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ECOLOGY AND MANAGEMENT OF MARAL (Cervus elaphus maral)
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Major professor

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ECOLOGY AND MANAGEMENT OF MARAL (*Cervus elaphus maral*) IN NORTHEASTERN IRAN, 1976-1978

By

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ABSTRACT

ECOLOGY AND MANAGEMENT OF MARAL (Cervus elaphus maral) IN NORTHEASTERN IRAN, 1976-1978

By

Bahram Hasanzadeh-Kiabi

Habitat and population interactions of the Persian red deer or maral (Cervus elaphus maral) were studied in the Mohammad Reza Shah National Park, Iran, during 1976-1978 in the three vegetation types present: Caspian deciduous forest, transition zone, and steppe.

Hahn's census method gave a population average of 1897 over an 18-month period for the entire park. Based on pellet group counts there was a population of about 2096 maral in the park.

The average maral group size was 4.6. The sex ratio among adults was 27 stags per 100 hinds. The number of calves produced per 100 hinds was 28. The annual mortality rate was 13.9% and life expectancy was 6.7 years.

The maral is mainly a grazer, preferring grasses over woody forages. Of the 19 plants eaten by the maral, Dactylis glomerata was the most-preferred food, the year around. Euonymus sp., and Colutea persica were highly-preferred winter browse species.

Pellet groups were correlated positively with shrub abundance. Showing a preference for forest meadow and transition zone habitats, the maral's food consumption was estimated to be at the rate of 2.87

and 3.6 kg/day in winter and spring, respectively. The carrying capacity of maral range was estimated to be 15.6 ha/maral and 11.0 ha/maral for transition zone and forest meadows, respectively.

Maral populations showed signs of over-abundance. There was an excess of old animals and, in comparison with American and European findings, the rate of recruitment was low. Of all the maral classified, 11.0 percent were in poor condition. Wild pigs were important competitors for food.

Leopards and wolves were the major predators capable of preying on maral. Together, it was judged that they killed about 153 or 7.7 percent maral annually. Poaching, however, may have caused more adult mortality than predators.

Recommendations are made for maintaining maral populations in the national park. It is believed that the excess animals, probably more than 160, should be removed by controlled shooting.

To:

Dr. George A. Petrides

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INTRODUCTION

The European red deer as well as the maral, other Asiatic forms and the North American elk all have been grouped in the species Cervus elaphus. The range of the maral (C. e. maral) includes the Caspian provinces of northern Iran, Crimea, Asia Minor, and Caucasus.

C. elaphus is a characteristic inhabitant of the deciduous forest regions of Eurasia and North America. It is also found in the Mediterranean chapparal. Mature stags in eastern Europe have been recorded with antlers over 130 cm long and weighing more than 12 kg. The largest pair of red deer antlers known weighed 19 kg (Corbet and Southern, 1977). In early spring, the stag's antlers are shed and six weeks later new antlers begin to grow. By the end of May, they are full size (Whitehead, 1950).

Red deer are herd animals, with the sexes separate most of the year. Female herds are made up of hinds, calves and include stags up to two years old. The stag herds consist of older males (Harris and Duff, 1970). With the mating season, or rut, the stag herds break up, usually in October. Each mature stag attempts to move into an area occupied by a herd of hinds. Under normal wild conditions, estrus probably first occurs in the third year of a hind's life (Chapman, 1974). Following a fertile mating, gestation occupies about 250 days (Chapman, 1974). The female does not produce a calf

every year (de Nahlik, 1974), especially in poor environments (Harris and Duff, 1970). In early summer the calves are born, usually singly. The weight of a newborn calf can vary between 5 and 10 kg (Harris and Duff, 1970). Full adult size is not attained before the 7th year (Lowe, 1971). Maximum longevity in captivity is about 20 years (Corbet and Southern, 1977).

Home ranges are variable in shape but in Scotland, on the island of Rhum, they involve areas of about 400 ha for a hind and 800 ha for a stag (Lowe, 1969). There is reason to believe that the farming of red deer for meat production will prove to be technically feasible (Blaxter et al., 1976).

The Present Investigation

An 18-month study of the maral or Persian red deer was started at Mohammad Reza Shah National Park in November 1976. Some findings from a 4-month investigation during the summer of 1975 also contributed to the effort.

Objectives were: (1) to determine the population characteristics and environmental interactions of the maral; (2) to assess the carrying capacity of the range for this large deer; (3) to describe interactions between other animals and the maral; and (4) to determine how maral abundance affected wildlife and wilderness standards in the national park.

The Study Area

The Mohammad Reza Shah National Park was the first area in Iran to be designated as a national park. Located in the province

of Khorasan from 37° 36' to 37° 16' north latitude and 56° 17' to 55° 44' east longitude (Figure 1), the terrain is mountainous with the altitude varying between 380 and 2819 meters. The park is about 126,000 hectares in area (de Vos et al., 1977).

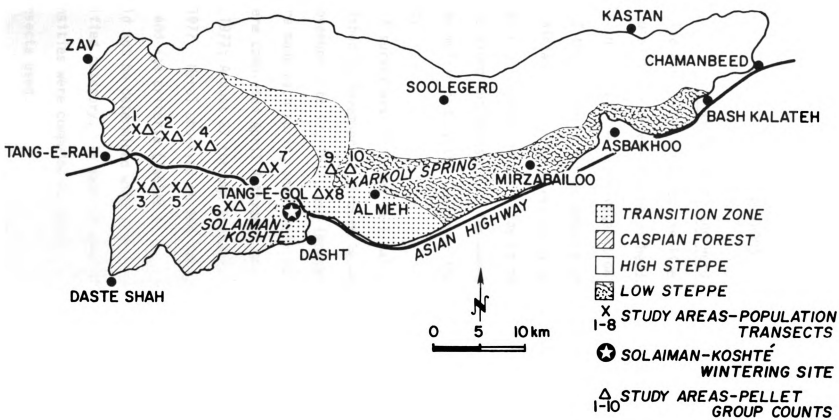

Figure 1. Major vegetation types in the Mohammad Reza Shah National Park, Iran. (From de Vos et al. 1977)

METHODS

Maral Abundance and Herd Composition

The Hahn (1949) deer cruise-line technique was one of two methods used to enumerate the maral herd. Transects were laid out randomly in each of the major vegetation types (Figure 1). The length of the transects varied because of topography. Prior to the census, distances to which maral could be seen were measured by pacing at right angles on each side of the center line at 100-meter intervals along the transect. The average of these visibility distances multiplied by the length of the transect gave the area censused.

A survey was conducted each fall and winter. These were accomplished on November 27 through December 12, 1976; March 1 to 12, 1977; November 1 to 12, 1977; and February 7 to 19, 1978. Two counts also were made each spring and summer following the same routes. These were completed April 4 through May 3, 1977; May 30 through June 9, 1977; August 27 through September 8, 1977; and September 13 to 24, 1977. Maral observed on the transects were tallied according to size and age criteria (Tables 1, 2). Specimens for which sex and age could not be determined with certainty were placed in an unclassified category. In each of the two census methods, population densities were computed by averaging the density estimates on all transects used.

TABLE 1.--Size categories of maral hinds, Mohammad Reza Shah National Park, Iran, 1976-1978.

Size Categories	Descriptions*
Calf	Spotted
Very young hinds (yearlings)	Smaller in the shoulder than the older animals, in a herd yearlings normally trail behind the most recent calf which follows the mother. Up to the age of 2 years, the short length of the head, which assumes full size by the age of 2½ years, is a good indicator of age.
Young but fertile hinds	Aged 3-5 years, head and body start to fill in.
Fully-matured hinds	Body looks sturdy and well-filled, ears appear firm and fully responsive to animal reflexes. Animals normally will not show their ribs other than perhaps at the end of winter. Aged 6-10 years.
Old hinds	The neck gets thinner. The ribs are visible through the skin for most of the year. The entire head appears longer and more emaciated. The ears become flabby. Aged over 10.

*From de Nahlik, 1974.

TABLE 2.--Size categories of maral stags, Mohammad Reza Shah National Park, Iran, 1976-1978.

Size Categories	Descriptions*
Calf	Spotted
Spike stag-yearling	Small head, short body, long ears, simple antlers without brow[1] and trey[3] tines. Up to 2 years.
Young but fertile stags	Antlers with beys[2] and brow[1] tines. Trey[3] are about to fork.[4] 2-5 years old.
Fully mature stags	The body looks sturdy and well-filled, antlers develop a crown.[5] 6-10 years of age.
Old stags	Antlers deteriorate, tines are shortened, crown disappears. Over 10 years.

*From de Nahlik, 1974.

[1]Brow = The lower point on the antler--sometimes called the first antler.

[2]Bey = The second point or tine of a stag's antlers.

[3]Trey = The thired point or tine of the antlers.

[4]Fork = The two points on the extremity of the antlers in the form of a fork.

[5]Crown = The uppermost cluster of three points of a red deer head, if they form a crown.

Transects were distributed so that all parts of the densely populated range was represented. They were spaced further than 3 km apart, however, to prevent counting a maral more than once. All census routes followed existing trails in order to reduce noise caused by the observer. From a statistical standpoint, locating transects randomly throughout each area being censused would have been desirable. Because of noise caused by the observer cruising through the vegetation, however, that procedure would have reduced the numbers of maral seen and seriously biased the results. Clearing new paths would, in addition, have modified the vegetation pattern.

The assumptions had to be accepted that: (1) the sample counts were equivalent to random samples and (2) the number of maral observed equalled the total number of maral present along the transects surveyed. The analysis of variance for deer counted was calculated on the basis of the number of maral seen per 1000 hectares. Because the standard deviation of counts within a month tended to vary in proportion to the average monthly maral count, the variate transformation $Y = \log (X + 73.10)$ was calculated and used in the analysis.

Using binoculars, care was taken not to disturb the deer. Most observations were near dawn and dusk when maral were most active. Notes were made also of other animals and their signs seen. This was in an effort to determine possible competition and other interactions with maral.

Pellet-groups were counted as an alternate method to determine maral density. The 4 m^2 circular plot (Riney, 1957) was used.

Sample plots were distributed randomly in areas of high-intensity use where it has been found to be more efficient (Neff, 1968). Few pellet-group sampling systems have employed a completely random distribution (Neff, 1968). Leopold et al. (1951) stated that best estimates of deer numbers in the California mountains were obtained from transects which were distributed by subjective selection and which followed trails or ridge tops.

In the present study, the number of plots needed at each sample site was determined from preliminary surveys applying the formula used by Grieb (1958):

$$N = \frac{(t\ 0.10)^2\ s^2}{(0.20 \times \bar{X})^2}$$

where:

N = number of plots needed

s^2 = variance in pellet density from preliminary data

X = mean pellet density based on preliminary data

0.20 = selected risk of error expressed as a fraction of mean pellet density

t 0.10 = tabular value of t for a selected level of probability.

Based on more or less randomized preliminary pellet-group surveys, 113, 284, 379, and 115 sample plots were calculated to be necessary in steppe, transition zone, Caspian deciduous forest, and

forest meadows, respectively. The distance between plots was decided on an arbitrary basis to be 10 meters. Pellet-group counts were conducted only in the autumns (of both 1976 and 1977) since the lush vegetation growth in spring and summer tended to hide pellet-groups at those seasons. Pellet-group counts were also conducted in late winter and early spring on a few wintering grounds while gathering data on maral food consumption and preferences.

Vegetation Types

Three major vegetation types were identified as the Caspian deciduous forest, a transition zone, and the steppe. Species composition was determined on sample-plots whose sizes were determined by the nested plot technique (Mueller-Dombois and Ellenberg, 1974). For the three vegetation types, the areas were 200 m^2, 40 m^2, and 4 m^2 for the Caspian deciduous forest, transition zone, and steppe, respectively (Figures 2, 3, 4). Choosing accuracy and t values which seemed appropriate, the number of plots needed for each vegetation type were determined by the de Vos and Mosby (1969) formula:

$$n = \frac{s^2 \, t^2 \, .05}{d^2 \, .10}$$

where:

n = number of plots needed

s^2 = variance in preliminary data

$d^2 = (0.10 \times \overline{X})^2$

$\overline{X}$ = mean of the prelimonary data

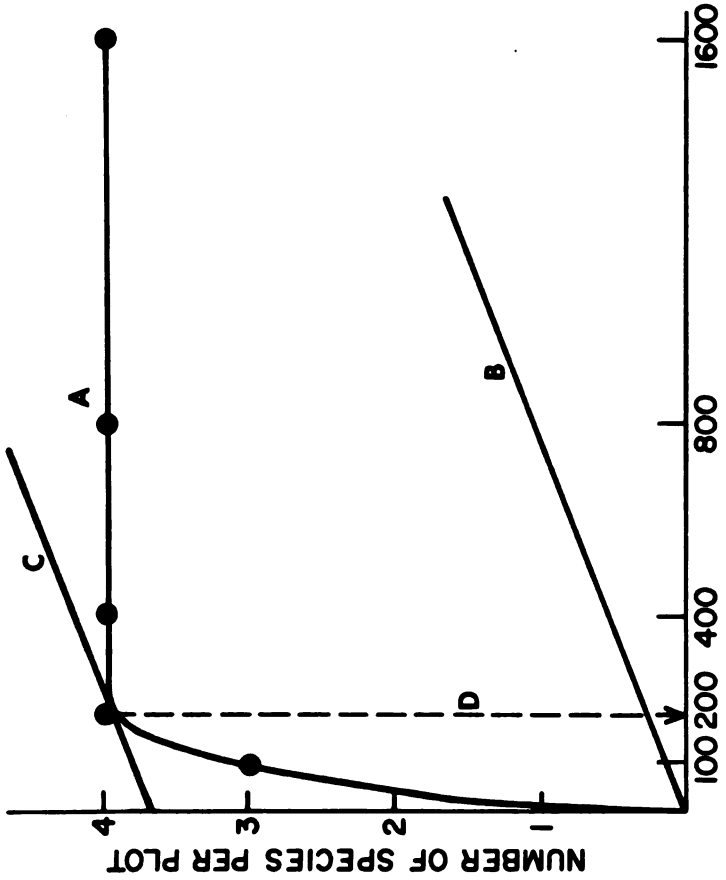

Figure 2. Species - area curve for the Caspian deciduous forest, Mohammad Reza Shah National Park, June - September 1977.

Legend: A = numbers of species found in plots of different area sizes.

B = 5 percent slope where a 10% increase in area would yield a 5% increase in species number.

C = tangent parallel to B

D = protraction to minimal plot area where species increase is equal to 5 percent.

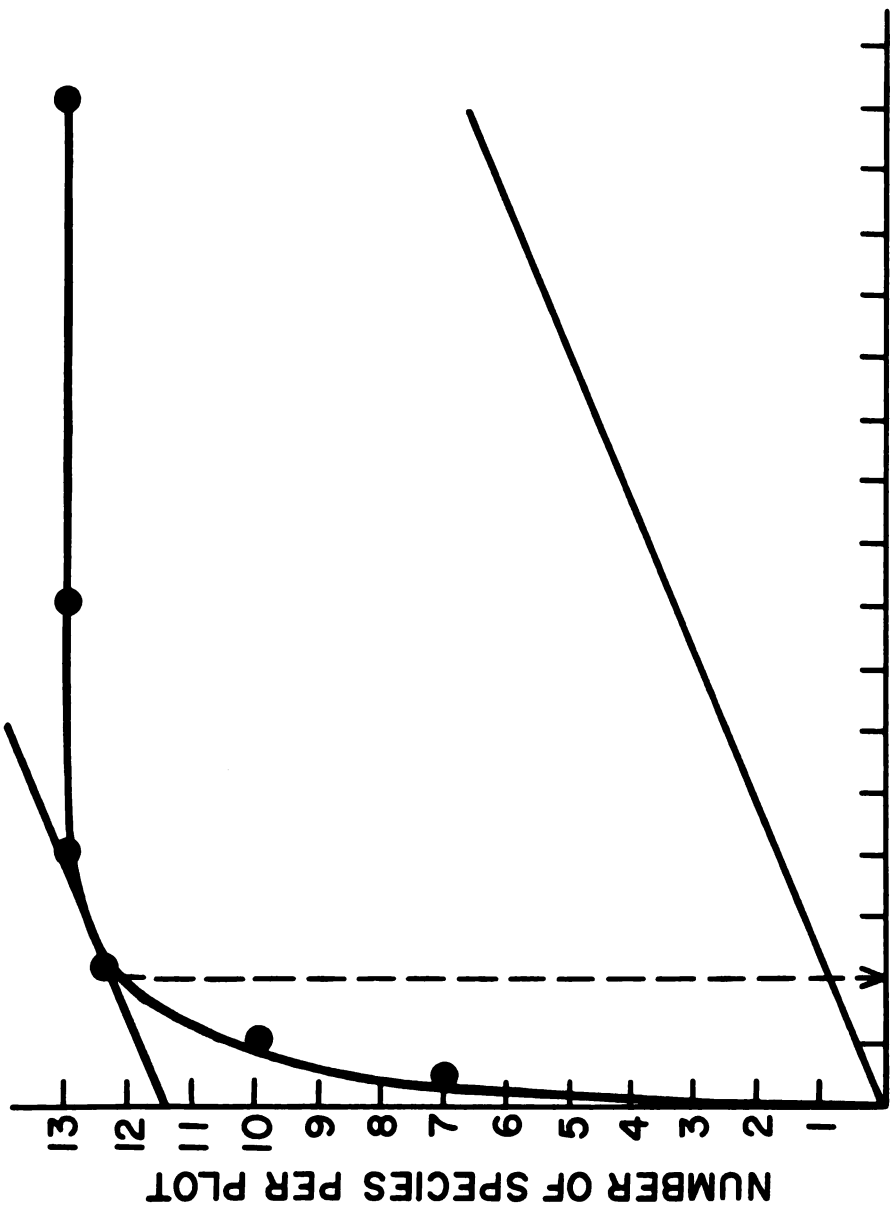

Figure 3. Species area curve for the transition zone, Mohammad Reza Shah National Park, Iran, June - September 1977.

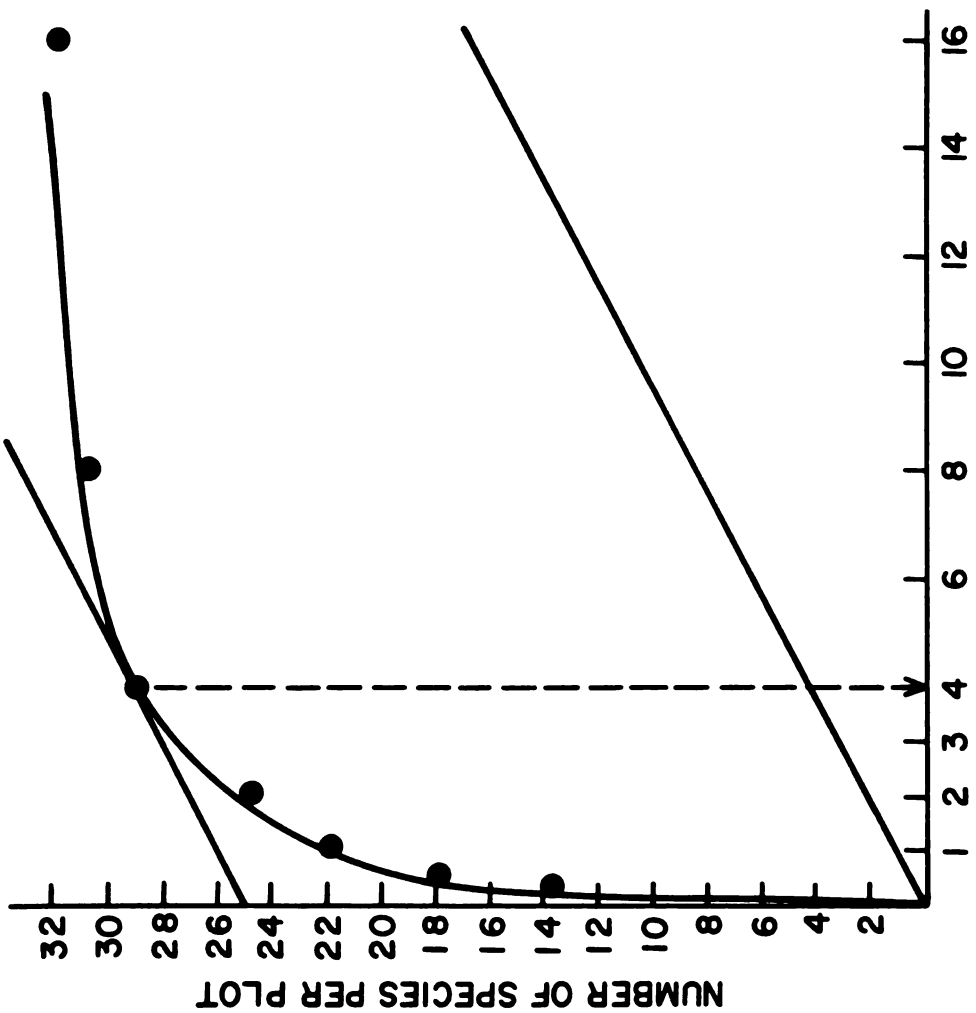

Figure 4. Species - area curve for the Steppe, Mohammad Reza Shah National Park, Iran, June - September 1977.

0.10 = designated accuracy

t 0.05 = tabular value of "t" for the selected level of probability.

Based upon the formula by de Vos and Mosby (1969), it was determined that sample sizes of 126, 114, and 118 plots were necessary for the Caspian deciduous forest, transition zone, and steppe, respectively. Within these plots, the numbers of living forbs, grasses, shrubs, and trees were tallied.

Frequency, density, and index of species associated were determined for each of the three major vegetation types. Absolute frequency refers to the number of plots in which a given species occurs. For comparing different plant communities, it is convenient to convert absolute frequency into relative or percentage frequency. Density refers to the total number of individuals per plot. The index of species association (IAp) is used to evaluate the correlation in presence and absence of species in a vegetation type, the floristic composition of the type, the distribution of the species therein, and their ecological relationships (Mueller-Dombois and Ellenberg, 1974).

Seasonal Use of Habitat

An index of habitat use by maral was calculated from pellet-group deposition over the three major habitat types plus forest meadows. Moran's utilization index (1973) was used to compare pellet group deposition between habitat types.

$$\text{Utilization index} = \frac{\text{Percentage of pellet groups in type}}{\text{Percentage of area occupied by type}}$$

Habitat use was measured in winter and in summer. Winter was identified as the 100-day period following the date of heaviest leaf-fall (November 19, 1976 and November 16, 1977) and extending through snow-free days in spring. Summer use was arbitrarily chosen as an indeterminate period prior to leaf fall (September, 1977).

Seasonal Food Availability

All plants within clip-plots, each 4 m^2 in area and located randomly in maral habitat, were sheared to a height of 1.8 meters to assess dry-weight forage composition and production. Specimens of both woody and herbaceous forages were randomly selected from different plants to determine mean dry weights for the uneaten plants of each species. All plants were dried in a standard laboratory oven at 105°C for 24 hours before weighing.

Measurements of acorn crops were made in various sections of the park because of the importance of acorns as a wildlife food. Measurements of acorn crops were made by counting acorns on sample branches, and by determining total number of branches per tree for the two different species of oaks. Counts of the fruits present were made before the acorns dropped, using binoculars. Mean dry weights for acorns were determined after treatment in a standard laboratory oven at 105°C for 24 hours.

Food Use and Preference Values

Shafer's (1963) twig count method and the dry-weight difference method of Beruldsen and Morgan (1934) were employed to determine the availability and ungulate use of woody browse and herbaceous forage.

Food habit studies of the maral were carried out at Karkoly-Spring (Figure 1). The sharp cuts made on vegetation by hares and mice were distinguishable from the broken vegetation induced by feeding ungulates, which lack upper front teeth. It was thought, therefore, that signs of the field mouse (Apodemus sylvaticus), social vole (Microtus socialis), Afghan mole vole (Ellobius fuscocapillus), and long-tailed hamster (Calomyscus bailwardi) were not misidentified as deer food removals. Winter food habits studies of the maral were carried out at Solaiman Koshte (Figure 1) where an area of approximately 380 ha supported a population of 16 maral. Only maral used this site. Winter food habits were determined by locating a fresh maral track and recording the signs of fresh browsing along its trail. Each browsed twig was designated as one instance of use. The number of twigs taken and the number of twigs available within one meter of each side of the trail were recorded by species. Besides the exact counting of bites on vegetation, a description of the habitat, snow depth, crust condition, and length of trail were recorded. To distinguish recent bites from old ones, fresh twigs were broken frequently and the color and condition of the broken surfaces compared. Shortly after a fall of snow, fresh

trails were followed backwards to avoid disturbing the animals. Each bitten twig was recorded and where tree bark was gnawed, the height, thickness, and area consumed were measured.

Though the percentage of each species utilized also indicates comparative forage preferences, the ratio $\frac{\text{percentage in diet}}{\text{percentage available}}$ yields a figure which, if over 1.00, indicates relative degrees of preference and if under 1.00, reveals degrees of unattractiveness (Petrides, 1975).

Competition for Food Between Maral and Other Large Herbivores

Feeding records were obtained for the wild pig (Sus scrofa), goitered gazelle (Gazella subgutturosa), wild sheep (Ovis ammon), wild goat (Capra hircus aegagrus), and roe deer (Capreolus capreolus) as opportunity afforded. Diets of these larger herbivores were compared for similarity with that of the maral, being expressed as the degree of overlap. "Overlap" was used in the same sense as Horn (1966) and calculated by summing the fraction of each herbivore's recorded diet which had counterparts in the diet with which it was being compared. The extent of habitat overlap also was estimated based on range use and preference as evidenced by field observation. The term "competition coefficient" is proposed and quantified as the product of diet-overlap and range-overlap fractions.

Range Condition and Trend

The effects of maral on vegetation were observed along the routes followed while making pellet-group counts. The three shrubs

nearest to each 4 m^2 plot were examined and the proportions of these plants which were hedged in varying degrees were recorded. The shrubby species available to maral were classified into five groups in the manner of Riney et al. (1959):

0 = No evident browsing effects

1 = Shrub lightly hedged, shape only slightly altered

2 = Plant hedged, but recovering or capable of recovering from browse pressure

3 = Shrub size held entirely in check by animals

4 = Plant killed by maral.

RESULTS

Population Densities

Maral densities per 1000 hectares were calculated by the Hahn method for each vegetation type and season (Table 3). Combining these densities with the areas of each cover type yielded an overall number of 1897 maral present on average during the 18-month study period in the entire park (Table 4).

When variance in the number of maral seen per 1000 hectares of land was appraised, there was an evident tendency (Figure 5) for the standard deviation of counts within a season to vary in proportion to the average seasonal maral count. Transforming the data (Table 3) by the variate $Y = \log (X + 73.10)$,* differences in deer densities between seasons, areas, and their interactions (Table 5) were indicated to be highly significant.

Using the fecal pellet-group data with a defecation rate of 10 pellet-groups per day for red deer (Riney, 1957), the mean autumn population estimate was 2096 deer (Tables 6 and 7).

Herd Composition

Average maral group size in the park was 4.6 $\pm$ 1.1 (Table 8). Female deer outnumbered males by more than 3 to 1. The average sex ratio observed among adults was 27 stags:100 hinds (Table 9).

*Based on Hartley et al. (1955); $Y = \log (X + \frac{a}{b})$.

TABLE 3.--Maral densities as determined by the Hahn transect method. Mohammad Reza Shah National Park, 1976-1978.

Site	Number of Deer per 1000 Hectares							
	Fall 1976	Winter 1977	Spring 1977	Spring 1977	Summer 1977	Summer 1977	Fall 1977	Winter 1978
CASPIAN DECIDUOUS FOREST:								
Adnasad - Ghamishlee	12	41	13	8	10	10	6	64
Late´- Khodagholi	0	36	7	14	15	10	11	35
FOREST MEADOWS:								
Afralee - Alidali	32	78	18	24	70	70	46	34
Khandooshan	91	89	52	122	74	111	66	76
Bozaghan	6	170	64	89	40	8	44	108
Takhte´ - Korda	5	29	24	61	27	27	8	33
Savarbaghi - Aghsoo	39	44	29	14	48	15	29	60
TRANSITION ZONE:								
Gharangine-ridge and upper Karkoly valley	74	17	99	38	126	47	85	56
AVERAGE	35	63	38	46	51	37	37	58

TABLE 4.--Average maral population densities as determined by the Hahn transect method, Mohammad Reza Shah National Park, Iran, 1976-1978.

Vegetation Type	Area in Hectares	Average Maral Density per 1000 Hectares	Population per Vegetation Type
Caspian Deciduous Forest	34,100	19	648
Forest Meadows	3,400	55	187
Transition Zone	14,000	68	952
Steppe-Border*	4,500	**	110**
Open Steppe	70,000	0	0
TOTAL	126,000	15	1,897

*Area adjacent to transition zone (1.5 km wide)

**Not surveyed by the Hahn method. Observations of maral over the 15-month period, however, showed that 5.8 percent of all deer seen were in the steppe-border area (see Table 15).

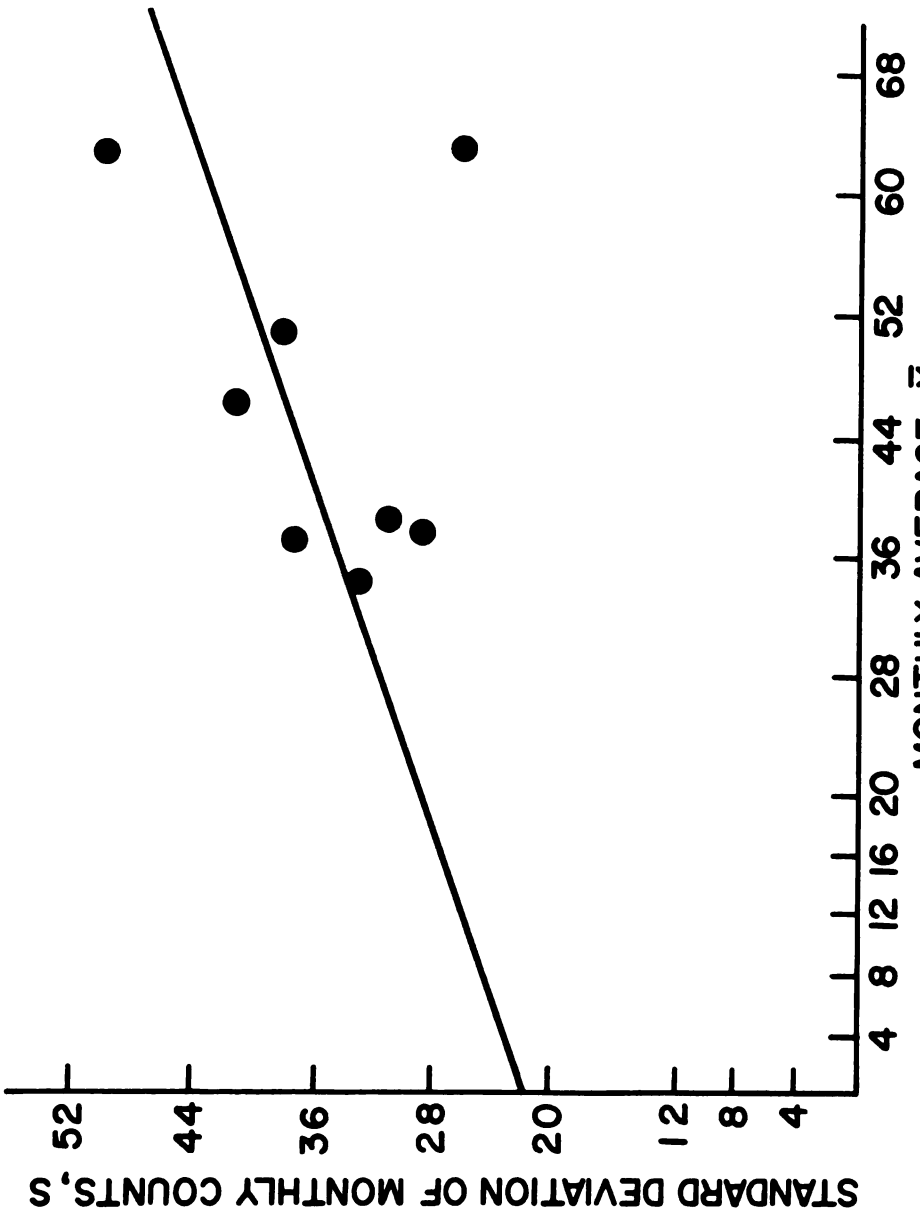

Figure 5. Regression of standard deviations on the average monthly maral count, Mohammad Reza Shah National Park, Iran, 1976-1978.

TABLE 5.--Analysis of variance in deer observation data, Mohammad Reza Shah National Park, Iran, 1976-1978.*

	df	ss	ms	F
Season	3	.08	.0297	5.68**
Areas	7	.44	.0628	13.36**
Season x Areas	21	.25	.0119	2.53**
Error	32	.15	.0047	
TOTAL	63	.92		

*Transformed, where y = log (X + 73.10)

**Significant at the 1 percent level.

TABLE 6.--Maral densities as determined from fecal pellet-group counts. Mohammad Reza Shah National Park, Iran, autumn seasons 1976, 1977.

Site	Deer per 100 hectares	
	Fall 1976	Fall 1977
CASPIAN DECIDUOUS FOREST:		
Adnasad - Ghamishlee	11	23
Laté - Khodagholi	11	10
Gharangine - Jangle	32	22
FOREST MEADOWS:		
Afralee - Alidali	14	50
Khandooshan	26	25
Bozaghan	24	40
Takhté - Korda	63	25
Sararbaghi - Aghsoo	42	29
TRANSITION ZONE:		
Charangine - ridge and upper Karkoly Valley	73	79
STEPPE - TRANSITION ZONE ECOTONE:		
Takhté - Almeh	39	52
OPEN STEPPE:	0	0
Average*	33.5	35.5

*Open steppe is not included

$$\text{Number of maral per 1000 hectares} = \frac{\text{(No. of pellet-groups/1000 ha)}}{\text{(No. of days since heaviest leaf fall x 10 groups/day/maral)}}$$

Heaviest leaf fall were recorded on November 19, 1976 and November 16, 1977.

TABLE 7.--Maral population densities as determined from fecal pellet-group counts, Mohammad Reza Shah National Park, Iran, Autumn 1976, 1977.

Vegetation Type	Area in Hectares	Average Maral Density per 1000 Hectares	Population for Vegetation Type
Caspian Deciduous Forest	34,100	18	714
Forest Meadows	3,400	34	116
Transition Zone	14,000	76	1,064
Steppe-Border	4,500	45	202
Open Steppe	70,000	0	0
TOTAL	126,000	16.6	2,096

TABLE 8.--Group size of maral in the Mohammad Reza Shah National Park, Iran, 1976-1978.

Group Size	Frequency	Percent Frequency	Cumulative Percentages
1	124	20.4	20.4
2	126	20.7	41.1
3	86	14.1	55.2
4	66	10.9	66.1
5	32	5.3	71.4
6	51	8.4	79.8
7	27	4.4	84.2
8	22	3.6	87.8
9	15	2.5	90.3
10	15	2.5	92.8
11	14	2.3	95.1
12	9	1.5	96.6
13	3	0.5	97.1
14	4	0.7	97.8
15	4	0.7	98.5
16	2	0.3	98.8
17	2	0.3	99.1
18	1	0.1	99.2
19	1	0.1	99.3
23	1	0.1	99.4
49	2	0.3	99.7
58	1	0.1	99.8
72	1	0.1	99.9

$$\text{Average group size} = \frac{\text{2785 maral tallied}}{\text{610 groups tallied}} = 4.6$$

TABLE 9.--Proportions of size categories from eight counts of maral between November 1976 and April 1978 in the Mohammad Raza Shah National Park, Iran.

Season	Numbers Seen	Stags				Hinds				Calves
		Yearling	Young Mature	Fully Mature	Old	Yearling	Young Mature	Fully Mature	Old	
September 1975	136	.05	.03	.07	.02	.28	.10	.23	.10	.12
Fall 1976	138	.10	.15	.07	0	.27	.18	.22	0	.01
Winter 1977	1617	.03	.06	.07	.04	.17	.27	.28	.08	0
Spring 1977	300	.05	.03	.03	.01	.21	.25	.11	0	.31
Summer 1977	357	.04	.05	.07	.05	.15	.27	.19	.04	.14
September 1977	900	.04	.05	.07	.04	.15	.27	.19	.05	.14
Fall 1977	209	.06	.04	.08	.01	.18	.33	.22	0	.08
Winter 1978	174	.01	.01	.06	.01	.30	.47	.13	.01	0
TOTALS 1975-78	3833	.04	.05	.07	.03	.18	.27	.23	.05	.08

If the cumulative herd-size frequencies were transferred to a normal probability scale and plotted against numbers per group then, the frequency distributions, if normal, would form a straight line. Actually, the data form approximate straight lines (Figure 6) between points 3-12 and 12-18.

The data from chamois (Rupicapra rupicapra) and red deer (Cervus elaphus) were bimodal (Caughley, 1964). The present data and those populations indicate that group size does not affect the animal's urge to join it.

Reproduction and Mortality Rates

The first calls of rutting male maral started as early as September 2 and continued through October 5. The number of females gathered by a breeding stag varied from 2 to 19. There was an average of 10 hinds per harem in the transition vegetation zone and 5 hinds per breeding stag in the Caspian deciduous forest.

Gestation in red deer has been reported to last about 8 months (de Nahlik, 1974). In the park, it was confirmed that gestation approximately lasted from about September 2, when the rutting season started, to May 10 when the calving season began, a total of 250 days.

Single calves were the rule. Only two instances of twins were seen. In 1977 the first report of a newborn calf was May 10. From the monthly distribution of 16 births between the years 1840 and 1870 published by Zuckerman (1953), the mean date of birth and standard error were determined as explained by Caughley (1977) to be 30 June $\pm$ 2 days.

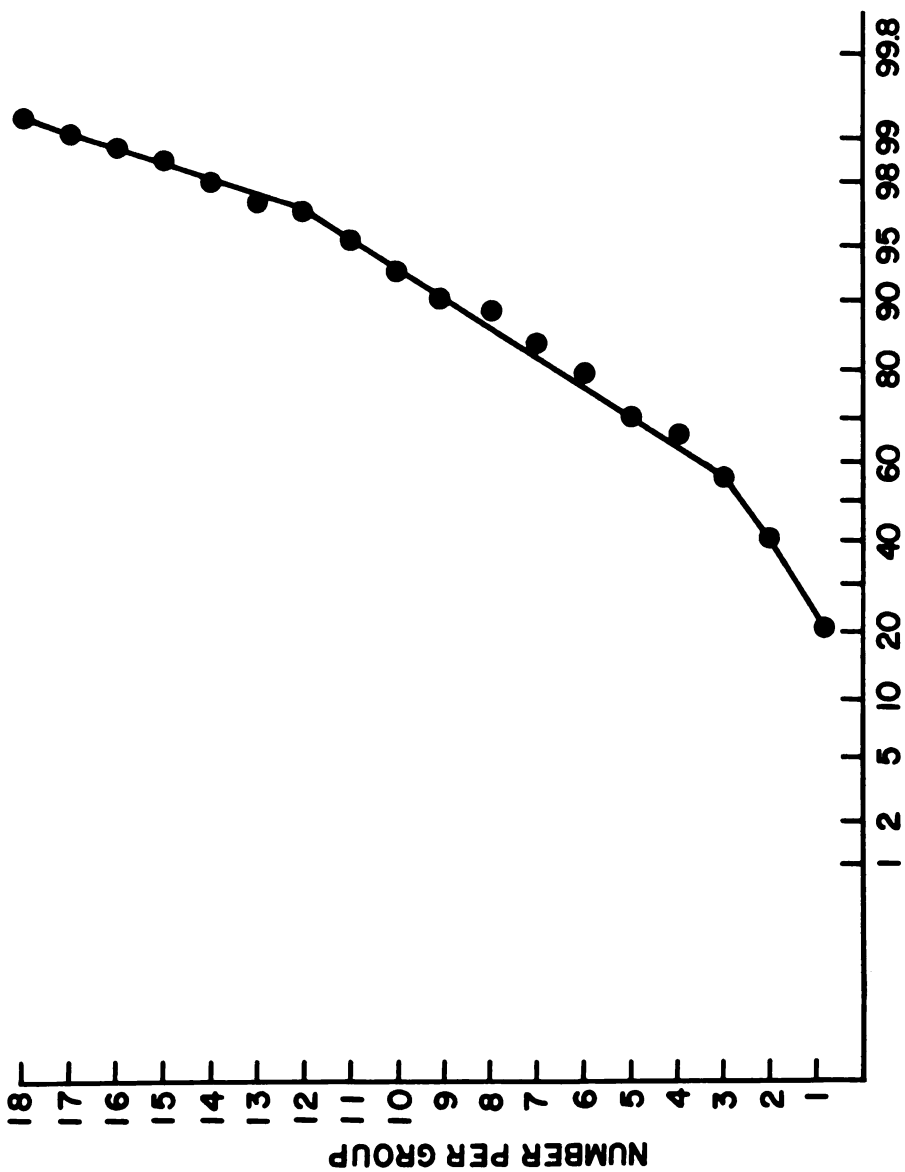

Figure 6. Relationship between numbers per group of red deer and their cumulative percentage frequencies on a normal probability scale. Frequencies beyond 99.2 percent are omitted (see Table 8)

The number of calves produced per 100 hinds based on summer data was 28 (Table 9).

Despite limited available data from the summer of 1975, a comparison between population numbers of 1975 and 1977 was made (Table 10). Census results for September 20 through September 30 were available for comparison and the Mann-Whitney U-test (Elliott, 1977) was computed. The U values of 5 and 10 suggest that the two populations were not different in density at the 5% level of significance. In order to gain at least an approximate measure of some maral population characteristics, it may be assumed that the population is stationary. If so, therefore, population mortality rate and life expectancy can be derived from the ratio of juveniles to adults. Where j is the number of 0-1 year old animals in a sample of n individuals drawn from a stationary population immediately after a restricted annual season of births, the population annual mortality rate is equal to the proportion of juveniles (j/n) and life expectancy in years is (2n-j)/2j (Caughley, 1967). Based on summer data (Table 9), the park maral had a yearly mortality rate of 13.9% and a life expectancy of 6.7 years.

TABLE 10.--A comparison of maral populations in 1975 and 1977, Mohammad Reza Shah National Park, September 1975 and 1977.

	September 1975	September 1977
Proportions of Size Categories:		
Calves	.12	.14
Hinds	.71	.66
Stags	.17	.20
Maral Seen per Census:	17, 8, 68	81,72,2,22,18
Mann-Whitney U-test:*		
R1, 2	11	25
U1, 2	5	10
N1, 2	3	4

*Where the calculated levels of U exceed the tabulated values of u, the mean levels of the two samples are accepted to be identical. U is not significant, therefore, at the 5 percent level of significance.

The Habitat and Its Use

Vegetation Types

In the 37,500 ha Caspian deciduous forest dominant trees were: Quercus castanaefolia, Parrotia persica, Carpinus betulus, and Crataegus sp. (Table 11). Man-caused forest meadows covered 8.7% of this area and were composed of (1) grasses 59.9 percent by stem count, including Avena sativa, Dactylis glomerata, Bromus briziformis, Bromus sterilis, Bromus japonicus, Bromus gracillinus, Hordeum bulbosum, and Aegilops tauschii; (2) legumes 13.8 percent in which Vicia persica, Vicia sativa, Medicago orgicularis, Medicago polymorpha, and Trifolium angustifolium were prominent; (3) other forbs 15.9 percent, mainly Achillea nobilis, Tragapogon graminifolius, Phleum paniculatum, Stachys olympica, Carex sylvaticum, Scabiosa micrantha; (4) shrubs 9.7 percent Rubus sp. and Rosa beggeriana; and (5) ferns 0.7 percent, mainly Pteridium aquilinum.

The transition zone, of approximately 14,000 ha, was characterized by shrubs and scrub trees, common among them were Acer ibericum, Paliurus spina-christi, Colutea persica, Quercus castanaefolia, Quercus macranthera, and Berberis vulgaris (Table 12). dominated by Festuca ovina and Artemisia sp. (Table 13). Broad-leaved forbs were frequent but trees (Acer ibericum) were present mainly in ravines and in the forest border ecotone.

TABLE 11.--Species composition of the Caspian deciduous forest relative to Quercus castanaefolia, Mohammad Reza Shah National Park, Iran, 1976-1978.

Species	Frequency*		Density**		IA_p***
	Absolute	Percent	Sum	Mean	
Quercus castanaefolia	126	100+	573	4.5	100+
Parrotia persica	77	61	225	2.9	61
Crataegus sp.	66	52	181	2.7	52
Colutea persica	66	52	167	2.5	52
Prunus caspica	63	50	169	2.7	50
Paliurus spina-christi	57	45	137	2.4	45
Mespilus germanica	54	43	154	2.8	43
Carpinus betulus	52	41	189	3.6	41
Rubus ulmifolius	39	31	86	2.2	31
Zelkova carpinifolia	28	22	73	2.6	22
Quercus macranthera	13	10	63	4.8	10
Vitis silvestris	10	8	25	2.5	8
Acer velutinum	7	6	15	2.1	6
Diospyros lotus	6	5	15	2.5	5

*Number of plots in which a given species occurred.

**Numbers and percentages of individual.

***Index of species association as compared with Quercus.

+Due to the 100 percent constancy for Quercus, values for its percent constancy and IA_p were identical.

$$IA_p = \frac{c}{a + b + c} \times 100$$

where c = the number of plots in which the two species occurred together;
a = the number of plots in which one of the two species occurred alone; and
b = the number of plots in which the other species was found alone.

TABLE 12.--Species composition of the transition zone relative to Quercus macranthera, Mohammad Reza Shah National Park, Iran, 1976-1978.

Species	Frequency*		Density**		IA_p***
	Absolute	Percent	Sum	Mean	
Quercus macranthera	101	89	161	1.6	100
Paliurus spina-christi	97	85	358	3.7	78
Colutea persica	97	85	272	2.8	78
Quercus castanaefolia	97	85	227	2.3	73
Berberis vulgaris	81	71	149	1.8	60
Acer ibericum	86	75	166	1.9	65
Crataegus sp.	64	56	88	1.4	50
Lonicera floribunda	53	46	103	1.9	42
Cotoneaster sp.	49	43	95	1.9	41
Rhamnus sp.	35	31	68	1.9	31
Euonymus sp.	34	30	77	2.3	25

*Number of plots in which a given species occurred.

**Numbers and percentages of individuals.

***Index of species associated as compared with Quercus.

TABLE 13.--Species composition of steppe zone relative to Festuca ovina, Mohammad Reza Shah National Park, Iran, 1976-1978.

Species	Frequency*		Density*		IA_p***
	Absolute	Percent	Sum	Mean	
Festuca ovina	84	71	562	6.7	100
Artemisia absinthium	68	58	547	8.0	56
Dactylis glomerata	67	57	214	3.2	47
Agropyron cristatum	47	40	172	3.7	46
Teucrium polium	57	48	135	2.4	44
Centurea bahen	49	41	154	3.1	40
Ephedra sp.	61	52	475	7.8	39
Galium tricorne	50	42	115	2.3	36
Poa bulbosa	42	36	126	3.0	33
Colutea persica	42	36	52	1.2	31
Acer ibericum	32	27	36	1.1	25
Juniperus sp.	18	15	18	1.0	19
Prunus sp.	18	15	21	1.2	15

*Number of plots in which a given species occurred.

**Numbers and percentages of individuals

***Index of species association as compared with Festuca.

The Caspian deciduous forest, the transition zone, and the steppe zone were judged to be Quercus-Parrotia-Carpinus, Quercus-Paliurus-Colutea, and Festuca-Artemisia associations, respectively.

Seasonal Use of Habitat

Utilization index values (Table 14) indicated that maral have both winter and summer preferences for meadows in the Caspian deciduous forest. It is interesting that 5.8 percent of the maral seen (Table 15), however, were in steppe vegetation. Their pellets were found even in the Almeh Valley, 3-4 km from the woodland.

Maral appear to have been numerous on the Caucasian steppes during the Pliocene (Verseshchagin, 1967) and to have occupied a more widespread range then than today. During recent times, major causes of maral reduction, according to Verseshchagin (1967), appear to have been a combination of competition from livestock and indiscriminate hunting. It is possible that stag hunts by horsemen forced the retreat of maral into the forests where they were out of reach of mounted hunters. Today in spring and summer deer tend to migrate from forests to the open steppe in escape from blood-sucking insects (Verseshchagin, 1967).

Shrub abundance seemed to be the most important vegetative factor associated with high pellet group density and mixed trees and shrubs was the vegetation type most preferred by maral (Table 16).

The number of pellet groups was considerably higher where numerous shrubs were associated with trees than where plots contained trees and few or no shrubs.

TABLE 14.--Comparative seasonal utilization of habitat types by maral as indicated by pellet group abundance, Mohammad Reza Shah National Park, Iran, 1976-1978.

Habitat Type	Average Pellet Groups per ha		Percent Area	Winter Percent Pellet	Summer Percent Pellet	Winter U-I*	Summer U-I*
	Winter	Summer					
Caspian Deciduous Forest	44	84	27.6	78.2	27.6	2.83	1.00
Forest Meadows	29	539	2.4	6.9	18.4	2.89	7.67
Transition Zone	18	426	11.0	11.3	47.4	1.02	4.33
Steppe-Transition Zone Ecotone	6	245	3.5	3.5	6.3	1.00	1.80
Open Steppe	0	0	55.5	0	0	0	0

*Utilization index (U.I) = $\frac{\%\ \text{pellet groups in type}}{\%\ \text{area occupied by type}}$.

TABLE 15.--Observations of maral by vegetation type, Mohammad Reza Shah National Park, Iran 1976-1978.

Vegetation Type	Number of Maral Seen				Percentages of Maral Seen				Total	
	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	1976 - 1978	
										%
Caspian Deciduous Forest	21	416	21	70	5.4	21.0	5.6	5.0	528	12.8
Forest Meadows	178	1424	175	535	46.1	71.8	46.7	38.4	2312	55.8
Transition Zone	165	136	143	615	42.8	6.8	38.1	44.1	1059	25.6
Steppe	22	8	36	175	5.7	0.4	9.6	12.5	241	5.8*
TOTAL	386	1984	375	1395	100.0	100.0	100.0	100.0	4140	100.0

*See Table 4.

TABLE 16.--Relations between maral pellet groups and numbers of trees, shrubs, and herbs, Mohammad Reza Shah National Park, 1976-1978.

Mean Pellet Groups Per Plot	Trees* No. per ha	Shrubs** No. per ha	Herbs*** kg/ha
0.6	0- 25	216	529
0.8	26- 50	362	451
3.2	51- 75	412	286
4.9	76-100	448	255
1.3	101-125	232	107
1.2	126-150	132	78

*75 percent Quercus castanaefolia and 25 percent other species.

**50 percent Quercus castanaefolia, 20 percent Colutea persica, 20 percent Prunus caspica, and 10 percent other species.

***45 percent Bromus sp., 25 percent Agropyron trichophorum, 10 percent Medicago sp., and 20 percent other species.

The two consecutive winter seasons during which studies were carried out differed considerably from each other with respect to the depth and persistence of snow. It seems that snow depths of about 45 cm seriously impeded the movements of maral. Two days after a snow of more than 45 cm., marals had moved to the Solaiman Koshte (a transition vegetation type) wintering ground at a lower elevation.

Maral stags tended to associate with hinds mainly during the rutting season. For most of the year they lived in segregated herds. Although it has been known (Darling, 1937) that stag leave the hinds after the rut and move to different home ranges, it evidently has not been published that such spatial segregation occurs on common winter ranges. Stags outnumbered hinds in winter at high elevations (Table 17, Upper Karkoly Valley) and are thought to be more abundant at other seasons as well. This type of habitat segregation has also been recorded for wapiti (Flook, 1970) and bighorn sheep (Geist and Petocz, 1977). In winter, the females and young stayed at lower elevations where the weather was milder, snow-free days were more frequent, and grasses were more abundant. As Geist and Petocz (1977) have pointed out, it is possible that spatial segregation of the sexes benefits hinds and calves and, therefore, maximizes herd reproductive fitness.

TABLE 17.--Percentage distribution of stags and hinds on wintering areas in winter 1977 and 1978, Mohammad Reza Shah National Park, Iran (n = 1984, including repeat observations).

Census Area	Approximate Altitudes (m)	Stags Percent	Hinds Percent
Caspian Deciduous Forest:			
Gharange Jangle	1500	17.07	3.97
Golestan - Golshan	500	2.44	20.90
Forest Meadows:			
Afralee - Adnasad	1000	4.88	15.92
Khandooshan	500	0	3.48
Bozaghan	1000	4.88	20.90
Takhté - Korda	1500	7.32	17.91
Transition Zone:			
Tunnell Solaiman Koshté	1500	2.44	16.94
Upper Karkoly Valley	2000	60.97	0
TOTAL	--	100.00	100.00

Seasonal Food Availability

The largest average supply of available herbaceous forages was recorded in summer, when it reached as much as 1253.4 kg dry wt/ha (Table 18). This was in contrast to the winter supply of only 11.5 kg dry wt/ha on the steppe.

On the average for all vegetation types, the largest supply of browse also was recorded in summer (Table 19). A drastic volume reduction in winter was due to the loss of leaves and to the disappearance of bushes under snow. The highest share of browse forage was produced by oaks (Table 20).

Ocular estimates of the acorn crop were calculated in kg dry wt/ha. It is recognized that approximate methods were used in this regard but it was felt that even a rough estimate was better than none at all. It was found in the Caspian deciduous forest 38.7 percent of the largest oak trees produced an acorn crop of 156.4 kg dry wt/ha. The crop produced in the transition zone was estimated to be 119.6 kg dry wt/ha and 42 percent of the trees produced acorns. Acorns possibly are the major fattening feed in the fall for maral as well as for other wild life, especially wild pig.

Food Use and Preference Values

Food composition determined by observations of wild maral were not amenable to precise quantification. Yet it is believed

TABLE 18.--Seasonal changes in the average available herbaceous forage supply in the Mohammad Reza Shah National Park, Iran, 1976-1978. All values are given in kg dry wt./ha.

Vegetation Type	Spring	Summer	Fall	Winter*
Caspian deciduous forest**	54.6	264.8	292.4	28.3
Transition zone	153.6	1253.4	743.3	35.1
Steppe	126.8	432.6	312.9	11.5
TOTALS***	108.3	503.6	354.6	19.1

*Available during snow-free days or mild winters like winter of 1978. Totally absent for about 2 months in winter 1977.

**Including forest meadows.

***Weighted according to the areas involved.

TABLE 19.--Seasonal abundances of the browse in the Mohammad Reza Shah National Park, Iran, 1976-1978. All values are given in kg dry wt./ha.

Vegetation Type	Spring	Summer	Fall	Winter
Caspian deciduous forest*	51.16	415.55	153.48	29.16
Transition zone	40.53	212.84	94.62	27.72
Steppe	13.76	29.44	24.44	7.78
TOTALS**	27.86	164.73	70.64	19.33

*Including forest meadows.

**Weighted according to the areas involved.

TABLE 20.--Browse supply (kg/ha) by species in the Mohammad Reza Shah National Park, October 1977.

Species	Caspian Deciduous Forest	Transition Zone	Steppe
Cotoneaster sp.	1.09	3.45	0
Lonicera floribunda	.75	1.90	0
Rhamnus sp.	.96	3.39	0
Euonymus sp.	1.95	7.86	0
Colutea persica	2.79	11.32	1.14
Ephedra sp.	0	5.09	22.95
Acer ibericum	0	68.30	3.01
Carpinus betulus	56.84	0	0
Viscum album*	3.96	0	0
Quercus sp.	301.10	93.46	0
Acorns	156.40	119.60	0
Other	50.09	18.07	2.34
TOTAL**	415.55	212.84	29.44

*Viscum is a saprophyte. A potential winter food in harsh winters, it grows mainly on Carpinus branches.

**Acorns and Viscum are not included.

that some insights into the feeding habits of the maral were gained.

In winter season, Colutea persica, Euonymus sp., and Quercus castanaefolia were preferred browses (Table 21). In spring, Euonymus sp., Ephedra sp., and Acer ibericum were highly preferred Table 22). Capsella bursa-pastoris, Phleum paniculatum, Poa bulbosa, Vicia persica, Dactylis glomerata, Onobrychis gobi, and Coronilla varia were also among the preferred forage species in that season (Tables 23 and 24). In summer Acer ibericum, and Quercus castanaefolia were highly preferred (Table 25). Dactylis glomerata, and Festuca ovina were the preferred forage species (Table 25). And finally in the fall, Dactylis glomerata, Poa bulbosa, plus acorns and Colutea persica were the preferred foods (Table 26).

Agropyron trichophorum, and Festuca ovina were the most abundant herbaceous species year around. In terms of bulk contribution to the maral's diet, the most important forage species was Agropyron trichophorum, a grass (Tabls 23). Of the 19 plants eaten by maral, Dactylis glomerata seemed to be the most preferred forage species on an all-year basis (Tables 21, 22, 23, 24, 25, and 26). The oaks were the most abundant food sources in the park. They produced the highest amounts of fruits as well as of browse, and in terms of bulk contribution to the maral's diet, they were the most important browse species.

The Persian red deer is mainly a grazer, preferring grasses over woody forages.

TABLE 21.--Maral food preference ratings as determined by bite counts. Mohammad Reza Shah National Park, Winter 1977.

Woody Forages	Forage no./m^2		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
Colutea persica	5.47	3.16	13.67	39.48	57.75	2.89
Euonymus sp.	3.50	1.29	8.76	16.13	36.81	1.84
Quercus castanaefolia	9.54	2.65	23.85	33.11	27.76	1.39
Rhamnus sp.	.58	.11	1.47	1.32	18.15	.90
Acer ibericum	1.49	.22	3.73	2.75	14.74	.74
Prunus caspica	2.23	.24	5.57	2.96	10.64	.53
Lonicera floribunda	.90	.08	2.24	.99	8.81	.44
Cotoneaster sp.	.78	.06	1.95	.71	7.30	.36
Viscum album	.82	.04	2.04	.46	4.51	.23
Carpinus betulus	1.80	.06	4.50	.78	3.44	.17
Ephedra sp.	.84	.02	3.11	.27	2.60	.13
Crataegus sp.	3.12	.04	7.81	.53	1.34	.07
Paliurus spina-christi	4.21	.04	10.53	.51	.97	.05
Other	4.71	0	11.78	0	0	0
TOTAL	39.99	8.01	100.00	100.00	20.03	

TABLE 22.--Browse consumption by 31 maral, 16 wild pigs and 2 wild sheep during a 114-day use at Karkoly Spring feeding ground, Mohammad Reza Shah National Park, June 1977.

Woody Forages	Forage Dry Weight kg/ha		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
Euonymus sp.	1.16	.25	15.74	20.33	21.5	1.29
Ephedra sp.	.05	.01	.68	.81	20.0	1.19
Acer ibericum	2.20	.43	29.85	34.96	19.5	1.17
Quercus castanaefolia	3.47	.50	47.08	40.65	14.4	0.86
Colutea persica	.25	.03	3.39	2.44	12.0	0.72
Rhamnus sp.	.24	.01	3.28	0.81	4.1	0.25
TOTAL	7.37	1.23	100.00	100.00		

TABLE 23.--Dry-weight herbaceous forages removed by 31 maral, 16 wild pigs, and 2 wild sheep during a 114-day use at Karkoly Spring feeding site, Mohammad Reza Shah National Park, June 1977.

Forage Species	Forage Dry Weight kg/na		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
Capsella buras-pastoris	.91	.62	.18	.54	68.13	3.00
Phleum paniculatum	6.93	4.44	1.40	3.89	64.07	2.78
Poa bulbosa	10.12	6.13	2.04	5.37	60.57	2.63
Dactylis glomerata	11.17	6.32	2.26	5.54	56.58	2.45
Vicia persica	7.59	4.14	1.53	3.63	54.54	2.37
Coronilla varia	17.04	8.42	3.45	7.38	49.41	2.14
Onobraychis gobi	35.83	12.58	7.25	11.03	35.11	1.52
Hordeum bulbosum	7.28	2.23	1.47	1.96	30.63	1.33
Avena staiva	18.76	5.35	3.79	4.69	28.51	1.24
Aegilops tauschii	21.84	5.83	4.42	5.11	26.71	1.13
Agropyron trichophorum	85.55	18.54	17.29	16.25	21.60	0.94
Trifolium angustifolium	37.04	7.67	7.49	6.72	20.70	0.89
Bromus tectorum	45.39	8.21	9.17	7.19	18.08	0.78
Festuca ovina	74.53	11.29	15.02	9.89	15.14	0.66
Bromus gracillinus	24.33	3.47	4.92	3.04	14.26	0.61
Bromus japonicus	32.36	4.43	6.52	3.88	13.66	0.59
Bromus briziformis	35.43	4.12	7.17	3.61	11.63	0.50
Medicago polymorpha	2.71	0.11	0.55	0.10	4.06	0.18
Medicago orbicularis	10.81	0.21	2.18	0.18	1.94	0.08
Other	9.30	-	1.90	-	-	-
TOTAL	495.00	114.11	100.00	100.00	23.05	

TABLE 24.--Maral food preference ratings as determined by observation, Mohammad Reza Shah National Park, Spring 1977.

Forage Species	Forage no./m^2		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
GRASS AND FORBS:						
Dactylis glomerata	1.35	.81	2.92	54.00	60.00	18.49
Poa bulbosa	1.19	.12	2.57	8.00	10.09	3.11
Avena sativa	2.54	.13	5.50	8.67	5.11	1.58
Medicago polymorpha	1.35	.06	2.92	4.00	4.04	1.37
Other Species	17.77	-	61.56	-	-	-
TOTAL	46.22	1.50	100.00	100.00	3.24	
SHRUBS AND TREES:						
Acer ibericum	13.2	7.9	22.07	36.41	59.84	1.65
Quercus castanaefolia	21.5	8.1	35.95	37.32	37.67	1.04
Colutea persica	14.4	4.8	24.08	22.12	33.33	.92
Euonymus sp.	6.9	0.9	11.54	4.15	13.04	.36
Other Species	3.8	-	6.36	-	-	-
TOTAL	59.8	2.17	100.00	100.00	36.28	

TABLE 25.--Maral food preference ratings as determined by observation of wild maral, Mohammad Reza Shah National Park, Summer 1977.

Forage Species	Forage no./m^2		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
GRASS AND FORBS:						
Dactylis glomerata	8.4	6.6	2.28	22.62	78.69	9.92
Festuca ovina	10.7	6.8	2.91	23.12	63.25	7.95
Avena sativa	10.8	6.4	2.92	21.94	59.72	7.51
Trifolium angustifolium	7.6	4.4	2.07	15.14	58.17	7.31
Poa bulbosa	9.5	5.0	2.58	17.18	52.88	6.66
Other	322.7	-	87.24	-	-	-
TOTAL	369.9	29.4	100.00	100.00	7.94	
SHRUBS AND TREES:						
Acer ibericum	6.25	.83	21.29	45.86	13.28	2.15
Quercus castanaefolia	11.75	.81	40.03	44.75	6.89	1.12
Colutea persica	7.24	.17	24.67	9.39	2.34	.38
Other	4.11	-	14.01	-	-	-
TOTAL	29.35	1.81	100.00	100.00	6.16	

TABLE 26.--Maral food preference ratings as determined by observation, Mohammad Reza Shah National Park, Fall 1977.

Forage Species	Forage no./m^2		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
GRASS AND FORBS:						
Dactylis glomerata	1.75	1.23	2.67	6.30	70.28	2.36
Poa bulbosa	1.65	1.09	2.51	5.59	66.06	2.23
Aegilops tauschii	3.56	2.14	5.42	10.97	60.11	2.02
Agropyron trichophorum	10.56	5.39	16.09	27.63	51.04	1.72
Bromus tectorum	6.95	3.45	10.59	17.68	49.64	1.67
Trifolium angustifolium	4.35	1.71	6.63	8.76	39.30	1.32
Avena sativa	3.43	1.19	5.22	6.10	34.69	1.17
Festuca ovina	9.76	3.31	14.87	16.97	33.91	1.14
Other	18.14	0	36.00	0	0	0
TOTAL	65.65	19.51	100.00	100.00	29.71	
SHRUBS AND TREES:						
Colutea persica	1.15	.35	5.39	11.25	30.43	2.09
Acorns	4.53	.71	21.22	22.83	15.67	1.07
Quercus castaneafolia	10.67	1.67	49.98	53.70	15.65	1.07
Acer ibericum	4.53	.38	21.22	12.22	8.38	0.57
Other	.47	0	2.19	0	0	0
TOTAL	21.35	3.11	100.00	100.00	14.56	

The amount of browse utilized by an average maral was estimated to be 2.87 kg/day (2.8% of body weight) during the winter of 1977 (Table 27). This seems to be normal when compared with food consumption of American elk (Telfer and Scotter, 1975). The amount of forage (browse, grass, and forbs) utilized by an average maral was estimated to be 3.6 kg/day (4.3% of body weight) during the spring of 1977 (Table 28).

Competition for Food

In addition to maral, other large herbivores also present in the park were wild pigs, goitered gazelles, wild sheep, wild goats, and roe deer. An attempt was made to estimate their numbers in the park (Table 29). The extent to which the recorded diet of maral was overlapped by those of the other five ungulate species was calculated (Tables 30 and 31). The competition coefficient (cc) values were determined to be .16, .08, .06, and .02 for wild pig, wild sheep, roe deer, and wild goat, respectively. The gazelles with a habitat totally separated from maral, had a cc = 0. Wild pig and maral competed heavily for acorns in the fall (Table 30).

Range Condition and Trend

More than 8 percent of the available shrubs were severely hedged in the transition zone by browsing deer (Table 32). A further fraying (debarking by rubbing antlers), threshing, and rubbing of sapling trunks was caused mainly by male deer, using their antlers. Stripping was done by both sexes using the teeth to cut through the bark and to tear off strips by an upward movement of the head. In

TABLE 27.--Dry-weight forages eaten by 16 maral (6 female yearlings, 2 spike stags, 3 young hinds, 4 mature hinds, and 1 fully-mature stag) during a 33-day period at Solaiman Koshté wintering ground, Mohammad Reza Shah National Park, January and February 1977.

Browse Species	Forage Dry Weight kg/ha		Percentages			Preference Ratings
	Available	Removed	Available	Diet	Removed	
Euonymus sp.	61.07	2.88	34.33	72.00	4.71	2.10
Colutea persica	14.34	0.57	8.06	14.25	3.97	1.77
Ephedra sp.	2.97	0.03	1.67	0.75	1.01	0.45
Quercus castanaefolia	79.60	0.52	44.75	13.00	0.65	0.29
Paliurus spina-christi	19.91	0	11.19	0	0	0
TOTAL	177.89	4.00	100.00	100.00	2.25	

$$\text{Food consumption rate} = \frac{\frac{\text{(area of wintering ground) ha}}{\text{(maral population)}} \quad \frac{\text{(forage consumption) kg/ha}}{\text{(duration of use)}}}{}$$

$$\text{Dry-weight forages eaten by an average maral per day} = \frac{(380 \text{ ha})\ (4.00 \text{ kg/ha})}{(16)\qquad(33)} = 2.87 \text{ kg}$$

If the body weight data published by Dzieciolowski (1970) for Polish red deer, apply to the maral herd seen, then the 16 maral weighed 1635 kg. Total food consumption of the maral population at the wintering ground was 2.87 kg x 16 deer = 45.92 kg. On the average, the food consumed per day equaled 2.8 percent of the animal's live weight.

TABLE 28.--Food consumption rate by 31 maral during a 114-day spring use at Karkoly Spring, Mohammad Reza Shah National Park, Iran, June 1977.

ANIMAL POPULATION:

Food habit studies of the maral were carried out at Karkoly-Spring where approximately 300 hectares supported a population of 31 maral, 16 wild pigs and 2 wild sheep. Spring and summer observations showed that the marals used this site daily while pigs and sheep were less frequent visitors. During an 11-day survey, maral herds were seen daily as compared with 2 times for pigs and once for sheep.

$\therefore$ 31 maral + 16 wild pigs + 2 wild sheep = 49

Average Adult Weight:

Red Deer = 168 kg (Dzieciolowski, 1970)
Wild Pig = 150 kg (Van Den Brink, 1968)
Wild Sheep = 60 kg (Firouz et al., 1970)

or in animal units: Wild Sheep = 1.0
Wild Pig = 2.5
Maral = 2.8

$\therefore$ Total Animal Population = Sheep: 2 (1.0) +
Pigs: 16 (2.5) +
Maral: 31 (2.3)
146.8 Animal Units

Since energy intake is proportional to energy expended in metabolism (Blaxter, 1962), total forage removed was approtioned to each species population according to the energy metabolized by each population.

$\therefore$ If all 3 game species are equally competitive for food, then the maral share of food removal was $\frac{31\ (2.8)}{146.8} \times 100 = 59.1\%$

$\therefore$ Maral daily forage consumption rate =

$$\frac{(300\text{ ha})\ (115.34\text{ kg/ha})\ (59.1)}{(49\text{ animal})\ (114\text{ days})\ \ (100)} = 3.6\text{ kg}$$

Maral population consisted of:

10 calves, 3 young hinds, 2 spike stags, 9 young but fertile hinds, 2 mature stags, and 5 mature and old hinds.

The population weighed approximately 2582 kg. Average food consumption was estimated to be 4.3 percent of live weight.

TABLE 29.--Estimated numbers of major prey and predator species in the Mohammad Reza Shah National Park, Iran, 1976-1978.

Animal Species	Total Population in the Park
Prey Species:	
Wild Sheep[1]	10,000 - 11,000
Wild Goat[2]	4,000 - 4,500
Wild Pig[3]	2,500 - 3,000
Maral[3]	1,900 - 2,100
Roe Deer[4]	600 - 700
Gazelle[5]	250 - 300
Hare[6]	8,000 - 12,000
Pheasants[6]	1,500 - 1,600
Chukar[6]	3,500 - 5,000
Predator Species:[6]	
Leopard	16 - 22
Wolf	22 - 29
Cheetah	3
Bear	22 - 24
Jackals	50
Fox	60
Wild Cats	100

[1]Based on actual counts of animals seen along transect lines established for sheep.

[2]Based on full day observation in sample areas.

[3]Based on actual counts of animals seen along transect lines established for maral.

[4]Based on full day observation at wintering grounds in January and February 1977.

[5]Based on herd counts at Mirza Bailou Plain.

[6]My impression of animal populations based on limited information of animal signs and few sample counts.

TABLE 30.--Proportions of the observed diet based on the number of bites per minute for large herbivores comprised of 8 forage species, Mohammad Reza Shah National Park, Iran, 1976-1978.

Food Plants	Wild Sheep	Wild Goat	Wild Pig	Maral	Roe Deer	Gazelle
Poa bulbosa	15.1%	9.6%	3.1%	7.7%	2.9%	9.9%
Festuca ovina	36.4	21.2	10.9	12.5	7.8	32.4
Dactylis glomerata	10.4	8.7	14.5	25.1	3.1	12.5
Ephedra sp.	4.9	14.4	0	4.2	0	3.1
Artemisia sp.	5.9	10.5	0	0.5	0	6.2
Acer ibericum	0.1	0.4	0	7.4	0	0
Quercus sp.	0	0.2	0	7.9	23.9	0
Acorns	0	0	33.9	5.7	0	0
Other	27.2	35.0	37.6	29.0	62.3	35.9
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 31.--Competition for food between maral and 5 other large herbivores, Mohammad Reza Shah National Park, Iran, 1976-1978.

Species	A Diet Overlap	B Range Overlap	A x B/10000 Competition Coefficient
	%	%	
Wild pig	34.2	48.2	.16
Wild sheep	35.4	22.4	.08
Roe deer	21.7	30.2	.06
Wild goat	34.2	5.4	.02
Gazelle	36.3	0	0

TABLE 32.--Occurrence of degrees of hedging on four major browse species, Mohammad Reza Shah National Park, Iran, 1976-1978.

Plant Species	Number Examined	Hedged form (in percent)*				
		0	1	2	3**	4**
Colutea persica	125	49	22	16	13	0
Euonymus sp.	115	54	22	16	8	0
Rhamnus sp.	44	55	45	0	0	0
Acer ibericum	34	60	40	0	0	0

*Based on Riney et al. (1959).

**Severely hedged = $\frac{16 + 9 + 0 + 0}{125 + 115 + 44 + 34} = \frac{25}{318} = .08 = 8\%$

the park, maral were seen to use the bark of Euonymus sp., Prunus caspica, Juniper sp., Rhamnus sp., Colutea persica, Carpinus sp., Acer sp., and Quercus sp. The debarking (fraying) of trees, however, is not yet a serious matter in the park (Table 33).

Carrying Capacity

The range carrying capacity is defined as the maximum number of physically fit maral that can, in the park ecosystem, survive through the least favourable environmental conditions within one year.

Hedging and debarking of shrubs and trees in the transition zone indicated that maral populations there had reached the range carrying capacity. Maral consumed 2.87 kg of browse per day there during winter (Table 27). There was 27.72 kg of winter browse available per hectare in the transition zone (Table 19). For a period of three months with 60 percent allowable utilization (Telfer and Scotter, 1975), the transition zone of approximately 14,000 hectares could support a population density of one deer per 15.6 hectares or 900 maral. The best estimate of maral population in the zone, based on the fall pellet-group counts (Table 7), however, was 1064 maral, 164 maral were in excess.

While the maral is the major and most abundant ungulate in the transition zone, it is outnumbered in the Caspian deciduous forest by both wild pigs and wild goats. Based on animal signs and several population censuses, there were approximately 3000 wild pigs, 700 roe deer, 1200 wild goats, and 830 maral. Without further study, it

TABLE 33.--Fraying behavior of maral, Mohammad Reza Shah National Park, Iran, 1976-1978.

Frayed Tree or Shrub	Number	Height of Frayed Plant cm	Upper Limit cm	Lower Limit cm	Average Diameter of Frayed Stem	Percent of Circumference Removed
Colutea persica	175	70 - 220	195	35	6	70
Quercus Castanaefolia	85	80 - 230	205	30	15	45
Carpinus betulus	58	70 - 210	197	30	10	30
Acer laetum	44	45 - 190	185	33	12	30

TOTAL plants tallied = 1985

TOTAL plants damaged = 362 or 18%

is difficult to determine the range carrying capacity of the Caspian deciduous forest for maral. But considering maral preference for forest meadows in winter (Tables 14 and 15) and 39.16 kg/ha winter supply of browse, meadows can support a population density of one deer per 11.0 hectares. The best estimate of maral populatin density in the zone, however, based on the pellet-group counts (Table 7) was 29.3 ha/deer. It was thought that some other limiting factor, other than available winter browse, caused a lower carrying capacty of the range there for maral. Probably this was competition by the pigs.

Physical Condition of Maral

In the U.S.A. an inadequate food supply for deer is commonly observed (Gwynn, 1965) to produce poor quality antlers. This has also been noted in European deer (Lowe, 1971 and Whitehead, 1972). According to Gwynn (1965) deer herds in the very best ranges average about 5 percent spikes (i.e., yearling had antlers with 2 to 6 points, spikes here referred to the yearling stags with a poor set of antlers; 2-pointed). The observed average of 20.1 percent spikes ($\frac{31 \text{ spike}}{154 \text{ 2-6 point}}$), then, might be an indication of the maral population being in poor condition.

Of 975 animals classified at the end of the summer period when they were expected to be most fit (Mautz, 1978), 11 percent were judged to be in poor condition (Table 34).

TABLE 34.--Physical condition of maral in the Mohammad Reza Shah National Park, Iran, September 1977.

Vegetation Type	Number Examined	Body Condition			
		Good		Poor	
		%	No.	%	No.
Caspian deciduous forest	430	94	404	6	26
Transition zone	545	85	463	15	82
TOTAL	975	89	867	11	108

Mortality Causes

Of the 27 kills found, only 11 were of maral (6 males and 5 females). Five of these were killed by leopards, two by wolves, one by a car, and three by poachers. Leopards and wolves were the major predators capable of preying on maral in the park but, from information provided by the villagers, local poachers killed more adult maral than park reports suggest. Though based on limited data, the maral was the most preferred prey species for leopards and the second most important prey species for wolves (Table 35).

If it can be assumed that a leopard consumes an average of 1000 kg of meat per year (Schaller, 1972) and that on the average 25 percent of a kill consists of inedible portions, then where 27.8 percent of this represents maral it must be that three maral are taken annually by each leopard. Pimlott et al. (1967) estimated the average daily meat consumption of a Canadian wolf to be 4.5 kg. Assuming that on the average, 25 percent of a kill consists of inedible portions, each wolf has to kill 2010 kg per year to survive. This would indicate that the wolves in the park, whose food consisted of about 77.8 percent prey of medium size and 22.2 prey of larger size (Table 35), each kill about three maral. The number of wolves and leopards in the park are believed to be 29 and 22, respectively (Table 29). If these estimates are accurate, then these two predator species kill about 153 maral annually, an estimated kill level of 7.7 percent. According to Mech (1970) and Schaller (1972, 1977), predators may become the major controlling mortality factor where prey-predator ratios fall to 100-150 prey

TABLE 35.--Prey preferences of leopards and wolves in the Mohammad Reza Shah National Park, Iran, 1976-1978, based on a small number of observed kills.

Prey species	Number Kills	Available Prey Percent	Percent in Leopards Kill	Percent in Wolves Kill	Preference Ratings*	
					Leopards	Wolves
Maral	7	10.0	27.8	22.2	2.78	2.22
Wild Pig	5	15.0	22.2	11.1	1.48	.74
Wild Sheep	8	50.0	16.7	55.6	.33	1.11
Wild Goat	6	20.0	33.3	--	1.67	--
Gazelle	1	1.5	--	11.1	--	7.4
Roe Deer	-	3.5	--	--	--	--
TOTAL	27	100.00	100.00	100.00		

SOURCE: Based on Petrides and Pienaar, 1966.

animals per predator or less. At higher ratios, however, predation becomes only one of several other contributing mortality factors and cannot normally be considered to be a primary controlling influence. Since there were 256 prey animals per predator (Table 29) in the park, it seems that the kill rate is too low for predators to act as the regulatory or controlling factor.

Red deer herds reject diseased animals in their midst (de Nahlik, 1974). Lone hinds often are (calving season apart) sick specimens and according to European standards (de Nahlik, 1974) should be shot. Winter observations showed 124 lone hinds (Table 8), possibly sick animals. No information is available on diseases carried by maral in the park but in Europe, the most common ones are louping-ill and tick-borne fever or rickettsial disease (Whitehead, 1950). Parasitic worms were the major cause of mortality among calves during the late winter and spring in Europe (Whitehead, 1950).

DISCUSSION AND RECOMMENDATION

Though deer are known to be highly selective in the food they eat, their distribution is not usually governed solely by the occurrence of a particular food species (Staines, 1974). Varying regionally in their occurrence or in their selection by deer, pine was an important food item in Dutch and Danish studies during late winter (Jensen, 1968), it was unavailable in the Scottish one (Staines, 1970), and was regarded as starvation food in Poland (Dzieciolowski, 1969). The highly selective nature of deer for food does not imply that they occupy areas only where a particular food species occurs, it is merely true that deer select from what is available. The presence or absence of nutrient chemicals in the soil also affects the degree to which deer are attracted to food plants (Staines, 1974). Food affects deer distribution daily and seasonally. Staines (1974) suggests that though the quality and quantity of food may be important in the distribution of red deer in spring and summer, it is probably not the main limiting factor on winter ranges. The relationship between food and availability of shelter also is important. Where winters are severe, black-tailed deer are seldom found feeding more than 100 yards from shelter (Taber and Dasmann, 1958).

Meadows are essential to maral in the woodland and their maintenance is of prime importance. Though the preservation of

natural conditions is the primary objective in national park management, the maintenance of at least some important meadows perhaps should be given priority if tourism is affected by maral abundance.

The vegetational evidence suggests that the maral range is changing in the direction of a replacement of preferred maral foods by undesirable forage species. An invasion by woody plant species has now progressed to an advanced stage and to the point where mechanical or chemical treatment must be applied in several areas. Since control by these methods results in dramatic changes in the landscape and there is now much concern about the environment, high priority must be placed on developing techniques and procedures which are consistent with national park objectives and which nevertheless meet management needs. The preservation of natural beauty must be a primary objective in plant control project planning. Plant control treatments must be aesthetically pleasing.

The meadows in the park once were cultivated plots. These areas, now about 20 years old, currently are the primary feeding sites for maral. They are also vital to other species of wildlife, particularly the more than 1500 pheasants in the park. What then are guidelines for meadow maintenance projects?

The management of animal life in national parks is so closely associated with the management of the vegetation which supports it. Forest meadows in the park are successional communities. It is, therefore, necessary to manage the habitat to achieve or stabilize a desired stage. Of the various methods of manipulating

vegetation, the controlled use of fire is the most natural to apply. On Isle Royale, in Michigan, USA, moose range is created by periodic blazes that open the forest canopy.

In comparison with American and European findings (Harper et al., 1967; Lowe, 1969; and de Nahlik, 1974), the Cervus population represents a high standing crop of low productivity. Park maral are growing and reproducing well below their potential rates.

The condition of the maral, coupled with the low calf:hind ratio, suggests that the population at the time of the study was above its range carrying capacity in the important transition zone of the park. This may make the population particularly sensitive to the stress of severe winters. Overstocking and range depletion give an advantage to females which have lower food requirements than males (Darling, 1939; Anderson, 1958; Flook, 1970), and results in a disproportionate sex ratio (Cowan, 1950; Taber and Dasmann, 1954; Robinette et al., 1957; Klein and Olson, 1960; Peek et al., 1967). Heavy selective shooting in the park also may have contributed to the disproportionate sex ratio. Both overgrazing and overshooting can be expected to cause a loss of high-quality stags in the park.

Stags outnumbered hinds in winter at the higher elevations. Although separation of the sexes helps limit intra-specific competition for food (Geist and Petocz, 1977) winter mortality will be higher for stags which winter where the snow is deeper and the temperature colder than on the lower ranges. The existence of appreciable numbers of mature yeld hinds (females that did not reproduce during the previous season, though not necessarily barren)

in the park population is symptomatic of a nutritionally inadequate environment, as also recorded for American elk (Greer and Howe, 1964; Harper et al., 1967). The low breeding success of hinds in the park can be explained largely in terms of the slow rate of recovery from the effects of pregnancy and lactation as a result of poor forage. This in turn affects the ovulation and conception rates.

According to Mitchell (1976), aspects of reproduction in both sexes of adults also are influenced by body weight and condition. For stags, the spring season is the most important since extra nourishment is required for antler growth and to regain physical condition.

Next in importance is the period following the rut, when the main need is albumen and carbohydrates to provide flesh to cover bones for as much as 14-17% weight has been lost during this period (Mitchell, 1976). The hinds require about half the quantity albumen, calcium, and phosphoric acid (for reproduction and lactation) needed by a strong stag during the eight-month period October to June (Whitehead, 1950). The size of antlers have been related to food supply, soil, light, and body size (Chapman, 1975).

Our knowledge of the genetics of deer is very limited and any attempt to alter antler characteristics by breeding, which often means selective shooting, rests largely on chance. Cadman (1967), for example, states that the antler-quality of fallow deer is controlled by shooting the less-desirable males selectively. While antlers are only carried by the male maral, their structure is affected by the genetic characteristics of both sexes. Selective shooting of roe

deer in Denmark did not increase the size of the antlers. Improved antlers were only obtained when the entire herd was killed and replaced by deer from another area where the deer grew larger antlers (Anderson, 1961). The trophy value of red deer antlers in many areas of Scotland has declined during this century despite efforts to stop or reverse it (Lockie et al., 1967; Lowe, 1971). There are experiments carried out in Britain today, however, which prove that with dietetic additions it is possible for randomly selected hill calves to develop six to eight pointer on its first rack at the age of about 10 months (de Nahlik, 1974).

A reduction in maral density in the park certainly would be reflected in improved reproductive and growth performances of individual animals. This could best be accomplished by removing the excess animals, probably more than 160. Perhaps the most feasible procedure is by controlled shooting but to avoid the encouragement of unregulated poaching and to insure the selective greater removal of reproductive age hinds and poorly-antlered stags, only park personnel should be involved in the hunt.

The adjustment of herd size may have to be carried out over a period of several years. There are a variety of requirements to be met in a well-devised and well-executed shooting plan:

1. The maintenance of a static-size population, adjusted to the carrying capacity of land with a correct ratio of sexes.

2. Adjusting deer numbers so as to achieve a density of one maral to 15.6 hectares (in the transition zone) as the highest density acceptable.

3. The achievement of a correct number and correct age structure.

4. The elimination of poor-quality old animals.

When confronted by a herd, it can be difficult for the park official to make a quick selection of a suitable animal to shoot. Certain points of guidance can be followed:

1. The leading animal may not be shot, unless it is necessary to split the herd. It is especially important when hind groupings are small, that the leader (normally a dominant female) should never be shot. But conversely, if hind herds are larger than desired, the shooting of the leading hind may result in a desired split-up of the herd.

2. Lone hinds normally (calving season apart) are sick animals and should be shot.

3. Each female without a calf should not automatically be shot, it is fairly certain that after a 'rest' such a hind can produce a strong calf.

When it is desired to keep numbers static:

1. The total number of animals to be shot should equal the net annual increase.

2. Stags of poor quality should be eliminated, ideally in their first autumn. A quick rule is that the antler in the first head must be at least equal in length to the ears. An antler which can be inscribed into a rectangle is one with a good future, whereas a triangular pattern is unlikely to develop well (de Nahlik, 1974).

Red deer, espeically hinds, are very fond of chewing cast antlers or any bones they may find (Whitehead, 1950) in the late spring and early summer. This is the antler growing season for the stags and calf-rearing season for the hinds. The collection of antlers by the park personnel should not be allowed since they provide appreciable amounts of calcium (28%) and phosphorus (22%) during the critical spring season (de Nahlik, 1974). Yet, according to park personnel, an average of 600 kg of good quality antlers are collected annually. This comprises 25-30% of all shed antlers and about 80% of all the high-quality antlers.

In considering a program to insure maintenance of the park ecosystems, it is suggested that:

1. Assessments of animal populations, range interactions and dynamics should be conducted annually in all important areas of the park and for all major animal species. Basic information is essential for the maintenance of both the park's animal inhabitants and its habitats.

2. Particular efforts should be made to identify areas where range use conflicts may occur between the maral and other species. Any ungulate range interactions which seem likely to endanger the quality or quantity of habitat conditions should be managed in favor of the restoration of natural conditions.

3. Several exclosures should be built, each perhaps 0.5 ha in area. These would exclude all large grazing animals so that comparisons could be made between grazed and ungrazed vegetation. Such exclosures would enable early detection of range over use.

4. Study of the effects on the range of rodents and hares and other small mammals is desirable in order to determine their importance as influents of environmental conditions. Smaller exclosures should be built to exclude small mammals. These may be made as a part of the larger exclosures.

5. In order to determine the range carrying capacity more accurately, seasonal food and nutrition requirements should be determined. Chemical composition of forages should be studied. As pointed out by Mautz (1978); the analysis of nutritive values of white-tailed deer foods perhaps should be shifted from an emphasis on winter forages to studies of summer and fall food availability and digestibility since these determine the accumulation of body fat. Browse evaluation studies have typically shown that most natural winter browse foods are poorly digested by white-tailed deer (Ullrey, et. al., 1964, 1967; Robbin and Moen, 1975; Mautz et al., 1976; Mautz, 1978). It now appears that the storage of a large energy reserve in the form of fat, prior to the winter season, is the major factor determining the survival of northern white-tailed deer (Mautz, 1978).

6. Regular surveys to appraise the occurence of erosion, depletion and pollution should be made with respect to park preservation.

7. In any case, where management is undertaken in order to preserve wilderness values, periodic assessments should be made of the effects of that management in order to modify procedures as required.

8. In order to conduct studies in national park management, a staff of university-trained wildlife ecologists should be assembled and assigned as park biologists.

SUMMARY

Habitat and population interactions of maral (Cervus elaphus maral) were studied in the Mohammad Reza Shah National Park, Iran, during 1976-1978 in the three vegetation types present: Caspian deciduous forest, transition zone, and steppe.

Maral densities per 1000 hectares were calculated by the Hahn method for each vegetation type and season. The maral population thus was estimated to be 1897 for the park. Transforming the data by the variate $y = \log(X + 73.10)$, significant differences in deer densities were indicated between seasons, areas, and their interactions.

Using the fecal pellet-group data with a defecation rate of 10 pellet-groups per day, the population estimate was 2096 deer for the park.

Based on the Hahn figures and pellet-group counts, the average maral density was 15 and 16.6 maral per 1000 hectares respectively.

The average maral group size was 4.6. The sex ratio among adults was 27 stags per 100 hinds. Based on summer data, the park maral had a yearly mortality rate of 13.9% and a life expectancy of 6.7 years. The number of calves produced per 100 hinds was 28. Single calves were the rule. Gestation approximately lasted about 250 days. The mean date of birth was estimated to be 30 June.

The maral is mainly a grazer, preferring grasses over woody forages. Of the 19 plants eaten by the maral, Dactylis glomerata was

the most-preferred food, the year around. Euonymus sp., and Colutea persica were highly-preferred winter browse species.

Pellet groups were correlated positively with shrub abundance. Showing a preference for forest meadow and transition zone habitats, food consumption was estimated to be at the rate of 2.87 and 3.6 Kg/day in winter and spring, respectively. The carrying capacity of maral range was estimated to be 15.6 ha/maral and 11.0 ha/maral for transition zone and forest meadows, respectively.

More than 8% of the available shrubs were severely hedged in the transition zone by browsing deer. Hedging and debarking of shrubs and trees in the transition zone indicated that maral populations there had reached the range carrying capacity. Maral populations showed signs of over-abundance. There was an excess of old animals and, in comparison with American and European findings, the rate of recruitment was low. Of all the maral classified, 11.0 percent were in poor condition.

Wild pigs were important competitors for food. Wild pig and maral competed heavily for acorns in the fall.

Leopards and wolves were the major predators capable of preying on maral. Together, it was judged that they killed about 153 or 7.7 percent maral annually. Poaching, however, may have caused more adult mortality than predators.

Recommendations are made for maintaining maral populations in the national park. It is believed that the excess animals, probably more than 160, should be removed by controlled shooting.

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