ECOLOGY AND CONSERVATION OF THE JEBEER GAZELLE AND WILD ASS IN THE DASHT E KAVIR, IRAN.

by

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ABSTRACT

The jebeer gazelle and the wild ass were studied for four years in two protected regions in the Dasht e Kavir, Iran, to provide information on their basic ecology and status for their conservation and management. One region was occupied by Man and his domestic sheep and goat, the other region was not. The regions were compared to determine the influence of domestics on the wild populations.

Road and aerial censuses were the main methods used. These are discussed at length. They obtained information on the population sizes, distribution, habitat preferences and structure and their seasonal and annual trends.

Daily activity and rutting behaviour were determined by observations from springs.

Feeding was determined by bite studies and faecal analysis.

The implications of the results for conservation, management and research are discussed and recommendations made.

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DECLARATION

No part of this thesis, in this or any other form, has been submitted for a degree to any other university.

B. P. O'Regan.
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ABBREVIATIONS

N.P. = National Park

P.A. = Protected Area

Chapter 1

INTRODUCTION

1.1 The Dasht e Kavir

The land mass of Iran emerged from beneath a Miocene Sea by compression between the Arabian and Asian tectonic plates. The intense orogenic folding produced a triangle of mountains enclosing a raised central plateau, and these features persist to the present day. The mountain ranges, the Alborz in the north, the Zagros in the south and west, and the Khorassan Mountains in the east, cause the air-laden moisture from the Caspian, Mediterranean, and Arabian Seas to precipitate before it reaches the central plateau, which, as a result, is a vast and arid rain shadow. Sixty per cent of the land area of Iran drains internally, producing extensive alluvial plains, with the run-off collecting in low-lying basins and evaporating to form salt and mud flats (Furon, 1941).

The central plateau comprises two huge depressions, the Dasht e Lut in the south, and the Dasht e Kavir in the north. The Dasht e Kavir is characterised by rocky mountain outcrops of sedimentary and extrusive igneous material separated by broad alluvial plains and low-lying salt and mud-flats. The largest of these is the Great Salt Lake in the north-west corner. Areas of sand dunes are scattered throughout the region.

Climate is seasonal. Temperatures range from below freezing in winter to 40°C in summer. Mean annual precipitation is less than 400 mm, and falls in winter and spring.

Vegetation cover is sparse, dominated by perennial shrubs. Spring annuals occur but are not well represented.

For an arid zone the mammal fauna is surprisingly diverse. This diversity arises from Iran's geographical position as a bridge between the Palearctic, Ethiopean and Indian faunal regions. Most of the mountain outcrops throughout the Dasht e Kavir contain populations of wild sheep (Ovis ammon) and wild goat (Capra aegagrus), while jebeer gazelle (Gazella dorcas) and wild ass (Equus hemionus) occur on the alluvial plains. Rodents and hares (Lepus capensis) are widespread and common. There is also a variety of predators; Ruppell's fox (Vulpes ruppelli), red fox (V. vulpes), wolf (Canis lupus), golden jackal (C. aureus), striped hyaena (Hyaena hyaena), caracal (Lynx caracal), leopard (Panthera pardus) and cheetah (Acinonyx jubatus) have all been seen regularly.

The economy of the Dasht e Kavir is mainly a nomadic pastoralism with domestic sheep and goat. The flocks and their shepherds spend the summer in the Alborz, Zagros and Khorassan Mountains, and the winter down at lower elevations in the Dasht e Kavir.

Villages are scattered around the edges of the Dasht e Kavir, supporting irrigated cultivation and a sedentary pastoralism.

1.2 The growth of conservation in Iran

The expansion of cultivation and pastoralism, and the emergence of modern firearms and vehicles used for unrestricted hunting, inevitably brought about a reduction in the range and numbers of most wildlife species. Alerted to their dwindling numbers, a group of conservation-conscious Iranians created the

Game Council in 1956, which was given legal powers to set aside Protected Regions in which hunting of wildlife and utilization of the rangeland was restricted. Since then the Game Council has grown, becoming the Department of the Environment in 1973, creating several levels of reserve classification, and expanding its responsibilities to develop tourism, education, and management of the wildlife resources.

1.3 The purpose of the study

Two of the more numerous and conspicuous of the large mammals of the Dasht e Kavir are the jebeer gazelle and the wild ass, and as such constitute an important part of the wildlife resource. Being plains-dwellers, they have been affected most by domestic grazing, cultivation and hunting. Two areas were set up for their protection in the Dasht e Kavir; the Kavir National Park, situated south east of the capital, Tehran, and adjacent to the Great Salt Lake, and the Turan Protected Area, situated in the north east corner of the Dasht e Kavir.

The Kavir National Park was established to recreate the natural climate conditions of the Dasht e Kavir in the absence of disturbance by Man. The Turan Protected Area was established to protect the large numbers of wild ass there, and domestic grazing and cultivation continue within its borders.

The purpose of the study was to gather information on the populations and basic ecology of the jebeer gazelle and wild ass in the Kavir National Park and Turan Protected Area which could be used for education, conservation, and management purposes. The two regions were used for comparison to determine the influence of man's activities on the two wildlife species.

1.4 Taxonomy

1.4.1 Jebeer gazelle

The classification of the jebeer gazelle, after Corbet (1978) and Harrington (1977), is as follows:

Order	:	Artiodactyla
Sub order	:	Ruminantia
Family	:	Bovidae
Sub family	:	Antilopinae
Genus	:	*Gazella*
Species	:	*dorcas*
Subspecies	:	*fuscifrons*

There has been some considerable confusion about the taxonomy of the gazelles in the past, arising from the close morphological similarities between species and their low numbers and patchy distribution in the wild. Lydekker and Blaine (1914) recognised some thirty species in the genus *Gazella*. This was reduced to six in the Palearctic region by Ellerman and Morrison-Scott (1951), who placed the jebeer gazelle of Iran and the chinkara of India in the species *Gazella gazella*. Gentry (1964) agreed in general with Ellerman and Morrison-Scott's classification, but suggested that the chinkara was more similar to *G. dorcas* than *G. gazella*, and this was confirmed by Groves and Harrison (1967) and Groves (1969). These authors recognised three species of the genus *Gazella* in Arabia and Asia; *G. dorcas*, *G. gazella*, and *G. subgutturosa*. *G. dorcas* includes the jebeer of Iran and the chinkara of India, *G. gazella* is found in the Arabian peninsula only, and *G. subgutturosa* is found in the

Arabian peninsula, the Iranian plateau and Central Asia. Harrington (1977) recognised two subspecies of G. dorcas in Iran; G. d. bennetti, the chinkara, along the Mekran Coast in southeast Iran, and G. d. fuscifrons, the jebeer, in the central plateau of Iran.

1.4.2 Wild ass

The classification of the wild ass, after Corbet (1978) and Harrington (1977) is as follows:

Order	:	Perissodactyla
Family	:	Equidae
Genus	:	Equus
Species	:	hemionus
Subspecies	:	onagar

Corbet (1978) recognises six subspecies of Equus hemionus, of which only one, E. h. onagar, occurs in Iran. This is supported by Groves (1963) and Harrington (1977).

1.5. Physical characteristics

1.5.1 Jebeer gazelle

The jebeer gazelle is a small gazelle, slenderly built, with relatively short legs. Colouration is light sandy brown, with white underparts and rump patch. The lateral band is absent or poorly marked.

It possesses the typical gazelline facial markings of dark bands running from the horns to the nose and from the eye to the mouth, separated by a white band. There is a degree of sexual dimorphism. Based on specimens collected in the Dasht e Kavir (8 male and 3 female) males are larger, a mature adult weighing 30 kg and standing 70 cm at the shoulder, with larger horns, up to 30 cm in length, arising close together and diverging slightly with a sigmoid curve when viewed from the side. Females weigh up to 20 kg, and stand 65 cm at the shoulder. They possess horns, which are thin, straight and parallel, reaching a similar length to the males'. Horn aberrations are common in the females. The chinkara differs from the jebeer in having a redder pelage, smaller body, and larger head and horns (Groves, 1969; Harrington, 1977).

1.5.2 Wild ass

The wild ass has a sandy grey coat with a short, erect mane of dark chestnut. This colouration extends in a thin line down the back to the base of the tail. The underparts are white. The dark bands on the lower legs of the African ass and the shoulder stripe of the Syrian ass are both missing in this species. There is a slight difference between the sexes in size. From individuals caught in Turan, males had a shoulder height of up to 140 cm and females 120 cm. This is larger than the African wild ass which has a shoulder height of 108 cm, but similar to the Burchell's zebra, which has a shoulder height of 125 to 138 cm. The weight of the Burchell's zebra is 250 to 350 kg (Dorst and Dandelot, 1970).

1.6 Distribution and status

1.6.1 Jebeer gazelle

The range of Gazella dorcas stretches from Morocco, Algeria, Tunisia, Lybia and Egypt, south to Abyssinia, Sudan and Lake Chad, and east to the Arabian peninsula, Iran, Pakistan and northern India. It inhabits the subdesert gravel and sandy plains surrounding the large basins in the central plateau of Iran, and the lower valleys and plains of the Persian Gulf watershed from Bushehr eastwards to the Mekran Coast (Fig 1.2). In the latter area it is replaced by the chinkara. In the wetter, more steppic areas it is replaced by the goitered gazelle, Gazella subgutturosa. It occurs in areas where permanent human presence is only sparse or absent.

Although the jebeer gazelle never reaches high densities, they are widely distributed throughout their range in Iran, and the continued occupation of that range is assured.

The jebeer gazelle is classified as a Protected Game Mammal, which means that a special licence has to be obtained to hunt it. Licences are not issued between 21 March and 21 June. About thirty licenses are issued annually for the whole of Iran.

1.6.2 Wild ass

The range of the wild ass stretches from West Manchuria and Kansu through Mongolia, Sinkiang and South Turkestan to Baluchestan and the Rann of Kutch, and into Iran. It occurred formerly in Iraq and Syria. Its range was probably continuous, but it is now fragmented by local extinctions so that some of the subspecies are isolated and discrete (Corbet, 1978). It occurs in Iran in the same range as the jebeer gazelle, but is restricted to the central plateau (Fig 1.2). In the Dasht e Kavir, large aggregations are seen in the Turan P.A. A smaller population occurs in the Kavir N.P. Elsewhere isolated groups are seen throughout the central plateau where disturbance from Man is at a minimum.

Their range is now very fragmented, and there are only four areas remaining where they can be regarded as common; Mongolia (Tsegevmid and Dashdorj, 1974), the Rann of Kutch (Gee, 1963), Turkmenia (Klingel, 1977) and the Dasht e Kavir. There are widespread reports of the reduction of its range in living memory (Groves, 1974). In Iran, the type specimen of the sub-species comes from Qazvin in north west Persia (Ellerman and Morrison-Scott, 1951). The nearest wild individuals are now over 250 km away in the Kavir N.P.

The wild ass is listed in the Red Data Book as an Endangered Species. As long as the protection enjoyed during the course of the study continues, the survival of the species is assured.

Hunting of the wild ass is totally prohibited by law, and no licenses are issued. Poaching outside reserves certainly goes on, but its extent is impossible to judge. No poaching occurs in the Kavir N.P. In the Turan P.A. poaching appears to be negligible. No arrests have been made by the game guards, and no evidence of poaching was encountered during the course of the study.

Figure 1.1

The main topographical features of Iran and location of study areas.

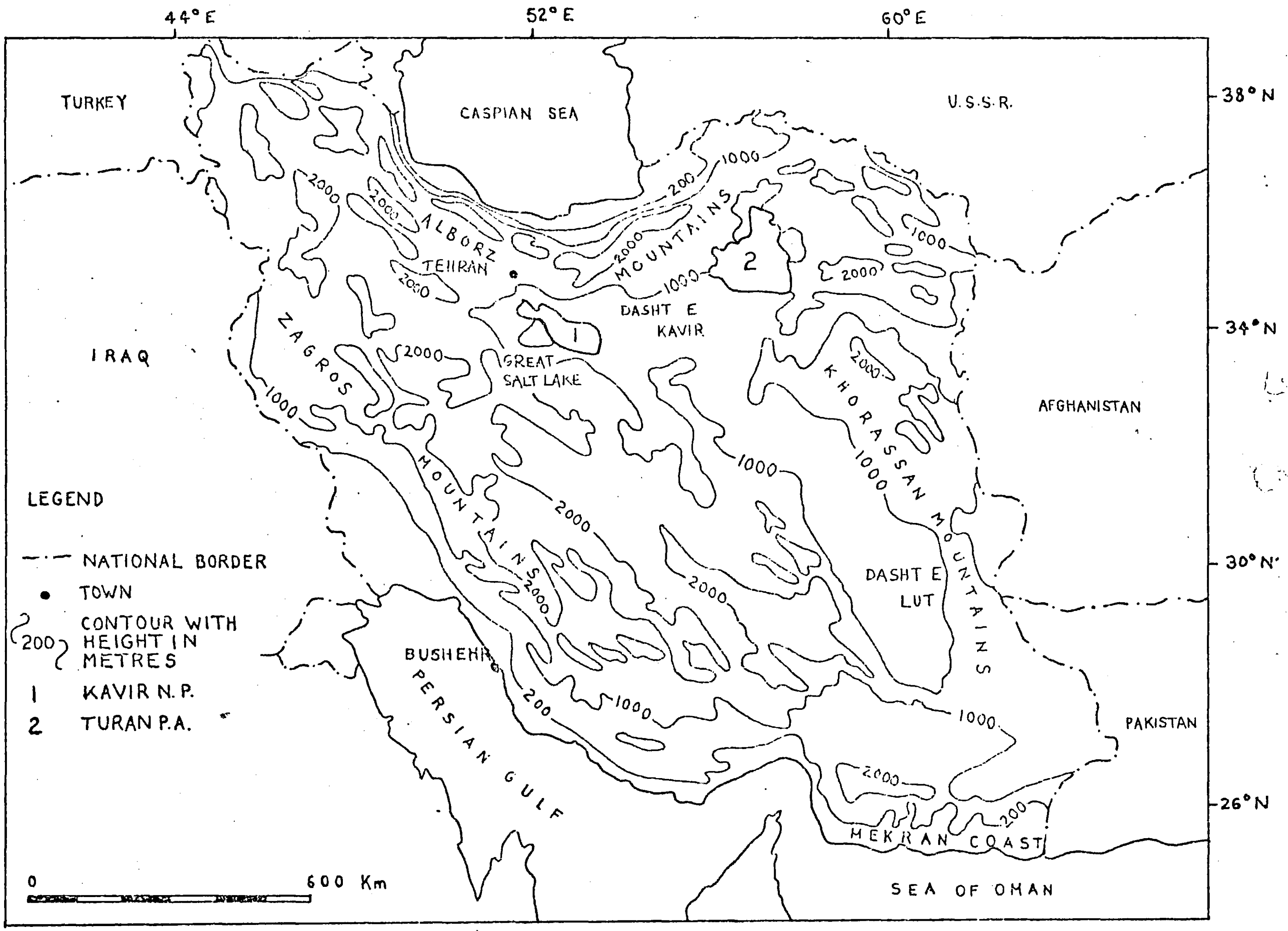
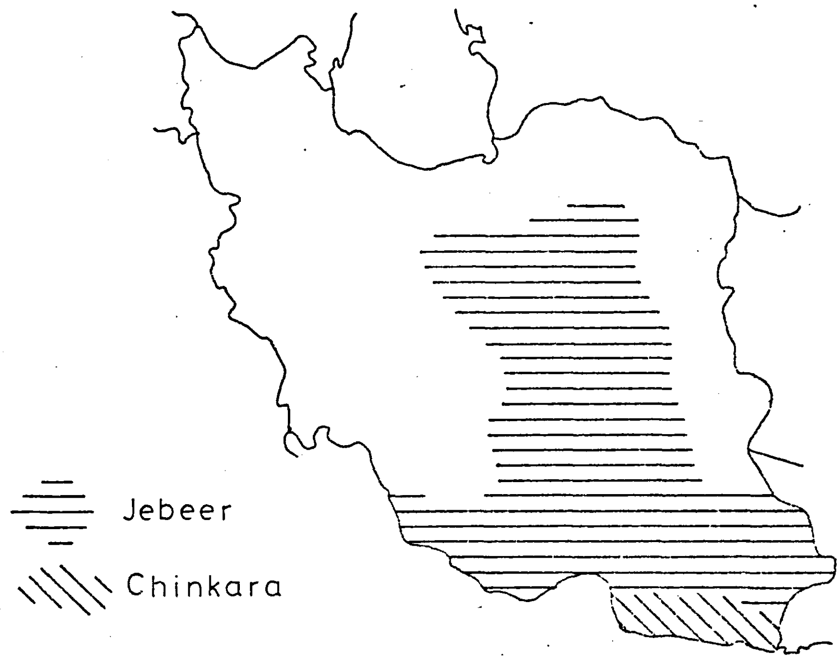

44° E
52° E
60° E
38° N
34° N
30° N
26° N
TURKEY
CASPIAN SEA
U.S.S.R.
IRAQ
AFGHANISTAN
PAKISTAN
ALBORZ MOUNTAINS
TEHRAN
DASHT E KAVIR
GREAT SALT LAKE
ZAGROS MOUNTAINS
KHORASSAN MOUNTAINS
DASHT E LUT
BUSHEHR
PERSIAN GULF
MEKRAN COAST
SEA OF OMAN
LEGEND
NATIONAL BORDER
TOWN
200 CONTOUR WITH HEIGHT IN METRES
1 KAVIR N.P.
2 TURAN P.A.
0
600 Km

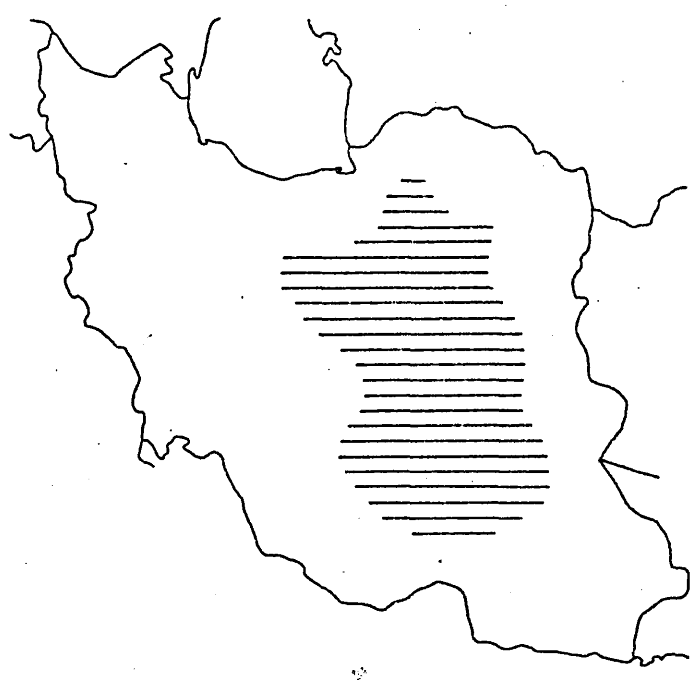
Figure 1.2

Range of jebeer gazelle and wild ass in Iran.

a) JEBEER GAZELLE



b) WILD ASS



Chapter 2

STUDY AREAS

2.1 Kavir National Park

2.1.1 History and location

The Kavir National Park was established in June, 1964, primarily to protect the Persian wild ass and the jebeer gazelle, but also to offer an area close to Tehran representative of the Dasht e Kavir as a whole for tourism, education, and research. From the data of establishment all grazing by domestic stock as well as fuel collecting was stopped. Feral camels persisted in the area until they were removed in 1971. The park covers 6,094 km^2 and is situated in the northwest corner of the Dasht e Kavir, adjacent to the Great Salt Lake, and some 170 km southeast of the capital city, Tehran (Fig 1.1).

2.1.2 Criteria of classification

Being a National Park, the Kavir is subject to the following criteria as laid down in the policy guidelines of the Department of the Environment (Firouz and Harrington, 1976):

" Purpose: Outstanding example of the nation's geologic, ecologic, geographic and scenic features of national significance, set aside in perpetuity for preservation, protection, conservation, and enjoyment in a natural condition.

" Use: Non-consumptive uses. Natural outdoor recreation experience with development facilities necessary for resource protection, public safety and interpretation as determined by zoning."

2.1.3 Topography and geology

The region comprises three rocky mountain outcrops, Kuh e Baba Hemat in the west, rising to a height of 1,375 m, Siah Kuh in the centre, rising to a height of 1,855 m, and Kuh e

Molkabad in the east, rising to a height of 1,608 m. They are mainly igneous extrusions, with Miocene calcareous lithosols at intermediate elevations. These give way to alluvial plains at about 1,000 m, which slope gently down to low-lying salt and solonchak at about 750 m; the Great Salt Lake to the southwest, and the Rudkhane ye Gelu to the north and east. An expanse of sand dunes occurs in the north east corner, north of Chah Qarqare. Elsewhere the soil is either exposed bare strata of calcareous lithosols, or sandy with a surface layer of stones (Fig 2.3).

2.1.4 Climate

Records of temperatures and precipitation from the region itself do not exist, and the following data are taken from the Climatic Atlas of Iran (1965). Mean annual precipitation is 100 mm, most of which falls in winter and spring (Fig 2.1). Mean daily maximum air temperature in July is 38°C, and in January is 13°C. Mean daily minimum air temperature in July is 25°C, and in January 2°C. Mean relative humidity at 0900 GMT in July is 26, and in January 47. Annual precipitation measured at Varamin meteorological station, 30 km northwest of the region, was above the mean from 1974 to 1977 (Fig 2.2).

2.1.5 Vegetation

The dominant vegetation is perennial shrubs. The salt and mud flats are plantless, and these are bordered by halophytic vegetation, dominated by *Tamarix* spp. (Tamaricaceae) on the moister soils, and *Seidlitzia rosmarinus* (Chenopodiaceae) on the drier soils. This merges with the gently rising ground of the alluvial plains dominated by Artemisia herba-alba (Compositae) on the moister soils, Zygophyllum eurypterum (Zygophyllaceae) on the drier soils, and Pteropyrum aucheri (Polygonaceae) in the outwash gulleys. On sand dunes and sandy soils Haloxylon spp. (Chenopodiaceae) and Stipagrostis spp. (Graminae) dominate. The mountain chains are dominated by Artemisia herba-alba, Zygophyllum eurypterum, and Amygdalus scoparia (Rosaceae). Springs occur at the base of the mountains, and these contain dense stands of Phragmites australis (Graminae). On severely overgrazed and degraded soils, particularly around old corrals, antipastorals such as Peganum harmala (Zygophyllaceae), Salsola spp., and Anabasis setifera (Chenopodiaceae) occur. The exposed strata of the calcareous lithosols support only very scant vegetation, owing to its friability and high concentration of solutes (Fig 2.4).

2.1.6 Mammals

Prior to protection in 1964 there were many domestic sheep, goats and camels. There is no record of any settlements within the region, but people from the nearby villages to the north and west grazed their flocks in the region throughout the year, and nomadic flocks would move into the region for the winter from the Allorz Mountains. Domestic flocks were removed from the region in 1964. Feral camels persisted in the region until they were removed in 1971.

The mammal species commonly seen are two species of gazelle, the goitered gazelle (Gazella subgutturosa) and the jebeer gazelle (G. dorcas). The former occurs around the farmland to the north and west of the region, and a few groups and individuals are seen around Mil spring. The wild ass (*Equus hemionus*) occurs in the eastern part of the region. Wild sheep (*Ovis ammon*) and wild goat (*Capra aegagrus*) occur on all three mountain outcrops. Hares (*Lepus capensis*), jerds (*Meriones* spp.), jerboas (*Jaculus* spp. and *Allactaga* spp.) and Ruppell's fox (*Vulpes ruppelli*) are abundant and easily seen at night with a spotlight. One live cheetah has been seen, and cheetah signs such as tracks and urine marks at springs and one kill, have been seen. A dead caracal lynx (*Lynx caracal*) was found on one occasion. No wolves or leopards have been reported.

2.1.7 Water availability

Water at springs was available for drinking throughout the park, except on the south side of Kuh e Baba Hemat. Most of the springs occurred at the base of the mountain outcrops where they met the alluvial plains. The only two springs to occur out on the alluvial plains were Chah Qarqare, a well where water was pumped to the surface by a windmill, and Takkuh, a natural spring. There were game guard posts at Molkabad and Sefid Ab springs, and a mine at Gel spring. Water was collected once a day from Nakhjil spring. All other springs were undisturbed.

2.2 Turan Protected Area

2.2.1 History and location

The Turan Protected Area was established in 1972, primarily to protect the population of wild ass, which is the largest in Iran. Villages occur in the region, mainly in the northern half, and irrigated cultivation of cereal crops and sugar beet, and sedentary and nomadic pastoralism occur. The region covers 18,420 km^2, and is situated in the north east corner of the Dasht e Kavir, between and south of Shahrud and Sabzevar (Fig 1.1).

2.2.2 Criteria of classification

Being a Protected Area, Turan is subject to the following criteria as laid down in the policy guidelines of the Department of the Environment (Firouz and Harrington, 1976):

> " Purpose: Lands of strategic conservation value set aside for the protection, management and restoration of plant and animal life in a manner that will prevent degradation. To provide conditions conducive to the conservation, regeneration or amelioration of habitats and species for their scientific, economic, educational, cultural and recreational values.
>
> " Use: Natural outdoor recreational pursuits and regulation of the limits, methods and types of exploitation as determined by zoning."

2.2.3 Topography and geology

The region comprises two broken chains of limestone mountains. The Shotor Kuh, Kuh e Delbar and Kuh e Do Shakh form three outcrops of a chain running from the south west to the north east of the region, and the Kuh e Chah Vekil, Kuh e Gharibe and Kuh e Peyghambar running from the centre of the region to the south east. The highest point is Shotor Kuh at 2,281 m. Igneous extrusions with Miocene calcareous lithosols occur in the region of Kuh e Chah Vekil. A river, the Kal e Shur, bisects the region. In summer it is just a series of isolated pools supersaturated with salt. For the rest of the year it flows north to south and empties into a vast expanse of salt and solonchak in the southern half of the region. Another expanse of solonchak occurs in the north east. These are at an elevation of about 750 m. Alluvial plains rise gently from the areas of solonchak to merge with the mountain ranges at elevations of 1,000 to 1,500 m. The mountains differ from those of the Kavir N.P. in that they plunge steeply to meet the alluvial plains without breaking up into foothills, except in the region of Kuh e Chah Vekil (Fig 2.5).

2.2.4 Climate

The climate is the same as the Kavir N.P. (2.1.4). As in the Kavir N.P., records from the nearby town of Shahrud showed annual precipitation was above average from 1974-77 (Fig 2.2).

2.2.5 Vegetation

The same vegetation occurs in Turan P.A. as in the Kavir N.P. However, *Zygophyllum eurypterum* forms denser stands and covers a larger area (Fig 2.6).

2.2.6 Mammals

Wild mammal species commonly seen are the same as the Kavir N.P. (2.1.6), with some additions. Leopard (*Panthera pardus*), wolf (*Canis lupus*) and hyaena (*Hyaena hyaena*) also occur, probably attracted by the domestic flocks. These number about 150,000 sheep and goat, of which 25,000 are sedentary and belong to local villagers (Spooner, 1977). Cattle, camels, and donkeys also occur in fewer numbers and are restricted to the villages around Ahmadabad and in the Biajomand plain (Fig 2.5).

2.2.7 Water availability

Springs occur frequently throughout the region, except in the plains east of Nour and between Majerad and Torud in the west of the region. Several of these springs occur out in the plains, for instance Abul Yahya, Sitel and Chahak. Most of them are visited by domestic flocks as well as wildlife. There are two springs at Majerad. One of these, as well as Delbar and Tejour, has permanent human presence and habitation. The shepherds of the nomadic flocks drill wells out on the plains to water their animals.

2.2.8 Study area

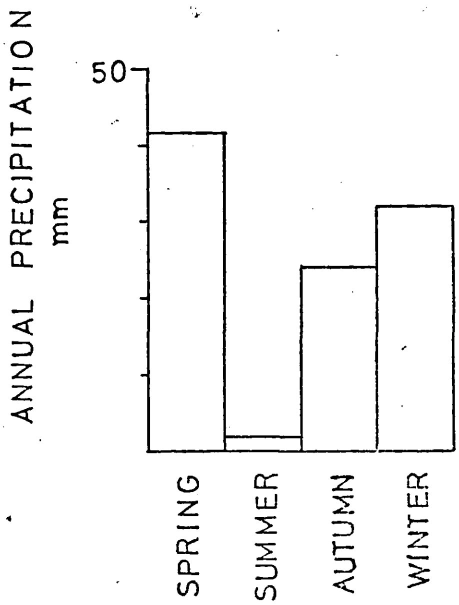
Owing to the large area of Turan P.A., only a part of the whole region was chosen as a study area. It contains the densest numbers of wild ass and jebeer gazelle and all the features of the region as a whole, and is presented in Figs 2.5 and 2.6.

Figure 2.1

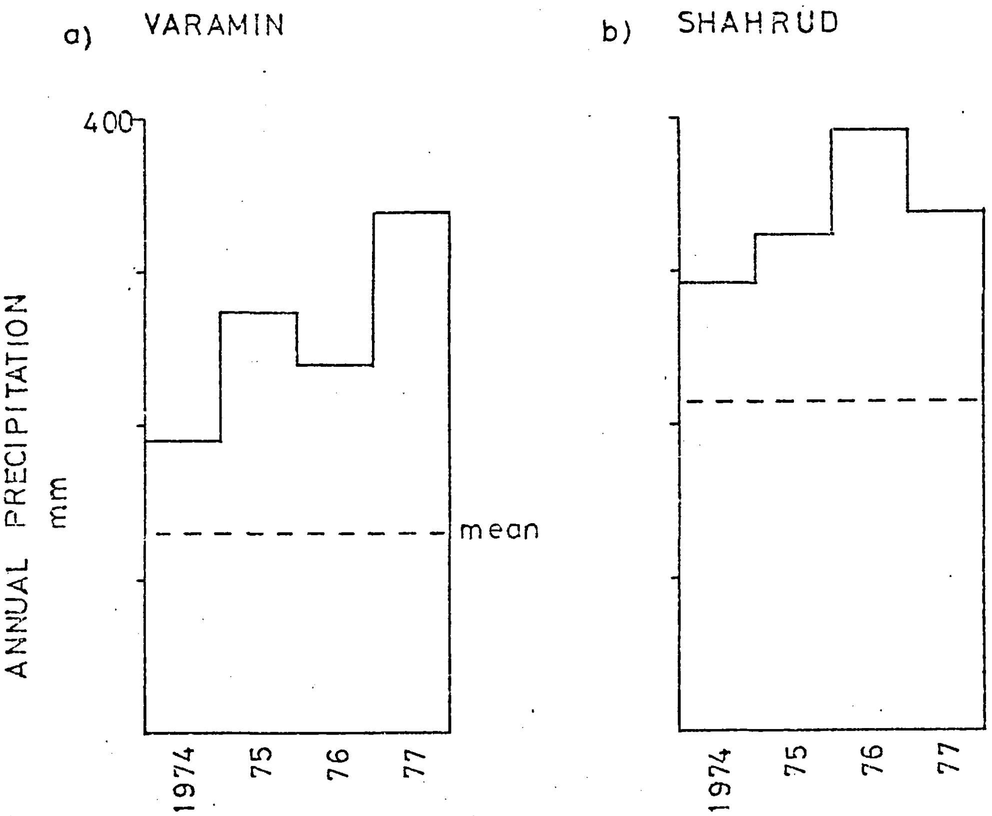
Mean seasonal precipitation, Kavir N.P. and Turan P.A.

Figure 2.2

Annual precipitation from 1974 to 1977.



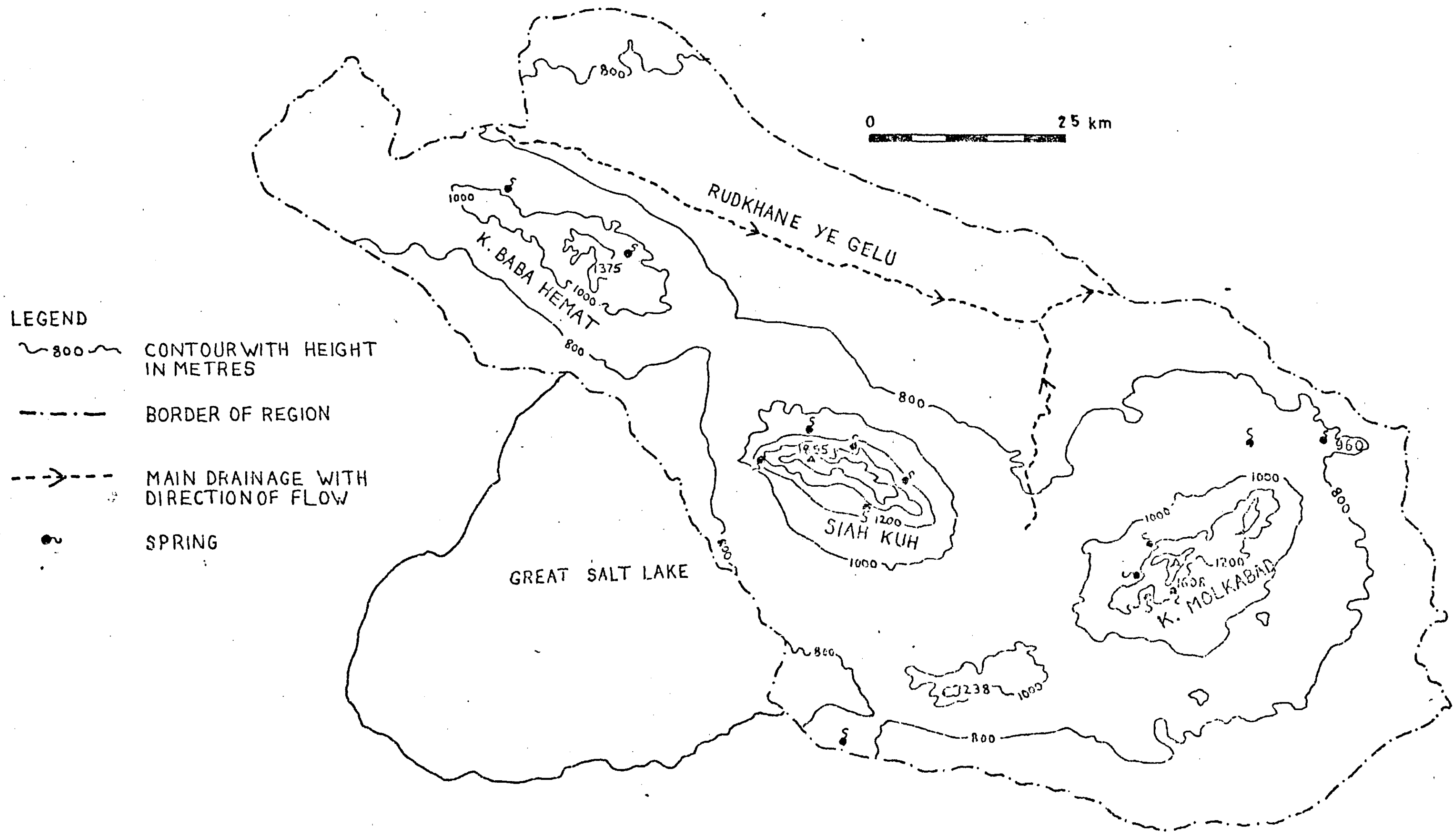
ANNUAL PRECIPITATION mm
50
SPRING
SUMMER
AUTUMN
WINTER



a) VARAMIN
b) SHAHRUD
ANNUAL PRECIPITATION mm
400
mean
1974
75
76
77
1974
75
76
77

Figure 2.3

Kavir N.P.: topographical features.



0
25 km
RUDKHANE YE GELU
K. BABA HEMAT
1375
SIAH KUH
1200
K. MOLKABAD
GREAT SALT LAKE
960
238
LEGEND
800
CONTOUR WITH HEIGHT IN METRES
BORDER OF REGION
MAIN DRAINAGE WITH DIRECTION OF FLOW
SPRING

Figure 2.4

Kavir N.P.: habitat types.

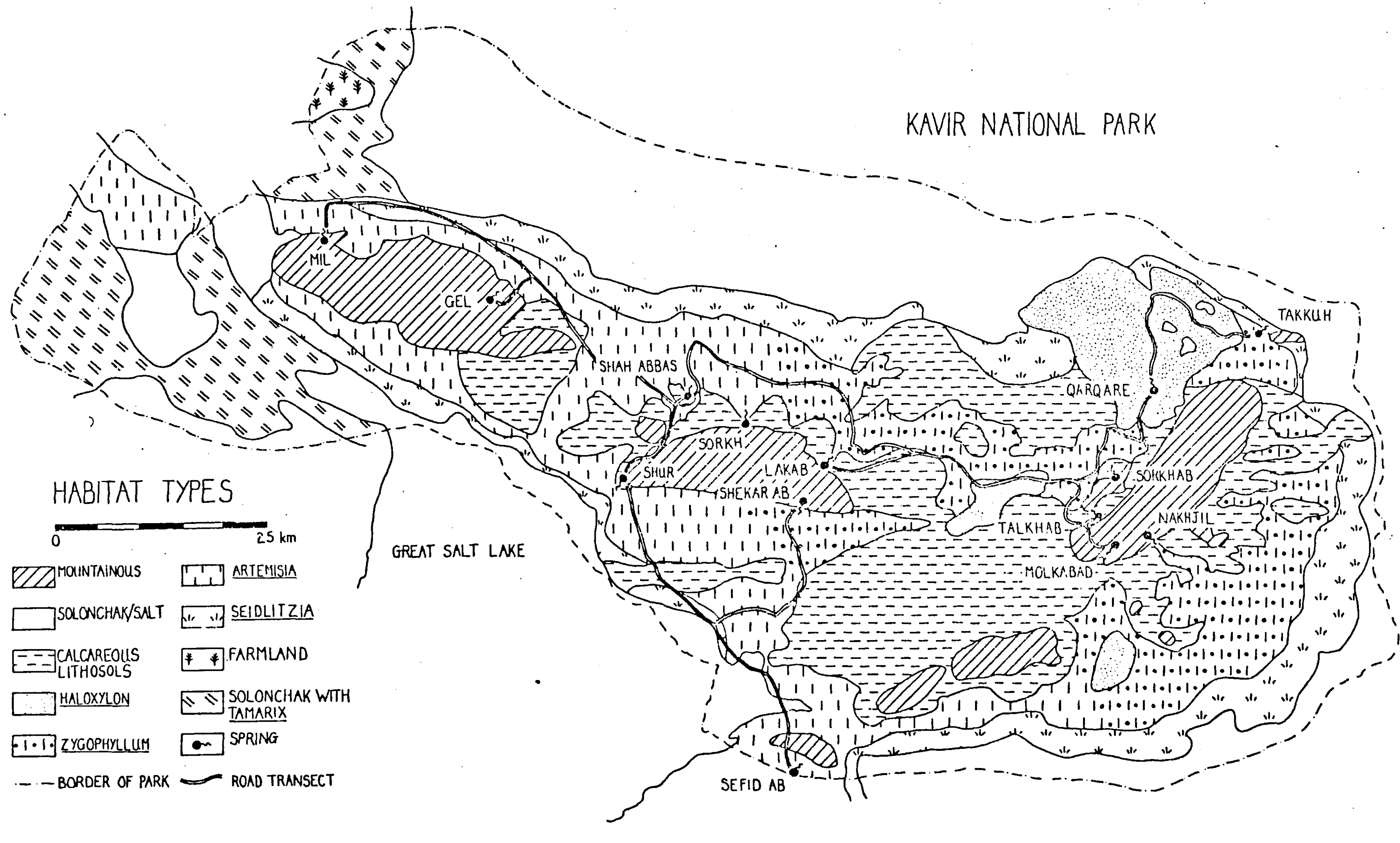

KAVIR NATIONAL PARK
TAKKUH
QARQARE
SOKKHAB
NAKHJIL
TALKHAB
MOLKABAD
MIL
GEL
SHAH ABBAS
SORKH
LAKAB
SHUR
SHEKAR AB
SEFID AB
GREAT SALT LAKE
HABITAT TYPES
0
25 km
MOUNTAINOUS
SOLONCHAK/SALT
CALCAREOUS LITHOSOLS
HALOXYLON
ZYGOPHYLLUM
ARTEMISIA
SEIDLITZIA
FARMLAND
SOLONCHAK WITH TAMARIX
SPRING
BORDER OF PARK
ROAD TRANSECT

Figure 2.5

Turan P.A.: topographical features.

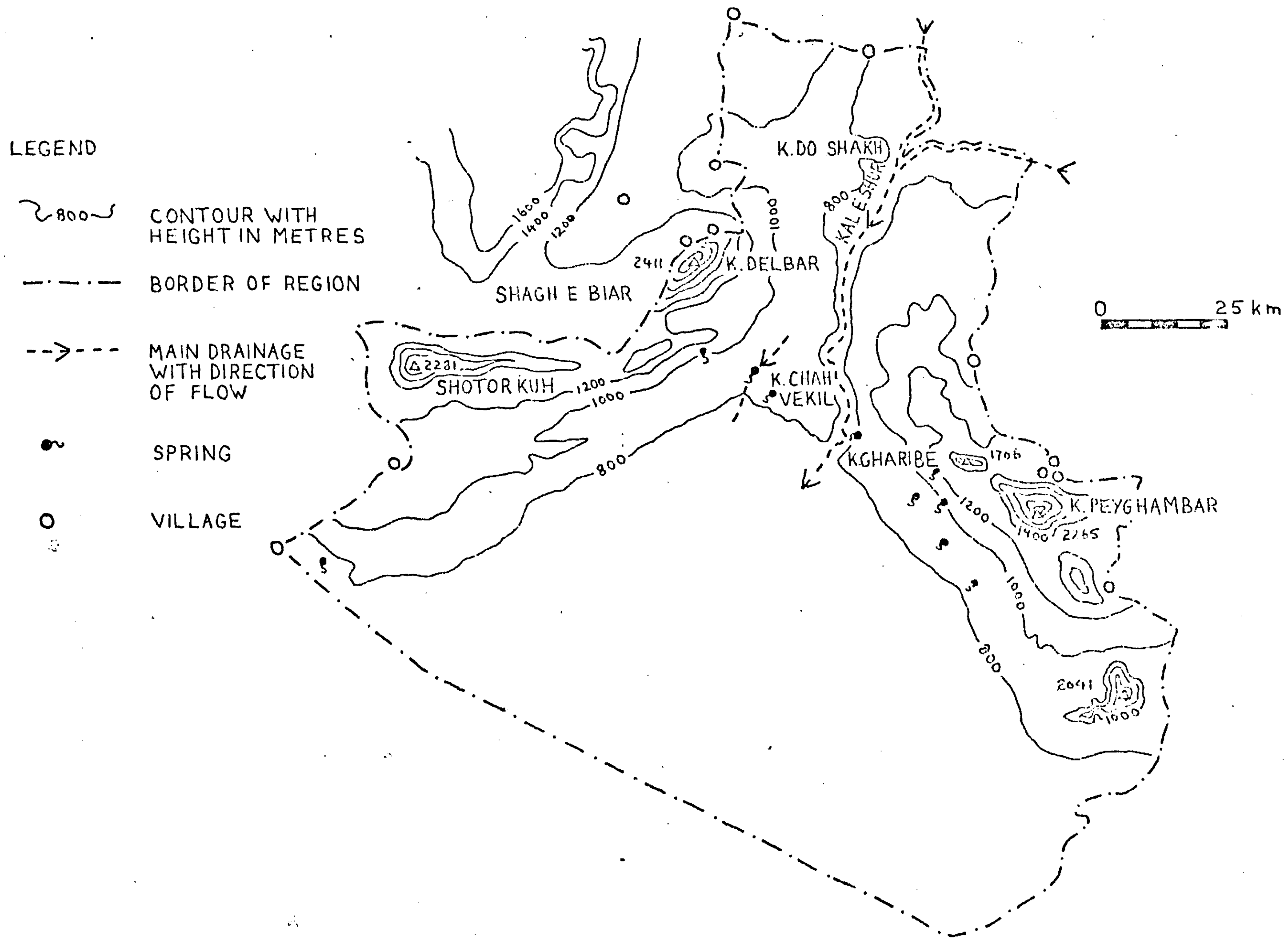
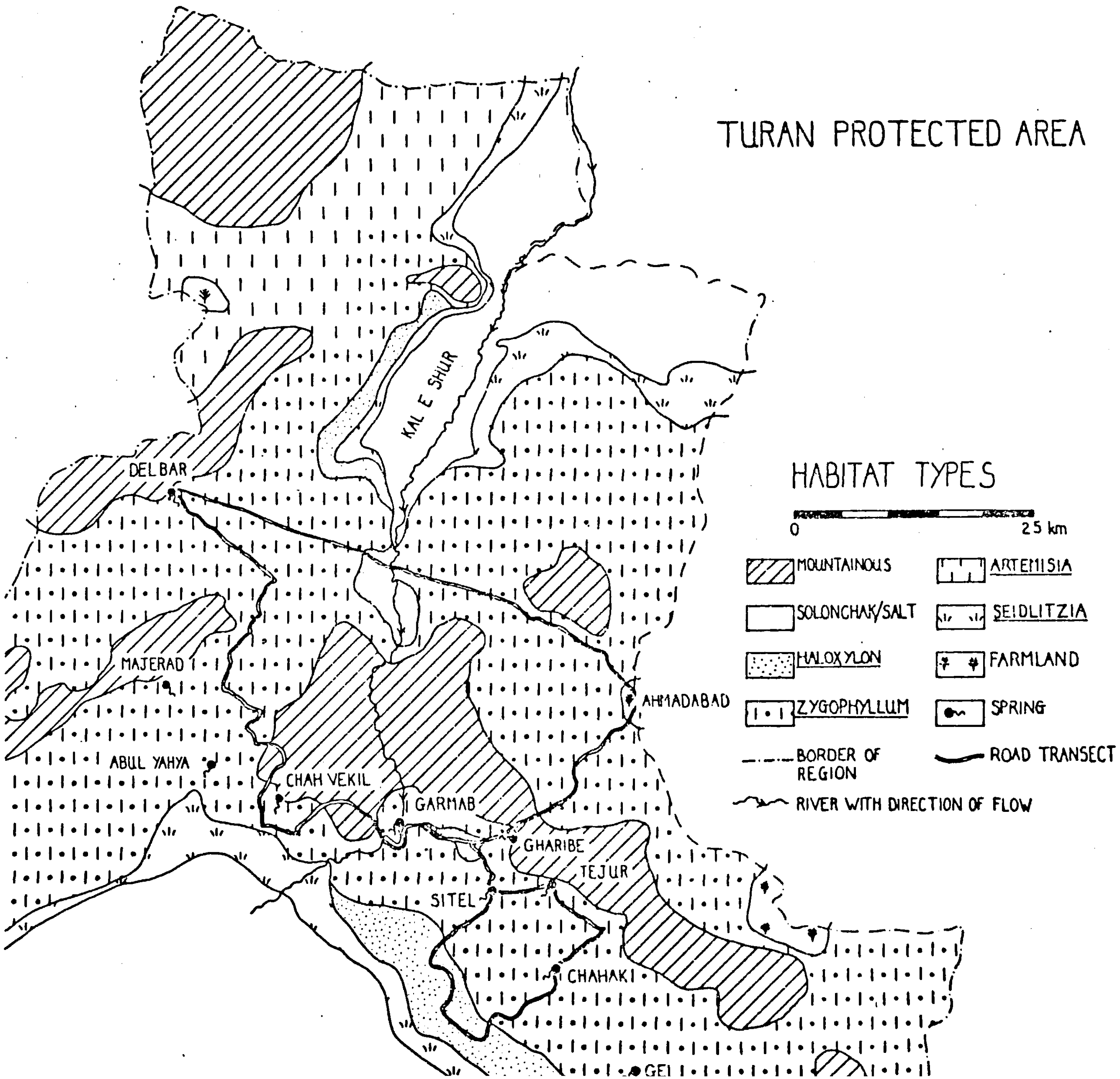

LEGEND
800
CONTOUR WITH HEIGHT IN METRES
BORDER OF REGION
MAIN DRAINAGE WITH DIRECTION OF FLOW
SPRING
VILLAGE
0
25 km
K. DO SHAKH
KAL E SHUR
K. DELBAR
SHAGH E BIAR
SHOTOR KUH
2231
2411
K. CHAH VEKIL
K. GHARIBE
K. PEYGHAMBAR
2765
1706
2041
1600
1400
1200
1000
800

Figure 2.6

Turan P.A.: habitat types of the study area.


TURAN PROTECTED AREA
HABITAT TYPES
0
25 km
MOUNTAINOUS
SOLONCHAK/SALT
HALOXYLON
ZYGOPHYLLUM
ARTEMISIA
SEIDLITZIA
FARMLAND
SPRING
BORDER OF REGION
ROAD TRANSECT
RIVER WITH DIRECTION OF FLOW
KAL E SHUR
DELBAR
MAJERAD
ABUL YAHYA
CHAH VEKIL
GARMAB
GHARIBE
TEJUR
SITEL
CHAHAKI
AHMADABAD
GEI

Chapter 3

CENSUS PROCEDURES

3.1 Introduction

At the start of the study very little was known about the jebeer gazelle and wild ass. Their range throughout the country and the type of habitat in which they occurred was known (1.6.1 and 1.6.2). In addition, jebeer gazelle were believed to be distributed evenly in small groups throughout their range, whereas wild ass were distributed patchily in larger groups. There was therefore a need to collect basic information about their ecology on which conservation, management and other measures could be based. A major part of this basic information is the population characteristics such as numbers, distribution, structure, habitat preferences and trends, and it is best collected using aerial and road censuses. Most of the data collection was done therefore using these methods, and since they constitute such an important part of the study, they are presented here in detail.

3.2 Aerial census

3.2.1 Introduction

One of the most widely used methods of censusing wild animals is by aerial transect sampling, and the techniques have been comprehensively reviewed by Jolly (1969). These techniques involve selecting transects at random, locating them on a map before the flight, demarcating the transect width in flight with the use of streamers attached to the wing struts of the aeroplane, and maintaining level flight at a fixed height above the ground. Where the animals are unevenly distributed or the habitat heterogeneous, the area is stratified.

The habitat of the Dasht e Kavir appears ideal for aerial census. It is flat with low shrubby vegetation, and there are extensive areas of continuous habitat uninterrupted by hills and gulleys. The light in summer is excellent, thus making the animals clearly visible. There are certain problems though. The terrain is relatively featureless and available maps are not good, which makes map reading difficult. There is a constant wind which becomes turbulent on the leeward sides of the mountain ranges, thus making level flight, and calculation of ground speed and distance covered difficult. The plains where the animals occur slope gently down from the mountain ranges to the salt flats, and this slope makes it difficult to maintain a constant height above the ground. Because of these difficulties, a few adaptations have been made to the methods proposed by Jolly.

3.2.2 Census procedure

Since the animals are distributed throughout the park and the habitat homogeneous, the census was not stratified. The regions were divided into several areas which corresponded with the springs. The limits to these areas were determined by features on the ground which were easily recognisable and identifiable on the map. Within each area transects were located parallel and equidistant from each other, and at right angles to the line of the mountain ranges. These areas, with the transects of the 1977 census, are presented in Figs 3.1 and 3.2.

In the Kavir N.P., on day one of the census, areas 1, 2, 3, 4 and 12 were flown, on day two areas 5, 6, 7 and 8, on day three areas 9, 10 and 11 (Fig 3.1).

In the Turan P.A., on day one of the census, areas 2 and 3 were surveyed, on day two areas 7, 4 and 5, on day three areas 6, 8 and 1 (Fig 3.2).

Within each area a baseline was drawn along the line of the mountain ranges (Figs 3.1 and 3.2), transects were aligned at right angles to this.

The flight path was worked out on a map beforehand, assuming an average air speed of 170 kph.

From the time available and the airspeed chosen, the number of possible transects for each flight was calculated. The transects were made parallel in each area and equidistant from each other. The flight would start and finish at a recognisable landmark (Figs 3.1 and 3.2). The bearing to be flown was calculated from the map, and at the start of the flight the aeroplane would be aligned along the bearing. To cancel out any effect of crosswinds, a visual fix would be made on a distant landmark in line with the bearing, and the plane flown towards this landmark. When the plane was judged to be out of habitat, that is over salt, or the foothills of the range, then the pilot made a right-angle turn, flew for the requisite length of time until the next transect, when he made another right-angle turn to start the new transect, which was aligned parallel to but flown in the opposite direction to the previous one. To align the transects during the flight, the plane was flown by dead reckoning. This was repeated until the whole length of the area was completed, keeping the flying time between transects constant. The flight procedure was as standardised as possible to cut down the amount of communication required and therefore the amount of misunderstanding and mistakes. Transects could only be flown during the first two and a half hours after sunrise. After that, turbulence from thermals made flying too hazardous.

The aeroplane used for the censuses was a Piper Super Cub, a single-engine plane with two seats in tandem. The pilot sat in front and the observer behind. Keeping a constant flying height was very difficult. The ground, although mostly flat, was seldom level, and sloped gradually down from the mountain ridges to the low-lying salt basins. Therefore maintaining a constant height above the ground using the altimeter was impossible. Strong winds and turbulence were frequently encountered and so the plane was constantly banking. By calibrating the altimeter on the ground at the airstrip in the park, whose height was known, and reading the altimeter when flying over the airstrip, it was calculated that the flying height varied between 200 and 400 feet.

If there was a crosswind, then this would affect the ground speed so that sometimes there would be one extra or less transect than planned. Nothing was done to counteract this, since it was considered more important to have as simple a procedure as possible while flying than to stick to the original flight plan. Changing the flying speed or the length of time flown between transects to accommodate crosswinds would have been too complicated.

Observations were made out of one side of the plane only, the side with better light conditions. Information was taken down on a tape recorder and transcribed onto data sheets after the flight was complete. The time at the start and finish of each transect was noted, and when gazelle were seen they were recorded with the following information:-

date
time
number
habitat
right-angle distance away

The plane travelled too fast to determine the age and sex of most individuals. This information was recorded on the ground surveys.

Flights were made in the early morning for 2½ hours after sunrise. During these times the light was flat and the gazelle most active and visible.

3.2.3 Transect width

Estimating transect width proved quite a problem. Determining transect width using markers on the wing struts has been described by several authors (Pennycuick, 1972; Bell et al., 1973; Pennycuick, 1969; Norton-Griffiths, 1978). This method requires flying at a constant and known height. This is ruled out by the conditions in the Dasht e Kavir. The method employed was to estimate by eye the distance away an animal was. This was checked by laying out six markers at 100 m intervals either side of the road at the airstrip. At the beginning of each flight the plane would make several passes at different altitudes to get one's eye in. From this method it was found possible to judge distances up to 500 m for gazelle on each side of the plane, so the transect width for gazelle was estimated at 500 m. All wild ass seen were recorded. It was estimated that they could be seen with ease up to 2 km away. Before the first transect survey was done in 1974, I had already done seven surveys in the Kavir N.P. and elsewhere, and so I was quite experienced by the time the transect sampling program was started.

3.3 Road census

3.3.1 Introduction

Road censuses are not usually as good as aerial transects in censusing wildlife populations, for reasons that are reviewed by Norton-Griffiths (1978) and discussed in section 3.6. Choice of road censuses in this study was dictated by circumstances; the aeroplane was available for only limited periods of time, whereas there was no such restriction on Land Rovers. Since it was decided that the main approach to the study was by censusing (Section 3.1) then road censuses had to be done.

Transects were located along existing roads.

3.3.2 Location of transects

a) Kavir N.P.

In the Kavir N.P. there were four transects as follows (Fig 3.1):

1. Shah Abbas to Mil, via Gel springs
   Distance: 60 km
   Average time taken for driving: 3 hrs.
2. Sefid Ab to Shur, via Shekar Ab springs
   Distance: 79 km
   Time taken: 4 hrs.

3. Shah Abbas to Talkhab, via Lakab springs
   Distance: 90 km
   Time taken: 4½ hrs

4. Talkhab to Takkuh, via Qarqare springs
   Distance: 75 km
   Time taken: 3.75 hrs

Owing to lack of roads, areas 11 and 12 were not sampled.

b) Turan P.A.

In the Turan P.A. there were three transects as follows (Fig 3.2):

1. Delbar to Gharibe, via Abul Yahya springs
   Distance: 78 km
   Average time taken for driving: 4 hrs

2. Tejour to Tejour, via Chahak and Sitel springs
   Distance: 62 km
   Time taken: 3 hrs

3. Gharibe to Delbar, via Ahmadabad
   Distance: 69 km
   Time taken: 3 hrs

Owing to lack of roads and time available, areas 1, 7 and 8 were not sampled.

3.3.3 Census procedure

One drive on consecutive days of each transect constituted one sample. Each census comprised two or three samples (Section 3.4.2).

Transects were driven by Land Rover in the early morning, starting at sunrise, when the visibility was best, at a maximum speed of 25 kph. Whenever animals were spotted the Land Rover was stopped and observations made from the stationary vehicle.

On some parts of the transects the Land Rover would have to retrace its tracks. In these instances the return journey was not considered part of the transect.

There were three people to a vehicle, the driver, myself and an Iranian biologist. All three sat in the front seat of the vehicle, the person in the middle next to the driver looking to the left of the road and the person on the right looking to the right. Whenever a group of animals was sighted, the vehicle approached until the group was 90° from the road, and observations made from inside the vehicle. For each group the following information was recorded:

location
species
number, age class and sex
time
date
right angle distance from transect
habitat type
weather.

The location was obtained by recording the kilometer reading on the vehicle odometer. Observations were made using 10 x 50 binoculars and were recorded straight onto data sheets. Any additional observations were taken onto a tape recorder and transcribed at the end of the day.

3.3.4 Transect width

a) Jebeer gazelle

All jebeer seen within a certain distance either side of the road were recorded and all others ignored. The right-angle distance of jebeer gazelle from the road was estimated by eye and checked regularly by pacing the distance on foot. It was found by this method that distance could be estimated accurately up to 300 metres on either side of the vehicle in Artemisia and Zygophyllum vegetation. This distance, that is 600 metres, was taken as the transect width, within which all animals present were seen and their distance from the transect estimated accurately. In dense Haloxylon vegetation I would place myself on top of the vehicle and observe from there. The width of the transect in this tall vegetation was reduced to 400 metres, that is 200 metres on either side of the vehicle.

If a group of gazelle straddled the boundary of the transect, that is, if some individuals of the group were less than 400 m and some more from the road, then the group as a whole was counted as inside if half or more of their number were within the transect, and outside if half or more of their number was beyond. If the group moved away, then the centre of the group was fixed on a feature of the terrain by the observer, and this was estimated as inside or outside the transect in the same way.

Observations were made using 10 x 50 binoculars, and were recorded straight onto data sheets. Any additional observations were taken onto a tape recorder and transcribed at the end of the day.

b) Wild ass

All wild ass groups seen were recorded, and no fixed width transect was used. The maximum distance at which wild ass could be seen with ease was 1.5 km.

c) Choice of transect type

The benefits and disadvantages of fixed width, indefinite and variable width transects have been discussed by several authors (Caughley, 1977; Eberhardt, 1968; Norton-Griffiths, 1978). A variable width transect is only feasible in heterogeneous vegetation. The advantage of fixed width is that it is simpler to use and analyse. The advantage of indefinite width transect is that a greater number of animals is recorded. Eberhardt (1968) argues that this is desirable when animals are at low densities. It would seem therefore than an indefinite width transect would be desirable for jebeer gazelle, since jebeer occur in low densities. However, it was found that the number of jebeer seen at greater distances depended a great deal on the light conditions, and so varied considerably. The fixed width transect was found to produce good enough results and so this was used.

An indefinite width transect was used for the wild ass because although they occurred in similar densities to jebeer in the Turan P.A., the group sizes were larger and so fewer groups were seen. Also wild ass were more timid and so moved away from the Land Rover which would make a fixed width transect more difficult to use. Being much larger animals, wild ass could be seen with ease at greater distances without being affected by light conditions.

3.3.5 Intensive sampling

In July 1976 a more thorough survey of area 3 in the Kavir N.P. was done to test the accuracy of the sampling procedure in estimating population size. The speed remained the same, 100 kph, but the flying height was lowered to 100 to 150 feet and the transect width was reduced to 300 m. Transects were flown closer together.

3.4 Dates of censuses

3.4.1 Aerial censuses

a) Kavir N.P.

In the Kavir N.P. aerial censuses were done in July of 1974 to 1977 inclusive. Each census lasted three days. Owing to the limited availability of the aeroplane, the region was sampled only once on each occasion.

b) Turan P.A.

In the Turan P.A. one census was done in July 1977, lasting four days. As in the Kavir N.P., the study area was sampled once.

3.4.2 Road censuses

a) Kavir N.P.

In the Kavir N.P. road censuses were done in the following months:

1974	July	3	samples
	September	3	"
	November	3	"
1975	May	3	samples
	July	3	"
	September	3	"
	November	3	"
1976	January	2	samples
	July	3	"
	November	2	"
1977	January	2	samples
	May	2	"
	July	3	"

b) Turan P.A.

In the Turan P.A. road censuses were done in the following months:

1976	May	2	samples
	August	2	"
	October	2	"
	December	2	"
1977	April	2	samples
	August	2	"

3.4.3 Incidental surveys

In March of all four years visits were made to the Kavir N.P. for between 7 and 10 days at a time. Casual flights over the region and drives along the roads were done, and jebeer seen were recorded as for transect sampling. Flights over the Kavir N.P. were made in October '73 and October '74, and these data were used only as incidental observations.

3.5 Purpose of censuses

3.5.1 Aerial census

The purpose of the aerial censuses was to determine population size (Chapter 4) distribution (Chapter 5) and habitat preferences (Chapter 6).

3.5.2 Road census

The purpose of the road censuses was to determine population distribution (Chapter 5), habitat preferences (Chapter 6), and structure (Chapter 7). Only the July and September censuses were good enough to determine population size (Chapter 4).

3.5.3 Incidental surveys

Incidental surveys were used to determine population distribution (Chapter 5), habitat preferences (Chapter 6) and structure (Chapter 7).

3.6 Discussion

3.6.1 Sources of bias and error

About the only thing common to all wildlife censuses by transect sampling is that not all animals within the transect are counted, no matter how good the viewing conditions and alert the observer. This is because:

1. the animals are lying down and thus hidden from view
2. they are hidden by features of the habitat such as hills and tall vegetation
3. they run away on the approach of the vehicle
4. they are visible, but just missed by the observer.

Other biases arise because:

5. distance away of an animal is under- or overestimated
6. transects may not be randomly located, and may favour a type of habitat unrepresentative of the area as a whole, or which is selected or avoided by the animals
7. transects may affect distribution of animals
8. the animals may move or change their activity during the course of the census.

Biases affect the results consistently in one direction. Errors affect them in either direction, and will arise from:

9. random variation.

3.6.2 Effects on aerial census

The conditions of the light and habitat in the Dasht e Kavir are excellent for censusing. The animals occur out on the plains which are flat, with few hills, and vegetation that is lower than both the jebeer gazelle and wild ass. Only <u>Haloxylon</u>

vegetation is higher, but this covers only a small part of the regions. The weather is permanently sunny in the summer months, and the atmosphere clear, particularly in the early morning at the time of the censuses, due to the low humidity. The animals, at least the jebeer gazelle, are at their most active in the early morning. The smaller groups will be missed more than larger groups since they are less visible. The aeroplane moves too fast for the animals to move out of the way. Their usual response is to stand still and look up. All these conditions therefore minimise points 1 to 4 above. Even so, some will inevitably be missed. In order to estimate this amount, an intensive census of area 3 in the Kavir N.P. was done in July 1976 at a lower height, narrower transect width and more transects.

Estimating distance away of animals (5 above) during aerial censuses was not checked by measuring. However, it was done on the road transects and it was found that the distance was usually overestimated for gazelle and underestimated for wild ass.

Although transects were not randomly distributed (6 above), they did cover the whole region and were not influenced by habitat. Aerial censusing was therefore assumed to be representative of the region as a whole. Nor was it considered that aerial censusing affected the distribution of animals (7 above), since it occurred only once a year, and animals did not seem unduly disturbed by the plane.

Aerial censuses were done during the two and a half hours after sunrise. Observations on daily activity in the Kavir N.P.

show that gazelle tended to move towards foothills and springs, and to bed down more around midday. This might influence the data of areas censused later in the day (8 above).

Random variation (9 above) is minimised by taking several samples and calculating mean and variance from these. Due to the limited availability of the aeroplane only one sample could be done on each census. The results of the aerial censuses were therefore compared with those of the road census.

3.6.3 Effects on road census

The excellent viewing conditions of the Dasht e Kavir habitat apply also to road censusing. However, animals will be less visible due to the lower height of observation during road censuses. This will be balanced by the slower vehicle speed of road censuses so that fewer animals will be missed. The slower vehicle speed also means that animals have time to move out of the way before they are sighted. In the Kavir N.P. the jebeer gazelle are not at all timid and seldom moved away on approach of a vehicle. In the Turan P.A. they were timid and often moved away. This was also the case with wild ass in both regions.

The effect would be that a larger proportion of the jebeer population would go unseen and would be incorrectly seen outside the transect in the Turan P.A. than in the Kavir N.P., and the distance away of wild ass and the proportion unseen would be greater.

To minimise this effect, when a group was first sighted its position would be fixed by the observer on a feature of the terrain, and this distance was judged. The second observer would take down the other information on the group.

As mentioned above, distance away of jebeer gazelle is usually overestimated and wild ass underestimated (5 above).

Road transects are not randomly located, but they do cover all habitats in the region (6 above). Since they are dirt tracks, they do not affect the habitat in any way. However, there is some traffic in the Kavir N.P. from the mine and game guard vehicles. Since jebeer gazelle were not apparently disturbed by vehicles, this was considered to have no effect. Vehicles used the Delbar to Ahmadabad road in the Turan P.A., and this could cause disturbance to the animals (7 above). The movement of jebeer gazelle towards springs and foothills and their lying down would affect the road censuses more than aerial since they were done later in the day (8 above). To account for random variation, two or three samples on each road census were done (9 above).

3.6.4 Effects on results

The effects of biases due to reduced visibility (1 to 4 above) on results would be to produce an underestimate of population density and size. The proportion of smaller groups would be underestimated, and if these comprised a certain age or sex class, then these too would be underestimated.

The effect of animals moving away would lead to an underestimate of population size and density.

It is expected that these effects would be more pronounced in the Turan P.A. and the road censuses than in the Kavir N.P. and aerial censuses.

Estimation of distance would affect estimation of population size and density. Since wild ass are usually underestimated, their population size and density would be overestimated. Aerial censuses of jebeer gazelle would be likely to produce underestimates of population size and density. Since distances were checked by pacing on road censuses, estimate of population size will not be affected.

Transects done later in the morning would produce an underestimate of population size and density since more animals would be lying down, and would show a distribution closer to springs and foothills. This would be more pronounced in the road censuses.

These points will be considered in the relevant chapters.

The aims and justifications of wildlife censusing have been reviewed by Caughley (1977). Considerable resources in time and effort are involved in accounting for biases and errors to produce accurate animal censuses. Accuracy is not the only aim of censusing, and is needed in instances, for example, where hunting or cropping quotas are to be set. Since the purpose of this study was to gather basic information pertaining to the ecology and conservation of jebeer and wild ass, it was more important to do censuses with standardized procedures that could be repeated, so that censuses between years and between areas and regions could be compared. In this approach, biases and errors remain constant so that comparisons can be made, and extra effort is not required to counteract their effect to produce accuracy.

Figure 3.1.a

Kavir N.P.: census areas and aerial transects.

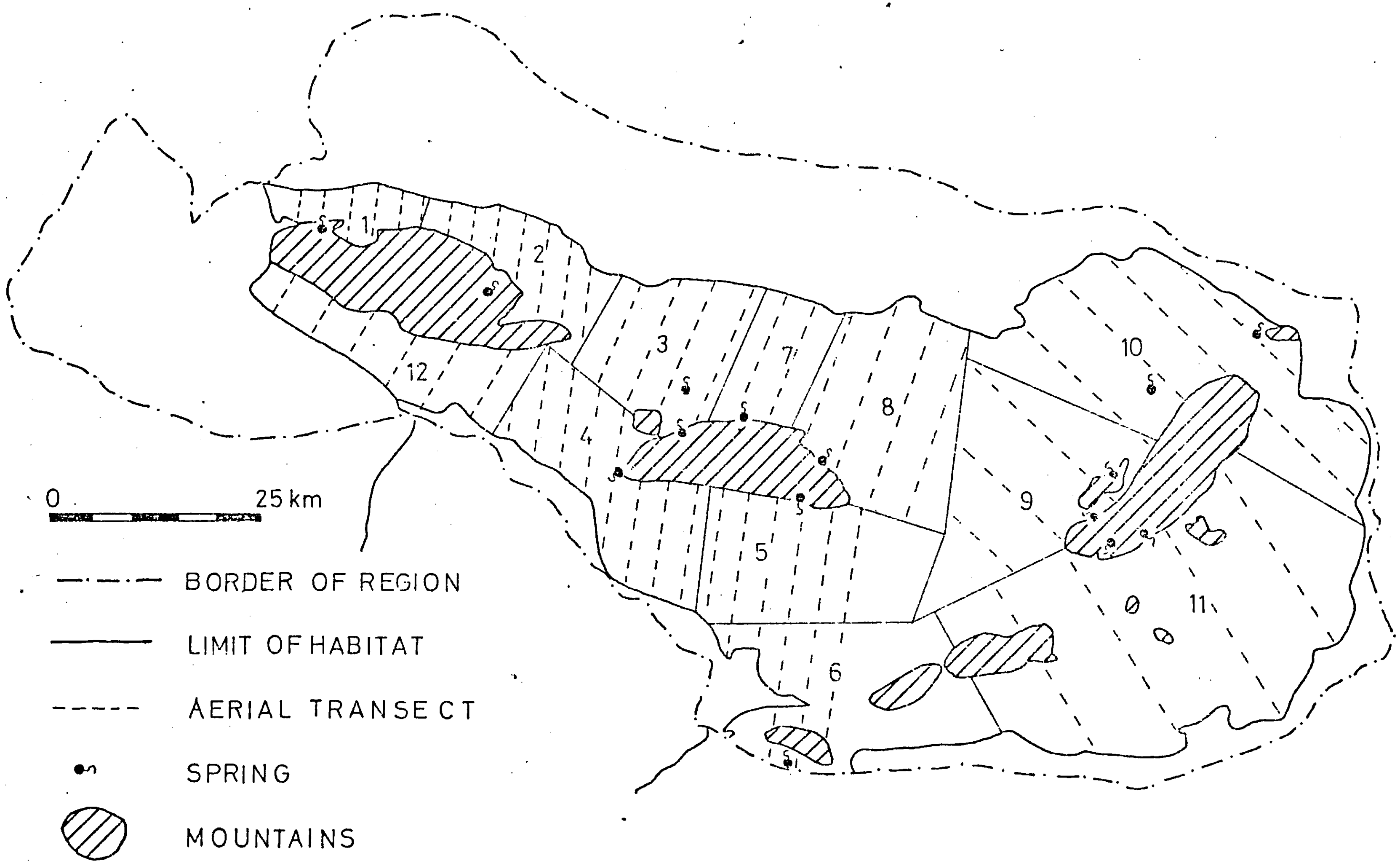
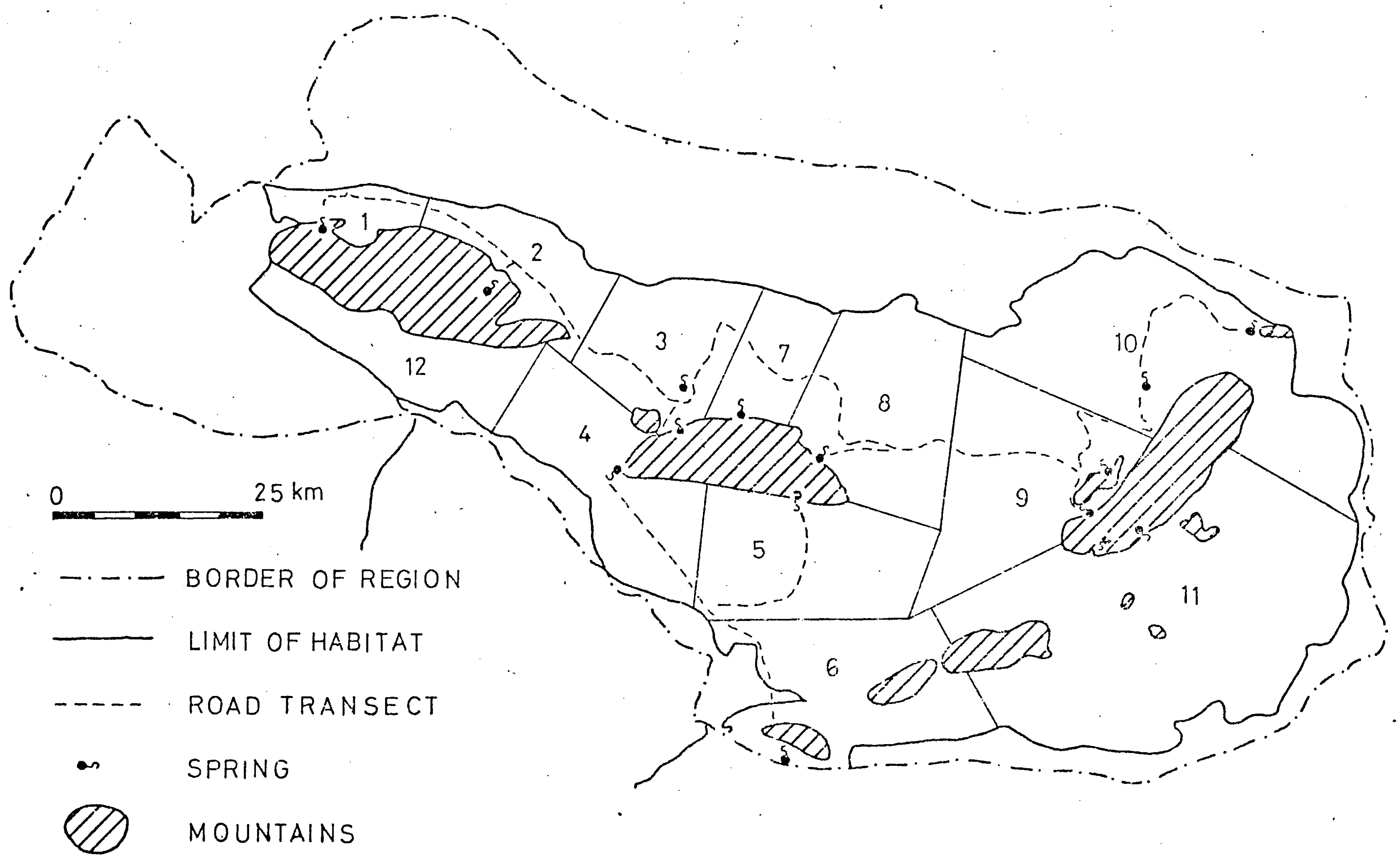

1
2
3
4
5
6
7
8
9
10
11
12
0
25 km
BORDER OF REGION
LIMIT OF HABITAT
AERIAL TRANSECT
SPRING
MOUNTAINS

Figure 3.1.b

Kavir N.P.: census areas and road transects.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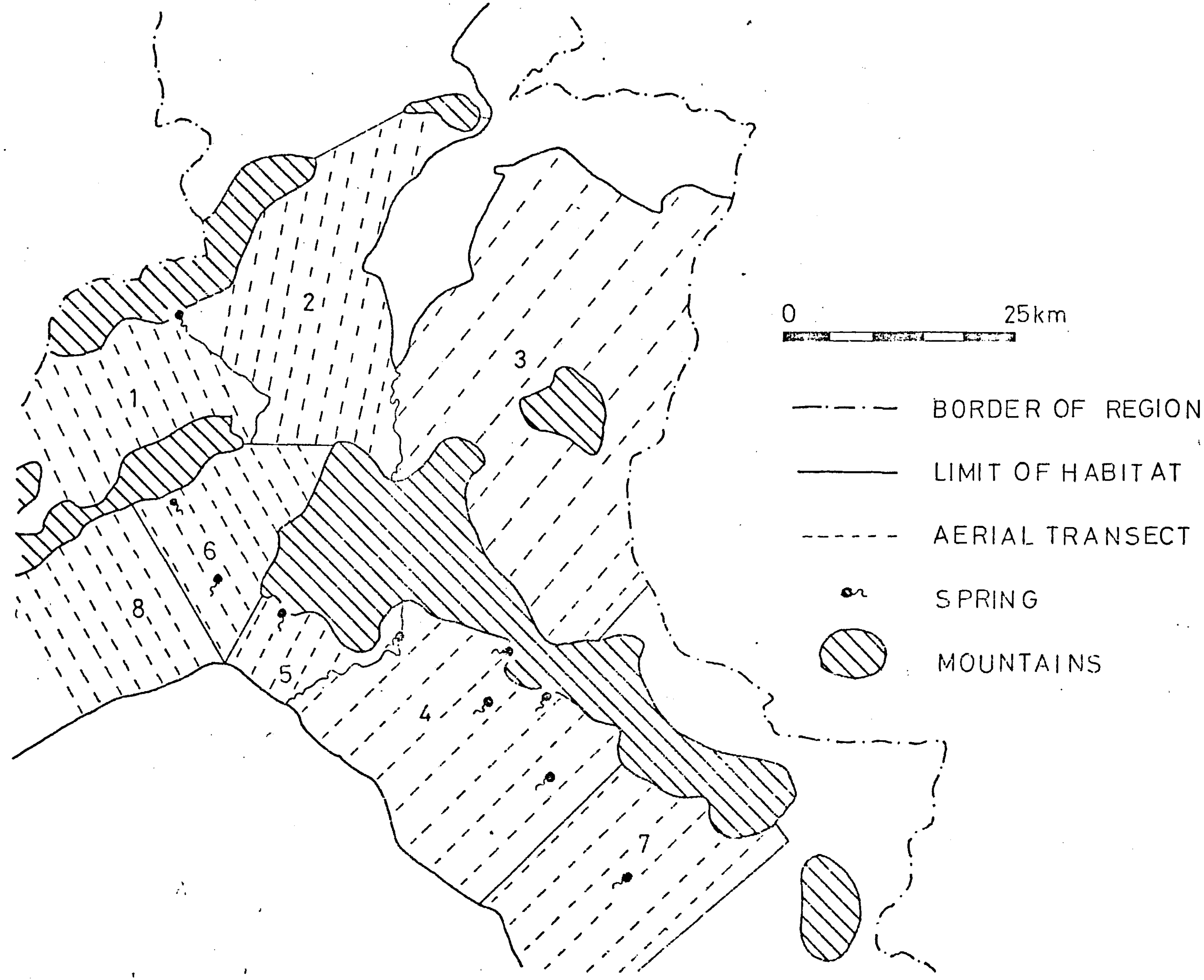
25 km
BORDER OF REGION
LIMIT OF HABITAT
ROAD TRANSECT
SPRING
MOUNTAINS

Figure 3.2.a

Turan P.A.: census areas and aerial transects.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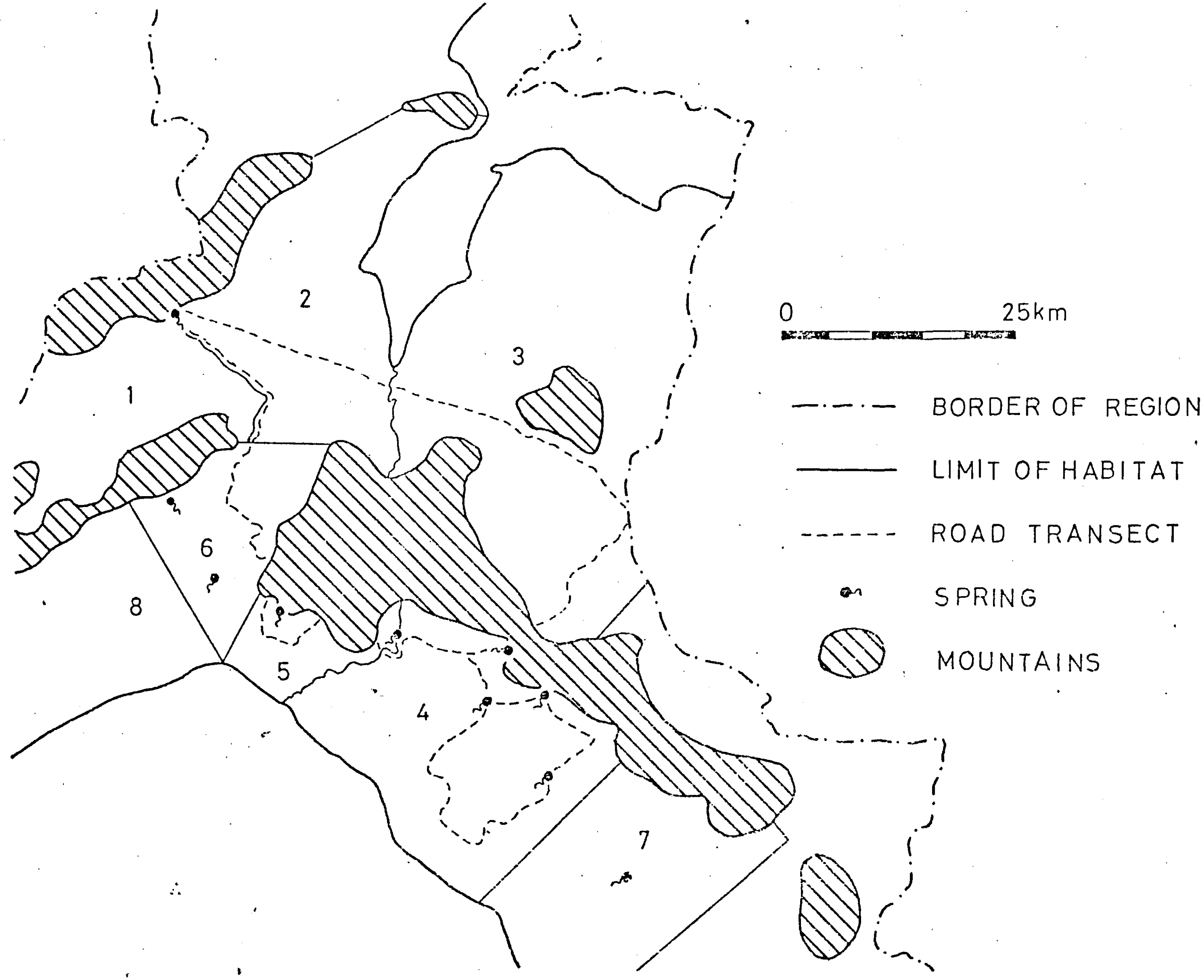
BORDER OF REGION
LIMIT OF HABITAT
AERIAL TRANSECT
SPRING
MOUNTAINS

Figure 3.2.b

Turan P.A.: census areas and road transects.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Chapter 4

POPULATION SIZE AND DISTRIBUTION

4.1 Introduction

Prior to the study no comprehensive survey had been done of either region to census jebeer gazelle and wild ass. An overflight of the Kavir N.P. had been done in 1969, and during the three hour flight 14 jebeer gazelle and 15 wild ass were seen. During a three day ground survey of the whole region in 1971, 29 jebeer gazelle and 2 wild ass were seen. During the latter survey, 4 jebeer were seen north of Siah Kuh, and the rest, including the wild ass, were seen in the region of Chah Qarqare. No surveys had been done of the Turan P.A.

4.2 Methods

4.2.1 Jebeer gazelle

a) Aerial census

To estimate the size of the jebeer populations from the aerial census, the transects were drawn onto maps at the end of the flight, and the number of individuals seen was summed for each transect. The length of the baseline in each area was then measured, and the number of possible transects in each area calculated by dividing the length of the baseline by 500 m, the width of a transect. The total number of individuals in each area was calculated by dividing the number of possible transects by the number of transects flown, and multiplying this figure by the total number of jebeer observed in the area. 95% confidence limits were calculated using Jolly's (1969) method for unequal sized sampling units.

b) Road census

Sightings of groups were transcribed onto maps using the kilometre reading from the odometer. From the map, the area in which they occurred and the distance from the spring could be determined. Total population for each area was then calculated by first of all finding the density of animals in the area sampled and multiplying by the total area. There was a significant difference in the density of animals in each vegetation type, and less than and greater than 12.5 km from springs, and so calculations were done separately for each vegetation type, and for distances nearer and greater than 12.5 km from springs.

Sometimes animals were encountered at the springs. In order to minimise disturbance to these individuals, the vehicle would stop up to a kilometer from the spring, in dead ground, and the spring approached on foot until it could be observed from a convenient and hidden vantage-point. Individuals counted at springs were not included in the calculation of population size from the transects, but were added to this figure to give an estimate of total population size. This was done because of the difficulty of deciding how many of these individuals were within the transect, and the fact that their distribution was highly contagious and determined by a feature of the habitat.

4.2.2 Wild ass

The population size of the wild ass was estimated using the formula suggested by Eberhardt (1968). Sightings for all four years were summarized in a histogram of number of individuals against right angle distances in 0.5 km intervals.

A curve was fitted by eye to these data (Fig 4.1) and the density of wild ass calculated using the formula:

$$\text{Density} = \frac{n\ (k + 1)^2}{4\,L\,\bar{x}\,k\ (k+2)}$$

where n = the number of animals seen

$\bar{x}$ = mean of their right angle distances from the line

L = total length of transect flown

k = constant describing the shape of the curve.

k is obtained from the formula:

$$P_x = 1 - \left(\frac{x}{W}\right)^k$$

where P_x = probability of seeing a wild ass x km from the line of flight

W = maximum distance at which an animal can be seen.

The density was multiplied by the area of each spring in which they were seen to obtain the population estimate. This was done for both aerial and road censuses.

4.2.3 Domestic sheep and goat

Sedentary domestic sheep and goat flocks were counted during aerial surveys. Since the flocks were large and visible, this was regarded as a total count. Average flock size was determined from counting flocks during road censuses.

Transhumant flocks were estimated by visiting all the corrals with local game guards familiar with the area in December when they were being used.

4.2.4 Statistical methods

Difficulties arise when calculating the variance of population estimates from the road transects, since there are no convenient units, and transects are not distributed randomly. The method employed was that of Hirst (1969).

For each census transects were driven three times each, and the population estimate calculated separately for each sample. The mean of these was taken as the final population estimate, and the 95% confidence limits calculated from the variance of the three estimates using the formula:-

$$\text{population variance} = \frac{1}{n} \cdot \left\{ \frac{\Sigma y^2 - (\Sigma y)^2}{n} \right\}$$

where n = no. of road counts, y = population estimate (Hirst, 1969).

The Spearman rank correlation coefficient (Siegel, 1956) was used to test the significance of the relationship between road and aerial census population estimates of jebeer gazelle.

4.2.5 Biomass

The mean weight of an individual was calculated by weighing shot specimens from different age and sex classes of the common goitered gazelle, and calculating the total weights from their proportions in observed wild populations. This mean weight was found to be 55% of an adult male.

Biomass of domestic sheep and goat were estimated by weighing different sex and age classes and calculating their proportions in the domestic population (Table 4.10).

4.3 Results

4.3.1 Kavir N.P.

a) Jebeer gazelle

The population estimates of jebeer increase over the four years of the study from about 650 in 1974 to about 1,100 in 1977. The mean finite rate of increase (Caughley, 1977) is

1.2 per year (Fig 4.2; Tables 4.1 and 4.2). The increase is not uniform throughout the region. Some areas show a steady increase, but others show marked increases or decreases between years (Fig 4.3).

The distribution of jebeer gazelle is not uniform throughout the region. Some areas have higher estimates of population size and density than others (Fig 4.4; Table 4.3).

There is a significant relationship between aerial and road censuses in the ranks of population estimates by area for 1975, 1976 and 1977 (Spearman rank correlation coefficient, r_S = 0.98; 1; 0.77 respectively, $P < 0.01$ in all cases (Siegel, 1956)) but not 1974 ($r_s = 0.55$, $P > 0.05$) (Table 4.4).

b) Wild ass

The estimates of population size and density of wild ass are very low. Their distribution is restricted to the eastern half of the region, mainly areas 10 and 11 (Fig 4.4; Table 4.5).

4.3.2 Turan P.A.

a) Jebeer gazelle

The population estimate of the jebeer gazelle from aerial census is 608 and from road census is 371 ± 78. The estimate from the road census is considerably lower (Tables 4.6 and 4.7).

There was variation in the population estimates and densities between areas. Areas 4 and 5 had the highest densities of jebeer (Fig 4.5; Tables 4.6 and 4.7). No jebeer occurred in areas 1, 3 and 8.

The data were not good enough to determine trends in population estimates. There was, however, a significant difference between summer/autumn and winter/spring road censuses in the number of jebeer observed in area 2 (Mann-Whitney U test, $U = 5$, $P = 0.021$ (Siegel 1956)) (Table 4.8).

b) Wild ass

The population estimates of wild ass are similar to those of jebeer. Estimates from aerial census were higher than road census; 638 and 283 respectively (Tables 4.6 and 4.7).

There was variation in the population estimates between areas, and this variation was greater than that shown by jebeer (Tables 4.6 and 4.7).

The wild ass occupied a similar range to that of jebeer (Fig 4.5). No wild ass were seen in areas 1, 2, 3 and 8.

The data were not good enough to determine trends in population estimates.

c) Domestic sheep and goat

There were large numbers of domestic sheep and goat in the region. There were more nomadic than sedentary domestics; 38,000 and 11,000 respectively.

Sedentary domestics occurred in varying densities throughout the region. Nomadic domestics occurred more evenly, but were more concentrated in the Delbar and Ahmadabad plains, areas 1, 2 and 3 (Table 4.9).

4.4 Discussion

4.4.1 Accuracy of census results

The intensive survey of area 3 in the Kavir N.P. did not produce a population estimate larger than that of the standard census (Table 4.1). Assuming that estimation of distance away of an animal has the same bias in both these censuses, then the same proportion of animals is being missed. The critical variable in the census procedure is probably the speed of the plane. This could not be reduced in the intensive survey because the engine would overheat. From this the conclusions to be drawn are that the estimates of jebeer are almost certainly underestimates for the reasons outlined in section 3.6, but the extent of the underestimate cannot be evaluated.

The accuracy of the wild ass population estimates could not be verified. The greater confidence limits compared to the jebeer (36% and 21% of the total estimate respectively (Table 4.7)) in the Turan P.A. means that conclusions should be drawn more tentatively. For the same reasons, population estimates are probably underestimates.

Areas censused later in the day, such as 1, 4, 9 and 10 in the Kavir N.P., which are at the ends of their respective transects, do not appear to be affected by jebeer lying down and going unseen. Estimates by road census are higher in areas 1 and 10 than by aerial census, which is done earlier in the day. Those for the other two areas are variable. The change in activity during the course of the transect sampling, that is, the first four hours after sunrise, is therefore not enough to affect the population estimate.

4.4.2 Comparison of aerial and road censuses

The estimates of population size by aerial and road censuses in the Kavir N.P. are very similar (Fig 4.2). The road censuses give a slightly higher figure for three of the four years, and this discrepancy would be greater but for the fact that areas 11 and 12 were not included in the road censuses. The estimates from aerial censuses are between 4% and 10% of the total for these areas.

The conditions of the habitat in the Kavir N.P. are so ideal for viewing that aerial censusing at the level done in this study does not improve on road censusing. The animals that are missed due to the lower height of a Land Rover are probably compensated for by those that are missed by the plane's greater speed, and overestimates of the distance away of jebeer, thus producing an underestimate of the population size. Aerial censuses are better in that they take a shorter time and cover areas inaccessible by road.

In the Turan P.A. the population estimates of jebeer by road census are considerably lower than by aerial census (Tables 4.6 and 4.7) and this must be due to the animals' timidity. They are moving out of the way on the approach of the Land Rover so that they are missed, or are counted as outside the transect. The plane, on the other hand, travels too fast for them to get out of the way. In the Kavir N.P. the jebeer are more tame and do not react to the Land Rover.

Censuses of wild ass produce the same pattern. More wild ass are missed during road censuses. A smaller proportion of animals are seen at greater distances during road censuses (Fig 4.1) so that when wild ass move away on the approach of the Land Rover there is a lower probability that they will be seen.

4.4.3 Population trends

The significant correlation between aerial and ground census results for jebeer in the Kavir N.P. (Table 4.4) suggests that these results reflect the real trends and differences between areas in the jebeer population.

The only population trend that emerges is that of the jebeer gazelle in the Kavir N.P. The population size increases over the four years of the study. The mean finite rate of increase is about 1.2 per year, and this is confirmed by both aerial and road censuses. The removal of domestic flocks, the cessation of hunting in 1964 and the succession of above average rainfall years may all be contributing to this.

The rate of increase is slightly higher than that encountered in Israel with the dorcas gazelle. Censuses done in two areas of the Arava Rift Valley between 1966 and 1971 produced finite rates of increase of 1.08 and 1.17 per year. This was the result of a cessation of hunting only. Previously unrestricted hunting had reduced the dorcas gazelle to near extinction. Domestic sheep and goat were also present in both areas (Mendelssohn, 1974).

The increase in numbers is not uniform throughout the Kavir N.P. Some areas show a steady increase such as 1. Some show a considerable increase suggested by both aerial and road censuses, such as area 7 from 1974 to '75 (0 to 60 and 3 to 76) and 1975 to '76 (60 to 179 and 76 to 140), and area 9 from 1976 to '77 (76 to 171 and 45 to 110). Others show decreases, such as area 10 from 1976 to '77 (283 to 88 and 359 to 260) (Tables 4.1 and 4.2). Discounting extremes of fecundity and mortality, these differences must be due to movement of animals. The increase in area 9 from 1976 to '77 is probably due to the movement of individuals from area 10, accounting for the latter's decrease. These mass movements were confirmed by an incidental aerial survey in October 1974, when 84 jebeer were seen in area 12 in 80 km of flying, considerably more than the previous maximum of 4 in 42 km.

There is a movement of jebeer into area 2 of the Turan P.A. during winter.

The data were not good enough to determine trends in the jebeer population in the Turan P.A. since fewer samples were taken and so variance was greater.

Similarly, no trend could be detected in the wild ass populations.

4.4.4 Population densities

a) Jebeer gazelle

Overall densities of jebeer gazelle are similar in both the Kavir N.P. and Turan P.A. study area. Since the Turan study area had the densest numbers in the region, the figure for the region as a whole would be less. The jebeer do reach higher densities in areas of the Kavir N.P. though. Areas 1 and 7 have densities of 1.52 and 1.34/km^2 in 1977, twice that of the highest figure in Turan, 0.67 in area 5 (Tables 4.3 and 4.6). This suggests that the presence of domestic flocks does suppress jebeer densities.

Densities encountered in good dorcas gazelle habitat in Israel are similar to those encountered in Iran. In the two areas of the Arava Rift Valley referred to in 4.4.3 the densities are 0.57 and 0.23/km^2 (Mendelssohn, 1974).

b) Wild ass

The wild ass in the Turan P.A. occur at a density several times greater than that in the Kavir N.P., 0.39/km^2 and 0.02/km^2 respectively (Tables 4.4 and 4.6). Since the wild ass do coexist with domestics in the Turan P.A., it does seem unlikely that the presence of domestics in the Kavir N.P. before protection in 1964 would be the cause of their lower densities. A more likely explanation is that hunting suppressed their numbers in the Kavir. They are very easy animals to hunt from vehicles, being large-bodied, living in flat terrain, and running in a straight line at a relatively slow speed when chased. The Kavir N.P. is located close to Tehran, and stories are common amongst Tehranis of motorised excursions to hunt wild ass. The Turan P.A., on the other hand, is remote from such a large concentration of people.

4.4.5 Biomass and carrying capacity

There is no way of telling what the wild large herbivore carrying capacity is. The Turan P.A. is supporting a much higher permanent biomass of large herbivores than the Kavir N.P. (114 compared with 7 kg/km^2), and 70% of this comprises domestics. This cannot be equated with wild herbivore carrying capacity since domestics are stocked at higher densities than those reached by wild herbivores (Pratt and Gwynne, 1977). Coe *et al*. (1976) produced a regression of large herbivore biomass against rainfall for East Africa, but this is little use here since the habitat is different, and the points at the 200 mm annual rainfall negligible.

4.4.6 Distribution

a) Jebeer gazelle

The jebeer gazelle are not evenly distributed over both regions. In the Kavir N.P. they are most common in areas which contain a spring undisturbed by human presence. Table 4.10 lists the areas ranked in order of population sizes. Those with the least jebeer are areas 2, 11, 12 and 6. Area 12 does not have a spring; area 2 has a mine in use next to the spring; area 6 has a game guard post next to its spring; and the two springs in area 11 have a game guard post and a cystern which is visited every day (Fig. 4.4; Table 4.11).

Similarly, in the Turan P.A. jebeer are absent from or occur in very low numbers in areas 1 and 8 which do not contain springs, and area 3 which has a village at the only water source. Jebeer occur in their greatest densities in areas 4 and 5, which also contain fewest sedentary domestics. The nomadic domestics occur throughout the region and do not appear to change the jebeer distribution in winter (Fig 4.5; Table 4.7).

b) Wild ass

Wild ass are restricted to the eastern half of the Kavir N.P., mainly areas 10 and 11 (Fig 4.4; Table 4.5). In these two areas much of the terrain is broken by calcareous lithosols and there are no roads, making it inaccessible to motor vehicles. They probably survive here as a refuge from motorised hunting.

In the Turan P.A. the wild ass show a very similar pattern of distribution to the jebeer, being absent from areas 1, 2, 3 and 8. They do, however, occur in much greater densities than jebeer in area 6 (Fig 4.5; Table 4.6).

4.5 Summary

1. Jebeer population estimates in the Kavir N.P. increase during the study at a finite rate of about 1.2 per year. Data were not good enough to determine trends in the Turan N.P.

2. Population estimates of areas in the Kavir N.P. fluctuate from year to year due to movement of jebeer between areas.

3. There is a significant correlation between aerial and road censuses in their population estimates in the Kavir N.P.

4. Wild ass are few in numbers in the Kavir N.P., and restricted to the remote eastern part due to overhunting in the recent past.

5. The Turan P.A. has a large number of wild ass. They have escaped hunting pressure due to the region's remoteness.

6. Road censuses produce lower population estimates than aerial censuses in the Turan P.A., due to the greater timidity of the animals compared with the Kavir N.P.

7. Jebeer gazelle reach higher densities in areas of the Kavir N.P. than the Turan P.A., suggesting that domestics suppress jebeer densities.

8. Jebeer and wild ass do not occur in areas without a spring, or where the spring is taken over by permanent human habitation.

Table 4.1

Population estimates of jebeer gazelle from aerial censuses, Kavir N.P.

Area	1974 July		1975 July		1976 July		1977 July	
	number observed	population estimate	number observed	population estimate	number observed	population estimate	number observed	population estimate
1. Mil	26	82	20	95	21	100	27	129
2. Gel	15	55	5	34	11	58	13	69
3. Shah Abbas	3	14	14	83	29	138	22	105
4. Shur	9	73	5	51	12	81	15	67
5. Shekar Ab	9	101	7	59	5	34	9	60
6. Sefid Ab	0	0	2	13	8	41	2	10
7. Sorkh	0	0	5	60	30	179	18	143
8. Lakab	3	33	9	75	12	100	9	75
9. Talkhab/Sorkhab	5	38	1	10	8	76	18	171
10. Qarqare/Takkuh	23	178	40	247	55	283	17	88
11. Nakhjil/Molkabad	4	52	7	74	0	0	5	52
12. S. Baba Hemat	0	0	4	24	3	41	1	8
Total	97	626	119	825	194	1131	156	977
95% confidence limits		± 325		± 347		± 644		± 303
No. transects	66		51		63		68	

Intensive census of area 3:	number observed	population estimate	number of transects
	66	114	19

Table 4.2 Population estimates of jebeer gazelle from road transects, Kavir N.P.

Area	1974 July/September		1975 July/September		1976 July		1977 July	
	Observed jebeer	Population estimate	Observed jebeer	Population estimate	Observed jebeer	Population estimate	Observed jebeer	Population estimate
1. Mil	39(184)	198	30(184)	206	16(166)	128	41(174)	249
2. Gel	9	17	15	28	24	45	37	73
3. Shah Abbas	5	22	31	121	26	105	40	160
4. Shur	2	13	4	25	8	51	9	57
5. Shekar Ab	15	69	7	39	3	18	9	41
6. Sefid Ab	7	46	4	36	4	21	4	22
7. Sorkh	1	3	26	76	48	140	38	111
8. Lakab	15(5)	45	25(18)	80	21	67	33	107
9. Talkhab/Sorkhab	6	16	17(2)	45	19	45	38	110
10. Qarqare/Takkuh	54	270	55(53)	326	62(52)	359	48(9)	260
Total	255(189)	699	386(257)	982	231(218)	979	297(196)	1190
95% confidence limits		± 183		± 219		± 346		± 220
Number of samples	6		6		3		3	

Numbers in brackets = number of individuals seen at springs.

Table 4.3

Densities of jebeer gazelle in the Kavir N.P.

Aerial census, July 1977.

Area	Area of jebeer and ass habitat	Density of jebeer
1. Mil	85 km^2	1.52/km^2
2. Gel	153	0.45
3. Shah Abbas	255	0.41
4. Shur	254	0.26
5. Shekar Ab	364	0.16
6. Sefid Ab	296	0.03
7. Sorkh	107	1.34
8. Lakab	323	0.23
9. Talkhab/Sorkhab	375	0.46
10. Qarqare/Takkuh	591	0.15
11. Nakhjil/Molkabad	965	0.05
12. S. Baba Hemat	253	0.03
	Mean	0.24/km^2

Habitat includes *Artemisia*, *Zygophyllum*, *Haloxylon*, *Seidlitzia* and calcareous lithosols.

Table 4.4

Relationship between aerial and road censuses of jebeer population estimates in Kavir N.P. Values of Spearman rank correlation coefficient (Siegel, 1956); N = 10 in all cases.

Year	r_s	P	
1974	0.55	> 0.05	NS
1975	0.98	< 0.01	*
1976	1.0	< 0.01	*
1977	0.77	< 0.01	*

NS = not significant

* = significant

Table 4.5

Estimates of population size and density of wild ass in Kavir N.P. from aerial censuses. All years combined.

Area	Population size	Density in habitat	Mean Number observed per census	Mean Number of transects per census
5. Shekar Ab	7	0.02/km^2	3.0	4.5
7. Sorkh	1	0.01	0.75	3.5
8. Lakab	2	0.01	0.5	4.0
10. Qarqare/Takkuh	16	0.03	4.5	5.5
11. Nakhjil/Molkabad	28	0.04	9.25	5.0
Total	54	0.02/km^2	18.0	22.5

Habitat includes Artemisia, Zygophyllum, Haloxylon, Seidlitzia and calcareous lithosols.

Table 4.6

Population estimates of jebeer and wild ass in the Turan P.A. from aerial census.

July 1977

a) Jebeer gazelle

Area	Number observed	Population estimate	Density in habitat
1. W. Delbar	0	0	0.0 /km^2
2. E. Delbar	3	16	0.03
3. Ahmadabad	0	0	0
4. Sitel	65	430	0.53
5. Chah Vekil	18	90	0.67
6. Abul Yahya	7	44	0.11
7. Gel	6	28	0.09
8. W. Majerad	0	0	0
Total	99	608	0.28/km^2
95% confidence limits		$\pm$ 537	

b) Wild ass

Area	Number observed	Population estimate	Density in habitat
1. W. Delbar	0	0	0.0 /km^2
2. E. Delbar	0	0	0
3. Ahmadabad	0	0	0
4. Sitel	92	255	0.32
5. Chah Vekil	53	87	0.65
6. Abul Yahya	161	328	0.86
7. Gel	45	78	0.25
8. W. Majerad	0	0	0
Total	382	638	0.39/km^2
95% confidence limits		$\pm$ 914	

Number of transects = 64

Total densities are calculated only from those areas in which jebeer and wild ass were seen.

Habitat includes *Zygophyllum*, *Haloxylon* and *Seidlitzia*.

Table 4.7

Population estimates of jebeer and wild ass in the Turan P.A. from road censuses. All censuses are combined.

Number of samples = 12

a) Jebeer gazelle

Area	Number observed	Population estimate	Density in habitat
1 & 2 Delbar	9	17	0.02/km^2
3. Ahmadabad	0	0	0
4. Sitel	198	270	0.33
5. Chah Vekil	38	45	0.34
6. Abul Yahya	24	39	0.1
Total	269	371	0.2/km^2
95% confidence limits		± 78	

b) Wild ass

Area	Number observed	Population estimate	Density in habitat
1 & 2 Delbar	0	0	0.0
3. Ahmadabad	0	0	0
4. Sitel	256	127	0.16
5. Chah Vekil	111	56	0.42
6. Abul Yahya	234	100	0.26
Total	601	283	0.2 /km^2
95% confidence limits		±103	

Habitat includes *Zygophyllum*, *Haloxylon* and *Seidlitzia*.

Table 4.8

Results of the Mann-Whitney U test to test the significance of the difference between winter/spring and summer/autumn in the number of jebeer gazelle seen during road censuses in area 2 (Delbar), Turan P.A.

	winter/spring	summer/autumn	U	P
number of individuals observed	23	4	5	0.021
population estimate	38	7		
number of samples	6	6		

Table 4.9

Population estimates of domestic sheep and goat in the Turan P.A.

a) sedentary

Area	Population estimate	Density in habitat	
1. W. Delbar	3,500	10.8/km^2	
2. E. Delbar	500	1.0	
3. Ahmadabad	5,000	0.5	Ratio of sheep:goat = 1:1
4. Sitel	500	0.6	
5. Chah Vekil	0	0	Mean flock size = 500
6. Abul Yahya	500	1.3	
7. Gel	1,000	3.1	
8. W. Majerad	0	0	
Total	11,000	2.9/km^2	

b) nomadic

Area	Population estimate	Density in habitat	
1. W. Delbar	8,000	24.6/km^2	
2. E. Delbar	8,000	15.9	
3. Ahmadabad	12,800	12.4	Ratio of sheep:goat = 1:0.23
4. Sitel	1,600	2.0	
5. Chah Vekil	1,200	9.0	Mean flock size = 400
6. Abul Yahya	2,800	7.3	
7. Gel	1,600	5.0	
8. W. Majerad	2,000	6.6	
Total	38,000	10.0/km^2	

Sedentary flocks are in the region throughout the year.
Nomadic flocks are in the region from November to March.
Habitat includes *Zygophyllum*, *Haloxylon* and *Seidlitzia*.

Table 4.10

Large herbivore biomass

a) Kavir N.P. (1977)

Species	Biomass	Density in habitat
Jebeer gazelle	16,600 kg	4.13 kg/km^2
Wild ass	10,300	2.56
TOTAL	26,900	6.69

b) Turan P.A.

Jebeer gazelle	10,300 kg	2.7 kg/km^2
Wild ass	122,800	32.3
Sedentary domestics	302,500	79.5
TOTAL	435,600	114.4
Nomadic domestics	950,000	24.9
TOTAL	1,385,600	364

Habitat includes *Artemisia*, *Zygophyllum*, *Haloxylon*, *Seidlitzia* and calcareous lithosols.

Table 4.11

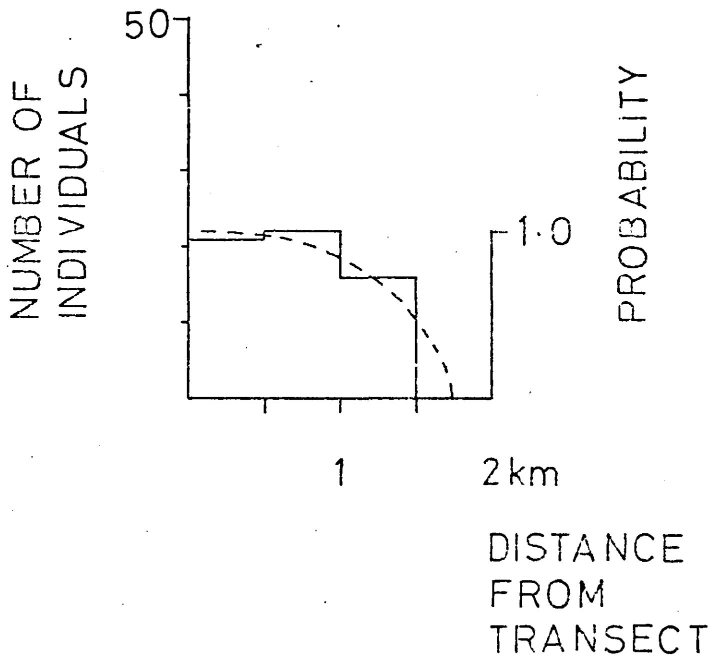
Areas of the Kavir N.P. ranked according to mean density of jebeer from the four aerial censuses.

Rank	Area	Mean density of jebeer (per km^2)
1	1. Mil	1.19
2	7. Sorkh	0.89
3	10. Qarqare/Takkuh	0.34
4	3. Shah Abbas	0.33
5	4. Shur	0.27
6	2. Gel	0.25
7	8. Lakab	0.22
8	9. Talkhab/Sorkhab	0.2
9	5. Shekar Ab	0.17
10	12. S. Baba Hemat	0.08
11	12. Sefid Ab	0.05
12	11. Nakhjil/Molkabad	0.04

Figure 4.1

Number of wild ass seen at various distances from the transect.

a) AERIAL



b) ROAD

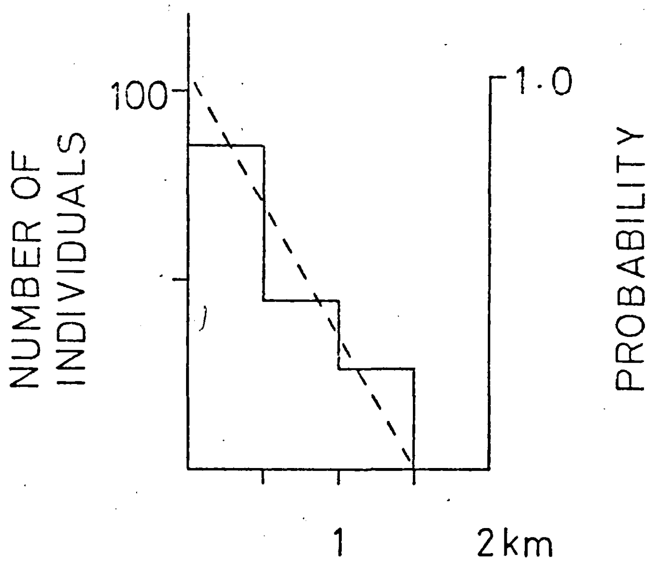


Figure 4.2

Population estimates of jebeer gazelle in the Kavir N.P.

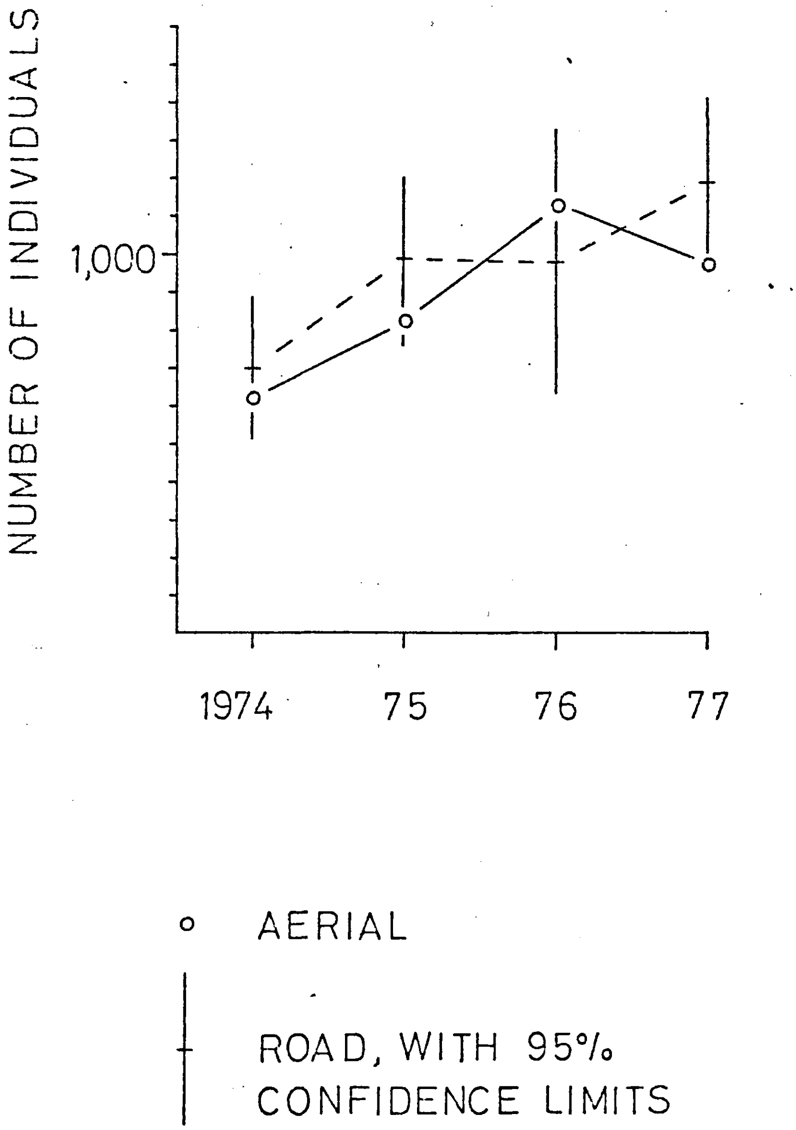
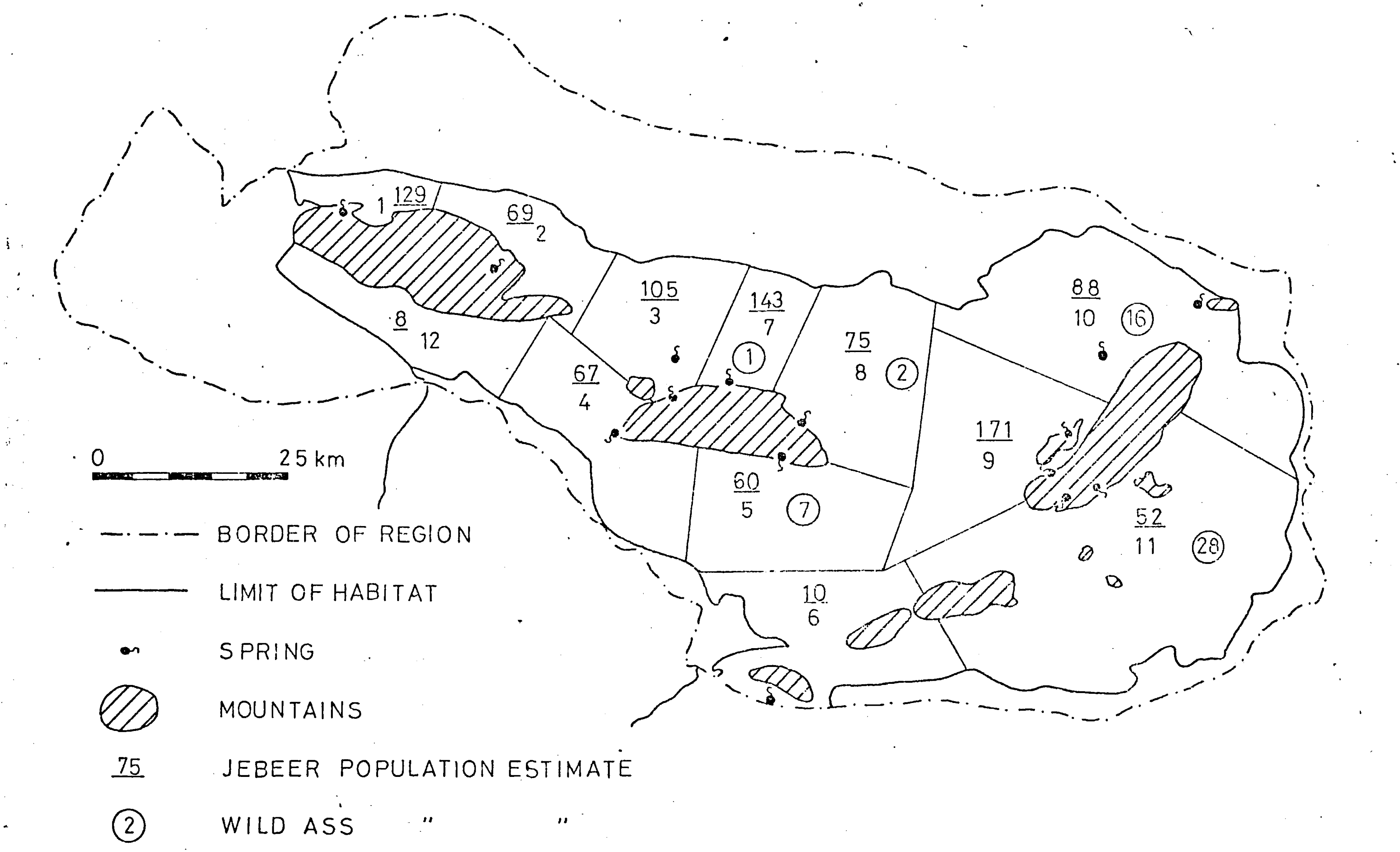

NUMBER OF INDIVIDUALS
1,000
1974
75
76
77
AERIAL
ROAD, WITH 95%
CONFIDENCE LIMITS

Figure 4.3

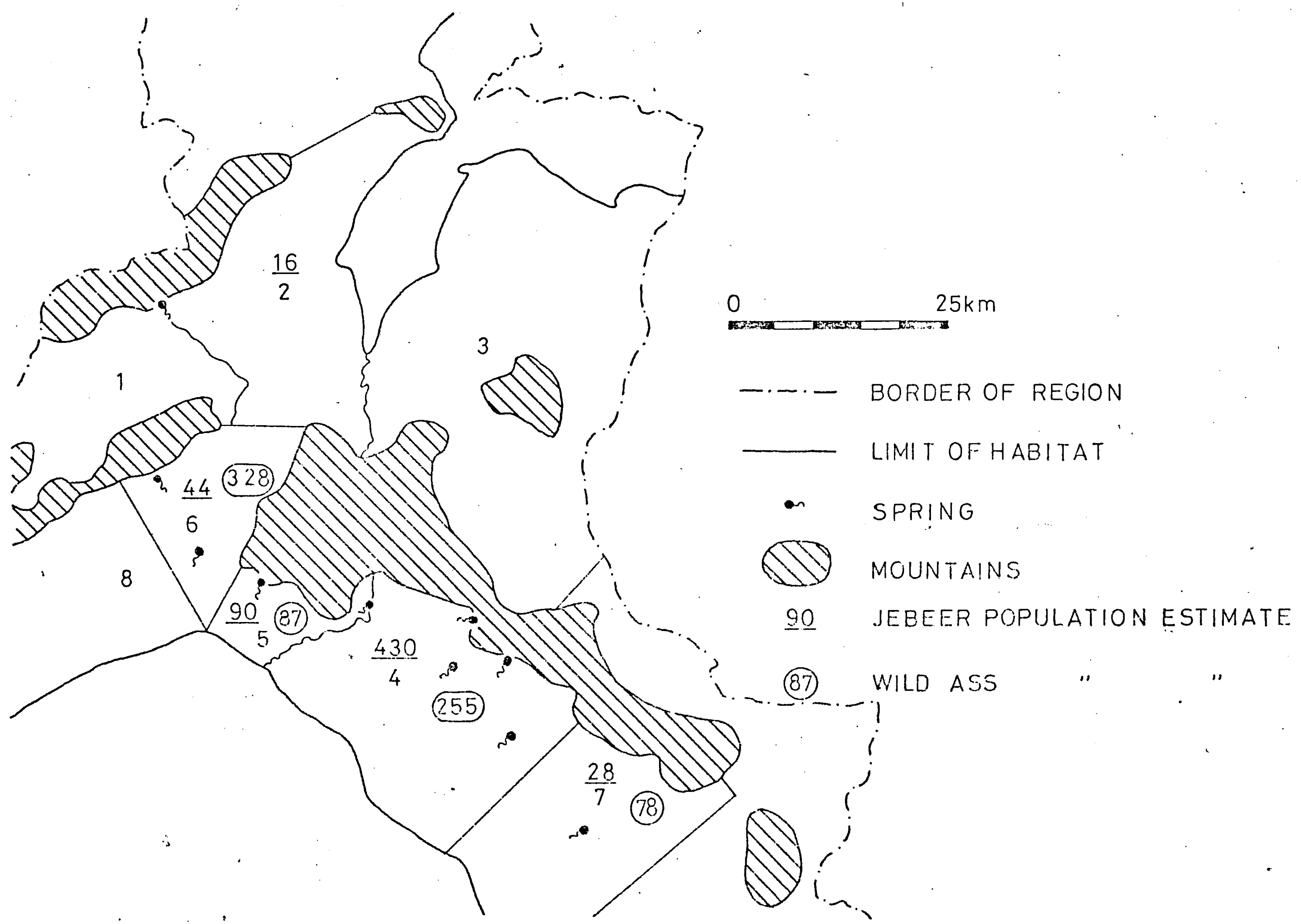
Map of Turan P.A. with population estimates from aerial censuses.



1 129
69 2
8 12
105 3
67 4
143 7
1
75 8
2
60 5
7
10 6
88 10
16
171 9
52 11
28
0 25 km
BORDER OF REGION
LIMIT OF HABITAT
SPRING
MOUNTAINS
75 JEBEER POPULATION ESTIMATE
2 WILD ASS " "

Figure 4.4

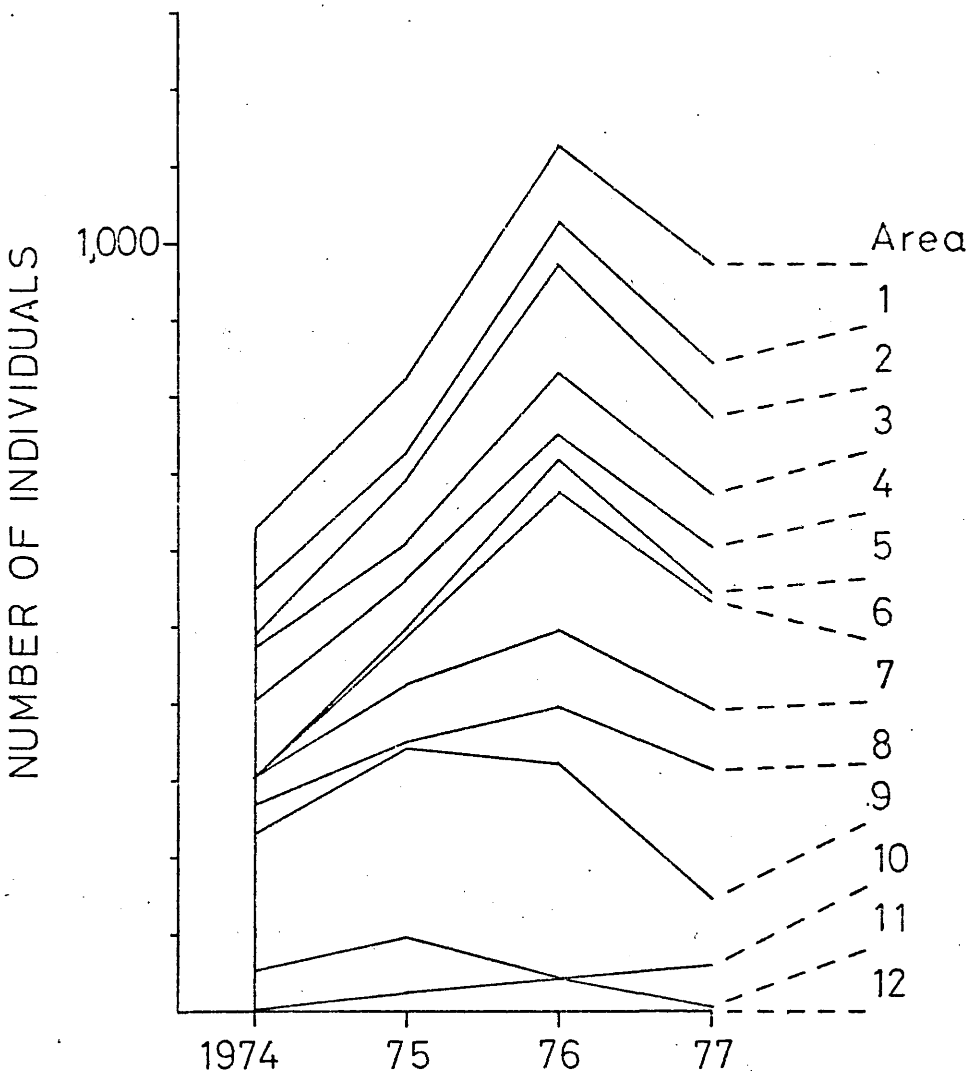
Map of Kavir N.P. with population estimates from aerial census.



16
2
1
3
44
328
6
8
90
87
5
430
4
255
28
7
78
0
25km
BORDER OF REGION
LIMIT OF HABITAT
SPRING
MOUNTAINS
90 JEBEER POPULATION ESTIMATE
87 WILD ASS " "

Figure 4.5

Population estimates of jebeer gazelle by area from aerial census in the Kavir N.P.



NUMBER OF INDIVIDUALS
1,000
Area
1
2
3
4
5
6
7
8
9
10
11
12
1974
75
76
77

Chapter 5

HABITAT PREFERENCES

5.1 Introduction

There is little evidence to suggest what the natural climax vegetation of the Dasht e Kavir should be. Pollen analysis from lake beds in the Zagros Mountains indicate that there has been a reduction in the proportion of woody vegetation, in particular oak and pistachio, associated with human disturbance at these sites in the last several thousand years (van Zeist, 1967). Domestic grazing and collecting of woody vegetation for charcoal has occurred in the Dasht e Kavir, so a similar modification of the habitat is possible. *Haloxylon* in particular is a favourite source of charcoal since it has a dense wood (Rechinger and Wendelbo, 1976). The Kavir N.P. had been protected for ten years at the start of the study, so it was expected that the habitat and its wildlife populations would have made some progress in recovering from this modification. Comparing this region with the Turan P.A., with its continued occupation by man and his domestics, might provide evidence of how the gazelle prefer to use their habitat, how this has been modified by disturbance, and what management procedures should be used if habitat is to be improved for jebeer and wild ass.

Since the distribution of jebeer and wild ass were determined by distribution of springs (Chapter 4), habitat preference was analysed by analysing the number of animals seen at various distances from springs. Densities in habitat types were also analysed.

5.2 Methods

5.2.1 Distance from springs

The distance from each animal sighting to the nearest spring was measured. The number of animals observed in each distance category - 0 to 5 km; 5 to 7.5 km; 7.5 to 10 km; 10 to 12.5 km; and > 12.5 km from the nearest spring - was summed. The number of animals expected in each category if the observed population was distributed at random was calculated from the proportions of total area sampled. A χ^2 value was calculated from the difference between observed and expected figures. To test whether animals were significantly selecting or avoiding a category a significance level of $P = 0.01$ was used rather than 0.05 since it is relatively easy to get a significant χ^2 value when sample size is large (Norton-Griffiths, 1978).

5.2.2 Habitat types

Six habitat types were recognised: foothills; calcareous lithosols; *Haloxylon*; *Zygophyllum*; *Artemisia*; and *Seidlitzia*. Habitat was recorded from aerial transects and drawn onto maps (Figs 2.4 and 2.6). Observed and expected numbers of animals and a χ^2 value and its significance was calculated in the same way as 5.2.1 for each type.

5.3 Results

5.3.1 Distance from springs in the Kavir N.P.

a) Jebeer gazelle

At the time of the sampling in the Kavir N.P. jebeer are significantly selecting sites closer to springs and significantly avoiding sites further away during the summer months (Table 5.1.a).

The road censuses show the same pattern, and that it persists into November, but to a less marked degree. In winter and spring the jebeer are more evenly distributed and show no significant preference for or avoidance of sites by distance (Table 5.2).

The jebeer do not significantly select sites close to springs in area 10 compared with the other more populated springs (Table 5.3).

b) Wild ass

Wild ass show no preference for distances from springs (Table 5.1.b).

5.3.2 Distance from springs in the Turan P.A.

a) Jebeer gazelle

Jebeer gazelle show no preference for sites within 5 km of the nearest spring (chi-squared one-sample test, $\chi^2 = 0.24$, $P > 0.99$ (Siegel, 1956)) or 5 to 7.5 km from the nearest spring ($\chi^2 = 6.3$, $P > 0.1$). They are significantly selecting sites between 7.5 and 10 km ($\chi^2 = 35.6$, $P < 0.001$) and 10 and 12.5 km ($\chi^2 = 62.2$, $P < 0.001$), and significantly avoiding sites further than 12.5 km ($\chi^2 = 41$, $P < 0.001$) (Table 5.4.a).

b) Wild ass

Wild ass show no preference for sites within 5 km of the nearest spring ($\chi^2 = 2.04$, $P > 0.5$), nor between 7.5 and 10 km from the nearest spring ($\chi^2 = 4.8$, $P > 0.1$). They are significantly selecting sites between 5 and 7.5 km ($\chi^2 = 34$, $P < 0.001$) and significantly avoiding sites further than 10 km ($\chi^2 = 25.4$, $P < 0.001$). Distances further than 12.5 km were not sampled in the range of the ass (Table 5.4.b).

5.3.3 Habitat types in the Kavir N.P.

a) Jebeer gazelle

In the Kavir N.P. the jebeer are significantly selecting *Haloxylon* and *Artemisia* and significantly avoiding *Seidlitzia* at all times of the year. The foothills and calcareous lithosols are avoided in summer, autumn and winter, but not in spring (Table 5.5).

b) Wild ass

In the Kavir N.P. wild ass are significantly selecting *Zygophyllum* habitat ($\chi^2 = 22.8$, $P < 0.001$) and significantly avoiding calcareous lithosols ($\chi^2 = 17$, $P < 0.01$) and *Seidlitzia* ($\chi^2 = 19$, $P < 0.01$) (Table 5.6).

5.3.4 Habitat types in the Turan P.A.

a) Jebeer gazelle

At the time of sampling in the Turan P.A., in autumn, winter and spring jebeer gazelle are significantly selecting Haloxylon ($\chi^2 = 53.4$, $P < 0.001$). In late spring and summer they are significantly selecting Haloxylon ($X^2 = 37.8$, $P < 0.001$) and foothills ($\chi^2 = 104$, $P < 0.001$). Artemisia and calcareous lithosols did not occur in the study area. Seidlitzia was not sampled (Table 5.7).

b) Wild ass

At the time of sampling in the Turan P.A., wild ass are significantly selecting Zygophyllum ($\chi^2 = 10.3$, $P < 0.01$) and significantly avoiding Haloxylon ($\chi^2 = 32.9$, $P < 0.001$) (Table 5.8).

5.4 Discussion

5.4.1 Jebeer gazelle

Jebeer gazelle prefer habitats close to springs in summer. They move in to springs during the middle of the day (Chapter 7) and this affects the results. Ground censuses in the Kavir N.P. show jebeer significantly selecting sites within 5 km of the nearest spring and significantly avoiding all other distances (Table 5.1). Aerial censuses, which are completed earlier in the day, show jebeer significantly selecting sites within 7.5 km, and significantly avoiding all other distances (Table 5.2). By the time the road sampling is completed, the jebeer have moved closer to the springs.

Around Qarqare and Takkuh springs in area 10 of the Kavir N.P. the jebeer are more evenly distributed in summer, and do not significantly select or avoid any distance (Table 5.3). This area differs from the others in having the springs out on the plains and not in foothills, and having extensive areas of Haloxylon, for which the jebeer are significantly selecting (Fig 2.4).

The Turan P.A. shows a different pattern. Jebeer are significantly selecting distances between 7.5 and 12.5 km from the nearest spring, but showing no preference for closer distances. Most of the jebeer occur in area 4, and in this area there is Haloxylon habitat at distances between 7.5 and 12.5 km from the nearest spring. Since they significantly select this habitat, then they correspondingly select for these distances.

Another difference between the regions is that during late spring and summer in the Turan P.A. jebeer are significantly selecting foothills (Table 5.7) which in the Kavir N.P. they are significantly avoiding (Table 5.5). In Turan only Kuh e Chah Vekil in area 5 and 6 contained foothills. The spring in this part of the region, Chah Vekil, is also the only spring in the region to occur in foothills. The other areas have springs out on the plains (Abul Yahya in area 6, Sitel and Chahak in area 4) (Fig 2.6). In the Kavir N.P. jebeer do move towards the springs situated in foothills as discussed above. The reason the data do not show they select for foothills is that the sampling is complete before the jebeer reach them. At Chah Vekil in area 5 of the Turan P.A., there is only a small area of plain at a small distance from the spring and foothills and so the jebeer have time to reach the foothills before the Land Rover.

The jebeer, therefore, are selecting for sites close to springs that occur in foothills. Where these springs occur out on the plains in association with *Haloxylon*, they select *Haloxylon* habitat rather than sites closer to springs. This selection for sites closer to springs does not occur in winter and spring.

It seems the reason they select foothills and *Haloxylon* is partly for shade. The open plains are flat and exposed, and in *Artemisia* and *Zygophyllum* habitat the vegetation too short to offer shade. *Haloxylon*, on the other hand, is taller than a jebeer and can offer shade. Bedding sites were often seen under Haloxylon bushes, but not under *Zygophyllum* or *Artemisia*. In the latter habitat they seek out foothills for shade in summer. This will be discussed further in Chapter 7.

In the Kavir N.P., jebeer avoid foothills and calcareous lithosols during summer, autumn and winter. In spring this is not the case, and their observed numbers are close to what would be expected (Table 5.5). This will be discussed in Chapters 6 and 7.

Calcareous lithosols are avoided since they are bare rock and very loose soil with very scant vegetation.

There is basically no difference between the Kavir N.P. and Turan P.A. in the habitat preferences of the jebeer gazelle.

5.4.2 Wild ass

In contrast to the jebeer, the wild ass do not select sites close to springs and do not select *Haloxylon* habitat. The only habitat they significantly select is *Zygophyllum*. *Artemisia* habitat occurs only to a small extent in their range in the Kavir N.P. and not at all in the Turan P.A., so it is not known if they would avoid this were it available. Wild ass were not seen to use Haloxylon for shade, possibly because they are much taller animals than jebeer, and so did not select this habitat. In fact they were not seen to seek out shade at all, and did not move into foothills during the midday in summer as jebeer were seen to do. In contrast to the jebeer, they did not select foothills in the Turan P.A. (Table 5.8). This probably accounts for their distribution further away from springs.

The reason why wild ass are significantly selecting sites between 5 km and 7.5 km in the Turan P.A. is that one group of 96 individuals was seen at this distance from Abul Yahy spring in area 6 in winter. If this group is ignored, then they have no preferences for distances closer than 10 km. The reason they are significantly avoiding distances between 10 and 12.5 km in the Turan P.A. is that the part of the region where these distances were sampled, in area 6, was outside their normal range. In the other areas where wild ass occurred in numbers, only distances closer than 10 km were sampled.

It is impossible to make comparisons between the Dasht e Kavir and other parts of the Gazella dorcas' range. The habitat in the Dasht e Kavir is unusual in that it contains low, shrubby vegetation. In other parts of its range where it has been studied it occurs in Acacia habitat (Mendelssohn, 1974; Carlisle and Ghobrial, 1968).

No difference was detected between the Kavir N.P. and the Turan P.A. in habitat preferences, which suggests that in the present habitat of the Dasht e Kavir, the presence of domestics has no effect in this respect. There are no data to show whether the situation now in the Dasht e Kavir is different from the natural climax conditions.

5.5 Summary

1. During summer jebeer gazelle occur close to springs in foothills, but are more dispersed around springs in the plains when they are associated with *Haloxylon*.

2. Jebeer significantly select *Artemisia* and *Haloxylon* habitat and significantly avoid calcareous lithosols and *Seidlitzia*.

3. Jebeer use *Haloxylon* and foothills for shade in summer.

4. Wild ass are more evenly distributed away from springs.

5. Wild ass significantly select *Zygophyllum* only, and significantly avoid calcareous lithosols and *Seidlitzia*.

6. Wild ass do not use *Haloxylon* and foothills for shade.

7. Domestics do not modify habitat preferences of jebeer and wild ass in the present conditions of the Dasht e Kavir. There are no data to suggest what the natural climax conditions are.

Table 5.1

Results of the chi-squared one sample test to test the significance of the distance of jebeer gazelle and wild ass from the nearest spring; aerial census.

Degrees of freedom = 4 Significance level = 0.01

	Distance from nearest spring in km					
	0-5	5-7.5	7.5-10	10-12.5	>12.5	Σ
a) Jebeer gazelle						
observed	232	171	105	44	14	566
expected	108	108	113	113	124	566
χ^2	142.37	36.75	0.57	42.13	97.58	
P	<0.001	<0.001	>0.95	<0.001	<0.001	
	SS	SS	NP	SA	SA	
b) Wild ass						
observed	16	4	14	13	25	72
expected	12	12	14	14	20	72
χ^2	1.3	5.3	0	0.07	1.25	
P	>0.8	>0.2	>0.99	>0.99	>0.9	
	NP	NP	NP	NP	NP	

SS = significantly selecting
NP = no preference
SA = significantly avoiding

Table 5.2

Results of the chi-squared one-sample test to test the significance of the distance of jebeer gazelle from the nearest spring; road census.

Degrees of freedom = 4   Significance level = 0.01

a) Kavir N.P.

	Distance from nearest spring in km					
	0-5	5-7.5	7.5-10	10-12.5	>12.5	Σ
Spring						
observed	59	72	83	34	18	266
expected	82	72	51	29	32	266
χ^2	6.45	0	20.08	0.86	6.13	
	>0.1	>0.99	<0.001	>0.9	>0.1	
	NP	NP	SS	NP	NP	
Summer						
observed	847	198	81	39	38	1203
expected	373	325	229	132	144	1203
χ^2	602.35	49.63	95.65	65.52	78.03	
P	<0.001	<0.001	<0.001	<0.001	<0.001	
	SS	SA	SA	SA	SA	
Autumn						
observed	244	101	56	25	36	462
expected	143	125	88	51	55	462
χ^2	71.34	4.61	11.64	13.25	6.56	
P	<0.001	>0.3	>0.1	>0.01	>0.1	
	SS	NP	NP	NP	NP	
Winter						
observed	107	81	60	19	37	304
expected	82	79	61	36	46	304
χ^2	7.62	0.05	0.02	8.03	1.76	
P	>0.1	>0.99	>0.99	>0.05	>0.7	
	NP	NP	NP	NP	NP	

SS = significantly selecting

NP = no preference

SA = significantly avoiding

Table 5.3

Results of the chi-squared one-sample test to test the significance of the distance from the nearest spring of jebeer gazelle in areas 1, 3, 7, 8 and 10, Kavir N.P.

Degrees of freedom = 4 Significance level = 0.01

	Distance from nearest spring in km					
1. Mil	0.5	5-7.5	7.5-10	10-12.5	>12.5	Σ
observed	57	29	5	3	0	94
expected	35	34	17	7	2	95
χ^2	13.83	0.74	8.47	2.29	2.0	
	<0.01	>0.1	>0.05	>0.5	>0.7	
	SS	NP	NP	NP	NP	
3. Shah Abbas						
observed	21	25	16	6	0	68
expected	16	12	16	20	4	68
χ^2	1.56	14.08	0	9.8	4	
P	>0.8	<0.01	>0.99	>0.02	>0.3	
	NP	SS	NP	NP	NP	
7 & 8. Sorkh and Lakab						
observed	32	31	19	0	3	85
expected	16	15	14	20	20	85
χ^2	16	17.07	1.79	20	14.45	
P	<0.01	<0.01	>0.7	<0.001	<0.01	
	SS	SS	NP	SA	SA	
10. Qarqare and Takkuh						
observed	48	13	21	8	0	90
expected	34	23	17	12	4	90
χ^2	5.76	4.35	0.94	1.33	4	
P	>0.2	>0.3	>0.9	>0.8	>0.3	
	NP	NP	NP	NP	NP	

SS = significantly selection
NP = no preference
SA = significantly avoiding

Table 5.4

Results of the chi-squared one-sample test to test the significance of the distance from the nearest spring of jebeer gazelle and wild ass in Turan P.A.; road census.

Degrees of freedom = 4 Significance level = 0.01

	Distance from nearest spring in km					
	0-5	5-7.5	7.5-10	10-12.5	>12.5	Σ
a) Jebeer gazelle						
observed	109	49	45	59	7	269
expected	105	70	19	22	54	270
χ^2	0.24	6.3	35.6	62.2	41	
P	>0.99	>0.1	<0.001	<0.001	<0.001	
	NP	NP	SS	SS	SA	
b) Wild ass*						
observed	215	251	37	23		526
expected	237	174	53	63		527
χ^2	2.04	34	4.8	25.4		
P	>0.5	<0.001	>0.1	<0.001		
	NP	SS	NP	SA		

* Degrees of freedom = 3 Significance level = 0.01

NP = no preference
SS = significantly selecting
SA = significantly avoiding

Table 5.5 Results of the chi-squared one-sample test on the habitat preferences of the jebeer gazelle in the Kavir N.P.; road census. Degrees of freedom = 5 Significance level = 0.01

	Habitat type						
	Foothills	Calcareous lithosols	Haloxylon	Zygophyllum	Artemisia	Seidlitzia	Σ
a) Spring							
observed	54	41	132	130	289	15	661
expected	40	66	66	172	224	93	661
χ^2	4.9	9.47	66	10.26	18.86	65.42	
P	>0.3	>0.05	<0.001	>0.05	<0.01	<0.001	
	NP	NP	SS	NP	SS	SA	
b) Summer							
observed	23	17	264	353	523	22	1202
expected	72	120	120	313	409	168	1202
χ^2	33.35	88.41	172.8	5.11	31.78	126.88	
P	<0.001	<0.001	<0.001	>0.3	<0.001	<0.001	
	SA	SA	SS	NP	SS	SA	
c) Autumn							
observed	6	8	80	109	263	2	468
expected	28	47	47	122	158	66	468
χ^2	17.29	32.36	23.17	1.39	69.78	62.06	
P	<0.01	<0.001	<0.001	>0.9	<0.001	<0.001	
	SA	SA	SS	NP	SS	SA	
d) Winter							
observed	0	0	15	21	79	0	115
expected	8	12	5	31	41	18	115
χ^2	8	12	20	3.23	35.22	18	
P	>0.1	>0.02	<0.01	>0.5	<0.001	<0.01	
	NP	NP	SS	NP	SS	SA	

SS = significantly selecting; NP = no preference; SA = significantly avoiding

Table 5.6 Results of the chi-squared one-sample test on the habitat preferences of wild ass in Kavir N.P. from aerial and ground censuses, all years summed. Degrees of freedom = 5 Significance level = 0.01

	Habitat type						
	Foothills	Calcareous	*Haloxylon*	*Zygophyllum*	*Artemisia*	*Seidlitzia*	Σ
wild ass observed	0	16	58	97	18	0	189
expected	4	43	38	60	25	19	189
χ^2	4	17	10.5	22.8	1.96	19	
P	>0.5	<0.01	>0.05	<0.001	>0.8	<0.01	
	NP	SA	NP	SS	NP	SA	

NP = no preference
SS = significantly selecting
SA = significantly avoiding

Table 5.7

Results of the chi-squared one-sample test on the habitat preferences of jebeer gazelle in Turan P.A.; road census.

Degrees of freedom = 2 Significance level = 0.01

a) Autumn/winter/spring (October to April census inclusive)

	Habitat type			
	foothills	Haloxylon	Zygophyllum	Σ
number observed	4	49	96	149
number expected	7	18	124	149
χ^2	1.3	53.4	6.3	
P	>0.5	<0.001	>0.02	
	NP	SS	NP	

b) Summer (May and August census)

	foothills	Haloxylon	Zygophyllum	Σ
number observed	31	37	52	120
number expected	6	14	100	120
χ^2	104	37.8	23.0	
P	<0.001	<0.001	<0.001	
	SS	SS	SA	

NP = no preference
SS = significantly selecting
SA = significantly avoiding

Table 5.8

Results of the chi-squared one-sample test on the habitat preferences of wild ass in Turan P.A.; road census

Degrees of freedom = 2 Significance level = 0.01

	Habitat type			
	foothills	Haloxylon	Zygophyllum	Σ
number observed	23	28	475	526
number expected	37	79	410	526
χ^2	5.3	32.9	10.3	
P	>0.05	<0.001	<0.01	
	NP	SA	SS	

SS = significantly selecting
NP = no preference
SA = significantly avoiding

Table 5.9

Results of the chi-squared one-sample test on the distance of wild ass from the nearest spring in Turan P.A. The group of 96 individuals seen in Abul Yahya area in December has been excluded.

Degrees of freedom = 4 Significance level = 0.01

	Distance from nearest spring in km				
	0-5	5-7.5	7.5-10	10-12.5	Σ
observed	215	155	37	23	430
expected	194	142	43	52	431
χ^2	2.3	1.2	0.8	16.2	
P	>0.5	>0.8	>0.9	<0.001	
	NP	NP	NP	SA	

NP = no preference
SA = significantly avoiding

Chapter 6

POPULATION STRUCTURE

6.1 Introduction

Group structure is understood here to mean the size and composition of groups and the proportions of age and sex classes in the population.

In species whose sexes can be distinguished in the field, four group classes are commonly recognised; male, female, harem and mixed (Leuthold and Leuthold, 1975). These four classes could be recognised for the jebeer. In addition the female group class was divided into female groups (adult females only) and fawn groups (fawns with or without adult females). Thus the five group classes are:

1. Male only
2. Female only
3. Fawn, with or without females
4. Harem
5. Mixed

A fawn with one or more males was classified as a harem or mixed group.

Since sexes of wild ass could not be easily distinguished, only two group classes were recognised, those with and those without foals.

The occurrence of the group classes and their variation with the seasons can provide useful information. For instance harem groups are associated with the breeding season. Females go off on their own to give birth to their young (Walther, 1972). If these activities are seasonal, then hunting should be restricted during these periods.

The proportions of age and sex classes in a population provide useful information on population dynamics. Expanding populations will have higher proportions of young than stable or decreasing populations. In social organisations where the male is territorial and polygamous, males can be selectively shot without reducing the reproductive performance of the population. The number to be shot can be set by determining and monitoring the number of males in the population.

Four age and sex classes could be distinguished for the jebeer in the field:

1. Fawns, up to one year of age, distinguished by smaller size, and horns on males shorter than the ears.
2. Yearling males, from one year to 15 months, distinguished by sharply pointed horns curving in at the tips.
3. Adult males, over 15 months old.
4. Adult females, over one year old.

Since there was one breeding and fawning season per year, these classes could be more easily distinguished.

Only three classes could be recognised for the wild ass in the field:

1. Newborn foal, up to about three months old, distinguished by small size; head at the base of the ears lower than the shoulder of an adult.
2. Foal, from three months to one year old, distinguished by small size.
3. Adult.

6.2 Methods

6.2.1 Jebeer gazelle

a) Group size

The size of each group of jebeer seen during the transects was recorded and mean group size and percentage frequency distribution of group sizes calculated. The road census data were summed for each month to show seasonal variation (Figs 6.1 and 6.3). July and November censuses were presented separately to show annual variation in the Kavir N.P. (Fig 6.2).

b) Group class

Percentage frequency distribution of jebeer group classes was calculated for each month to show seasonal variation (Figs 6.4 and 6.5). Mean size of each group class was calculated (Table 6.1).

c) Sex and age composition

The proportions of male, female and fawn were calculated for the summer months. The yearling and adult male classes were combined.

Starting with a theoretical population of 1,000 individuals and assuming a finite rate of increase of 1.2 per year, the annual change in age and sex classes in the Kavir N.P. over the four years of the study was calculated from the proportions in the observed population. The yearling class was calculated by assuming an equal sex ratio and doubling the observed yearling male proportion, decreasing the adult female proportion by a corresponding amount (Fig 6.6).

Female : fawn ratios were calculated, and their seasonal variation (Table 6.2), and annual variation in the Kavir N.P. (Table 6.3).

A chi-squared two sample test (Siegel, 1956) was done to test the significance of the difference between open (Zygophyllum and Artemisia) and closed (Haloxylon, foothills and calcareous lithosols) habitats (Table 6.4).

6.2.2 Wild ass

a) Group size

Wild ass groups were placed in seven group size classes and their percentage frequency distribution calculated. All censuses were summed together for each region (Fig 6.7). The significance of the seasonal variation was tested using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956).

b) Group class

Since there were only two wild ass group classes, no analysis was done.

c) Sex and age composition

The proportion of age classes of the wild ass was calculated (6.3.2 b)).

6.3 Results

6.3.1 Jebeer gazelle in the Kavir N.P.

a) Group size

The jebeer occurred in very small groups. Mean group size and percentage frequency of larger groups was smallest in May and gradually increased to reach a peak in January. There is a significant difference in the frequency distribution of group size between May and November (Kolmogorov-Smirnov two-sample test, D = 0.29, P < 0.001) and between November and January (D = 0.23, P < 0.02 (Siegel, 1956)) in the Kavir N.P. (Fig 6.1).

Although the difference in distribution of group sizes between 1974 and 1977 was not significant for the July censuses combined (D = 1.92, P > 0.1), there was a trend towards a higher mean group size and frequency of larger groups from year to year, which was shown also by the November censuses (Fig 6.2).

b) Group class

The percentage frequency of harem groups reaches a pronounced peak in November; in mixed groups it reaches a pronounced peak in January. Percentage frequencies of female groups and fawn groups are largest in May and July respectively (Fig 6.4).

c) Age and sex composition

The jebeer population for July (all years combined) in the Kavir N.P. comprised 31% adult male, 36% adult female, and 33% fawn (number of individuals = 1,444). Male category includes adult and yearling.

The female:fawn ratio increased from July to March (Table 6.2 a), and decreased from 1974 to '77 (Table 6.3).

There was a significant difference between open plains and enclosed habitats in the age and sex composition of jebeer in May (chi-squared two-sample test, $\chi^2 = 55.9$, P < 0.001 (Siegel, 1956)) but not in March ($\chi^2 = 2.04$, P > 0.3) or July and September ($\chi^2 = 2.26$, P > 0.3) (Table 6.4).

6.3.2 <u>Wild ass in the Kavir N.P.</u>

a) <u>Group size</u>

Mean group size and the range of group sizes of wild ass in the Kavir N.P. was small (Fig 6.7 a).

b) <u>Age composition</u>

In the wild ass population in the Kavir N.P. newborn foals appear in July. They were seen only in July and September. The population comprised 22% foal and newborn foal, and 78% adult (number of individuals = 189, all censuses summed together).

6.3.3 <u>Jebeer gazelle in the Turan P.A.</u>

a) <u>Group size</u>

There was no significant variation in the percentage frequency distribution of jebeer group sizes in the Turan P.A. (Kruskal-Wallis one-way analysis of variance, degrees of freedom = 4, $H = 2.39$, $P > 0.5$ (Siegel, 1956)). There was, however, a significant difference between April/May and December (Kolmogorov-Smirnov two-sample test, $D = 0.22$, $P < 0.001$ (Siegel, 1956)) (Fig 6.3).

b) <u>Group class</u>

The percentage frequency of harem groups is largest in October; mixed groups have the largest percentage frequency in December, female groups show a pronounced peak in April/May, and in fawn groups it is largest in July and August (Fig 6.5).

c) <u>Age and sex composition</u>

The jebeer population in the Turan P.A. comprises 27% adult male, 43% adult female, and 30% fawn (number of individuals

= 60). Female:fawn ratio increases from July to December (Table 6.2 b).

There is a significant difference between open and enclosed (Haloxylon and foothills) habitats in the age and sex composition of jebeer in Turan P.A. in May (chi-squared two-sample test, $\chi^2 = 22.95$, $P < 0.001$), but not in April ($\chi^2 = 5.72$, $P > 0.05$) or July ($\chi^2 = 0.05$, $P > 0.95$) (Table 6.4).

6.3.4 Wild ass in the Turan P.A.

a) Group size

There is a large range of group sizes of wild ass in the Turan P.A. From April to October it is 1 to 29. One group of 96 was seen in December. The group size class with the highest percentage frequency was 1 to 5 (Fig 6.7).

b) Age composition

In the wild ass population in the Turan P.A. newborn foals appear in July, and were seen in July, August and October only. The population comprised 10% foal and newborn foal, and 90% adult (number of individuals = 487, all censuses combined).

6.4 Discussion

6.4.1 Seasonal change in group size and class

a) Jebeer gazelle

The mean group size and range of group sizes of jebeer is smallest in April and May, and gradually increases to reach a peak in December and January. This peak is more pronounced in the Kavir N.P. The larger size in the winter months is associated with a more frequent occurrence of mixed groups. This trend towards larger group size during the dry season has been observed in the Grant's gazelle in the Serengeti (Walther, 1972) and happens prior to their migration. The goitered gazelle in Iran also forms large aggregations in winter in areas adjacent to towns where winter wheat has been planted. Other ungulate species show the opposite trend. Herds of buffalo (Sinclair, 1974) and impala (Jarman and Jarman, 1974) in the Serengeti split up in the dry season, and wildebeest and impala do the same in Selous Game Reserve, Tanzania (Rodgers, 1977). Sinclair (1974) and Pienaar (1969) argue that the buffalo groups split up in the dry season in response to a more localised food supply which cannot support the large wet season herds. From these observations it may be argued that the larger winter group size of the jebeer is due to either migration or a more evenly distributed food supply. Although the jebeer do move between areas in the Kavir N.P. (Chapter 4) it cannot be regarded as a migration in the same way as the Serengeti Grant's gazelle. In the Dasht e Kavir there is no local abundance of food in different areas at different seasons as in the Serengeti to cause migration. It is more likely to be a response to the availability of food, and this will be discussed more fully in chapter 8.

The seasonal change in food supply is only part of the reason. There is also a seasonal change in social organisation associated with change in group size. Fawns are dropped in April/May and the females go off on their own to give birth. This accounts for the peak in female groups at this time of year (Figs 6.4 and 6.5). Females are actually seeking out closed habitats such as the foothills, the broken calcareous lithosols, and _Haloxylon_ (Table 6.4). Similar behaviour has been observed in Grant's gazelle (Walther, 1972) and Thomson's gazelle (Brooks, 1961). Having given birth the females and their fawns move back onto the plains. Fawns continue to lie out for up to a month (Walther, 1972) and so they are not fully seen until the end of June. Females stay on their own with their fawns throughout the summer, during which time the sexes are separate.

The preponderance of females and their reduced visibility in foothills and calcareous lithosols produces a skewed sex ratio in the observed population. For censuses in May in the Kavir N.P. the observed sex ratio for the region was male:female = 1:0.56, compared with 1:1.05 for July and September.

Gazella dorcas has a gestation period of 5½ months (Dittrich, 1968). If the fawns are born in April/May, then they are conceived in November, and this coincides with the peak in the percentage frequency of harem groups (Figs 6.4 and 6.5). In all gazelle species studied (Walther, 1972; Brooks, 1961; Baharav, 1973; Mendelssohn, 1974) the males are territorial and polygamous during the breeding season when territorial breeding males occur singly or with females in harem groups. The jebeer is no exception, and observations on behaviour confirm this (Chapter 7). The jebeer, living in a highly seasonal environment, has a highly seasonal social organisation. Where the environment is not seasonal gazelle breed the whole year round, such as Grant's and Thomson's gazelle in the Ngorongoro Crater (Leuthold, 1977).

b) Wild ass

Wild ass shown the same seasonality in birth of foals and group size. In the Turan P A. mean group size is highest in

December (20.5) compared with the other months between April and October (range of 5.05 to 6.48). The higher value for December is due to one group of 96 individuals. This does not seem to be a chance observation, since large winter groups have been seen previously. In December 1973 I observed two separate aggregations of over 100 individuals in the region of Kuh e Do Shakh in area 2 of the Turan P.A. Local game guards regularly report similar observations. For the same reasons as discussed above this is likely to be a response to both food availability and social organisation.

The wild ass have a gestation period of 11 months (Groves, 1974). Foals are born in June and July, which means that breeding occurs in July and August. Klingel (1977) observed *Equus hemionus* in Turkmenia to be territorial. He reports observations made by Solomatin in the same area that during the breeding season territorial males hold harems and are intolerant of other males older than 1½ years. Outside the rut males are tolerant of each other and mixed herds are common. Although group classes could not be distinguished in this study, there is no reason to suppose that the wild ass in the Dasht e Kavir are any different from those in Turkmenia. That they are territorial is suggested by the occurrence of dung piles in both the Kavir N.P. and Turan P.A. The intolerance of males during the breeding season would contribute to a splitting up of the winter aggregations into smaller groups.

c) Difference between the Kavir N.P. and Turan P.A.

The mean group size and percentage frequency of larger groups in winter is much higher in the Kavir N.P. than in the

Turan P.A. (Figs 6.1 and 6.3). This is probably due to the disturbance caused by the domestic flocks in the latter region during winter.

There is an even more pronounced difference in the mean group size and range in the wild ass. In the Kavir N.P. all groups observed were 10 or less, while in the Turan P.A. they were commonly up to 29 and on one occasion 96 (Fig 6.7). This is probably due to their differing densities. In the Kavir N.P. they are less dense and form smaller groups. This correlation between group size and density has been observed in waterbuck in Uganda (Spinage, 1969) and impala and wildebeest in Tanzania (Rodgers, 1977).

The mean group size and range is smaller in the Turan P.A. than in the population studied by Klingel (1977) in Turkmenia. In that population the mean group size was 15.8 and the range 1 to 135, compared to 6.0 and 1 to 96 in Turan. The density of the Turkmenia population was $0.45/km^2$, which is similar to $0.39/km^2$ in Turan. The population in Turkmenia occurs in a reserve without domestics, so, as with the jebeer, the presence of man and domestics is probably contributing to a reduced group size in the Turan P.A.

6.4.2 Annual variation in group size

Associated with an annual increase in the density of jebeer in the Kavir N.P. there is an increase in their mean group size and range. This trend is shown by the March, July and November censuses (Fig 6.2).

6.4.3 Age and sex composition

a) Jebeer gazelle

Two differences stand out between the Kavir N.P. and the Turan P.A. in the sex and age composition of the jebeer populations. In the Turan P.A. there is a lower male:female ratio (1:1.6 compared with 1:1.05 in the summer) (Table 6.4) and a higher female:fawn ratio (1:0.8 compared with 1:0.93 in July) (Table 6.2).

The lower male:female ratio can be accounted for by poaching, and decreased availability of food due to the presence of domestics. Poaching is highly likely. Its extent is impossible to judge, but it was certainly at a low level during the study due to a lack of firearms amongst the local population. Also there was no evidence of poaching during the course of the study. Poor range quality does lead to a higher mortality in males in populations of ungulates living in a seasonal environment with a rut occurring just before winter. Due to the physiological demands of the rut, males enter the winter with less fat than females and thus sustain a higher mortality (Mitchell *et al.* 1977; Klein, 1970). A preponderance of males has been observed in deer on poor range in Minnesota (Gunvalson *et al.*, 1952) and Alaska (Klein, 1965). In the Kavir N.P. in the absence of domestic and with a low jebeer density food would not be limiting in this way.

Similarly the higher female:fawn ratio in the Turan P.A. can be accounted for by the presence of domestics. Cheatum and Severinghaus (1950) observed a reduced fertility in deer on poor quality and overcrowded range, due to a lower rate of conception rather than in utero mortality.

b) Wild ass

There is also a difference between the Kavir N.P. and the Turan P.A. in the proportion of foals and newborn foals in the wild ass populations, 22% in the Kavir N.P. (6.3.2 b)) compared with 10% in the Turan P.A. (6.3.4 b)). This is probably also due to the presence of domestics and higher density of the wild ass reducing fertility.

6.4.4 Mortality and fecundity

The mortality rate of jebeer fawns is higher than that of adult females in both regions (Table 6.2). This is to be expected, since the highest mortality is incurred in the first year of life.

An observed fawn proportion of 33% of the jebeer population in the Kavir N.P. in July (6.3.1 c)) could lead to an annual increase of 20% if the mortality rate of the whole population is 23% per year. There was no way of directly observing mortality. Fawn mortality, calculated from Fig 6.6, varies between 61% and 23%, with a mean of 34% of the fawn population per year.

6.5 Summary

6.5.1 Jebeer gazelle

1. Mean group size and range vary seasonally.
2. Females separate on their own and seek out hilly and Haloxylon habitats to give birth in May.
3. Harem groups occur most frequently in November.
4. Mean group size and range is smaller during winter in the Turan P.A.

5. Mean group size and range increases annually in the Kavir N.P.

6. There is a smaller proportion of males and fawns in the Turan P.A.

6.5.2 Wild ass

1. Larger groups occur in winter.

2. Mean group size and range is suppressed by presence of Man and domestics.

3. Foals are born in June and July.

4. Males are probably territorial and intolerant of each other during rut in May/June, accounting for smaller group size compared with winter.

5. There is a smaller proportion of foals in the Turan P.A.

Table 6.1

Mean size of group classes of jebeer

a) Kavir N.P.

	male only	female only	fawn	harem	mixed
mean size	1.7	1.12	2.62	5.76	9.03
number of groups	446	113	362	114	33

b) Turan P.A.

	male only	female only	fawn	harem	mixed
mean size	1.33	1.44	2.34	3.46	4.67
number of groups	42	27	38	13	3

Table 6.2

Seasonal variation in the female:fawn ratio of jebeer gazelle.

	Month	female:fawn	number of individuals
a) Kavir N.P.			
	July	1 : 0.93	767
	September	1 : 0.82	184
	November	1 : 0.81	324
	March	1 : 0.74	212
b) Turan P.A.	July	1 : 0.8	18
	August	1 : 0.69	44
	October	1 : 0.7	34
	December	1 : 0.57	22

Table 6.3

Annual variation in the female:fawn ratio of jebeer gazelle in the Kavir N.P.

Year	July		November		March	
	female:fawn	n	female:fawn	n	female:fawn	n
1974	1 : 0.88	150	1 : 0.77	78	1 : 0.65	33
1975	1 : 0.9	280	1 : 0.79	134	1 : 0.7	63
1976	1 : 0.88	277	1 : 0.87	112	1 : 0.8	45
1977	1 : 1.03	290			1 : 0.78	71

Table 6.4

Results of the chi-squared two-sample test on the significance of the difference between open and enclosed habitats in the sex and age composition of jebeer. Degrees of freedom = 2 in all cases.

a) Kavir N.P.

	Number of jebeer observed								
	March all years			May all years			July & September all years		
Habitat	Male	Female	Fawn	Male	Female	Fawn	Male	Female	Fawn
Haloxylon, foothills and calcareous lithosols	13	18	15	33	53	17	61	81	70
Zygophyllum and _Artemisia_	118	104	75	91	16	4	412	417	383
χ^2	2.04			55.9			2.26		
P	>0.3 NS			<0.001 *			>0.3 NS		

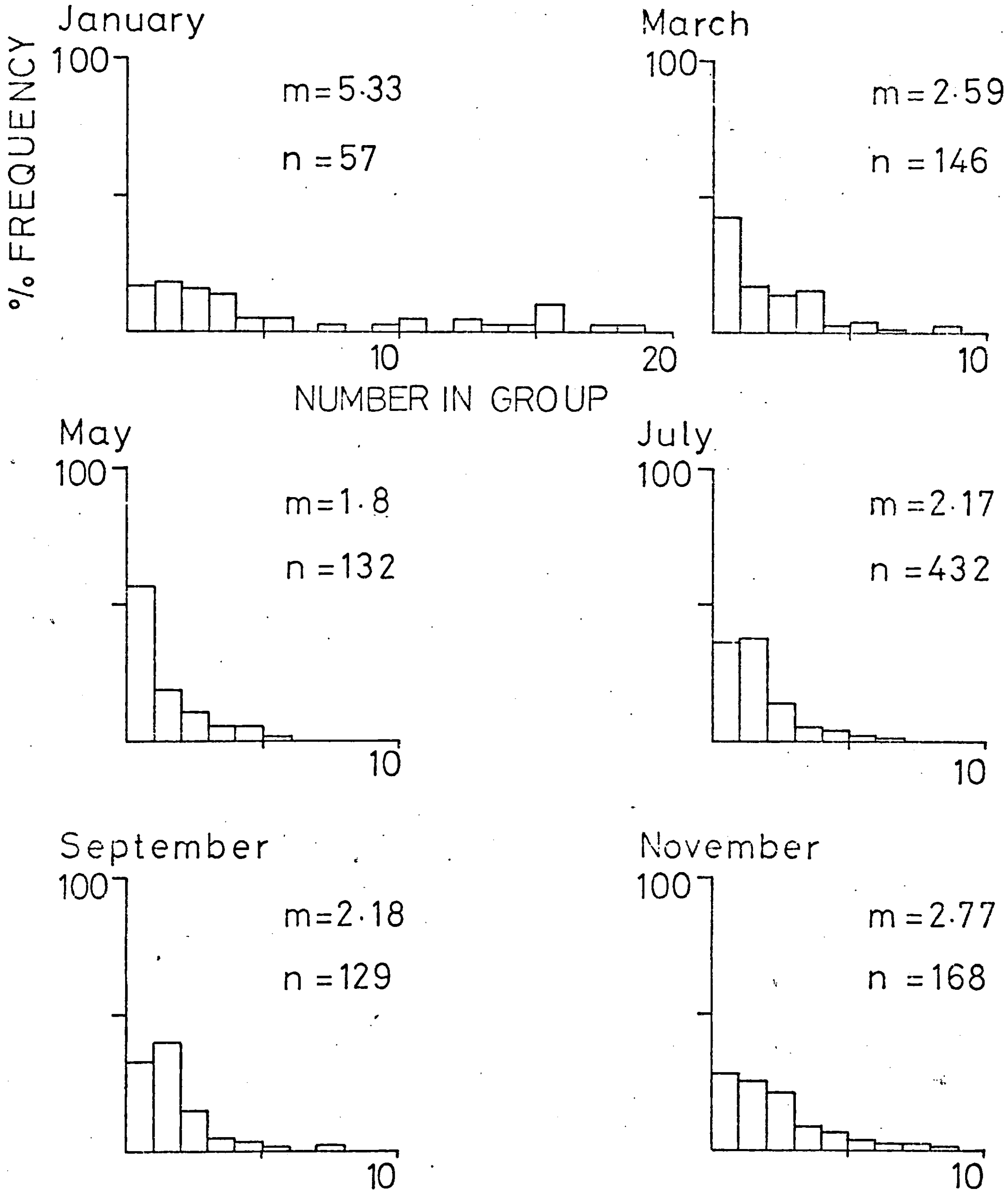
b) Turan P.A.

	April			May			August		
Haloxylon and foothills	3	10	4	2	14	5	6	16	12
Zygophyllum	13	8	11	16	3	0	10	10	6
χ^2	5.72			22.95			3.4		
P	>0.05 NS			<0.001 *			>0.1 NS		

NS = not significant
* = significant

Figure 6.1

Seasonal variation in percentage frequency distribution of jebeer group sizes, Kavir N.P.



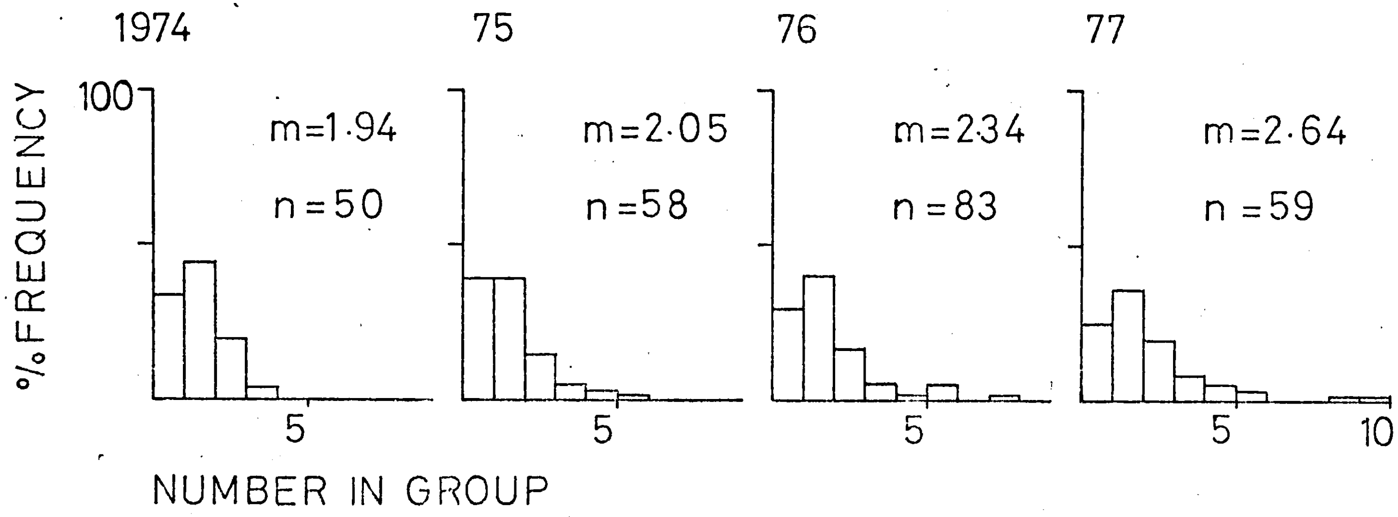
m= mean group size

n = number of groups

Figure 6.2

Annual variation in percentage frequency distribution of jebeer group sizes, Kavir N.P.

a) July aerial censuses



m = mean group size

n = number of groups

Figure 6.2 /continued...

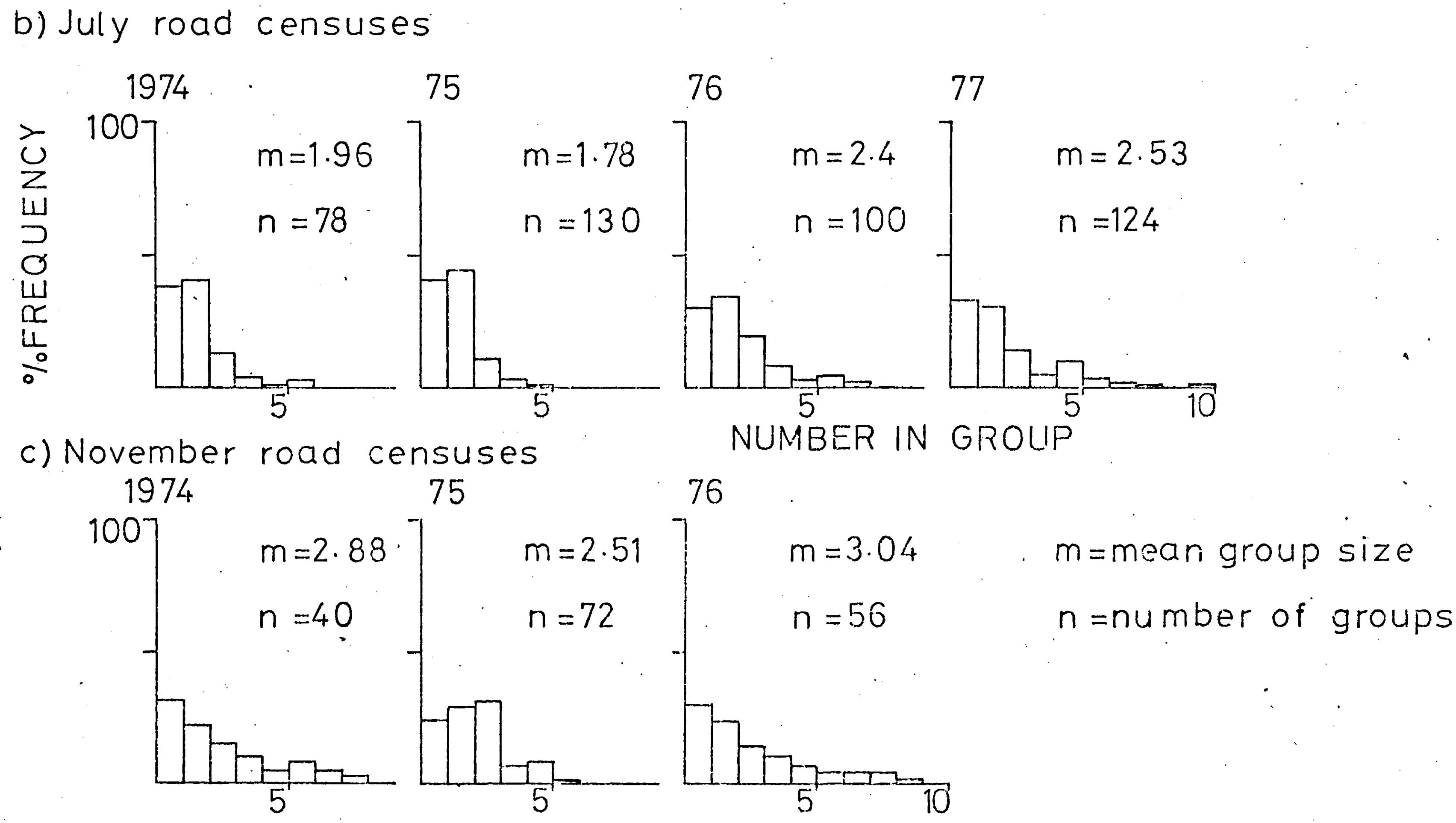

b) July road censuses
1974
75
76
77
100
%FREQUENCY
m=1·96
n =78
m=1·78
n =130
m=2·4
n =100
m=2·53
n =124
5
10
NUMBER IN GROUP
c) November road censuses
1974
75
76
m=2·88
n =40
m=2·51
n =72
m=3·04
n =56
m=mean group size
n =number of groups

Figure 6.3

Seasonal variation in percentage frequency distribution of jebeer group sizes, Turan P.A.

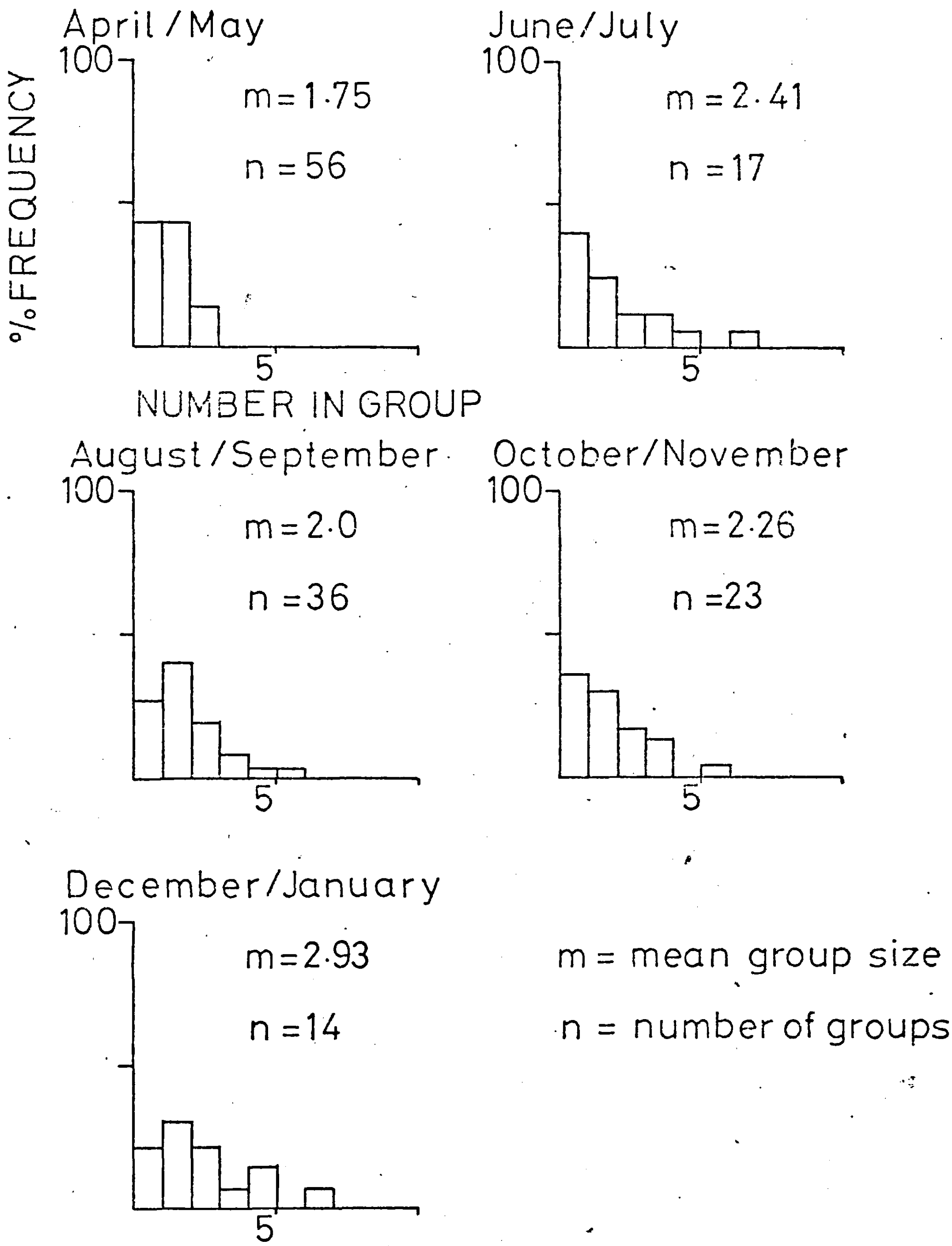
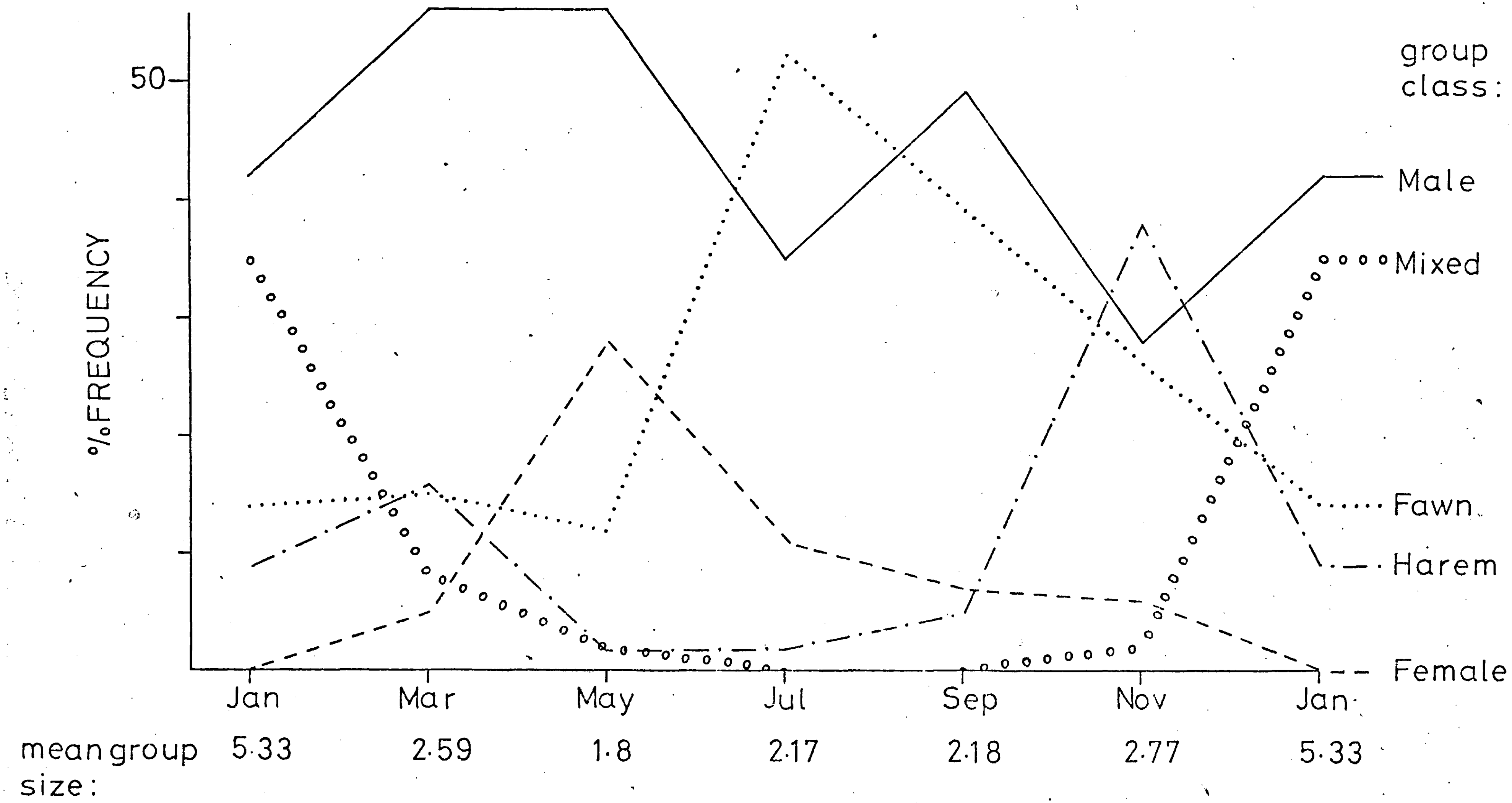

April/May
100
m=1·75
n=56
5
% FREQUENCY
NUMBER IN GROUP
June/July
100
m=2·41
n=17
5
August/September
100
m=2·0
n=36
5
October/November
100
m=2·26
n=23
5
December/January
100
m=2·93
n=14
5
m = mean group size
n = number of groups

Figure 6.4

Seasonal variation in percentage frequency distributions of jebeer group classes, Kavir N.P.



50
%FREQUENCY
group class:
Male
Mixed
Fawn
Harem
Female
Jan
Mar
May
Jul
Sep
Nov
Jan
mean group size:
5·33
2·59
1·8
2·17
2·18
2·77
5·33

Figure 6.5

Seasonal variation in percentage frequency distribution of jebeer group classes, Turan P.A.

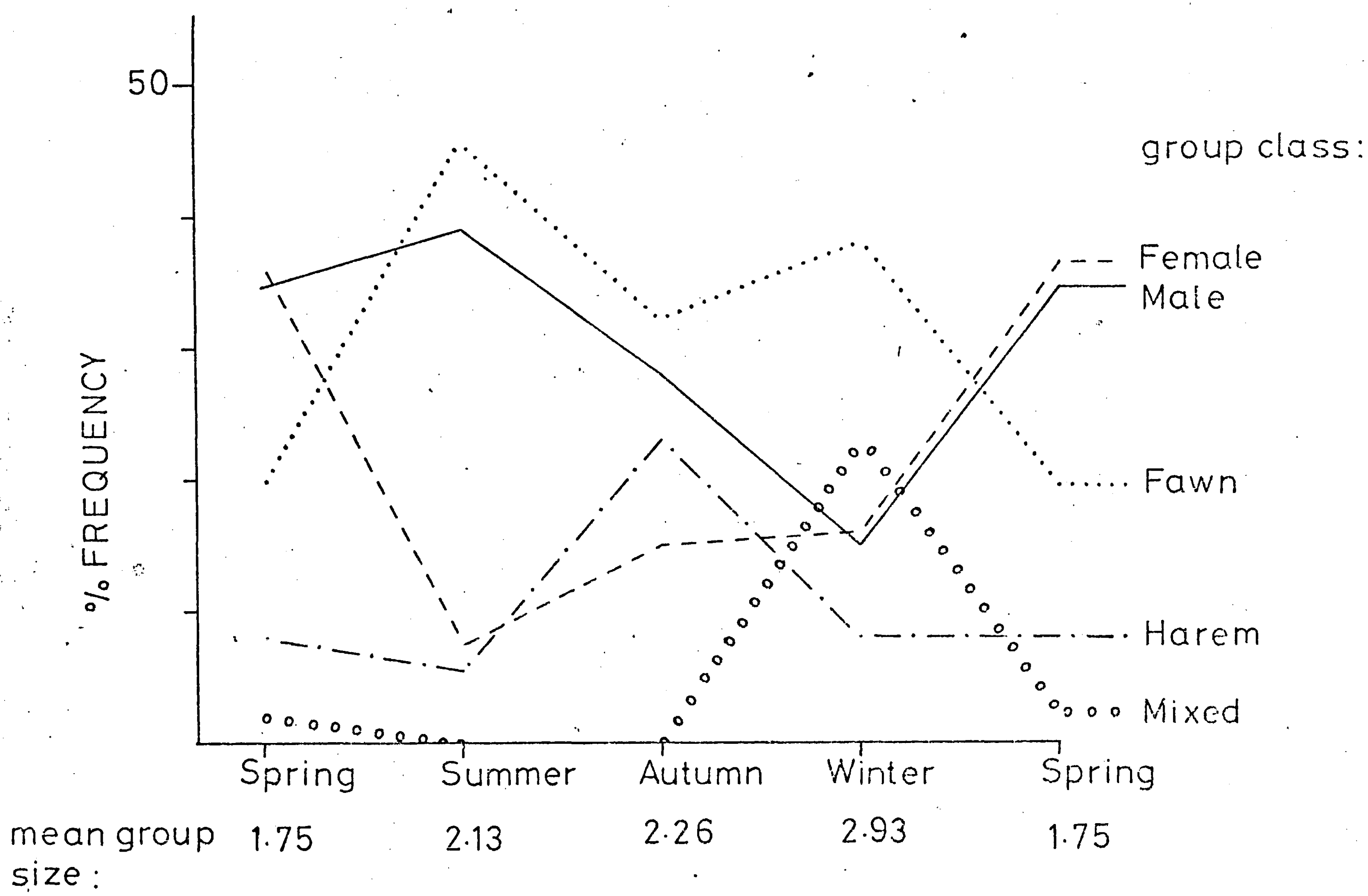

50
% FREQUENCY
group class:
Female
Male
Fawn
Harem
Mixed
Spring
Summer
Autumn
Winter
Spring
mean group size:
1·75
2·13
2·26
2·93
1·75

Figure 6.6

Change in numbers of different age and sex classes of jebeer from an initial population of 1,000 individuals, assuming an annual increase in population size of 20%, Kavir N.P.

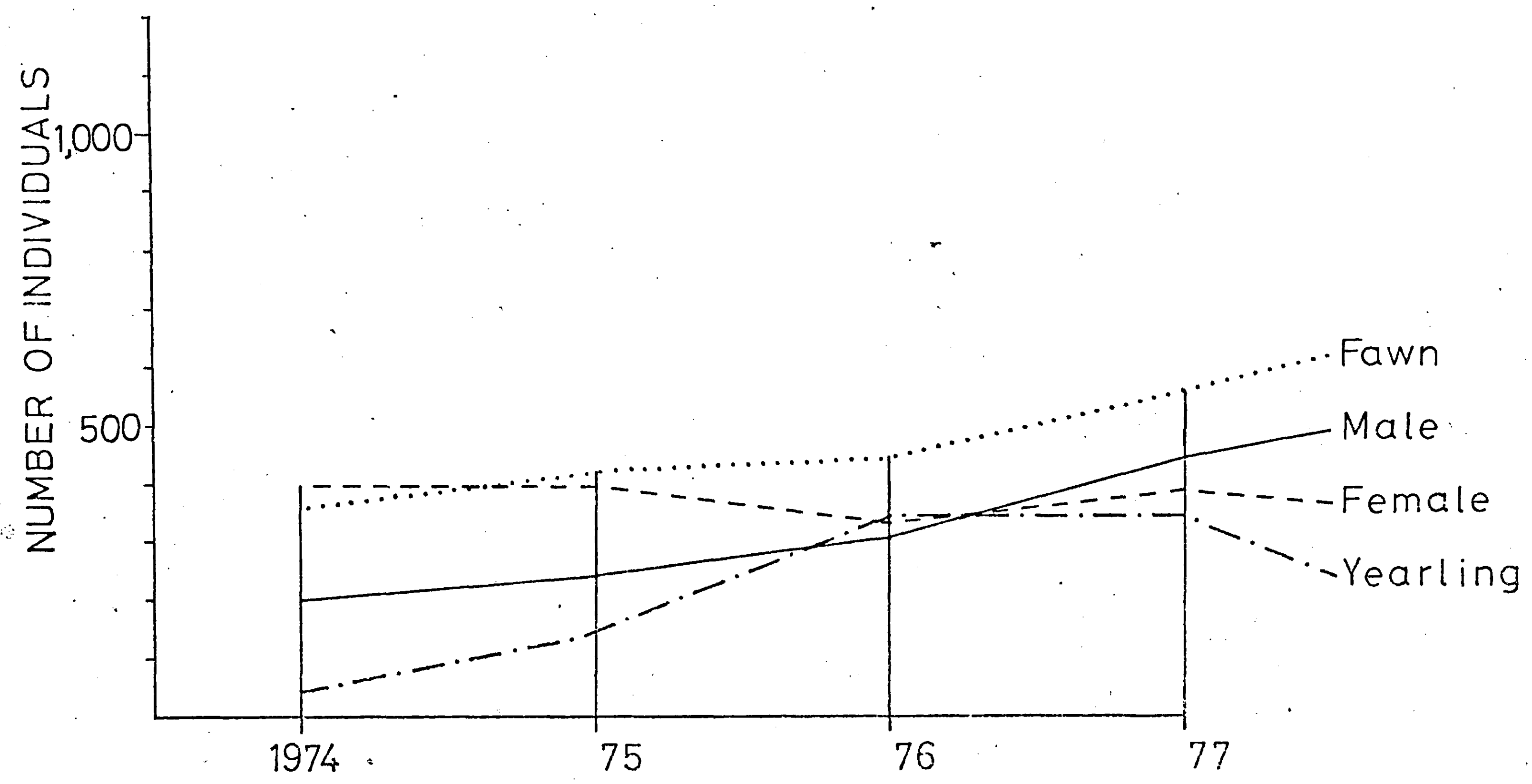

NUMBER OF INDIVIDUALS
1,000
500
1974
75
76
77
Fawn
Male
Female
Yearling

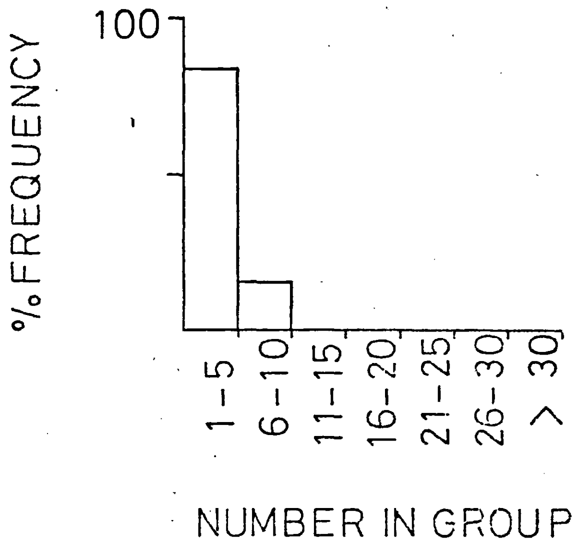
Figure 6.7

Percentage frequency distribution of wild ass group sizes

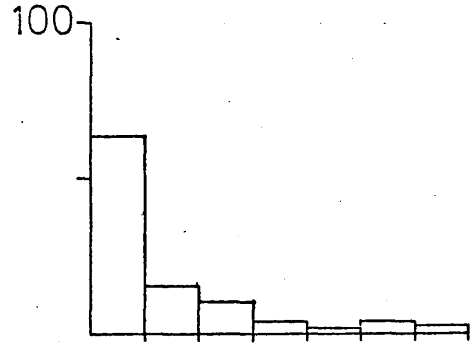
a) Kavir N.P.

b) Turan P.A.

a) Kavir N.P.



b) Turan P. A.



Chapter 7

DAILY ACTIVITY AND RUTTING BEHAVIOUR

7.1 Introduction

There is a need to understand the activity and behaviour of animals when planning and implementing their management and conservation. Activity patterns will determine what census, capture or culling techniques to employ. For instance, if the animals are lying down during the middle of the day there is no point censusing at that time. If males are territorial and polygamous, then an excess of males over females can be culled without adversely affecting reproductive potential.

Understanding the activity and behaviour of animals leads to a better interpretation of other data. For instance, the jebeer might be most active at night, during which time they are evenly distributed round springs. The census data might show that they are concentrated round springs because the jebeer have moved in this direction prior to the start of the census.

Aspects of activity and behaviour in relation to management have been discussed by Cowan (1974), Geist (1971), Leuthold (1970, 1977) and Pratt and Gwynne (1977).

Observations of behaviour and activity were made at springs.

7.2 Methods

7.2.1 Spring observation

a) Kavir N.P.

Observations were made during the censuses in 1975 at four springs in the Kavir N.P.: Mil (area 1), Shur (4), Talkhab (9) and Qarqare (10). At Shur and Mil observations were made from disused man-made structures. At Talkhab an old poacher's cave was used. At Qarqare a net was draped over a Haloxylon bush and the observer. Only at Shur and Mil was there a panoramic view over the surrounding plain.

During each census observations were made on three days at each of these four springs in May, July, September and November.

At Mil observations were made from sunrise to sunset on all three days. At Qarqare observations were made from sunrise until 1800 hrs on one of the three days. On the other two, and at Talkhab for all three days, observations were made from the time of arrival (on completion of the transect) until 1800 hrs. At Shur observations were made from the time of arrival until sunset on all three days.

Between 16 October and 12 December weekend visits were made to the region and observations made of jebeer rutting activity at Shur for one and a half days on each visit.

b) Turan P.A.

Observations were made at springs in the Turan P.A. in August 1976. Springs observed were Abul Yahya (area 6), Chah Vekil (5), Sitel (4), Chahak (4), Gharibe (4), and Garmab (4). Six whole days were devoted to watching each spring for one day from sunrise to sunset.

In July 1977 the ground around the spring at Majerad, Abul Yahya, Chah Vekil, Garmab, Sitel, Gharibe and Chahak was loosened and smoothed over with a rake and inspected and re-raked on three subsequent, consecutive days to determine presence or absence of domestics, wild ass and gazelle spoor (Table 7.3).

Tracks of the different animals could be easily distinguished. Gazelle hoofprints have pointed front ends and straight edges, those of domestic sheep and goat have blunt front ends and curved edges. Domestic ass are shod and can thus be distinguished from the unshod wild ass.

7.2.2 Spring visitation

At quarter to and quarter past the hour the number of individuals of each species at the spring was recorded.

For each census, the number of individuals at all the observed springs was summed for each of these times and the mean calculated by dividing by the number of days' observation to show the pattern of spring visitation throughout the day (Figs 7.1 to 7.4).

The proportion of the jebeer population in each area visiting the spring on any one day was calculated by dividing the population estimate for the area by the total number of individuals visiting the spring on one day. Population estimates for areas in the Kavir N.P. were the mean of aerial and road censuses (Table 7.4).

7.2.3 Daily activity

Five activity classes were recognised:

1. Feeding, when the animal was standing with its head down at the level of the vegetation.
2. Standing, when the animal was standing with its head up, whether it was chewing, alert, or resting.
3. Walking
4. Lying

5. Other, such as defaecating, urinating, agonistic encounters, etc.

At quarter to and quarter past the hour, and at ten minute intervals in between, all jebeer visible and their activity were recorded. Each jebeer recorded at each of these time intervals was one observation. The number of observations in each activity class was summed and their percentage calculated for the first half and the second half of each hour. Observations of daily activity were made at Mil and Shur springs in the Kavir N.P. only, since they had good views over the surrounding plain (Fig 7.5).

The percentage of observed jebeer arriving from plains and foothills and departing to plains and foothills was calculated for Mil and Shur springs (Table 7.1).

The mean length of time and the range of time spent at the springs by recognised individuals was calculated for the Kavir N.P. and the Turan P.A. (Table 7.2).

These observations were made only for jebeer.

Daily activity of domestics was observed by following the flocks with their shepherds (7.3.4).

7.2.4 Rutting behaviour

All male jebeer observed at the ten-minute intervals at Shur spring were scored as sexually active or inactive (7.3.1 b)). Observations were summed and the percentage of "sexually active" observations calculated for each week between 16 October and 12 December 1975 (Fig 7.6).

7.2.5 Territory size

Mean territory size of males was estimated by dividing the area of a demarcated zone below Mil and Shur springs by the number of single males observed in it. The areas were demarcated by natural features of the habitat (7.3.1 b)).

7.3 Results

7.3.1 Jebeer gazelle in the Kavir N.P.

a) Daily activity

Jebeer visit springs from May to November.

The number of jebeer at springs increases rapidly from nought within an hour after sunrise, reaches a peak in the late morning, and decreases rapidly in the early afternoon. A few jebeer continue to visit in the afternoon (Fig 7.1).

There is a large variation between the springs in this pattern (Fig 7.2).

There are two peaks of feeding activity, one in the early morning and the other in the late evening. There is a peak of inactivity during the middle of the day. There is a peak in the walking activity during mid-morning (Fig 7.5).

During May, July and September the jebeer would actually drink at the springs. During November only a few would drink. There was a lot of agonistic behaviour between females at springs in November.

During July and September the jebeer would leave the springs for the foothills at Mil and Shur. During November they would leave the springs and return straight to the plains (Table 7.1).

A smaller proportion of the jebeer population visits

Qarqare spring each day than Mil, Shur and Talkhab (Table 7.4).

b) Rutting activity

Most of the rutting activity was observed between late October and mid-November, with a peak in the first week of November (Fig 7.6).

Male behaviour associated with the rut were Flehmen, low-stretch, leg-beat, sampling females' urine (Leuthold, 1977), headlong chase after individual females and linked urination/defaecation on dung piles. No fights between males and no mountings were seen at springs. Fights between males and evidence of fights from tracks were seen during transects in September and November censuses. On one occasion a male was observed marking a *Zygophyllum* plant with his preorbital gland.

Single males could be seen regularly spaced out on the plain below Mil and Shur springs. These were assumed to be territorial. Female and fawn groups would move from one male to another without the males making any effort to keep them or to fight off other males.

c) Territory size

Mean territory size was estimated at 35 hectares at Mil (N = 23 individual males) and 60 hectares at Shur (N = 9 individual males). These must be regarded as minimum sizes since jebeer were concentrated around springs.

7.3.2 Wild ass in the Kavir N.P.

Wild ass visited Takkuh spring in July, September and November irregularly throughout the day, with a period in the afternoon when they did not visit (Fig 7.3).

7.3.3 Jebeer gazelle and wild ass in the Turan P.A.

Jebeer and wild ass visited springs to drink in August during the morning, with a peak at midday (Fig 7.4).

Some springs were used by both wild and domestic species (Table 7.3).

Only a small proportion of the jebeer population visits springs each day.

7.3.4 Domestic flocks in the Turan P.A.

In the Turan P.A. the sedentary domestic flocks belong to the villages and remain in the region throughout the year. In April the flocks with their offspring belong to Delbar, Majerad and Tejour spend all their time out on the plain away from the villages, and do not come in to the springs to drink. The shepherds camp and move with their flocks. In August they come in to drink twice a day, between 1200 and 1300 hrs and between 1800 and 1900 hrs. They are milked in the early afternoon between 1400 and 1600 hrs, and have two feeding periods out on the plain, one between 1600 and 1800, and the other between 1900 and 1200 the next day. In December the flocks are penned at night and have two feeding periods during the day, one from about sunrise to 1200, and the other from 1400 to 1800. Domestic flocks visit springs to drink in December.

The migratory flocks are in the area only from October to April, when they are distributed over the plains. At night they are penned in covered corrals made of brushwood, commonly with two flocks to a corral. They are taken out to feed during the day, and they drink approximately every other day, either at a well situated between 3 and 6 km from the corral, or at springs. In spring they move out of the region to spend the summer in the Alborz Mountains to the northwest.

7.4 Discussion

7.4.1 Purpose of spring visitation

Although jebeer visit springs to drink, this is not the only reason. They are also visiting for the social interaction and to rest in the foothills. Observations at Mil and Shur in July and September show that the jebeer arrive at the spring in the morning from the plains and leave for the foothills. In *Haloxylon* habitat at Qarqare spring there are no foothills, and a smaller proportion of the population visits the spring. During November only a few of the jebeer at Mil and Shur springs were seen to drink. They were not resting in the foothills during the middle of the day since they were seen to depart for the plains. They are probably visiting springs at this time of year for the social interaction associated with the rut.

The proportion of the jebeer population lying down is certainly underestimated (Fig 7.5), since by doing so they usually cannot be seen. All those observed in July and September were lying down next to springs and not out on the plain. The observation that between 76% and 100% of the estimated population visit Mil, Shur and Talkhab springs in July suggests that, if the estimates are accurate, then very few jebeer spend the middle of the day in summer out in the plains. This is true only for springs in foothills and *Artemisia* and *Zygophyllum* habitats. In November jebeer were seen to lie down out on the plain. This would suggest that jebeer are using foothills and *Haloxylon* to rest and shelter during the middle of the day in summer.

7.4.2 Daily activity

Jebeer will walk long distances to reach springs in foothills. Jebeer at Mil and Shur were seen to walk purposefully towards the springs in the morning, and away from the foothills towards the plains in the late afternoon, which accounts for the two peaks in this activity at these times (Fig 7.5).

The jebeer are probably most active at night. Their feeding during the day is restricted to early morning and late evening. When jebeer were spotlighted at night from a Land Rover they were usually feeding.

The impression is that jebeer do not disperse further away from springs in summer during the night. When they were seen at first light they were out on the plain feeding, and were not observed to be walking in any particular direction. It was only later in the morning that they started walking towards the springs.

7.4.3 Variations in the pattern of spring visitation

In the Turan P.A. in August the proportion of the total jebeer population visiting springs each day is small and similar to that at Qarqare (Table 7.4). For springs in area 4 this is probably due to the fact that the springs are not in foothills and there is *Haloxylon* habitat out on the plain, and so the jebeer are not coming into the springs to rest in the foothills but solely to drink. The same is true for Abul Yahya in area 6 which is situated out on the plain. However, only a small proportion is visiting Chah Vekil which is situated in foothills. The average time spent at springs is less in the Turan P.A. than the Kavir N.P. (Table 7.4). This is probably due to disturbance by domestics which also visit springs at midday (Table 7.3; Section 7.3.2), which is causing fewer jebeer to visit Chah Vekil, and causing them to spend less time at all springs.

Brooks (1961) observed that Thomson's gazelle also drank at the same springs as domestics, but just adapted themselves to visit springs in the early morning and late evening when the domestics were not there. Jebeer and wild ass still drink mostly at midday (Fig 7.4), but domestics do not come to drink every day at the same spring and disturbance is less.

Jebeer and wild ass did not visit springs in the Turan P.A. where there was permanent human presence, such as Majerad 1, Delbar and Tejour (Table 7.3).

Wild ass and jebeer visit Qarqare spring throughout the day (Fig 7.2) since it is situated out on the plains in their normal range.

Jebeer arrive earlier at Mil spring (Fig 7.2) since the area of gazelle habitat is close to the spring, and the jebeer are distributed close to the spring and do not have far to walk.

7.4.4 Effect of spring visitation on disturbance

Because they do not drink in winter, the jebeer range further away from springs (Section 5.4.1) and move into areas without springs, such as area 2 in the Turan P.A., at this time of year (Section 4.4.3).

From the conservation and management point of view the important observation is that, whether jebeer have a physiological requirement for free water or not, they do visit springs to drink, and their distribution in summer is limited by the distribution of springs (Section 4.4.6).

7.4.5 Drinking and water requirements

It is possible that the jebeer visit springs because they happen to be there rather than they have a physiological need to drink water. The peak in spring visitation at midday at Qarqare spring in July (Fig 7.2) suggests that they are purposefully visiting the spring to drink, and not because it is randomly encountered during their daily movement or for any other reason. *Gazella dorcas* in the Negev desert (Baharav, pers. comm.) and in the Sudan (Carlisle and Ghobrial, 1968) do not visit springs to drink. However, the habitat and climate is different in both these areas. The dominant vegetation is *Acacia* which also constitutes the major food item. Carlisle and Ghobrial showed that *G. dorcas* can get sufficient water from the *Acacia* leaves in the Sudan. In both these areas the relative humidity is greater than in the Dasht e Kavir. Dew forms at night, which it does not do in the Dasht e Kavir, and so the vegetation and the animals will retain more water, thus decreasing the need to drink.

Restricting activity to the nighttime escapes the heat of the day and conserves water. Taylor (1972) observed that *G. granti* in the Northern Territory of Kenya restricted its activity mainly to nighttime and did not drink. Its main food item was leaves of *Disperma*. The proportion of water by weight in the leaves varied from 1% during the day to 40% at night. The gazelle restricted their feeding to the nighttime and in this way got their water requirement. Relative humidity in the area was 85%, compared with 26% in the Kavir N.P. and Turan P.A. Although the jebeer are inactive for most of the day, and seem to be restricting their feeding to the night, early morning and late evening, the humidity is apparently too low for them to get their water requirement purely from the vegetation.

7.4.6 Territories and territorial behaviour

Jebeer social organisation and behaviour fits the general gazelle pattern. All species that have been studied, such as Grant's gazelle (Walther, 1972; Estes, 1967), Thomson's gazelle (Estes, 1967), mountain gazelle (Baharav, 1973) and dorcas gazelle (Baharav, pers. comm.), have territorial males with female groups moving through the territories without any apparent permanent association. Estes (1967) observed a spacing of 200 to 300 yards between territorial Thomson's gazelle males, which gives a territory size of 3 to 7 hectares. He observed a spacing of about half a mile between Grant's gazelle males, giving an estimated territory size of 60 hectares. The jebeer territory size is therefore similar to that of the Grant's gazelle.

Klingel (1977) observed distances of 5, 7 and 10 km between territorial wild ass, giving a territory size of 20 to 80 km^2. Wild ass in the Dasht e Kavir were assumed to be territorial from the presence of dung piles in both regions.

Male jebeer did visit springs together in November during the rut, and no conflict was observed between them. Brooks (1961) also observed that the territorial pattern breaks down temporarily when Thomson's gazelle go to drink.

7.4.7 Effect of daily activity on census results

In July, the jebeer were observed to start lying down from two and a half hours after sunrise. Since aerial censuses are done during the first two and a half hours after sunrise, this activity would not be expected to affect the population estimate. It would be expected to affect the road census estimates. However, as discussed in Section 4.4.1, it does not appear to do so.

Aerial censuses of Mil (area 1) in the Kavir produce population estimates much lower than those by road censuses (Tables 4.1 and 4.2). The jebeer start visiting Mil spring from much earlier in the morning than at other springs (Fig 7.2), and are already concentrating at the spring by the time the plane arrives. If the spring is not included within the transect, then a significant proportion of the population will be missed. Also, because the plane travels fast, a greater proportion of the population will be missed the more concentrated they are. Both these factors will produce an underestimate of population size by aerial census.

7.5 Summary

1. Jebeer gazelle visit springs to drink in summer, and for social interaction during the rut in autumn.
2. During the middle of the day in summer they are inactive and rest in foothills and *Haloxylon*.
3. Springs in foothills and *Artemisia* and *Zygophyllum* habitats are visited by a greater proportion of the jebeer population than those springs out on the plains and in *Haloxylon* habitat.
4. Jebeer gazelle were observed to feed in the early morning

and late evening. They probably also feed at night.

5. Jebeer and wild ass visit springs that are visited by domestics, but do not visit springs where there is permanent human presence.

6. Jebeer gazelle range further in winter because they do not drink.

7. Jebeer and wild ass probably drink because they have a physiological need to due to the heat and low humidity of the Dasht e Kavir in summer.

8. Jebeer are territorial, and the common behaviours associated with territoriality were observed.

9. Wild ass are probably also territorial.

10. Jebeer concentrating early in the morning at Mil spring daily activity produces an underestimate of population size by aerial census.

11. Jebeer lie down during road transect sampling, but this does not appear to affect the population estimates.

Table 7.1

Direction of arrival and departure of jebeer at springs in the Kavir N.P.

Spring	Date	Proportion of jebeer arriving from plains	Proportion of jebeer arriving from foothills	N	Proportion of jebeer departing to plains	Proportion of jebeer departing to foothills	N
Shur	July 1975	83%	17%	84	0	100%	58
	Sept 1975	95%	5%	73	0	100%	81
	Nov 1975	100%	0	62	100%	0	62
Mil	July 1975	76%	24%	202	7%	93%	176
	Sept 1975	81%	19%	123	26%	74%	139
	Nov 1975	72%	28%	57	64%	36%	51

Table 7.2

Length of time that jebeer remain at springs.

a) Kavir N.P.

		♂	♀
Mean length of stay	= 63 mins	65 mins	51 mins
range	= 8-96 mins	11-80 mins	8-96 mins
N (recognised individuals)	= 73	51	22

b) Turan P.A.

Mean length of stay	= 19 mins
range	= 5-35 mins
N (recognised individuals)	= 28

Table 7.3

Use of springs by domestic sheep and goat, wild ass and jebeer gazelle in the Turan P.A. as shown by presence or absence of fresh tracks. July 1977.

Area	Spring	Day 1 domestic sheep & goat	Day 1 jebeer	Day 1 wild ass	Day 2 domestic sheep & goat	Day 2 jebeer	Day 2 wild ass	Day 3 domestic sheep & goat	Day 3 jebeer	Day 3 wild ass
6.	Majerad 1	+	-	-	+	-	-	+	-	-
6.	Majerad 2	+	-	+	-	+	+	-	-	+
6.	Abul Yahya	-	+	+	-	-	+	-	+	+
5.	Chah Vekil	-	+	-	-	+	-	-	+	+
4.	Garmab	-	-	-	-	-	-	-	-	-
4.	Gharibe	+	-	-	-	+	-	-	-	-
4.	Sitel	-	+	+	+	+	+	-	+	+
4.	Chahak	-	+	+	-	+	+	-	+	-
4.	Tejour	+	-	-	+	-	-	+	-	-
1.	Delbar	+	-	-	+	-	-	+	-	-

+ = tracks present
- = tracks absent

Table 7.4

Proportion of the jebeer population in each area visiting springs each day.

a) Kavir N.P.

Spring	Area	Population estimate	Number visiting in one day	Proportion of total population visiting in one day
Mil	1	150	164	100%
Shur	4	38	29	76%
Talkhab	9	33	33	100%
Qarqare	10	144	21	15%

b) Turan P.A.

Spring	Area	Population estimate	Number visiting in one day	Proportion of total population visiting in one day
Sitel Chahak Gharibe Garmab	4	430	11	3%
Chah Vekil	5	90	12	13%
Abul Yahya	6	44	5	11%

Figure 7.1

Seasonal variation in the mean number of jebeer at springs throughout the day, Kavir N.P.

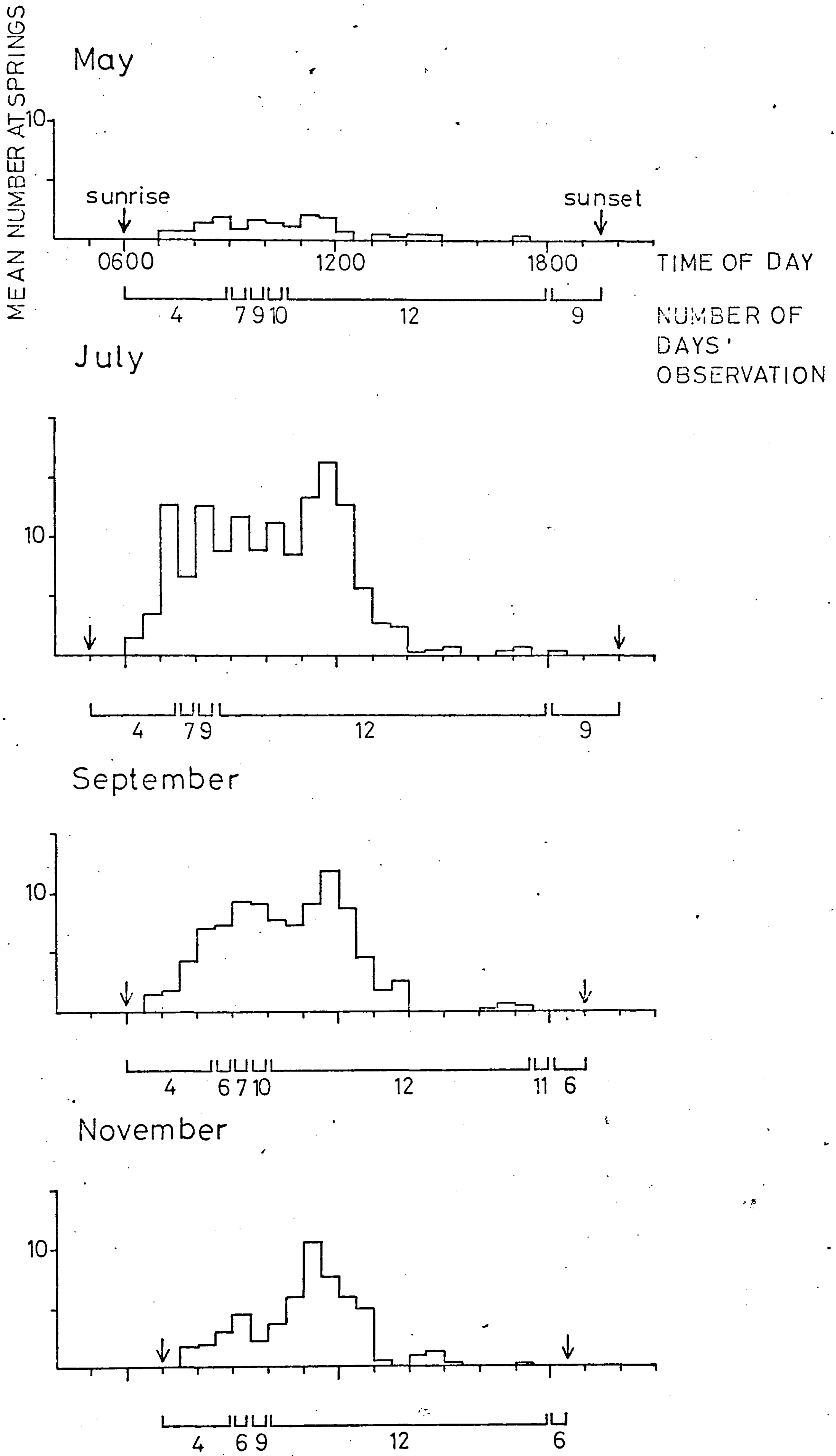
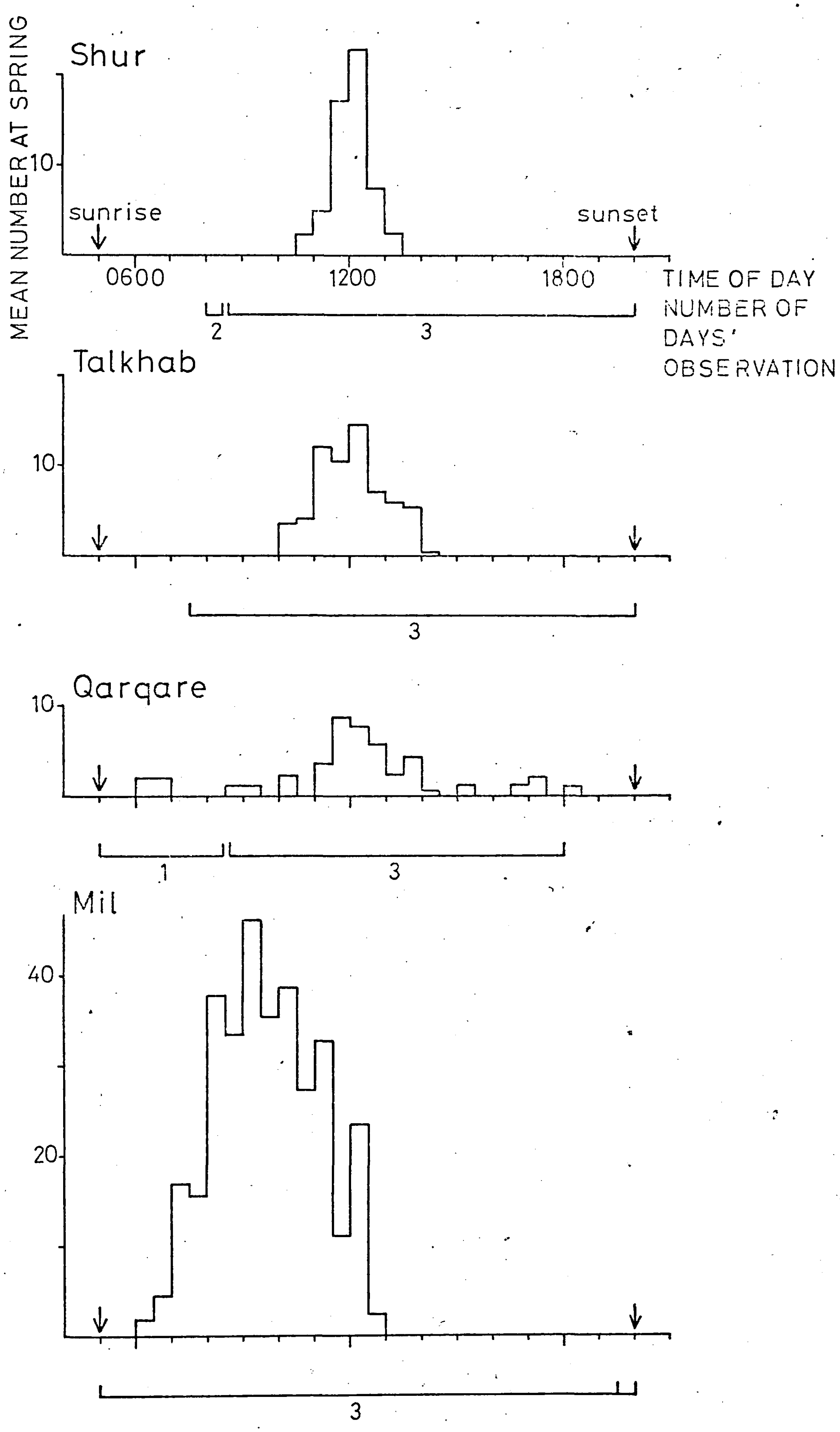

May
MEAN NUMBER AT SPRINGS
10
sunrise
sunset
0600
1200
1800
TIME OF DAY
4
7 9 10
12
9
NUMBER OF DAYS' OBSERVATION
July
10
4
7 9
12
9
September
10
4
6 7 10
12
11
6
November
10
4
6 9
12
6

Figure 7.2

Variation between springs in the mean number of jebeer at springs throughout the day in July, Kavir N.P.



Shur
MEAN NUMBER AT SPRING
10
sunrise
sunset
0600
1200
1800
TIME OF DAY
NUMBER OF DAYS' OBSERVATION
2
3
Talkhab
10
3
Qarqare
10
1
3
Mil
40
20
3

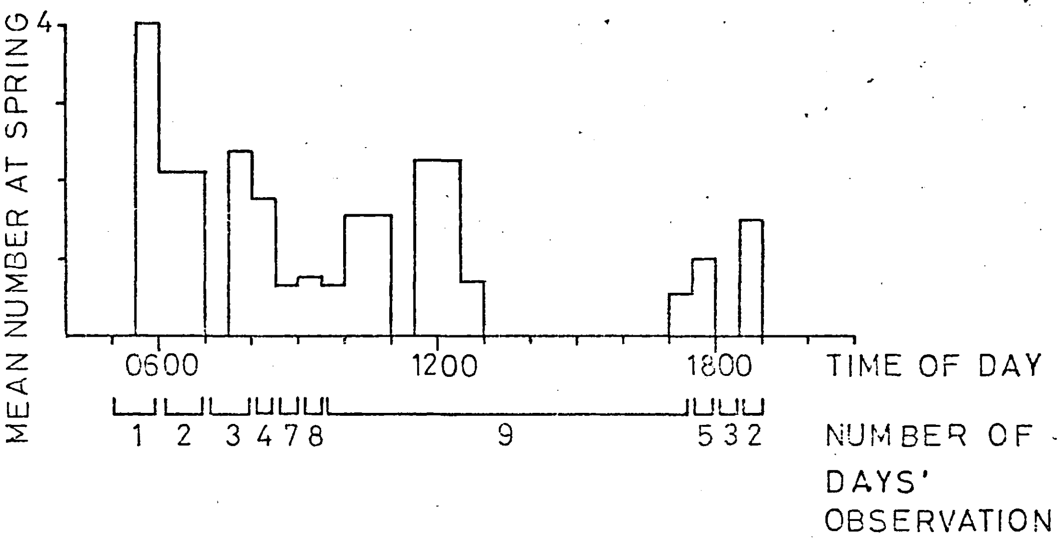
Figure 7.3

Mean number of wild ass visiting Qarqare spring throughout the day.

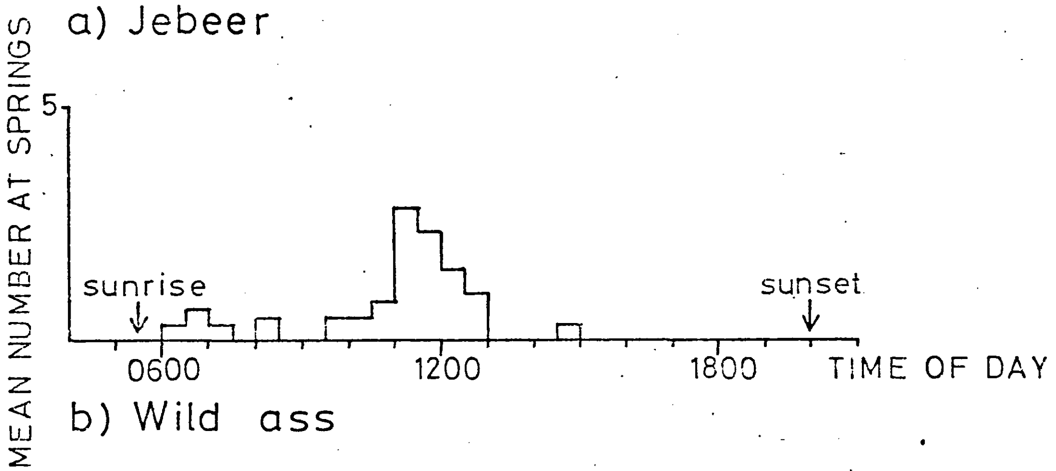
July, September and November censuses are combined.

Figure 7.4

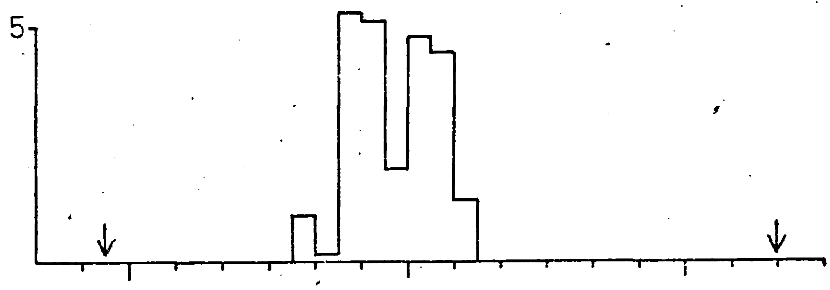
Mean number of jebeer and wild ass at springs throughout the day in August, Turan P.A.



a) Jebeer



b) Wild ass

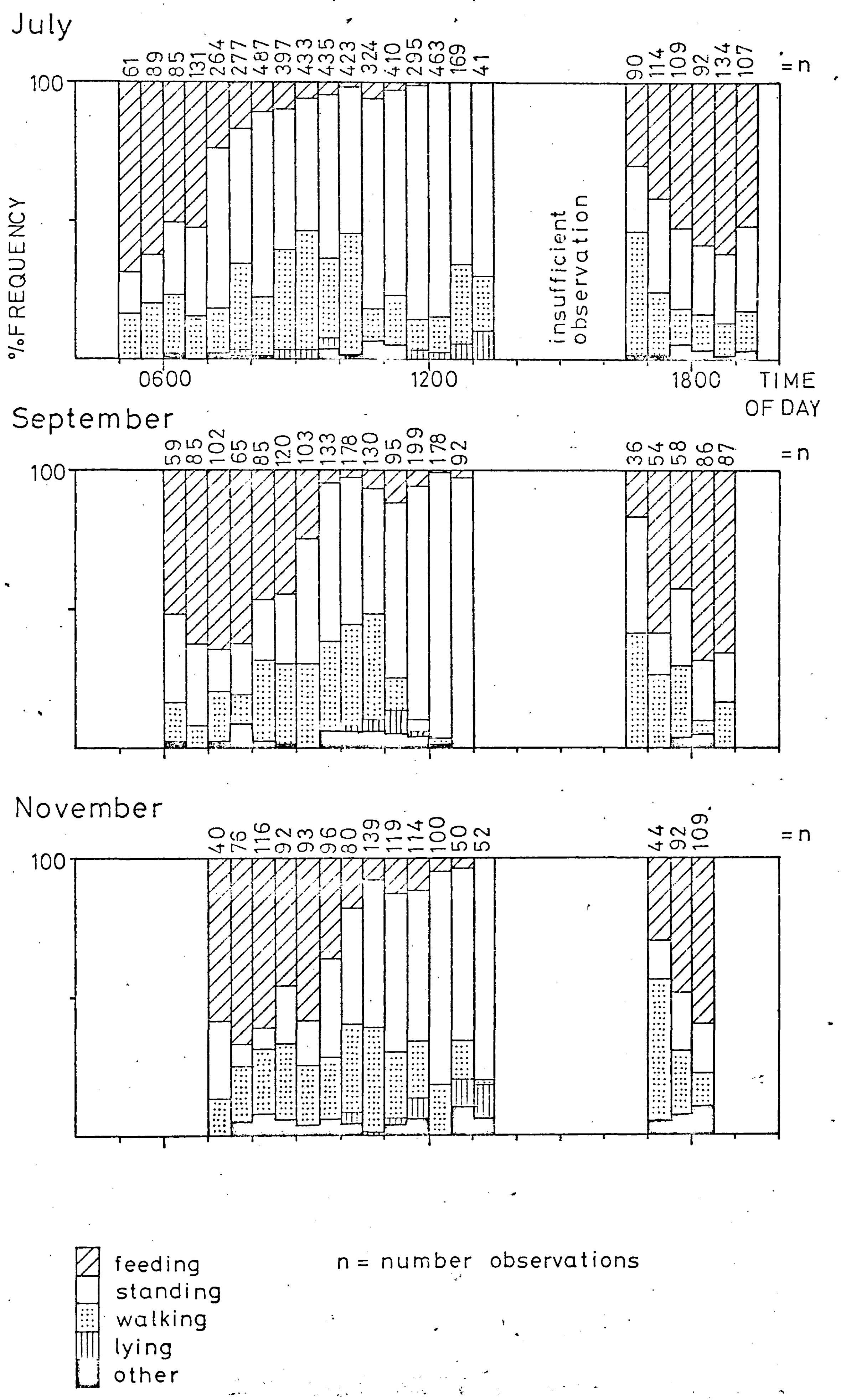


c) Number of individuals observed

SPRING	JEBEER	WILD ASS
Abul Yahya	5	2
Chah Vekil	12	0
Garmab	0	0
Gharibe	2	0
Chahak	6	37
Sitel	3	41

Figure 7.5

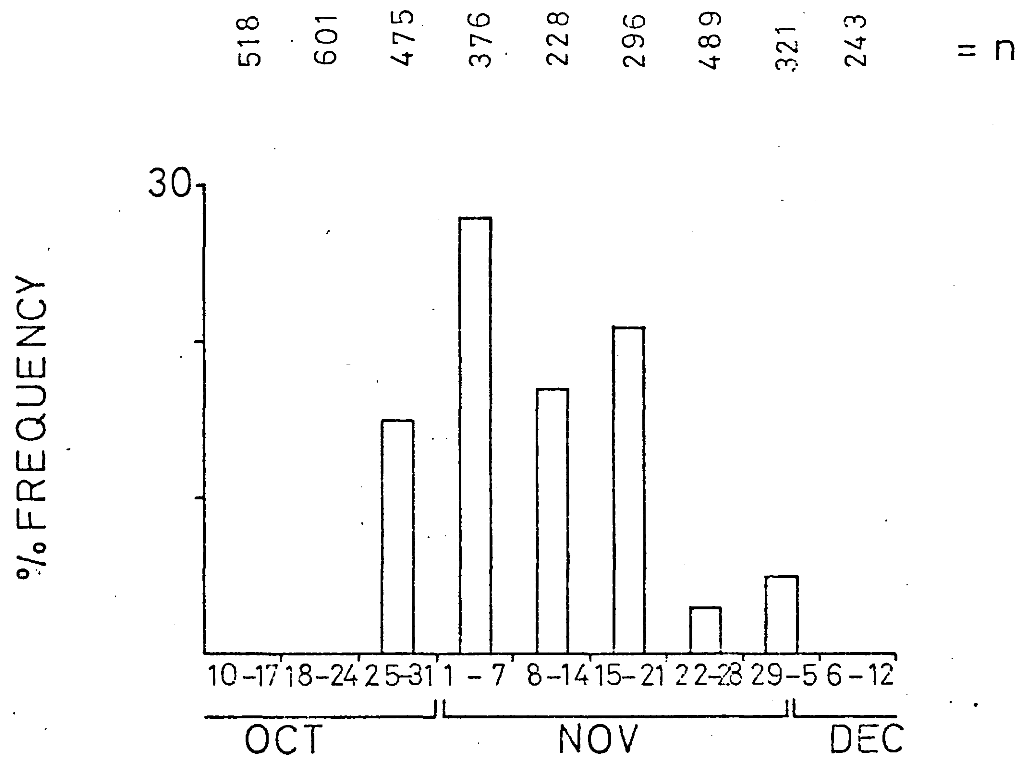
Seasonal variation in daily activity of jebeer, Kavir N.P.



July
61 89 85 131 264 277 487 397 433 435 423 324 410 295 463 169 41
90 114 109 92 134 107
=n
100
% FREQUENCY
insufficient observation
0600
1200
1800
TIME OF DAY
September
59 85 102 65 85 120 103 133 178 130 95 199 178 92
36 54 58 86 87
=n
100
November
40 76 116 92 93 96 80 139 119 114 100 50 52
44 92 109
=n
100
feeding
standing
walking
lying
other
n = number observations

Figure 7.6

Percentage frequency of observations of sexual behaviour in male jebeer throughout the rut, Kavir N.P.



n = number of male observations

Chapter 8

FEEDING

8.1 Introduction

Geist (1974) has reviewed the feeding strategies evolved by ungulates according to what he calls the "Jarman-Bell principle", based on the work of Bell (1970) and Jarman (1974). Feeding strategy is determined by body size, the nutrient quality of the food items, and their distribution in the habitat. These factors also determine aspects of social organisation such as group size and territoriality. Hofmann and Stewart (1972) recognised three types of feeders; bulk and roughage feeders; concentrate selectors; and intermediate feeders. The latter are capable of adapting seasonally to the other two types.

Lack (1954) considered food supply to be the most important factor in regulating animal populations. Lack of food has caused high mortality in a number of large herbivore populations, such as reindeer (Klein, 1968), African elephant (Corfield, 1973), reedbuck (Ferrar and Kerr, 1971) and wildebeest (Child, 1972).

Owing to the importance of food in the ecology of large herbivores, conservation and management of their habitat involves primarily conservation and management of their food resources. It is essential, therefore, to determine their diet.

Three methods are commonly used to determine diet of wild large herbivores; direct observation of feeding animals; stomach analysis of shot specimens; and faecal analysis.

Direct observation is the simplest and can be done on animals that are not disturbed by the observer's presence. If the animals are too shy or the habitat too enclosed for direct observation, then the other two methods have to be used. Stomach analysis is the better since the food items have not been digested, and are more easily recognised and their respective quantities representative of the actual quantities eaten. This can only be done when the animals are abundant. When they are not, faecal analysis has to be resorted to. This is unsatisfactory in that the plant parts have been digested, and are either not present or are difficult to identify. The proportions of plant parts in the faeces will not necessarily be the same as the proportions eaten.

8.2 Methods

8.2.1 Bite studies

a) Jebeer gazelle

Direct observation of jebeer feeding was done in the Kavir N.P. only; in the Turan P.A. they were too timid to approach. On the return journey to Shah Abbas, having completed the road transects, whenever jebeer were sighted close enough to the road, observations were made from inside the stationary vehicle using a pair of 10 x 50 binoculars. The number of bites and the plant species was recorded onto a tape recorder with location, date and habitat. Jebeer were observed in all habitat types at all seasons of the year throughout the four years of the study. The proportion of bites of each plant species was calculated per month to determine seasonal variation (Fig 8.1).

b) Domestic sheep and goat

During road censuses in the Turan P.A. domestic flocks from Delbar and Tejour were followed on foot. During each census two 24-hour periods were spent with each flock. Individual animals were followed for twenty minutes at a time and the number of bites and the plant species was recorded onto a tape recorder with habitat, time and location. The proportion of bites of each plant species was calculated per month to show seasonal variation (Fig 8.2).

8.2.2 Vegetation sampling

The aim of the vegetation sampling was to determine the relative availability of plant species to compare with the proportion in the jebeer diet, as estimated from bite studies. This required sampling over the whole region. Two constraints, the large areas involved and the short time available on each field trip, severely limited the choice of sampling method. The point-centred quarter method was adopted because it offers a means of taking rapid, quantitative samples, and is particularly useful in vegetation where it is difficult to delimit large enough quadrats for adequate sampling, such as in the relatively sparse vegetation of the Kavir (Ayyad, 1970; Cottam & Curtis, 1956; Dix, 1961).

Since it was important to sample the whole region, and since detailed analysis was not required, randomisation was not done in selecting sampling points. Instead, vegetation transects were selected at 2 km intervals along the road transects. Each vegetation transect comprised twenty-five points. The first point was located ten metres from the edge of the road on the left hand side of the vehicle to avoid any influence by the road on the vegetation. Points were 10 metres apart in a straight line, measured with a 10-metre piece of string.

The area around each point was divided into four equal quarters, with the "north-south" axis aligned along the line of the transect. Within each quarter, the distance from the point to the nearest living emergent stem, and the maximum height and diameter of the whole plant, was measured and recorded by species. Two people were involved, one measuring and the other recording. The habitat category of each transect was recorded.

Only perennial vegetation was recorded.

For each transect, the area sampled was obtained by summing the squares of the distances from point to emergent stem. By assuming each plant to be cylindrical the volume of each species in this area was calculated and expressed as density (m^3 of each species per 100 m^2). Within each habitat, these densities were summed for each species and their percentage of the total volume calculated (Tables 8.4 and 8.5). The volume of a plant was thought to be a better approximation of its availability to jebeer than surface area, since jebeer were seen to bite food items from the centre of plants as well as the periphery.

Vegetation transects were done after completion of the road transects in 1976 and 1977 in the Kavir N.P., and May and August 1976 in the Turan P.A.

8.2.3 Preference index of plant species

Calculation of a preference index of the perennial plant species followed that of Jacobs (1974). The proportion of bites taken of each plant species was divided by the proportion by volume in the habitat. The log of this figure gave the preference index (Tables 8.6 and 8.7). Negative values indicated a negative preference, and positive values a positive preference.

8.2.4 Faecal analysis

Jebeer, wild ass and domestic sheep and goat faeces were collected when they were encountered in the field and placed separately in 20 ml glass containers with F.A.A. as preservative. Only fresh faeces, those that were moist on the surface, were collected. The date, location and habitat was recorded.

To prepare them for microscopic examination, each faecal sample was washed to remove the preservative, and then crushed in a pestle and mortar to mix up the contents. These were then placed in 100 mls of water with 3 mls domestic bleach and brought slowly to boil. They were then removed and allowed to cool and the contents settle. The supernatant was drained off and fresh water added. When the contents had settled again the supernatant was drained off and the process repeated twice more. Finally the faecal sample was placed in a petri dish and dried in an oven.

The method used for microscopic examination followed that of Williams et al. (1974). Three subsamples of 0.25 g were taken from each dried sample and spread evenly on a petri dish on the bottom of which was a grid square of 100 points, 0.5 cm apart. The petri dish was examined under a low-power zoom dissecting microscope.

Each point on the grid was scored as follows: monocotyledonous leaf; monocotyledonous stem; dicotyledonous leaf;

dicotyledonous stem; seed; unclassified. Thus, for each faecal sample, the material at 300 points was recorded. "Unclassified" included those points which did not contain any plant material, or which contained plant material which could not be identified as any of the other categories. The other five categories were regarded as "hits".

The proportion of hits of each plant category was calculated separately for each sample. The mean of these proportions was calculated for each month for each species (Figs 8.3 and 8.4).

8.2.5 Statistical analysis

The significance of the seasonal variation in the proportion of plant species eaten (Tables 8.1 and 8.2) and the proportion of plant parts found in the faeces (Tables 8.8 and 8.10) was tested using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956).

For the less common shrubs *Pteropyrum* and *Ephedra* only those animals that were observed feeding in habitat containing these two species were used in the analysis. Otherwise there were too many zero values to produce a significant result.

The significance of the differences between sheep and goat in the proportion of bites taken of different plant species (Table 8.3), between areas in the proportion of plants by volume in the habitat (Table 8.11) and between jebeer and wild ass (Table 8.9) in the proportion of plant parts found in the faeces were tested using the Mann-Whitney U test (Siegel, 1956).

8.3 Results

8.3.1 Proportions of bites taken by jebeer gazelle in the Kavir N.P.

There was significant variation in the proportion of bites taken of all perennial plant species by jebeer in the Kavir N.P. (Kruskal-Wallis one-way analysis of variance, $P < 0.001$ in all cases (Siegel, 1956)) (Table 8.1). The greatest proportion of bites was of Artemisia for all months except May. The greatest proportion of bites in May was of grasses and forbs. The greatest proportion of bites of Ephedra was in January (Fig 8.1).

8.3.2 Proportion of bites taken in the Turan P.A.

a) Domestic goat

There is significant seasonal variation in the proportion of bites taken by domestic goat of Artemisia (Kruskal-Wallis one-way analysis of variance, $H = 51$, $P < 0.001$ (Siegel, 1956)), forbs ($H = 39.5$, $P < 0.001$), grasses ($H = 19.8$, $P < 0.001$), Pteropyrum ($H = 10.9$, $P < 0.01$), Ephedra ($H = 47.6$, $P < 0.001$), litter ($H = 98$, $P < 0.001$), and other species ($H = 62$, $P < 0.001$). There is no significant variation in the number of bites taken of Zygophyllum ($H = 5.4$, $P > 0.05$) (Table 8.2).

In April and August, only the fruit on Zygophyllum plants were eaten. In December the ends of the branches were eaten. Leaves on the plants were not eaten. Most of the leaf litter contained dry leaves and fruit of Zygophyllum.

In April, the largest proportion of bites taken by goats is of forbs. Forbs and grasses are taken throughout the year. Artemisia is taken most in December and least in April. The proportion of bites taken of *Ephedra* is greatest in December. The proportion of bites taken of other species is least in December. Litter is not taken in April (Fig 8.2.a).

b) Domestic sheep

There is significant seasonal variation in the number of bites taken by sheep of *Artemisia* (H = 74, $P < 0.001$), forbs (H = 28.7, $P < 0.001$), grasses (H = 34.1, $P < 0.001$), *Ephedra* (H = 56.8, $P < 0.001$), litter (H = 37.6, $P < 0.001$), and other species (H = 51, $P < 0.001$) (Table 8.2).

Forbs and grasses are taken throughout the year. The proportion of bites taken of forbs and grasses is largest in April and smallest in December. The proportion of bites taken of *Artemisia* is largest in December and smallest in April. The proportion of bites taken of *Ephedra* is largest in December. Other species are taken in similar proportions throughout the year (Fig 8.2.b).

c) Wild ass

One group of 27 wild ass was seen at Chahak spring in August 76. A total of 893 bites of identifiable plant species were observed, and these comprised 78% forb/grass, 19% *Zygophyllum*, and 3% *Lactuca*. Both fruit and leaves of *Zygophyllum* were taken.

d) Difference between domestic sheep and goat

Domestic goat take a larger proportion of bites of *Artemisia* than sheep. This is significant for April (Mann-Whitney U-test, U = 487, P = 0.0003 (Siegel, 1956)). They also take a larger proportion of Ephedra. This is significant for April (U = 423, P = 0.0329) and August (U = 259, P = 0.0244). Sheep take a larger proportion of forbs and grasses than goat. This difference is significant for forbs in April (U = 472, P = 0.0013), August (U = 304, P = 0.0007) and December (U = 525, P = 0.00007), and significant for grasses in April (U = 447, P = 0.0075) and August (U = 276, P = 0.0071). Goat take a larger proportion of bites of Pteropyrum for all three months, but this is only significant for August (U = 250, P = 0.0436). Sheep do not feed on Pteropyrum (Fig 8.2; Table 8.3).

e) Supplemental feed

Barley is given to the domestic sheep and goat to supplement their diet from January to March.

8.3.3 Preference indices of perennial plant species

a) Jebeer gazelle diet

Artemisia, Pteropyrum, Ephedra, Astragalus, Salsola arbuscula, and others are preferred by jebeer while Zygophyllum, Haloxylon, Seidlitzia, Salsola spp., Anabasis, Stipagrostis plumosa, and Aellania subaphylla are avoided. Astragalus has the highest preference index (Table 8.6).

b) Domestic goat diet

Domestic goat preferred Artemisia, Pteropyrum, Ephedra, Astragalus, Aellania subaphylla, Lactuca, and other species, and avoid Zygophyllum, Haloxylon, Seidlitzia, Salsola spp., Anabasis setifera, and Salsola arbuscula (Table 8.7).

c) Domestic sheep diet

Sheep select *Artemisia*, *Ephedra*, *Lactuca* and others, and avoid all others of the abundant plant species (Table 8.7).

8.3.4 Faecal analysis in the Kavir N.P.

a) Jebeer gazelle

There is significant seasonal variation in the proportions of each plant part found in jebeer faeces (Kruskal-Wallis one-way analysis of variance, $H \geqslant 27.31$, $P < 0.001$ in all cases (Siegel, 1956) (Table 8.8). Dicotyledonous stem forms the highest proportion of plant parts. The proportion of monocotyledonous leaf and stem is high in the spring, and low for the rest of the year. Dicotyledonous leaf is high in spring, summer and autumn and low in winter. Seeds occur in summer and autumn (Fig 8.3.a.).

b) Wild ass

There is significant seasonal variation in the proportions of dicotyledonous leaf and seed (Kruskal-Wallis one-way analysis of variance, $H > 19.11$, $P < 0.001$ in both cases) but not monocotyledonous leaf and stem and dicotyledonous stem ($H \leqslant 5.98$, $P > 0.2$ in all cases) in will ass faeces (Table 8.8). Dicotyledonous leaf is present in spring, summer and autumn, but not winter. Seed is present in summer and autumn (Fig 8.3.b).

c) Difference between jebeer and wild ass

There are significant differences between wild ass and jebeer in the proportions of monocotyledonous leaf and stem (Mann-Whitney U-test, $U = 2$, $P = 0.016$ in both cases (Siegel, 1956), but not dicotyledonous leaf (U = 6, P = 0.11), dicotyledonous stem (U = 8, P = 0.21), or seed (U = 11.5, P > 0.42) found in the faeces for all months summed. Wild ass take more monocotyledonous leaf and stem than jebeer in winter, summer and autumn (Table 8.9).

8.3.5 Faecal analysis in the Turan P.A.

a) Jebeer gazelle

There was significant seasonal variation in the proportion of seed (Kruskal-Wallis one-way analysis of variance, H = 31, P < 0.001 (Siegel, 1956), dicotyledonous stem (H = 7.4, P < 0.05) and leaf (H = 47, P < 0.001) and monocotyledonous stem (H = 13.6, P < 0.01) and leaf found in jebeer faeces in the Turan P.A. (Table 8.10).

Monocotyledonous stem and leaf and dicotyledonous leaf constituted only small proportions of the plant parts found in the faeces of jebeer, and these are largest in April (Fig 8.4).

b) Wild ass

There was a significant seasonal variation in the proportion of seed (H = 8.3, P < 0.02) and dicotyledonous leaf (H = 28, P < 0.001) found in the faeces of wild ass in the Turan P.A., but not in dicotyledonous stem (H = 0.98, P > 0.5), or monocotyledonous stem (H = 1.7, P > 0.3) and leaf (H = 5.6, P > 0.05) (Table 8.10).

The proportion of seed was largest in April. Most of the seeds were *Zygophyllum*. The proportion of dicotyledonous leaf was largest in April and August (Fig 8.4).

c) Domestic goat

There was significant seasonal variation in the proportions of all plant parts found in the faeces of domestic goat ($\geqslant$ 8.37, P < 0.02 in all cases)(Table 8.10).

Monocotyledonous stem and leaf and dicotyledonous leaf constituted small proportions throughout the year, and were largest in April. Seeds were found only in August (Fig 8.4).

d) Domestic sheep

There was significant variation in the proportion of dicotyledonous stem (H = 15.8, P < 0.001) and monocotyledonous stem (H = 9.1, P < 0.02), but not monocotyledonous leaf (H = 4.9, P > 0.05) in the faeces of domestic sheep (Table 8.10).

The proportions of monocotyledonous stem and leaf and dicotyledonous leaf were largest in April and August, but were less than the proportion of dicotyledonous stem for all months. No seeds were scored in the faeces (Fig 8.4).

8.4 Discussion

8.4.1 Diet of the jebeer gazelle

Jebeer are predominantly browsers. In spring however they eat a large proportion of annuals. Faecal analysis shows that they also eat monocotyledons in spring. This coincides with the spring growth of annuals. When these mature and die the jebeer turn to the perennial browse species, predominantly *Artemisia*.

Other gazelle species are mixed feeders showing a varying preponderance of grazing or browsing. Brooks (1961) and Talbot (1962) observed that Thomson's gazelle is predominantly a grazer, with perennial shrubs constituting less than 20% of the diet.

Talbot (1962) observed that Grant's gazelle is predominantly a browser, with browse constituting 60% of the diet. Where dorcas gazelle has been studied, in the Sudan (Carlisle & Ghobrial, 1968) and the Negev Desert (Baharav, pers. comm.), Acacia leaves are the main food item.

Other ruminants have a similar seasonal variation in their diet. Stewart and Stewart (1971) found a significant proportion of dicotyledonous material in the faeces of Thomson's gazelle which increased as the annuals matured and dried up with the dry season. Todd (1975) found that the largest proportion of plant fragments in the faeces of bighorn sheep on Artemisia range in southern Colorado was Artemisia spp. in winter (60% of all fragments), spring (23%) and autumn (27%). In summer Artemisia spp. constituted only 5%, and the largest proportion was grasses and forbs. Schwartz and Nagy (1976) found that consumption of shrubs by pronghorn in Colorado was greatest during the winter, and declined during the growing season in spring and summer when forbs became available and were consumed more.

Despite the narrow range of available vegetation in habitats such as arid rangelands, ruminants still show a degree of selectivity in their diet. Several studies have shown that ruminants select the most nutritive items available in the vegetation (Klein, 1970; Swift, 1948) and that the nutritive value is correlated with the crude protein content of the plants (Thomas et al., 1964). Dirschl (1963) found a close correlation between the plant species preferred by pronghorn in Saskatchewan and their crude protein content. Artemisia had the highest crude protein content in the vegetation in winter and this was the major food item at this time of year. In spring, grasses had the highest crude protein content and was the major food item, and in summer it was forbs. In the Kavir N.P. the jebeer show the same selectivity.

8.4.2 Importance of individual plant species in the habitat

Of the four dominant plant species only Artemisia is a preferred food item. Zygophyllum, Haloxylon and Seidlitzia are hardly eaten. Jebeer still select Haloxylon habitat, but this is probably because it offers shade in summer. Zygophyllum offers neither shade nor food which would account for lower densities of jebeer in this habitat (Table 5.5).

Members of the family Chenopodiaceae are not preferred food items, except Salsola arbuscula (Table 8.6). This family includes Haloxylon and Seidlitzia. Many of the Chenopodiaceae contain oxalic acid and salts which render them unpalatable. For this reason they are common on overgrazed and degraded areas (Zohary, 1973).

Ephedra is an evergreen shrub which would account for its being taken in winter more than at any other time of year (Fig 8.1). Astragalus has the highest positive preference index (Table 8.6) and this is probably because it is of the family Leguminosae whose members have a high protein content.

The grass Stipagrostis plumosa is not eaten when it is dry and dormant. Young green shoots in March and May were seen to be eaten. It is an important species, along with Haloxylon and the less common Stipagrostis pennata, as a sand dune stabiliser.

8.4.3 Diet of the wild ass

On the evidence of the faecal analysis wild ass take the same proportion of monocotyledonous material as jebeer in spring, but differ from the jebeer in taking the same proportion throughout the year. The proportion of monocotyledonous material in the faeces does appear to be correlated with the proportion eaten, as shown by the similar seasonal variation in both these items in jebeer (Figs 8.1 and 8.3) and domestic sheep and goat (Figs 8.2 and 8.4). On this evidence wild ass are continuing to take the same proportion of grasses and forbs throughout the year, and are therefore taking them in winter when, according to Dirschl (1963), they have a low protein content compared with other plants in the habitat. Wild ass do not appear to be varying their diet to select the plants with the highest protein content.

Wild ass are also taking coarse, woody material, as shown by its occurrence in the faeces.

8.4.4 Feeding strategies of ruminants and equids

The equids and the ruminants have evolved different feeding strategies associated with their different methods of digestion. There is a limit to the rate of throughput of ingested material in ruminants, since material does not pass beyond the rumen until it has been broken down to a small particle size. Ruminants therefore maximise their assimilation by selecting higher quality food items in terms of coarseness and protein content. Equids have no rumen to limit rate of throughput and so they increase their assimilation by increasing the bulk and rate of throughput rather than selecting the high quality food items (Janis, 1976). This strategy has been observed in the Serengeti, where a grazing succession exists. Zebra eat the coarser stems of grasses and wildebeest eat the more succulent leaves. Removal of the grass stimulates the growth of dicotyledons which are eaten by gazelle (Gwynne & Bell, 1968). It appears that the jebeer and wild ass in the Dasht e Kavir are following similar strategies.

8.4.5 Competition with domestic sheep and goat

Jebeer and domestic goat have very similar diets as shown by bite studies (Figs 8.1 and 8.2). When food is scarce then they will be competing with each other. It seems likely that competition is occurring in the Turan P.A. The higher female: fawn ratio and lower male:female ratio in the Turan P.A. would suggest that the population is not in as good a condition as that in the Kavir N.P., and this most likely is due to the presence of domestic goat.

Domestic sheep are taking a greater proportion of grass and forbs compared with jebeer and domestic goat (Fig 8.2). In the United States pronghorn and domestic sheep show a similar separation of diets on *Artemisia* range. Severson and May (1967) found little overlap in the diets of these two species in Wyoming. The major plants in the pronghorn diet were the shrubs *Artemisia* and *Chrysothamnus*, while the major item in the sheep diet was grass.

Domestic sheep and wild ass would appear to have similar diets, although sheep show more seasonal variation (Fig 8.4). There is therefore potential competition for food between these two species.

Arid environments are subject to fluctuations in annual rainfall with subsequent fluctuations in plant and animal populations. Hillman and Hillman (1977) reported a higher mortality for grazing species such as kongoni, wildebeest and zebra in the Nairobi National Park during a drought year than for the mixed feeders and browsers such as impala, Grant's gazelle and giraffe. Since grasses and other annuals are shorter rooted, they are more adversely affected by the drought than the deeper rooted perennials. On this evidence one would expect the wild ass and domestic sheep to do worse than the jebeer or domestic goat in drought years in the Dasht e Kavir.

Firmer conclusions cannot be drawn from the data, and the whole picture of competition for food and the impact of domestics on the habitat is probably more complex. The value of the data is that it can indicate what further research is needed to determine these inter-relationships.

8.4.6 Zygophyllum habitat in the Turan P.A.

One visible feature of most of the habitat in areas 1, 2 and 3 of the Turan P.A. is the very dense *Zygophyllum*. There is a significantly greater density of *Zygophyllum* in these areas than in area 4 (Mann-Whitney U test, U = 800, P = 0.0073 (Siegel, 1956)). Jebeer do not eat *Zygophyllum*, and this could account for their low numbers in areas 1, 2 and 3. However, this does not seem to be the reason, since although there is more *Zygophyllum*, there is also a greater density of palatable species such as *Artemisia* in areas 1, 2 and 3 than in area 4 (U = 736, P = 0.0465) (Table 8.11).

Although wild animals are absent from these areas of dense Zygophyllum, it is because this type of habitat occurs at large distances from undisturbed springs, such as in areas 1, 2 and 3, and also the Shagh e Biar to the north of Delbar, and the plain west of Majerad, between Majerad mountain and the salt (Fig 2.5).

The biomass of vegetation was not estimated during this study, but Moore and Bhadresa (1978) estimated Zygophyllum to be 2600 kg/ha in area 2.

8.5 Summary

1. Jebeer and domestic goat have similar diets and are predominantly browsers.

2. Wild ass and domestic sheep have similar diets and eat predominantly grasses and forbs.

3. Forbs and grasses constitute the major food item of all species in spring.

4. Artemisia is the major food plant of jebeer and domestic goat, and of domestic sheep to a lesser extent.

5. The other three dominant plant species, Zygophyllum, Haloxylon and Seidlitzia, are not eaten.

6. Ephedra is an evergreen and constitutes a larger proportion of the diet of jebeer and domestic sheep and goat in winter than in other seasons.

7. Plants of the family Chenopodiaceae are not eaten, except Salsola arbuscula.

8. The very low densities of jebeer and wild ass in the dense Zygophyllum habitat of the Turan P.A. is not due to the lack of

available palatable plants, but to the large distances from undisturbed springs.

Table 8.1

Results of the Kruskal-Wallis one-way analysis of variance to test the significance of seasonal variation in the proportion of bites taken of each plant species by jebeer, Kavir N.P. Degrees of freedom = 4 in all cases.

Plant	Number of animals observed	H	P	
Artemisia	242	55.53	< 0.001	**
Pteropyrum	173	18.97	< 0.01	*
Other	242	28.71	< 0.001	**
Ephedra	77	26.16	< 0.001	**
Grass/forb	242	63.28	< 0.001	**
Unidentified	242	34.47	< 0.001	**

** = Significant at < 0.001
* = Significant at between 0.01 and 0.001
For Pteropyrum and Ephedra, only those individuals observed in habitat containing these two species were used in the analysis.

Table 8.2

Results of the Kruskal-Wallis one-way analysis of variance to test the significance of seasonal variation in the proportion of bites taken of each plant species by domestic sheep and goat, Turan P.A.

Degrees of freedom = 2 in all cases.

	Domestic goat				Domestic sheep			
Plant	N	H	P		N	H	P	
Artemisia	70	51	<0.001	**	63	74	<0.001	**
Zygophyllum	70	5.4	>0.05	NS	63			
Forb	70	39.5	<0.001	**	63	28.7	<0.001	**
Grass	70	19.8	<0.001	**	63	34.1	<0.001	**
Pteropyrum	31	10.94	<0.01	*	26			
Ephedra	43	47.6	<0.001	**	48	56.8	<0.001	**
litter	70	98	<0.001	**	63	37.6	<0.001	**
other	70	62	<0.001	**	63	0.19	>0.9	NS

** = Significant at <0.001
* = Significant at between 0.01 and 0.001
NS = Not significant
N = Number of individuals observed

For Pteropyrum and Ephedra, only those individuals observed in habitat containing these two species were used in the analysis.

Table 8.3

Results of the Mann-Whitney U test to test the significance of the difference between domestic sheep and goat in the proportion of bites taken of different plant species.

	April			August			December		
Plant	U	P		U	P		U	P	
<u>Artemisia</u>	487	0.0003	**	197	0.4052	NS	335	0.4247	NS
<u>Zygophyllum</u>	351	0.47	NS	190	0.488	NS	406	0.0643	NS
Forb	472	0.0013	**	304	0.0007	**	525	0.00007	**
Grass	447	0.0075	**	276	0.0071	**	374	0.1762	NS
<u>Pteropyrum</u>	374	0.0516	NS	250	0.0436	*	353	0.2981	NS
<u>Ephedra</u>	423	0.0329	*	259	0.0244	*	354	0.2912	NS
Litter	348.4	0.496	NS	209	0.2877	NS	347	0.3409	NS
Other	348.8	0.492	NS	219	0.2005	NS	402	0.0735	NS
n goats	24			21			25		
n sheep	19			18			26		

** = significant at < 0.01
 * = significant at between 0.01 and 0.05
NS = not significant

Table 8.4

Proportions of the different plants in the vegetation of the Kavir N.P.

Plant	Family	Percentage by volume in *Artemisia* habitat	*Zygophyllum* habitat	*Haloxylon* habitat	*Seidlitzia* habitat	Mean
Artemisia	Compositae	37	16	14	7.4	24
Zygophyllum	Zygophyllaceae	10	57	11	2.3	20
Haloxylon	Chenopodiaceae	6.5	12	55	2.1	14
Seidlitzia	"	1.0	1.7	0.2	64	11
Salsola spp	"	7.4	2.2	3.1	8.0	5.6
Pteropyrum	Polygonaceae	31	5.8	3.7	0.4	17
Anabasis	Chenopodiaceae	2.4	1.7	0.1	6.0	2.4
Stipagrostis plumosa	Graminae	0.2	0.5	4.3	0	0.8
Ephedra	Ephedraceae	1.1	1.7	0.9	0.1	1.0
Astragalus	Leguminosae	0.4	0.1	0.1	0	0.2
Salsola arbuscula	Chenopodiaceae	0.9	1.1	5.4	0.1	1.4
Aellania subaphylla	"	0.8	0.2	0.1	0.1	0.4
Other		1.7	0.6	2.5	10	2.8
Total		100.4	100.6	100.4	100.5	100.6
Number of plants		4900	2400	1400	1600	10300

Table 8.5

Proportions of the different plants in the vegetation of the Turan P.A.

Plant	Family	Percentage by volume in Areas 1, 2 *Zygophyllum* habitat	Area 3, 4 *Zygophyllum* habitat	Area 5 *Haloxylon* habitat	Area 6 *Zygophyllum* habitat
Artemisia	Compositae	5.1	15	3.7	6.3
Zygophyllum	Zygophyllaceae	78	48	19	62
Haloxylon	Chenopodiaceae	1.3	6.8	6.4	17
Seidlitzia	"	0	0	3.0	0
Salsola spp	"	1.5	5.8	0.4	2.3
Pteropyrum	Polygonaceae	11	17	6.1	2.9
Anabasis	Chenopodiaceae	0	0	1.2	0.2
Ephedra	Ephedraceae	1.7	2.9	0.9	1.5
Astragalus	Leguminosae	0.5	0.5	0	0.2
Salsola arbuscula	Chenopodiaceae	0.7	1.4	1.5	7.3
Aellania subaphylla	"	0.02	0.2	0	0.1
Lactuca	Compositae	0.09	1.1	0	0.1
Other		0.04	0.9	0.5	1.1
Total		99.95	99.6	100.3	101
Number of plants		4400	2700	1200	3100

Table 8.6

Preference index of perennial plants to jebeer in the Kavir N.P.

Plant	Family	Mean % by volume in habitat	Observed % of bites by jebeer	Preference index
Artemisia	Compositae	24	34	+ 0.15
Zygophyllum	Zygophyllaceae	20	0.2	- 2.0
Haloxylon	Chenopodiaceae	14	0.2	- 1.85
Seidlitzia	"	11	0.05	- 2.34
Salsola spp	"	5.6	0.08	- 1.85
Pteropyrum	Polygonaceae	17	21	+ 0.09
Anabasis	Chenopodiaceae	2.4	0	- ∞
Stipagrostis plumosa	Graminae	0.8	0.05	- 1.2
Ephedra	Ephedraceae	1.0	5.9	+ 0.77
Astragalus	Leguminosae	0.2	9.7	+ 1.69
Salsola arbuscula	Chenopodiaceae	1.4	10.5	+ 0.88
Aellania subaphylla	"	0.4	0.02	- 1.3
Other		2.8	18	+ 0.8
Σ		100.6	99.7	
N		12900 plants	27851 bites	

- = avoiding
+ = selecting

Table 8.7

Preference index of perennial plants to domestic sheep and goat in the Turan P.A.

Plant	Family	% by volume in areas 1, 2 and 4.	% number of bites taken		Preference index	
			Goat	Sheep	Goat	Sheep
<u>Artemisia</u>	Compositae	8.1	43	70	+0.72	+0.94
<u>Zygophyllum</u>	Zygophyllaceae	60	7.2	6.5	-0.92	-0.97
<u>Haloxylon</u>	Chenopodiaceae	12	0	0	- ∞	- ∞
<u>Seidlitzia</u>	"	0.4	0	0	- ∞	- ∞
<u>Salsola</u> spp	"	2.7	1.6	0	-0.23	- ∞
<u>Pteropyrum</u>	Polygonaceae	12	16	0	+0.12	- ∞
<u>Anabasis</u>	Chenopodiaceae	0.2	0	0	- ∞	- ∞
<u>Ephedra</u>	Ephedraceae	2.0	22	11	+2.04	+0.74
<u>Astragalus</u>	Leguminosae	0.4	0.6	0	+0.18	- ∞
<u>Salsola arbuscula</u>	Chenopodiaceae	1.0	0.1	4.9	-1.0	+0.69
<u>Aellania subaphylla</u>	"	0.07	1.4	0	+1.3	- ∞
<u>Lactuca</u>	Compositae	0.4	6.0	2.7	+1.18	+0.83
Other		0.1	2.6	4.1	+1.4	+1.6
Total		99.37	100.5	99.2		
N		6100 plants	15647 bites	13454 bites		

- = avoiding
+ = selecting

Table 8.8

Results of the Kruskal-Wallis one-way analysis of variance to test the significance of the seasonal variation in the proportions of each plant part found in the faeces of jebeer gazelle and wild ass in the Kavir N.P.

Degrees of freedom = 4 in all cases.

Plant part	Jebeer			Wild ass		
	H	P		H	P	
Seed	33.27	<0.001	*	21.73	<0.001	*
Dicotyledonous stem	27.31	<0.001	*	4.88	>0.2	NS
Dicotyledonous leaf	138.79	<0.001	*	19.11	<0.001	*
Monocotyledonous stem	145.31	<0.001	*	2.34	>0.7	NS
Monocotyledonous leaf	189.23	<0.001	*	5.98	>0.2	NS
Number of samples	182			39		

* = Significant
NS = Not significant

Table 8.9

Results of the Mann-Whitney U test to test the significance of the difference between jebeer gazelle and wild ass in the proportions of plant parts found in the faeces in the Kavir N.P.

$n_1 = n_2 = 5$

Plant part	Mean % in jebeer faeces	Mean % in ass faeces	U	P
Seed	2	2	11.5	>0.421 NS
Dicotyledonous stem	78	66	8	0.21 NS
Dicotyledonous leaf	13	9	6	0.111 NS
Monocotyledonous stem	5	13	2	0.016 *
Monocotyledonous leaf	2	9	2	0.016 *

* = Significant
NS = Not significant

Table 8.10

Results of the Kruskal-Wallis one-way analysis of variance to test the significance of the seasonal variation in the proportions of each plant part found in the faeces of wild and domestic animals in the Turan P.A. Degrees of freedom = 2 in all cases.

Plant part	Jebeer			Wild ass			Domestic goat			Domestic sheep		
	H	P		H	P		H	P		H	P	
Seed	31	<0.001	**	8.3	<0.02	*	72	<0.001	**			
Dicotyledonous stem	7.4	<0.05	*	0.98	>0.5	NS	8.37	<0.02	*	15.8	<0.001	**
Dicotyledonous leaf	47	<0.001	**	28	<0.001	**	33	<0.001	**	39	<0.001	**
Monocotyledonous stem	13.6	<0.01	*	1.7	>0.3	NS	11.2	<0.01	*	9.1	<0.02	*
Monocotyledonous leaf	12.3	<0.01	*	5.6	>0.05	NS	22	<0.001	**	4.9	>0.05	NS
Number of samples	50			62			112			131		

** = Significant at 0.001
 * = Significant at between 0.05 and 0.001
NS = Not significant

Table 8.11

Results of the Mann-Whitney U tests to test the significance of differences between areas 1, 2 and 3 and 4 in the proportion of plants in Zygophyllum habitat.

Plant	Mean volume (m^3/ha) Areas 1, 2 and 3	Area 4	U	P
Artemisia	18	10	736	0.0465 *
Zygophyllum	169	91	800	0.0073 *
Number of samples	44	39		

* = Significant

Figure 8.1

Seasonal variation in the proportions of bites taken of different plants by jebeer, Kavir N.P.

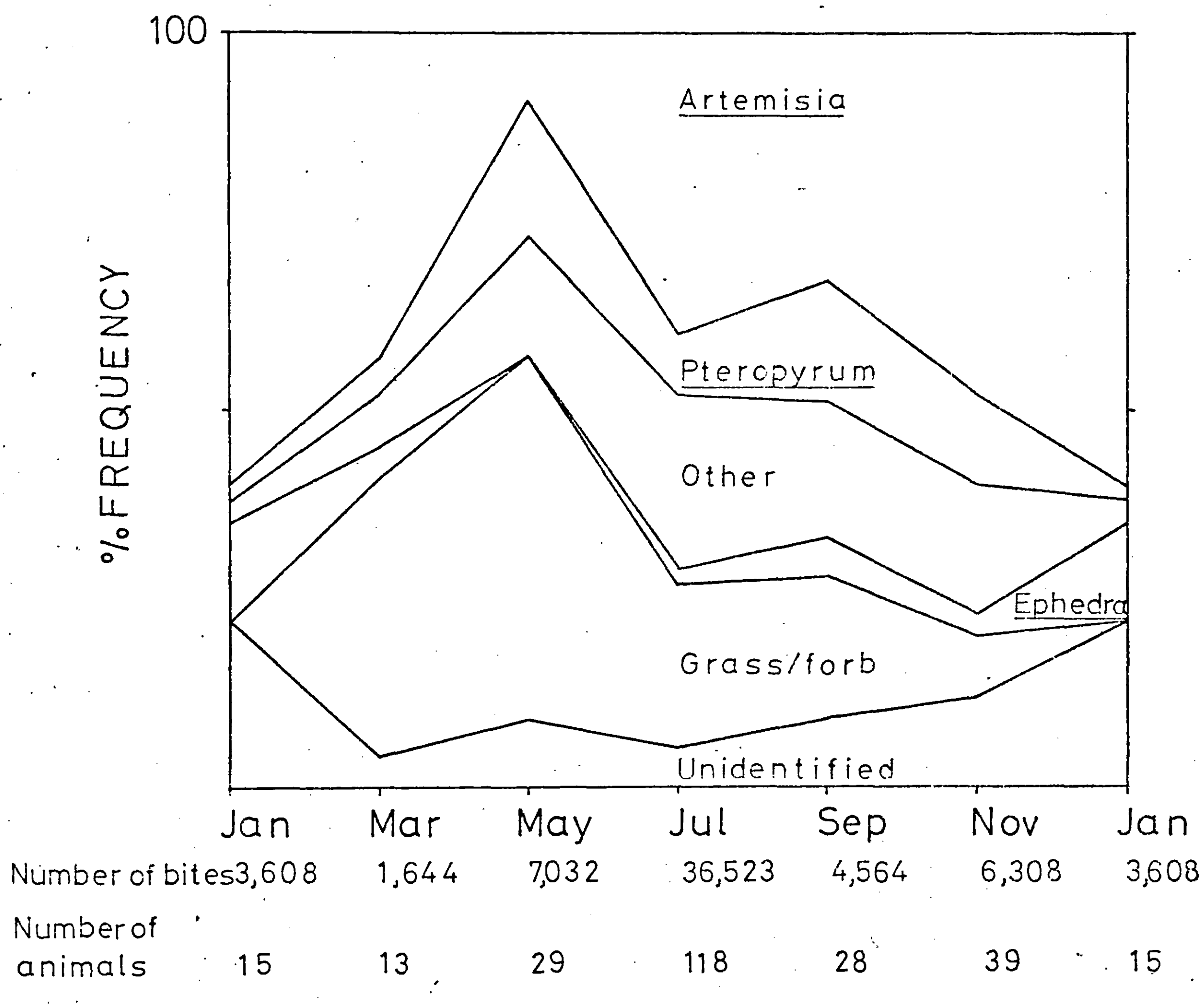
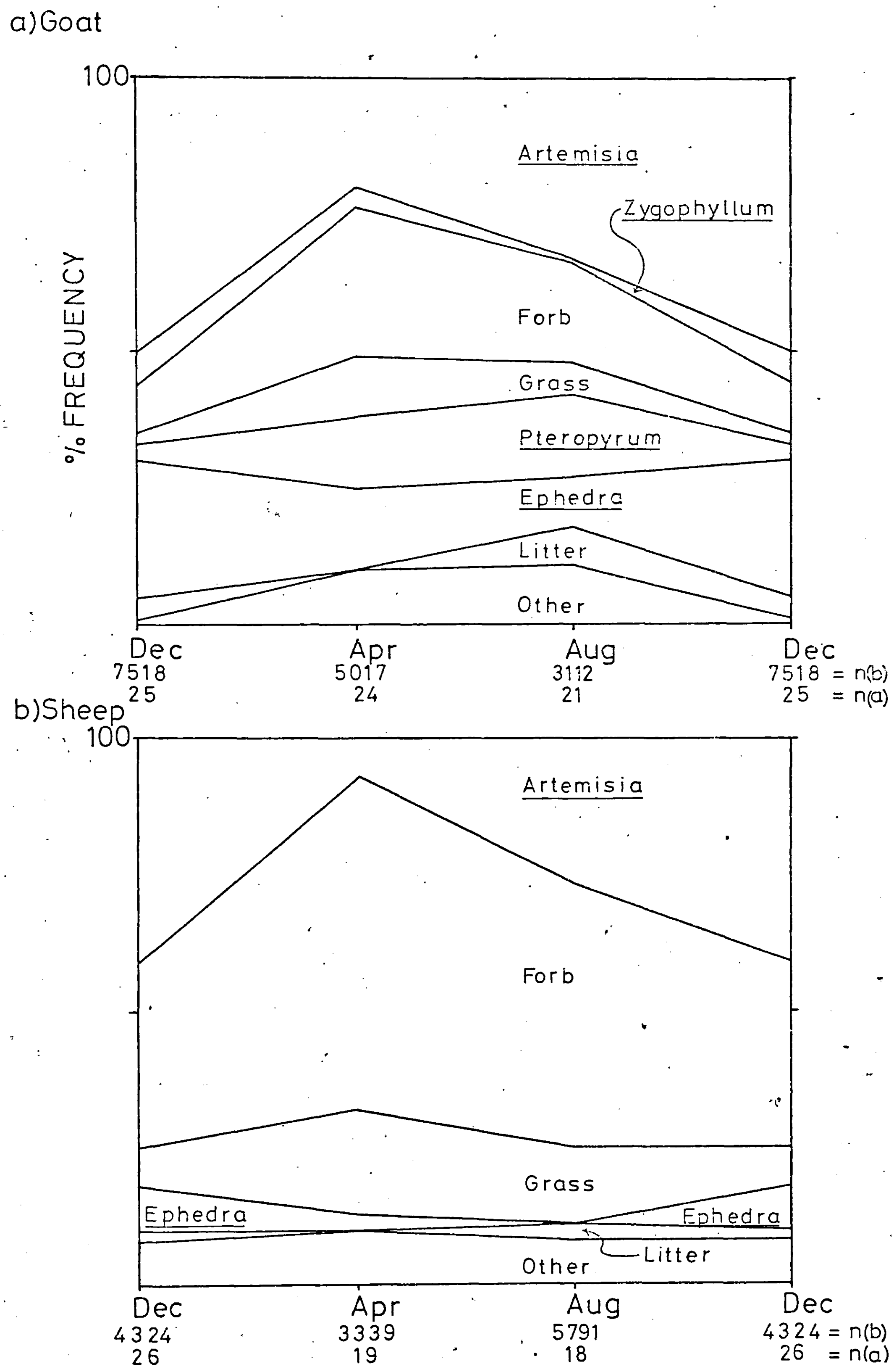

100
% FREQUENCY
Artemisia
Pteropyrum
Other
Ephedra
Grass/forb
Unidentified
Jan
Mar
May
Jul
Sep
Nov
Jan
Number of bites 3,608
1,644
7,032
36,523
4,564
6,308
3,608
Number of animals
15
13
29
118
28
39
15

Figure 8.2

Seasonal variation in the proportions of bites taken by domestic sheep and goat, Turan P.A.

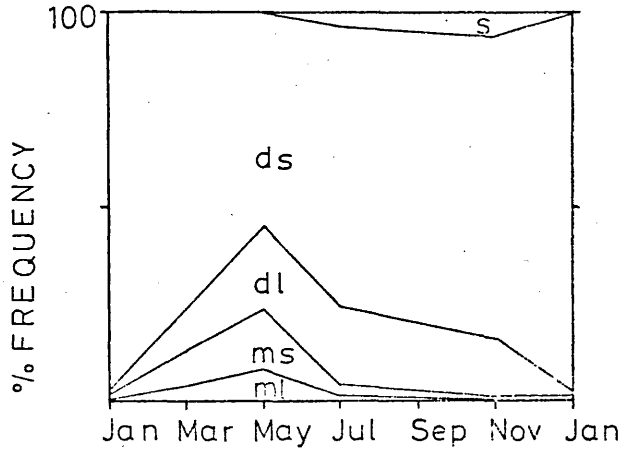


n(b) = number of bites
n(a) = number of animals

Figure 8.3

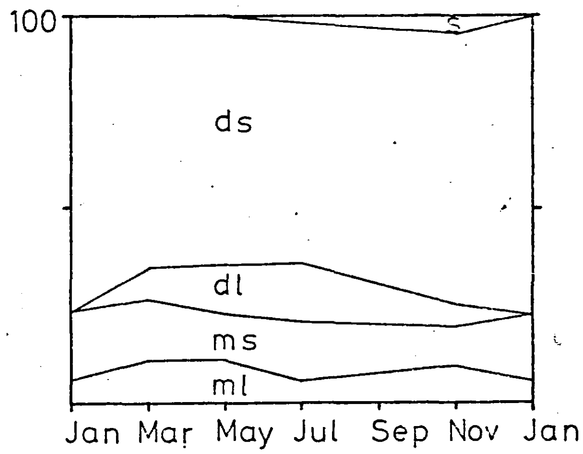
Seasonal variation in the proportions of plant parts found in the faeces, Kavir N.P.

a)Jebeer



n =	51	32	27	43	0	29	51
% hits =	16	17	19	18		14	16

b)Wild ass



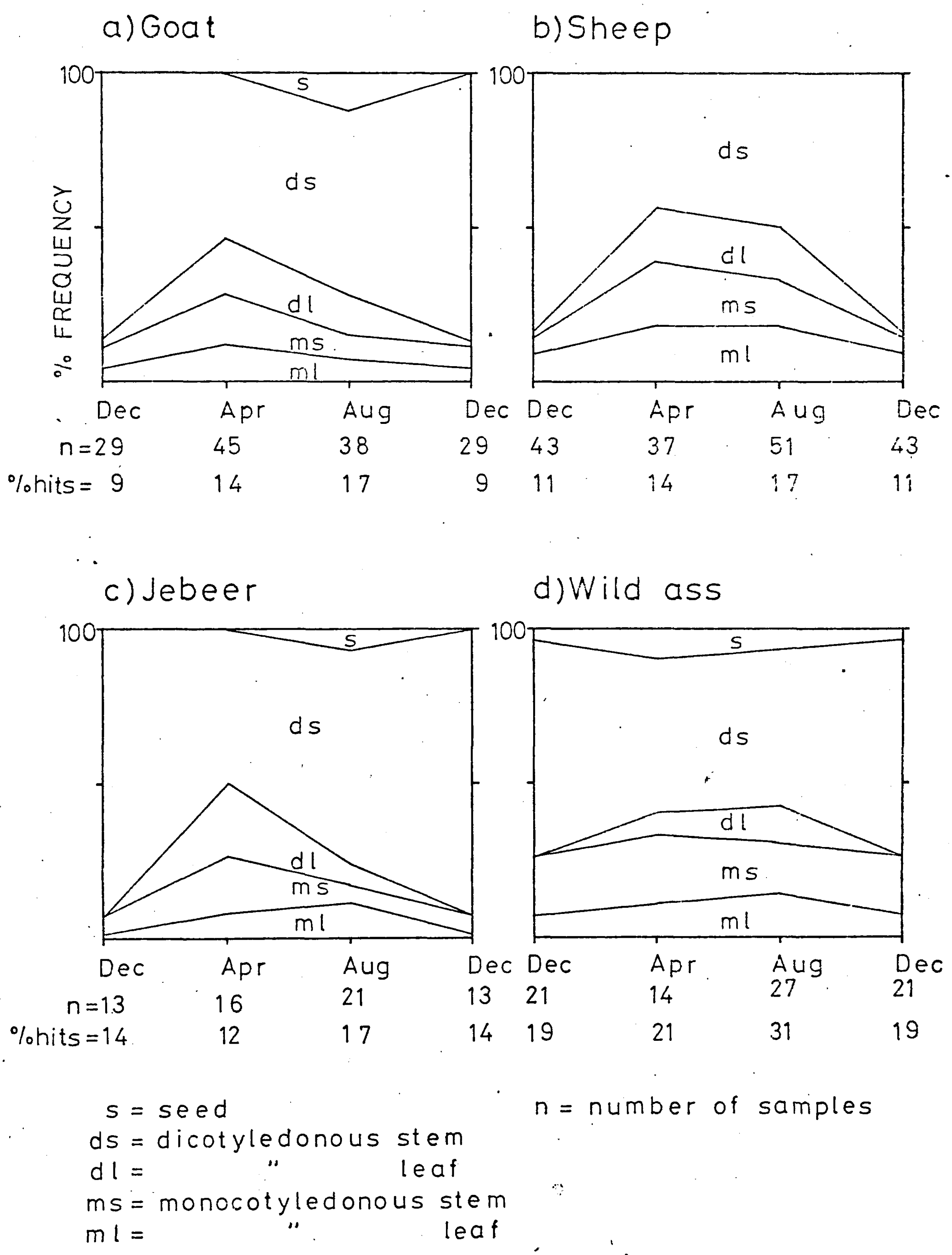
n =	2	7	10	7	0	13	2
% hits =	20	34	31	35		31	20

s = seed
ds = dicotyledonous stem
dl = " leaf
ms = monocotyledonous stem
ml = " leaf

n = number of samples

Figure 8.4

Seasonal variation in the proportions of plant parts found in the faeces, Turan P.A.


a) Goat
b) Sheep
c) Jebeer
d) Wild ass
100
% FREQUENCY
s
ds
dl
ms
ml
Dec
Apr
Aug
Dec
n=29 45 38 29
%hits= 9 14 17 9
n= 43 37 51 43
%hits= 11 14 17 11
n=13 16 21 13
%hits=14 12 17 14
n= 21 14 27 21
%hits= 19 21 31 19
s = seed
ds = dicotyledonous stem
dl = " leaf
ms = monocotyledonous stem
ml = " leaf
n = number of samples

Chapter 9

CONSERVATION, MANAGEMENT AND RESEARCH IMPLICATIONS

9.1 Conservation

9.1.1 Habitat requirements and threats to the status of jebeer gazelle and wild ass

Threats to the status of jebeer and wild ass come from occupation of springs, presence of domestic sheep and goat and unrestricted hunting. Wild ass are more susceptible to hunting from vehicles due to the ease with which they can be hunted. Under the protection afforded during the course of the study unrestricted hunting had ceased to be a threat to both species. Permanent occupation of springs prevents jebeer and wild ass from using them. This is more critical for the jebeer since wild ass range further from springs. Domestics will not eradicate jebeer or wild ass from an area but will reduce their densities. It is possible that domestics can degrade the vegetation to such an extent that it becomes too poor for wildlife. The data from this study are not good enough to prove this point.

9.1.2 Recommendations to improve the status of the jebeer gazelle and wild ass

The range of the jebeer and wild ass can be extended by the formation of artificial springs. Jebeer have been observed to move between areas and so they could quickly colonise these new areas.

Area 2 of the Turan P.A. is suitable for such range expansion. It contains suitable vegetation, and contains a band of <u>Haloxylon</u>. Jebeer move into the area in winter, but do not occur there in summer due to lack of water.

Since the Turan P.A. contains the only large population of wild ass in the country, and because of its status as an Endangered Species, it should be given special protection. It would be advantageous to set aside a refuge in the Turan P.A. for the wild ass in which the domestic presence would be reduced. The most obvious areas for this would be where they are in their greatest densities at present, that is areas 4, 5 and 6. Migratory domestics should not be allowed into the refuge. The sedentary domestics from Tejour and Majerad are in low densities in these areas, so it is not recommended that they be removed, only that their maximum numbers be restricted to those occurring at present. Removing these flock owners from their homes would cause unnecessary rancour.

9.2 Exploitation

With pressures for use of rangelands for domestic grazing increasing as the human population increases, justification for wildlife conservation rests more, rightly or wrongly, on its commercial viability. Principle ways in which wildlife populations can be exploited commercially are through game viewing, sport hunting and harvesting.

9.2.1 Game viewing

Jebeer and wild ass are conspicuous animals and have a potential to reach high enough densities to make them ideal for game viewing. At present in the Kavir N.P. neither is in high enough densities to make them easy to see for tourism. The attraction of the region to tourists is that it gives the visitor an experience of the desert as a whole. This experience could be greatly enhanced by close views of these wild animals. This could be achieved by constructing a hide at Shur spring. There is plenty of dead ground so that visitors' approach to the spring could be undetected. Jebeer could be observed coming to drink in the summer, and rutting in October and November. Shur spring has the advantage of being situated close to the headquarters of the region at Shah Abbas and therefore tourists have easy access to it. The wild ass occur too far away and visit springs too irregularly to warrant developing springs for viewing them.

9.2.2 Sport hunting

Revenue can be obtained from selling licenses for sport hunting. The conservation status of the jebeer population in the Turan P.A. would not be threatened by controlled hunting, and the criteria of classification of the region would allow hunting (Section 2.2.2). Assuming that the maximum potential rate of increase in the population is 20% per year, then theoretically this is the maximum rate of harvest that can be maintained without reducing the population. However, in reality it is more complicated. After drought years if there has been a high mortality it is important that the population increase, and so hunting should be less. In a fluctuating environment such as an arid rangeland maintaining a constant hunting quota is not appropriate. To maintain its maximum reproductive potential then males only should be hunted. The limit should be less than 20% of the male population, and a safe enough figure would be 10%, which is 16 individuals per year at the present population size.

It is recommended that a certain proportion of these licenses be reserved for local villagers within the region so that they can feel involved in the activities of their local environment.

9.2.3 Harvesting

Assuming that the maximum potential rate of increase is 20% per year, then the jebeer population can be harvested at this rate and maintain its numbers from year to year. As discussed above, this will be subject to fluctuations. But for the theoretical consideration of harvesting let us assume 20% to be the maximum rate of harvesting. Within the study area, at present densities this would produce an annual harvest of 122 individuals, which would be 2074 kg/year, or 0.54 kg/km^2/year. The saleable meat and bone weight of a jebeer is 60% of its total body weight, so the saleable harvest would be 1244 kg/year or 0.32 kg/km^2/year. The sale price of meat from sheep and goat in 1977 was 80 to 100 rials/kg. One would expect gazelle meat, regarded as a delicacy, to sell at more than this, say 120 to 150 rials/kg. Assuming the price to be 150 rials/kg, the returns from harvesting jebeer in the study area would be 186,600 rials/year.

The quickest and surest way of shooting gazelle is with a spotlight at night. On past experience, at densities encountered in the Kavir N.P. and Turan P.A., the rate of shooting is one gazelle every two nights per vehicle. This would entail 244 vehicle nights a year to harvest 122 individuals. Cost of petrol and ammunition is estimated at 67,250 rials.

Shooting would be done by Game Guards so there would be no extra cost for labour. This gives a net profit of 119,350 rials/year, or 31 rials/km^2/year. Net profits from pastoralism are between 2,500 to 4,500 rials/km^2/year (Spooner, 1977). Wildlife harvesting produces meat and hides, whereas the products of pastoralism are mainly wool and dairy products. Harvesting of wildlife populations is therefore not a commercially viable alternative to pastoralism.

In addition, the amount of disturbance to the wildlife populations would be considerable, and would be contrary to the priority of conservation of strategic wildlife resources. A cropping program should therefore not be entertained.

Commercially successful cropping schemes have been carried out at densities of 11 individuals/km^2 or 900 kg/km^2 for springbok (Sichel, 1976), 2,500 kg/km^2 in Zululand for impala and wildebeest (Deane & Feely, 1974), and 27 animals/km^2 or 3,340 kg/km^2 in Southern Rhodesia (Dasman, 1964). These figures are considerably higher than densities found in the Kavir N.P. and Turan P.A.

9.3 Research

This study points to the following lines of research:

1. The most important is to determine the impact of the domestics on the range, and in particular what times of the year are critical and what happens to the range in drought years. This would entail setting up exclosures in which there were no domestics and comparing productivity inside and outside the exclosures.

2. To monitor the vegetation change in the Kavir N.P. and determine what the natural vegetation should be. In particular Haloxylon should be studied. It is possible that it covered a wider range, which would have been important for jebeer since it would have allowed them to disperse further away from springs and use more of the range in summer. Haloxylon could probably reach much greater height than at present in the Dasht e Kavir. Iljin (1936) reported that Haloxylon persicum, the more common species in the Dasht e Kavir, reached a height of 5 metres in parts of Russia, where it forms the basis of a charcoaling industry. Plants in the Kavir N.P. and Turan P.A. reach a height of only 2.5 metres, probably due to its recent uncontrolled use for charcoal.

3. It is possible that the very dense Zygophyllum is a result of overstocking of domestics. It is not eaten and so could have increased at the expense of more palatable species. Areas should be cleared in exclosures and the recolonisation by plants in the absence of grazing studied.

9.4 Implications of the present political situation

Since the demise of the old regime which supported the Department of the Environment and the conservation programme, there has come a new regime with new ideas. No information has come out of the country on the status of the Department or the regions and their wildlife populations. It is probable that the Kavir N.P. is now opened up to domestic grazing, and that with the distribution of arms among the population unrestricted hunting has increased. One can therefore expect a reduction in the number of jebeer, but it is unlikely that the extent of their range will be reduced by hunting. The wild ass on the other hand is more vulnerable. Its habitat in the Kavir N.P. will ensure its survival, since it is inaccessible. Also the remoteness of the Turan will lend some protection to its population of wild ass, but with the greater number of vehicles in the country now compared to when conservation was first implemented in the 1950's, this protection will be considerably reduced. The wild ass population in the Turan P.A. must be regarded as vulnerable, and one can expect a reduction in numbers. One can only wait until conservation is resurrected in the country.

REFERENCES

Ayyad, M. (1970) Application of the point-centred quarter method to the vegetation of two types of desert habitat at Mareotis. U.A.R. J. Bot. 13 (2), 225-234.

Baharav, D. (1973) Population structure and biomass of the mountain gazelle. Proc. 4th Sci. Conf., Israel Ecol. Soc. 33-44.

Bell, R. H. V. (1970) The use of the herb layer by grazing ungulates in the Serengeti. In: Animal Populations in Relation to their Food Resources. Ed. A. Watson. Brit. Ecol. Soc. Symp. 10, 111-124.

Brooks, A. C. (1961) A study of the Thomson's gazelle (Gazella thomsoni Gunther) in Tanganyika. London: Col. Res. Publ. No. 25.

Carlisle, D. B. & Ghobrial, L. I. (1968) Food and water requirements of Dorcas gazelle in the Sudan. Mammalia 32 (4), 570-576.

Caughley, G. (1974) Bias in aerial survey. J. Wildl. Manage. 38, 921-933.

Caughley, G. (1977) Analysis of vertebrate populations. J. Wiley & Sons, London.

Cheatum, E. L. & Severinghaus, C. W. (1950) Variations in fertility of white-tailed deer related to range conditions. Trans. N. Am. Wildl. Conf. 15, 170-189.

Child, G. F. T. (1972) Observations on a wildebeest die-off in Botswana. Arnoldia 5 (31), 1-13.

Climatic Atlas of Iran (1965) University of Tehran.

Coe, M. J., Cumming, D. H. & Phillipson, J. (1976) Biomass and production of large African herbivores in relation to rainfall and primary production. Oecologia (Berl.) 22, 341-354.

Corbet, G. B. (1978) The mammals of the Palearctic region: A taxonomic review. Trustees of the British Museum (Natural History).

Corfield, T. F. (1973) Elephant mortality in Tsavo National Park, Kenya. E. Afr. Wildl. J. 11, 339-368.

Cottam, G. & Curtis, J. T. (1956) The use of distance measures in phytosociological sampling. Ecology 37, 451-460.

Cowan, I. McT. (1974) Management implications of behaviour in the large herbivorous mammals. In: The Behaviour of Ungulates and its Relation to Management, Eds. V. Geist and F. Walther. I.U.C.N. Publication, New Series No. 24, 921-934.

Dasmann, R. F. (1964) African game ranching. London & New York: Pergamon Press & The Macmillan Company.

Deane, N. N. & Feely, J. M. (1974) The development of a South African game ranch. In: The Behaviour of Ungulates and its Relation to Management. I.U.C.N. Publication No. 24, 882-887.

Dirschl, H. J. (1963) Food habits of the pronghorn in Saskatchewan. J. Wildl. Manage. 27 (1), 81-93.

Dittrich, L. (1968) Keeping and breeding gazelles at Hanover Zoo. Int. Zoo Yearbook 8, 139-143.

Dix, R. L. (1961) An application of point-centred quarter method to sampling of grassland vegetation. Range Mangt. 14, 63-69.

Dorst, J. & Dandelot, P. (1970) A field guide to the larger mammals of Africa. Collins, London.

Eberhardt, L. L. (1968) A preliminary appraisal of line transects. J. Wildl. Mgmt. 32, 82-88.

Ellerman, J. R. & Morrison-Scott, T. C. S. (1951) Checklist of Palearctic and Indian mammals, 1758-1946. London, Trustees of the British Museum (Natural History).

Estes, R. D. (1967) The comparative behaviour of Grant's and Thomson's gazelles. J. Mammal. 48, 189-209.

Ferrar, A. A. & Kerr, M. A. (1971) A population crash of the reedbuck Redunca arundinum (Boddaert) in Kyle National Park, Rhodesia. Arnoldia 5 (16), 1-19.

Firouz, E. & Harrington, F. A. (1976) Iran: Concepts of biotic community conservation. I.U.C.N. Occasional paper no. 15 Morges, Switzerland.

Fisher, W. B. (1968) Physical geography. In: The Cambridge History of Iran. Cambridge University Press, 3-110.

Flook, D. R. (1970) Causes and implications of an observed sex differential in the survival of wapiti. Canad. Wildl. Serv. Report, Series 11, 1-71.

Furon, R. (1941) Géologie du plateau Iranien. Mém. Mus. Natn. Hist. Natur., N.S., v. 7, Fasc. 2, 177-414.

Gee, E. P. (1963) The Indian wild ass. Oryx 7, No. 1, 9-21.

Geist, V. (1971) A behavioural approach to the management of wild ungulates. In: The Scientific Management of Animal and Plant Communities for Conservation, Eds. E. Duffey & A. S. Watt. Brit. Ecol. Symp. 11, 413-424.

Geist, V. (1974) On the relationship of social evolution and ecology in ungulates. Am. Zool. 14, 205-220.

Gentry, A. W. (1964) Skull characters of African gazelles. Ann. Mag. N.H. 13 (7), 353-382.

Groves, C. P. (1963) Results of a multivariate analysis on the skulls of Asiatic wild asses. Ann. Mag. Nat. Hist. 6, 13th series, 329-336.

Groves, C. P. (1969) On the smaller gazelles of the genus Gazella de Blainville, 1816. Sonderdruck Aus Z.F. Saugetierkunde Bd. 34, 38-60.

Groves, C. P. (1974) Horses, asses and zebras in the wild. David & Charles: London.

Groves, C. P. & Harrison, D. L. (1967) The taxonomy of the Gazelles (genus Gazella) of Arabia. J. Zool. Lond. 152, 381-387.

Gunvalson, V. E., Erickson, A. G., & Burcalow, D. W. (1952). Hunting season statistics as an index to range conditions and deer population fluctuations in Minnesota. J. Wildl. Manage. 16, 121-131.

Gwynne, M. D. & Bell, R. H. V. (1968) Selection of vegetation components by grazing ungulates in the Serengeti National Park. Nature (Lond.) 220, 390-393.

Harrington, F. A. (1977) A guide to the mammals of Iran. Dept. of the Environment, Tehran.

Hillman, J. C. & Hillman, A. K. K. (1977) Mortality of wildlife in Nairobi National Park during the drought of 1973-74. E. Afr. Wildl. J. 15, 1-18.

Hirst, S. M. (1969) Road strip census techniques for wild ungulates in African woodlands. J. Wildl. Mgmt. 33 (1), 40-48.

Hoffman, R. R. & Stewart, D. R. M. (1972) Grazer or browser: a classification based on the stomach structure and feeding habits of East African ruminants. Mammalia 36, 226-240.

Iljin, M. M. (1936) Chenopodiaceae. Flora U.S.S.R., 6. Moskva, Leningrad. (Translated into English by the Israel Program for Scientific Translations. Jerusalem, 1970).

Jacobs, J. (1974) Quantitative measurement of food selection. A modification of the forage ratio and Ivlev's electivity index. Oecologia (Berlin) 14, 413-417.

Janis, C. (1976) The evolutionary strategy of the Equidae and the origins of rumen and cecal digestion. Evolution 30, 757-774.

Jarman, P. J. (1974) The social organisation of antelope in relation to their ecology. Behaviour 48, 215-267.

Jarman, P. J. & Jarman, M. V. (1974) Impala behaviour and its relevance to management. In: The Behaviour of Ungulates and its Relation to Management, Eds. V. Geist & F. Walther. I.U.C.N. Publication New Series No. 24, 871-881.

Jolly, G. M. (1969) Sampling methods for aerial census of wildlife populations. East African Agr. For. J. 34, 46-49.

Klein, D. R. (1965) Ecology of deer range in Alaska. Ecol. Monogr. 35, 259-284.

Klein, D. R. (1968) The introduction, increase and crash of reindeer on St. Mathews Island. J. Wildl. Manage. 32, 350-367.

Klein, D. R. (1970) Food selection by North American deer and their response to overutilization of preferred food species. In: Animal Populations in Relation to Their Food Resources. A. Watson (Ed.). Blackwell Scientific Publications, Oxford, 25-46.

Klingel, H. (1977) Observations on social organization and behaviour of African and Asiatic wild asses (Equus africanus and Equus hemionus). Z. Tierpsychol. 44, 323-331.

Lack, D. (1954) The natural regulation of animal numbers. Clarendon Press, Oxford.

Leuthold, W. (1970) Ethology and game management. Trans. IX Int. Cong. Game Biol., 78-88.

Leuthold, W. (1977) African ungulates: A comparative review of their ethology and behavioural ecology. Springer-Verlag, Berlin.

Leuthold, W. & Leuthold, B. M. (1975) Patterns of social grouping in ungulates of Tsavo National Park, Kenya. J. Zool., Lond. 175, 405-420.

Lydekker, R. & Blaine, G. (1914) Catalogue of ungulate mammals in the British Museum, 3. London. Trustees of the British Museum.

Mendelssohn, H. (1974) The development of the populations of gazelles in Israel and their behavioural adaptations. In: The Behaviour of Ungulates and Its Relation to Management, Vol. 2; 722-743. I.U.C.N. Publications, Switzerland.

Mitchell, B., Staines, B. W. & Welch, D. (1977) Ecology of red deer. A research review relevant to their management in Scotland. Institute of Terrestrial Ecology, Cambridge.

Moore, P. D. & Bhadresa, R. (1978) Population structure, biomass and pattern in a semi-desert shrub, Zygophyllum eurypterum, in the Turan biosphere reserve of North-eastern Iran. J. appl. Ecol. 15, 837-845.

Nagy, J. G., Steinhoff, H. W., Ward, G. M. (1964) Effects of essential oils of sagebrush on deer rumen microbial function. J. Wildl. Manage. 28, 785-790.

Norton-Griffiths, M. (1978) Counting animals. Handbook No. 1 African Wildlife Leadership Foundation, Nairobi.

Pienaar, U. de V. (1969) Observations on developmental biology, growth and some aspects of the population ecology of African buffalo in the Kruger National Park. Koedoe, 12, 29-52.

Pratt, D. J. & Gwynne, M. D. (1977) Rangeland management and ecology in East Africa. Hodder & Stoughton, London.

Rechinger, K. H. & Wendelbo, P. (1976) Plants of the Kavir National Park, Iran. Iran J. Bot. 1, 23-56.

Rodgers, W. A. (1977) Seasonal change in group size amongst five wild herbivore species. E. Afr. Wildl. J. 15, 175-190.

Schwartz, C. C. & Nagy, J. G. (1976) Pronghorn diets relative to forage availability in northeastern Colorado. J. Wildl. Manage. 40 (3), 469-478.

Severson, K. E. & May, M. (1967) Food preferences of antelope and domestic sheep in Wyoming's Red Desert. J. Range Manage. 20 (1), 21-25.

Sichel, A. (1976) Venison venture. South African Panorama, September 1976, 42-44.

Siegel, S. (1956) Non parametric statistics for the behavioural sciences. McGraw-Hill Kogakusha, Tokyo.

Sinclair, A. R. E. (1974) The social organisation of the East African buffalo (Syncerus caffer Sparrman). In: The Behaviour of Ungulates and Its Relation to Management. I.U.C.N. Publication No. 24, 2, 676-689.

Sokal, R. R. & Rohlf, F. J. (1969) Biometry. W. H. Freeman & Co., San Francisco.

Spinage, C. A. (1969) Territoriality and social organisation of the Uganda Defassa waterbuck. J. Zool. Lond. 159, 329-361.

Spooner, B. (1977) Case study on desertification. Iran: Turan. Iran Department of the Environment Publication, Tehran.

Stewart, D. R. M. & Stewart, J. (1971) Comparative food preferences of five East African ungulates at different seasons. In: The Scientific Management of Plant and Animal Communities. Duffey, E., Wyatt, A. S. (Eds.) Oxford: Blackwell Scientific Publications, 351-366.

Swift, R. W. (1948) Deer select most nutritious forages. J. Wildl. Manage. 12, 109-110.

Talbot, L. M. (1962) Food preferences of some East African wild ungulates. East African Agr. and Forest J. 27, 131-138.

Taylor, C. R. (1972) The desert gazelle: A paradox resolved. Symp. Zool. Soc. Lond. 31, 215-227.

Thomas, J. R., Cosper, H. R. & Bever, W. (1964) Effects of fertilizers on the growth of grass and its use by deer in the Black Hills of South Dakota. Agron. J. 56, 223-226.

Todd, J. W. (1975) Foods of Rocky Mountain bighorn sheep in Southern Colorado. J. Wildl. Manage. 39, 108-111.

Tsegevnid, D. & Dashdorj, A. (1974) Wild horses and other endangered wildlife in Mongolia. Oryx 12, No. 3, 361-370.

Van Zeist, W. (1967) Late quaternary vegetation history of western Iran. Rev. Palaeobot. Palynol. 2, 301-311.

Walther, F. R. (1972) Social groupings in Grant's gazelle (Gazella granti Brooke 1872) in the Serengeti National Park. Z. Tierpsychol. 31, 348-403.

Williams, O. B., Wells, T. C. E. & Wells, D. A. (1974) Grazing management of Woodwalton Fen: Seasonal changes in the diet of cattle and rabbits. J. appl. Ecol. 11, 499-516.

Zohary, M. (1973) Geobotanical foundations of the Middle East, 2 Vols. Stuttgart, Amsterdam.