FOOD PREFERENCES AND SURVIVAL OF THE AGRIMI (CAPRA AEGAGRUS CRETENSIS) ON CRETE

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ABSTRACT

FOOD PREFERENCES AND SURVIVAL OF THE AGRIMI (CAPRA AEGAGRUS CRETENSIS) ON CRETE

by

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A study was conducted on Theodorou Island, Crete, Greece during the summer of 1971 to determine the food preferences, range conditions and population densities of the Cretan wild goat or agrimi (Capra aegagrus cretensis).

A survey of the 68-hectare island determined that 137 animals were present with 58 percent adults, 20 percent yearlings and 22 percent kids. The adults were nearly equally divided by sex.

Shrubs made up 79.0, forbs 17.8 and grasses 3.2 percent of the animal's diet during spring to mid-summer. In late summer, however, the agrimi's diet changed to 39.9 percent shrubs, and 60.1 percent forbs. Grasses were not used.

Highly preferred species for the agrimi from March to mid-July were: Teurium pollium, Cistus incanus, Cupressus sempervirens, Rheichardia picroides, Olea oleaster, Calycotome villosa, and Siderides sp. In late summer, preferred species were Olea oleaster, Rheichardia pieroides, Asphodelus

microcarpus, *Cistus incanus* and *Scilla maritima*.

Euphorbia paralias, *Thybra capitata*, *Helichrysum italicum* and *Anthoxanthum odoratum* were widely distributed over the range but were not utilized.

The present agrimi population was found to be causing serious range deterioration since the four highly preferred species were 68 and 98 percent utilized during spring and the vegetation consisted only of 11.5 percent preferred species, 38.1 percent less preferred, and 50.2 percent avoided food plants.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The agrimi or Cretan wild goat (Capra aegagrus cretensis Schinz) is one of the world's rarest hoofed mammals and one of the four subspecies from which our domestic goat may have been derived (Sclater, 1886; Dolan, 1965). The species ranges from the Greek islands across Asia Minor and southern Russia to the mountains of western India.

The agrimi is interesting from both historical and zoological points of view. Knowledge of the subspecies dates back 3500 years to when it was represented upon official seals and appeared in numerous early Minoan paintings (Dolan, 1965). The agrimi was still common on Crete as late as 1850 when a sharp decline began with the introduction of modern firearms and lack of protection (Butler, 1951; Farmar, 1952). Today it is a rare subspecies, being found wild only in rugged and inaccessible areas of the White Mountains of western Crete at altitudes of 3500 to 7000 feet. The agrimi population on Crete and introduced islands was roughly estimated several years ago to be 400 (Dolan, 1965).

Interbreeding occurs freely between the agrimi and the widespread domestic goat (Danford, 1875; Hatzisarantos and Kanelis, 1955) and hybridization threatens the existence of the pure agrimi. Diseases and parasites of the domestic

goat (Zervas, 1961) present a further serious threat to the agrimi.

Considering these factors, the first major aim of the Greek Forest Service was to insure the survival of wild agrimia by capturing and transporting them to reserves acquired for this purpose. Sanctuaries for the agrimi were established on uninhabited islands off the coast of Crete. In 1928, the first introduction of the agrimi took place when a pair was released on the 68-hectare offshore island, St. Theodori, locally referred to as Theodorou. Agrimi were next introduced on two other uninhabited coastal islands off Crete. The 1350-hectare island Dias and the 40-hectare island Agii Pantes were stocked in 1957 and 1960, respectively (Schultze-Westrum, 1963). These islands serve as official reserves for the agrimi and belong to and are administered by the Greek Forest Service. This project was initiated during the summer of 1971: (1) to determine food availability, forage use and forage preference values, (2) to estimate present agrimi densities and their effects on range conditions, and (3) to appraise prospects for successful species preservation.

Previous Studies

Intensive studies of the agrimi, especially with regard to its ecology, seem to be lacking. The few studies which

have been made are related to taxonomic status (Hatzisarantos, 1950), life history (Hatzisarantos and Kanelis, 1955; Zervas, 1961) and distribution (Schultze-Westrum, 1963). The rarity and restricted distribution of the agrimi and the relative inaccessible habitat of the species in the White Mountains may partially account for this (Farmar, 1952).

Study Area

The portions of the investigation which will be reported here were conducted on St. Theodori Island. Of the three islands on which agrimi have been introduced, Theodorou is the only one where wild stock still exist in pure form (Dolan, 1965; Schultze-Westrum, undated).

The island lies about eight kilometers northwest of Chania, the capital of Crete, and is roughly triangular in shape. It is, at most, 1550 meters in length and 750 meters in width, with an area of approximately 68 hectares (Figure 1). At its highest point, the island rises 156 meters above the sea. Its north and west sides terminate abruptly in impressive near-perpendicular limestone cliffs (Figure 2), making access to the island from these sides difficult.

Climate

Climatically, the area is semi-tropical with year-round high temperatures. Available data for the last decade

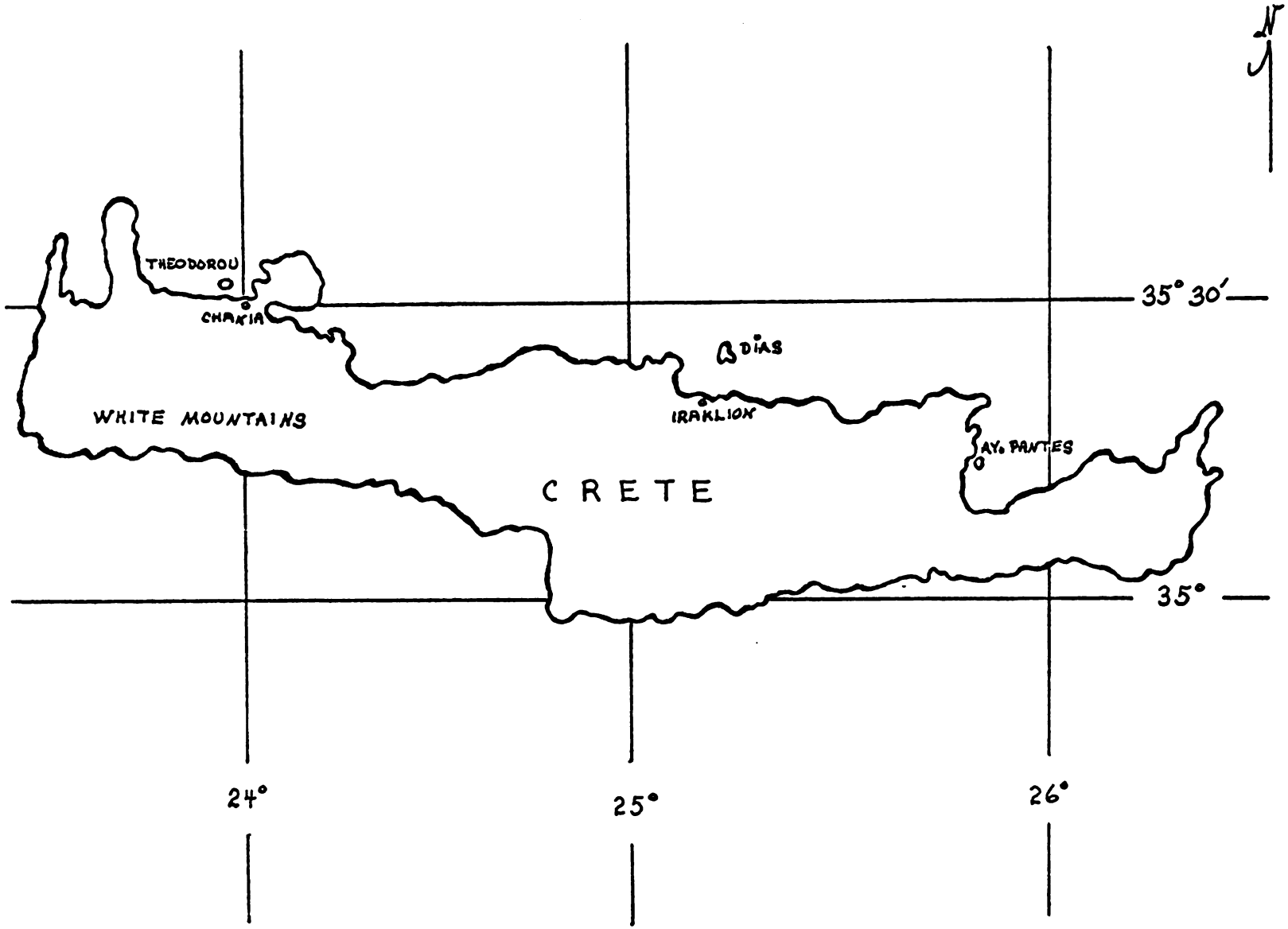
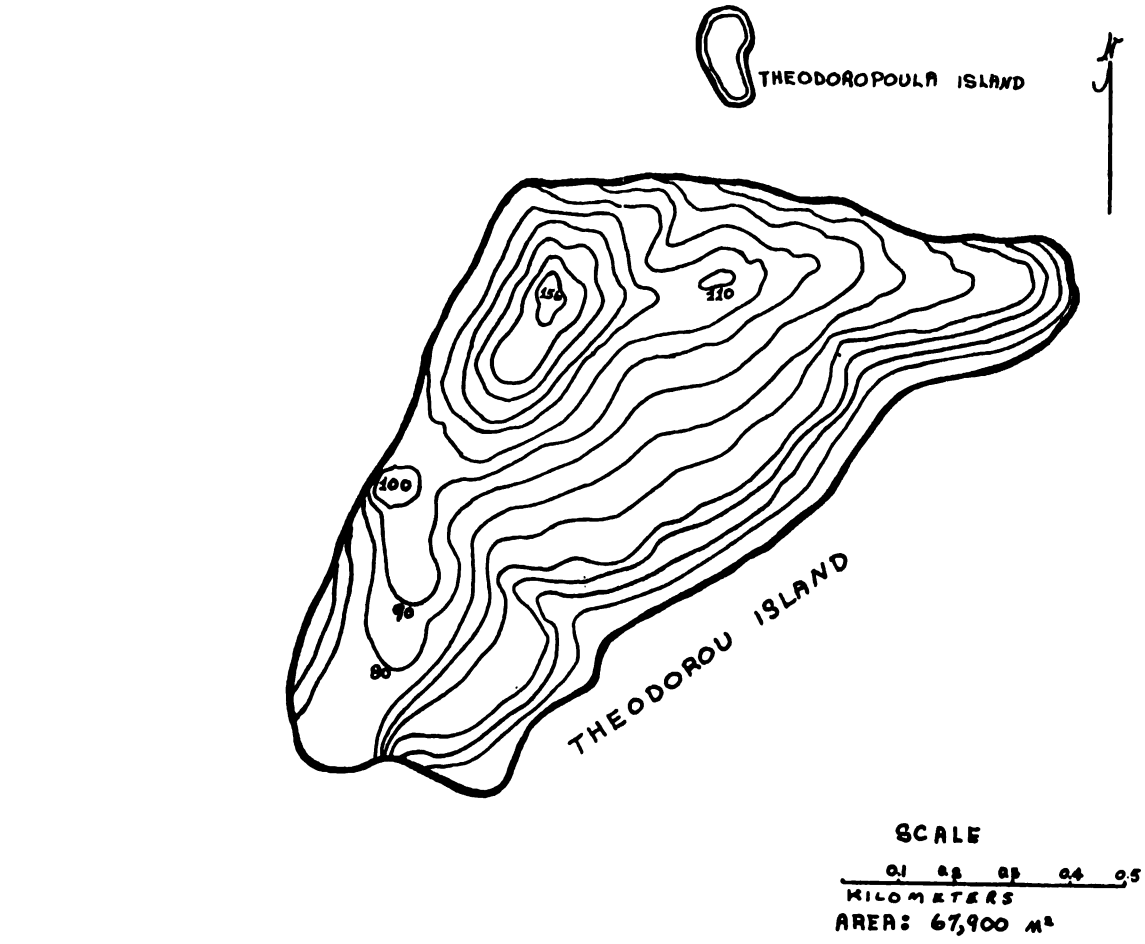


Figure 1 . Map of Crete.

Figure 2. Topographic map of Theodorou Island.


THEODOROPOULA ISLAND
N
120
110
100
90
80
THEODOROU ISLAND
SCALE
0.1 0.2 0.3 0.4 0.5
KILOMETERS
AREA: 67,900 M²
CRETE

(National Meteorological Service, Chania) show a mean annual temperature of +18.8°C with mean annual maxima and minima at +22.6°C and +15.1°C, respectively. Readings have been recorded, however, as low as +1.8°C (January, 1968) and as high as +41.4°C (July, 1960).

Rainfall

Rainfall is low and unevenly distributed over the year (Figure 3). Of the average 691 millimeters annual rainfall, about 75-80% occurs from November through April. Monthly precipitation is usually highest in January, averaging nearly 130 millimeters in that month. Rainless periods of as much as two to three months duration are common during summer. Neither frost nor snow have ever been recorded in this area.

Water

Running streams and freshwater springs are non-existent. Therefore, to meet the water requirements of the agrimi herd, a system was constructed by the Forest Service to collect runoff in two fenced reservoirs of about 100 m^3 each. The main responsibility of an appointed Forest Service guard is to dip water from these reservoirs for the agrimi population. On some occasions, however, agrimia have been seen ~~to~~ drinking from the sea.

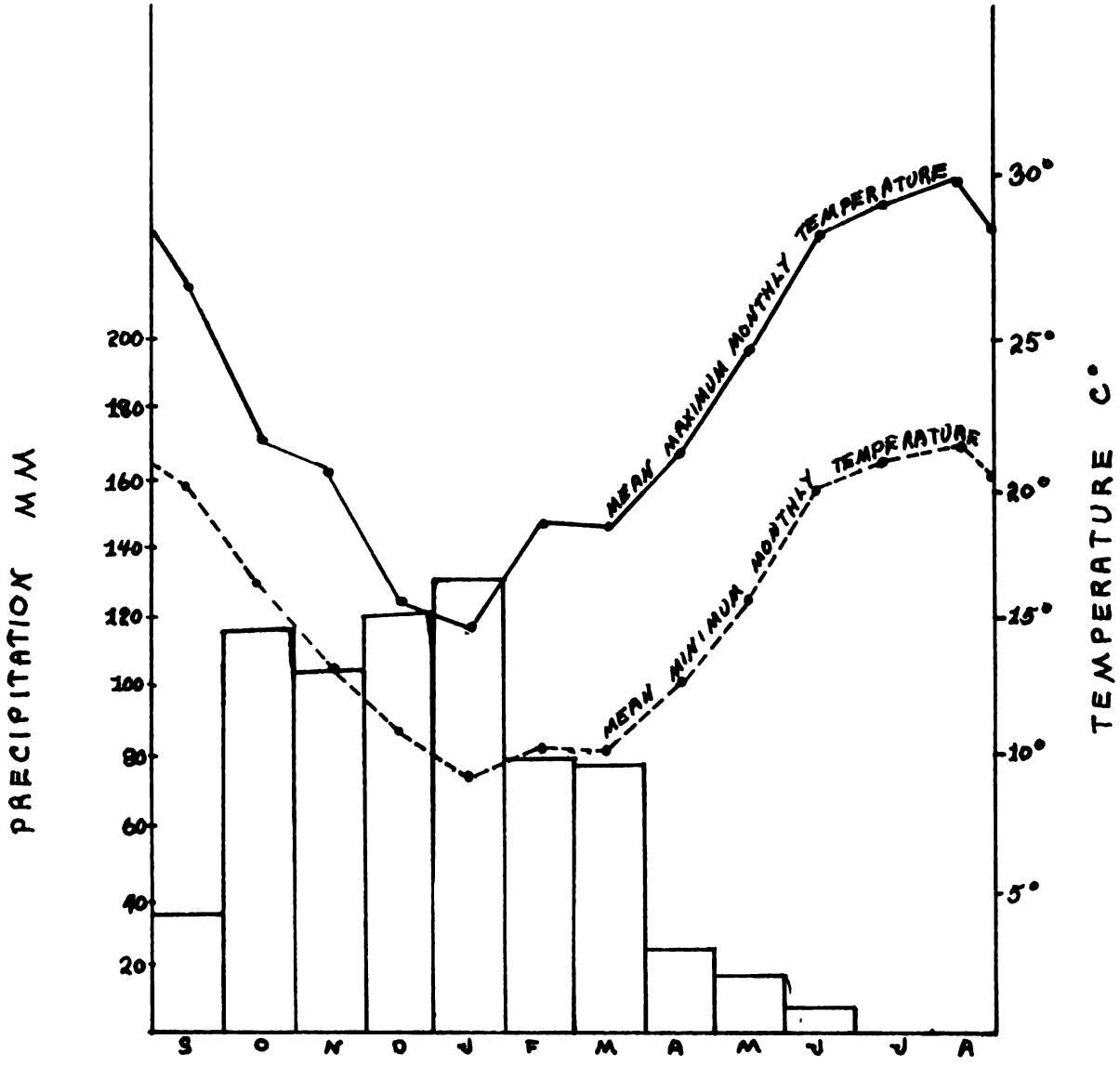


Figure 3. Distribution of precipitation and maximum and minimum air temperatures during the year. Based on 1960-70 climatic data of National Meteorologic Service Chania, Crete, Greece.

Soils

Soils on Theodorou Island are shallow and poorly developed. Derived almost entirely from metamorphosed limestone, they are stony, well-drained and limited to B and C horizons. The B horizon is reddish and though basic in reaction, mostly lacks lime though rich in Al_2O_3 and Fe_2O_3 (Table 1). The island's soils lack decaying organic matter and at a depth of 15-50 cm, the B horizon with blocky to prismatic structure lies on limestone parent-material.

Temperature and rainfall are generally favorable to plant growth from late winter to early spring. Additional moisture in autumn results in some late growth but the amount of forage produced then is usually of little grazing importance (Liacos, personal communication).

Vegetation

Theodorou Island supports basically a *Pistacea-Poterium-Thybra* plant community, with other vegetation present in degraded form. Plants which have been identified include the grasses *Andropogon pubescens*, *Anthoxanthum odoratum*, *Avena* sp., *Bromus sterilis*, *Dactylis glomerata*, and *Trifolium* spp.; forbs *Asphodelus microcarpus*, *Caparis spinosa*, *Crithmum maritimum*, *Euphorbia paralias*, *Helichrysum italicum*, *Pheichardia picroides*, *Phlomis fruticosa*, *Platago lagopus*, *Scilla maritima*, *Siderides* sp; numerous shrubs *Calycotome villosa*,

Table 1. Analysis* of 3 soil samples from widely separated sites on Theodorou Island, Crete, Greece, July, 1971.

Sample	pH	$CaCO_3$ %	Al_2O_3 %	Loam %	Sand %	Evident Horizons
1	7.5	0.0	27.4	46.0	27.4	B-C
2	7.1	0.0	20.6	55.2	23.6	B-C
3	7.3	0.0	26.2	44.2	25.7	B-C

*Made at Agriculture and Forest Department, Aristotelion University, Thessalonici, Greece.

Cistus incanus, Olea oleaster, Pistacea lentiscus, Poterium spinosum, Teurim pollium, Thybra capitata; and some trees Ceratonia siliqua, Cupressus sempervirens, Ficus carica, Pinus halepensis, Prunus communis.

Other Animals

Relatively few animal species are present. Though no attempt was made during the present study to compile a complete list, several species were recorded as present: Eleonora falcon (Falco eleonorae), black bird (Turdus menula), Greek partridge (Pedrix greaca), raven (Coruus corax), rock martin (Hirundo rupestris), sea duck (Scoter sp.), Norway rat (Rattus norvegicus), and European hare (Lepus europeus).

Hares are not native to the island and their presence is due to a previous release by the Forest Service. Fortunately the population seems to be small since only 2-3 were actually observed during the study period. Pellet density was extremely low and four mummified carcasses were found. Their causes of death could not be determined.

The paucity of tracks, feces, and burrows indicated that the population of rats also was not very high. Disease and limited food supplies may be the main reasons for the low numbers of hares and rats. Whether they have previously been more abundant is not known.

METHODS

Forage Availability and Utilization Surveys

Browse availability and use were determined by the twig-count method (Shafer, 1963), in which a count of twigs is converted to weight by using an average weight per twig for browsed and unbrowsed forage.

The original availability and utilization of grasses and forbs were determined by a modification of the weight measurement procedure (Beruldsen and Morgan, 1934). Both availability and utilization are measured by clipping forage samples before and after the grazing period, using different randomly selected plots. The difference in dry weight between the two clippings is taken to represent consumption by herbivorous animals.

Since this study was started in summer and forage clippings before the grazing period were unavailable, Beruldsen and Morgan's procedure was modified. Hence, the original available and final grazed herbaceous plant weights were estimated from comparisons of ungrazed plants with plant stubble found in the sample areas.

Unfortunately, an existing exclosure (80m x 30m) could not be used for comparative studies because of evidence that agrimia had used the exclosure, entering through a small

opening in the fence. This exclosure did provide a less-heavily grazed area, however, in which ungrazed plants of several species were found.

The forage inventory data were gathered from 68 one-square meter plots arranged in a grid and covering the entire island. Plots were spaced at 100 meter intervals along north-south lines which were 100 meters apart. The distances between plots were measured using a metal tape; the lines were kept equidistant using a hand compass. The outlines of the plots were determined by a wooden frame 2 by 0.5 meters. Using the area-species curve method, the homogeneity of the range was tested to determine the number of plots required. A sample size of 36 plots one square meter each was found to be sufficient to determine vegetation composition since it included 80 percent of the plant species (Gain and Castro, 1959).

In each plot, the number of individual shrubs, forbs and grasses present, and the number of browsed and unbrowsed twigs per shrub were tallied by species. In addition, the overhanging cover intercepted by the line along the right-hand border of each plot was measured for each plant species. After these data were collected, unused plants were clipped at the mean grazing height observed to be normal for each forage species. The collected clippings were separated by species and placed in paper bags for drying and weighing.

The original lengths of browsed twigs were estimated by comparisons of the diameters of browsed and unbrowsed twigs as described by Shafer (1963). Specimens of unbrowsed twigs were randomly selected from different plants, sites, and heights in order to determine the mean dry weight per twig per species. Dry weights of forb and grass specimens were determined for plants collected randomly from inside the exclosure because no adequate number of ungrazed plant species could be found otherwise on the open range. The clippings were cut to the mean grazing height observed to be normal for each species. Between 30 and 50 specimens each were collected for most species.

All plants were dried at 105°C for 24 hours in a standard laboratory oven. The mean dry weight per plant was determined and the percentage of moisture content noted. The nutrient characteristics of forage species used by the agrimi were analyzed by the Forest Service Research Center in Thessaloniki, Greece. Proteins, fats and fiber were determined by the Kjeldahl, Soxhlet, and Henneberg-Stohann methods, respectively. Caloric values were determined in the Department of Animal Husbandry's laboratories at Michigan State University using a Brent oxygen bomb calorimeter.

Food Habits Studies

There are two important aspects of herbivore food habits studies which must not be confused: (1) The percentage of the animal's diet which each plant species contributes, and (2) the percentage of each plant species which is cropped by the feeding animal. The dietary percentage indicates which species are the principle foods consumed. In contrast, the percentage cropped reveals the degree to which that species is chosen from among those available to be eaten. The reasons why certain foods are preferred over others is not disclosed by percentage utilization data.

If all forage species were present and available in equal quantities, the composition of the animal diet could be used as an index to food preference. However, such a condition never occurs naturally.

While forage species preferences may be expressed as the percentage of each species which is removed by the feeding animal (Casebeer, 1948), it is often more revealing to calculate forage preference ratings as the quotients which result when the percentages of each plant species in the animal's diet is divided by its percentage availability (Petrides, unpublished). Either type of preference value indicates the degree of avidity which the animal shows for one plant species over another when the abundance of that species on the range is equalized.

The composition of the diet can be used as an index to the dietary importance of forage species on a particular range. The percentage abundance of a food in the diet indicates directly the importance of that forage to the animal, at least in terms of bulk. The dietary use of a food, in contrast to food preference ratings, may very well be related to its availability.

Food preferences, especially if they are expressed as ratios can be used to compare the relative likelihood that some species will be eaten rather than others. Because of this differential feeding, the relative abundance of forages can be used to appraise range condition and trend. Highly preferred species can be used as "indicator" or "key" species to evaluate population levels with respect to range carrying capacity (Stoddart and Smith, 1955). High, low, or proper productivity of these species indicates over, under or proper herbivore abundance, respectively, and the likelihood of maintaining sustained population levels.

Food Preferences

Because of the shy behavior exhibited by the agrimi, close-range observation of individual animals feeding was practically impossible. Furthermore, specimen stomach analyses was not feasible due to the protected status of the animal as an endangered native species.

The formula used to calculate preference ratings for each food plant enables the clear determination of preferred food species as opposed to those which are neglected or avoided (Petrides, unpublished). Although providing values which parallel the percentage of each species which is eaten, 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.

The percentages used in the ratios are best calculated from species dry weights of the total diet and of the available forage but, where the species involved have nearly equal moisture contents, that refinement may be disregarded if extreme accuracy is not critical. A ratio of 1.00 demonstrates that a species is taken as it is encountered and is neither sought out nor neglected. This value serves as a standard for relative comparison and the computed ratings rank individual foods according to their degree of preference.

The computed ratios obviously refer to the particular time that the data are obtained and are restricted to the particular locality involved. The other food species present and the chemical composition of the soil and plants are factors which affect seasonal preference ratings. Though it is desirable that food preference ratings be calculated seasonally and that year-around food preferences be determined, it was possible in this study to calculate food preference

ratings of the agrimi only for the spring and summer seasons. Summer, however, is the critical season when habitat and agrimi production is limited by drought.

Vegetation was analyzed in mid-summer to obtain both the percentage availability of each species in early spring (at the end of the growing season), and the percentage of species eaten between early spring and the time of data collection.

A basic assumption using this method in the field was that only the agrimi cropped the foods measured, or in case of more than one herbivore being present, they do not compete for the same forage species.

Feeding Trial

A brief study of one penned agrimi was designed to determine summer food preference ratings and to determine the average daily forage consumption. The animal was held in captivity for 20 days prior to the feeding trial in order for it to become accustomed to captivity. The agrimi, a 1½ year old male, was weighed before and after the feeding trial to ascertain any weight change.

Forage items were put daily in compartments of wooden boxes after previous weighing. The amount of each species offered to the agrimi was proportional to its availability on the range as determined by field measurements (Table 2).

The weight of each forage species eaten per day was calculated by subtraction. A conversion of wet to dry weight was made using the moisture content factor previously calculated. The experiment was continued over seven days.

Population Census Determination

On July 8, 1971, five game scouts and the author undertook an agrimi census on the island. Two additional men used boats to check against animals hiding on the steep shoreline cliffs.

The six men on land formed a line of drivers. The average distance between them, about 70m, insured visual contact between crew members. The sex and size of each animal was tallied during the census and also from later daily records of animals observed during the study.

To estimate the age structure of the wild agrimi population in the field, body size and horn development were used to identify three classes: kids, yearlings, and adults. There were obvious differences in body weights and in horn lengths in these categories. Absolute weights were not determined, but horn length in centimeters for these groups was approximately, 2-4, 18-20, and 70-80 for male, and 2-4, 8-10, and 20 for female animals, respectively.

Young are born in March and the horns appear in both sexes during the second month of age, but they develop sooner and grow faster in males. Sex determination was based on

horn development. The horn length ratio between adult males and females is about 4:1. Though that ratio in yearlings is approximately 2:1, yearlings were not classified by sex in the field because of the possibility of error when seen at a distance. Kids also were not classified because they showed no obvious differences in horn development or other sexual characteristics.

Range Condition

Two indicators were used as guides to range condition and trend: (1) the degree of utilization of highly preferred species (Stoddart and Smith, 1955) and (2) the extent to which the more heavily-utilized forage species were holding their places in the plant community.

As is frequently done in order to show plant responses to intensive grazing, plant species with preference ratings above 1.00 were termed as "decreasers" and those below 1.00 as "increasers" (Table 8). Those species which were not utilized at all for food were classified as "avoided-increasers."

The cover, density and frequency of these groups were calculated. The line interception method developed by Canfield (1941) was used as a measure of vegetative cover for each plant species. Species density per plot and frequency of distribution were calculated from the recorded number of species present per plot.

RESULTS AND DISCUSSION

Food Preferences

Analyses of available and browsed vegetation was made at a season when utilization was considered to be near optimum. That is, normal feeding on forage species had taken place long enough after springtime growth had occurred to give a measurable feeding pattern but had not advanced to the point of abnormal use of less-palatable species. Field data were obtained on (1) species availability after the growing season ended in March, and (2) utilization of those foods between March and mid-July.

Of the 33 plant species occurring on the island, only 12 were eaten by the agrimi. These comprised 6 shrubs, 5 forbs and 1 grass species, while the percentage availability of forage species in the field was shrubs 68.10, forbs 28.52, and grasses 3.38 percent. Their percentages in the foods consumed by agrimia were 79.06, 17.79, and 3.29 percent, respectively (Figure 4). Thus during spring at least, the agrimi was mainly a browser.

In descending order of species food preference (Table 2) during the spring period, the agrimi utilized: Teurium pollium, Cistus incanus, Cupressus sempervirens, Reichardia

Table 2. Basic data for the calculation of relative consumption and preference ratings for forage eaten by the agrimi during March-mid-July. Theodorou Island, Crete, Greece, 1971.

Forage Species	Average Dry Weights*			Percentages			
	A Per twig or plant (gr.)	B Originally available/ hectare (kgr.)	C Consumed per hectare (kgr.)	$D=\frac{B}{SB}x100$ Available forage	$E=\frac{C}{SC}x100$** Dietary consumption	$F=\frac{C}{B}$ Plant removal	$G=\frac{E}{D}$ Forage preference rating
Teurium pollium	0.101	9.87	9.68	2.61	10.31	98.07	3.95
Cistus incanus	0.272	3.38	2.79	0.89	2.97	82.54	3.34
Cupressus sempervirens	0.425	2.67	2.18	0.71	2.32	81.65	3.27
Rheichardia picroides	0.252	2.20	1.44	0.58	1.53	65.45	2.64
Olea oleaster	0.321	12.21	6.08	3.23	6.48	49.80	2.01
Calycotome villosa	0.462	25.80	12.56	6.82	13.38	48.68	1.96
Siderides sp.	0.201	0.85	0.29	0.22	0.30	34.12	1.36
Andropogon pubescens	0.836	12.78	3.08	3.38	3.28	24.10	0.97
Scilla maritima	2.086	19.01	4.12	5.02	4.39	21.67	0.87
Pistacea lentiscus	0.416	203.83	40.98	53.85	43.66	20.10	0.81
Asphodelus microcarpus	3.410	14.54	2.59	3.84	2.76	17.81	0.72
Phlomis fruticosa	0.631	71.35	8.07	18.85	8.60	11.31	0.46
Total=S		378.49	93.86	100.00	100.00		

*Total weights per hectare were calculated from data obtained from 68 sample plots, each one square meter. Data are for the current year's plant growth only. See text for explanation of different procedures used for shrubs versus herbaceous plants.

**Or, E = (D x F) B/C (Petrides, unpublished).

picroides, Olea oleaster, Calycotome villosa, and Siderides sp. These species may be termed preferred or "ice cream" foods in the agrimi's normal diet on this range. Species with high preference and low availability mainly occurred protected beneath thorny shrubs. Some were utilized to between 65.79 and 98.0 percent.

Species which tended to be avoided (that is, for which low preference was exhibited) were: Pistacea lentiscus, Scilla maritima, Andropogon pubescens, Asphodelus microcarpus, and Phlomis fruticora. Species which did not show any feeding even though their abundance on the range was high were: Euphorbia paralias, Thybra capitata, Bromus sterilis, Dactylis glomerata, Plantago lagopus, Helichrysum italicum, and Pinus halepensis. A few additional plants did not occur on the study plots and were not sufficiently abundant to provide an appreciable portion of the agrimi's diet. Those which showed a considerable degree of utilization were: Arbutus unedo, Caparis spinosa, and Ficus carica. The shrub Poterium spinosum also showed a slight use of newly-growing twigs before the development of thorns.

The calculated food preferences for the agrimi are based on the assumption that the low rat population present did not leave browse marks which resembled those of the wild goat. Rats are mainly seed-eaters and grazers and would seem normally not to be competitive with the mainly

browsing agrimi. Any error which may have occurred in hand-clipped samples is believed to have affected both utilization and availability data in similar proportions and the calculated food preference ratios were not affected in their relative values.

As evidenced by the data of Table 2, the most valuable species in terms of bulk contribution to the agrimi's diet on this particular range were Pistacea lentiscus, Calycotome villosa, Teurium pollium, Phlomis fruticosa and Olea oleaster. These species comprised 82.43 percent of the diet. They were not highly preferred foods, since they comprised 85.33 percent of the forage and totaled 82.43 percent of the agrimi diet. Yet these species were of definite significance in that they formed the major foods eaten.

Pistacea lentiscus comprised 53.84 percent of the available forage and was the most abundant forage plant on the range. It is evergreen and made up 43.66 percent of the animal's diet from spring to mid-July and seemed likely to be used rather consistently throughout the year. It appears to be the most important plant species for the agrimi on this particular range.

The agrimi's preferences for Teurium pollium, Cistus incanus and Cupressus semperuirens were very high; and for the species Pistacea lentiscus and Phlomis fruticosa were very low (Table 2). Yet in terms of total dietary intake,

the species Pistacea lentiscis and Phlomis fruticosa, were most important and the species Teurium polium, Cupressus sempervirens and Cistus incanus had little dietary significance.

The results of this study may not be applicable to establish broad regional references for preferred foods of the agrimi. This is because of the local diversity in plant communities, and because the preferences exhibited by the agrimi in any area are dependent on the plant species present. But it is believed that these data can be used to indicate grazing intensities and range trends for areas with similar vegetation types. Furthermore, these preference data may also be equally applicable to ranges where domestic goats are grazed since these livestock originated, in large part at least, from the agrimi.

Summer Food Preferences

According to the 7-day feeding trial, the agrimi's summer diet was made up of 60.1 percent forbs and 33.9 percent shrubs as compared with their 58.4 and 37.9 percent summer availability, respectively. Grasses showed no use in spite of their 36 percent availability (Figure 5). In descending order of preference (Table 3) determined during the summer for a captive yearling agrimi, preferred food species were: Olea oleaster, Rheichardia picroides, Asphodelus microcarpus,

Table 3. Consumption of summer and preference ratings for forage plants offered to a captured yearling (14.1 kg.) agrimi. Theodorou Island, Crete, Greece, August 12-19, 1971.

Species	A Dry weight per species available (gr.)	B Percent available	C Dry weight per species in diet (gr.)	D Percent in diet	$E=\frac{D}{B}$ Forage preference ratings
Olea oleaster	175	5.6	175	7.2	1.29
Rheichardia picroides	168	5.4	161	6.7	1.24
Asphodelus microcarpus	540	17.3	443	18.3	1.05
Cistus incanus	81	2.6	66	2.7	1.04
Scilla maritima	548	17.6	423	17.8	1.01
Pistacea lentisus	987	31.7	729	30.0	0.95
Phlomis fruticosa	617	19.8	420	17.3	0.87
	3,116	100.0	2,426	100.0	

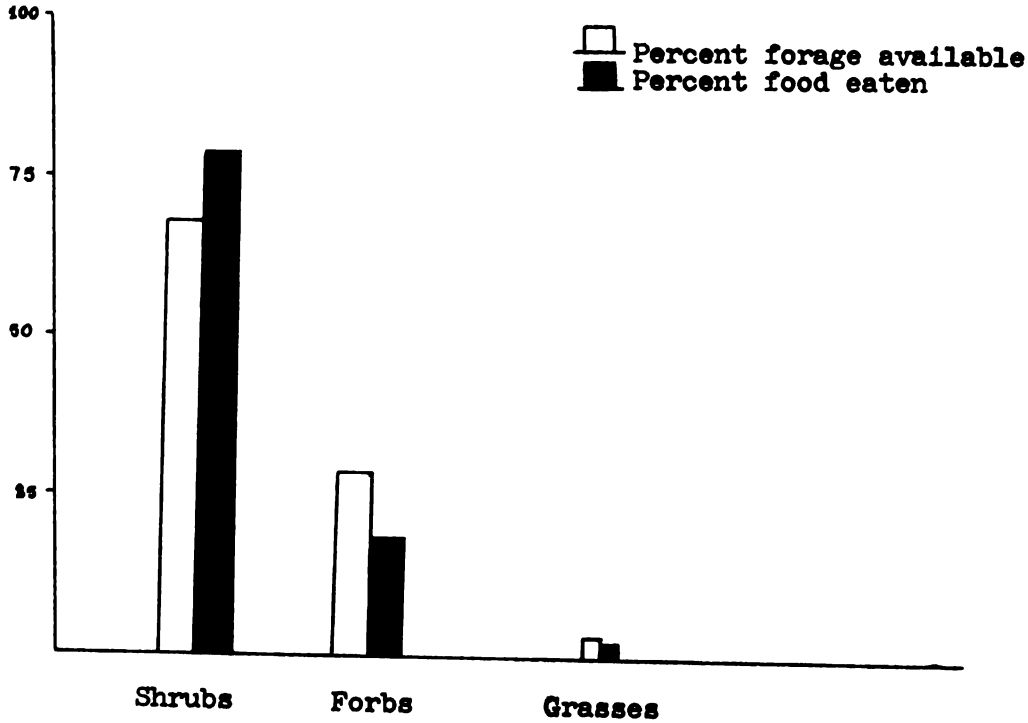


Figure 4. Percentages of forage classes available and eaten by the wild agrimi population. Theodorou Island between March and July 20, 1971.

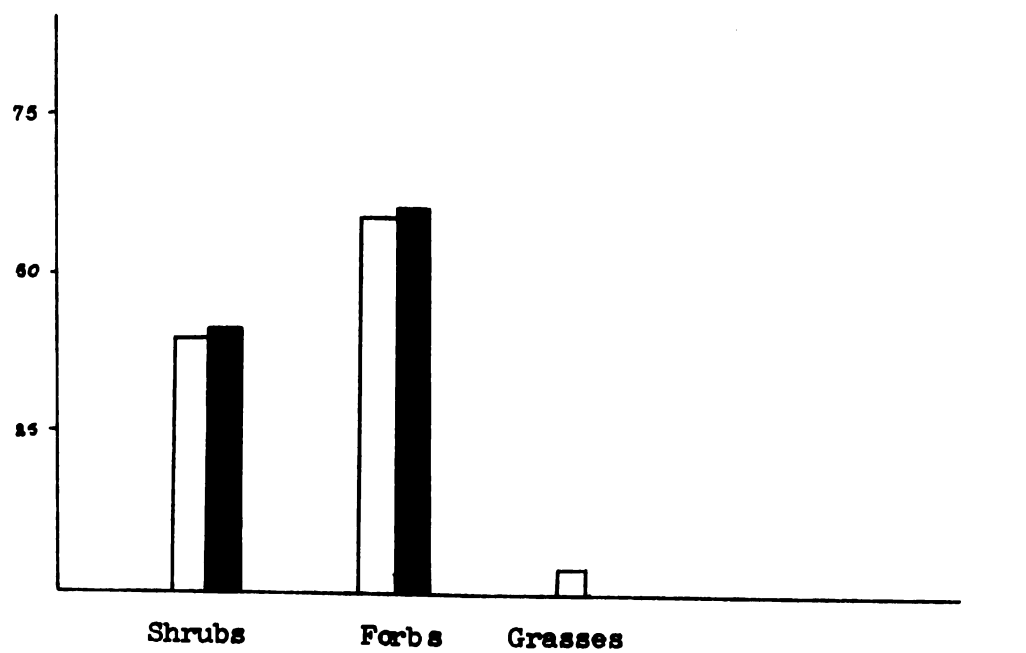


Figure 5. Percentages of forage classes available and eaten by a captive yearling agrimi during feeding trial. August 12 to 19, 1971.

Scilla maritima, and Cistus incanus. Species of low preference were Pistacea lentiscus and Phlomis fruticosa, while other plant species eaten during the spring such as Cupressus sumpervirens, Calycotome villosa, Andropogon pubescens, were not eaten during the late summer even though available.

There was a conspicuous shift from browse species during the spring to a variety of forbs during the summer. The development of thorns in the case of Calycotome villosa and physiological changes in Cupressus and Andropogon species are believed to account for their unpalatability. Forbs which were not much eaten during spring, were far more important in the summer diet. Most shrubs were not as succulent as the forbs were. Though the plants offered during the feeding trial were presented in amounts which were proportional to their presence on the range, it is possible that the preferences displayed then were somehow affected by the captive situation.

The evidence is that agrimi welfare is directly related to the quantity and quality of their food supply during the summer. Knowledge of food preferences and the nutritional values of range vegetation at that season is essential to the proper management and continued survival of these remnant agrimi populations.

The average daily forage consumption during the feeding trial was found to be 347 grams (dry weight) (Table 3), which was nearly 2.5 percent of the animal's total weight. It was

determined (Table 4) that the average daily diet was made up of 4.51 percent proteins, 9.89 percent fats, and 25.3 percent crude fiber. The daily energy requirements were calculated to be about 1,467.80 kcal. The animal's weight of 14.150 kilograms remained unchanged during the period of the feeding trial.

The daily water consumption of the captive agrimi was measured and was approximately 1.1 kg. without taking into consideration the (certainly minimal) losses due to evaporation from the container.

Further feeding and primary production experiments must be carried out using representative animals of both sexes and all weight classes if data of this type are to be applied to the entire wild agrimi population in order to determine the carrying capacity of the island.

Population Size and Structure

The census on July 8, 1971, counted 137 agrimia on Theodorou Island. Comprising 42 adult males, 38 adult females, 27 yearlings, and 30 kids (by percentages: 30.7 males, 27.7 females, 19.7 yearlings, and 21.9 kids). The overall density was almost exactly two per hectare.

The sex ratio among 80 identified adults was nearly even (Table 5). The yearlings and kids did not exhibit clear sexual dimorphism and were not sexed. Eighty to eighty-five

Table 4. Results of forage analysis and feeding trial involving a single agrimi. Theodorou Island, Crete Greece, August 12-19, 1971.

Species	Crude proteins (a) %	(b) gr.	Crude fats (a) %	(b) gr.	Crude fiber (a) %	(b) gr.	Ash (a) %	Crude energy (a) Kcal/ gr.	(b) Kcal/ gr.	Dry weight* (b) gr.
Pistacia lentiscus	4.731	4.929	9.74	10.154	22.54	23.486	3.614	4.738	493.69	104.2
Phlomis fruticosa	8.412	5.047	11.57	6.942	31.82	19.092	4.396	4.137	248.22	60.0
Olea oleaster	3.750	0.937	8.09	2.022	30.68	7.670	3.897	5.158	128.95	25.0
Scilla maritima	2.781	1.724	10.21	6.330	19.69	12.207	10.440	3.673	227.77	62.0
Asphodelus microcarpus	2.331	1.474	10.30	6.519	22.76	14.407	8.859	3.775	238.96	63.3
Rheichardia picroides	4.668	1.073	5.42	1.247	32.86	7.557	7.105	3.868	88.96	23.0
Cistus incanus	4.825	.458	11.58	1.100	26.58	2.525	6.032	4.342	41.25	9.5
Total		15.643 (4.51%)		34.314 (9.89%)		86.844 (25.03%)			1467.80	347.0

(a) Results of analysis of forage species.

(b) Mean quantity consumed daily

* Based on data from Table 3 (column C) but computed here on a daily basis.

Table 5. Sex and age composition of the agrimi population. Theodorou Island, summer 1971.

Date	Observations	Totals	Adults		Yearlings	Kids	Kids per	
			Males	Females			Adult	Adult Females
July 8, 1971	Census Drive	137	42	38	27	30	.37	.80
July-September	Direct Observations	234	60	65	54	55	.44	.85

percent of adult females were accompanied by young of the year and the number of yearlings was scarcely less than the number of kids (Table 5). Adults were about three times as numerous as yearlings. There was no indication from this of other than generally high survival rates.

Some general body characteristics of the agrimi were summarized (Table 6) from measurements of four adult animals captured during the study. The age of agrimia is determined easily by merely counting the annual rings on the horns (Couturier, 1961).

Range Condition

The degree of utilization of accessable parts of edible species and the vegetation composition were taken as guides to range condition.

Utilization of edible species: Although the proper degree of browsing of palatable species on agrimi ranges is not known, it is a general rule in temperate-zone range management that 50 percent of vigorous forage can be removed annually without harm (Stoddart and Smith, 1943). The exhibited degree of use on Theodorou by mid-July was determined to be far in excess of this limit for the preferred species (Table 7).

The utilization of preferred species on the study area indicated that these species were in serious danger of total

Table 6. Body measurments of four captured animals (centimeters). Theodorou Island, summer, 1971.

Age (years)	1.5	4.5	5.5	5.5
Sex	M	F	F	M
Weight (kg.)	14.1	16.0	16.8	50.5
Total length	80	90	92	110
Height at front shoulder	51	45	45	74
Ear length	9.5	10.0	10.0	12.0
Tail length	9.2	7.2	7.4	10.3
Front hoofs				
length	4.5	5.5	6.0	7.0
width	3.2	3.0	3.0	5.1
Hind hoofs				
length	3.8	4.0	4.0	5.0
width	2.0	2.5	2.5	2.7
Horns				
length along curve of front ear	20	19	20	90
tip to tip spread	15	8	9	10
mean circumference at base	12	7.5	7.5	12.0

Table 7. Utilization by agrimi and the availability of highly-preferred forage species. Theodorou Island. Crete, Greece, March to mid-July, 1971.

Food Plant Species	Degree of Utilization %	Original Availability %
Teurium pollium	98.0	2.61
Cistus incanus	82.5	0.89
Cupressus sempervirens	81.6	0.71
Rheichardia picroides	64.4	0.58
Olea oleaster	49.8	3.23
Calycotome villosa	48.7	6.82

extermination. Furthermore, these species tend to be replaced by less palatable plants. At the end of the growing season their contribution to the total forage supply was only 15.8 percent and many were quite rare indeed.

Vegetation composition: The vegetation analysis of the range revealed that the contribution of the preferred forage species (decreasers) to the total floristic composition was extremely low. The avoided and less-palatable (increasers) species made up most of the island's vegetation.

The percentages of vegetative cover were found to consist of decreasers 11.57, increasers 38.16 and avoided-increasers 50.27, respectively. The percentages of density for decreasers, increasers and avoided-increasers were calculated to be 19.22, 35.12, and 45.66 and of frequency were 19.29, 33.96, and 46.75, respectively (Table 5).

Among further signs of intensive overuse of the island vegetation were:

1) A high proportion (84.2%) of relatively unpalatable species in the agrimi's diet (Table 2).

2) A total-vegetation cover of the island of only about 54.38 percent (Table 8).

3) A lack of soil development, an absence of decaying organic matter on the ground surface, and an exposure to erosion of surface soils (Table 1).

These data show clearly that heavy utilization of forage

Table 8. Food preferences and plant cover, frequency and density on 68 plots on Theodorou Island, Greece, July, 1971.

Plant species	Food preference rating*	Canopy Coverage: Area covered per plant species under 136 m line meters	Canopy Coverage: Vegetation cover per species %	Frequency: Number of plots in which species were present	Frequency: %	Density: Number of plants per plot	Density: %
Decreasers:							
Teurium pollium	3.95	0.51	0.68	6	1.63	0.147	1.40
Cistus incanus	3.34	0.52	0.70	4	1.08	0.161	1.54
Cupressus sempervirens	3.27	0.62	0.84	2	0.54	0.029	0.28
Rheichardia picroides	2.64	0.25	0.34	26	7.07	0.882	8.43
Olea oleaster	2.01	1.79	2.41	9	2.45	0.161	1.54
Calycotome villosa	1.96	4.85	6.54	14	3.80	0.205	1.36
Siderides sp.	1.36	0.05	0.06	10	2.72	0.426	4.07
			11.57		19.29		19.22

Table 8 (con't.)

Increasers:							
Andropogon pubescens	0.97	**1.29**	**1.74**	37	10.05	**1.529**	**14.62**
Scilla maritima	0.87	**2.26**	**3.06**	23	6.25	**0.911**	**8.72**
Pistacea lentiscus	0.81	**17.81**	**24.08**	29	7.88	**0.426**	**4.07**
Asphedelus microcarpus	0.72	**1.20**	**1.73**	19	5.16	**0.426**	**3.07**
Phlomis fruticosa	0.46	**5.58**	**7.55**	17	4.62	**0.485**	**4.64**
			38.16		33.96		35.12
Avoided-Increasers:							
Euphorbia paralias	0.00	**6.45**	**8.72**	9	2.45	**0.220**	**2.10**
Thybra capitata	0.00	**12.77**	**17.26**	26	7.07	**0.676**	**6.46**
Helichryium italicum	0.00	**1.84**	**2.48**	10	2.72	**0.161**	**1.54**
Poterium spinosum	0.00	**14.22**	**19.22**	38	10.33	**0.882**	**8.43**
Dactylis glomerata	0.00	**0.10**	**0.13**	21	5.71	**0.470**	**4.50**
Platago lapopus	0.00	**0.50**	**0.67**	14	3.80	**0.617**	**5.90**
Trifolium sp.	0.00	**0.35**	**0.42**	19	5.16	**0.573**	**5.48**
Anthoxanthum Odoradum	0.00	**1.01**	**1.37**	35	9.51	**1.176**	**11.25**
		73.96	50.27		46.75		45.66
Total		100.00			100.00		100.00

Vegetation cover area 54.38%.

*From Table 2.

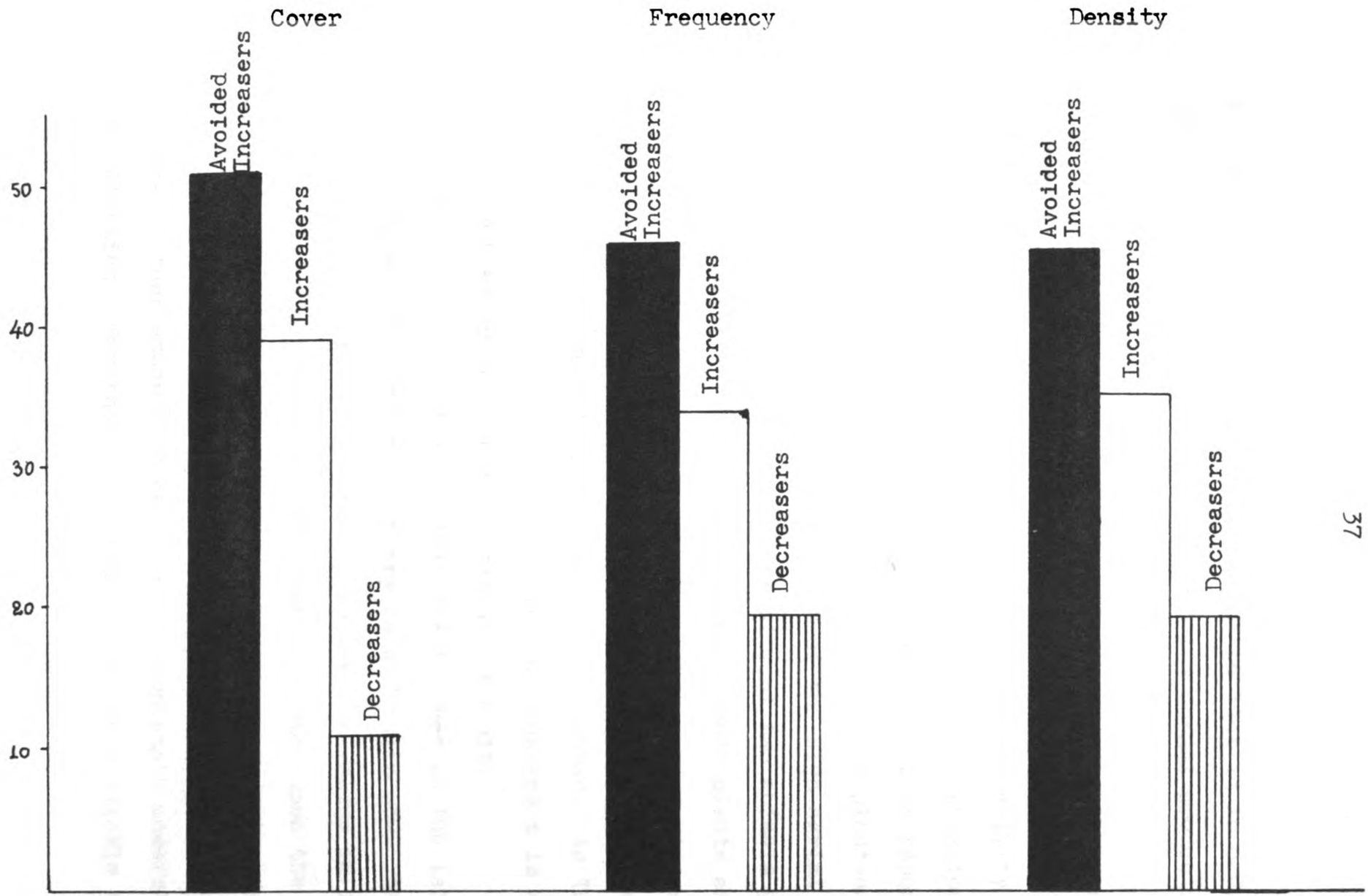


Figure 6. Cover, frequency and density of avoided increasers, increasers and decreasers found in 68 plots on Theodorou Island, July 1971.

by the high population of agrimia must be limited in order to enable restoration of the range to its normal productive ability.

The low availability of desirable species on the range because of their continuous overuse indicates that their gradual replacement by plant species of low palatability is occurring. (This will be further confirmed by observations on the tiny ungrazed islet Theodompoula, which will be reported in a later publication.) It is obvious that the plant-animal interaction on the island is a result of the high agrimi population density. The current density of two animals per hectare obviously is highly detrimental to both plants and animals. A balanced use of the range resources, in terms of proper numbers of grazing animals using the range is urgently needed if the range-animal complex is to be saved. As Taylor (1930) points out, the problem of grazing management is one of proper handling of the total biotic community.

The restoration of a suitable plant cover on the island at this late stage of depletion may be difficult now. The actual length of time required to restore the island in its various stages of depletion will depend in part upon the degree of depletion of the most important plants and upon soil moisture-penetration conditions. All of these factors require further study in order to more completely understand the situation. But enough information is now available to

show the serious situation which now faces the program of species preservation for the agrimi and its vegetative habitat.

CONCLUSIONS AND RECOMMENDATIONS FOR MANAGEMENT

Theodorou Island is severely overgrazed as a result of an agrimi density of two animals per hectare. If the agrimi is to be preserved as a wild species in a secure habitat a reduced herd size is essential. Unless that policy is adopted, severe range deterioration will continue on Theodorou Island and all hope for the last pure strain of agrimi will be lost in its most favorable habitat.

One of the biggest obstacles to establish proper management practices on Theodorou Island is the lack of information on the island's carrying capacity and on the agrimi's survival and productivity characteristics. This information is essential in order to determine the herd size which can be supported in harmony with the range on a sustained basis. The carrying capacity of the island must be estimated and a reduction in agrimi numbers must be made in order to reduce the grazing pressure on the habitat. Because of the badly depleted condition of the range the agrimi population should be lowered somewhat beneath the actual carrying capacity of the vegetation in order to allow for recovery of the range.

A program of trapping and transporting surplus animals to new favorable reserves should be undertaken especially on uninhabited islands if prior ecological studies indicate that

range conditions on such islands are suitable. Removals from Theodorou should be undertaken at least annually until the determined carrying capacity of the island has been reached.

The White Mountains National Park, the original native range of the agrimi, would be a preferred site for restoration of this valuable species except for the danger of hybridization with domestic goats. This could destroy the agrimi as a wild species there. Only if the park could be completely and adequately fenced, should this area be considered as a possible refuge for the species. Though desirable from other standpoints as a natural area, almost certain hybridization there, however, makes the White Mountain National Park deserving of consideration only as a secondary site.

Measures which should be undertaken for habitat improvement on Theodorou Island are:

1) The investigation of aritficial control of undesirable plants by chemical and non-chemical means since the established and vigorous woody plants there, such as Thybra capitata, Euphorbia paralia, and Poterium spinosum, cannot be eliminated by release from grazing alone within a practical time period.

2) The testing of a program of seeding desirable plant species such as Olea oleaster, Calyotome villosa, Cistus incanus, Teurium pollium, and Cupressus sempervirens on

favorable sites in order to increase the island's potential for forage production.

3) The control of rats and hares and possibly other seed eaters should be appraised.

4) The provision of an automatic supply mechanism at the cistern to insure that water is available at all times.

5) Annual censuses and range surveys as a basis for a continuing management.

6) The establishment of several exclosures of suitable size so as to enable continuing assessments of the effects of agrimi, and possibly rat and hare, numbers on the vegetation.

7) A continuing research program to study the effects of management recommendations and to enable their modification if necessary.

SUMMARY

In an effort to ascertain the ecological factors basic to the preservation of the agrimi or Cretan wild goat (Capra aegagrus cretensis Schinz), an investigation was undertaken to determine its population densities, food preferences, habitat relations, and prospects for species survival.

The study was conducted in the summer of 1971 mainly on Theodorou Island, a costal islet of 68 hectares just off Crete, Greece. It is likely that this site is the only one where a wild agrimi population still exists as a pure stock. Yet an overpopulated condition there is causing severe overgrazing and habitat deterioration.

The agrimi population on the island was found to total 137 animals, exactly two per hectare. The herd consisted of 58 percent adults, 20 percent yearlings and 22 percent kids. The adults were nearly equally divided by sex.

From analyses of browsed vegetation on the islet, the preferred food species of the agrimi for the March to mid-July season were calculated to be Teurium pollium, Cistus incanus, Cupressus sempervirens, Rheichardia picroides, Olea oleaster, Calycotome villosa, and Siderides sp.

To determine summer food preferences, one agrimi held in captivity from mid-July to mid-August was offered samples

of island vegetation. Olea oleaster, Rheichardia picroides, Asphodelus microcarpus, Cistus incanus, and Scilla maritima were calculated to be the plant species which were consumed to a greater extent than would be indicated by their abundance.

The species Euphorbia paralias, Thybra capitata, Helichrysum italicum, and Anthoxanthum odoratum were widely distributed over the island but were not utilized during either study period.

Although not a preferred food species, the most important forage plant for the agrimi on this range from the standpoint of bulk was Pistacea lentiscus. The twigs and foliage of this shrub comprised 43.66 and 30.0 percent, respectively, of the animal's diet during the spring and summer, respectively. Two other shrubs, Calycotome villosa and Teurium pollium contributed 13.38 and 10.31 percent, respectively, to the spring diet of the agrimi.

The agrimi's food from spring to mid-July was composed of 79.0 percent shrubs, 17.8 percent forbs and 3.2 percent grasses. The availability of these plant groups indicated no marked preference for plants of a particular growth form and was calculated to be 68.1, 28.5 and 3.4 percent, respectively. In late summer, however, the agrimi's diet changed to 39.9 percent shrubs and 60.1 percent forbs, in contrast to their 58.4 and 37.9 percent availability. Grasses were not consumed in spite of their 3.7 percent availability.

The agrimi thus changed from being mainly a browser during the spring to performing as a grazer of forbs during the summer.

The daily food consumption of a yearling held captive in summer was determined to be 347 grams forage dry weight or approximately 2.5 percent of the animal's weight.

The present agrimi population was found to be causing serious range deterioration. The four most highly preferred forage species were 68 to 98 percent utilized during the March-July season and were being replaced by plants of less food value, or by those which were totally avoided by the agrimi. Preferred food plants have been reduced to only 11.6 percent of the island's total production of edible forage and 4.8 percent of the total vegetative cover of the island.

The prospects for survival of the agrimi on Theodorou Island are good in view of the present attitude of the Greek Forest Service to accept these findings and to adopt measures for limiting agrimi population densities.

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APPENDIX

Definitions

Since a number of different terms are widely employed to express similar concepts, those used in this report are defined briefly:

Availability: the amount of plant parts available for use expressed here in dry-weight grams.

Utilization: the degree to which animals have removed forage from that available.

Overgrazing: excessive cropping of range plants by animals with consequent damage to the soil and with effects on both flora and fauna.

Carrying Capacity: that population or biomass of animals which can be supported by a given habitat without damage to it and on a sustained basis.

Forage: all vegetation, harvested and unharvested, that is available and possibly acceptable to animals (except mast seeds and fruits of woody plants).

Browse: the leaf and current twig growth of shrubs, vines, and trees available for animal consumption.

Forb: any herb or flowering plant, other than grasses, which lacks persistent above-ground woody stems.

Shrub: any plant with persistent woody stems and relatively low (under about 5 meters) form which generally produces several basal shoots instead of a single bole or stem.

Range: land producing native forage available for herbivorous domestic or wild animals.

Cover: the degree to which plants, by overhanging, protect the ground surface from rainfall.

Density: population number per unit area.

Frequency: the regularity with which a species is distributed throughout a community.