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COMPARATIVE FOOD HABITS OF DEER AND THREE CLASSES OF LIVESTOCK

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Abstract: To observe forage competition between deer and livestock, the forage selections of a tame deer (*Odocoileus virginianus*), a goat, a sheep, and a cow were observed under four range conditions, using both stocked and unstocked experimental pastures, on the Kerr Wildlife Management Area in the Edwards Plateau region of Texas in 1959. The animals were trained in 2 months of preliminary testing. The technique employed consisted of recording the number of bites taken of each plant species by each animal during a 45-minute grazing period in each pasture each week for 1 year. Results indicated moderate to heavy competition for browse and mast between the deer and goat in all pastures during all seasons, and between the deer and all three classes of livestock in the winter. Browse and mast comprised over 50 percent of the deer's diet, except in the spring and summer, and over 50 percent of the goat's diet in all seasons. Following a decrease in available browse, sheep become competitive with deer for forbs. Forbs formed an average of 68 percent of the deer's diet and 65 percent of the sheep's diet in the ungrazed control pasture in the summer; the animals generally were grazing the same species. The added factors of bearing and nursing fawns, and growing antlers, contribute to the nutritional stresses on deer in the summer, the period when extensive die-offs of deer most frequently occur in the Edwards Plateau region. Competition for grass between deer and livestock probably is important only when grass is in a succulent stage in the spring and no other forage is available in quantity. Continuous grazing by animals tends to remove the most palatable species and concentrates competition on fewer, less palatable ones. Observations from the numerous replications of feeding times and places allow the conclusion that this technique provides a reliable index to preferred foods and staple foods.

In the Edwards Plateau region of Texas, most of the rangelands are grazed by two or more classes of livestock along with deer. Research on the Kerr Wildlife Management Area, near Hunt, Texas, indicates that deer when managed and harvested properly can provide economic returns comparable to those from domestic livestock. But a study of the economic feasibility of management for livestock and deer in combination revealed the need for more exact knowledge of their competition for forage. To provide such information, a study of the food habits of cattle, sheep, goats, and deer was initiated in May, 1959, and concluded in May, 1960.

The Kerr Wildlife Management Area is a research facility of the Texas Parks and Wildlife Department located in Kerr County in the eastern portion of the Edwards Plateau. This region, encompassing some 26,000 square miles of central Texas, probably is unique in its combined produc-

tivity of deer and livestock in high densities (Hahn 1945, Taylor and Hahn 1947). Previous studies of its vegetation in relation to deer and livestock were reported by Buechner (1944), Taylor and Beuchner (1943), and Whisenhunt (1949). On the Kerr Area, particularly the pastures involved in this study, the prominent vegetal expression is a savannah of live oak, in which Ashe juniper (*Juniperus ashei*) and shin oak are conspicuous.

Part of the Kerr Wildlife Management Area contains 10, 96-acre deer-proof pastures which are used for a long-term study of the influence of combined sheep, goat, and cattle grazing rates on deer production. Each species of animal obviously has a different influence on the welfare of the others and on the forage resource in general, but the experimental design had revealed only the gross influence of combinations of animals.

Performances of deer in experimental pas-

tures (Table 1) indicated clearly that livestock grazing had a pronounced effect on deer production. Only with little or no competition from livestock did deer survive and reproduce satisfactorily. More exact knowledge of the kinds and quantities of forage necessary for successful deer production was needed.

Previous measurements of use on vegetation (May 1959, Vallentine 1959) did not distinguish the effects of each kind of animal. To obtain this information, we used tame animals whose grazing activities could be observed at close range with accuracy by what was called the *animal bites* method. To our knowledge this method has been used previously only by Wallmo (1951).

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PRELIMINARY TESTS

Prior to initiating the study, the animals to be used were trained for 2 months during March and April, 1959. A mature male deer that had been raised as a pet was obtained and used because of his availability and familiarity with the vegetative complex on the area. Two nanny goats, two ewes, and two cows were borrowed from the grazing lessee on the area. Adult female livestock were used because they represented the kind of animals most common on range-lands.

Table 1. Average performances of deer maintained in experimental pastures with and without livestock from 1957 through 1962.

PASTURES AND STOCKING RATES*	YEARLY STARTING POPULATION†	LOSSES OF ADULTS (PERCENT)	HERD INCREMENT (PERCENT)
1 and 4			
Heavy use by livestock	6	40	-43
2 and 5			
Moderate use by livestock	9	14	9
3 and 6			
Light use by livestock	8	14	6
7			
Deer only, 8.0 acres per deer	12	3	42
8			
Deer only, 6.4 acres per deer	15	5	32

* Each pasture contains 96 acres.

† Summation of all sex and age-classes of deer in paired pastures.

This provided two groups of domestic livestock, A and B, with one animal of each species in each group. In the testing schedule, each animal in Group A was grazed during two different times on 1 day, and the following day Group B was grazed in the same manner, during the same times and under the same conditions as Group A on the previous day.

In addition to training the animals, the preliminary tests were intended to determine: (1) the individual differences in preference for plant species within species of livestock, (2) the influence of various degrees of supplementary feeding (moderate, light, or no feed) upon grazing behavior, (3) the influence of time of day on forage preferences, (4) the length of grazing period (1 hour, 45 minutes, or 30 minutes) most suitable for providing the desired body of data, and (5) the feasibility of using gentle animals in food habits research.

The preliminary tests were conducted on a 22-acre area of uniform topography, soil

type, and vegetative cover. The deer was conditioned to respond to call, to following, and to being led. The animals were transported to and from the grazing area in either an open or closed (with sideboards) pickup truck, with a small livestock trailer. This mode of transportation did not disturb the deer to any observable extent.

A separate series of tests was also run in which the animals were allowed to run free in a 90-acre trap while not being used in grazing observations. When a test was desired, each animal was called to the truck, transported to the feeding area, and observed during either the early morning or late evening. Even though these periods are times of concentrated grazing by range livestock and deer, the experimental animals frequently would not graze at all or would not eat enough to provide an adequate sample of normal activities.

Retaining the animals in pens and controlling food intake between grazing trials provided better results. In the case of the deer, supplementary feed was varied until the animal grazed and behaved most nearly in the manner observed in wild deer. There was relatively little difference noted in the deer's grazing behavior from either light or no supplementary feeding, and a twice-daily, light supplementary feed was adopted, consisting of $1\frac{1}{4}$ pounds of whole-grain corn and 1 pound of alfalfa hay. With no supplementary feeding, the livestock grazed in an intent, greedy manner with less selection than was evidenced following light feeding. The light, twice-daily supplementary feeding rate adopted for each sheep and goat was $2\frac{1}{2}$ pounds of 20 percent protein range cubes and 1 pound of prairie or cane hay. The cow was fed 5 pounds of 20 percent protein range cubes and 5 pounds of prairie or cane hay twice daily. Kinds and amounts of supplementary feed were varied during the actual study with livestock, however, to

correspond with the feeding normally given range stock in different seasons.

Several major conclusions pertinent to the conduct of the study were drawn from the preliminary tests:

(1) Retaining the animals in pens and providing controlled supplementary feed was preferable to allowing them to graze freely in a pasture between observation periods.

(2) Comparison of Groups A and B indicated that the two individuals of each species among the sheep and goats made forage choices that were significantly different in statistical terms. This was not true of the two cows. The differences found were attributable to the greater docility of the animals in Group A which ate more, and more often, than did those in Group B. In view of this, Group A animals were finally chosen for the study. Since there was no opportunity to compare the forage selections between two tame deer, observations were made on wild deer feeding in the same area as the tame animal. These comparative observations gave the impression that the gentle deer's grazing habits were not different from those of wild deer. Both the tame deer and the wild animals appeared to eat the same browse and weed species.

(3) Early morning, 7:00 to 8:00 AM, and late evening, 5:00 to 7:00 PM, seemed the most desirable grazing periods; during these times all animals behaved and grazed well and their selections included more species of plants.

(4) A 45-minute grazing period yielded about the same number of species grazed as did a 1-hour period, and considerably more than a 30-minute period.

Since there seemed to be no great deviations between feeding behavior of tame and normal animals, the study was deemed feasible.

METHODS

The animals used and their ages at the beginning of the study were a white-tailed buck deer, 3.5 years; Hereford cow, 9 years; Rambouillet ewe, 3 years; and Angora nanny, 5 years.

These animals were grazed in four pastures which represented the range of conditions existing in the 10 experimental pastures. The prevailing year-long stocking rates are shown in Table 2. All of the four test animals were grazed in one of these pastures 1 day, and the following day were taken to another pasture; thus, all of the pastures were covered in a 4-day period each week in the year. The daily grazing period was 45 minutes per animal. Standing near the animal, an observer noted the number of bites taken of each species and reported it to a recorder. Data for each animal were summarized in terms of percentage of total bites of species and forage classes by pastures and seasons. In a factorial analysis of variance applied to these data, the pertinent variables were animals, pastures, and seasons. We looked for *between* and *within* differences in all combinations with regard to species of plants and classes of forage taken.

The classes of forage considered were: browse (all woody plants, principally trees and shrubs, all mast, and lichens epiphytic on trees and shrubs); forbs (broad-leaved herbaceous plants, including prickly pear (*Opuntia* spp.)); and grass (plants of the grass and sedge families).

Seasons as defined were spring (March, April, and May); summer (June, July, and August); fall (September, October, and November); winter (December, January, February).

Accompanying Studies of the Vegetation

The abundance of forage available for

Table 2. The prevailing year-long stocking rates in the three experimental pastures stocked.

PAS- TURE*	RATE	ACRES PER ANI- MAL UNIT†	SHEEP	GOATS	COWS	DEER
1	Heavy	8	23	22	3	1
2	Moderate	16	10	10	2	5
3	Light	24	8	7	1	3

* Each pasture contains 96 acres.

† The components of an animal unit are considered to be five sheep, five goats, or one cow; deer not considered.

grazing was estimated by the use of 10, 50-foot line transects in each pasture, using the line-intercept method described by Canfield (1941). Readings recorded in $\frac{1}{400}$ foot and expressed as a percentage of the combined 10 lines provided an index to the difference in forage species availability within and between grazing treatments.

Following the last grazing observation each morning, 30–45 minutes were devoted to a visual survey of the phenological condition of vegetation in the pasture; thus an account of the vegetal conditions in each pasture was made on each week.

An herbarium with an essentially complete collection of the local flora previously had been established on the area. Any newly occurring plants were collected as they were found.

FINDINGS

Considering the sum of data for the year, the differences in diets of each species of animal were slight between the stocked pastures (pastures 1, 2, and 3) as compared with the differences between the ungrazed pasture (pasture 9) and the stocked pastures. An example of the analytical procedure used to elicit diet differences is presented in Table 3. Generally the species prominent in the diets in pasture 9 were taken only in trace amounts, commensurate with their availability, in stocked pastures. This was most pronounced during the spring

Table 3. Class forage percent composition of the total diet.

ANIMALS	SEASONS											
	Spring			Summer			Fall			Winter		
	B*	F†	G‡	B*	F†	G‡	B*	F†	G‡	B*	F†	G‡
Pasture 1 (Heavy use)												
Deer	41	44	15	91	4	5	85	2	13	89	5	6
Cow	0	2	98	0	0	100	21	0	79	10	0	90
Sheep	8	27	66	13	4	83	18	1	81	15	1	84
Goat	50	7	43	82	2	16	59	1	40	70	0	30
Pasture 2 (Moderate use)												
Deer	48	42	11	88	6	6	87	8	6	100	0	0
Cow	1	9	91	0	11	89	17	1	82	8	4	88
Sheep	16	47	37	31	8	61	28	3	68	17	1	82
Goat	62	12	26	88	2	10	76	5	18	87	0	13
Pasture 3 (Light use)												
Deer	53	35	12	84	7	9	79	10	11	93	2	5
Cow	4	3	93	1	15	84	23	2	75	27	11	62
Sheep	24	38	38	33	7	60	20	3	77	30	2	68
Goat	58	14	28	82	3	16	71	7	22	91	0	9
Pasture 9 (No other use)												
Deer	37	56	7	32	68	1	57	37	6	89	8	3
Cow	30	22	49	5	10	85	17	10	73	73	15	12
Sheep	27	61	12	14	65	22	28	31	41	51	9	40
Goat	59	36	5	55	38	7	50	41	10	95	2	3

* B—Browse.

† F—Forbs.

‡ G—Grass.

and summer months and with such palatable species as big bluestem, little bluestem, fall witchgrass, knotweed leafflower, arrowleaf sida, shin oak, hackberry, and numerous forb species.

In the lumped data for the year, the relative consumption of browse and forbs by the deer was not significantly different between stocked pastures, but there was a significant difference (at the 0.05 confidence level) between pasture 9, where more forbs were taken, and each stocked pasture, where more browse was taken. The percentage of grass in the deer's diet was not significantly different between any pastures in the year's sum of data. Combining all seasons, significant differences were noted in the relative amounts of browse and grasses consumed by livestock in all pas-

tures. The sheep exhibited significant differences in forb consumption between all pastures; however, the other two species of livestock only exhibited differences between each stocked pasture and pasture 9 with regard to forb consumption. In general, data within seasons revealed that the outstanding differences in animal diet were between pasture 9 and the stocked pastures.

It is apparent from these findings that all stocking rates in the grazed pastures materially reduced the availability of preferred and some staple foods and modified the diets of the experimental animals. Regardless of stocking rate, only trace amounts of the most preferred foods (Table 5) remained. Under these conditions, as discussed below, the result was more direct competition between all species of animals.

Competition for Browse and Mast

The results indicated moderate to heavy competition for browse and mast between the deer and the goat in all pastures during all seasons. Browse and mast comprised over 50 percent of the deer's diet in all seasons and pastures except during the spring in pastures 1 (average 41 percent), when succulent grasses were consumed in quantity, and in the summer in pasture 9 (average 32 percent), when forbs were the major food class taken. Over 50 percent of the goat's diet consisted of browse and mast in all pastures and all seasons. In general, as indicated by choices made in pasture 9, the browse preferences of the deer and the goat were similar, with acorns, shin oak, hackberry, greenbrier, woollybucket bumelia, and live oak being relished.

The heaviest use of browse by the sheep was during the winter in pasture 9, when it constituted an average 51 percent of the diet. At that time the major items of browse in the sheep's diet were live oak shoots and leaves. The cow also used browse, principally live oak shoots, heavily in winter in pasture 9, when over 60 percent of her diet consisted of oak browse and mast. In pastures 1, 2, and 3, the high browse lines and the absence of oak shoots precluded any earnest browsing activities by the cow. Acorns were heavily utilized by the cow and the sheep in fall and winter in all pastures.

In terms of the use of browse, the deer and goat diets were similar, and the cow and sheep diets were similar. It is clear, however, that under these conditions competition for browse is severe in winter between deer and all of the classes of livestock tested.

Competition for Forbs

The sheep and deer were the heaviest users of forbs. Similarity in their diets was

Table 4. Example of analytical procedure used in determining differences in forage utilization between animals in pasture 1 in the summer season.*

KEY FORAGE SPECIES	ANIMALS		
	Cow	Sheep	Goat
Live oak	< x [†]	< x	
Shin oak			
Woollybucket bumelia			
Greenbrier			
Hackberry			
Ashe juniper			x>
Lichen species	< x	< x	< x
Texas winter grass	x>	x>	
Curly mesquite	x>	x>	
Knotweed leafflower			
Horseweed fleabane			
Fall witchgrass			
Arrowleaf sida			
Oxalis			

* Factorial analysis of variance based on the least significant difference test.

† Letter "X" denotes significant difference in mean bites at 0.05 confidence level between deer and indicated class of livestock.

most apparent in pasture 9 during the summer season. Forbs formed an average of 68 percent of the deer's diet and 65 percent of the sheep's diet in this pasture in summer. In pastures 1, 2, and 3, where palatable forbs were sparingly found, they constituted only 4, 6, and 7 percent, respectively, of the deer's diet and 4, 8, and 7 percent of the sheep's diet. In general, the sheep and deer grazed the same species. Preferred plants were knotweed leafflower, whorled nodviolet, careless weed, arrowleaf sida, mat euphorbia, wild lettuce, fleabane, rainlily, and redseed plantain.

Utilization of forbs by the goat was appreciable only in summer in pasture 9 where they constituted an average 38 percent of the diet. The goat showed a preference for whorled nodviolet, careless weed, knotweed leafflower, and oxalis. Utilization of forbs by the cow was most apparent during the spring season in pasture 9 where they constituted an average 22 percent of the total diet. Vigorous clumps of velvet bundle-

Table 5. Preferred forage species within seasons.

FORAGE SPECIES	SEASONS			
	Spring	Summer	Fall	Winter
Live oak (<i>Quercus virginiana</i>)	G		G	DCSG*
Live oak mast			D	DCSG
Texas oak (<i>Quercus texana</i>)	DC		G	
Texas oak mast			DCSG	DCSG
Shin oak (<i>Quercus breviloba</i>)	C			
Shin oak mast			DSG	
Greenbrier (<i>Smilax bona-nox</i>)	DSG	DSG		
Woollybucklet bumelia (<i>Bumelia lanuginosa</i>)	DCSG	DSG	SG	
Hackberry (<i>Celtis texana</i>)	DSG	DSG	DSG	
Texas winter grass (<i>Stipa leucotricha</i>)				C
Curly mesquite (<i>Hilaria belangeri</i>)				C
Little bluestem (<i>Andropogon scoparius</i>)		C		
Big bluestem (<i>Andropogon gerardi</i>)		C		
Fall witchgrass (<i>Leptoloma cognatum</i>)			CS	
Rescue grass (<i>Bromus catharticus</i>)	DCSG			
Ozarkgrass (<i>Limnodea arkansana</i>)	D			
Arrowleaf sida (<i>Sida filicaulis</i>)		DSG	DSG	
Knotweed leafflower (<i>Phyllanthus polygonoides</i>)		DSG		
Careless weed (<i>Amaranthus graecizans</i>)		DSG		
Rainlily (<i>Cooperia drummondii</i>)		DSG		
Redseed plantain (<i>Plantago rhodosperma</i>)	DSG			
California filaree (<i>Erodium cicutarium</i>)	DS			
Mat euphorbia (<i>Euphorbia serpens</i>)	DSG	DSG	DSG	
Wild lettuce (<i>Lactuca serriola</i>)	DCG			
Whorled nodviolet (<i>Hybanthus verticillatus</i>)	DSG	DSG	DSG	
Dayflower (<i>Commelina</i> spp.)	DCSG	DCSG		
Horseweed fleabane (<i>Erigeron canadensis</i>)	DSG			
Velvet bundleflower (<i>Desmanthus velutinus</i>)	DCSG			
Sideoats grama (<i>Bouteloua curtipendula</i>)			CS	
Plains lovegrass (<i>Eragrostis intermedia</i>)			DS	
Pinhole bluestem (<i>Andropogon perforatus</i>)		C		
Southwest carrot (<i>Daucus pusillus</i>)	DSG			
Oxalis (<i>Oxalis dillenii</i>)	SG	DSG	DSG	
Texas vetch (<i>Vicia texana</i>)	CSG			

* Animal legend:

D—Deer

S—Sheep

C—Cow

G—Goat

flower, redseed plantain, and Texas vetch were commonly grazed by the cow.

Forbs apparently are important to deer and sheep when available, and direct competition between them probably exists under those conditions. Cattle and goats would seem to contribute relatively little to competition with deer for this class of forage.

Competition for Grasses

Grass normally was preferred more by the cow and sheep than by the other two

animals in all pastures and during all seasons. Although consumption of grass by the cow in summer and fall was fairly uniform in all pastures, the species in the diet were markedly different in the ungrazed pasture as distinguished from the three stocked pastures. Curly mesquite and Texas winter grass formed the major items in the grass diet of the cow in all stocked pastures during the spring, summer, and fall growing seasons. In pasture 9, she consumed large amounts of Texas winter grass only in the spring months (average 21

percent of the diet). Otherwise, her preference was for big bluestem, little bluestem, and fall witchgrass, which, as in the case of preferred forbs, were almost nonexistent in the stocked pastures. The same general feeding pattern was also true for the sheep, except the transposition in pasture 9 was to fall witchgrass almost exclusively. The sheep's use of grass decreased in pasture 9 during the summer season as the abundance and variety of forbs increased.

Grasses were taken by the deer in very small amounts in summer, fall, and winter, but in appreciable quantities in spring. Then, abundant use was made primarily of the succulent growth of rescue grass, and secondarily of Texas winter grass and ozark-grass. In the spring this forage class comprised 16, 11, and 12 percent of the deer's diet in pastures 1, 2, and 3, respectively, and 6 percent in pasture 9. Presumably, grasses were taken more heavily in stocked pastures because of the lack of sufficient browse and forbs.

The greatest use of grass by the goat was also during the spring and, as with the deer, where little else was available. In stocked pastures, Texas winter grass and rescue grass were the principal grasses used by the goat; in pasture 9 fall witchgrass was her choice.

Competition for grass between deer and livestock probably is important only when grass is in a succulent stage and no other forage is available in quantity. Competition between sheep and cattle for this class of forage apparently is consequential.

The Critical Season

Special consideration was given to the problems of forage conditions and competition in the summer season because this is the period when extensive die-offs of deer most frequently occur in the Edwards Pla-

teau region. While in long-term records, monthly precipitation means are highest in summer, the occasional failure of summer rains, accompanied by hot weather and high evaporation losses (Bloodgood et al. 1954), severely inhibits growth of vegetation. Where livestock grazing has already depleted the range forage under these conditions, game managers in the Edwards Plateau have learned to anticipate the loss of deer to starvation. The added factors of bearing and nursing fawns, and growing antlers, contribute to the nutritional stresses on deer in this period.

The relative performance of wild deer maintained in the experimental pastures on the Kerr Area (Table 1) clearly indicates that excessive forage competition with livestock is ultimately detrimental to the welfare of deer. Under the heavy grazing rate in replicate pastures 1 and 4, the lowest reproductive rate occurred (6-year mean herd increment, minus 43 percent). Deer in pastures 7 and 8 (no livestock) have consistently maintained healthy productive deer herds (Table 1). Close attention was given these deer throughout the study, and no explanation other than nutritional limitations was found for these increment rates.

Conditions in the various pastures in relation to the observed forage preferences of deer in pasture 9 seem to provide clues to the problem. In pasture 1, the mean height of the browse line on the staple browse, live oak, was 57.5 inches. The only browse species that was available in abundance was Ashe juniper, which, as indicated by preferences in pasture 9, is low in palatability to all of the animals tested. Although late spring forbs were present in pasture 1 in limited amounts in June, there was very little herbaceous forage thereafter. A heavy grass cover was evident, but it was composed almost entirely of low palatability grasses.

Conditions in pasture 2 were essentially like those in pasture 1, except that slightly more oak browse and forbs were available. In pasture 3 the gross quantity of available vegetation was notably greater than in pastures 1 and 2, but the most preferred species were still scarce.

The great contrast was in pasture 9 where there was no browse line, and the variety and quantity of browse and forbs were remarkably greater than in the stocked pastures. Although the poorer species made up a large percentage of the copious grass cover, the preferred species were present in abundance. Grass conditions in pasture 9 were comparable to those in pastures 7 and 8 where deer grazing alone performed so well. The deer-only pastures did not have the luxuriant growth of browse and forbs found in the control pasture, but they did support most staple species in fair abundance.

The data from this study point to the paucity of preferred forbs in the stocked pastures as a limiting factor in deer performance during the critical season. It will be noted in Table 4 that as range conditions improved from pasture 1 to pasture 9, the mean percentage of grass in all diets decreased, and the mean percentage of browse decreased for the goat and deer, while it increased for the sheep and cow, but the mean percentage of forbs increased for all classes of animals. These data impute a greater importance to forbs, at least in the Edwards Plateau region, than ordinarily accredited them by range managers.

DISCUSSION

Competition

Considering all seasons, rainfall fluctuation, and plant grazing tolerance, goats seem to be the most competitive with deer for food, principally browse. Following a

decrease in available browse, sheep become the first competitor with deer for weeds when they are available. Judging from the preference by deer and sheep for forb species during the summer, it is felt that competition from sheep is more influential on deer than is competition from cattle or goats at that time. This is further substantiated in the findings by Merrill et al. (1957) on the Texas Agricultural Experiment Station, Sub-Station No. 14, Sonora, Texas. They reported that deer numbers varied with kinds and intensities of live-stock grazing in study pastures that were not fenced against deer. Under heavy year-long stocking with sheep, goats, or both, there was low occupancy by deer. Progressive moderation of the stocking rate, even with sheep and goats present, resulted in increased occupancy of the pastures by deer. During this period, the drought years of the mid-1950's, all heavy grazing, where sheep or goats were involved, effectively deterred deer use. After the drought broke, Merrill et al. (1957) reported that heavy sheep grazing was accompanied by lowest deer numbers, while heavy goat grazing was accompanied by large numbers of deer. The inference was that the concentration of sheep grazing on available forbs will influence deer more than will the foraging by goats or cattle. But when there are no weeds, deer are forced into more direct competition with goats. Competition for grass apparently is of minor importance except in the relationships between sheep and cattle.

The paucity of staple and preferred deer forage in the stocked pastures, as suggested by their preferences in the unstocked pasture, is considered to be the factor limiting reproduction and survival of the wild deer maintained in those pastures. It is essential, however, to mention the possible effect on deer of artificial confinement with livestock

in small areas. Restricted movement and the inevitable close association with livestock might be stress factors. Also, small pastures may result in uniform overgrazing, while in pastures of operational size, several hundred or more acres, there exist larger remnants of palatable deer forage. Under heavy grazing on an operational basis, deer herds ultimately suffer, but their performance is appreciably better than that of the deer in the experimental pastures. These problems are being investigated at the present time.

Appraisal of Technique

The methods employed did not provide an opportunity to learn how closely the diet of an individual animal resembles that of a population of like animals. However, the data that were acquired correlated well with the performance of normal animals in the series of experimental pastures.

It was assumed that the experimental animals were physiologically representative of the population. As they were apparently normal, healthy animals, this may have been a safe assumption except for some limitations. At the end of the first summer the deer became belligerent, so he was castrated and his antlers were sawed off to eliminate the possibility of harm to the observers. The cow, ewe, and nanny were bred at the appropriate times, but only the cow and ewe produced offspring. However, all of the animals remained in good health and maintained their weight throughout the study.

Technical Procedures

The presence of the observer during the grazing trials occasionally would influence the animals' behavior. All animals except the deer would shy off if approached too closely.

The behavior of the animals was not constant. Avidity of grazing differed from 1 day to the next, even though supplemental feeding was unchanged. Fluctuations in total bites taken were particularly evident with the sheep; no conclusive explanation was found, although variations in atmospheric pressure were thought to be a factor.

The animals commonly followed different grazing routes from the same starting point. Thus the four animals, when grazed on the same day in the same pasture, actually were sampling from somewhat different vegetation complexes. Direction and velocity of wind seemed to be the major influences on the grazing routes of the deer and sheep; they tended to graze into the wind during most observations. If only a slight breeze or no wind was evident, the deer would graze in an aimless circling manner. Although the goat grazed into the wind most of the time, her grazing route appeared to be influenced by her visual inspection of the area. Commonly she sought out clumps of woody vegetation, particularly live oak. The cow was not affected by wind direction, but grazed in an erratic manner which indicated searching for desired forage.

There was no evidence that the anticipation of supplementary feed after the grazing period had psychological effect on grazing activities. Nor was there any apparent difference in psychological response to different pastures. This was suspected once with the sheep when she declined to graze in pasture 1 (heavily stocked). As a check, she was taken immediately to the ungrazed pasture where she still showed no desire to eat.

Difficulty in identification of the forage taken was occasionally a problem only with grasses in pastures 1, 2, and 3. This was more common in summer when grasses

were sun-burnt, closely grazed, and lacking seed heads.

Observations from numerous replications of feeding times and places allow the conclusion that this technique provides a reliable index to preferred foods and staple foods.

The advantages of positive identification of species and gross estimates of quantities ingested under conditions and times controllable by the researcher offset the disadvantage of tedium in the technique. Monotony was not a limiting factor in accurately observing the foraging of the deer. It seemed to act much like wild deer, intermingling foraging with such activities as scratching, watching, and rubbing antlers. To keep an accurate tally of bites was not difficult.

Proper gentling, training, and supplementary feeding are essential to effective employment of this technique. The deer used was very amenable to such conditioning. In the numerous repetitions of feeding places in this study, animals developed familiarity with the environment and available forage. This experience suggests that such familiarity is essential to satisfactory sampling. Transportation of properly conditioned deer to and from feeding grounds seem to pose no difficulties. Travel distances on the study area varied from 1½ to 2 miles, but the deer used was hauled as far as 80 miles in the back of a pickup truck with no disquieting effects.

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