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A342-927-16,000-L180

TEXAS AGRICULTURAL EXPERIMENT STATION

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 367

NOVEMBER, 1927

DIVISION OF FARM AND RANCH ECONOMICS

ACTIVITIES OF LIVESTOCK ON THE RANGE



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****In cooperation with the School of Agriculture.

SYNOPSIS

This bulletin is a report of monthly observations of the activities of cattle, sheep, and goats on the range of the Ranch Experiment Station for the three years of 1924, 1925, and 1926.

The average animal day for cattle was 13.6 hours, for sheep 13.2 hours, and for goats 12.8 hours. Of their respective animal days cattle spent 56 per cent, sheep 50 per cent, and goats 46 per cent of the time at feeding.

In pastures averaging slightly less than one section in area the daily travel of cattle averaged 3.3 miles, of sheep 3.8 miles, and of goats 6.0 miles.

The turf-forming grasses, curly mesquite and buffalo, furnish 50 per cent of the grazing of goats, 53 per cent of the grazing of sheep, and 78 per cent of the grazing of cattle. Weeds furnish 21 per cent of the grazing of goats, 24 per cent of the grazing of sheep, and only 9 per cent of the grazing of cattle.

The live oak supplies more than one-half of the browsing for all three types of livestock, the percentages being 64 per cent for cattle, 69 per cent for sheep, and 55 per cent for goats. In importance as a browse plant the ill-scented sumac is second, it being a favorite browse plant of sheep and cattle, but for goats it is exceeded in importance by the shin oak, the latter also being a favorite browse plant of cattle.

In the class of miscellaneous feeding sacahuista was of dominating importance by reason of supplying of the total miscellaneous feeding, 96 per cent to cattle, 93 per cent to sheep, and 30 per cent to goats.

The use of supplemental feedstuffs was a practice each year, the nature and extent of the same depending largely upon existing circumstances. A larger use of supplemental feedstuffs, such as roughages and cottonseed cake, is recommended.

The important forage plants of the range are identified botanically and are described in a manner to permit the reader to recognize those with which he is familiar.

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ACTIVITIES OF LIVESTOCK ON THE RANGE

V. L. CORY

Nearly three-fourths of the land area of Texas at the present time is devoted to grazing,* and even though this area is being encroached upon by farming operations, it always will be a very large and important factor in the agriculture of the State. The crop produced by the range is the vegetation that grows upon it, whether or not any use is made of it. From an economic standpoint it is important not only that this crop be utilized but also that it be utilized in the most advantageous manner. Either under-use or over-use may result in deterioration of the range; hence an effort should be made to avoid both. Thus the carrying capacity of the range, when grazing is done to the proper extent, should not only be maintained but also be improved. The management of grazing operations should include practices that guard against the possible extermination of valuable forage plants or even their reduction in numbers, and, in addition, should favor their increase. Desirable plants must be permitted to reproduce themselves, for otherwise their places will be taken by less valuable or even harmful ones. Cattle, sheep, and goats show different preferences in their feeding on the native plants, and any one of these types of livestock alone may utilize only slightly certain portions of the range vegetation while utilizing excessively other portions of the same to the detriment of the whole. Thus it is that the system of grazing where this study was conducted provides for a certain proportion of cattle, sheep, and goats to be grazed in each pasture.

Based on carrying capacity units, each of which is equivalent to the feed used by a cow averaging 900 pounds in weight, the standard allows for 23 units of cattle, 19 units of sheep, and 10 units of goats for each section, which means that of the total feeding 44.23 per cent is done by cattle, 36.54 per cent by sheep, and 19.23 per cent by goats. Under ranching conditions it is possible to follow any grazing standard only approximately, as is evidenced by the data collected in this study. It is not intended to state that the above grazing standard is the best possible one, but merely to call attention to the fact that it is the one that has been adopted for use at the Ranch Experiment Station.

PREVIOUS WORK

At the time the present study was undertaken the writer was not familiar with any previous work of a similar nature. Some months after this study was initiated, a Norwegian publication† reported a

*Texas Agricultural Experiment Station Bulletin 297.

†"How the Animals Use the Time in the Pasture" (translated title), by Martin Ellingboe from *Tidskrift for Det Norske Landbrug*, 3 die Hefte, March, 1924.

study relative to the use of time made by animals in the pasture. The work reported therein was very general in nature and the animals observed were not exactly range animals. The purpose of that investigation was to learn definitely how the animals make use of the 24 hours when they are in the pasture continuously, and concerned only the grazing hours and the resting hours and the periods of the solar day when these occurred. The study was limited in scope and, while interesting in a general way, it has little specific value for our conditions and problems.

Since the conclusion of the present study the author's attention has been called to work reported by J. H. Shepperd in 1921 from North Dakota.† In that work, observations were made simultaneously in four pastures of different areas, 100 acres, 70 acres, 50 acres, and 30 acres, in each of which were 10 two-year-old steers (there were 42 steers in the four pastures). The observations were made by use of a field glass from a convenient shed roof and notes were recorded from time to time at 15-minute intervals. The work was conducted for only one day, August 20, 1921. The trail of the leader,—in one instance a shaggy Angus, in another a well-fleshed Hereford, and in the others Short-horns,—was mapped for each pasture, and the distance traveled was derived from these maps. It was shown that the larger the pasture the greater the distance traveled. In other work in this connection the gains in live weight per acre over a period of six years in these four pastures were found to be greater in the smaller pastures.

The Forest Service of the United States Department of Agriculture has done much work concerning systems of grazing and studies of range vegetation in connection with their administration of the grazing lands of the public domain and of the national forests. A recent publication (1926) of theirs that is of great interest is the bulletin "The Story of the Range" by Will C. Barnes.

OBJECT AND PROCEDURE

This study was undertaken in order to obtain definite information concerning the behavior of livestock on the range, their requirements, and their preferences for range forage under the conditions obtaining in general on the Edwards Plateau of Texas, a region somewhat exclusively devoted to ranching. Such information should be helpful in developing a system of grazing that approximates the very best utilization of the range vegetation.

Plan: At first it was planned to follow cattle, sheep, and goats on the range for a period of 24 hours each month on separate days for these three types of livestock. The method of doing this developed as experience was gained. The work of the first two months, November and December of 1923, led to methods more specific in nature; for example, it was decided to follow the one class, mature female animals (commonly

†Bulletin No. 154, North Dakota Agricultural Experiment Station.

referred to as mother animals), of the three types of range livestock, whereas the first work was done by following cows, rams, and bucks. Also at first several animals of the same class were observed simultaneously, but it soon developed that data could be collected more conveniently and more accurately by noting closely the activities of one particular animal. It took considerably longer to develop the fact that it was better to make use of two consecutive dates to complete one period of observation. As the work progressed it became possible to collect the data more easily and more definitely than was the case at first.

As it developed, the method of collecting the data consisted of selecting a suitable day for making the observations, making preparations for a long stay in the pasture by eating breakfast, filling lunch kit and canteen, and equipping oneself with a notebook and field glasses, proceeding to the pasture in which was the class of livestock upon which the observations were to be made, and finally the locating of the animals and the selecting of the particular individual whose activities were to be noted and recorded. Then this individual was followed closely until she had bedded down that night, the observations being completed the following morning by following her from the time of her getting up to the time the observations were begun the preceding morning.

In selecting the dates for making observations, it is desirable to have fair weather and moonlight nights; for the activities of range livestock are normal in fair weather, while the light of the moon is a big aid in making observations on a particular animal at night. In selecting the particular animal, a Hereford cow, a Rambouillet ewe, or an Angora doe, to be observed, much depends upon chance, although there are certain requirements that should be met. The chosen animal should be normal in her activities in order to be a fair representative of her class; she should not be of an excitable nature nor be afraid of a man on foot, for otherwise her activities would likely be abnormal and difficult to observe accurately; and she should be one that may be distinguished somewhat readily from other individuals of her class, for otherwise she would be lost in mixing and crowding with them.

The trail of the animal under observation is followed closely in order to note the distance she travels. This distance of travel is recorded as is the time of travel and her various other activities at the times these take place. With the aid of the field glass special attention is given to her choice of forage, the same being noted in considerable detail. The field glass makes it possible to determine more accurately at distances of fifteen to fifty feet the choice the animal is making in partaking of the forage plants of the range than ordinarily would be the case at closer distances with the unaided eye.

Period Covered: Observations were begun in November of 1923 and were completed through March of 1927. However, only the data obtained in the three years from January, 1924, to December, 1926, inclusive, are used in the tabulations herewith. While these data apply only to mature female animals, it is desired to call attention to the fact

that some work has been done at following rams and bucks, and that both the Hereford and the Brahma bull were followed each month of the four months of the breeding season of the year of 1926. The data were written up each month and a summary prepared at the end of each year. The tabulations that are given in this discussion will be the averages of the 36 observations made in the above three years.

Location: The work was conducted on the Ranch Experiment Station (Texas Substation No. 14), which is located in Sutton and Edwards Counties, Texas, in the heart of the Edwards Plateau, a region in which range livestock are confined to fenced pastures instead of being under herd, and in which the grazing is continuous throughout the year. Also it is customary to pasture cattle, sheep, and goats together in these



Figure 1.—Slope in one of the pastures of the Ranch Experiment Station. Soil erosion has left many rocks exposed. The clumps of Sacahuista and the growth of Shin Oak are features of such slopes. The flock of goats are resting during the heat of the day.

fenced areas. By road on the Rock Springs-Sonora highway, the headquarters of the Ranch Experiment Station is thirty-one miles from Sonora and thirty-four miles from Rock Springs, the county seats of the above counties.

Vegetation: The range consists of the mixed grassland type of vegetation, and is characterized by somewhat numerous small thickets of oak set in open grassland. The dominant plant is curly mesquite grass, while the other plants lending character to the range are the oaks (live oak and shin oak), sacahuista (*Nolina texana*), prickly pear, and the mesquite.

Open grassland areas are not extensive, but the grass cover extends throughout, except in bare areas, areas of deposition from surrounding areas of greater elevation, and areas of the denser thickets. In the

lower part of the draws buffalo grass covers limited areas, and in the thickets grow the shade-enduring grasses, but elsewhere in all but the poorer areas, such as dry hillsides, curly mesquite grass constitutes the grass cover. When curly mesquite grass is out of season, as in the late winter months, other grasses such as the winter annuals, fescue grass and trisetum, and a perennial species or two of needle grass become of great importance. Other herbaceous plants, chiefly annuals, at times are very numerous and form an important part of the range.

Pastures Used: Observations were made from time to time in each one of five different pastures of the Ranch Experiment Station, depending upon the circumstance of where the Hereford cows, the registered Rambouillet ewes, and the registered Angora does were being pastured. These pastures vary in size from six-tenths to one and four-tenths of a section in area and comprise four and three-fourths sections, the average being a little less than one section in area. The variation in the size of the pastures is not sufficient to influence markedly the activities of livestock, and this feature also is cared for by observing the animals in each of them.

All the pastures have draws originating in them, while three of them have draws that originate in other pastures running through them. The elevation is well towards the summit of the Edwards Plateau (about 2,400 feet) lying below the divide between the South Llano and the Devils River, the drainage being entirely to the latter stream. Only in times of rain do the draws have running water in them. Much of the area is of the divide type (upland lying between draws) rather than of slopes or valleys. As the draws lengthen they widen and with respect to the upland become deeper so that they are included between more or less steep slopes that form rocky hillsides and give three types of topography, valleys, slopes, and divides.

Table 1.—Average general activities of range livestock in minutes and in percentages of the total activity.

Activity	Minutes Daily			Percentages of Total Activity		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Traveling.....	84.5	106.8	148.4	10.34	13.45	19.31
Feeding.....	461.4	396.8	351.2	56.46	49.96	45.68
Licking salt.....	7.6	2.5	2.7	.93	.32	.35
Drinking water.....	2.4	1.0	.9	.29	.13	.12
Resting.....	102.2	122.5	121.5	12.51	15.42	15.81
Ruminating.....	76.3	78.4	83.5	9.34	9.87	10.86
Idling.....	82.8	86.2	60.5	10.13	10.85	7.87
Total.....	817.2	794.3	768.8	100.00	100.00	100.00

DEFINITIONS OF TERMS USED

The "animal day" is that portion of the solar day (24 hours) occurring between the getting up and the bedding down of the animal under

observation. The general activities of range livestock express the total use made of the time of their animal day. These activities are classified as follows: traveling, feeding, licking salt, drinking water, resting, ruminating, and idling. Each of these separate activities will be so defined as to be completely exclusive of all the others and strictly in accord with the data obtained in these observations.

Traveling is the term used to express movement from one point to another one, and with range livestock consists of walking or running. It is considered from the standpoints of the distance traversed and the time used for that purpose.

Feeding expresses the activity of the animal at gathering and taking into her body the feedstuffs she appropriates for her own use. The feeding activities are classified as follows: grazing, browsing, miscellaneous, and supplementary.

Licking salt is that activity of the animal which is indulged while partaking of salt. Usually the animal's tongue is not applied continuously to the salt, but she takes time to enjoy the taste, a legitimate part of this activity.

Drinking water is that activity of the animal by which she takes water into her body from a free water surface. There are no means of measuring water acquired through eating succulent vegetation or plants wet with dew. So far as possible only the actual time spent at drinking is recorded in this activity, but in practice this has varied from noting to the nearest minute at the beginning, and later, to the nearest quarter of a minute, there having been no attempt at minute exactitude in this respect.

Resting while lying down is that activity of range livestock by which the weight of the body is taken off their limbs and is supported on the ground. While thus engaged at resting, the animals may be ruminating, sleeping or in repose, but no consideration is taken of these circumstances. On account of their tendency to crowd together in shady thickets at the resting periods, it is difficult to keep resting animals under constant observation, and frequently this could not be done without disturbing the entire flock at one thicket and thereby materially influencing their activities, a condition that was avoided to the fullest extent possible.

Ruminating while standing up expresses the activity of range livestock at cud-chewing while on their feet. As much of the total rumination is done while lying down during the animal day and usually much more outside of this time while bedded down for the night, the data herewith represent only a minor phase of the ruminating an animal does.

Idling while standing up expresses the activity of range livestock while on their feet and not engaged in the other activities noted. Thus, in-

cluded herewith is the time spent at fighting, at rubbing or scratching themselves, at licking the coats of other animals, at chewing on sticks, bones or tins, at suckling their young, at calling their young to them, at observing other animals and more especially intruders, at a state of tranquillity, and at waiting for an expected happening, such as a forthcoming supplementary feeding or the opening of a gate.

Grazing refers to the feeding of range livestock on herbaceous plants in their natural state. Herbaceous plants are those not having a woody stem, and are further characterized by dying completely or down to the ground at the end of the growing season. Thus all the annual plants and many of those living more than one year are herbaceous, the common grasses and weedy plants being familiar examples. For the purposes of this study grazing has been classified into four groups, which will be named and discussed in order.

Browsing refers to the feeding upon the buds, flowers, fruits, twigs, and foliage of those woody plants commonly recognized as trees or shrubs while these parts remain a part of the plant. This purposely excludes the feeding on fallen foliage and fruit that is picked up from the ground as feedstuff by range livestock, the same being included in another class of feeding. The oaks, sumacs, and the mesquite tree are common examples of browse plants. Because of the greater size of shrubs and trees and the greater difference in their vegetative characters a classification into a larger number of classes of browsing plants than of grazing plants is both feasible and desirable. Of the 23 classes of browsing recognized herewith all but three consist of but a single species, and in these instances the component species are not readily separated or they are of only minor importance. The separate classes of browsing will be enumerated and discussed in order.

Miscellaneous feeding refers to that done on woody plants not so commonly recognized as such (for example; sacahuista, yucca, and cacti), on the fallen fruit or foliage of shrubs and trees, and on other than flowering plants. The ten classes of miscellaneous feeding recognized herewith will be enumerated and discussed in order.

Supplementary feeding is all the feed supplied to the animal apart from what is obtained from the range, such as roughages and concentrates or mineral mixtures, with the exception that licking salt is considered as a separate activity. The data herein apply to six classes of supplementary feeding, and these will be enumerated and discussed in order.

DISCUSSION OF THE GENERAL ACTIVITIES OF RANGE LIVESTOCK

The activities are classified herein as follows: traveling, feeding, licking salt, drinking water, resting while lying down, ruminating while standing, and idling while standing. The sum of the minutes of time devoted to each of these activities is equal to the animal day. The

animal day will be discussed as such later, as will be the distance traveled by the range livestock; both of these being features not capable of presentation in a tabulation in which is presented the number of minutes each day which range livestock devote to their various activities. Inasmuch as each of these activities will be discussed separately somewhat in detail, it is intended here to mention some general observations not essentially belonging to any of them.

Both goats and sheep tend to feed towards the side or corner of the pasture from which the wind is blowing, and both will bed down there at night. (Cattle apparently are not greatly influenced by the wind in either feeding or bedding down, except that they are likely to seek a place sheltered to some extent from the wind in which to bed down.

➤ Cows usually suckle their calves for periods of 10 to 15 minutes each, three times daily, morning, noon, and night, and this standard is somewhat maintained until the time of weaning. Ewes and does suckle their young frequently and at short periods each time, but longer just before bedding down. As the lambs and kids develop, the tendency is to decrease the number of such feedings and to increase the time, and this frequently progresses so far that the young are entirely weaned before the forced separation from their mothers takes place.

With goats it is customary to stake the kids for about the first six weeks of their lives, as they would likely be lost from their mothers in the confusion of the returning flock if left loose; but when the kid is staked the mother (seeking her kid) returns to that place. After six weeks the kids have gained in size and strength to the point where they are able to keep the pace set by their mothers on the range. While staked out the kids are provided with shelter, and their mothers, when not out feeding on the range, are free to be with them. When the kids are first turned out with their mothers on the range they are likely to stop near the pasture gate or near the water supply while their mothers make one or two rounds of the pasture. The does by this time are able to pick out their own kids, and when they return at three o'clock or later in the afternoon are joined by their kids for the remainder of the day. Some of the more husky kids may follow their mothers throughout the day from the first day they are turned out with them, while the others gradually accustom themselves to doing so.

Calves are quite able to take care of themselves from the very first, while lambs usually are not overtaxed to keep up with their mothers while feeding.

In Table 1 is given the average both in minutes daily and in percentages of the animal day devoted to the separate activities by cattle, sheep, and goats. No attempt at a discussion of this tabulation will be made at this point, for the reason that this will be done separately and in detail for each of the activities.

Table 2.—Average animal day in hours for range livestock.

Month	Cattle	Sheep	Goats
January.....	12.1	11.4	11.0
February.....	12.8	11.9	11.7
March.....	13.6	9.7	12.2
April.....	14.2	13.9	12.6
May.....	15.1	15.6	14.1
June.....	15.3	16.3	15.2
July.....	15.0	15.7	15.3
August.....	13.9	13.9	14.1
September.....	13.5	13.1	12.8
October.....	12.9	12.1	12.5
November.....	13.2	11.4	11.6
December.....	11.8	10.8	10.6
Average.....	13.6	13.2	12.8

The Animal Day

That portion of the solar day (24 hours) occurring between the getting up and the bedding down of the animal is here referred to as the "animal day." Hereafter in this study, the period referred to as a day will be the animal day. It has been assumed that the remainder of the solar day is devoted by the animal exclusively to rest, and therefore need not be considered in these data. This assumption is based on the more or less common knowledge that such is the case, and it receives support from the observation by Ellingboe that animals having gone to their rest will stay at rest during the night.

In each case efforts were made to get the animal day complete, but sometimes this was not accomplished. Experience demonstrated that this was more conveniently done by beginning the observations in the morning of one day as soon as possible after breakfast and keeping the animal under continuous observation until she bedded down at night and then returning to this place before she arose the next morning, after which she was kept under observation as before until the time corresponding to the beginning of the observations on the preceding morning. When this was accomplished the day was complete. This saves the observer from a continuous watch of nearly sixteen hours without rest. The data for the various activities are presented as three-year averages for all three types of livestock.

The length of day corresponds to the length of the daylight hours, being greatest in the month of June and least in the month of December; and by seasons, the day is longer in the spring than in the fall. For all types the average day for the animals throughout the year is approximately 13.25 hours, varying from 11 hours in December to 15.5 hours in June. The range animals are somewhat regular in their habits, and deviations from their customs are due to weather conditions or special handling that is given them.

In all but the summer months cattle have a longer day than sheep or goats, and this is especially noticeable in the cooler or winter months.

During the summer months both sheep and goats have longer days than do cattle, largely because of the fact that cattle do more feeding in the heat of the day and consequently do not feed so late into the night. In general, goats have a shorter day than do cattle or sheep, largely because of their habit of bedding down somewhat consistently soon after dark. The length of day usually is increased when there are moonlight nights. In 36 observations of each type in 6 instances for cattle, 10 for sheep, and 5 for goats, the day was of 15 hours or more, whereas, on the other hand, cattle had no day less than 11 hours in length while sheep had 3 and goats 4 such days. The longest day observed for cattle was 16 hours and 15 minutes; for sheep 16 hours and 30 minutes; and for goats 15 hours and 46 minutes. The minimum length of days was influenced by bad weather or by such special care as that of supplemental feeding.

Table 3.—Average daily travel of range livestock in miles.

Month	Cattle	Sheep	Goats
January.....	1.8	3.1	5.3
February.....	2.9	2.8	5.9
March.....	4.2	4.0	5.2
April.....	4.0	3.8	7.6
May.....	4.7	3.4	5.4
June.....	3.0	2.3	4.2
July.....	3.5	4.1	5.2
August.....	2.8	2.8	8.0
September.....	4.4	5.3	6.9
October.....	3.7	5.6	7.1
November.....	3.7	4.6	6.9
December.....	1.4	3.7	4.1
Average.....	3.3	3.8	6.0

Traveling

The distance traveled by the animal under observation is noted and recorded by following her course and taking steps of 30 inches and counting these steps. While the animal is traveling the time is noted as such. All range animals do more or less traveling while feeding, and this travel also is allowed for by deducting the proper amount of time from their feeding activities and crediting it to travel. The basis used throughout was obtained by testing out the rate of travel of cows, ewes, and does while traveling in to the water and salt supply at such times when there was no interruption whatever in their travel. The various rates of travel were found to be approximately that of 250 feet (100 steps) in 72 seconds for cattle, in 80 seconds for sheep, and in 70 seconds for goats. In recording the activities, it is possible to allow the correct time for travel at the times the distance traveled is noted so that little or no correction is necessary at the time the data are analyzed to have the total time of travel what it should be.

The average daily travel is approximately three miles for cattle, four miles for sheep, and six miles for goats. In nearly all cases part of the

travel is required for coming in to the supply of water and salt. In the case of sheep and goats part of the travel very frequently is due to travel from the pasture or water lot or from their preferred bedding ground, out into the pasture some distance where the feed supply is much better than in the more frequented places. Cattle do not come into the corrals to bed down, and thus from one-half to one mile of travel per day is saved for them. The greater amount of travel of the goats is due to their habit of staying together while feeding, the flock remaining only a short while in any one locality, no matter how good the feeding may be; whereas cattle and sheep have a tendency to remain for considerable periods in the good feeding areas. While feeding in suitable places, cattle confine their activities to a limited area by circling around in it and crossing and recrossing their track; sheep go ahead to the limit of the area and then turn sharply back, but at an angle to their previous travel; and goats go straight on ahead until near the pasture limits, when they usually circle and return to the corral or near to it, and after resting make an additional round trip, or two or more such trips each day.

In general, range animals do more travel in the late summer and fall and less in the winter and warmer part of the summer. While goats travel more when grazing conditions are good, cattle and sheep are inclined to travel less.

The extremes of travel of range livestock in the 36 observations of each type were, for cattle, a maximum of 6.38 miles in September, 1926, and a minimum of 1.07 miles in December, 1925; for sheep, a maximum of 6.62 miles in October, 1925, and a minimum of 1.44 miles in August, 1924; and for goats, a maximum of 11.87 miles in October, 1925, and a minimum of 2.11 miles in December, 1925. Thus the daily range of travel of goats is greater than the total daily travel of cattle and sheep.

In many instances the first activity of range animals after they get up in the morning is travel. This is particularly true where they have spent the night in a preferred bedding ground, as is very frequently the case with sheep and goats. It is not unusual for goats to travel half a mile or more in the early morning before they begin to feed, and sometimes sheep may travel quite a distance likewise, but rarely to the extent that is common for goats. Cattle commonly stop feeding abruptly to bed down and when arising begin where they left off, thereby saving considerable extra travel.

The three-year average percentage of the day spent in travel is approximately 10 per cent for cattle, 13 per cent for sheep, and 19 per cent for goats. Cattle do their greatest amount of traveling in the spring months, while sheep and goats travel most in the fall months. The least amount of travel is done by cattle in the winter months and by sheep and goats in the summer months. On a time basis, cattle average daily throughout the year approximately 85 minutes of travel, sheep 107 minutes, and goats 148 minutes.

Feeding

Only about one-half of the animal day is taken up by feeding activities, the average percentages being approximately 56 per cent for cattle, 50 per cent for sheep, and 46 per cent for goats. This allows for the loss of time in moving about while feeding.

The tendency of cattle is to feed as individuals and to remain somewhat continuously in a good feeding place of limited area by circling around in it and crossing and recrossing their tracks. This custom reduces their travel and permits them to put in more actual time at feeding than do sheep or goats. In going to and from one good feeding area to another, or to and from the supply of water and salt, cattle are much less likely to feed along the way than are sheep and goats.

The tendency of sheep is to feed in small groups and to travel in the same general direction for some time while feeding. They may prolong their feeding in a limited area, but when doing so, usually travel ahead and then turn sharply back, but at an angle.

The tendency of goats is to feed in large flocks, and while doing so to travel almost or entirely to the pasture limits in the same general direction, when they make wide, circling turns. If they start out in the early morning from near the water supply, they make at least one round trip before going to the water or to the salt trough. As the usual thing, two or more round trips are made daily, although the same points may not be touched in these trips. No matter how good the feeding may be, goats remain only a short while in any one locality while feeding.

Cattle are grazing animals, and browse even to a less extent than do sheep, and show a decided preference for the grasses, weeds being taken usually only incidentally; but they do eat certain weeds that sheep and goats do not eat. Usually there is an attempt at variety in their feed, the same being evidenced by a little browsing even when the growth of grass and weeds is good. Grazing conditions are very good for cattle when there is much cured grass available for them. When grazing conditions are poor, as in the winter months of most years, the major portion of the feeding of cattle is on sacahuista; but for all the other months grazing forms more than half of their feeding activity. For the year, cattle feed nearly twice as much on sacahuista as do sheep and seven and one-half times as much as do goats. Only twice, in February and in December of 1925, did it happen that cattle browsed more than they grazed; but at no time has browsing formed as much as half of their feeding activity, the average for the year being about one-twelfth of the total feeding.

Sheep are primarily grazing animals, and have a preference for weeds rather than for grass. However, the weed growth in the station pastures usually is somewhat limited, and this results in grass constituting the larger portion of their feed. Sheep graze very little on cured grass or on a luxuriant growth of grass, their preference being for the new growth of grass and weeds. For the year, grazing forms approximately four-fifths, browsing slightly more than one-tenth, and the feeding on

sacahuista less than one-fifteenth of the feeding activity of sheep. In only three months, in February and December of 1925 and January of 1926, did grazing form less than half of the feeding activity of sheep, and in the winter months the feeding on sacahuista is likely to exceed browsing in importance. When there is an abundance of succulent weeds and of green grass, sheep do very little browsing and little or no feeding on sacahuista.

Goats are primarily browsing animals, as they somewhat frequently browse to a greater extent than they graze. Thus of the 36 months their major feeding activity in 20 was browsing; in 14, was grazing; and in 2, was feeding on sacahuista. Nevertheless, when grazing conditions are good, goats show a preference for grazing, and, in such times, may do more than twice as much grazing as browsing. Like sheep, goats show a strong preference for succulent weeds and green grass, and in the

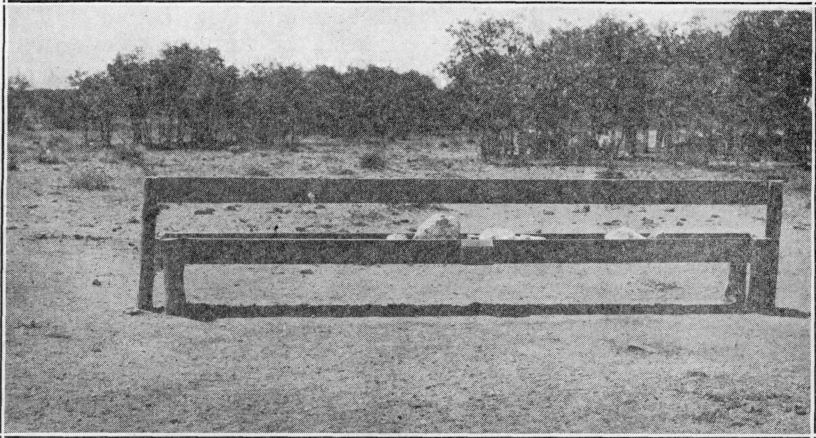


Figure 2.—Salt trough in one of the pastures of the Ranch Experiment Station. Since this photograph was taken a concrete base has been added to do away with water and mud around the salt trough after rains. In background note sheep sheltering from the sun.

absence of such do little or no grazing. In browsing, goats show a variety in their appetite not approached by cattle or sheep, for they feed upon 25 or more species of browse plants, while cattle feed upon only half, and sheep upon only less than half as many. Unlike cattle and sheep, goats commonly rear up on their hind legs and browse with their bodies erect, but even then are unable to reach as high as cattle. Not infrequently goats bend down a shrub and stand on it while partaking of its foliage, flowers, or fruit. With some woody plants the buds, flowers, and fruit in general may be of more importance to goats than is the foliage. At times, when mast and fallen mesquite pods are available, goats frequently run from one thicket or one tree to another, and in their haste leave a small portion for the sheep to clean up. Goats eat much more than their share of the budding flower stalks of sacahuista and

yucca, even though cattle and sheep are very fond of both. Goats eat the buds, fruits, and new growth of both the prickly pear and the tasajillo, while sheep do not touch the cacti and cattle only rarely will eat the joints or the new growth of the prickly pear. Both goats and cattle seem to be fond of mushrooms.

Generally calves associate with each other while their mothers are feeding, and do not seek the cows but rather the cows seek the calves. Both lambs and kids usually feed along with their mothers, or rest near by. Should the mothers get far away, it is largely up to the youngsters to find them. The young animals very soon learn to do more or less feeding on the range. They taste of various plants that their mothers do not feed upon, and apparently learn for themselves the palatability of the various plants growing on the range. Calves and lambs are likely to do more browsing proportionately than their mothers, just as the kids are likely to do more grazing than the does do.

For the three years, the average percentage of the day devoted to feeding activities is approximately 56 per cent for cattle, 50 per cent for sheep, and 46 per cent for goats, or an average for the three types of approximately 51 per cent. As would be expected, a larger percentage of the shorter days of winter is devoted to feeding; however, cattle devote the highest percentage of the day to feeding in the fall months, and next highest in the winter months. Both sheep and goats feed to the greatest extent in the winter months, but sheep feed to the least extent in the summer months, while goats do so in the fall months. While cattle feed to the least extent in the spring months there is more uniformity in this respect throughout the seasons than is the case with goats, which in turn are more consistent feeders throughout the year than sheep. Calculated to a time basis, cattle average approximately 461 minutes at feeding daily, sheep 397, and goats 351 minutes.

Licking Salt

In all cases the salt provided for the range livestock is the ordinary stock salt, and it is placed before the animals in elevated troughs set above a concrete base. These salt troughs are usually from 100 to 150 feet away from the water trough. While the salt troughs are usually kept supplied with salt, in a number of our observation periods they were empty, and so the animals had no opportunity of licking salt. Where the animals did not come in for water, they likewise failed to have an opportunity to take any salt. When the opportunity was afforded them, only very rarely did any fail to partake of salt to at least some extent. Hence it may be said that all range live stock will take a little salt if available either before or after drinking, but more generally the latter. Sheep and goats rarely spend more than a minute or two at the salt trough, but they may repeat their visits the same day, while cattle may spend fifteen or more minutes but in only one such visit. In a few instances bone meal was mixed with the salt, but usually the salt and bone meal were in separate halves of the trough. Where the bone

meal was mixed with the salt, allowance was made for feeding on bone meal. Frequently some idle time is spent at the salt troughs, but so far as noticed this has been recorded as such.

Cattle lick salt on an average of nearly eight minutes daily, while sheep and goats do so less than three minutes daily, or approximately one-third that of cattle. There is little difference between sheep and goats in the time spent at licking salt, although there are wide variations from month to month for both types. There is no consistency in this variation, although there seems to be more salt taken in the winter months and less in the spring months, the latter somewhat below that taken in the summer and fall months, which are approximately equal in percentage of time; but on account of the longer days of the summer the amount of salt taken is greater. In the 36 observations the maxi-

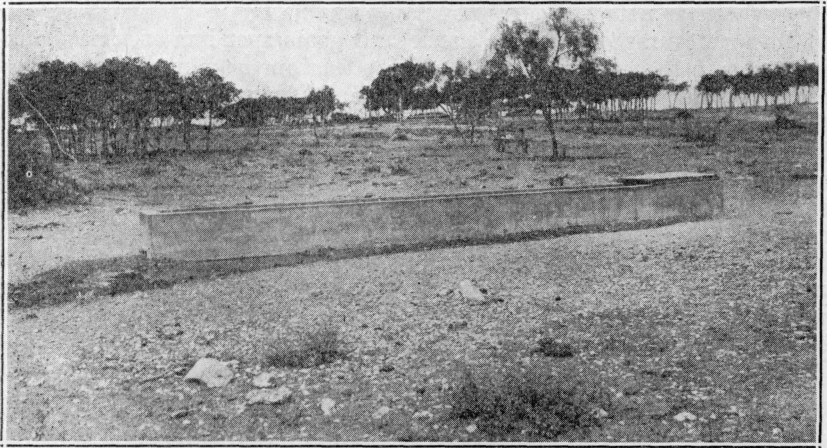


Figure 3.—Concrete water trough in one of the pastures of the Ranch Experiment Station. A concrete base has been added to do away with mud around the trough after rains and to make it easier for the smaller sheep and goats to drink.

imum time spent in one day at licking salt was 22 minutes for cattle, 12 minutes for sheep, and 18 minutes for goats. The activity of licking salt is usually a leisurely one, and is one that the range animal enjoys.

Drinking Water

In all but one of the pastures a supply of good clean water is at all times available in concrete troughs, and only a relatively few observations were made in this one pasture. The water is obtained from three wells, at two of which are concrete storage tanks of ample capacity, and from which the water flows by gravity into troughs in each of the various pastures, traps, and corrals. In each case the water is pumped by windmills.

When water is available in pools in the draws or in pockets of the flat rocks after rains, all range animals satisfy their requirements for water without traveling in to the regular source of supply, even where this water is almost a thin mud. It is also not unusual for both sheep and goats to gain their water requirements in feeding upon green and succulent plants or on plants wet with dew. In the warmer months occasionally cattle may go to the water supply twice daily, while in the other months it was observed in a two-section pasture, having its source of water supply at one corner, and where three of the observations were made, that cattle avoided excessive travel by going in for water only on alternate days. On a few occasions various range animals took water both at the water trough and at pools in a draw. At shallow pools some time is wasted at getting a fill of water. Usually some idle time is spent at the trough between drinks, but this has been accounted for as such whenever noted.

On a percentage basis both cattle and goats spend most time drinking water in the summer months and the least in the winter months, and more in the spring months than in the fall months; but with sheep this is somewhat different, for they spend most time in drinking water in the winter months and least in the summer months, and more in the spring months than in the fall months. Apparently the reason for the smaller amount of water drunk in the fall and summer months and to a lesser extent in the spring months is the quantity of succulent herbaceous plants that frequently are available for forage during these months. For the three years the average daily time spent at drinking water was 2.4 minutes by cattle, 1.0 minutes by sheep, and .9 minutes by goats.

Resting While Lying Down

All types of range animals feed for some time, and then cease for a time; and at such times they may be ruminating or idle while standing or they may be resting while lying down. Extremes of temperature cause all the animals to seek protection from the sun or wind, and in doing so they may largely or altogether cease their feeding activities. In the warmer months, it is usual for the animals to remain in the shade for five or six hours during the heat of the day and then prolong their feeding activities at the end of the day well along into the night, and especially so when there is bright moonlight. Only when the animal was lying down, was she recorded as resting; for otherwise she was recorded as merely idle or ruminating when not engaged in the other activities noted. The more resting an animal does, the less feeding she can do, unless her day is prolonged accordingly.

For the three years cattle averaged 12.5 per cent of their day at resting, while both sheep and goats averaged in excess of 15 per cent, although there was greater variation in the data concerning sheep. On an average, cattle rested approximately 102 minutes a day, sheep 122.5 minutes, and goats 121.5 minutes. In general, range animals do most resting in the summer months and least in the winter months, and more

in the spring than in the fall months. However, cattle do more resting in the spring months and also in the winter months than they do in the summer, and do their least resting in the fall months. Both sheep and goats do the most resting in the summer months and the least in the winter months, but sheep do more resting in the spring than in the fall, and goats do more resting in the fall than in the spring. These differences are accounted for by the heavier body covering of sheep and goats than of cattle and by the difference in feeding habits of sheep and goats. In explanation it may be stated that there is a variety of browse available for goats in the spring which causes them to be more active than in the fall when there is little or no choice of browse and a portion of their feeding is on mast.

Ruminating While Standing Up

Cattle, sheep, and goats are all ruminants and swallow their herbaceous food unchewed. This, after remaining for some time in the first and second stomachs, is regurgitated in masses and thoroughly chewed while the animal is not feeding, the mass being termed the cud. When the cud is chewed the semifluid mass resulting passes into the second stomach and through the third to the fourth where it is acted upon by the gastric juice. It is known that a very large portion of the ruminating of range animals is done while they are lying down (as explained where the term was defined), possibly as much as four-fifths, but the data herewith concern only that done by the animal while on her feet; therefore, they are not an indication of the total amount of ruminating the animal does. It is known that when the animals bed down at night they ruminate for some time, and also very frequently they ruminate in the early morning before getting up. This is especially true of sheep and goats. Occasionally sheep and goats, after they get up, may ruminate to some extent in the morning, before beginning their feeding activities. Cows frequently ruminate while suckling their calves, and it is not unusual for them to get up and feed for some time in the early morning before calling their calves to breakfast and then to ruminate while suckling them.

The data show that while standing cattle ruminate approximately 9 per cent, sheep ruminate 10 per cent, and goats ruminate 11 per cent of the day. On a per minute basis, it is shown that while standing cattle average approximately 76 minutes daily at ruminating, sheep 78 minutes, and goats 84 minutes. These figures indicate that goats do more ruminating on their feet than do sheep, while sheep do more than cattle. All animals do most of their ruminating while standing in the summer months and least in the winter months; this is due to the shortness of the days in the winter, which do not permit so much time for ruminating and consequently more of it is done while resting at night. Goats and sheep ruminate while standing more in the spring months than in the fall, while cattle do not.

Idling While Standing Up

All range livestock at times cease all their other noted activities to rest on their feet or to observe other animals or objects or to wait for some expected happening. In the summer months very frequently they tire of lying down and rise to rest on their feet, or they alternate their periods of lying down by rising and ruminating or remaining idle. There is some idle time spent usually in connection with supplemental feeding, especially where there is some regularity in this feeding.

For the three years the average percentage of idle time was approximately 10 per cent for cattle, 11 per cent for sheep, and 8 per cent for goats. On a per minute basis for idle time cattle averaged daily 83 minutes, sheep 86 minutes, and goats 61 minutes. The seasonal variation of idle time was different for the three types, as in each case the occasion for excess of idle time was more or less different. With cattle idle time is greatest in the winter and least in the fall, much of their excess of idle time being used in chewing on tins, sticks, and bones, especially when grazing conditions are poor. With sheep idle time is greatest in the summer and least in the spring, much of their idle time being used in seeking shelter from the heat of the sun. With goats the greatest amount of idle time is in the fall months, when a portion of their feeding is on mast and when their kids have been weaned. Both sheep and goats have least idle time in the spring months, when both have been shorn of their fleeces and have to produce a supply of milk for their lusty youngsters.

Table 4.—Average of the classes of feeding activities of range livestock in minutes and in percentages of the total feeding activity.

Class of Feeding Activity	Minutes Daily			Percentages of Total Feeding		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Grazing.....	350.2	317.0	134.1	75.90	79.89	38.18
Browsing.....	39.0	40.0	186.5	8.45	10.08	53.10
Miscellaneous.....	63.6	29.4	20.6	13.79	7.42	5.87
Supplementary.....	8.6	10.4	10.0	1.86	2.61	2.85
Total.....	461.4	396.8	351.2	100.00	100.00	100.00

CLASSES OF FEEDING ACTIVITIES OF RANGE LIVESTOCK

The four classes of feeding activities, grazing, browsing, miscellaneous, and supplementary, already have been defined. Table 4 presents the data concerning these classes as a whole, whereas later, each one will be taken up and treated separately in detail. The data show the number of minutes daily and the percentages of the total feeding time devoted to grazing, browsing, miscellaneous feeding, and supplementary feeding each by cattle, sheep, and goats. Thus it is shown that grazing forms more than three-fourths of the feeding done by cattle, about four-fifths of the feeding done by sheep, and less than two-fifths of the feeding

done by goats; browsing forms about one-twelfth of the feeding of cattle, one-tenth of the feeding of sheep, and more than one-half the feeding of goats; miscellaneous feeding forms more than one-seventh of the feeding of cattle, less than one-fourteenth of the feeding of sheep, and about one-seventeenth of the feeding of goats; and supplementary feeding forms about one fifty-fourth of the feeding of cattle, one thirty-eighth of the feeding of sheep, and on one thirty-fifth of the feeding of goats.

Description of the Classes of Grazing

Even under close observation of grazing animals, especially where there is a variety of immature plants that are not readily recognizable, it is impractical to attempt any minute division into separate classes of grazing. Thus the classification herewith comprises only four groups or classes and some of these necessarily are broad ones.

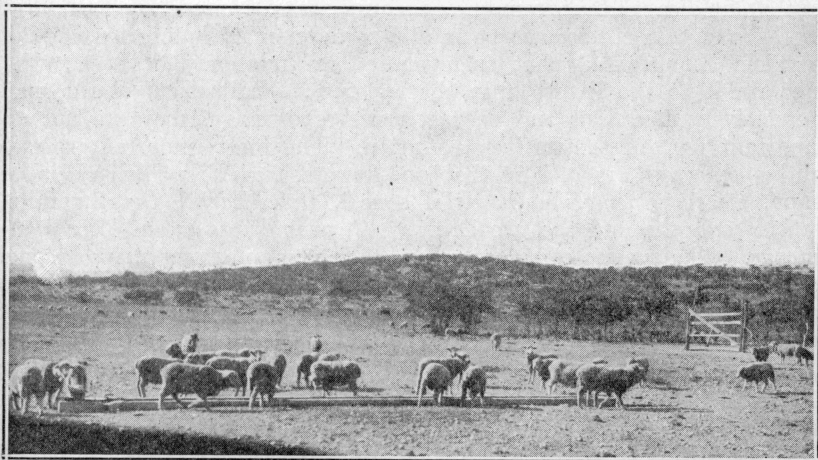


Figure 4.—Scene on the ranch of Mr. John Ward in Sutton County, Texas, some twenty miles from the Ranch Experiment Station. Sheep commonly graze while coming in and going away from the water trough. Usually they do not crowd around the water trough, while they are quite likely to do so around the salt trough.

The first, and surpassing all other classes in importance, is the curly mesquite type of grass. Curly mesquite grass, *Hilaria Belangeri*, is a turf-forming grass that constitutes approximately 85 per cent of the soil cover in the pastures where these observations were made. Included in this class is buffalo grass, *Bulbilis dactyloides*, a turf-forming grass of a grayish-green color, but in general appearance very similar to the curly mesquite and by many is not distinguished from it.

The second class consists of the herbaceous plants other than grasses and grass-like plants, and is referred to for convenience as weeds. With a few exceptions plants in this group are annuals, and the few perennials are unimportant. The importance of the various species depends upon

the abundance of their occurrence, for apparently nearly all are palatable to the range livestock. The annuals depend upon seed for their reproduction, and when moisture conditions are favorable, the range becomes something of a flower garden. Of the many species that are to be found from time to time a daisy-like plant with white ray flowers, *Aphanostephus ramosissimus*, is perhaps the one of most value. A succulent plant of small growth, forking branches and small white flowers, known sometimes as corn salad or lamb lettuce, *Valerianella amarella*, is another important species. A shade-enduring flimsy plant, very succulent and of semi-transparent appearance, having entire leaves and inconspicuous flowers, the pellitory, *Parietaria obtusa*, is a favorite food plant of goats and to a lesser extent of sheep. Where the range is heavily stocked, especially with sheep or goats, the weed growth is eaten when young and small, and so the more palatable species may be but little in evidence. Already several species formerly somewhat common have about disappeared from the ranching areas. In occupied pastures wherever certain species are permitted to develop in abundance, it may be taken for granted that such plants are relatively or even quite unpalatable to the livestock in that pasture. While such plants may be relatively abundant and characteristic of a range, they are not an important part of the native vegetation. The most important species in this category are one of the cone-flowers, *Ratibida columnifera*, a senna, *Cassia Roemeriana*, a wild sage, *Salvia Earlei*, the limonillo, *Actinea odorata*, and the two Crotons, *C. neomexicanus* and *C. corymbulosus*. The species of broom weed when at or near maturity become a characteristic feature of the range where only cattle or horses are pastured. Sheep eat the young broom weeds, and hence these weeds do not become a prominent feature of the range where sheep are pastured. Of the broom weeds the common species here is *Gutierrezia texana*.

The third class is a comprehensive one consisting of the other grasses, usually perennial bunch grasses of the open or the shade-enduring grasses of the thickets. This class of grazing is of importance more especially when grazing conditions as a whole are poor. The more important species are one of the needle grasses (of which there are five species here), *Aristida glauca*; a spear grass, *Stipa leucotricha*; black grama, *Bouteloua hirsuta*; a similar species of grama grass, *Bouteloua trifida*; and a sedge, *Carex planostachys*.

The fourth class consists of winter annual grasses that are of much importance in the winter months at a time when there is no green growth of curly mesquite grass. The two species of importance are *Festuca octoflora* and *Trisetum interruptum*, the former being a fescue grass and the latter not having a common name, or at least one that is in general use. Both of these grasses mature quickly, seed heavily, and disappear after maturity.

Table 5.—Average of the classes of grazing of range livestock in minutes and in percentages of the total grazing.

Class of Grazing	Minutes Daily			Percentage of Total Grazing		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Curly mesquite grass.....	273.7	166.5	67.5	78.15	52.53	50.36
Weeds.....	31.8	75.1	27.8	9.08	23.68	20.73
Other grasses.....	38.1	30.3	10.6	10.89	9.57	7.90
Winter annual grasses.....	6.6	45.1	28.2	1.88	14.22	21.01
Total.....	350.2	317.0	134.1	100.00	100.00	100.00

Data Relative to the Classes of Grazing: The data in connection with the classes of grazing were obtained by noting the approximate time the animals used in feeding upon each and making the estimate in percentages of the total grazing. At that time no attempt was made to convert these estimates into minutes, and doing so at a later date has resulted in more fractional numbers than otherwise would have been the case. The data are given showing the number of minutes daily and the percentages of the total grazing time devoted to each of the four classes of grazing by cattle, sheep, and goats.

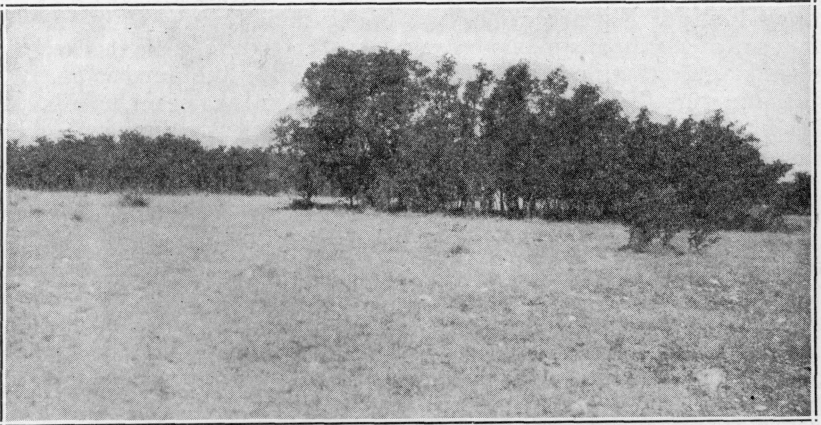


Figure 5.—Live oak in open grassland in one of the pastures of the Ranch Experiment Station. The grass cover is of curly mesquite grass. The live oak is the most important of the browse plants.

With all three types of livestock curly mesquite grass is more important than all the other classes. While this may be due to its great abundance, it is certain that its value is the highest, as is indicated by the preference for it that all the animals show. With cattle and sheep weeds are next in importance, but with goats they are exceeded in importance by the class of winter annual grasses. Cattle feed on weeds more or less incidentally, and usually do not seek them out as do goats

and sheep. The winter annual grasses are of less importance to cattle because of their small growth, which forms no hindrance to their utilization by sheep and goats. It is possible that the custom of grazing sheep and goats is favorable to increasing the abundance of these grasses, for they grow very much better where the curly mesquite class is closely grazed, as it is in pastures well stocked with those animals.

Description of Classes of Browsing

In contrast to that of grazing it usually is feasible to note each species that is fed upon while browsing, because of the greater size of the plants and the greater differences in their vegetative characters. However, in three of the classes, catclaws, forestieras, and junipers, more than one species is included, largely because the species are not readily separated or because all or some are of minor importance.

Still another contrast to grazing in which all parts of the plant are readily accessible to range livestock is the feature that many browse plants bear a portion or even all of their edible parts out of the reach of domestic animals. This is a factor also in the preservation of the species, and possibly also in an increase of its numbers. Thus there is indication that some of these plants are increasing in numbers, while only Ephedra and Eysenhardtia appear certain to lose out, and the mesquite to be losing out to some extent. Whenever the extent of this trend towards an increase in numbers of the browse plants becomes great enough to make its checking advisable, the checking can be done by increasing the number of goats to the pasture, but under the system of ranch management now in use the increase of browse plants is retarded sufficiently in many cases. However, it would seem desirable not to permit undue encroachment of trees and shrubs on good grass land.

The classes of browsing are discussed in the order of their importance to the range livestock as a whole, where 45 per cent of the total feeding is done by cattle, 35 per cent by sheep, and 20 per cent by goats. Each of the 23 classes will be described briefly, and then the tabulations will serve to indicate the relative importance of each one.

The live oak, *Quercus virginiana*, grows from Virginia and Florida to Western Texas and south into Mexico and to Cuba, usually as a large tree, as it does here when isolated from its species, but commonly under the conditions on the Edwards Plateau it grows in thickets having a height of four to twelve feet. Only where this plant somewhat habitually makes rather a bushy growth can it be of primary importance to browsing animals, for otherwise its foliage would be above their reach. The live oak is evergreen in its foliage habit; it is abundant and its foliage is quite palatable to all range livestock. These characteristics tend to make this species of surpassing importance as a browse plant. The live oak suckers very freely when the plants are in thickets, and these thicket areas tend very noticeably to increase in size. The acorns are eaten almost altogether as mast and few germinate to make seedlings.

The ill-scented sumac, *Rhus trilobata*, occurs mostly as an under-

shrub in live oak thickets. It grows from one to five feet or more tall, and is characterized by having foliage of three leaflets with rounded lobes, a short and dense inflorescence (flower cluster) of greenish-yellow flowers, and a hairy, one-seeded dry fruit that is bright red in color. Although somewhat offensively scented it is the favorite browse plant of sheep, and is liked nearly as well by cattle and goats. This shrub leafs out early in the year, but the flowers appear before the leaves. The buds and flowers are relished by goats, and before many of the flowers are open the goats may strip the branches of all the flowers and many of the buds. The fruit is unpalatable.

The lanceolate-leaved sumac, *Rhus lanceolata*, occurs in the vicinity but no specimen occurs on the station and is not included in the 23 classes discussed; but the plant is considered a good browse plant.

The shin oak, *Quercus breviloba*, is deciduous in foliage habit, and grows here in thickets characterized by a thick growth of plants a foot or two in height among which are scattering small trees, six to twelve feet tall; but occasionally either the shinnery or the small trees may be absent. In this species the leaves are shallowly round-lobed, green and shining above and transiently silvery beneath; the bark is gray or silvery white and scales off in thin strips; and its acorns are about one-half inch long and are half-included in the cup. At certain times the shin oak appears to be a favorite browse plant for cattle and goats. The acorns on the smaller plants are eaten mostly by the goats while browsing, but more commonly the acorns are borne above the reach of the browsing animals; so they are harvested mostly as mast.

The catclaws are leguminous shrubs armed with recurved spines. Their flowers, which are small, are grouped in a head or in a spike. The catclaws belong either to the genus *Mimosa* or to the genus *Acacia*. In the mimosa the flowers have either 5 or 10 stamens, while in the acacias the flowers have numerous stamens, always more than 10. In both genera some of the species are unarmed and some have straight spines, and all such should not be considered as catclaws. The two unarmed species here, *Mimosa leucaenoides* and *Acacia filicioides texensis*, grow only in cultivated fields and other protected places and hence have not been available to the browsing animals. The other species here, *Acacia Roemeriana* (some specimens intermediate between this and *A. malacophylla* have been collected; hence it is possible that this species may grow here also), *Mimosa fragrans*, *Acacia Greggii* and *Mimosa biuncifera* have recurved spines and are sufficiently similar in appearance to be grouped together as catclaws. Possibly these four species are of importance as browse plants in the order given, but separate data have not been kept. The foliage of catclaws is relished by sheep and goats, and in spite of the protection afforded by their spines the catclaws furnish browsing to a considerable extent.

The wild plum, *Prunus minutiflora*, is a densely branched shrub one or two feet high with small leaves clustered on shortened branches and with solitary, very small flowers that are spaced rather closely together.

The fruit is thin-fleshed and is velvety hairy. The flowers appear before or at the time the leaves do in the month of February; so the earliness of the new foliage tends to make this an important browse plant. The shrubs occur grouped together on well-drained elevations above and near the head of draws, where they may form thickets of more or less density. The foliage is browsed by sheep and goats and the flowers also are eaten by goats.

The small-leaved sumac, *Rhus microphylla*, is a stiff, widely branching shrub that is frequently six feet in height and also in diameter of spread having compound leaves and small white flowers in crowded clusters. Each leaf has about seven short and entire leaflets. The flowers appear before the leaves. The fruit is small, dry, one-seeded, and orange-scarlet in color, and is bristly hairy. This species is not of common occurrence here, but its buds, flowers and foliage are browsed by goats, and where abundant, likely would be a valuable browse plant.

The coral bean, *Sophora secundiflora*, is an evergreen shrub or small tree with leathery, glossy, dark-green compound leaves of about nine leaflets and with showy, fragrant, violet-blue flowers. Its fruit is a hard, woody pod that contains three or four large, round beans which are bright red and are very hard. The seeds are poisonous, but they pass unchanged through the digestive tract of goats, which are fond of the fruit and which are the only range livestock that eat it. Goats are fond of the flowers as well as the fruits of this species, and the foliage also is palatable to them. The foliage is somewhat palatable to sheep and cattle, but in its limited occurrence the species is of importance only to goats.

The mesquite, *Prosopis chilensis glandulosa*, here is a shrub in habit, and has two or more trunks from one base, but each trunk becomes a small tree; hence the foliage and fruits usually are borne above the reach of browsing livestock. Both the foliage and fruits are palatable, but only cattle are able to feed on either while browsing. An interesting feature is that with dehorned cows the bull in the breeding season makes a practice of hooking his horn over mesquite branches to break them down and so makes the browse available both to himself and to the nearby cows.

The lote bush, *Condalia obtusifolia*, is a rigid spiny and much-branched shrub, three to six feet high, of the buckthorn family. It is one of the most abundant shrubs in western and southern Texas, and because of this abundance and the fact that at times goats browse its foliage it has some importance as a browse plant. The foliage is palatable, but it is somewhat efficiently protected by the stout, spinose branchlets of the shrub. This species may be recognized through its flowers having petals and its leaves being green beneath and somewhat three-nerved at the base. Its fruit is small, black, fleshy, one-seeded, and edible, but not very palatable.

The Mexican persimmon, *Diospyros texana*, grows here as a shrub, four to eight feet high. It has a smooth, thin bark, the outer layers of

which peel off, and a fruit that is a large berry, three-fourths of an inch in diameter, with dark, sweet pulp containing three to eight seeds. When mature the fruit is edible and palatable, but no observations have been made of domestic animals eating it. This species is somewhat common here, but its foliage seems not to be palatable to sheep and goats, while cattle browse the same only at times in the fall when it is approaching maturity.

The forestieras, of which there are two species here, *Forestiera neomexicana* and *F. pubescens*, are rather large, wide branching shrubs of similar appearance usually growing as undershrubs in the thickets. The leaves are broad, simple, opposite or sometimes clustered, and deciduous. The flowers are small, inconspicuous, without petals, crowded in scaly buds and appear before the leaves. Some of the plants do not develop pistillate flowers, hence do not produce fruit. The fruit is small, fleshy, blue-black, and one-seeded. This is among the earliest of the shrubs to flower and to leaf out, but its foliage is bitter in taste and seems to be not very palatable, although it is browsed by goats and to a slight extent by cattle and sheep.

The shittimwood, *Bumelia texana*, is a small tree that is armed with spines and has a milky sap and a very hard wood. The leaves are entire and alternate or frequently clustered, while the small white flowers are crowded in clusters in the axils of the leaves. The fruit is black and cherry-like with one large seed, and is edible although not very palatable. The foliage is palatable, at least to goats, but browsing of it necessarily is confined to seedlings or to trees that have been chopped or broken down. This species frequently is the only one bothered where wild animals bark the trees while feeding during the winter months. As this tree has various other common names frequently used for various other plants, we shall refer to it hereafter as bumelia.

A somewhat common species that has no common name reported for it is that of *Colubrina texensis*, of the buckthorn family. This is a much-branched, unarmed shrub of three to five feet in height, the branches being arranged zigzag; the leaves are alternate, and three-nerved at the base; the flowers are small, greenish and clustered in the axils of the leaves; and the fruit is dry, berry-like, slightly three-lobed, the three cells being one-seeded and opening at full maturity. The foliage of this species is browsed to some extent by cattle and goats, but seems not to be a favorite browse plant with them.

The Mexican buckeye, *Ugnadia speciosa*, is a shrub or small tree with reddish twigs and large compound leaves, each with about seven leaflets. This species bears showy, large purplish-pink flowers that appear before the leaves, and its fruit is a leathery three-lobed, three-celled capsule, each cell being one-seeded, the seeds being large, black, shiny, and poisonous. The Mexican buckeye is not common in occurrence here, but its foliage seems to be highly palatable to cattle and to goats.

The hackberry, *Celtis reticulata*, is an unarmed small tree, having leaves that are thick, rough, and strongly netted with veins, and fruit

that is small, orange-red in color, one-seeded, with scanty pulp and edible. The bark of the older trees is rough with high, corky warts. The hackberry's foliage is quite palatable to all range livestock, but it usually is borne out of their reach.

The evergreen sumac, *Rhus virens*, is a shrub or small tree, usually six or seven feet high with evergreen, compound leaves of seven or nine leaflets, which are entire, thick, leathery, and shining above and with a dry, one-seeded hairy fruit that is red or orange in color. Its foliage is quite palatable to goats; hence the few plants here are kept rather closely browsed.

The cedars or junipers are evergreen shrubs or trees with scale-like leaves and with fruit consisting of a cone composed of fleshy scales making it berry-like in appearance. Of the two species here the one-seeded juniper, *Juniperus monosperma*, is usually a small tree having a small, thick, bluish, fleshy one- or two-seeded fruit, while the Utah juniper, *J. utahensis*, is usually a much-branched shrub having a larger fruit, which is brown at maturity, but also has only one or two seeds. It is known that the fruit of both species is palatable to goats, and that the lower-growing Utah juniper furnishes the most of this feed supply. Goats occasionally nibble at the twigs or foliage of the junipers and sheep do so rarely, but this feature is entirely unimportant.

The agrito, *Odostemon trifoliatu*s, is an evergreen shrub of quite common occurrence throughout western Texas, where frequently its common name is corrupted into "agrita" and "algerita." The leaves of agrito have three leaflets and these are thick, stiff, pale, and with spiny lobes or teeth. The fruit is a red berry about the size of a pea, acid in taste. On account of its spiny teeth the foliage is rarely utilized as browse, and its importance as a browse plant depends upon the fact that its flowers are highly palatable to goats.

A joint-fir, *Ephedra pedunculata*, occurs here to a limited extent. Like other species of this genus, this is a shrub with slender, jointed stems and with leaves reduced to scales. In this particular species the leaf-scales are opposite and the fruit is stalked, fleshy, red or salmon-colored, and edible. Where accessible, these joint-firs are kept browsed to the ground by goats; hence in all occupied pastures they are doomed to extinction.

The prickly ash, *Zanthoxylum Clava-Herculis fruticosum*, is an aromatic, prickly shrub or small tree growing up to ten feet or more in height, and having its twigs, leaf-stalks, and inflorescence finely hairy. Its leaf is compound and usually has seven or nine leaflets. The foliage is palatable to goats, but generally it is borne above their reach.

The white-flowered honeysuckle, *Lonicera albiflora*, is a shrubby, spreading or partially twining vine with shreddy bark, and having opposite entire leaves, the uppermost pair being united by their bases around the stem. The fruit is a fleshy, red berry having few seeds, and it is somewhat persistent after the leaves have fallen. The honeysuckle is not common here, and the few plants bear their foliage almost altogether

out of the reach of goats, which animals eat with eagerness all of it that they can reach. Very likely this accounts for the fact that the honeysuckle plants are so scarce.

A rather common plant, *Condalia spathulata*, of the buckthorn family, has been browsed upon to a small extent by goats, although it is such a spinose plant that range livestock usually avoid it. This species is a densely-branched shrub with slender, spinose branchlets and with small leaves that are more or less persistent; hence it is nearly always leafy. The fruit is small, fleshy, black or purplish, bitter, and one-seeded. This species is one of the least desirable ones of the range here.

An unarmed shrub, *Eysenhardtia texana*, somewhat similar in general appearance to some of the catclaws, occurs very sparsely here. This shrub has small, pea-like flowers loosely arranged on a single axis at the ends of branches, while the fruit is a one-seeded pod that does not open at maturity. This is such a good browse plant that the few plants here will sooner or later be killed out.

Table 6.—Average of the classes of browsing or range livestock in minutes and in percentages of the total browsing.

Classes of Browsing	Minutes Daily			Percentage of Total Browsing		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Live oak	25.0	27.6	102.4	64.15	69.20	54.94
Ill-scented sumac	6.3	11.0	27.9	16.16	27.42	14.98
Shin oak	5.1	.2	33.5	13.05	.61	17.96
Catclaws	x	.9	4.3	.01	2.29	2.30
Wild plum	x	.1	5.0	.14	.13	2.68
Small-leaved sumac			4.6			2.46
Coral bean		.1	2.9		.18	1.56
Mesquite	1.4	x	x	3.46	.02	.02
Lote bush			2.3			1.21
Mexican persimmon	1.1		x	2.70		.01
Forestiera	x	x	1.9	.01	.01	1.01
Bumelia			.4			.21
Colubrina	x		.2	.06		.12
Mexican buckeye	.1		.1	.25		.06
Hackberry	x	.1	.1	.01	.14	.06
Evergreen sumac			.1			.02
Juniper			.2			.12
Agrito			.3			.14
Joint-fir			.1			.06
Prickly ash			.1			.04
Honeysuckle			x			.01
Condalia spathulata			.1			.02
Eysenhardtia texana			x			.01
Total	39.0	40.0	186.5	100.0	100.0	100.0

x—Indicates trace.

Data Relative to the Classes of Browsing: In all cases except where the browsing was desultory the data were obtained in minutes at the beginning and later to the nearest quarter of a minute. In those cases where the time involved was too small to record accurately an estimate in the percentage of the day was made for the feeding on the plant or plants thus fed upon. At the time the data were analyzed the records were made on the basis of the total browsing time; hence, in the prepara-

tion of the tables it has been necessary to convert the percentages into minutes. This has resulted in fractional parts of minutes which were not apparent when the data were taken. The data show the average number of minutes devoted daily to each class of browsing and the percentage of the total browsing which each furnishes to cattle, to sheep, and to goats.

The live oak is browsed upon to a greater extent by all three types of range livestock than are all the other species of browse plants together. The other important classes of browsing are the ill-scented sumac, which is strongly favored by sheep; the shin oak, which for goats is next in importance to live oak; the catclaws; the wild plum; and the small-leaved sumac.

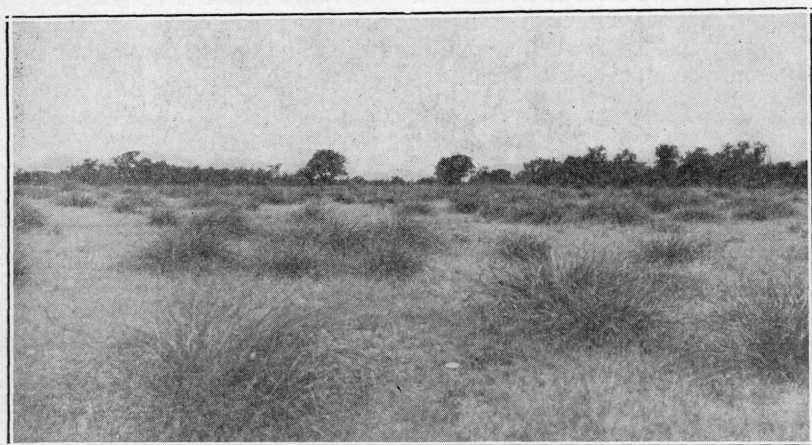


Figure 6.—Sacahuista in open grassland, which is characteristic of gentle slopes where the soil is very shallow. Live oak in the background.

Description of the Classes of Miscellaneous Feeding

Miscellaneous feeding becomes of great importance at times when grazing and browsing conditions are poor, but throughout the year it averages approximately only ten per cent of the total feeding. The various feeding activities included in this group will be discussed in the order of their importance as shown by the data for three years for the three types of range livestock.

In miscellaneous feeding, sacahuista, *Nolina texana*, a plant of the lily family, has a dominating influence similar to that of curly mesquite grass in grazing and to that of live oak in browsing. Sacahuista is a perennial plant from rather a succulent caudex (woody base), having numerous long and narrow leaves that are ribbed and are roughened on the margin; small flowers that are not perfect (some plants bearing flowers that are not fruit-producing), are whitish, and are borne in open

panicles; and a deeply three-lobed fruit that is not winged, is papery, and contains three globose seeds. This species is differentiated from the other species of *sacahuista* in Texas by its prominent and long-tapered lower bracts (leaves subtending the branches of the inflorescence) with dilated and papery bases. The various short branches of the caudex may bear as many as twenty or more leaves, which may have a length of three feet or more and a width of one-eighth inch or less (in some other species they are wider). Each plant forms a clump with a base of one foot or more in diameter, and, with its abundant growth of foliage, forms a prominent and characteristic feature of the range where it grows. Where *sacahuista* grows somewhat commonly the plants will average about one thousand to the acre. In vegetation survey work in December, 1926, counts were made on two typical areas of approximately one acre each in which it was found that on one there were 1,051 and on the other 974 plants to the acre. A typical stand of *sacahuista* supplies a valuable reserve feed supply on the range, as it is not freely eaten when there is a good supply of other grazing plants and as it seems to be as palatable in the winter or in drouth as at any time.

The foliage of *sacahuista* is the most important part as a feed for range livestock. It is eaten extensively by cattle and sheep and to a lesser extent by goats, more especially when grazing or browsing conditions are poor, as in periods of drought or during the winter months. At such times it is rather usual for the major portion of the feeding of range animals to be upon the foliage of *sacahuista*. Cattle are especially fond of the succulent short branches of the caudex, which they separate from the plant by seizing the group of leaves of one branch and pulling on them until the branch is wrenched off. This method of feeding is destructive to the plant, and where done excessively kills it; so over-stocking with cattle in dry periods, or during the winter months, may result in the extermination of *sacahuista*. Sheep and goats bite off the foliage near its top, rejecting the dead tip, and so their feeding is not injurious to the plant. Where the plants have been cropped down to the base by the cattle, all range livestock seek out the new foliage growth. The recovery of the plant is, therefore, a very difficult matter, and death usually ensues.

Another part of the *sacahuista* plant that furnishes a palatable and valuable feed supply to range animals is that of the budding inflorescences, of which there may be as many as twenty or more on one plant. Where cattle, sheep, and goats are feeding in the same pasture, the latter, by reason of their greater agility, may get a very large proportion of these buds, or at times almost all of them. However, both cattle and sheep are very fond of the buds, sheep especially seek them out eagerly, and in occupied pastures few or no plants ever develop the buds into flowers. Thus *sacahuista* comes into flower so rarely that no opportunity has been afforded of noting whether the flowers are palatable or not, but in one instance a cow was noted eating the flowers. It seems probable that the flowers are much less palatable than the buds, and that they

would be more or less free from destruction by range livestock. It appears unlikely that the fruit is eaten by any of the range animals.

Attention should be called to the very probable impending extermination of sacahuista from the range, for even now in many pastures and in some sections sacahuista has entirely disappeared. Just what may be necessary in order to permit this plant to reproduce itself and still make a fairly full use of the range has not been demonstrated. It is believed that deferred grazing at the time when the inflorescences are in the bud would permit nearly all fruit-producing plants to develop seed, but as to the further development into seedlings and then to established plants there is much doubt. The foliage of seedlings very likely is more palatable than that of mature plants, and very likely would be destroyed by range livestock even at times when little or no feeding was being done on the foliage of established plants. Another point concerns the number of seedlings that would result under natural conditions, and in this connection it seems likely that this would be insufficient to justify deferred grazing primarily for their protection. By artificial assistance the number of seedlings could be increased sufficiently to give this justification, and wherever it becomes desirable to reinstate the stand of sacahuista this method combined with deferred grazing could be employed.

Next in importance of the miscellaneous feeding activities is that of mast, which herein is limited to the feeding on acorns that have fallen. The acorn crop is consumed largely as mast and mostly at about the rate of fall; hence there is no accumulation of acorns on the ground under the trees at any time. The fall of acorns in this area is extended over a period of several weeks, usually beginning early in September and ending in December, so that at no time is there any excessive feeding upon acorns, which elsewhere and under other conditions is known to cause "acorn poisoning" and to result in severe losses of both sheep and goats. With cattle, sheep, and goats in the same pasture, the goats, in all cases, eat a large proportion of the crop of mast, while sheep eagerly seek out most of the remainder. This is fortunate inasmuch as goats are not so susceptible to tannic acid poisoning from eating acorns as are sheep. Should grazing conditions be poor at a time when the fall of acorns is good, goats may do all their feeding on one species of oak, the major portion being of mast and the remainder of browse. When there is much mast a plentiful supply of salt is helpful in guarding against tannic acid poisoning.

The importance of mushrooms as a feed supply may be due to their palatability or to some corrective quality rather than to their ordinary food value. In the case of cows it is certain that feeding on mushrooms requires time out of all proportion to the amount of feed obtained, but with goats there is little time wasted in searching for mushrooms, although they are eaten as a delicacy when found. With cattle it is not known whether this unusual activity is evidence of a depraved appetite or an opportune seeking of an amendment.

All three species of yucca occurring here are readily distinguished, but inasmuch as only one of these is common here no attempt has been made to keep data separately on each one. In general, yuccas are characterized by having perfect flowers (all capable of producing fruit) that usually are large and showy and are arranged in large panicles, by a prominent three-celled, many-seeded fruit, which is dry or in some species fleshy, and by narrow leaves that are thick, mostly stiff and sharp-pointed.

Yucca Treculeana differs from the other two species in having a fleshy fruit and a tall trunk. The fruit is berry-like and hanging and does not open at maturity. In this area its trunk is usually five or six feet high, but in some places may grow to be two or three times as high. Its leaves are from two to nearly four feet long and from one to two inches wide, and are bluish-green, thick, rough, concave, sharp-pointed and brown-margined. Where the flowers can be reached they are eaten by cattle and goats; and in doing so these animals may break off and destroy the whole inflorescence. The plants are protected quite effectively by the stout, sharp points of the spreading leaves, but in times of food scarcity cattle may break through this protection in order to feed on the leaves, beginning at or near their succulent bases. In such manner the younger plants may be destroyed. Cattle occasionally use the trunk of this yucca for a rubbing post.

In the two other species the fruit is dry (capsular) and there is no tall trunk, the caudex being short or entirely underground. In both species the fruit is erect and opens at maturity. In *Yucca glauca* the leaves are about one-fourth inch wide, very thick, stiff, white-margined and sparsely filiferous (having thread-like fibers hanging loose from the leaf margins), while in *Y-rupicola*, by far the most abundant one here, the leaves are markedly wider, usually only relatively firm, often twisted, brown or yellowish-margined, and not at all filiferous. As food plants the lower-growing yuccas are of importance largely because of the palatability of their budding inflorescences, which are sought eagerly by all range livestock. For this reason it is rare for any of the plants in occupied pastures to escape attention at this stage of growth and thus succeed in developing flowers. Thus no opportunity has been afforded to learn by observation whether the flowers of these two species are palatable to range animals, although the probability is that they are. In periods when green forage is scarce the leaves of both species are eaten by cattle and goats, for the more or less whitened bases of the leaves are somewhat succulent and are quite palatable, the remainder being less so. In much the same manner as with sacahuista it is possible for range livestock to exterminate yuccas, but where both sacahuista and yucca are present, the former will be killed out first.

The feeding upon mesquite pods after they have become detached from the tree follows yucca in importance as a miscellaneous feeding activity. In common use the term "mesquite beans" is used to designate the fruit and not the seed of this species. The mesquite tree is common in west-

ern Texas, but on account of its requirement of more depth of soil than usually obtains it is not abundant here, where it is found usually in "mesquite flats," which are relatively level bodies of land at the head of draws or in the valleys where the draws have widened out. As a food supply the pods are the most important part of the mesquite, for usually the yield is abundant and they are highly palatable to all livestock. The pulp of the fruit contains 25 to 30 per cent of grape sugar, and in places some use is made of the pods as human food. The mesquite may fruit two or more times each year, and under favorable conditions the yield of pods may be as much as one hundred bushels to the acre annually. As in other cases where a feed item is in great favor, the goats eat the larger portion of the mesquite pods, while the sheep get the remainder. Under the conditions here the mesquite pods are fed upon by cattle only when they are hanging in the trees.

The eating of mesquite leaves after they have fallen to the ground is an activity of some importance. When these leaves fall more or less intact without having lost all their green color, sheep and goats feed with relish upon them. When the numerous leaflets become detached from the leaf, they are likely to be dry; this condition, together with their smallness in size, discourages livestock from eating them, but, at times, a slight feeding of this nature is done.

The various species of prickly pears, called by the Mexicans, 'Nopal, have in common the features of being perennial plants with a fleshy, jointed and flattened stem; bearing leaves (these are small and fleshy, and soon fall off) only on the young joints and young fruits; bearing spines and barbed bristles (glochids) at areas which are known as areoles, on the joint and fruit; and usually having large yellow flowers that are reddish without. The species here, *Opuntia Engelmanni*, is the common one of southern and southwestern Texas, and is a characteristic feature of the range. This is a plant of bushy growth having large joints, which are usually over six inches broad but somewhat small here, and a large fruit that is nearly two inches long and is red and succulent. The areoles are distant and become large and bulging, and each bears numerous glochids, which are brown with yellowish tips, and usually three or four spines that are more or less white and with dark red or brownish base, the larger ones much flattened and the longest two inches in length.

The young joints and the buds of the prickly pear are eaten by cattle and goats while the leaves are still there and before there is a development of glochids and spines to hinder their doing so. Likewise in times of drought the mature fruit is eaten by goats and the mature joints are eaten both by cattle and by goats. While the latter feeding is done somewhat laboriously, not infrequently the lower areoles are free from spines and here a successful attack may be made upon the joint. Usually the joint must be torn loose from the plant before much progress towards eating it can be made, and frequently the spine-bearing areoles may be rejected without much loss of material desirable as feedstuff.

When leaves of the oaks fall while still more or less green, goats feed on them to some extent. With the live oak, in which the leaf-fall is gradual and prolonged in time, these leaves are scattering and are eaten more or less incidentally while goats are grazing near the thickets. While goats may eat all the green leaves that are lying on the ground, it is not often that they devote continuous periods of time to feeding alone upon them. Because of the fact that shin oak leaves usually are dry and discolored at the time of their fall, they are eaten only to a more limited extent.

The tasajillo, *Opuntia leptocaulis*, is one of the cane cacti. It is a shrubby plant with slender, cylindric, and ascending branches, which are thickly set with short, usually spineless joints standing off nearly at right angles to the main branches and very easily detached. The spines are usually solitary, except at the older areoles, are loosely covered with a papery sheath, and are from less than one to two inches long. The flowers are small, three-fourths inch or less in diameter, and are greenish-yellow. The fruit also is small, one-half inch or so long, scarlet and but slightly fleshy and delightfully flavored. The buds, fruits, and joints of tasajillo are eaten by goats, and, where not abundant, the plant is not especially objectionable even though the long spines are very offensive. In some sections there is a tendency for this species to form dense and impenetrable thickets, and in such cases it should be eradicated wherever possible.

Table 7.—Average of the classes of miscellaneous feeding of range livestock in minutes and in percentages of the total miscellaneous feeding.

Class of Miscellaneous Feeding	Minutes Daily			Percentages of Total Miscellaneous Feeding		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Sacahuista.....	61.2	27.3	6.2	96.29	92.68	29.98
Mast.....		1.9	8.5		6.46	41.40
Mushrooms.....	1.6		x	2.53		x
Yucca.....	.6	x	1.6	.92	.01	7.77
Mesquite pods.....		.1	1.3		.28	6.51
Mesquite leaves.....		.1	1.3		.57	6.40
Prickly pear.....	.2		1.0	.26		4.86
Oak leaves.....			.4			1.91
Tasajillo.....			.2			1.16
Echinocereus paucispinus.....			x			.01
Total.....	63.6	29.4	20.6	100.00	100.00	100.00

x—Indicates trace.

The flowers of another cactus, *Echinocereus paucispinus*, are fed upon to a slight extent by goats. Two other species of this genus occur here, but the one named is in greater abundance than the others. In general these cacti have a thick, spiny, short, or long-cylindric stem with the spine-bearing areoles on vertical ribs. In some of the species, as in the one named, the plant is branched so that it presents a mass as much as a foot or more in diameter of stems some 3 inches in diameter. The flowers are bright-colored and are borne on the side some distance from

the top, and the fruits are spiny and edible. This particular species is characterized by having five to seven ribs; by having areoles, remote, each with three to six stout radial spines an inch or so long and usually no central spine, or sometimes one; and by having showy scarlet flowers that are open day and night. Soon after the fruit ripens it disappears; so it is likely that birds or other wild animals feed upon it.

Data Relative to the Classes of Miscellaneous Feeding: The data are given showing the average number of minutes daily devoted to each class of miscellaneous feeding and the percentage of the total miscellaneous feeding each one supplies to cattle, sheep, and goats. Cattle spend more than twice as much time as do sheep and more than three times as much time as do goats at miscellaneous feeding. This is due to the great amount of feeding they do upon sacahuista during the winter months and periods of drought.

GENERAL DISCUSSION OF SUPPLEMENTARY FEEDING

At certain times it is necessary to supply to range livestock feed additional to that which they procure through their own efforts from the range, and this extra feeding, of whatever nature it may be, constitutes supplementary feeding. Under favorable conditions some or all of the supplemental feedstuffs may be produced on the ranch where used; but to the extent that this cannot be done or is not done, when there is necessity for their use, they are purchased. Where any extensive use of purchased feedstuffs is required it forms the most expensive part of the feeding activities of livestock that run on the range.

The extent and nature of the supplementary feeding varies from season to season and from ranch to ranch from rather a large to a little or no use at all. Perhaps it is the general practice to avoid supplemental feeding to the greatest possible extent, which is not always a sound policy. The advisability of giving range animals extra feed does not depend upon an actual necessity of doing so, inasmuch as this condition takes in consideration only one desire, that of keeping the animals themselves alive. Rather the advisability depends upon whether the resultant increases in the crops that the animals produce promise to be sufficient to justify the added care and expense involved. It is believed that this would be true much more generally than has been recognized. The larger use of supplemental feedstuffs as an insurance of healthier animals and of the corresponding increase in their production of wool and mohair or of calves, lambs, and kids, is to be commended.

On account of the limited area of land in this vicinity suitable for farming there is an insufficiency of cultivated feedstuffs in this section, and, moreover, other supplies are located at considerable distances. The situation here involves hauls of eighty miles in one direction and one hundred miles in another from railway points, the nearest sources of supplies for purchased feedstuffs, and such long hauls materially increase the cost of hay, grain, and cottonseed cake over the purchase

price, even sometimes to the extent of doubling it. The actual values of purchased feedstuffs at delivered prices may vary from year to year; it may therefore be practicable to feed one feedstuff in certain years and another in others. Ordinarily under these conditions the greatest value is obtained through the purchase of cottonseed cake, and on many ranches it is the only supplemental feedstuff purchased.

At the Ranch Experiment Station, in addition to cottonseed cake, there is considerable hay and grain (chiefly oats) purchased, while some roughage and grain are grown and utilized in supplementary feeding. However, only a smaller portion of the supplemental feedstuffs goes to the animals in the pastures, the major portion going to those in the traps, corrals, and barns or to those in enclosures or lots in which experimental work is being conducted. Thus it is somewhat usual to separate from the others those animals that show the greatest need for supplementary feeding in order that they may receive this extra attention more efficiently while permitting the other animals to remain in the pasture without any extra feeding, or at least without the same until a more urgent need develops. Therefore, the maximum extent to which supplementary feeding is used here is not indicated in the data herewith. On the other hand, the registered flocks (the observations of sheep and goats were made on registered animals) receive more of this extra supply of feed than do the grade flocks, a circumstance causing the data to show a greater amount of supplementary feeding than would generally obtain on the ranches of this section, where such feedstuffs are both scarce and expensive.

There is no expectation that all of any one year will be so highly favorable that supplementary feeding will become impracticable or undesirable, and so it is that these data show more or less such feeding in each one of the three years they were collected. Since the nature of the supplementary feeding was somewhat different each year, the relative importance of the various supplemental feedstuffs is largely a matter of circumstances. However, as a record of what has been done and possibly some indication of what may be done in the years to come, the discussion is confined to the supplementary feedstuffs noted in these data, and these are treated in the order of importance as shown by the three-year average per cent of the total feeding activity. However, the table of data following this discussion will be based on percentages of the total supplementary feeding.

Description of Classes of Supplementary Feeding

Hay is the leading supplemental feedstuff. Nearly all of it is purchased and has to be hauled eighty miles before it can be used. Usually it is alfalfa or of mixed alfalfa and Johnson grass, but at times a little straight Johnson grass hay is used. While none of the hay is fed to cattle and but little to the sheep and goats in the pastures, the latter put in considerable time on it when it is so fed, and, in general, stay

with it until every stray piece has been picked up. At times it has happened that other animals have been fed hay in a pasture and have left more or less of it when their wants were satisfied, and it is usual at such times for the sheep and goats to come along and pick up all the remnants. This is especially true where the hay is alfalfa. In picking up these remnants very likely they spend more time than did the other animals at the original feeding. It may be said that hay is very desirable as a supplemental feed, but it is so bulky that its cost, where long hauls are involved, precludes it from the general use that it merits as such.

Another roughage, fodder, is next in importance as a supplemental feedstuff, and for cattle it is first in importance. The fodder used is home-grown, and generally consists of the stalks and foliage of the grain sorghums, more particularly feterita and hegari, harvested after the heads have been removed. Where sorgo has been used the heads are not removed, but usually this crop is intended and is used for making into ensilage. While it is not fed to sheep or goats, these animals pick up the remnants, if any, left by the cattle, and so occasionally they may spend considerable time at eating fodder.

Bulk is essential in the ration and serves to make the concentrates more effective; therefore when feeding concentrates the animals should be given access to roughage either from the range or in the form of hay, fodder, or hulls.

Where long hauls are involved, cottonseed cake generally proves to be the cheapest and best concentrate to purchase. Although here it is hauled one hundred miles, a considerable quantity is used each year. In times of drought it is fed to all breeding stock, while at other times it is fed to those animals that seem to need more feed than they are able to get from the range. When fed in the pastures, the cottonseed cake is usually strung out in a thin stream on the ground, and this is done quickly in order that all animals may have somewhat of an equal chance to get their share of the feed. Usually in four or five minutes the cottonseed cake will be gone, but at times some of the animals will remain as much as an hour longer seeking stray pieces of it, and they even will lick up the dirt where very small pieces have fallen. When fed in the lots or corrals cottonseed cake is placed in troughs.

The spineless prickly pear, *Opuntia Ellisiana*, is similar to the native species, except that it has no spines. However, it does have glochids in the areoles on or near the edges of the joints and on the fruits; for this reason it is desirable to handle the joints with gloves. Whereas the two or three species of spineless prickly pears from tropical or semi-tropical regions are not adapted to the conditions here, this particular species is so adapted. At the Ranch Experiment Station there is a field of eight acres devoted to growing this cactus. After four seasons of growth the yield of green forage was at the rate of 60 to 70 tons to the acre. This cactus was fed to a small extent in 1925 and to a larger extent in 1926, and is likely to be used to a greater extent in the future. The joints are

eaten by cattle without further preparation, but for sheep and goats it is desirable to cut them up in smaller pieces. Even then sheep do not readily feed upon this material unless they previously have acquired a taste for it. In times when succulent green forage is scarce, the spineless prickly pear should prove to be a valuable supplemental feedstuff.

In only one winter of the three has ensilage been used. Then it was fed to sheep and goats in connection with the feeding of cottonseed cake, the feeding being done in troughs. The value of ensilage is very well known, but here, where there is a haul of nearly three miles from the field to the silo, it is a somewhat expensive feedstuff; hence it is probable that less rather than more reliance will be placed in the future on ensilage as an insurance of a food supply for periods of drought.

Bone meal was fed to a small extent in 1925 and at times in 1926, towards the latter part of which year the feeding was continuous. Usually it has been supplied to the animals by placing it in one-half of the salt trough, the other half being filled with salt. At times it has been noted that more of the bone meal than of the salt is taken, while at other times it is not touched. It is somewhat of a problem to get all the animals, especially those that need the mineral matter most, to eat the bone meal. Possibly it may be better to supply a mixture of salt and bone meal for use in the salt trough in order to insure that all the animals will get some of the latter. It has been found that the cheapest grade of bone meal is to be preferred, the animals seeming to like it the better the more odor it has. The importance of bone meal as a supplemental feed for range livestock should be recognized to a much greater extent than is now the case, for its proper use will guard against a mineral deficiency in the diet of the animals and therefore make for stronger and better livestock.

Table 8.—Average of the classes of supplementary feeding of range livestock in minutes and in percentages of the total supplementary feeding.

Class of Supplementary Feeding	Minutes Daily			Percentages of Total Supplementary Feeding		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Hay.....		6.7	4.6		64.84	46.02
Fodder.....	4.9	.1	2.6	56.98	1.07	25.78
Cottonseed cake.....	2.0	3.0	1.7	23.26	28.96	16.84
Spineless prickly pear.....	1.2	.1	.5	13.95	.54	4.99
Ensilage.....		.4	.5		4.06	5.54
Bone meal.....	.5	.1	.1	5.81	.53	.83
Total.....	8.6	10.4	10.0	100.00	100.00	100.00

Data Relative to the Classes of Supplementary Feeding: The data are given showing the average number of minutes daily devoted to each class of supplementary feeding and the percentage of the total supplementary feeding each one supplies to cattle, sheep, and goats. As the sheep and goats were registered animals, they received more attention in the way of supplementary feeding than would have been the case

ordinarily with grade flocks, and likewise they received more supplemental feedstuffs than did the cattle. On the average approximately 10 minutes daily is devoted by the range livestock here to the various classes of supplementary feeding.

Table 9.—Summary of the feeding activities of range livestock in minutes and in percentages of the total feeding.

Feeding Activity	In Minutes			In Percentages		
	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Curly mesquite grass	273.7	166.5	67.5	59.32	41.96	19.22
Weeds	31.8	75.1	27.8	6.89	18.93	7.91
Other grasses	38.1	30.3	10.6	8.26	7.64	3.02
Winter annual grasses	6.6	45.1	28.2	1.43	11.36	8.03
Grazing	350.2	317.0	134.1	75.90	79.89	38.18
Live oak	25.0	27.6	102.4	5.42	6.95	29.16
Ill-scented sumac	6.3	11.0	27.9	1.36	2.77	7.94
Shin oak	5.1	.2	33.5	1.10	.05	9.54
Catclaws	x	.9	4.3	x	.23	1.22
Wild plum	x	.1	5.0	x	.03	1.42
Small-leaved sumac			4.6			1.31
Coral bean		.1	2.9		.02	.83
Mesquite	1.4	x	x	.30	.01	.01
Lote bush			2.3			.65
Mexican persimmon	1.1		x	.23		x
Forestiera	x	x	1.9	x	x	.54
Bumelia			.4			.11
Colubrina	x		.2	.01		.06
Mexican buckeye	.1		.1	.02		.03
Hackberry	x	.1	.1	.01	.02	.03
Evergreen sumac			.1			.03
Juniper			.2			.06
Agrito			.3			.08
Joint-fir			.1			.02
Prickly ash			.1			.02
Honeysuckle			x			.01
Condalia spathulata			.1			.02
Eysenhardtia texana			x			.01
Browsing	39.0	40.0	186.5	8.45	10.08	53.10
Sacahuista	61.2	27.3	6.2	13.27	6.88	1.77
Mast		1.9	8.5		.48	2.42
Mushrooms	1.6		x	.35		.01
Yucca	.6	x	1.6	.13	x	.46
Mesquite pods		.1	1.3		.03	.37
Mesquite leaves		.1	1.3		.03	.37
Prickly pear	.2		1.0	.04		.29
Oak leaves			.4			.11
Tasajillo			.2			.06
Echinocereus paucispinus			x			.01
Miscellaneous	63.6	29.4	20.6	13.79	7.42	5.87
Hay		6.7	4.6		1.69	1.31
Fodder	4.9	.1	2.6	1.06	.02	.74
Cottonseed cake	2.0	3.0	1.7	.43	.76	.49
Spineless prickly pear	1.2	.1	.5	.26	.02	.14
Ensilage		.4	.5		.10	.14
Bone meal	.5	.1	.1	.11	.02	.03
	8.6	10.4	10.0	1.86	2.61	2.85
Total feeding	461.4	396.8	351.2	100.00	100.00	100.00

x—Indicates trace.

WHAT THE RANGE LIVESTOCK FEED UPON

In the data already presented the percentages in each general class of feeding have been based on the total feeding of that class, and to the extent that these various classes vary in proportion to the total feeding, to that extent the values of the constituent activities of the different classes are not comparable. In order to make these constituent activities comparable with each other it is necessary to show the percentages based upon the total feeding activity, and this is done in Table 9. The data for each separate feeding activity are shown in this tabulation, indicating to what extent each one is utilized by each of the three types of range livestock.

It is seen that goats feed to a greater or less extent of each one of the listed feeding activities. In all of the grazing activities their interest in each is exceeded by either sheep or cattle or by both of them; in all but two of the browsing activities, feeding on mesquite and Mexican persimmon, they do more feeding than either cattle or sheep. In the miscellaneous feeding activities this is likewise the case, the goats doing less feeding on sacahuista than do either cattle or sheep and less feeding on mushrooms than do cattle; while in supplementary feeding there is but one activity at which they exceed either cattle or sheep, and this is the feeding on ensilage. In regard to the use made of the four more important separate feeding activities, goats feed on curly mesquite grass approximately one-third as much as do cattle and one-half as much as sheep; on live oak they feed about five times as much as do either cattle or sheep; on sacahuista they feed about one-eighth as much as do cattle and one-fourth as much as do sheep, and on weeds they feed more than do cattle and less than half as much as do sheep. Of the 42 separate feeding activities cattle feed to some extent on 23, sheep on 24, and goats on all.

PERCENTAGE OF DRY MATTER UTILIZED BY TYPES OF RANGE LIVESTOCK

Attention has been called to the fact that cattle, sheep, and goats are pastured on the same range. Carefully kept records on six of the pastures for the three years of these observations show that of the total dry matter consumed by the range livestock in these pastures 44.22 per cent was by cattle, 35.76 per cent by sheep, and 20.02 per cent by goats. By making use of these figures, the percentage of the entire feed supply of the range livestock that each class of feeding activities accounts for is readily tabulated. The same is true, of course, for each separate activity, and therefore the relative importance of each under the system of range management in use is indicated. The tabulation showing the per cent of dry matter consumed by the range livestock will be given first.

Table 10 shows that a little more than two-thirds of the total feeding of all the range livestock consisted of grazing, less than one-fifth con-

sisted of browsing, about one-ninth consisted of miscellaneous feeding, and about one thirty-fourth consisted of supplementary feeding.

Table 10.—Three-year average of classes of feeding activities under the system of range management obtaining.

Type of Livestock	Class of Feeding Activities				Per Cent of Dry Matter Consumed by Range Livestock
	Grazing	Browsing	Miscellaneous	Supplementary	
Cattle.....	32.52	3.99	6.68	1.03	44.22
Sheep.....	28.03	3.64	2.86	1.23	35.76
Goats.....	7.03	10.83	1.49	.67	20.02
Per cent of total feeding...	67.58	18.46	11.03	2.93	100.00

Under the system of range management used it is shown in Table 11 that curly mesquite grass supplied approximately 45 per cent of the forage, live oak 11 per cent, weeds 11 per cent, and sacahuista 9 per cent, with the remaining portion divided among thirty-eight other feeding activities.

Table 11.—Percentage of the total feeding of the range livestock of the Ranch Experiment Station devoted to the individual feedstuffs.

Feeding Activities	Cattle	Sheep	Goats	Total
Curly mesquite grass.....	26.23	15.01	3.85	45.09
Weeds.....	3.05	6.77	1.58	11.40
Other grasses.....	3.65	2.73	.60	6.98
Winter annual grasses.....	.63	4.06	1.61	6.30
Grazing.....	33.56	28.57	7.64	69.77
• Live oak.....	2.40	2.49	5.84	10.73
• Ill-scented sumac.....	.60	.99	1.59	3.18
• Shin oak.....	.49	.02	1.91	2.42
• Catclaw.....	x	.08	.24	.32
• Wild plum.....	x	.01	.28	.29
• Small-leaved sumac.....			.26	.26
• Coral bean.....		.01	.17	.18
• Mesquite.....	.13	x		.13
• Lote bush.....			.13	.13
• Mexican persimmon.....	.10		x	.10
• Forestiera.....	x	x	.11	.11
• Bumelia.....			.02	.02
• Colubrina texensis.....	.01		.01	.02
• Mexican buckeye.....	.01		.01	.02
• Hackberry.....	x	.01		.01
• Evergreen sumac.....			.01	.01
• Juniper.....			.01	.01
• Agrito.....			.01	.01
• Joint-fir.....			.01	.01
• Prickly ash.....			.01	.01
• Honeysuckle.....			x	x
• ConDALIA spathulata.....			x	x
• Eysenhardtia texana.....			x	x
Browsing.....	3.74	3.61	10.63	17.98
• Sacahuista.....	5.87	2.46	.36	8.69
• Mast.....		.17	.49	.66
• Mushrooms.....	.15		x	.15
• Yucca.....	.06	x	.09	.15
• Mesquite pods.....		.01	.08	.09
• Mesquite leaves.....		.01	.07	.08
• Prickly pear.....	.02		.06	.08
• Oak leaves.....			.02	.02
• Tasajillo.....			.01	.01
• Echinocereus paucispinus.....			x	x
Miscellaneous.....	6.10	2.65	1.18	9.93

Table 11.—Percentage of the total feeding of the range livestock of the Ranch Experiment Station devoted to the individual feedstuffs—Continued.

Feeding Activities	Cattle	Sheep	Goats	Total
Hay.....		.60	.26	.86
Fodder.....	.47	.01	.15	.63
Cottonseed cake.....	.19	.27	.10	.56
Spineless prickly pear.....	.11	.01	.03	.15
Ensilage.....		.04	.03	.07
Bone meal.....	.05	x	x	.05
	.82	.93	.57	2.32
Total.....	44.22	35.76	20.02	100.00

x—Indicates trace.

SUMMARY AND CONCLUSIONS

Cattle spend approximately 10 per cent of the day in travel, sheep 13 per cent, and goats 19 per cent, which is equivalent in time to 85 minutes for cattle, 107 minutes for sheep, and 148 minutes for goats. The average daily travel of cattle is 3.3 miles, of sheep 3.8 miles, and of goats 6.0 miles.

The time occupied in the feeding activity of range livestock usually equals or exceeds that used in all their other activities, and in percentages of the animal day is approximately 56 per cent for cattle, 50 per cent for sheep, and 46 per cent for goats, and in time, 461 minutes for cattle, 397 for sheep, and 351 for goats.

When salt is available all range livestock commonly do some licking of salt each day; the average percentage is approximately one per cent for cattle and one-third of one per cent for sheep and goats, which is equivalent to a time of nearly eight minutes for cattle and less than three minutes each for sheep and goats.

In percentages of the day used for drinking water the averages are for cattle ten thirty-fourths of one per cent, for sheep ten seventy-sixths of one per cent, and for goats ten eighty-thirds of one per cent, the equivalents in time being 2.4 minutes for cattle, 1.0 minutes for sheep, and .9 minute for goats.

Usually all range livestock in the course of the day will lie down to rest, and frequently there may be repetitions of this action. In percentages of the animal day given approximately the average resting for cattle is 12.5 per cent and for both sheep and goats more than 15 per cent, and in time 102 minutes for cattle, 122.5 minutes for sheep, and 121.5 minutes for goats.

Inasmuch as the data for rumination include only that done while the animal is not lying down, there is no indication of her total rumination, which is several times greater than is shown. Approximately 9 per cent of the day is spent by cattle, 10 per cent by sheep, and 11 per cent by goats at ruminating while standing, the equivalents in time being 76 minutes for cattle, 78 minutes for sheep, and 83.5 minutes for goats.

At idling approximately the average percentages of the animal day

spent by cattle are 10 per cent, by sheep 11 per cent, and by goats 8 per cent, the equivalents in time being 83 minutes for cattle, 86 minutes for sheep, and 61 minutes for goats.

Grazing forms more than three-fourths of the total feeding of cattle and sheep and one-third the feeding of goats. Four groups of plants are included in this category, of which one, the curly mesquite and buffalo group, supplies of the total grazing from 50 per cent for goats to 78 per cent for cattle.

Browsing forms approximately one-twelfth of the total feeding of cattle, one-tenth of the total feeding of sheep, and more than one-half the feeding of goats. Twenty-three species or groups of species are recognized separately as browsing activities, of which the live oak supplies more than one-half of the browse for cattle, sheep, and goats. Other browse plants of major importance are the ill-scented sumac, which is a favorite browse plant for sheep and cattle and ranks third in importance for goats, and the shin oak which is important as a browse plant for cattle and goats but not for sheep.

The miscellaneous feeding activities form approximately 14 per cent of the feeding of cattle, 7 per cent of the feeding of sheep, and 6 per cent of the feeding of goats, but at times, when grazing and browsing conditions are poor, this class of feeding is of major importance. Of the miscellaneous feeding sacahuista supplies approximately 96 per cent to the cattle, 93 per cent to the sheep, and 30 per cent to the goats.

Supplementary feeding forms from about one thirty-fifth to one fifty-fourth of the total feeding, and varies in extent and nature from time to time. The importance of the various supplemental feedstuffs depends upon whether they are made available to the range livestock and the extent to which this is done.

The pasture records for these years show that of the total feeding 44.22 per cent was done by cattle, 35.76 per cent by sheep, and 20.02 per cent by goats. Using these figures, we show that of the total feeding of range livestock approximately 70 per cent was of grazing, 18 per cent of browsing, 10 per cent of miscellaneous feeding, and 2 per cent of supplementary feeding.

Likewise under the above percentages of the total feeding of range livestock, the four feeding activities of most importance were as follows: grazing on curly mesquite grass, which supplied approximately 45 per cent of the feedstuffs; grazing on weeds, which supplied 11 per cent; browsing on live oak, which supplied 11 per cent; and feeding on sacahuista, which supplied 9 per cent.

As has been pointed out, cattle, sheep, and goats have different preferences in feeding on range vegetation, and therefore to graze heavily with one type of livestock and lightly or not at all with the other types has two consequences. On the one hand, certain portions of the range vegetation will be utilized slightly or not at all, while, on the other hand, other portions will be utilized excessively. This latter condition will

result in a deterioration of the vegetation so used and of the range as a whole.

Not only the destruction of certain plants, but also the encroachment of others may result in deterioration of the range. This is obvious in various particulars, but particularly is noticeable in the erosion of soil and its occupancy by harmful weeds where the grass cover has been destroyed, by the extermination of sacahuista and yucca and of certain palatable herbaceous plants, and by the encroachment of woody plants and weeds, such as needle grass and broom weed, where these plants are not kept in check by pasturing the type of livestock that does feed upon them.

Continuous grazing, where any full use is made of the range, reduces the carrying capacity of that range. It is desirable to permit grasses and weeds, or other desirable plants, to reproduce themselves, and this is done most satisfactorily in giving the various pastures a rest at times when these plants are flowering and fruiting.

The division into pastures of one or two sections in area where only one location of water supply is provided is advisable; otherwise there will be over-grazing near this supply and under-grazing away from it. Also, livestock will abstain from taking water regularly when they have to travel a mile or more to reach the supply. Moreover, the division into smaller pastures permits the practice of giving a rest to a portion of the range, and of giving a change of range for certain herds or flocks, or a separation of classes within a type of livestock; all of which can be made a means for improvement of the range.