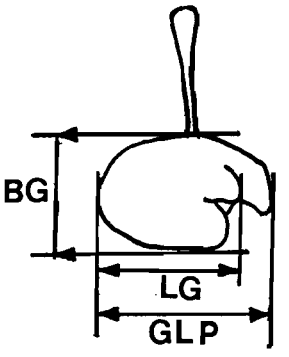
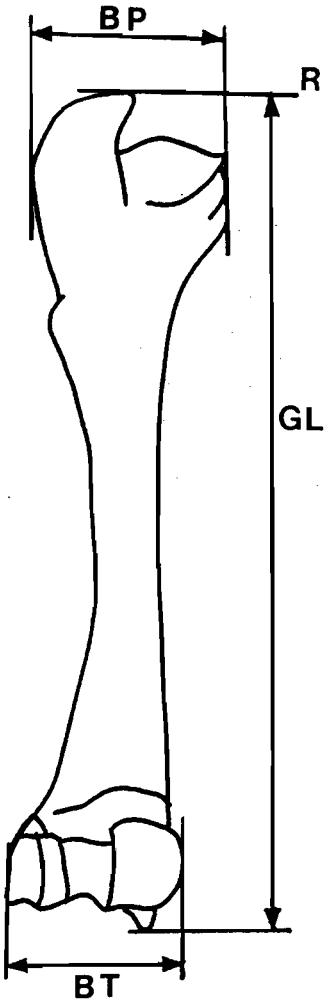


B

Figure 9.8A. Humerus, cranial view.

Figure 9.8B. Humerus, caudolateral view.



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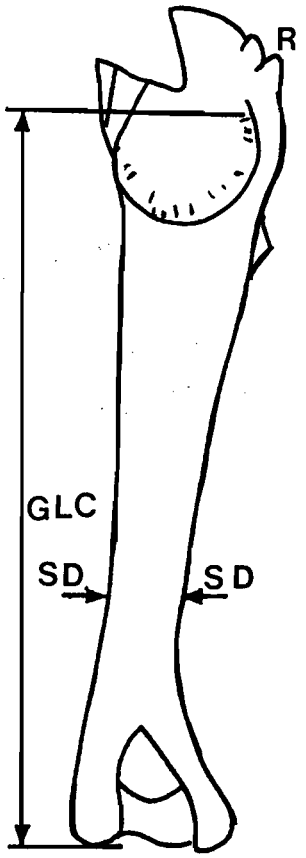


B

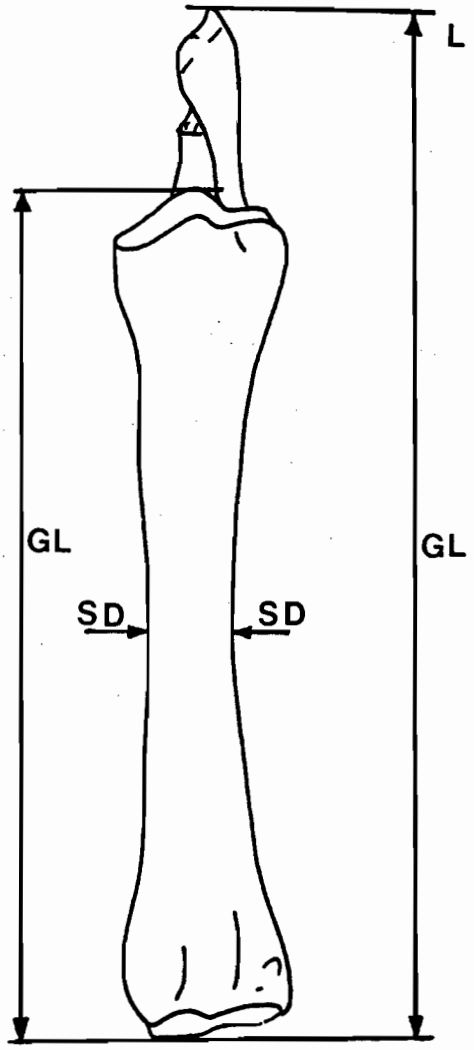
Figure 9.9A. Radius and ulna, dorsal view.

Figure 9.9B. Radius and ulna, lateral view.

Figure 9.9C. Ulna, proximal end dorsal view.

Figure 9.9D. Radius, proximal view.

Figure 9.9E. Radius, distal view.



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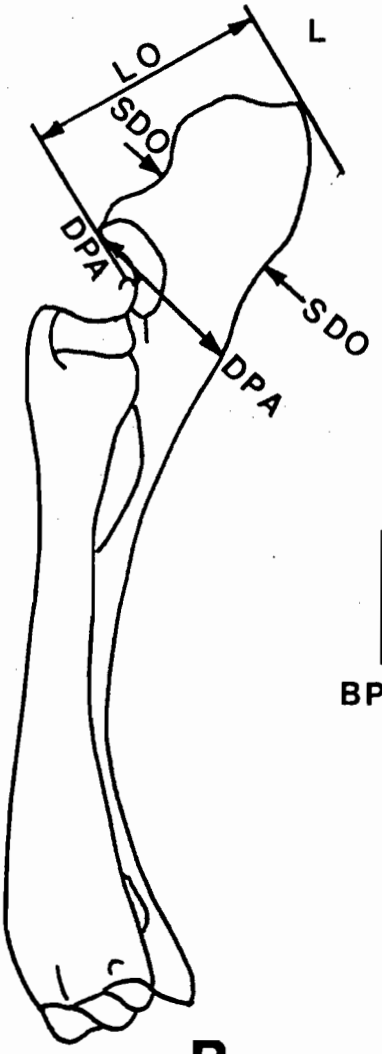

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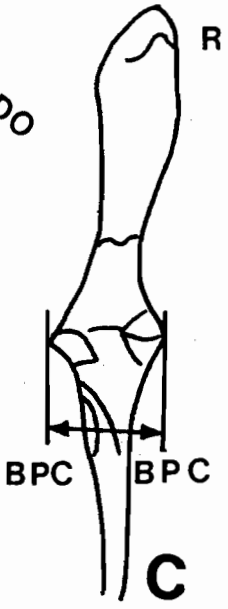

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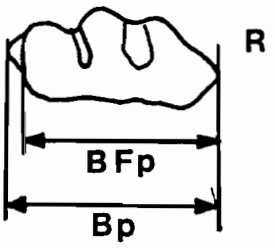

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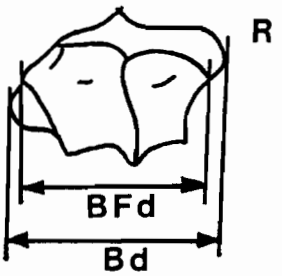


Figure 9.10. Pelvis, ventral view.

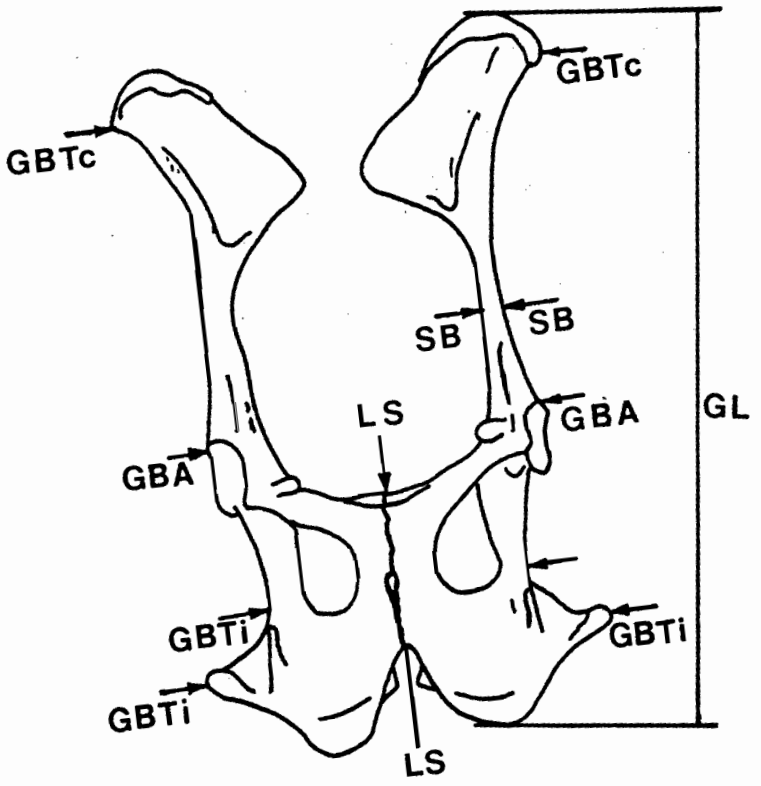
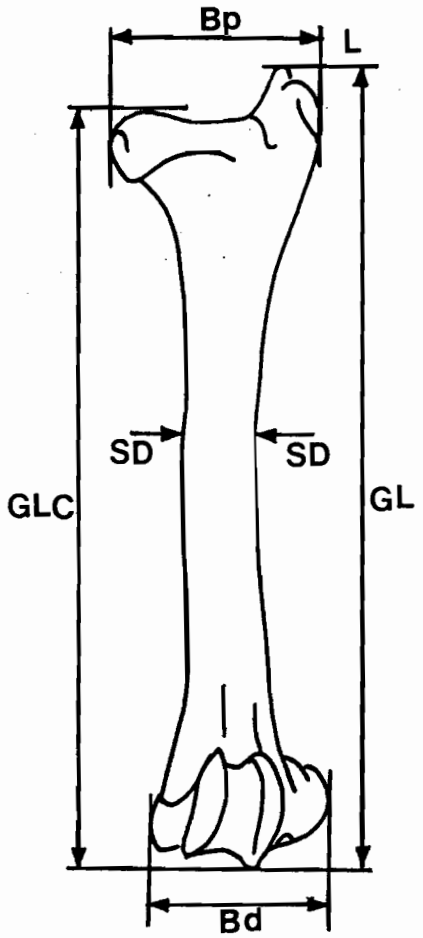

GBTc
GBTc
SB
SB
LS
GBA
GL
GBA
GBTi
GBTi
GBTi
LS

Figure 9.11A. Femur, proximal view.

Figure 9.11B. Femur, cranial view.

Figure 9.12. Patela, cranial view.



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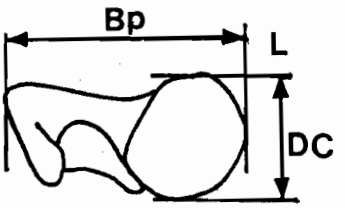

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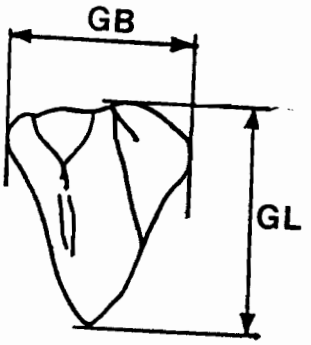
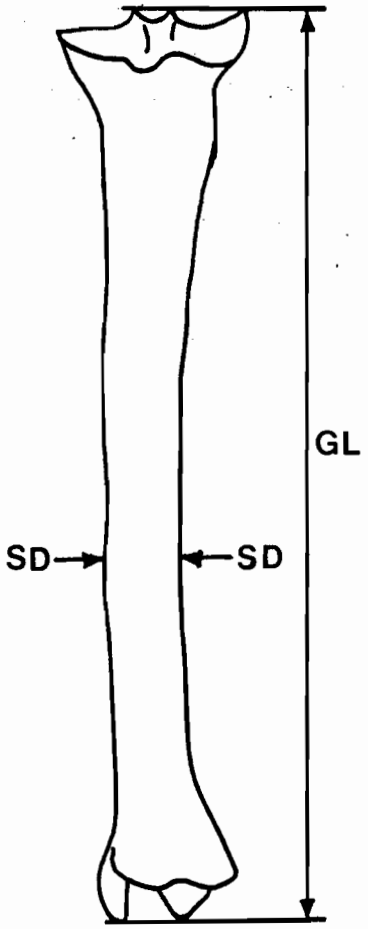


12

Figure 9.13A. Tibia, cranial view.

Figure 9.13B. Tibia, proximal view.

Figure 9.13C. Tibia, distal view.



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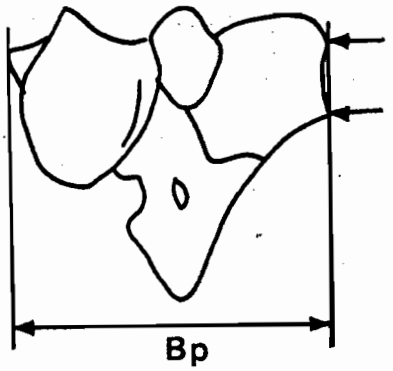

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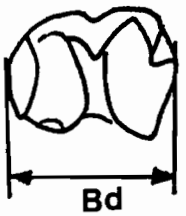


C

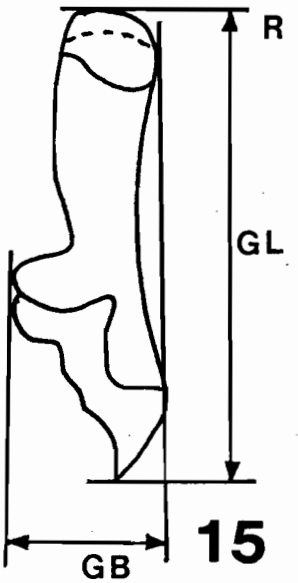
Figure 9.14A. Astragalus, medial view.

Figure 9.14B. Astragalus, lateral view.

Figure 9.14C. Astragalus, dorsal view.

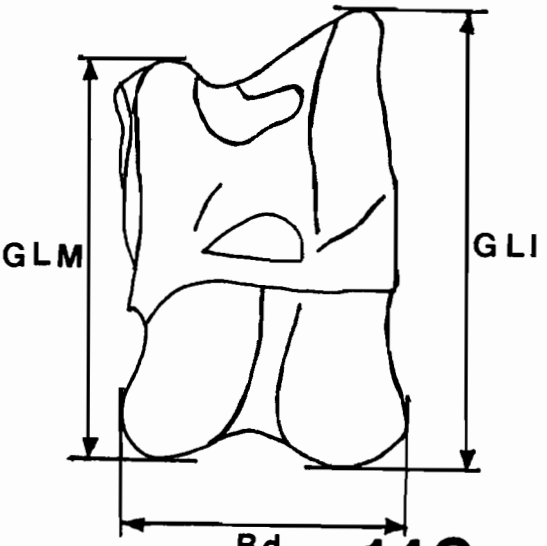
Figure 9.15. Calcaneus, dorsal view.

14A



15

14B



14C

Figure 9.16A. Metacarpus, dorsal view.

Figure 9.16B. Metacarpus, side view.

Figure 9.16C. Metacarpus, proximal view.

Figure 9.16D. Metacarpus, distal view.

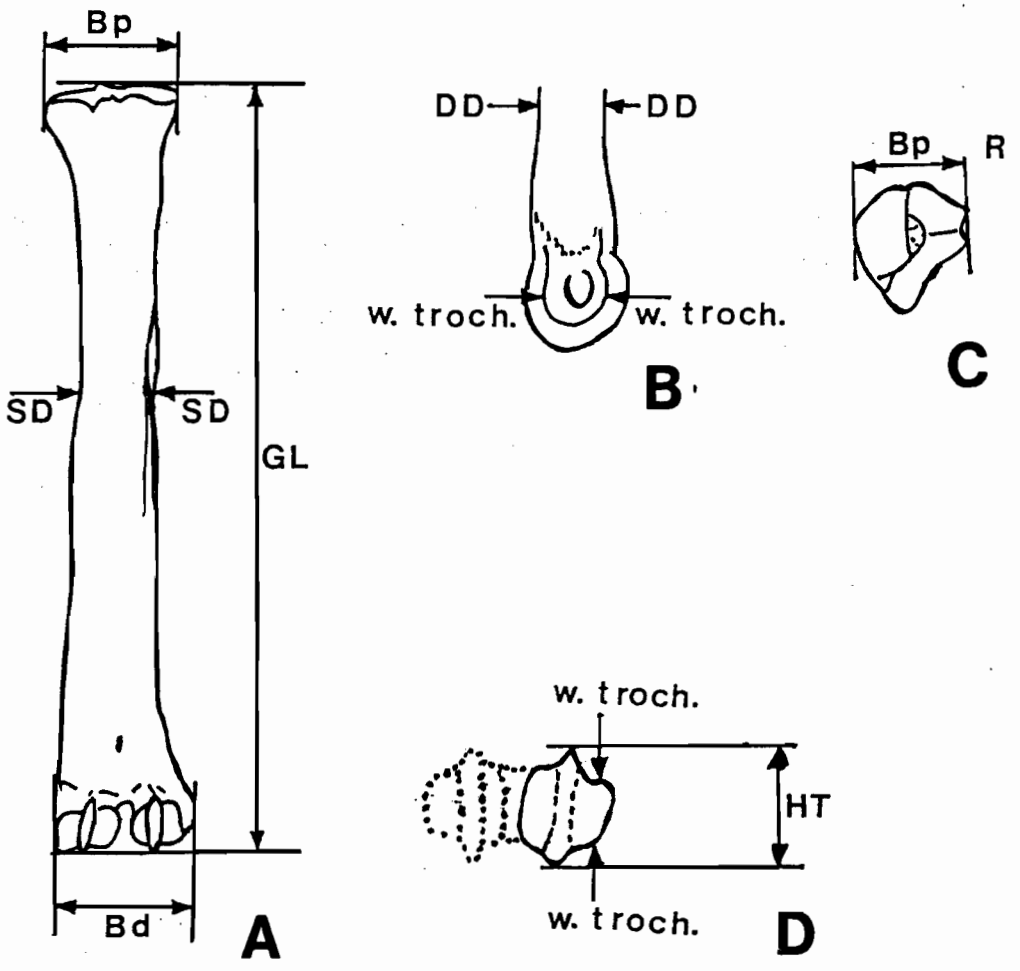

Bp
SD
SD
GL
Bd
A
DD
DD
w. troch.
w. troch.
B
Bp
R
C
w. troch.
HT
w. troch.
D

Figure 9.17. Breadth of the distal end of metatarsi of the sheep (mouflon) of Khirokitia (Davis, 1984) and the modern sexed Cyprus mouflon.

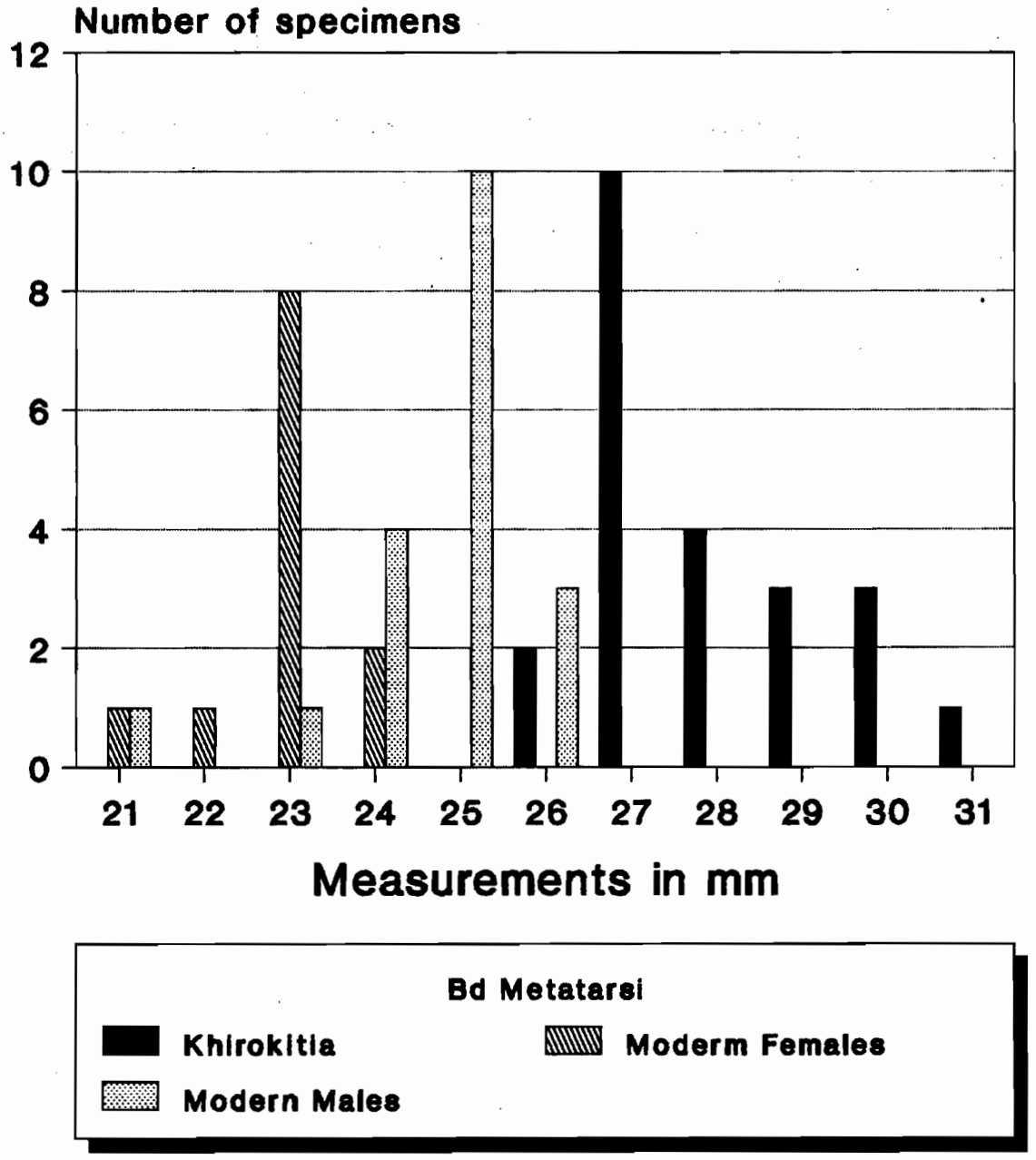
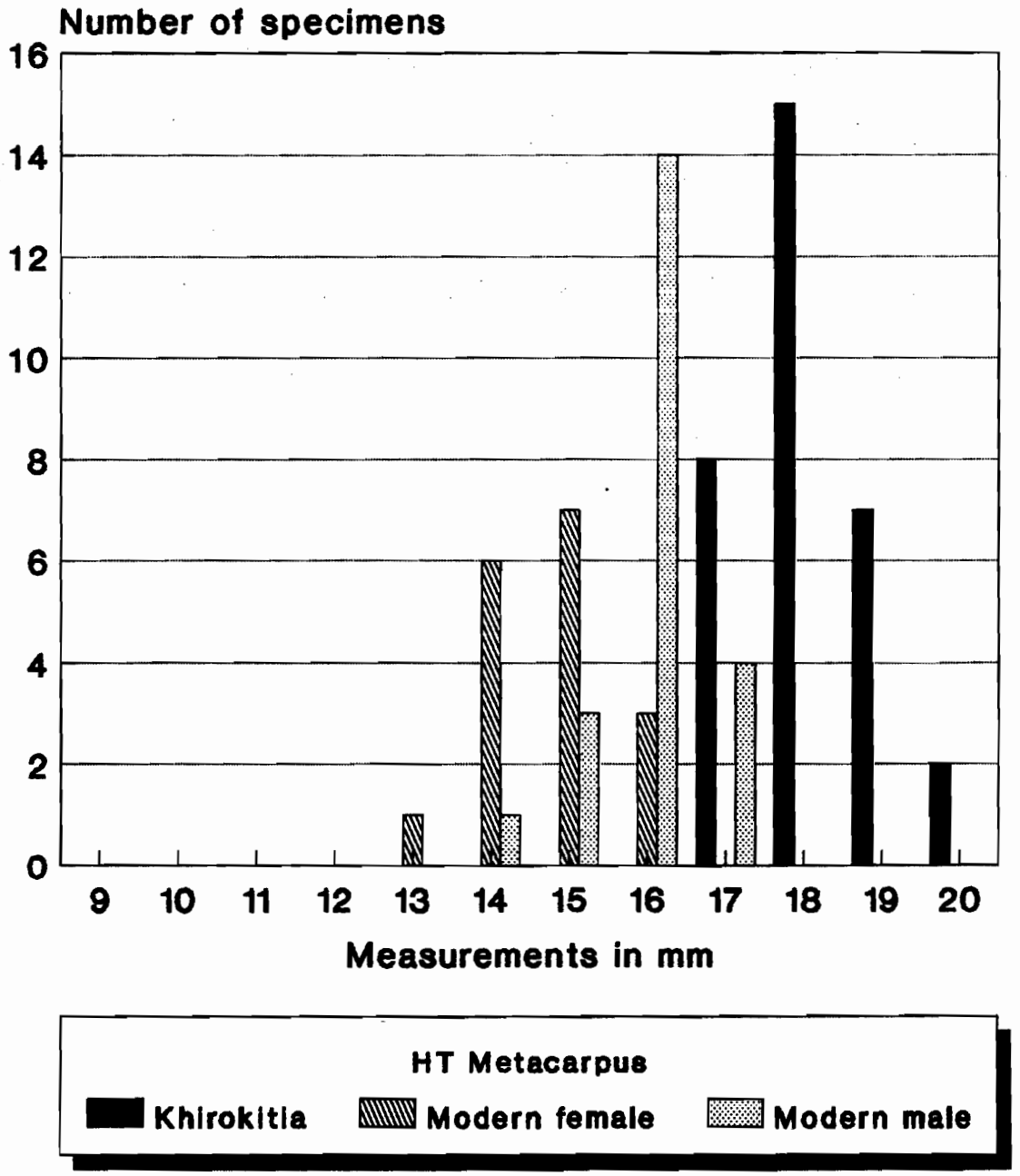

Number of specimens
12
10
8
6
4
2
0
21
22
23
24
25
26
27
28
29
30
31
Measurements in mm
Bd Metatarsi
Khirokitia
Moderm Females
Modern Males

Figure 9.18. Height of metacarpi of the sheep of Khirokitia (Davis, 1984) and the modern sexed Cyprus mouflon.


Number of specimens
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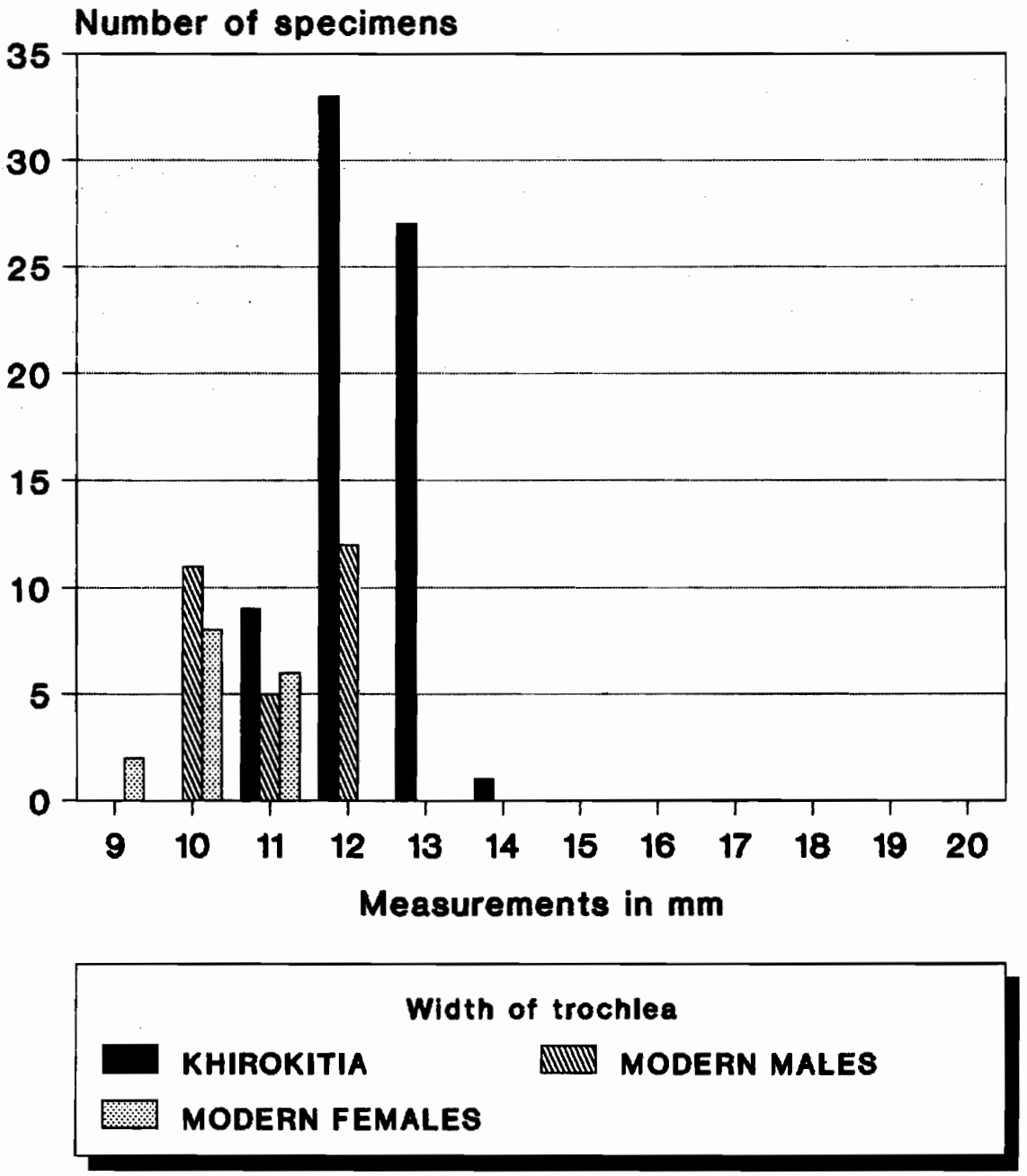
14
12
10
8
6
4
2
0
9
10
11
12
13
14
15
16
17
18
19
20
Measurements in mm
HT Metacarpus
Khirokitia
Modern female
Modern male

Figure 9.19. Width of trochlea of the sheep of Khirokitia (Davis, 1984) and the modern sexed Cyprus mouflon.


Number of specimens
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30
25
20
15
10
5
0
9
10
11
12
13
14
15
16
17
18
19
20
Measurements in mm
Width of trochlea
KHIROKITIA
MODERN MALES
MODERN FEMALES

CHAPTER 10

EFFECTIVENESS OF ELECTRIC FENCING USED BY SHEEP AND CATTLE RANCHERS AS MOUFLON REPELLENT

10.1 INTRODUCTION

Agricultural crops grown in regions neighbouring the Paphos Forest, the only remaining habitat for Cyprus mouflon, are liable to depredation by wild sheep. Short term solutions such as the use of scarecrow devices, scenting with repellents and using dogs may help, but where the problem is severe these efforts must be repeated regularly. Shooting of mouflon was conducted for crop protection in 1956 without lasting success and it is now illegal because of the mouflon's endangered status. Electric fencing is used as a long term solution for other big game mammals. This report describes the effectiveness of electric fencing in preventing depredation from mouflon.

10.2 MATERIAL AND METHODS

Electric fences were tested at two locations. The first was a commercial cherry farm and vineyard located on a terraced hillside at Yerakies village. The second was a vineyard at the forest edge near Kannaviou village. Half of the field at Kannaviou was left unfenced as control. At

Yerakies a vineyard located 200 m from the fence was used as test control.

The fields were examined for mouflon tracks approximately once a week. At Yerakies, four observations were made by game wardens and the rest of the observations by the owner of the field or the author. At Kannaviou all observations were made by the author.

10.2.1 Acreages and crop protected.

Fencing wire could fence either 500m as single line or 250m as double line. Two lines were used at the field of Yerakies and a single line at Kannaviou. The fenced parts were towards the forest, where depredation pressure was highest.

10.2.2 Material and cost

Each shock unit contained one 12 volt energizer, 20 fiberglass posts, ground rods, insulators, 2 insulated fence reels, tighteners and 1 coil of 500m long plastic twine with 3 stainless steel wires woven in. These come in one package at the cost of Cy£ 150.00 or $300 U.S. Six batteries 1.5V each are not included in the package and cost Cy£ 3.00

10.2.3 Fence construction

Fences were constructed as instructed by the manufacturer. At Yerakies the upper wire was set at height of approximately 70cm, which is the head height of mouflon. The lower wire was placed at the height of 30-35 cm to keep foxes out and to discourage mouflon from crawling underneath the wire. At Kannaviou, the height of the wire was approximately 60 cm. In August, aluminium foil spread with peanut butter was hung every few meters on the twine to cause mouflon to touch the wire with their tongue and make direct conduct with the electric wires. The bush along the field margins was cut to ensure straight alignment of the posts. Where the ground was not rocky a meter wide path was cleared outside the fences to register mouflon tracks.

10.2.4 Fence maintenance

Batteries were changed every 3 months as recommended by the manufacturer. Weeds and broken branches occasionally touched the fence line, but the energizer had the ability to maintain high voltage. Weeds and other brush were cleared from the fence lines.

10.2.5 Duration of the experiment

Fence and energizer were left in the field at Yerakies from 1 September until the end of December 1986, and at the field of Kannaviou from 2 May until the end of October 1987. Observations ended in winter since no more damage was expected from wildlife following tree defoliation due to cold weather and harvesting of the fruit.

10.2.6 Other observations

The reaction of mouflon towards plastic twine was tested using 8 captive animals at Stavros tis Psokas Forest Station. A long twine was tight from side to side separating their enclosure in 2, at a height that allowed the animals to walk underneath. The animals were forced to walk across the enclosure six times before positioning the twine, and 6 times after positioning the twine.

10.3 RESULTS

At Yerakies, of 15 observations, tracks were registered outside the fence once and no penetrations occurred. However, the control area suffered considerable damages. Damage to the fence was caused by hunters and their dogs on two occasions. At Kannaviou, of 20 observations, tracks adjacent to the fence occurred 10 times and 6 times the mouflon penetrated the fence. At four occasions plants

were damaged. All penetrations occurred after August. By August all leaves from the vines in the control area were eliminated. The aluminium foil with peanut butter was not effective in reducing the ingress of mouflon into the vineyards.

In the enclosure before placing the twine the animals walked from one side to the other without stopping. After positioning the line of the electric fence the animals avoided the line the first five times they approached it, but eventually touched it with their noses. After being shocked the animals ran under it.

DISCUSSION

The fence at Yerakies was constructed when grapes were ripe, and mouflon was being sustained on grape leaves and occasionally on grapes. A faecal analysis of fox scats found in the area revealed that the major food item of foxes was grapes. Although mouflon avoided the fenced area after construction, they visited the control area and nearby fields. A properly protected and maintained double lined fence seems to be effective in preventing sheep damage.

The second experiment at Annadhiou provided further evidence for this since there was no damage in the fenced area compared to the unfenced, which was heavily depredated by sheep. The following August however, sheep

learned to crawl under the single wire fence. This fence was constructed when the fresh shoots of the vines were first appearing and were attractive to sheep.

The Standard electric fence design used for livestock has proven unsatisfactory at times for big game control in parts of the West and Southwest U.S.A. This is generally during the dry season when lack of moisture in the ground prevents good grounding of current (Yoakum et al. 1980).

Based on the experiment with the captive sheep it is possible that the animals, led by a curiosity for new objects test them by touching with their nose or tongue. This behaviour may eliminate the need for peanut butter as bait, and suggests that a two-line electric fence may prove effective for crop protection, if properly maintained and regularly inspected.

CHAPTER 11

CONCLUSION

11.1 Introduction

The Cyprus mouflon population has existed for 8000 years. It is a feral domesticate and with the exception of the mouflon of Corsica and Sardinia, it differs from the other populations of wild sheep in that it is a forest animal. Part of the population seemed to live at the forest edge and foraged in pastures and vineyards. Since mouflon are said to be sedentary and faithful to their small home ranges (Pfeffer, 1967), it provided the opportunity to determine to what extent forest and forest edge subpopulations differed. In addition, since the animal is unique and classified as an endangered species by the International Union for the Conservation of Nature, it was deemed important to collect as much data as possible that could contribute towards its management and conservation.

11.2 DIFFERENCES AND SIMILARITIES BETWEEN THE TWO POPULATIONS

Based on the evidence presented, the Cyprus mouflon appears to occupy a summer and a winter home range, possibly a breeding home range, and a spring lambing home range for the females.

The seasonal home range area of the Cyprus mouflon

seems to be determined by the availability of forage. During the summer when forage is reduced in quantity and quality, the mouflon inside the forest expands its home range. At the edge of the forest there is much more grass and the home range of mouflon was observed to be about half the size of that inside the forest.

Although the number of animals observed was small, the existence of home ranges similar to the size of other races of wild sheep, and the overwhelming evidence from other studies that sheep are faithful to their seasonal home range, appears to indicate that there should not be any association of the animals living at the centre of Paphos Forest with the animals at the edge, because the distance between the two areas is larger than their home range areas.

Although data from rumen analysis could be compared only during fall and winter, as expected I found proportionately more woody material and fruit in the diet of the forest dwellers than those at the forest edge. This variation in diet possibly reflects the forested habitat in which mouflon lives, or a lack of grass in the forest. Fruit were abundant during fall and winter and for the first time reported as a considerable item in the diet of the Cyprus mouflon. During fall when most of the other forage species were low in some nutrients, fruits possibly contributed to a balance diet.

During spring and summer mouflon fed mainly on

grasses and forbs. In spring a larger quantity of tree leaves were eaten, particularly in April when they were just sprouting. Ruminants eat more shrubs and trees during this time because they are low in toxins (Geist, 1983, Personal correspondence). As the summer progressed shrubs were eliminated from the sheeps' diet. This was, as has been outlined in the discussion in section 2.E, possibly linked with the secondary plant compounds in many of the shrubs of Cyprus as well as seasonal fluctuations in protein. At the edge of the forest mouflon had access to a variety of cultivated plants both for human and livestock consumption and therefore free from toxins.

Reproductive success are affected by food availability. Pregnant ewes need more nutrients than non-pregnant ones (NRC, 1988). The requirements for energy and protein are small during the first two-thirds of the gestation period, but increase during the last third. The Cyprus mouflon followed a pattern similar to Soay sheep (Boyed and Jewel, 1974) and red deer (Clutton-Brock et al. 1982). Domestic ewes in peak lactation require three times more food than those without lambs and intake is 30-50% higher during lactation than during late pregnancy (Owen, 1976). The cost for mouflon ewes are probably similar in their timing and dimensions. Gestation period for Soay sheep is about 148 days (Doney et al. 1974), for domestic sheep about 142-152 days (loc. cit.) and for Corsican mouflon about 148-159 days (Pfeffer, 1967). The ges-

tation period of three Cyprus female mouflon was 156-158 days (Personal observations, 1987-1988). Furthermore, since lambing takes place between the end of March and the beginning of May, the energy and protein requirements for pregnancy should start to rise, in late January. At this time there was an abundance of grass and forbs particularly at the edge of Paphos Forest. During the peak lactation period the females had a high quality food available. At the weaning of the young, the grasses matured, flowered, and were dying. By August, all animals had to rely on low quality dried grass litter, the remaining forbs, and the leaves of shrubs and trees. During this time there were notable shortages in protein and some nutrients. Shortages were less evident at the edge of the forest because there were available large areas of cultivated plants and meadows.

Though the mouflon inside the forest must rely on forage which is low in protein and some nutrients, they need more energy. Since the energy cost of vertical travel is approximately 10 times the energy cost of horizontal travel (Clapperton, 1964), animals living on steeper slopes must need much more energy than the animals at the edge of the forest. Also, as density of grazeable forage decreases or distance to water increases, energy needs to satisfy daily requirements increase. During this time mouflon increase their intake of specific plants with higher content of the needed minerals.

The timing of the reproductive cycle (fall rut, spring births) (Schaller, 1977) in temperate ungulates is the same as that of the Cyprus mouflon. Decreasing daylight is the proximate stimulus to onset of oestrus (Yeates, 1949; Pevet, 1987). The onset of the reproductive cycle of animals at the edge of the forest occurs approximately two weeks earlier than the animals of the forest, and the lambing period was longer. According to Geist (1971) and Schaller (1977) the shorter lambing season indicates that the forest population lives in an environment less favourable to the survival of their young.

The shortage in protein and nutrients inside the forest also seems responsible for the observed reduced pregnancy rate (Chapter 2.F), the lower number of twins produced, and the lower lamb per ewe ratio. In addition the lambs inside the forest suckled significally shorter periods of time than the lambs at the edge of the forest (Chapter 2.G).

Male ruminants, especially mature, reproductively active male sheep, and males of many deer species, have their highest energy costs during the rut. Many lose body condition during the rut, because the time that would otherwise be spent grazing is taken up with activities such as following oestrus females and discouraging competitors. Bighorn, Dalls and Stones sheep (Geist, 1971), Soay sheep (Grubb and Jewell, 1974) and red deer (Clutton-Brock et al., 1982) are in poor condition in the rut. Since the

available forage in these temperate climates is low (Grubb, 1974) there is little opportunity to recover condition after the rut, and there is high post-rut mortality (Geist, 1971; Grubb, 1974; Clutton-Brock, 1982). High post-rut mortality was also observed for Cyprus mouflon, even though food was abundant. In the forest, November was the month with the highest mortality, while February, June and July had the lowest. In the forest-agriculture interface the differences in mortality between months were not different but the sample was small.

The loss of condition probably in combination with the sudden drop in the fall temperature coupled with an increase energetic demand and parasitic and other diseases (Chapter 4) led to the highest monthly mortality observed. Depending on the rains fresh grass might not appear inside the forest until a month after the rut and this could lead to the high losses. Grass growth inside the forest is much slower than that at forest edge. By January - February however, the animals had the opportunity to recover as the fresh high protein grass appeared.

There was no difference in most plant chemical content between plants at the edge and inside the forest. Comparing the nutrient content between plants inside and at the edge of the forest, it can be seen that some plants inside the forest were richer in some nutrients and poorer in others, depending on the soil content of that mineral. For example, plants inside the forest were richer in

sodium, but poorer in sulfur.

Animals occasionally eat small rocks, or soil impregnated with natural salts, to alleviate possible mineral deficiencies (Schaller, 1977). Animals inside Paphos Forest ate small stones of gabbro, which suggests that they might take soil or rocks as a nutrient supplement. However, wild mouflon never licked any of the mineral blocks provided during this study. This could be because the animals failed to "recognize" the supplement as useful, since it is an unnatural food (Gordon, 1970). In terms of a management practice these results indicate that supplying mouflon with salt blocks is not worthwhile.

Lamb survival during the first month of their life was high at both areas as long as they used the cliffs for refuge. The mortality rate of lambs after leaving the lambing ground appears to be higher at the edge of the forest than inside the forest. However, this might have to do more with human (poaching) than environmental factors.

The only wild predator on the island of Cyprus is the red fox (Chapter 2.H). Although seldom seen, fox tracks are common within the limits of Paphos Forest. The foresters at Stavros tis Psokas Forest Station believe that foxes kill a large number of lambs and is the main limiting factor in the increase of the population. Contrary to the beliefs of the Forestry Department I found red fox was not a major limiting factor as it is believed to be, par-

ticularly for newborn lambs using the steep lambing grounds. However, more research is necessary to clarify the impact of fox on lambs after they leave the cliffs. Eagles are rare in Paphos Forest and are not considered important mouflon predators.

Dogs can, and do kill mouflon however, more chases end in either the sheep escaping, or the dogs being chased by sheep (Chapter 3). Of the three postmortems made on sheep known to be killed by dogs, all had pathological handicaps. Dog predation is not selective of either sex, although rams can kill dogs. The limited data could support the hypothesis that the dogs do a certain amount of culling of diseased, parasitized or otherwise handicapped animals and therefore dog predation is not a serious problem.

Although mouflon are susceptible to most of the diseases and parasites of the domestic caprins, they do not seem to be seriously affected by them (Chapter 4). Far more important as mortality factors are the predators, road kills, poaching and accidental deaths from falling.

In the case of the captive (Chapter 4) animals, there are many avoidable deaths. A simple collection of the plastic bags and strings from the enclosure could avoid intestinal obstructions of the animals. Effective prevention of enterotoxaemia can be achieved by vaccination with enterotoxaemia vaccine. Heavy concentrations of small lambs on small areas, which favours the spreading of coc-

cidiosis, should be avoided. Construction of food troughs which will prevent lambs from standing inside the trough to feed, will prevent contamination of their food and the spreading of parasites. Small pens, or high densities seemed to be the primary cause of mortality.

The Cyprus mouflon suffer from a large range of bone problems similar to those of domestic animals (Chapter 5). These problems could possibly affect the fitness of individuals to varying degrees, from slowing them down and making them less competitive during the rutting season, to rendering them susceptible to predation. Possibly the most important defect, which affects mainly old males, is spondylosis. Based on this finding, it is suggested that in the case of hunting, old rams over 9 years old could be removed from the population without affecting it.

The wild sheep of Cyprus is one of the most endangered Mediterranean races (Cassola, 1976) and captive breeding can be used as a conservation strategy to ward off extinction (Chapter 7). This was done at the Limassol Zoological Garden, but it did not maintain a captive population which would be of any use to a conservation program. During this program all the basic rules to avoid inbreeding were ignored. Had the animals been left at Paphos rather than being brought to the zoo, a larger number of progeny of better genetic quality would have been added to the population, since juvenile mortality was much higher at Limassol than at Paphos forest. All the signs of

1951; Schaller, 1977; Valdez, 1982; Geist, 1986), under the name Ovis gmelini Ophion (Hadjisterkotis, 1992). In addition, since the Cyprus mouflon does not possess Hb M, which is characteristic of the European mouflon, it is evident that the Cyprus mouflon is not "absolutely identical" with the European mouflon, as it was stated by Pfeffer (1967).

The bone measurements in chapter 9 provided evidence about the evolutionary history of the Cyprus mouflon. The modern Cyprus mouflon is compared with the Neolithic remains of the sheep of Khirokitia, which is dated to approximately 6,000 B.C., and is considered to be the founding population of the modern Cyprus mouflon (Davis, 1984). The modern mouflon is smaller than the sheep of Khirokitia by 15.0-18.4%, and suggests that it might be an example of island dwarfism.

The bones of the male mouflon are considerably larger than those of the female mouflon, particularly in the greatest length of some bones. Bones which are most representative of this difference is the cranium, sacrum, femur, atlas, axis, pelvis, metacarpus, radius and ulna.

As long as mouflon continue to come into conflict with farmers, nothing can guarantee the well being of the population (Chapter 10). Attempting to find cheap methods to protect agricultural crops, it was found that a two-line electric fence may prove effective for crop protec-

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tion, if properly maintained and regularly inspected.

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APPENDIX 1

BONE MEASUREMENTS OF CUPRUS MOUFLON

Table 1a. Male mouflon: Cranial measurements

Animal code no	1	2	3	4	5	6	7	8
1	213.6	209.8	190.0	138.5	56.2	113.6	120.5	115.9
6				135.7		114.5		119.3
7				149.3		122.6		
8				141.7		121.0		123.7
11				145.8		18.0		121.0
12				150.2		122.8		
13				146.8		119.9		122.4
14				139.9		113.3		116.6
18				149.2				122.5
22	225.7	211.3	195.9	143.5	53.4	118.6	126.0	119.8
25				147.1		123.6		126.0
28	222.7					124.0		
38				147.3				121.4
44								
48				137.5		111.4		
67	224.6	221.1	203.9	146.2	58.7	120.0	134.6	122.1
72	223.0	220.0	243.3	145.4	57.4	122.1	128.5	125.6
78				143.8		119.7		122.5
85	231.7	227.2	240.4	150.0	60.4	124.2	131.9	129.6
93						119.9		
111				142.2		122.4		123.5
117				146.9		118.5		123.7
119				141.6		113.2		116.3
122	232.5	227.7	211.3	149.5	61.6	123.0	134.5	125.8
170	229.8	224.3	229.2	148.3	61.1		132.6	125.8
189								
N	8.00	7.00	7.00	22.00	7.00	21.00	7.00	19.00
MAX	232.50	227.70	243.30	150.20	61.60	124.20	134.60	129.60
MIN	213.60	209.80	190.00	135.70	53.40	18.00	120.50	115.90
AVG	225.45	220.20	216.29	144.84	58.40	114.59	129.80	122.29
STDS	5.73	6.66	19.87	4.17	2.74	21.94	4.78	3.52
VARS	37.49	51.71	460.47	18.21	8.74	505.52	26.67	13.06

Table 1b. Male mouflon: Cranial measurements

Animal code no	9	10	11	12	13	14	15	16
1	60.3	82.4	101.5	148.0	150.9	77.7		149.0
6	61.0	82.0	104.0		150.0	71.0		144.0
7	60.0		107.0		162.0	88.0		155.8
8			110.2		156.0			153.8
11	63.0	84.5	104.0		159.0			155.0
12	61.0		106.0		150.0	86.3		156.4
13	67.0	84.0	106.0		150.2	85.3		152.0
14	59.6	80.1	105.4		160.3	90.2		160.4
18	61.0	88.3	107.9	150.4	154.6	83.2	132.0	151.0
22	62.4	85.0	107.4		158.6	81.8		155.9
25	62.7	89.8	109.4	152.2		86.0	130.0	
28					148.7			145.5
38			107.0	157.9	158.4	90.1	141.0	156.0
44	57.2			156.6	158.5	82.0	131.8	155.8
48	62.5		104.6		164.9	71.2		165.0
67			110.1		158.0	88.0		156.1
72	63.3	87.2	108.4	160.8	164.0	82.0	139.0	160.6
78	56.9	85.0	109.0					152.7
85	66.4	90.5	113.0		155.0	83.0		159.7
93					160.0	88.0		150.0
111	63.0	84.0	106.0		154.8	79.0		160.6
117	64.8	84.0	109.5	161.6	164.2	89.7	140.6	158.9
119	59.8	79.8	116.7	157.9	162.6		135.9	
122			111.8		156.0			
170	65.6							
189	61.0		104.9					
N	20.00	14.00	22.00	8.00	22.00	18.00	7.00	21.00
MAX	67.00	90.50	116.70	161.60	164.90	90.20	141.00	165.00
MIN	56.90	79.80	101.50	148.00	148.70	71.00	130.00	144.00
AVG	61.97	84.76	107.85	155.68	157.12	83.47	135.76	154.96
STDS	2.71	3.14	3.35	4.62	4.85	5.65	4.22	5.07
VARS	7.38	10.63	11.65	24.42	24.66	33.77	20.73	26.97

Table 1c. Male mouflon: Cranial measurements

Animal code no	17	18	19	20	21	22	23	24
1	122.0		64.9	68.3	47.6	22.0	22.0	41.2
6				56.2	39.9	18.8	18.8	41.6
7				68.7	36.0	24.2	24.2	42.7
8				66.9	43.2	22.2	22.2	41.5
11				67.9	45.6	22.5	23.6	43.3
12				66.9	36.0	24.2	22.5	41.8
13				68.7	43.8	21.5	24.2	42.7
14				68.0	41.2	28.0	21.5	40.8
18	100.0	93.0	65.0	69.3	48.0	22.0	28.0	44.3
22				65.0	43.5	23.0	22.0	41.8
25	122.0	94.0	63.2	62.2	42.3	24.8	23.0	43.0
28				68.0	43.8	21.5		
38	121.0	97.9	64.1	68.6	44.6	21.4	22.4	43.2
44	122.5	93.7	62.0	65.6	42.5	65.6	24.8	41.9
48	127.8	96.6	62.4	65.7	45.3		21.5	40.8
67				63.3	43.9	20.1	21.4	41.3
72	123.8	99.1	67.0	64.6	43.7	21.5	22.6	43.2
78							20.1	40.3
85				66.0	46.8	19.9	21.5	42.5
93				64.0	42.2	22.8		
111				65.5	46.0	21.6	19.9	41.2
117	127.7	101.1	62.5	66.4	45.3	21.8	22.8	42.0
119							21.6	42.3
122							21.8	44.1
170								
189								
N	8.00	7.00	8.00	21.00	21.00	20.00	22.00	22.00
MAX	127.80	101.10	67.00	69.30	48.00	65.60	28.00	44.30
MIN	100.00	93.00	62.00	56.20	36.00	18.80	18.80	40.30
AVG	120.85	96.49	63.89	65.99	43.39	24.47	22.38	42.16
STDS	8.25	2.83	1.59	2.90	3.10	9.63	1.85	1.05
VARS	77.72	9.37	2.88	8.81	10.07	97.58	3.57	1.15

Table 1d. Male mouflon: Cranial measurements

Animal code no	25	26	27	28	29	30	31	32
1	38.0	93.5	46.0	64.5	18.2	19.2	52.1	100.3
6	40.0	92.3	43.3	64.5	18.9	20.3	53.1	100.1
7	38.5	95.0	46.3	68.9	18.9	19.6	55.2	103.8
8	40.4	96.0	46.0	68.6	17.7	20.0	52.5	103.7
11	38.2	91.8	43.6	66.6	17.8	18.2	50.9	101.6
12	38.4	94.2	44.6		18.0	18.7	56.6	104.0
13	38.5	95.0	46.3	68.9	18.9	19.6	55.2	106.6
14	38.0	93.2	46.0	67.0	18.0	19.6	55.6	98.0
18	40.6	98.4	48.8	71.5	20.0	19.4	53.3	105.0
22	38.1	97.0	43.6	68.4	18.0	17.9	48.6	104.4
25	40.3	98.3	49.0	71.2	18.2	19.5	54.0	106.4
28								
38	41.3	92.1	44.0	66.5	16.7	17.6	54.0	100.3
44	39.9							
48	38.0	93.2	46.0	67.0	18.0	19.6	55.6	99.1
67	39.0	91.0	47.8	69.0	18.6	19.3	52.5	104.3
72	41.9	95.5	47.0	67.5	19.1	20.1	53.0	106.4
78	39.0	96.1	45.4	70.6	18.0	19.4	52.5	104.1
85	40.0	24.6	46.6	66.0	18.9	20.0	52.7	103.1
93								
111	41.9	92.0	50.4	68.0	19.6	20.2	55.5	104.3
117	39.8	93.3	47.1	66.8	18.0	20.3	52.3	102.6
119	39.0	91.9	45.2	67.7	18.6	20.8	52.9	97.2
122	40.7	91.0	49.6	68.2	19.0	19.1	52.4	102.6
170								
189								
N	22.00	21.00	21.00	20.00	21.00	21.00	21.00	21.00
MAX	41.90	98.40	50.40	71.50	20.00	20.80	56.60	106.60
MIN	38.00	24.60	43.30	64.50	16.70	17.60	48.60	97.20
AVG	39.52	90.73	46.31	67.87	18.43	19.45	53.36	102.76
STDS	1.24	14.95	1.94	1.85	0.71	0.79	1.80	2.64
VARS	1.62	234.58	3.94	3.61	0.53	0.66	3.41	7.33

Table 1e. Male mouflon: Cranial measurements

Animal code no	33	34	35	36	37	38	39
1	73.5	117.3	75.1	69.6	30.1	38.0	63.8
6	76.4	116.0	75.0	70.3	33.4		62.6
7	81.0	116.2		72.9	38.7		65.2
8	78.9	119.9	78.5	72.5	31.6		65.7
11	76.6	119.2	76.3	72.0	31.3		62.5
12	74.8	120.9		72.1	37.7		63.7
13	81.4	124.5	80.4	74.3	31.7		68.0
14	70.4	116.2	75.0	62.6	27.9		60.8
18	82.6	125.0	82.4	74.7	39.0		67.0
22	77.8	120.0	78.1	70.4	30.1		64.6
25	72.5	127.0	80.0	74.9	33.7		67.6
28		116.1	74.7	69.0	31.9	40.3	62.2
38	71.4		81.3	70.2	34.7	41.1	65.4
44		111.0	73.7	67.8			62.0
48	71.0	121.1	77.5	71.3	30.7	41.7	64.2
67	72.0	121.5	80.7	74.5	35.1		65.1
72	82.9	119.6	78.0	72.3	31.0	41.4	63.3
78	74.2	120.2	76.9	70.6	31.6	39.7	64.0
85	82.0	120.2					
93		114.9		70.4	35.3		63.1
111	78.3	117.9	80.0	73.4	32.3		63.7
117	77.7	116.9	74.7	71.9	31.0		66.2
119	71.9						
122	82.0						
170							
189							
N	21.00	21.00	18.00	21.00	20.00	6.00	21.00
MAX	82.90	127.00	82.40	74.90	39.00	41.70	68.00
MIN	70.40	111.00	73.70	62.60	27.90	38.00	60.80
AVG	76.63	119.12	77.68	71.32	32.94	40.37	64.32
STDS	4.16	3.60	2.59	2.72	2.92	1.25	1.85
VARS	18.14	13.58	7.11	7.75	8.95	1.89	3.59

Table 1f. Male mouflon: Cranial measurements

Animal code no	40	41	42	43
1	62.0	59.0	37.4	270.0
6	62.0	64.1	39.0	341.0
7	58.0	58.9	40.2	392.0
8	82.0	70.1	44.0	330.0
11	60.0	59.6	42.0	380.0
12	70.0	62.4	44.9	265.0
13	68.0	63.7	40.0	355.0
14	60.0	60.3	39.6	332.0
18		64.8	39.0	
22	71.0	62.8	46.3	330.0
25	79.0	64.7	46.3	
28	39.0	59.1		330.0
38				
44	56.0	60.3	36.8	
48	76.0	67.4	42.4	330.0
67	70.0	41.1	64.8	300.0
72	68.0	62.3	45.9	357.0
78	73.0	66.5	42.9	375.0
85				
93	58.0	60.4	38.7	300.0
111	64.0	61.2	40.0	335.0
117	58.0	60.6	39.4	295.0
119				
122				
170				
189				
N	19.00	20.00	19.00	17.00
MAX	82.00	70.10	64.80	392.00
MIN	39.00	41.10	36.80	265.00
AVG	64.95	61.47	42.61	330.41
STDS	9.59	5.54	5.98	34.91
VARS	97.05	32.27	37.73	1295.01

Table 2a. - Female moufion: cranial measurements

Animal code no.	1	2	3	4	5	6	7
2	210.5		188.5	131.9	56.8		
3							
23							
24							
26	211.5			131.4			
34		205.9	189.0	133.3	55.6	107.7	117.2
42				126.6			
43	213.6	207.1	185.1	126.3	58.7		
52				128.0			
53	213.1			121.2			
55		207.5	189.4	131.8	57.1	106.8	117.4
56	211.8	206.4	189.3	133.2	55.4		
58				132.4			
59				126.3			
61							
68				139.0			
75							
87							
95	207.5	198.1	181.5	126.8	54.6		
105							
118				127.7			
121				126.4		113.7	
129							
139				130.2			
150	200.7	194.8	179.1	126.8	52.2		111.3
152							
N	7.00	6.00	7.00	17.00	7.00	3.00	3.00
MAX	213.60	207.50	189.40	139.00	58.70	113.70	117.40
MIN	200.70	194.80	179.10	121.20	52.20	106.80	111.30
AVG	209.81	203.30	185.99	129.37	55.77	109.40	115.30
STDS	4.49	5.44	4.21	4.10	2.07	3.75	3.47
VARS	20.13	29.55	17.73	16.82	4.28	14.07	12.01

Table 2b. - Female mouflon: cranial measurements

Animal code no.	8	9	10	11	12	13	14
2		58.5		93.2	150.9	143.8	45.0
3		56.6		93.2			47.0
23		59.6	82.8	91.5		150.3	
24		59.6					
26		57.3	84.6	95.6		145.4	49.2
34	116.2	59.0	78.1	93.3	143.9	143.7	
42		59.0		92.2		150.0	
43		59.0		91.0	154.7	149.6	
52		59.1		93.1			
53		57.5		88.4		135.6	
55	119.9	60.4	82.8	94.2	152.0	146.9	
56		55.8		93.6	148.6	151.0	
58		58.8		90.8		145.8	
59		59.0		93.1		141.0	
61		59.1		94.2			
68		57.8		92.8			
75		56.9		87.3		143.1	
87	112.4	60.1	69.5	91.0			
95		58.0		92.8	148.7	143.1	
105		57.0		91.7			
118		56.3				143.4	
121	111.2		76.9	90.6		140.2	
129		58.6		89.1			
139		56.6				145.0	
150	105.2	59.1	72.3	89.9	141.7	144.2	46.0
152		55.0		88.0			
N	5.00	25.00	7.00	23.00	7.00	17.00	4.00
MAX	119.90	60.40	84.60	95.60	154.70	151.00	49.20
MIN	105.20	55.00	69.50	87.30	141.70	135.60	45.00
AVG	112.98	58.15	78.14	91.77	148.64	144.83	46.80
STDS	5.53	1.40	5.71	2.15	4.54	3.99	1.80
VARS	30.57	1.97	32.58	4.63	20.63	15.94	3.23

Table 2c. - Female mouflon: cranial measurements

Animal code no.	15	16	17	18	19	20	21
2		128.0	141.0	114.6	88.3	58.0	59.8
3							58.9
23			143.6				64.4
24			140.5				60.4
26			141.9				66.8
34	74.0	128.7	140.5	120.0	91.3	62.0	65.4
42			138.1				58.4
43		127.7	142.7	121.4	95.5	65.0	64.7
52							
53			130.9				61.7
55	74.7	129.3	141.4	118.8	94.2	59.0	63.0
56		124.9	146.2		90.6	58.3	63.7
58			140.1				61.8
59		136.0	136.0				63.0
61							
68							64.1
75							68.9
87	85.7						62.3
95		125.3					66.0
105							63.4
118							58.4
121	67.3						58.5
129							
139							
150	71.0	118.9	135.6	114.2	88.4	56.3	63.5
152							61.0
N	5.00	8.00	13.00	5.00	6.00	6.00	22.00
MAX	85.70	136.00	146.20	121.40	95.50	65.00	68.90
MIN	67.30	118.90	130.90	114.20	88.30	56.30	58.40
AVG	74.54	127.35	139.88	117.80	91.38	59.77	62.64
STDS	6.89	4.82	3.95	3.24	2.96	3.17	2.86
VARS	47.45	23.23	15.61	10.50	8.78	10.05	8.20

Table 2d. - Female mouflon: cranial measurements

Animal code no.	22	23	24	25	26	27	28	29
2			41.4	39.4	86.7	40.7	58.0	19.0
3	43.1	21.4				42.8	58.7	18.8
23	41.5	20.7	42.8	37.9	88.7	42.9	56.8	20.2
24	40.9	21.2	40.0	37.0	88.6	39.8	54.3	18.9
26	44.7	23.6		37.0	90.3	40.8	57.6	20.0
34	44.5	21.4	40.8	37.7	91.6	41.8	59.2	18.0
42	39.1			39.1	90.1	44.4	59.0	18.7
43	41.3	23.9	39.4	38.0	86.4	39.0	55.0	21.0
52								
53	39.6	22.3		37.3	85.0	39.1	53.4	18.0
55	42.6	21.3	41.3	37.8	85.8	41.3	57.8	18.2
56	42.7	21.2	42.2	39.1	87.4	40.7	56.4	19.7
58	42.2	20.9	40.4	39.4	90.0	42.0	56.6	17.7
59	41.7	20.4	40.4	39.4	90.0	42.0	56.6	17.7
61					94.7	46.6	59.6	19.6
68	44.6	20.8	42.1		85.2	39.8	55.2	19.0
75	46.2	22.6	39.3	37.1		40.0	56.0	19.0
87	43.3							
95	44.1	20.9	40.3	38.0	83.9	41.1	55.1	18.4
105	42.4	20.8				43.0	54.6	19.0
118	39.3							
121	40.4	19.3	40.8	38.8	88.1	41.5	54.7	18.0
129						37.0		18.4
139								
150	42.0	19.6	43.1	39.8	86.2	43.3	58.7	19.3
152	42.3	19.4				38.0	51.1	18.2
N	21.00	18.00	14.00	16.00	17.00	22.00	21.00	22.00
MAX	46.20	23.90	43.10	39.80	94.70	46.60	59.60	21.00
MIN	39.10	19.30	39.30	37.00	83.90	37.00	51.10	17.70
AVG	42.31	21.21	41.02	38.30	88.16	41.25	56.40	18.85
STDS	1.88	1.26	1.19	0.97	2.76	2.15	2.17	0.86
VARS	3.52	1.59	1.41	0.95	7.65	4.63	4.73	0.73

Table 2e. - Female mouflon: cranial measurements

Animal code no.	30	31	32	33	34	35	36
2	19.1	45.8		68.0	106.3	67.0	66.9
3	19.6	46.0		69.0	106.8		
23	19.9	46.2		65.2	110.0	69.7	
24	20.3	44.3		66.1		69.7	
26	17.8	48.4		68.8		70.0	67.3
34	28.9	46.1		66.0	112.0	67.7	70.0
42	19.3	47.0		67.9	110.8	67.7	70.0
43	15.7	47.9		67.0	111.0	67.3	63.5
52							
53	19.5	45.0		65.4		64.2	62.8
55	20.2	47.4		65.7	108.4	68.5	65.7
56	21.7	40.7		68.0	109.1	67.9	68.2
58	19.2	46.9		64.6	109.1	70.4	65.6
59	19.2	46.9		64.6	109.1	66.3	51.1
61	19.8	48.3		68.1	112.4	74.2	
68	23.2	46.0		66.4	102.8		
75	18.7	45.7		66.2	115.0	65.9	65.9
87							
95	19.6	46.8		68.2		64.3	62.1
105	20.2	47.4		69.2			
118						71.0	69.2
121	19.3	45.6		64.6	117.9	66.0	67.6
129	20.8	44.6		64.2	106.2		
139							
150	21.3	48.3		68.7		67.8	64.9
152	18.4	44.0		63.0			
N	22.00	22.00		22.00	15.00	18.00	15.00
MAX	28.90	48.40		69.20	117.90	74.20	70.00
MIN	15.70	40.70		63.00	102.80	64.20	51.10
AVG	20.08	46.15		66.59	109.79	68.09	65.39
STDS	2.45	1.76		1.80	3.72	2.48	4.64
VARS	6.00	3.09		3.24	13.81	6.13	21.55

Table 2f. - Female moution: cranial measurements

Animal code no.	37	38	39
2		35.3	59.2
3			
23			
24			
26			59.9
34		35.9	61.4
42		35.9	61.4
43		59.4	63.3
52			
53		27.8	57.7
55	25.0	34.6	62.7
56		41.6	61.3
58			60.6
59			58.1
61			
68			61.4
75			58.8
87			
95		34.1	58.6
105			
118			62.5
121	22.3		58.9
129			
139			
150	21.8	31.6	62.8
152			
N	3.00	9.00	16.00
MAX	25.00	59.40	63.30
MIN	21.80	27.80	57.70
AVG	23.03	37.36	60.54
STDS	1.72	9.05	1.82
VARS	2.96	81.88	3.32

Table 3a. - Male mouflon: measurements of mandible

Animal code no.	1	2	3	4	5	6	7	8
1	161.6	170.6	41.9	116.7	108.8	131.7	68.6	48.5
2	163.7							
6		168.3		106.3			57.8	
8	165.0	180.0	60.9	115.8	113.1	135.7	62.9	
9	171.2				117.2		67.6	45.0
13	163.5							
14	161.5	173.4	48.0	118.3	113.1	132.7	68.6	47.4
20	164.5							
24								
25								
29								
30								
39	169.9	182.4	52.6	119.7	120.3	137.6	69.8	48.4
44	167.7	179.1	47.6	121.2	113.8	134.3	66.7	45.6
45							66.7	
48	160.4	172.8	44.0	119.8	112.9	130.1	71.9	48.1
67	167.8	183.0	49.9	119.2	115.4	133.5	66.0	45.9
73	176.3	188.3	52.1	124.8	121.1	140.1	70.7	49.1
78		181.9		120.5			66.7	46.6
85	171.6	189.4	51.1	122.4	115.9	139.2	65.8	45.2
95								
103	165.5	179.6	45.7	121.0	113.3	133.3	69.4	48.3
113	169.6							
N	15.00	12.00	10.00	12.00	11.00	10.00	14.00	11.00
MAX	176.30	189.40	60.90	124.80	121.10	140.10	71.90	49.10
MIN	160.40	168.30	41.90	106.30	108.80	130.10	57.80	45.00
AVG	166.65	179.07	49.38	118.81	114.99	134.82	67.09	47.10
STDS	4.46	6.65	5.35	4.62	3.54	3.27	3.52	1.49
VARS	19.89	44.25	28.58	21.30	12.55	10.71	12.37	2.21

Table 3b. - Male mouflon: measurements of mandible

Animal code no.	9	10L	10B	11	12	13	14
1	20.0	20.5	7.7	45.2	57.0	51.6	79.8
2				41.9			
6		20.5	8.5	42.1			
8		22.4	8.8	45.3	66.0	57.9	89.7
9	23.4			45.1			
13				48.4			
14	20.4	21.2	7.4	42.2	60.7	56.8	88.0
20							
24				44.6			
25				46.9	66.5	59.9	92.7
29				43.3			
30				45.3			
39	22.0	21.4	8.2	42.6	61.7	55.1	88.3
44	20.9	23.0	9.8	45.0	61.5	55.7	90.9
45							
48	24.9	19.4	6.6	37.9	57.4	52.5	83.5
67	19.4	21.1	8.7				
73	23.1	23.6	9.7		66.1	58.2	89.3
78	20.6	21.8	8.6	46.8			
85	20.8	20.5	8.8	47.0	64.1	55.3	88.8
95							
103	21.0	21.9	8.7				
113							
N	11.00	12.00	12.00	16.00	9.00	9.00	9.00
MAX	24.90	23.60	9.80	48.40	66.50	59.90	92.70
MIN	19.40	19.40	6.60	37.90	57.00	51.60	79.80
AVG	21.50	21.44	8.46	44.35	62.33	55.89	87.89
STDS	1.67	1.18	0.90	2.59	3.62	2.67	3.92
VARS	2.78	1.40	0.81	6.73	13.08	7.15	15.40

Table 3c. - Male mouflon: measurements of mandible

Animal code no.	15a	15b	15c
1	32.4	19.6	17.7
2			
6	29.9		16.5
8	28.3		14.2
9	31.1	20.7	16.3
13			
14	32.9	20.0	17.8
20			
24			
25	32.3	22.4	20.2
29			
30			
39	32.7	19.9	15.8
44	33.7	22.3	18.2
45			
48	34.7	16.9	15.8
67	30.0	20.1	15.2
73	34.4		15.8
78	33.3	20.7	16.4
85	31.7	19.2	16.9
95			
103		19.8	17.8
113			
N	13.00	11.00	14.00
MAX	34.70	22.40	20.20
MIN	28.30	16.90	14.20
AVG	32.11	20.15	16.76
STDS	1.87	1.49	1.50
VARS	3.50	2.23	2.24

Table 4a. - Female mouflon: measurements of the mandible

Animal code no.	1	2	3	4	5	6	7	8
23							64.3	45.8
24								
34	167.8	171.9	47.2	120.8	110.0	135.5	65.8	48.7
42								
43	161.3	172.4	46.5	115.0	108.6	130.9	63.1	42.5
52	160.2	171.9	51.7	109.3	110.1	129.6	59.4	43.5
53								
55		174.7					65.2	45.0
56	164.2	174.0	47.3	116.0	111.5	112.1	65.8	46.3
59	149.6	160.8	42.8	108.8	108.1	123.9	66.5	46.7
61	162.8	175.8	48.3	110.8	112.9	130.6	65.8	43.9
68							66.3	46.9
75		165.1		114.7	104.4		66.9	47.4
86	167.7			112.0			64.1	43.9
118		169.5		108.0	112.0		59.2	40.0
121	155.7	168.5	48.4	108.5	106.8	126.0	60.2	42.5
150		167.2		109.8	107.2		64.2	43.7
N	8.00	11.00	7.00	11.00	10.00	7.00	14.00	14.00
MAX	167.80	175.80	51.70	120.80	112.90	135.50	66.90	48.70
MIN	149.60	160.80	42.80	108.00	104.40	112.10	59.20	40.00
AVG	161.16	170.16	47.46	112.15	109.16	126.94	64.06	44.77
STDS	6.13	4.51	2.66	4.02	2.64	7.53	2.64	2.34
VARS	37.60	20.34	7.05	16.15	6.96	56.63	6.97	5.49

Table 4b. - Female mouflon: measurements of the mandible

Animal code no.	9	10L	10B	11	12	13	14
23	19.4	22.6	8.5	45.3			
24				44.6	59.6	53.9	85.1
34	20.3	19.3	8.7	45.1	64.4	57.8	89.4
42				37.3			
43	20.5	20.6	9.1	42.9	56.4	50.9	79.6
52		20.0	8.9	44.3	57.0	50.8	82.8
53							
55	19.8	22.1	8.3	41.0			
56	20.7	19.9	7.7	42.5	61.7	54.4	84.6
59	20.5	18.3	7.9	37.9	54.9	48.5	75.5
61	21.8	23.6	9.6	40.0	56.4	51.8	83.1
68	19.3	20.7	7.5	40.0			
75	20.5	20.8		43.3	53.5	49.7	77.1
86	20.9	19.7	8.0	42.7			
118	20.5	21.6	9.6	40.4			
121	18.4	20.8	8.7	39.8			
150	20.8	21.0	8.5	38.9	59.0	54.6	85.3
N	14.00	14.00	13.00	16.00	9.00	9.00	9.00
MAX	21.80	23.60	9.60	45.30	64.40	57.80	89.40
MIN	0.00	18.30	7.50	37.30	53.50	48.50	75.50
AVG	18.81	20.79	8.54	41.63	58.10	52.49	82.50
STDS	5.48	1.38	0.66	2.56	3.43	2.91	4.38
VARS	30.00	1.90	0.44	6.56	11.76	8.48	19.21

Table 4c. - Female mouflon: measurements of the mandible

Animal code no.	15a	15b	15c
23	30.7	19.1	15.8
24			
34	33.9	14.0	17.4
42			
43	28.2	17.8	18.3
52	28.4	18.2	14.2
53			
55	29.6	18.9	15.5
56	31.7	17.8	14.5
59	31.0	17.0	12.7
61	27.4	19.3	16.7
68	30.9	17.1	13.6
75	31.4	18.0	15.0
86	29.7	17.7	15.8
118	28.0	16.6	14.0
121	26.6	15.3	13.2
150	29.8	18.0	14.6
N	14.00	14.00	14.00
MAX	33.90	19.30	18.30
MIN	26.60	14.00	12.70
AVG	29.81	17.49	15.09
STDS	1.97	1.45	1.61
VARS	3.87	2.10	2.58

Table 5. - Male mouflon:measurements of atlas

Animal code no.	Atlas				
	GB	GL	BFcr	BFcd	GLF
8	72.4	82.0	44.4	47.0	48.5
9	79.3	96.5	46.3	48.0	50.3
13					
14	69.6	90.0	42.8	44.4	49.5
25	73.5				
30					
38			44.5	45.8	49.2
44			45.0	44.2	50.2
45			44.0	45.0	50.0
48			43.3	43.6	46.0
50	76.8	99.0			
62			46.0	46.8	48.8
67			43.6	46.5	50.0
70	69.6	82.0	40.1	44.2	48.0
73	76.0	97.3	46.5	46.9	53.4
77	72.5	77.5			
103		86.9			
111					
119	71.3	78.8			
122				47.7	52.3
127	71.3	77.1			
N	10.00	10.00	11.00	12.00	12.00
MAX	79.30	99.00	46.50	48.00	53.40
MIN	69.60	77.10	40.10	43.60	46.00
AVG	73.23	86.71	44.23	45.84	49.68
STDS	3.20	8.52	1.84	1.51	1.92
VARS	10.26	72.67	3.37	2.28	3.67

Table 6. - Male mouflon: measurements of axis

Animal code no.	Axis							
	LCDe	LAPa	BFcr	BPacd	BPtr	SBV	BFcd	H
8								
9		59.1	47.2	38.4	43.7	28.0	26.5	62.2
13	60.9	49.5	45.3	40.7	45.8	23.2	29.0	63.2
14	58.0	48.0	43.0	35.3	42.4	27.2	24.4	58.0
25	58.9		47.5	34.4	43.6	23.0	29.1	
30								
38	59.4	53.4	44.0	32.4	41.3	25.7	26.0	58.9
44	60.7	57.4	44.0	39.6	43.3	27.4	28.2	60.7
45	59.1	45.5	44.4	36.1	42.2	22.7	27.2	57.6
48								
50								
62	58.0	53.1	45.3	37.3	40.8	26.6	27.2	55.2
67	59.7	50.6	45.3	35.0		27.4	30.2	59.6
70								
73	62.4	57.9	46.0	37.5	44.9	23.8	30.3	65.1
77								
103	57.5	52.8	46.0	36.6	44.3	22.4	29.1	
111								
119	58.8	56.8	44.1	37.0	42.6	21.6	27.5	57.9
122	64.8	58.1	46.5	37.0	44.1	28.8	25.6	61.2
127								
N	12.00	12.00	13.00	13.00	12.00	13.00	13.00	11.00
MAX	64.80	59.10	47.50	40.70	45.80	28.80	30.30	65.10
MIN	57.50	45.50	43.00	32.40	40.80	21.60	24.40	55.20
AVG	59.85	53.52	45.28	36.72	43.25	25.22	27.72	59.96
STDS	2.09	4.44	1.35	2.19	1.46	2.49	1.80	2.86
VARS	4.36	19.75	1.82	4.79	2.13	6.21	3.25	8.16

Table 7. Female mouflon: measurements of atlas

Animal code no.	Atlas				
	GB	GL	BFcr	BFcd	GLF
34	59.0	51.0	38.7	40.4	43.4
42	57.7	51.0	38.7	39.7	42.5
45	53.5	49.2	41.1	37.9	41.0
52	56.9	45.3		41.5	43.2
53		49.9	41.3	39.1	39.8
55	58.8		38.4	41.6	44.5
56		51.4	41.6	40.9	44.5
58	56.8	51.0	41.0	40.0	44.8
59	53.7	52.5	41.3	37.5	43.2
75		49.9	38.0		
61					
95					
118			40.1	37.8	41.5
124		47.0	41.0	37.8	41.5
		46.4			
N	7.00	11.00	11.00	11.00	11.00
MAX	59.00	52.50	41.60	41.60	44.80
MIN	53.50	45.30	38.00	37.50	39.80
AVG	56.63	49.51	40.11	39.47	42.72
STDS	2.23	2.31	1.38	1.55	1.62
VARS	4.99	5.33	1.90	2.40	2.61

Table 8. Female moution: measurements of Axis

Animal code no.	Axis							
	LCDe	LAPa	BFcr	BPacd	BPtr	SBV	BFcd	H
34	56.3	47.2	40.0	26.0	33.3	21.1	20.6	44.6
42	53.5	46.8	39.7	28.5	34.0	19.6	20.0	
45	55.1							41.2
52	55.3	48.1	39.2	27.4	33.2	19.4	20.0	42.2
53					29.8			
55	54.0	51.2	39.3	29.0		20.5	21.0	44.4
56	54.4	50.3	38.0	24.1	30.5	19.7	18.3	44.9
58	56.2	48.0	38.3	27.2		19.4	19.2	
59	55.1	48.0	38.4	24.7	37.2	19.2	18.8	42.6
75	55.2	50.4	39.2	24.9		21.8	18.5	
61	53.3	55.6	40.7	23.2	21.0	21.9	21.6	46.8
95								
118	51.7	53.2		26.0		18.2	18.2	48.4
124								42.2
N	11.00	10.00	9.00	10.00	7.00	10.00	10.00	9.00
MAX	56.30	55.60	40.70	29.00	37.20	21.90	21.60	48.40
MIN	51.70	46.80	38.00	23.20	21.00	18.20	18.20	41.20
AVG	54.55	49.88	39.20	26.10	31.29	20.08	19.62	44.14
STDS	1.36	2.84	0.87	1.91	5.14	1.21	1.20	2.36
VARS	1.85	8.09	0.76	3.66	26.45	1.46	1.44	5.58

Table 9. - Male mouflon: measurements of sacrum

Animal code no.	BFcr	HFcr	GL	PL	GB
8	44.4		82.0	74.9	72.4
9	46.3	13.9	96.5	89.0	79.3
13		13.6	83.1	77.8	73.8
14	42.8	13.0	90.0	85.1	69.6
25		14.8			73.5
38	44.5		95.8	92.3	72.1
44	45.0				
45	44.0				
48	43.3				
50		15.0	99.0	93.0	76.8
62	46.0				
67	43.6				
70	40.1	12.5	82.0	73.5	69.6
73	46.5	13.3	97.3	91.0	76.0
77		12.7	77.5	73.6	72.5
103		12.9	86.9	82.0	
119			78.8	72.0	71.3
127		12.5	77.1	72.0	71.3
N	11.00	10.00	12.00	12.00	12.00
MAX	46.50	15.00	99.00	93.00	79.30
MIN	40.10	12.50	77.10	72.00	69.60
AVG	44.23	13.42	87.17	81.35	73.18
STDS	1.84	0.90	8.24	8.38	2.92
VARS	3.37	0.82	67.92	70.23	8.54

Table 10. - Female mouflon: measurements of sacrum

Animal code no.	BFcr	HFcr	GL	PL	GB
42	25.3	12.1			70.7
52		11.7	73.8	72.6	77.2
53	25.7	10.0	70.9	67.5	
55	27.1	11.5	78.0	75.8	72.6
56	17.6	11.1	76.8	72.7	74.6
58			86.5	83.3	73.0
59	27.0	10.7	75.8	72.5	69.5
61		12.9	75.8	87.3	76.2
75			97.5	92.7	71.6
86	27.1	12.4	85.0	83.6	72.3
95	24.9	9.2	78.7	71.6	67.0
118			88.0	83.7	69.9
N	7.00	9.00	11.00	11.00	11.00
MAX	27.10	12.90	97.50	92.70	77.20
MIN	17.60	9.20	70.90	67.50	67.00
AVG	24.96	11.29	80.62	78.48	72.24
STDS	3.37	1.18	7.78	7.97	3.00
VARS	11.36	1.39	60.58	63.55	8.98

Table 11a. - Male mouflon: measurements of vertebrae C3.

Animal code No.	BPacr	BPacd	GLPa	BPtr	H
9				56.1	
13	40.3	41.9	48.9		48.0
14					
25	38.5	37.2	48.6	61.8	50.0
38	36.9	35.0	47.9	56.0	44.5
44					
45	37.7	39.5	47.7		47.8
62	36.9	37.5	47.0	49.9	45.0
73	41.4	43.1	50.9	65.5	50.8
111	36.8	36.8	48.6	63.1	48.2
119	38.0	38.4	47.8	64.6	46.6
122	40.2	38.0	49.9	62.6	49.0
127	39.2	41.6	51.7	60.8	49.1
N	10.00	10.00	10.00	9.00	10.00
MAX	41.40	43.10	51.70	65.50	50.80
MIN	36.80	35.00	47.00	49.90	44.50
AVG	38.59	38.90	48.90	60.04	47.90
STDS	1.63	2.58	1.50	5.06	2.03
VARS	2.65	6.65	2.25	25.61	4.14

Table 11b. - Male mouflon: measurements of vertebrae C4

Animal code no.	H	BPacr	BPacd	GLPa	BPtr
9					
13	49.2	43.3	44.2	47.2	67.4
14	48.0	38.2	37.2	44.0	61.1
25	51.8	40.8	38.2	48.1	63.0
38	40.0	37.8	36.2	47.5	61.6
44	49.8	39.8	38.1	46.4	61.3
45	49.4	41.5	41.7	48.5	59.9
62					
73	53.2	45.4	46.0	51.3	69.6
111					
119	46.2	38.5	38.7	44.5	65.0
122	53.1	39.9	42.2	47.3	65.0
127	54.4	42.5	43.0	48.1	65.0
N	10.00	10.00	10.00	10.00	10.00
MAX	54.40	45.40	46.00	51.30	69.60
MIN	40.00	37.80	36.20	44.00	59.90
AVG	49.51	40.77	40.55	47.29	63.89
STDS	4.21	2.44	3.30	2.06	3.07
VARS	17.73	5.96	10.91	4.26	9.45

Table 11c. - Male mouflon: measurements of vertebrae C5.

Animal code no.	H	BPacr	BPacd	GLPa	BPtr
8					
13	54.4	45.3	49.2	46.8	56.4
14	53.1	40.6	41.6	44.3	47.6
25	54.5	43.1	43.7	44.0	53.4
38	51.3	41.0	41.2	45.0	53.8
39					
44	52.2	40.6	45.4	45.0	55.3
45	53.0	44.2	41.1	45.8	52.5
62					
73	60.6	46.9	41.1	48.1	
117					
119	52.4	40.1	40.9	42.2	58.0
122	59.9	43.0	45.1	46.5	58.3
127	59.5	43.4	46.3	46.8	54.8
N	10.00	10.00	10.00	10.00	9.00
MAX	60.60	46.90	49.20	48.10	58.30
MIN	51.30	40.10	40.90	42.20	47.60
AVG	55.09	42.82	43.56	45.45	54.46
STDS	3.53	2.25	2.86	1.71	3.25
VARS	12.45	5.08	8.19	2.92	10.54

Table 11d. - Male mouflon: measurements of vertebrae C6.

Animal code no.	BPacr	BPacd	GLPa	BPtr	H
9	47.0	44.6	41.5		
13	50.5	45.5	40.2	52.1	65.6
14	43.0	41.6	38.2	53.1	66.0
25	46.0	45.1	41.0	54.0	66.2
38	44.6	44.6	44.3		61.5
44	42.4	38.8	38.4	49.2	60.8
45	46.9	45.1	42.2	51.7	65.4
62	45.5	45.2	43.5	55.0	63.6
73	42.3	39.0	38.1	49.3	61.1
111	49.7	43.5	42.0	58.0	71.5
119	48.0	46.0	47.0		
122	42.2	40.3	38.6	49.4	62.5
127	46.7	43.3	41.6	54.0	
127	48.4	44.2	40.8	46.8	72.2
N	13.00	13.00	13.00	11.00	11.00
MAX	50.50	46.00	47.00	58.00	72.20
MIN	42.20	38.80	38.10	46.80	60.80
AVG	45.86	43.25	41.22	52.05	65.13
STDS	2.84	2.51	2.66	3.21	3.88
VARS	8.09	6.28	7.06	10.32	15.02

Table 11e. - Male mouflon: measurements of vertebrae C7.

Animal code no.	BPacr	BPacd	GLPa	BPtr	H
9	47.6	37.7	42.2	54.0	82.4
13	43.7	35.6	37.7	52.2	71.7
14	48.0	39.4	40.4	58.4	
25		38.1	41.0	51.8	74.7
38	47.7	38.3	44.2	53.4	78.3
44		36.9	43.1	55.3	
45	48.0	39.4	44.4	55.4	88.5
62	42.2	36.3	37.1	49.9	74.4
73	45.0	36.6	41.0	56.0	85.6
111	45.7	37.6	38.8		85.1
119		41.3	40.8	55.3	
122					
127					
N	7.00	10.00	10.00	9.00	7.00
MAX	48.00	41.30	44.40	58.40	88.50
MIN	42.20	35.60	37.10	49.90	71.70
AVG	45.76	37.95	40.85	54.19	79.76
STDS	2.28	1.73	2.52	2.59	6.59
VARS	5.22	2.98	6.37	6.70	43.41

Table 12a. - Female mouflon: measurements of vertebrae C3 and C4.

Animal code no.	C3 BPacr	C3 BPacd	C3 GLPa	C3 BPtr	C4 BPacr	C4 BPacd	C4 GLPa	C4 BPtr
34	27.2	30.5	46.0	39.9	31.0	29.9	42.8	42.2
42	28.0		44.1		29.7	30.5	42.6	
52	28.4	29.6	49.2	37.1	30.5	30.5	47.0	40.7
55	29.3	31.0	48.6	38.2	32.0	31.1	43.4	42.5
56	28.8	30.2	49.0	39.7	31.0	30.5	45.6	41.6
59	22.1	27.3	44.7	36.8	27.1	27.5	41.8	39.0
61	29.6	30.0	50.5	43.4	31.6	34.2	51.3	
92	27.5	26.7	42.4	37.7				
118	27.2	29.5	49.0		29.0	28.6	40.6	
129	25.9	28.5	43.0		31.2	30.4	45.8	41.8
N	10.00	9.00	10.00	7.00	9.00	9.00	9.00	6.00
MAX	29.60	31.00	50.50	43.40	32.00	34.20	51.30	42.50
MIN	22.10	26.70	42.40	36.80	27.10	27.50	40.60	39.00
AVG	27.40	29.26	46.65	38.97	30.34	30.36	44.54	41.30
STDS	2.17	1.46	2.95	2.29	1.53	1.83	3.27	1.28
VARS	4.69	2.14	8.70	5.24	2.34	3.36	10.70	1.65

Table 12b. - Female mouflon: measurements of vertebra C5

Animal code no.	BPacr	BPacd	GLPa	BPtr	H
34	31.0	33.2	39.2	42.8	33.5
42	31.4		39.1		
52	32.0	32.7	41.5	39.4	
55	31.6	33.0	38.7		33.2
56	30.6	33.2	41.3		36.1
58					
59	28.3	30.0	38.5	37.2	36.6
61	35.5	38.3	49.0	43.6	39.4
87					
92					
118	32.7	34.0	45.6		30.8
?	32.0	33.3	41.0		34.5
N	9.00	8.00	9.00	4.00	7.00
MAX	35.50	38.30	49.00	43.60	39.40
MIN	28.30	30.00	38.50	37.20	30.80
AVG	31.68	33.46	41.54	40.75	34.87
STDS	1.90	2.29	3.56	2.99	2.78
VARS	3.62	5.23	12.65	8.92	7.73

Table 12c. - Female mouflon: measurements of vertebra C6

Animal code no.	BPacr	BPacd	GLPa	BPtr	H
34	34.0	33.0	36.0	42.7	43.9
42	32.5		36.4		
52	33.6	34.8	37.4	42.9	42.4
55	33.6	33.4	36.1	40.3	43.1
56					
58	34.3	35.3	37.7		38.6
59	30.7	32.1	35.8	38.9	42.7
61	39.8	36.6	42.4		45.8
87	32.5	32.4	35.4		
92	31.6	31.4	33.2	41.5	38.0
118	35.0	36.0	38.1	42.4	41.1
N	8.00	8.00	8.00	5.00	7.00
MAX	39.80	36.60	42.40	42.90	45.80
MIN	30.70	31.40	33.20	38.90	38.00
AVG	33.89	34.00	37.01	41.20	41.67
STDS	2.77	1.94	2.68	1.62	2.71
VARS	7.69	3.77	7.18	2.63	7.32

Table 12d. - Female mouflon: measurements of vertebra C7

Animal code no.	BPacr	BPacd	GLPa	BPtr	H
34	33.9	30.0	33.2	44.7	53.3
42	33.6		33.7		
52	35.0	30.4	33.4	45.0	50.9
55	33.8	30.2	35.1	43.1	52.5
56	34.5	30.4	34.7	43.7	
58	32.8	28.5	32.7	44.0	48.2
59	33.9	29.9	32.7		
61	32.0	28.1	31.8	41.7	50.0
87	35.3	30.8	34.4		
92	35.1	28.1	32.0		
118					
N	8.00	9.00	8.00	5.00	4.00
MAX	35.30	30.80	35.10	45.00	52.50
MIN	32.00	0.00	31.80	41.70	48.20
AVG	34.05	26.27	33.35	43.50	50.40
STDS	1.17	9.91	1.26	1.22	1.79
VARS	1.37	98.13	1.58	1.48	3.22

Table 13a.-Male mouflon: measurements of vertebrae T1. and T2.

Animal code no.	T1 PL	T1 BPtr	T1 H	T2 PL	T2 BPtr	T2 H
8	21.8	48.5		21.6	44.9	89.4
9						
13						
14	21.7	49.3	89.6	21.4		84.1
25	21.7	54.1		22.2	50.2	
38	20.7	51.3		20.5	46.2	92.2
44	23.1	48.4	94.6	23.0	45.0	93.6
45	22.2	49.5				
50	23.5	53.0				
73	22.2	56.6	97.3	21.4	49.5	103.4
111	22.5	54.2	94.5	22.6	47.8	90.1
119	22.8	50.2		22.2	45.7	
122	23.1	52.0	93.8	24.0	46.3	92.5
127	22.0	50.2		21.9	47.0	
M	12.00	12.00	5.00	10.00	9.00	7.00
MAX	23.50	56.60	97.30	24.00	50.20	103.40
MIN	20.70	48.40	89.60	20.50	44.90	84.10
AVG	22.28	51.44	93.96	22.08	46.96	92.19
STDS	0.78	2.58	2.78	0.97	1.88	5.85
VARS	0.60	6.67	7.72	0.95	3.54	34.22

Table 13b.-Male mouflon: measurements of vertebrae T3. and T4.

Animal code no.	T3 PL	T3 BPtr	T3 H	T4 PL	T4 BPtr	T4 H
8				21.7	43.5	85.8
9						
13						
14	22.0	44.2	82.0	22.2	42.2	77.5
25	21.5	45.3				
38						
44	22.7	45.4	97.9	22.7	43.0	88.5
45						
50						
73						
111	23.2	44.6				
119			95.0	24.6	42.8	93.5
122	23.8	41.8				
127						
M	5.00	5.00	3.00	4.00	4.00	4.00
MAX	23.80	45.40	97.90	24.60	43.50	93.50
MIN	21.50	41.80	82.00	21.70	42.20	77.50
AVG	22.64	44.26	91.63	22.80	42.88	86.33
STDS	0.92	1.46	8.47	1.27	0.54	6.69
VARS	0.84	2.14	71.70	1.61	0.29	44.79

Table 13c.-Male mouflon: measurements of vertebrae T5, and T6.

Animal code no.	T5 PL	T5 BPtr	T5 H	T6 PL	T6 BPtr	T6 H
8	21.0	41.8	87.5	20.6	40.0	77.3
9						
13						
14	21.3	40.7	73.0	21.1	37.8	74.3
38						
44	22.0	40.2	85.0	21.6	38.1	83.1
45						
50						
73				20.8	38.8	83.1
111		40.9	84.0	19.9	39.7	87.3
119				21.9	39.1	73.5
122	23.4	41.1	90.6	23.0	40.0	83.0
127				20.8	39.0	
N	4.00	5.00	5.00	8.00	8.00	7.00
MAX	23.40	41.80	90.60	23.00	40.00	87.30
MIN	21.00	40.20	73.00	19.90	37.80	73.50
AVG	21.93	40.94	84.02	21.21	39.06	80.23
STDS	1.07	0.59	6.67	0.95	0.82	5.21
VARS	1.14	0.34	44.45	0.90	0.68	27.20

Table 13d.-Male mouflon: measurements of vertebrae T7, and T8.

Animal code no.	T7 PL	T7 BPtr	T7 H	T8 PL	T8 BPtr	T8 H
8	21.0	38.9	74.5	21.2	41.0	71.0
9						
13	20.8	42.5	82.7	21.7	41.6	75.0
14	21.2	37.6	70.6	22.0	38.6	65.1
38		39.1			39.1	
44	21.8	40.5	76.2	22.3	42.7	75.0
45						
50						
73	20.0	40.1	90.2	20.1	41.7	69.8
111	18.0	40.4	71.9	17.7	43.0	75.8
119	21.3	38.6	68.5	22.0	38.6	66.0
122	23.6	42.1	79.0	24.2	44.0	71.0
127	20.6	39.3		21.2	40.8	69.0
N	9.00	10.00	8.00	9.00	10.00	9.00
MAX	23.60	42.50	90.20	24.20	44.00	75.80
MIN	18.00	37.60	68.50	17.70	38.60	65.10
AVG	20.92	39.91	76.70	21.38	41.11	70.86
STDS	1.49	1.54	7.13	1.76	1.88	3.87
VARS	2.21	2.36	50.87	3.11	3.53	15.01

Table 13e.-Male mouflon: measurements of vertebrae T9. and T10.

Animal code no.	T9			T10		
	PL	BPtr	H	PL	BPtr	H
8	21.1	42	65.9	22.6	41.6	64
9						
13	22.7	41.8	68.3	23.4	42.8	65.6
14	22.6	38.5	62.7	23.2	39.5	60.4
38	18.9	41.1		20.6	41.3	
44	22.8	43.6	69.6	23.8	43.9	66.9
45						
50						
73	21.3	42	67.2	23.1	42.7	67.5
111	19.9	43.1	65.7	22	41.7	64.5
119	22.9	41.2	64	23.4	41.4	62
122	24.4	45.7	70	25.1	44.7	68.1
127	22.7	41.9	67.8	23.4	41.7	64.6
N	10.00	10.00	9.00	10.00	10.00	9.00
MAX	24.40	45.70	70.00	25.10	44.70	68.10
MIN	18.90	38.50	62.70	20.60	39.50	60.40
AVG	21.93	42.09	66.80	23.06	42.13	64.84
STDS	1.63	1.86	2.45	1.18	1.46	2.53
VARS	2.65	3.46	6.02	1.38	2.14	6.40

Table 13f.-Male mouflon: measurements of vertebrae T11. and T12.

Animal code no.	T11 PL	T11 BPtr	T11 H	T12 PL	T12 BPtr	T12 H
8	28.7	38.8	61.5	26.0	42.7	58.2
9						
13	24.2	41.0	64.8	26.4	44.5	60.9
14	23.8	37.1	58.4			
38		40.1			41.6	
44	23.5	41.0	65.1			
45				20.7	41.7	59.8
50				25.7	41.2	62.0
73	24.6	40.5	66.9	25.9	42.7	62.8
111	23.8	39.4	62.1	25.5	41.3	59.7
119	24.5	38.6	60.7		40.3	58.0
122	26.0	43.7	67.0	27.7	44.5	63.6
127	23.9	39.0	62.0	25.4	42.3	60.0
N	9.00	10.00	9.00	8.00	10.00	9.00
MAX	28.70	43.70	67.00	27.70	44.50	63.60
MIN	23.50	37.10	58.40	20.70	40.30	58.00
AVG	24.78	39.92	63.17	25.41	42.28	60.56
STDS	1.64	1.80	2.94	2.04	1.38	1.94
VARS	2.70	3.23	8.64	4.16	1.90	3.78

Table 13g.-Male mouflon: measurements of vertebrae T13.

Animal code no.	T13 PL	T13 BPtr	T13 H
8			
9	28.6		60.2
13	28.3	47.2	59.0
14	27.4	45.6	54.2
38	28.2	45.3	59.5
44	27.7	44.6	56.1
45			
50			
73	28.0	46.5	60.0
111	28.0	48.0	60.7
119		48.0	57.0
122	27.6	47.7	56.6
127	30.3	52.6	61.6
	27.7	46.0	55.9
N	10.00	10.00	11.00
MAX	30.30	52.60	61.60
MIN	27.40	44.60	54.20
AVG	28.18	47.15	58.25
STDS	0.83	2.25	2.39
VARS	0.68	5.06	5.70

Table 14a.-Female mouflon: measurements of vertebrae T1 and T2.

Animal code no.	T1			T2		
	PL	BPtr	H	PL	BPtr	H
34	20.6	45.4	62.5			
42	20.9	44.1				
52	21.5	44.4		20.6	41.6	63.5
53	19.3	40.9	54.6			
55	21.8	43.6				
56	20.8	41.5	57.8	20.5	41.4	66.0
58	21.3	44.8		20.5	39.8	
59	20.4	42.3				
61						
92	20.3	42.3	58.2	19.3	37.2	68.8
118						
N	9.00	9.00	4.00	4.00	4.00	3.00
MAX	21.80	45.40	62.50	20.60	41.60	68.80
MIN	19.30	40.90	54.60	19.30	37.20	63.50
AVG	20.77	43.26	58.28	20.23	40.00	66.10
STDS	0.74	1.56	3.24	0.62	2.03	2.65
VARS	0.56	2.45	10.53	0.38	4.13	7.03

Table 14b.-Female mouflon: measurements of vertebrae T3 and T4.

Animal code no.	T3			T4		
	PL	BPtr	H	PL	BPtr	H
34				20.6		
42						
52	21.0	40.3	54.0		39.0	59.0
53						
55				20.9		
56						
58	20.5	39.0			38.3	
59						
61						
92	19.6	38.1	65.7	19.5	36.2	59.2
118						
N	3.00	3.00	2.00	3.00	3.00	2.00
MAX	21.00	40.30	65.70	20.90	39.00	59.20
MIN	19.60	38.10	54.00	19.50	36.20	59.00
AVG	20.37	39.13	59.85	20.33	37.83	59.10
STDS	0.71	1.11	8.27	0.74	1.46	-0.14
VARS	0.50	1.22	68.45	0.54	2.12	0.02

Table 14c.-Female mouflon: measurements of vertebrae T5 and T6.

Animal code no.	T5 PL	T5 BPtr	T5 H	T6 PL	T6 BPtr	T6 H
34	19.9	37.8	59.3	18.8	35.6	56.6
42						
52	20.0	38.8	65.9	20.0	36.2	54.5
53						
55						
56						
58		36.1			35.1	
59						
61				19.6	36.2	54.2
92	18.7	35.3	50.0	18.0	38.8	54.6
118						
N	3.00	4.00	3.00	4.00	5.00	4.00
MAX	20.00	38.80	65.90	20.00	38.80	56.60
MIN	18.70	35.30	50.00	18.00	35.10	54.20
AVG	19.53	37.00	58.40	19.10	36.38	54.98
STDS	0.72	1.59	7.99	0.89	1.43	1.10
VARS	0.52	2.53	63.81	0.79	2.04	1.20

Table 14d.-Female mouflon: measurements of vertebrae T7 and T8.

Animal code no.	T7 PL	T7 BPtr	T7 H	T8 PL	T8 BPtr	T8 H
34	19.0	37.0	54.2	20.3	39.4	60.4
42						
52	19.6	37.4	60.6	20.5	37.6	57.9
53						
55						
56				20.5	38.1	57.2
58		36.4			37.6	57.2
59						
61	19.7	38.1	62.0	21.8	37.9	58.2
92	18.5	34.2	54.3	19.1	34.9	49.0
118						
N	4.00	5.00	4.00	5.00	6.00	6.00
MAX	19.70	38.10	62.00	21.80	39.40	60.40
MIN	18.50	34.20	54.20	19.10	34.90	49.00
AVG	19.20	36.62	57.78	20.44	37.58	56.65
STDS	0.56	1.49	4.11	0.96	1.47	3.93
VARS	0.31	2.21	16.90	0.92	2.17	15.43

Table 14e.-Female mouflon: measurements of vertebrae T9 and T10.

Animal code no.	T9 PL	T9 BPtr	T9 H	T10 PL	T10 BPtr	T10 H
34	20.0	37.5	52.0	21.0	36.6	53.2
42						
52	21.2	39.0	54.6	21.6	39.0	53.6
53						
55						
56	21.3	38.9	54.8	22.3	39.4	52.7
58	19.3	37.0	54.9	22.0	38.6	52.0
59			55.8			
61	21.1	38.9		22.5	38.8	55.2
92				20.5	35.7	48.4
118				22.3	37.7	51.3
N	5.00	5.00	5.00	7.00	7.00	7.00
MAX	21.30	39.00	55.80	22.50	39.40	55.20
MIN	19.30	37.00	52.00	20.50	35.70	48.40
AVG	20.58	38.26	54.42	21.65	38.02	52.52
STDS	0.89	0.94	1.43	0.75	1.37	2.14
VARS	0.79	0.88	2.04	0.56	1.88	4.56

Table 14f.-Female mouflon: measurements of vertebrae T11 and T12.

Animal code no.	T11 PL	T11 BPtr	T11 H	T12 PL	T12 BPtr	T12 H
34	22.1	33.6	50.6	23.7	36.8	49.3
42						
52	22.8	35.4	52.0	24.5	38.2	48.2
53						
55	23.2			24.6	38.0	49.6
56	23.5	36.8	53.1	25.0	40.6	51.3
58	23.2	36.9	52.2	25.0		49.2
59	22.1	36.4	50.2			
61	23.3	37.0	54.6	20.8	35.1	51.0
92	21.3	35.0	47.5	22.8	34.8	45.9
118	22.0	36.0		23.7	38.8	
N	9.00	8.00	7.00	8.00	7.00	7.00
MAX	23.50	37.00	54.60	25.00	40.60	51.30
MIN	21.30	33.60	47.50	20.80	34.80	45.90
AVG	22.69	35.87	51.46	23.77	37.25	49.21
STDS	0.76	1.17	2.29	1.42	2.06	1.81
VARS	0.58	1.38	5.23	2.00	4.26	3.28

Table 14g.-Female mouflon: measurements of vertebrae T13.

Animal code no.	T13 PL	T13 BPtr	T13 H
34	25.9	39.8	48.1
42			
52	26.3	41.2	46.5
53			
55	26.9		
56	27.4	44.2	49.0
58			
59	27.6	48.4	49.6
61	24.9	42.2	45.7
92	25.8		
118			
N	7.00	5.00	5.00
MAX	27.60	48.40	49.60
MIN	24.90	39.80	45.70
AVG	26.40	43.16	47.78
STDS	0.96	3.34	1.65
VARS	0.93	11.15	2.72

Table 15a.-Male mouflon: measurements of vertebrae L1. L2.

Animal code no.	L1			L2		
	PL	BPtr	H	PL	BPtr	H
8	29.6		56.3	30.4		45.8
9	30.2		57.7	30.6		54.4
13	29.6	80.3	58.0	30.3	108.4	57.9
14	28.5		53.8	29.6		54.2
25	30.0			30.6		
30						
38	28.5		53.8	29.6		54.2
44	29.9	77.2	50.0	31.0	103.0	57.3
62	28.1					
73	29.5	74.0	57.9	30.9		57.5
79	29.7		55.7	31.3		56.6
111	29.7	74.6	56.2	31.0	103.0	56.0
119	29.8	76.0	55.0	30.6		54.4
122	31.6	84.8	52.0	31.8	105.8	60.1
127	29.1	78.1	54.6	31.0	98.0	54.2
128	30.0	73.7	55.0	30.9		54.4
N	15.00	8.00	13.00	14.00	5.00	13.00
MAX	31.60	84.80	58.00	31.80	108.40	60.10
MIN	29.60	0.00	56.30	30.40	0.00	45.80
AVG	29.59	77.34	55.08	30.69	103.64	55.15
STDS	0.83	3.76	2.33	0.60	3.87	3.38
VARS	0.70	14.10	5.44	0.36	14.99	11.40

Table 15b.-Male mouflon: measurements of vertebrae L3. L4.

Animal code no.	L3			L4		
	PL	BPtr	H	PL	BPtr	H
8	30.5		53.1	31.4		52.4
9	30.4		53.7	30.8		30.1
13	30.6	109.6	57.1	31.5	106.0	55.7
14	30.1			30.5		
25	31.4		56.3	31.8		55.7
30						
38	30.1			30.5		
44	31.1	106.0	55.9	31.0	105.6	54.8
62	30.6		52.2	30.5		51.6
73	31.3		56.6	32.2	102.7	56.0
79	32.1	102.4	56.1	32.1	102.2	54.0
111	31.0	105.0	54.0	31.6	101.2	52.3
119	30.4		53.7	30.8		53.1
122	32.5		58.6	33.1		57.8
127	31.4	97.8	52.8	31.2	98.7	54.1
128	31.2		53.6	31.3		52.7
N	15.00	5.00	13.00	15.00	6.00	13.00
MAX	32.50	109.60	58.60	33.10	106.00	57.80
MIN	30.50	0.00	53.10	31.40	0.00	52.40
AVG	30.98	104.16	54.90	31.35	102.73	52.33
STDS	0.70	4.39	1.96	0.73	2.75	6.91
VARS	0.49	19.31	3.84	0.54	7.56	47.80

Table 15c.-Male mouflon: measurements of vertebrae L5. L6.

Animal code no.	L5			L6		
	PL	BPtr	H	PL	BPtr	H
8	31.8		52.3	27.1		
9	31.8		53.8	28.5		52.1
13				22.6	87.6	51.0
14	30.8	99.6	51.5	27.4	83.1	48.1
25	32.6		54.6	29.7		52.8
30				28.3		51.0
38						
44	31.3			29.0		
62	32.2	106.2	51.4	27.4		49.4
73	31.4		50.5	28.3	84.6	48.2
79	32.7		54.5	28.4	89.8	50.4
111	32.0	98.7	52.2	26.8	79.0	49.7
119	32.3	99.0	51.0	27.7	81.0	48.2
122	31.5		51.4	27.8		49.2
127	31.9	97.6	53.5	27.3		50.0
128	32.0		51.7	28.6		48.8
N	13.00	5.00	12.00	15.00	6.00	13.00
MAX	32.70	106.20	54.60	29.70	89.80	52.80
MIN	31.80	0.00	52.30	27.10	0.00	0.00
AVG	31.87	100.22	52.37	27.66	84.18	49.92
STDS	0.53	3.42	1.39	1.60	4.04	1.50
VARS	0.28	11.70	1.94	2.56	16.31	2.24

Table 16a.-Female mouflon: measurements of vertebrae L1, L2.

Animal code no.	L1			L2		
	PL	BPtr	H	PL	BPtr	H
34	27.7	62.2	47.5	28.8	84.9	46.9
42	26.6		48.9	27.3		46.4
52	28.0	66.2	45.2	28.8	91.9	46.6
55	27.7		47.5	28.6		47.4
56	28.3	67.4	48.7	29.1	96.4	48.6
58	28.5		47.1	29.3		47.0
59	26.4		42.6	27.0		46.0
61	28.8		49.9	28.3		50.0
86	27.2		46.7	28.2		
92	25.7	69.8	45.5	26.0	85.7	45.1
95				28.0	86.0	44.7
N	10.00	4.00	10.00	11.00	5.00	10.00
MAX	28.80	69.80	49.90	29.30	96.40	50.00
MIN	25.70	62.20	42.60	26.00	84.90	44.70
AVG	27.49	66.40	46.96	28.13	88.98	46.87
STDS	1.00	3.17	2.12	1.00	5.00	1.56
VARS	1.00	10.08	4.48	1.00	24.97	2.44

Table 16b.-Female mouflon: measurements of vertebrae L3, L4.

Animal code no.	L3			L4		
	PL	BPtr	H	PL	BPtr	H
34	28.6	88.9	45.7	28.7		45.8
42	27.7		48.0	28.0		46.7
52	29.1	97.1	44.4	29.5		
55	29.5		47.7	29.7	87.8	46.4
56	28.9		47.8	29.7		47.2
58	29.7		47.6	30.2		45.7
59	27.7	89.0	43.6	28.0		44.2
61	29.0	92.7	48.7	30.0		49.4
86	28.4			29.2		
92	26.8	88.7	45.1	27.1	89.0	42.5
95	28.1		44.9	29.0		44.1
N	11.00	5.00	10.00	11.00	2.00	9.00
MAX	29.70	97.10	48.70	30.20	89.00	49.40
MIN	26.80	88.70	43.60	27.10	87.80	42.50
AVG	28.50	91.28	46.35	29.01	88.40	45.78
STDS	0.87	3.65	1.80	0.97	0.85	2.01
VARS	0.76	13.35	3.24	0.94	0.72	4.05

Table 16c.-Female mouflon: measurements of vertebrae L5. L6.

Animal code no.	L5			L6		
	PL	BPtr	H	PL	BPtr	H
34	29.6	86.4		26.2		
42	28.8		46.0	25.4		43.7
52	31.0			26.6	82.3	
55	30.1		44.8	26.0		42.4
56	30.0	97.4	46.4	26.0	85.2	44.4
58	28.5		42.7			
59	29.2	92.9		26.7	80.7	
61	29.7		43.8			
86	26.9	87.0	42.0	22.7	70.0	39.0
92	29.0		42.2	23.8	72.0	38.0
95						
N	10.00	4.00	7.00	8.00	5.00	5.00
MAX	31.00	97.40	46.40	26.70	85.20	44.40
MIN	26.90	86.40	42.00	22.70	70.00	38.00
AVG	29.28	90.93	43.99	25.43	78.04	41.50
STDS	1.11	5.22	1.80	1.43	6.66	2.85
VARS	1.22	27.24	3.23	2.05	44.40	8.14

Table 17.-Male mouflon: measurements of scapula

Animal code no.	HS	DHA	LD	SLC	GLP	LG	BG
8R	161.6	171.0	97.0	19.9	43.4	27.0	22.3
9L	150.0	158.0	87.0	17.9	31.2	24.0	21.1
13R	164.0	175.0	106.0	20.5	35.0	27.2	23.0
14R	153.0	165.0	99.0	19.6	30.0	24.8	21.3
25R				21.2	33.2	25.4	22.8
37R	156.0			19.5	32.4	25.8	21.7
44R	135.5	167.0	103.0	20.0	33.0	25.4	23.1
53R	157.0	167.0		19.0	32.6	25.6	22.3
62R		162.0		19.2	32.1	25.0	22.3
73R	168.0	175.5		20.7	35.5	27.3	23.7
77R	156.0	167.0	96.0	17.6	30.4	24.0	21.1
79L	159.0	169.0	104.0	20.3	33.2	26.4	21.8
111R	154.0	164.0	97.0	20.2	34.1	21.5	22.6
116R	154.0	162.0	100.0	19.0	31.7	25.0	21.7
122R	164.0	175.0	103.0	20.0	35.3	26.8	23.9
127R	160.0	170.0	97.0	20.0	33.7	25.5	23.1
128R	158.0	169.0		19.6	33.6	25.8	21.5
157R	154.0			19.2	32.2	26.0	22.6
N	16.00	15.00	11.00	18.00	18.00	18.00	18.00
MAX	168.00	175.50	106.00	21.20	43.40	27.30	23.90
MIN	135.50	158.00	87.00	17.60	30.00	21.50	21.10
AVG	156.51	167.77	99.00	19.63	33.48	25.47	22.33
STDS	7.33	5.13	5.22	0.90	2.91	1.39	0.85
VARS	53.77	26.32	27.20	0.82	8.49	1.93	0.72

Table 18.-Female mouflon: measurements of scapula

Animal code no.	HS	DHA	LD	SLC	GLP	LG	BG
23L	144.4	159.0	90.0	17.8	31.6	24.6	20.6
26R	142.0	157.0		16.7	29.5	23.3	19.5
34R	143.0	155.0	97.0	17.2	29.3	21.8	19.0
43?	143.0	153.0	88.0	18.2	32.2	24.2	20.6
45L	157.0	168.0		19.1	38.7	27.0	25.7
43R	144.0	154.0	89.0	18.3	31.1	23.0	20.8
48R				18.5	30.5	24.4	21.0
52R	144.0	154.0	89.0	17.3	32.2	25.0	22.5
55R				17.0	31.2	22.6	20.3
56R		157.0		17.0	30.6	22.7	20.6
58R				16.5	30.1	19.3	20.2
59L		150.0	88.0	16.8	28.8	23.0	18.4
61R	144.0	155.0		17.3	31.1	22.3	22.3
74L	142.0	154.0	87.0	17.1			
75L				20.5	32.6	25.2	21.8
81L	140.0	156.0		16.4	29.4	22.6	18.9
92?	136.0	146.0	80.0	16.5	29.0	22.3	20.0
95R				16.4	28.0	20.9	19.1
150R	136.0	145.0	85.0	16.6	28.7	23.3	20.8
N	12.00	14.00	9.00	19.00	18.00	18.00	18.00
MAX	157.00	168.00	97.00	20.50	38.70	27.00	25.70
MIN	136.00	145.00	80.00	16.40	28.00	19.30	18.40
AVG	142.95	154.50	88.11	17.43	30.81	23.19	20.67
STDS	5.31	5.57	4.48	1.08	2.38	1.74	1.69
VARS	28.18	31.04	20.11	1.16	5.68	3.01	2.85

Table 19. -Male mouflon: measurements of humerus

Animal code no.	GL	GLC	Bp	SD	BT
9L	160.4	145.1		16.0	29.1
13R	164.6	148.6	44.5	16.4	28.0
14R	161.3	145.0	19.4	16.1	23.0
25R	162.5	146.0		16.4	30.0
31R	150.6	137.2	37.1	13.0	22.0
37R	162.5	144.3		15.5	23.1
38L	158.9	143.1		16.3	28.9
39L	169.0	51.0	40.1	15.0	29.4
44R	164.4	146.8	39.4	15.6	29.0
44R	164.4	146.8	39.4	15.6	29.0
45R	159.6	142.6		16.2	28.6
48R	156.7	142.0		15.5	22.4
53R	168.7	155.5	42.6	16.3	29.0
52R	162.6	146.6	40.6	16.0	28.8
73R	170.1	153.0	43.2	17.7	29.9
77R	162.4	146.0	39.5	15.0	28.3
79L	166.5	150.5	40.3	16.5	29.4
95R	150.6	135.3	38.2	14.0	26.6
107L				14.8	23.3
111R	162.0	145.8	39.8	15.9	28.8
116R	155.4	141.5	37.9	15.4	28.4
157R		142.5		15.2	
N	20.00	21.00	14.00	22.00	21.00
MAX	170.10	155.50	44.50	17.70	30.00
MIN	150.60	51.00	19.40	13.00	22.00
AVG	161.66	140.72	38.71	15.65	27.38
STDS	5.36	21.06	5.92	0.96	2.75
VARS	28.78	443.67	35.08	0.92	7.54

Table 20. -Female mouflon: measurements of humerus

Animal code no.	GL	GLC	Bp	SD	BT
23L	153.4	139.4	37.5	14.4	22.0
34R	147.5	133.5	36.0	14.6	21.4
55R	148.4	134.2	35.1	14.0	25.8
56L	151.0	136.0	37.5	13.9	26.5
58R				13.5	26.5
59R	144.4	129.8	31.0	13.0	21.0
61R	151.5	137.5		14.4	27.6
74L				13.3	26.1
92R	140.9	128.4	35.1	14.0	25.4
95L	143.4	129.7	34.5	12.7	25.5
118L	142.7	129.4	30.5	18.3	25.4
150R	140.7	127.3	34.5	13.7	25.6
152R	150.7	136.1	36.3	14.1	21.3
N	11.00	11.00	10.00	13.00	13.00
MAX	153.40	139.40	37.50	18.30	27.60
MIN	140.70	127.30	30.50	12.70	21.00
AVG	146.78	132.85	34.80	14.15	24.62
STDS	4.56	4.11	2.39	1.37	2.31
VARS	20.77	16.90	5.73	1.87	5.32

Table 21a. -Male mouflon: measurements of radius and ulna.

Animal code no.	Radius & ulna GL	Radius GL	Radius BP	Radius BFp	Radius SD	Radius Bd	Radius BFd
8L	217.0	174.0	31.1	29.6	16.6	29.4	23.4
13L	222.0	178.6	33.5	30.4	18.3	31.5	25.5
14R	214.0	170.5	31.0	28.5	17.2	29.2	23.6
25R			32.6	30.7			
30L	224.0	179.0	32.6	29.7	17.0	30.0	24.7
37R	213.0	171.0	31.7	28.7	16.6	29.4	23.6
44R	220.0	175.5	31.0	29.0	17.6	19.0	24.4
45L	216.6	174.3	32.6	29.1	17.0	29.8	24.0
52R	215.0	171.0	31.7	29.2	16.4	30.2	25.6
73R	225.0	181.3	33.4	30.2	18.2	30.2	25.0
&&R	218.6	175.7	30.7	28.3	16.6	29.9	24.4
79L		179.0	31.7	29.7	17.0	29.4	23.9
111R	218.2	176.0	32.0	29.0	17.2	30.0	22.3
116R	210.0	169.0	30.6	28.4	17.0	28.5	24.4
122R	227.2	180.0	33.4	30.6	17.7	31.0	24.9
127R	224.5	180.5	31.7	28.9	16.7	30.0	23.2
157R		170.2			17.0	29.0	25.1
N	14.00	16.00	16.00	16.00	16.00	16.00	16.00
MAX	227.20	181.30	33.50	30.70	18.30	31.50	25.60
MIN	210.00	169.00	30.60	28.30	16.40	19.00	22.30
AVG	218.94	175.35	31.96	29.38	17.13	29.16	24.25
STDS	5.09	4.10	0.97	0.78	0.56	2.80	0.90
VARS	25.92	16.83	0.94	0.61	0.31	7.86	0.80

Table 21b. -Male mouflon: measurements of ulna.

Animal code no.	Ulna				
	GL	LO	DPA	SDO	BPC
8L	210.4	47.0	27.7	23.6	20.0
13L	214.2	46.3	27.9	23.6	20.8
14R	207.4	45.2	26.4	22.1	18.9
25R		46.3	26.0	23.8	20.2
30L	224.2	47.0	27.3	23.5	19.9
37R		44.6	26.5	22.8	19.0
44R	240.0	47.3	28.0	23.6	20.2
45L	210.3	46.9	28.3	24.7	18.9
52R	209.2	46.0	26.7	22.2	18.9
73R	217.4	47.0	27.9	22.5	19.9
&&R	212.0	45.7	26.5	21.3	19.1
79L					
111R	220.0	46.0	28.1	22.6	18.7
116R	203.7	44.0	26.5	22.2	19.0
122R	220.2	48.6	27.9	23.5	19.9
127R	217.2	45.4	26.5	22.2	19.4
157R					
N	13.00	15.00	15.00	15.00	15.00
MAX	240.00	48.60	28.30	24.70	20.80
MIN	203.70	44.00	26.00	21.30	18.70
AVG	215.86	46.22	27.21	22.95	19.52
STDS	9.29	1.16	0.79	0.89	0.64
VARS	86.22	1.34	0.62	0.80	0.41

Table 22a. -Female mouflon: measurements of radius and ulna.

Animal code no.	Radius & ulna	Radii					
	GL	GL	BP	BFp	SD	Bd	BFd
23L	200.7	160.0	30.1	28.0	15.4	28.7	22.8
34R	192.0	155.0	29.0	26.3	15.4	25.6	22.0
43R	192.5	155.6	28.7	26.9	14.6	26.3	22.0
44R	192.0	153.5	29.0	26.3	15.4	25.6	22.0
52R	197.5	159.0	29.2	27.3	15.0	25.8	23.3
56R	201.5	151.4	29.9	27.3	15.4	27.1	22.1
58R		157.8	29.8	27.4	13.6	26.6	22.4
61R	204.0	163.1	31.6	29.0	14.9	27.6	
92R	187.0	151.5	28.0	26.6	15.7	28.0	25.9
95L	189.5	152.3	27.4	26.0	14.1	25.7	20.0
148L	191.5	154.0	28.5	26.6	13.6	26.0	21.0
150R	188.5	153.9	28.3	26.0	14.7	25.7	21.5
N	11.00	12.00	12.00	12.00	12.00	12.00	11.00
MAX	204.00	163.10	31.60	29.00	15.70	28.70	25.90
MIN	187.00	151.40	27.40	26.00	13.60	25.60	20.00
AVG	194.25	155.59	29.13	26.98	14.82	26.56	22.27
STDS	5.73	3.66	1.11	0.89	0.72	1.06	1.49
VARS	32.87	13.42	1.24	0.79	0.52	1.12	2.21

Table 22b. -Female moufion: measurements of uina.

Animal code no.	GL	LO	DPA	SDO	BPC
23L	194.0	41.0	24.1	20.5	19.8
34R	186.5	38.0	22.2	20.5	17.1
43R	184.2	38.8	25.8	21.8	17.6
44R	186.5	38.0	22.2	20.5	17.5
52R	191.0	39.4	24.3	21.2	17.4
56R	195.0	41.8	25.4	21.3	17.8
58R			24.0		17.9
61R	197.2	41.5	25.6	21.5	18.4
92R	181.7	35.5	22.8	19.8	17.5
95L	183.7	31.5	23.2	19.1	16.7
148L	186.0	39.4	24.1	19.8	17.3
150R	183.8	37.5	24.0	21.0	16.7
N	11.00	11.00	12.00	11.00	12.00
MAX	197.20	41.80	25.80	21.80	19.80
MIN	181.70	31.50	22.20	19.10	16.70
AVG	188.15	38.40	23.98	20.64	17.64
STDS	5.26	2.95	1.22	0.82	0.83
VARS	27.72	8.72	1.49	0.68	0.69

Table 23a. -Male mouflon: measurements of pelvis

Animal code no.	GL(L)	GL(R)	GBTi	GBA	SBI	GBTc
8		221.6	105.7	106.5	65.3	
9	217.3	221.6	112.6	105.4	70.0	
13			119.0	109.0	71.2	153.4
14	214.5	213.7	100.8	104.3	62.8	
25				107.5	69.0	
30		217.3	110.1	107.7	69.7	
31			97.7	95.6	61.6	
37				103.2	66.4	
38				102.7	64.0	
44	217.5	216.4	112.5	106.7	69.9	147.2
50				106.5	71.0	
62			99.1	103.6	64.4	
71						
73	216.1	216.1		107.3	67.6	
75				101.7	65.0	
77			99.0	100.2	64.4	
79				102.7	65.5	
103				103.5	65.5	
111	216.8	216.7	118.2	103.0	68.4	143.3
104						
119			104.0	102.6	66.6	
128	216.8		103.5	101.7	66.0	
157			103.2	103.3	65.0	
N	6.00	7.00	13.00	21.00	21.00	3.00
MAX	217.50	221.60	119.00	109.00	71.20	153.40
MIN	214.50	213.70	97.70	95.60	61.60	143.30
AVG	216.50	217.63	106.57	104.03	66.63	147.97
STDS	1.09	2.94	7.23	3.06	2.72	5.09
VARS	1.20	8.63	52.25	9.36	7.40	25.94

Table 23b. -Male mouflon: measurements of pelvis

Animal code no.	SB(R)	LS	LFo(L)	SB(L)	SH
8	12.0	62.5	35.4	11.9	16.0
9	10.5	64.5	36.7	10.6	16.7
13	11.5	58.8	39.3	10.9	17.0
14	10.5	57.6	36.3	10.4	15.4
25	10.5		36.8	10.6	16.8
30	11.0	63.8	38.0	11.0	15.3
31	8.6	54.0	34.0	8.7	15.0
37	10.0	60.7	38.2	9.9	15.1
38	10.9	59.3	33.5	10.8	16.7
44	9.9	64.6	37.8	10.3	16.5
50	11.7	63.5	38.8	11.5	16.8
62	10.5	60.0	38.6	10.6	17.0
71	11.1	67.3	40.2	11.7	16.3
73	11.0	64.3	37.8	11.8	17.9
75	9.9	59.6	33.0	10.2	16.4
77	9.9	61.5	39.6	10.2	14.5
79					
103	9.7		36.5	10.1	15.8
111	11.6	58.9	35.6	11.5	16.8
104	10.0		34.0	10.6	16.1
119	10.7	59.1	37.6	11.4	15.9
128	9.8	63.2	36.2	10.0	15.6
157	9.8	62.8	38.5	10.5	15.6
N	22.00	19.00	22.00	22.00	22.00
MAX	12.00	67.30	40.20	11.90	17.90
MIN	8.60	54.00	33.00	8.70	14.50
AVG	10.50	61.37	36.93	10.69	16.15
STDS	0.81	3.14	2.03	0.75	0.81
VARS	0.66	9.85	4.12	0.57	0.66

Table 24a. -Female mouflon: measurements of pelvis

Animal code no.	GL(L)	GL(R)	GBTi	GBA	SBI	GBTc	SB(L)
34	196.4			101.3	71.4		8.9
42				102.6	69.5		9.7
43	193.9			103.9	70.9		9.5
52	194.0	195.0	101.6	103.6	67.9		9.4
55				103.4	67.5		9.5
56	100.2		100.4	105.7	67.7		9.3
58				103.1	67.5		9.7
59	190.1	180.6		98.9	62.6	132.2	8.8
61			109.7	107.0	72.4		10.0
67				99.8	65.5		10.2
68				102.1	61.9		9.2
71				101.6	70.0		9.4
81					70.3		8.9
83			91.2	96.1	68.4		8.3
86				102.6	65.7		9.3
87			94.6	103.6	63.2		9.2
92	185.2	186.0	89.2	93.4	61.3	113.3	8.3
95			94.2	98.8	65.0		8.8
97				104.0	68.1		10.3
118				101.0	67.8		9.3
129				100.3	66.7		8.3
150	182.0	181.9	95.7	98.5	64.9		10.2
N	7.00	4.00	8.00	21.00	22.00	2.00	22.00
MAX	196.40	195.00	109.70	107.00	72.40	132.20	10.30
MIN	100.20	180.60	89.20	93.40	61.30	113.30	8.30
AVG	177.40	185.88	97.08	101.49	67.10	122.75	9.30
STDS	34.43	6.50	6.59	3.16	3.09	13.36	0.59
VARS	1185.32	42.30	43.39	10.01	9.52	178.60	0.35

Table 24b. -Female mouflon: measurements of pelvis

Animal code no.	SB(R)	LS	LFo(L)	SH(R)
34	9.1	54.7	34.4	13.4
42	9.6	52.5	34.7	14.6
43	9.1	59.3	35.5	13.9
52	9.4	56.3	33.9	13.3
55	9.8	54.7	33.4	14.0
56	9.2	57.1	35.2	14.2
58	9.6	52.5	34.7	14.6
59	8.5	51.9	34.6	13.1
61	9.8	56.0	36.0	15.5
67	10.1		37.3	16.2
68	9.2	47.5	35.0	10.8
71	9.7	59.7	37.3	14.6
81	8.8	57.0	37.5	14.5
83	8.4	54.2	31.7	13.5
86	8.5		34.6	14.5
87	9.1		32.9	18.8
92	8.4	52.7	31.0	14.2
95	9.0	52.8	34.8	14.0
97	10.2		38.1	15.3
118	8.5		33.0	13.8
129	8.2		34.5	12.8
150	9.4	54.4	32.7	14.6
N	22.00	16.00	22.00	22.00
MAX	10.20	59.70	38.10	18.80
MIN	8.20	47.50	31.00	10.80
AVG	9.16	54.58	34.67	14.28
STDS	0.58	3.04	1.84	1.48
VARS	0.34	9.24	3.38	2.18

Table 25. -Male mouflon: measurements of femur

Animal code no.	GL	GLC	Bp	Bd	DC	SD
8L	198.0	191.0	51.8	40.5	22.6	17.5
13L	200.0	194.0	52.0	41.7	23.0	17.5
14L	193.0	186.8	48.1	40.6	20.9	17.2
25L	195.8	191.3	49.4	40.5	22.5	17.7
31L	187.4	182.2	46.7	38.3	19.4	16.0
37R	191.0	184.5	50.1	39.0	21.2	16.2
38L	194.0	188.0	51.0	38.3	22.3	17.2
39L	200.6	197.6	51.5	45.5	22.4	16.4
45R	199.0	191.0	51.0	39.5	21.5	17.6
48L	191.0	187.0	48.4	39.3	21.1	15.4
50R	203.0	197.0	52.0	42.0	22.1	17.9
50L	202.0	197.0	51.5	40.4	22.2	18.6
67L		188.0		39.1	21.3	16.6
79L	199.0	194.0	51.1	40.1	21.8	17.7
103L		185.5		38.9	20.6	16.0
103R		186.0		38.0	20.7	15.8
119L	194.0	190.0	51.5	41.0	22.3	17.6
122L	203.1	195.1	52.7	42.2	23.5	18.6
N	15.00	18.00	15.00	18.00	18.00	18.00
MAX	203.10	197.60	52.70	45.50	23.50	18.60
MIN	187.40	182.20	46.70	38.00	19.40	15.40
AVG	196.73	190.33	50.59	40.27	21.74	17.08
STDS	4.84	4.67	1.71	1.82	1.00	0.95
VARS	23.40	21.77	2.91	3.31	1.00	0.90

Table 26. -Female moufion: measurements of femur

Animal code no.	GL	GLC	Bp	Bd	DC	SD
23L	187.0	183.0	46.4	39.0	21.5	16.0
34L	179.0	175.0	43.9	35.9	19.7	15.7
42R	183.0	176.0	47.3	37.3	20.5	16.5
43L	178.0	175.0	46.3	36.7	21.4	16.0
55L	181.4	177.7	47.5	37.3	21.6	16.5
56L	186.2	182.0	46.6	37.7	19.5	15.9
59L	174.0	171.6	42.7	37.0	20.7	15.1
61L	186.8	182.6	47.7	38.4	20.3	16.8
68L		172.0		31.6	20.2	14.9
71R		175.4		38.0	20.6	15.3
81R	185.3	181.3	45.0	39.3	19.5	15.6
86L	177.0	173.3	45.2	37.0	20.1	15.4
92R	174.4	171.2	43.2	35.6	22.2	15.4
97R	192.7	189.7	50.6	40.0	20.0	17.0
118R	177.0	173.7	45.1	35.7	20.0	15.0
129R	172.0					14.2
N	14.00	15.00	13.00	15.00	15.00	16.00
MAX	192.70	189.70	50.60	40.00	22.20	17.00
MIN	172.00	171.20	42.70	31.60	19.50	14.20
AVG	180.99	177.30	45.96	37.10	20.52	15.71
STDS	6.04	5.31	2.12	2.00	0.82	0.75
VARS	36.52	28.23	4.51	3.99	0.67	0.57

Table 27. -Male mouflon: measurements of astragali.

Animal code no.	GLI	GLm	DI	Dm	Bd
8	30.5	29.0	17.6	18.6	18.7
13	29.8	28.5	17.5	19.5	18.9
14	28.9	27.2	16.8	18.3	18.6
25	29.5	27.2	17.7	19.0	18.8
37	29.6	27.8	17.1	18.0	18.5
38	29.5	27.5	17.6	18.1	18.8
44	28.8	27.4	16.9	18.8	18.4
73	30.0	28.0	17.5	19.0	19.0
77	29.9	27.5	17.0	17.4	17.1
79	29.9	28.0	17.2	18.3	18.3
111	29.0	27.4	16.8	18.4	18.1
116	28.2	26.5	16.5	17.5	17.7
119	29.8	28.0	17.0	17.8	18.5
122	31.3	29.2	17.9	19.8	19.5
127	30.0	28.0	17.2	17.7	18.1
157	28.6	27.3	16.5	17.7	18.3
N	16.00	16.00	16.00	16.00	16.00
MAX	31.30	29.20	17.90	19.80	19.50
MIN	28.20	26.50	16.50	17.40	17.10
AVG	29.58	27.78	17.18	18.37	18.46
STDS	0.76	0.69	0.43	0.71	0.55
VARS	0.58	0.48	0.18	0.50	0.31

Table 28. -Female mouflon: measurements of astragali.

Animal code no.	GLl	GLm	Dl	Dm	Bd
34	28.0	26.2	16.2	16.7	16.7
42	28.6	27.0	16.7	17.3	17.8
55	28.8	26.8	16.2	17.4	17.1
61	29.2	27.3	16.8	16.7	18.0
71	28.1	25.9	15.6	16.4	17.2
81	28.6	27.0	16.2	17.7	16.8
93	27.3	25.3	15.0	16.8	16.5
118	27.9	27.1	16.5	17.3	17.2
124	26.7	25.4	15.1	16.7	16.5
129	26.4	24.5	15.5	15.7	16.4
N	10.00	10.00	10.00	10.00	10.00
MAX	29.20	27.30	16.80	17.70	18.00
MIN	26.40	24.50	15.00	15.70	16.40
AVG	27.96	26.25	15.98	16.87	17.02
STDS	0.92	0.95	0.64	0.58	0.55
VARS	0.84	0.90	0.41	0.34	0.30

Table 29. Male and female mouflon: Patelae measurements.

Females			Males		
Animal code no.	GL	GB	Animal code no.	GL	GB
34	29.0	22.1	14	31.6	25.1
42	29.5	24.0	44	31.6	25.0
61	29.1	23.9	111	28.2	24.3
81	28.8	20.9			
118	29.9	24.1			
N	5.00	5.00		3.00	3.00
MAX	29.90	24.10		31.60	25.10
MIN	28.80	20.90		28.20	24.30
AVG	29.26	23.00		30.47	24.80
STDS	0.44	1.44		1.96	0.44
VARS	0.19	2.06		3.85	0.19

Table 30. -Male mouflon: Measurements of tibia

Animal code no.	GL	Bp	SD	Bd
8L	239.5	43.0	15.5	27.7
13R	247.0	47.5	16.1	28.5
14R	238.0	43.8	15.6	26.8
25R	243.0	45.6	16.3	28.2
30L	242.0	45.4	16.1	28.1
37R	233.0	42.0	15.1	27.6
45R	238.0	44.2	15.7	27.4
50R	248.4		16.8	23.2
48R	233.7	41.1	14.1	25.8
62R	239.5	43.1	15.3	27.3
73R	251.0	45.6	16.9	27.9
75L	233.0	43.0	15.7	27.1
77L	239.0	44.8	16.3	24.7
77R	240.0	42.6	15.7	27.3
103R	234.0		15.0	26.7
111R	242.0	43.9	16.1	27.3
119R	238.6	44.1	15.4	27.7
127R	241.5	45.3	15.6	27.6
157R	235.0	43.3	15.0	27.1
N	19.00	17.00	19.00	19.00
MAX	251.00	47.50	16.90	28.50
MIN	233.00	41.10	14.10	23.20
AVG	239.80	44.02	15.70	27.05
STDS	5.11	1.57	0.67	1.27
VARS	26.07	2.46	0.45	1.62

Table 31. -Female mouflon: Measurements of tibia

Animal code no.	GL	Bp	SD	Bd
55R	223.0	41.1	14.1	25.5
56L	222.0	41.2	14.5	21.3
59R	218.0	39.0	14.6	25.5
71R	221.2		14.0	24.4
81R	211.8	41.8	13.6	25.5
92R	210.0	40.0	14.6	25.7
95R	211.3	38.6	13.8	24.8
97R	239.0	44.5	15.5	27.8
118R	229.7	41.0	14.6	25.7
124R	215.4	40.0	13.4	25.9
129R	216.0		13.6	24.4
150R	209.2	39.2	14.4	24.5
N	12.00	10.00	12.00	12.00
MAX	239.00	44.50	15.50	27.80
MIN	209.20	38.60	13.40	21.30
MEAN	218.88	40.64	14.23	25.08
STDS	8.82	1.72	0.59	1.51
VARS	77.75	2.96	0.35	2.27

Table 32. -Male and female moution: measurements of calcaneum

Males			Females		
Animal code no.	GL	GB	Animal code no.	GL	GB
8R	61.8	21.6	42R	58.8	19.4
13R	61.7	22.0	55L	58.7	19.3
14L	60.8	20.3	56R	59.4	19.5
25R	61.0	22.1	59R	56.4	17.9
37R	58.8	17.7	61R	58.7	19.4
38R	59.9	20.8	71R	56.4	19.5
44R	61.6	21.2	92L	55.0	18.1
45R	61.5	21.1	118R	55.1	18.1
48L	59.0	19.8	129L	55.6	16.7
62L	59.9	20.6			
73R	63.7	22.0			
79R	62.8	20.6			
103R	61.2	20.8			
111R	61.7	20.3			
116R	58.2	20.0			
122R	65.7	22.2			
127R	63.0	21.9			
157L	60.7	21.0			
N	18.00	18.00	N	9.00	9.00
MAX	65.70	22.20	MAX	59.40	19.50
MIN	58.20	17.70	MIN	55.00	16.70
AVG	61.28	20.89	AVG	57.12	18.66
STDS	1.83	1.09	STDS	1.77	1.00
VARS	3.34	1.20	VARS	3.12	1.00

Table 33a. Male mouflon: measurements of metacarpi.

Animal code no.	GL	Bp	SD	DD	Bd
8R	144.0	25.2	14.9	10.3	25.6
25R	146.2	25.6	14.9	10.6	26.0
30L	150.8	25.4	14.1	11.1	25.4
37R	142.6	23.2	13.3	10.5	23.1
44R	141.2		14.1	10.3	24.9
45L	144.3	24.2	13.3	10.8	24.4
48R	144.0	23.8	13.0	10.1	24.6
62R	145.0	25.2	14.1	10.4	25.6
73R	150.4	26.2	14.4	11.4	25.5
77R	147.0	24.0	13.7	10.1	24.7
79L	149.3	24.5	14.4	10.6	24.8
111R	148.2	23.6	14.4	10.4	25.2
116R	143.1	24.4	13.4	10.1	24.7
122R	145.3	25.6	14.5	10.7	25.5
N	14.00	13.00	14.00	14.00	14.00
MAX	150.80	26.20	14.90	11.40	26.00
MIN	141.20	23.20	13.00	10.10	23.10
AVG	145.81	24.68	14.04	10.53	25.00
STDS	2.96	0.91	0.61	0.38	0.72
VARS	8.78	0.83	0.37	0.15	0.52

Table 33b. Male moufion:
measurements of metacarpi.

Animal code no.	W. Troc (R)	W. Troc (L)	HT (L)	HT (R)
8R	10.4	11.7	16.9	15.8
25R	10.6	11.7	16.5	15.5
30L	12.0	10.7	15.8	16.8
37R	10.9	11.8	16.1	15.5
44R	10.4	11.6	16.2	15.5
45L	11.7	10.2	15.4	16.3
48R	9.6	11.0	15.2	14.3
62R	10.3	11.7	16.4	15.6
73R	10.4	12.0	16.7	15.7
77R	10.2	11.7	16.5	15.5
79L	11.6	10.1	15.3	16.1
111R	10.0	11.5	15.7	15.1
116R	10.0	11.5	15.9	15.1
122R	11.2	11.2	17.4	16.3
N	14.00	14.00	14.00	14.00
MAX	12.00	12.00	17.40	16.80
MIN	9.60	10.10	15.20	14.30
AVG	10.66	11.31	16.14	15.65
STDS	0.72	0.60	0.64	0.61
VARS	0.51	0.36	0.41	0.38

Table 34a. Female mouflon: measurements of metacarpi.

Animal code no.	GL	Bp	SD	DD	Bd
34R	136.0	22.6	12.9	9.2	
43R	133.5	21.7	11.9	9.4	22.9
44R	130.2	21.7	12.7	8.7	22.7
52R	139.1	22.1	11.9	9.2	22.3
56R	138.6	23.4	12.7	9.4	23.2
61R	137.5	23.5	12.6	9.2	23.8
95R	130.4	21.4	11.9	8.8	22.4
92R	130.0	22.1	13.1	10.0	22.8
150R	127.8	21.5	11.9	9.0	22.0
N	9.00	9.00	9.00	9.00	8.00
MAX	139.10	23.50	13.10	10.00	23.80
MIN	127.80	21.40	11.90	8.70	22.00
AVG	133.68	22.22	12.40	9.21	22.76
STDS	4.25	0.79	0.49	0.38	0.56
VARS	18.07	0.62	0.24	0.15	0.32

Table 34b. Female mouflon: measurements of metacarpi.

Animal code no.	W. Troc (R)	W. Troc (L)	HT (L)	HT (R)
34R	9.9			14.4
43R	10.3	11.0	15.3	14.5
44R	9.3	10.5	14.9	14.1
52R	10.2	10.9	15.7	15.1
56R	10.2	11.4	16.0	15.1
61R	9.2	10.6	14.6	13.8
95R	10.2	11.4	15.6	15.1
92R	9.8	10.8	14.8	14.0
150R	9.1	10.4	14.5	13.4
N	9.00	8.00	8.00	9.00
MAX	10.30	11.40	16.00	15.10
MIN	9.10	10.40	14.50	13.40
AVG	9.80	10.88	15.18	14.39
STDS	0.48	0.38	0.55	0.62
VARS	0.23	0.15	0.31	0.39

Table 35. Male mouflon: measurements of metatarsi

Animal code no.	GL	Bp	SD	DD	Bd
8	156.6	21.6	12.3	9.8	25.5
13	157.4	22.7	12.7	10.1	21.3
25	158.1	22.0	13.0	10.6	25.9
30	164.8	21.4	12.4	10.1	25.0
37	154.4	20.1	12.0	10.0	23.5
38	154.6	21.9	12.1	10.1	25.7
39	167.0	21.7	12.9	10.0	25.1
44	155.0	21.7	12.4	10.0	24.3
45	159.0	21.3	11.9	10.1	24.9
48	155.0	20.5	11.6	9.0	24.1
50	160.0	21.8	12.9	10.1	25.7
73	162.0	21.9	12.7	10.3	25.0
75	157.0	20.9	12.6	10.2	24.6
79	162.3	20.8	13.0	10.1	24.8
103	156.2	20.8	12.6	9.6	24.3
111	158.7	21.5	12.5	10.1	25.0
116	155.0	21.3	12.2	9.5	24.6
157	157.0	20.9	12.3	9.8	24.1
N	18.00	18.00	18.00	18.00	18.00
MAX	167.00	22.70	13.00	10.60	25.90
MIN	154.40	20.10	11.60	9.00	21.30
AVG	158.34	21.38	12.45	9.97	24.63
STDS	3.63	0.63	0.39	0.35	1.04
VARS	13.19	0.39	0.16	0.12	1.09

Table 36. Female mouflon: measurements of metatarsi

Animal code no.	GL	Bp	SD	DD	Bd
34	146.6	19.6	11.3	9.2	22.9
42	145.0	20.2	11.0	9.3	24.0
43	146.4	18.8	10.7	9.0	22.8
55	149.9	20.0	11.0	9.0	23.5
56	150.0	19.8	11.3	9.0	23.4
59	146.3	19.6	10.7	8.8	22.6
61	151.0	20.3	11.0	9.3	23.1
71	148.0	19.4	10.4	8.7	22.7
81	152.0	20.6	10.9	8.8	23.6
83	139.5	17.8	11.2	9.0	21.0
86	141.4	19.0	11.3	8.7	22.7
129	144.3	19.0	11.0	8.4	22.3
N	12.00	12.00	12.00	12.00	12.00
MAX	152.00	20.60	11.30	9.30	24.00
MIN	139.50	17.80	10.40	8.40	21.00
AVG	146.70	19.51	10.98	8.93	22.88
STDS	3.79	0.77	0.28	0.27	0.77
VARS	14.39	0.60	0.08	0.07	0.59

Table 37a. RATIO: FEMALE MEAN BONE MEASUREMENTS /MALE MEAN BONE MEASUREMENTS

Cranium

M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
1	0.93	11	0.85	21	0.95	31	0.86
2	0.92	12	0.95	22	0.97	32	
3	0.86	13	0.92	23	0.94	33	0.86
4	0.89	14	0.56	24	0.97	34	0.92
5	0.95	15	0.54	25	0.97	35	0.87
6	0.95	16	0.82	26	0.89	36	0.92
7	0.89	17	0.91	27	0.89	37	0.70
8	0.92	18	0.96	28	0.83	38	0.93
9	0.94	19	0.95	29	1.02	39	0.94
10	0.92	20	0.93	30	1.03		

Mandible

M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
1	0.97	6	0.94	10B	1.00	15a	0.93
2	0.95	7	0.95	11	0.94	15b	0.87
3	0.96	8	0.95	12	0.93	15c	0.90
4	0.94	9	0.87	13	0.94		
5	0.95	10L	0.97	14	0.94		

Atlas		Axis		Sacrum		C3	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
GB	0.77	LCDe	0.91	BFcr	0.56	BPacr	0.71
GL	0.57	LAPa	0.93	HFcr	0.84	BPacd	0.75
BFcr	0.90	BFcr	0.86	GL	0.92	GLPa	
BFcd	0.86	BPacd	0.71	PL	0.96	BPtr	0.65
GLF	0.86	BPtr	0.72	GB	0.98	H	
		SBV	0.80				
		BFcd	0.70				
		H	0.74				

C4		C5		C6		C7	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
BPacr	0.74	BPacr	0.74	BPacr	0.74	BPacr	0.74
BPacd	0.75	BPacd	0.77	BPacd	0.79	BPacd	0.69
GLPa	0.94	GLPa	0.91	GLPa	0.89	GLPa	0.64
BPtr	0.65	BPtr	0.75	BPtr	0.79	BPtr	0.80
H		H	0.64	H	0.64	H	0.63

M/t = Measurement

Table 37b. RATIO: FEMALE MEAN BONE MEASUREMENTS /MALE MEAN BONE MEASUREMENTS

T1		T2		T3		T4	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
PL	0.93	PL	0.92	PL	0.90	PL	0.89
BPtr	0.84	BPtr	0.85	BPtr	0.88	BPtr	0.88
H	0.62	H	0.71	H	0.65	H	0.68

T5		T6		T7		T8	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
PL	0.89	PL	0.90	PL	0.92	PL	0.96
BPtr	0.90	BPtr	0.93	BPtr	0.92	BPtr	0.91
H	0.70	H	0.69	H	0.75	H	0.80

T9		T10		T11		T12	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
PL	0.94	PL	0.94	PL		PL	0.92
BPtr	0.91	BPtr	0.90	BPtr		BPtr	0.90
H	0.81	H	0.81	H		H	0.81

T12		T13		L1		L2	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
PL	0.94	PL	0.94	PL	0.93	PL	0.92
BPtr	0.92	BPtr	0.92	BPtr	0.86	BPtr	0.86
H	0.82	H	0.82	H	0.85	H	0.85

L3		L4		L5		L6	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
PL	0.92	PL	0.93	PL	0.92	PL	0.92
BPtr	0.88	BPtr	0.86	BPtr	0.91	BPtr	0.88
H	0.84	H	0.87	H	0.84	H	0.83

Scapula		Humerus		Ulna		Radius	
M/t	Ratio	M/t	Ratio	M/t	Ratio	M/t	Ratio
HS	0.91	GL	0.91	GL	0.87	GL	0.89
DHA	0.92	GLC	0.94	LO	0.83	BP	0.91
LD	0.89	Bp	0.90	DPA	0.88	BFp	0.92
SLC	0.89	SD	0.90	SDO	0.90	SD	0.87
GLP	0.92	BT	0.90	BPC	0.90	Bd	0.91
LG	0.91					BFd	0.92
BG	0.93	M/t = Measurement					

Table 37c. RATIO: FEMALE MEAN BONE MEASUREMENTS /MALE MEAN BONE MEASUREMENTS

Pelvis

M/t	Ratio
GL(L)	0.88
GL(R)	0.85
GBTi	0.91
GBA	0.98
SBI	1.01
GBTc	0.83
SB(R)	0.87
LS	0.89
LFo(L)	0.94
SB(L)	0.87
SH	0.88

Femur

M/t	Ratio
GL	0.92
GLC	0.93
Bp	0.91
Bd	0.92
DC	0.94
SD	0.92

Astragali

M/t	Ratio
GLI	0.95
GLm	0.94
DI	0.93
Dm	0.92
Bd	0.92

Tibia

M/t	Ratio
GL	0.91
Bp	0.92
SD	0.91
Bd	0.93

Calcaneum

M/t	Ratio
GL	0.93
GB	0.89

Metacarpi

M/t	Ratio
GL	0.92
Bp	0.90
SD	0.88
DD	0.87
Bd	0.91
W. Troc. (R)	0.92
W. Troc. (L)	0.96
HT (L)	0.94
HT (R)	0.92

Metatarsi

M/t	Ratio
GL	0.93
Bp	0.91
SD	0.88
DD	0.90
Bd	0.93

Patelae

M/t	Ratio
GL	0.96
GB	1.08

Radius and Ulna

M/t	Ratio
GL	0.89

M/t = Measurement