Measuring Consumption and Digestibility of Winter Range Plants by Sheep

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INTRODUCTION

EXTENSIVE areas of desert range in the intermountain area are the sole source of forage for sheep during the winter grazing season. The diversity in soil, climate, and topography provides a variety of native forage for grazing animals, and the nutritive content of the diet varies widely depending upon environmental conditions, and animal selectivity for various species and parts of plants.

Thus, a knowledge of the nutritive qualities of native forage plants is of extreme importance for a better understanding and appraisal of the animal's diet under range conditions.

Most studies of the nutrients supplied by range forage have dealt with chemical analyses of bulk samples of herbage collected from the range. However, chemical content is not a reliable index to availability of the various nutrients and is of limited value unless accompanied by digestibility determinations or balance trials.

For this reason a method for determining digestibility of native forage under range conditions was developed and used in obtaining the data presented in this paper.

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REVIEW OF LITERATURE

Little attention has been devoted to digestibility determinations of the separate nutrients in range forage. Kennedy and Dinsmore (1909) in their early work on digestibility of range forage found that feeding native forage plants to animals in digestion crates did not adequately evaluate the diet under range conditions. They found that sheep when fed in crates did not show the normal selectivity for plants or portions of plants and frequently they did not eat adequate amounts for a maintenance ration.

Feeding trials in California (Hart et al., 1932), dealing with digestibility of range forage in the late stage of maturity, showed negative values for crude protein digestibility and lambs ate only one pound of the forage daily, indicating a low palatability of the collected material.

A limited number of digestion trials dealing with mature range forage (grasses and forbs) indicate that this type of herbage is much inferior to alfalfa and grass hays in feeding value (Catlin, 1925; Guibert et al., 1944).

It has long been recognized that digestion coefficients could be determined and feed intake calculated for animals grazing on the range if an indicator plant constituent could be found. This indicator constituent should appear normally in the
plant and be indigestible so that it may be recovered in the feces. Animals can then be equipped with fecal bags and allowed to select their forage in a normal manner.

For practical purposes, lignin meets this requirement as shown by Ellis et al. (1946), Forbes and Garrigus (1948), and Forbes et al. (1946). However some controversy has arisen over the validity of the assumption that lignin is not digested (Bondi, 1948; Crampton et al., 1938; Csonka et al., 1929; Davis et al., 1947; Forbes et al., 1948). Reports by Ellis et al. (1946) and Forbes et al. (1946) stated that many of the discrepancies concerning the digestibility of lignin might be attributed to the chemical procedures used to isolate it from the feeds and feces, and failure to analyze material comparable to that actually being consumed by the animal. In the studies by Ellis et al. (1946); Forbes et al. (1946); and Chi (1951) it was shown that the digestibility of lignin fluctuated slightly above and below zero and the average approached zero.

Gallup (1929) and Gallup et al. (1931) suggested that naturally occurring silica in feed could be used as an indicator or tracer substance for determining digestibility of nutrients by grazing animals. However Knott (1936) found that silica was unsatisfactory because of the dirt that may be incorporated in the feed. The use of naturally occurring iron substances as an index for determining digestibility also was found to be subject to considerable error.

Reid et al. (1950) suggested that chromogens (plant pigments absorbing light at a wavelength of 406 millimicrons) could be used as indicator substances for certain plant species. However, studies in Utah (Cook et al., 1951) have shown that this method is unsatisfactory for desert range plants, especially those high in ether extract and essential oils. Fecal material from these plants contained considerably less chromogen substance than the original plant which in turn indicated a negative digestion coefficient for all nutrients.

Although the recovery of forage lignin in the feces shows a slight variability, the lignin-ratio technique is sufficiently accurate to make it of practical value for determining digestibility of range forage. Digestion coefficients for any particular species varies with environmental conditions, stage of plant maturity, animal selectivity, site and soil conditions, species of animal, age of animal, plane of nutrition and nutritive balance of the diet. In spite of these variabilities, digestion coefficients are considered the most feasible means of obtaining information on nutrient value of native forage plants and predicting nutritive deficiencies of range forages. Knowledge of the plants from the standpoint of nutrition is important to the land manager so that he can point his management toward maintaining desirable species in a productive state of vigor. In addition, such information is useful in compounding supplements best suited for various range types.

**METHOD AND PROCEDURE**

Since there is no standard method for direct determination of nutrient digestibility in range forage, it was believed that a sound approach to measuring the nutritional value of the native forage plants was to allow the animals to select the forage normally and, by the lignin-ratio technique, to determine digestion coefficients.

Hence, such determinations were made during the winter grazing season of 1950–51 on desert ranges in northwestern Utah. The area receives approximately nine inches of precipitation annually and supports typical northern-desert shrub vegetation. Dominant plant species are shadscale (*Atriplex confertifolia*), Nuttall
saltbush (*Atriplex nuttallii*), winterfat (*Eurotia lanata*), big sagebrush (*Artemisia tridentata*), black sage (*Artemisia nova*), and squirreltail grass (*Sitanion hystrix*).

The diversity in soil types, topography, and salt content of the soil solution causes great variability of native forage even on local areas. Forage types vary from a few acres dominated by a single species to large areas of complex mixtures.

Digestion trials were conducted on both pure species and mixtures of various species. The procedure consisted of collecting feces from seven wethers that grazed temporary enclosures. These areas averaged approximately four acres in size (Fig. 1A). The wethers were of Rambouillet and Columbia breeding and were raised on the range from birth.

Digestion trials were conducted on both pure species and mixtures of various species. The procedure consisted of collecting feces from seven wethers that grazed temporary enclosures. These areas averaged approximately four acres in size (Fig. 1A). The wethers were of Rambouillet and Columbia breeding and were raised on the range from birth.

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Digestion trials were conducted on both pure species and mixtures of various species. The procedure consisted of collecting feces from seven wethers that grazed temporary enclosures. These areas averaged approximately four acres in size (Fig. 1A). The wethers were of Rambouillet and Columbia breeding and were raised on the range from birth.
analyzed. The difference in weight between the before-grazing sample and the after-grazing sample served as a quantitative measure of the forage actually eaten and the chemical composition of the after-grazing sample subtracted from the analysis of the before grazing sample served as a measure of the chemical content of the ingested material. Each species included in the diet was weighted by the degree of use and its abundance on the area.

for protein (nitrogen X 6.25), ether extract, lignin, cellulose, ash, other carbohydrates (by difference), and gross energy. The plant samples were also analyzed for calcium and phosphorus. Nitrogen was determined by the Gunning method as outlined by the A.O.A.C. (1945) except that ammonia was collected in boric acid as outlined by Scales and Harrison (1920). Ether extract was determined with a Goldfisch extraction ap-

The sheep were equipped with specially constructed fecal bags (Fig. 2) and allowed to graze in the pastures in a normal manner. The bags were emptied twice daily and placed in 5 gallon jars with tight lids. The feces were weighed at the end of the collection period and a composite sample was taken for chemical analyses. The samples were preserved by freezing until dried. They were dried at 65°C and ground through a Willey mill to pass through a one millimeter screen. Plant and fecal samples were analyzed paratus using an extraction period of 8 hours. Lignin was determined by the method suggested by Ellis et al. (1946), cellulose by the method of Matrone et al. (1946), ash and calcium by the A.O.A.C. method (1945), phosphorus by the method of Koenig et al. (1942) and gross energy by a Parr oxygen bomb adiabatic calorimeter.

RESULTS AND DISCUSSION

In order to manage grazing lands properly it is important to know the nutri-

Fig. 2. A sheep equipped with a specially constructed fecal bag and urinal.
tional qualities and deficiencies of the major forage species. For instance mature grasses are high in energy, yet they are generally deficient in protein and phosphorus on winter ranges. Some browse species may furnish ample amounts of protein and phosphorus, yet be deficient in meeting the energy requirements (Cook et al., 1950). Still other browse plants may appear to meet all of the nutritional requirements from the standpoint of adequate nutrients, yet may be so low in palatability that animals do not consume sufficient quantities for even a maintenance ration.

For these reasons palatability of the various species and weight changes of the sheep during each digestion trial were observed in order to obtain a more adequate appraisal of the forage plants found in each area.

Nutrient Requirements

The National Research Council (1949) has presented recommended nutrient allowances for sheep based upon feed lot practices. These allowances may not be applicable to range animals since more energy is expended to secure feed and to maintain body temperatures. However, they are generally considered standard recommendations for animals to produce efficiently. These allowances are helpful in appraising range forage diets furnished by various species. When these recommended allowances are consumed, expected daily gain for a 140-pound ewe during the first 100 days of pregnancy is 0.12 pounds per day with a dry-matter intake of 4.3 pounds. The diet should supply 0.18 percent phosphorus, 0.23 percent calcium, 5.5 percent digestible protein, and 56 percent total digestible nutrients (energy) on a moisture free basis. With the exception of total digestible nutrients, these allowances may be applied to most range forage with reasonable accuracy.

Total digestible nutrients are determined by multiplying the digestible ether extract by 2.25 because fats composed of fatty acids supply two and one-quarter times more energy than do carbohydrates and proteins. This product is then added to other digestible organic substances in the forage to obtain the total digestible nutrients. However, this cannot be relied upon for range plants having a high content of ether extract since, in some species, from 25 to 40 percent of this fraction is composed of materials other than true fats. These materials, generally, are readily absorbed but may not yield energy for body processes (Maynard, 1947).

Other measures sometimes used for presenting energy values of forages are: digestible dry matter, digestible organic matter, digestible energy, and metabolizable energy.

Digestible dry matter is not a reliable index for energy because of the inclusion of ash which is not a source of energy.

Digestible organic matter appears more suitable as a measure of energy-yielding capacity of range forages. This determination does not give emphasis to the ether extract fraction since fat is not multiplied by 2.25. Neither does it include ash. Although there is no recommended allowance for this determination, an adequate diet should contain approximately 52 percent as compared to 56 percent for total digestible nutrients.

Digestible energy is calculated by determining gross energy values on both forage and feces by the bomb calorimeter and the difference represents digestible energy. This determination is a direct and accurate method for calculating energy values, but is subject to considerable error when plants are high in ether extract material other than true fats.

Metabolizable energy appears to be the best criterion for evaluating the relative nutritive energy of forage (Swift et al.,
Metabolizable energy differs from digestible energy since it considers the energy lost in the urine and gasses in addition to the amount lost in the feces. This method of calculating energy values is sound but the determination requires collection of urine as well as feces and the collection of methane or the estimation of losses through gas by appropriate formulas. Also corrections should be made for nitrogen balance. The authors have collected urine from sheep grazing on the range and it is not considered an insurmountable obstacle in the evaluation of energy in range plants. A method is now being developed to determine metabolizable energy of forage plants under range conditions. Extensive areas throughout the Great Basin area are covered with big sagebrush and associated species. Sheep graze many winter ranges composed of almost pure stands of big sagebrush and these animals receive little forage other than big sagebrush for 5 to 7 months during the winter. Therefore, information concerning the nutrients furnished by this species is of great importance. As shown in Table 1, big sagebrush is high in protein, phosphorus, gross energy, and ether extract material.

The apparent digestion coefficients in sagebrush are rather high for most nutrients (Table 2). The quantity of ether

**Forage Plants Studied**

**Big sagebrush**

Extensive areas throughout the Great Basin area are covered with big sagebrush and associated species. Sheep graze many winter ranges composed of almost pure stands of big sagebrush and these animals receive little forage other than

### TABLE 1

Chemical composition of the forage plants constituting the grazing sheep's diet during digestion trial periods on a dry weight basis

<table>
<thead>
<tr>
<th>PERIOD*</th>
<th>FORAGE SPECIES</th>
<th>DIET</th>
<th>ETHER EXTRACT</th>
<th>TOTAL PROTEIN</th>
<th>LIGNIN</th>
<th>CELLULOSE</th>
<th>OTHER CARBOHYDRATES</th>
<th>TOTAL ASH</th>
<th>CALCIUM</th>
<th>PHOSPHORUS</th>
<th>GROSS ENERGY Cal./kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Big sagebrush</td>
<td>100</td>
<td>17.5</td>
<td>10.9</td>
<td>11.9</td>
<td>17.5</td>
<td>37.3</td>
<td>4.9</td>
<td>0.24</td>
<td>0.237</td>
<td>5481</td>
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<tr>
<td>2</td>
<td>Shadscale</td>
<td>100</td>
<td>2.5</td>
<td>7.6</td>
<td>12.4</td>
<td>16.1</td>
<td>36.1</td>
<td>25.3</td>
<td>1.21</td>
<td>0.090</td>
<td>3706</td>
</tr>
<tr>
<td>3</td>
<td>Winterfat</td>
<td>100</td>
<td>2.5</td>
<td>9.8</td>
<td>8.1</td>
<td>21.9</td>
<td>32.7</td>
<td>25.0</td>
<td>1.24</td>
<td>0.148</td>
<td>3575</td>
</tr>
<tr>
<td>4</td>
<td>Nuttall saltbush</td>
<td>100</td>
<td>1.6</td>
<td>6.6</td>
<td>10.1</td>
<td>19.8</td>
<td>39.7</td>
<td>22.2</td>
<td>1.39</td>
<td>0.093</td>
<td>3586</td>
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<tr>
<td>5</td>
<td>Winterfat</td>
<td>49</td>
<td>2.2</td>
<td>8.8</td>
<td>9.7</td>
<td>21.0</td>
<td>29.6</td>
<td>28.7</td>
<td>1.25</td>
<td>0.130</td>
<td>3416</td>
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<tr>
<td>6</td>
<td>Big sagebrush</td>
<td>51</td>
<td>16.2</td>
<td>12.5</td>
<td>11.8</td>
<td>18.6</td>
<td>35.8</td>
<td>5.1</td>
<td>0.26</td>
<td>0.255</td>
<td>5406</td>
</tr>
<tr>
<td>7</td>
<td>Shadscale</td>
<td>78</td>
<td>2.2</td>
<td>7.7</td>
<td>11.9</td>
<td>15.9</td>
<td>35.5</td>
<td>26.8</td>
<td>1.24</td>
<td>0.091</td>
<td>3491</td>
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<tr>
<td>8</td>
<td>Black sage</td>
<td>100</td>
<td>11.1</td>
<td>8.2</td>
<td>16.1</td>
<td>25.4</td>
<td>34.1</td>
<td>5.2</td>
<td>0.32</td>
<td>0.152</td>
<td>5100</td>
</tr>
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<td>9</td>
<td>Squirreltail grass</td>
<td>100</td>
<td>2.2</td>
<td>3.1</td>
<td>8.3</td>
<td>40.4</td>
<td>29.0</td>
<td>17.0</td>
<td>0.37</td>
<td>0.057</td>
<td>3785</td>
</tr>
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<td>10</td>
<td>Alfalfa hay</td>
<td>100</td>
<td>3.2</td>
<td>15.4</td>
<td>7.9</td>
<td>30.6</td>
<td>32.6</td>
<td>10.3</td>
<td>1.51</td>
<td>0.210</td>
<td>5010</td>
</tr>
</tbody>
</table>

* Period one started on Oct. 29 and terminated Nov. 10, whereas, period eight started Dec. 16 and terminated Dec. 28.
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extract in big sagebrush is extremely high and in addition is highly digestible. How-
never it is known that a large percentage of the ether extract is composed of es-
ential oils which are readily digested (Guenther, 1948; 1949). It is generally
believed that these oils do not represent

energy for big sagebrush are compara-
tively high (Table 3). These high figures
are perhaps due to the high content of
essential oils and therefore, are unreliable
as indexes to energy.

Thus ether extract material should be
broken down into its various constituents

TABLE 2

Apparent digestibility and limit of error for nutrients in alfalfa and winter range plants as determined
by the lignin-ratio technique*

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>FORAGE SPECIES</th>
<th>ETHER EXTRACT</th>
<th>TOTAL PROTEIN</th>
<th>CELLULOSE</th>
<th>OTHER CARBOHYDRATES</th>
<th>GROSS ENERGY</th>
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</thead>
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<tr>
<td>1</td>
<td>Big sagebrush</td>
<td>91.2</td>
<td>72.9</td>
<td>37.8</td>
<td>65.1</td>
<td>61.2</td>
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<td></td>
<td></td>
<td>0.8</td>
<td>2.4</td>
<td>4.3</td>
<td>2.2</td>
<td>1.5</td>
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<td>2</td>
<td>Shadscale</td>
<td>37.0</td>
<td>61.2</td>
<td>26.1</td>
<td>62.4</td>
<td>41.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1</td>
<td>0.9</td>
<td>5.8</td>
<td>2.2</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>Winterfat</td>
<td>38.4</td>
<td>64.9</td>
<td>43.6</td>
<td>52.9</td>
<td>45.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.7</td>
<td>3.3</td>
<td>5.7</td>
<td>3.4</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Nuttall saltbush</td>
<td>-75.2</td>
<td>36.7</td>
<td>63.2</td>
<td>52.4</td>
<td>36.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1</td>
<td>3.3</td>
<td>7.1</td>
<td>3.6</td>
<td>0.3</td>
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<td>5</td>
<td>Winterfat and Big sagebrush</td>
<td>82.4</td>
<td>70.7</td>
<td>46.0</td>
<td>53.8</td>
<td>51.4</td>
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<td></td>
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<td>3.5</td>
<td>5.1</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>Winterfat and Shadscale</td>
<td>41.3</td>
<td>61.7</td>
<td>22.0</td>
<td>60.0</td>
<td>37.8</td>
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<td>1.1</td>
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<td>0.6</td>
</tr>
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<td>7</td>
<td>Black sage</td>
<td>68.2</td>
<td>51.1</td>
<td>15.7</td>
<td>56.0</td>
<td>44.9</td>
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<td></td>
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<td>3.3</td>
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<td>8</td>
<td>Squirreltail grass</td>
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<td>57.9</td>
<td>53.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.8</td>
<td>3.0</td>
<td>1.6</td>
<td>2.7</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Alfalfa hay</td>
<td>31.0</td>
<td>70.0</td>
<td>54.7</td>
<td>85.0</td>
<td>55.1</td>
</tr>
</tbody>
</table>

*The limit of error is sometimes expressed as ±\% the 95 percent confident interval.
a diet of any single range shrub for extended periods of time as evidenced by their tendency to graze closely any occasional inferior plant which occurred in pure types. Big sagebrush was perhaps the least palatable of the species studied but was considered a good feed when occurring in minor quantities with other forage plants.

TABLE 3

Dry matter consumed daily and digestibility of alfalfa and various winter range plants found in foraging sheep's diet as determined by the lignin-ratio technique

<table>
<thead>
<tr>
<th>FORAGE SPECIES</th>
<th>SHEEP WEIGHT</th>
<th>WEIGHT GAIN OR LOSS*</th>
<th>DRY MATTER CONSUMED</th>
<th>DIG. DRY MATTER</th>
<th>DIG. ENERGY</th>
<th>T.D.N.</th>
<th>DIG. ORGANIC MATTER</th>
<th>DIG. PROTEIN IN DIET</th>
<th>Pounds</th>
<th>Pet.</th>
<th>Cal/kg.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big sagebrush</td>
<td>151</td>
<td>+0.5</td>
<td>3.28</td>
<td>50.4</td>
<td>3352</td>
<td>74.7</td>
<td>54.8</td>
<td>8.0</td>
<td></td>
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<tr>
<td>Shadscale</td>
<td>150</td>
<td>+1.5</td>
<td>2.93</td>
<td>48.6</td>
<td>1522</td>
<td>33.4</td>
<td>32.3</td>
<td>4.6</td>
<td></td>
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<tr>
<td>Winterfat</td>
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<td>3.16</td>
<td>33.5</td>
<td>1618</td>
<td>35.0</td>
<td>33.8</td>
<td>6.3</td>
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<td>Nuttall saltbush</td>
<td>157</td>
<td>+1.5</td>
<td>3.79</td>
<td>26.7</td>
<td>1290</td>
<td>35.5</td>
<td>35.5</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Winterfat and Big sage-brush</td>
<td>141</td>
<td>-1.5</td>
<td>3.60</td>
<td>40.1</td>
<td>2273</td>
<td>51.3</td>
<td>41.8</td>
<td>7.5</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Winterfat and Shadscale</td>
<td>158</td>
<td>0.0</td>
<td>4.50</td>
<td>43.7</td>
<td>1335</td>
<td>31.8</td>
<td>30.6</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black sage</td>
<td>138</td>
<td>-1.0</td>
<td>3.24</td>
<td>40.7</td>
<td>2315</td>
<td>51.9</td>
<td>42.5</td>
<td>4.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Squirreltail grass</td>
<td>160</td>
<td>+1.5</td>
<td>4.36</td>
<td>48.7</td>
<td>2021</td>
<td>49.3</td>
<td>48.2</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Alfalfa hay</td>
<td>140</td>
<td>+1.0</td>
<td>3.65</td>
<td>62.3</td>
<td>2761</td>
<td>57.5</td>
<td>56.2</td>
<td>10.7</td>
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</tbody>
</table>

* This represents pounds lost or gained during the last 7 days of a 14-day period while feeding upon the plants tested in each period, respectively.

**Shadscale**

This plant is a dominant species of the salt-desert shrub association and is abundant on Utah deserts. It is a spiny browse plant of moderate size and produces an abundance of seed and foliage which furnishes considerable forage for sheep especially during early winter.

This species contained only moderate amounts of most desirable nutrients (Table 1). It furnished only about one-half the phosphorus requirement recommended by the National Research Council (1949). Cellulose was not highly digested which may account for the rather low digestible energy furnished by this species (Table 3). This was likewise reflected in the total digestible nutrients which was 33.4 percent compared to alfalfa hay which furnishes 57.5 percent. The 4.6 percent digestible protein contained in shadscale was lower than the accepted standard of 5.5 percent and less than one-half the amount furnished by alfalfa which was 10.7 percent. In spite of these deficiencies and the fact that sheep consumed less dry matter than for any other species, they gained an average of 1.5 pounds during the collection period.

**Winterfat**

Winterfat is a small, half-shrub found in various amounts on most desert ranges of Utah and is generally considered a valuable forage plant both from the standpoint of palatability and nutrient content. However, as shown in Table 1, it was not outstandingly high in any particular nutrient and, as shown in Table 2, most constituents were only average in digestibility.

The low digestibility of dry matter (Table 3) for this species resulted from the high ash content which was only slightly digested. The values, 35 percent total
digestible nutrients and 33.8 percent digestible organic matter, are considered low but winterfat forage compares favorably with the recommended allowances in other respects. However the animals lost an average of 1 pound during the 7-day collection period and consumed only 3.16 pounds of forage per day. There is no apparent explanation for weight loss during this period since similar animals, on shadscale at approximately the same time, consumed less forage of comparable nutritive value, yet, gained an average of 1.5 pounds.

**Nuttall Saltbush**

This small browse species is abundant on Utah deserts on heavy, alkaline soils. As shown in Table 1, this species is moderately high in carbohydrates and low in protein and phosphorus. In addition the digestibility of protein (36.7 percent) is low resulting in only 2.4 percent digestible protein in the diet. Nuttall saltbush had a high content of ash which was only slightly digested. This accounted for the low digestibility of dry matter. Total digestible nutrients which were 35.5 percent are likewise considered low; however, animals consumed almost 4 pounds of this species daily and gained an average of 1.5 pounds during the 7-day collection period.

Nuttall saltbush was highly relished by grazing sheep, and range managers should be concerned in maintaining this plant in a high state of vigor and production. It should, however, be mentioned that the feces from all sheep became soft before the grazing period was terminated. Animals grazing this plant for extended periods will become scoured and may develop physiological disturbances.

**Black Sage**

This species is sometimes considered a variety of big sagebrush but leaf characteristics and general habitat are sufficiently different to consider them as separate forage plants. The chemical composition shown in Table 1 is similar to that of big sagebrush; however, the coefficients of digestibility for the various nutrients are markedly different. The digestibility of dry matter (40.7 percent) was lower than big sagebrush (50.4 percent) and about the same comparison existed between all other digestion coefficients except for cellulose (Tables 2 and 3). Black sage contained about 8 percent more cellulose than big sagebrush and likewise had a much higher digestion coefficient for cellulose.

Because of the lower digestibility for most nutrients, black sage yielded less total digestible nutrients and less digestible protein than big sagebrush (Table 3). Black sage meets most nutrient allowances except for digestible protein which is slightly lower than recommended. Digestible energy and total digestible nutrients are comparatively high which indicate high energy values; however, the ether extract fraction of this species contains considerable quantities of essential oils which are not considered energy supplying substances to the animal. Therefore, this plant, like big sagebrush, actually may not be a good energy feed.

Black sage generally is considered a good forage plant. It is used rather readily by sheep, especially in mixed stands, and is relatively high in most of the required nutrients.

**Squirreltail Grass**

This grass is widely distributed on desert ranges of the Great Basin area and is considered a valuable forage plant because it generally furnishes some green growth during the winter season. However, the late summer of 1950 was dry and green growth was not available during the present trials.
Even though this grass appeared to be dry and worthless the animals ate it readily. The average daily consumption was 4.36 pounds of dry material and sheep gained an average of 1.5 pounds for the 7-day collection period. As shown in Table 1, both protein and phosphorus were extremely low, being only 3.1 percent and 0.057 percent respectively. However this species was high in cellulose which was highly digestible thus furnishing a large quantity of energy (Tables 2 and 3).

Digestible energy and total digestible nutrients were comparatively high, and in the case of this species, can be considered a reliable index to energy available to the animal because of the low content of ether extract. The energy values (digestible energy, total digestible nutrients, and digestible organic matter) for squirreltail grass are only slightly lower than alfalfa hay and approach the recommended allowances. However protein and phosphorus are seriously deficient and would require supplements for adequate nutrition if animals were to graze this type of forage over extended periods of time.

**Mixed Diets**

Diets composed of mixtures of various species gave digestion coefficients which were about average for the species when grazed individually except for cellulose (Table 2). This explains variability in digestible energy, total digestible nutrients and digestible organic matter (Table 3). During periods 5 and 6 (Table 1) the weather was moderately cold and two light snows covered considerable amounts of winterfat for a day or so and sheep consumed the taller browse species, big sagebrush and shadscale, in each period. Sheep grazing the sagebrush-winterfat area were not satisfied with a sudden change in diet from a mixture of the two species to a pure diet of sagebrush. Therefore during these two brief periods while snow covered winterfat, sheep lost weight. Winterfat was considerably more palatable than big sagebrush but because of restricted use during periods when covered by snow it constituted only about the same proportion as sagebrush in the diet.

During period 6, sheep were grazing winterfat and shadscale and when winterfat was covered with snow they adjusted rather readily from a mixed diet to shadscale alone. Winterfat was more palatable than shadscale but, because of snow, the diet for this period was composed of 78 percent shadscale and only 22 percent winterfat (Table 1). Sheep grazing this mixture maintained their weight and remained in a good state of vigor compared to sheep grazing sagebrush and winterfat at about the same time. Sheep on the sagebrush and winterfat mixture lost weight and appeared restless and in a lowered state of vigor.

**Summary**

A method for determining digestibility of native forage under range conditions was developed and used on desert ranges in northwestern Utah during the winter grazing season of 1950–51. Briefly the method consists of grazing wether sheep equipped with fecal bags in temporary enclosures on both pure and mixed stands of native forage plants.

Forage was sampled both before and after grazing and by difference in weight and chemical analyses the degree of utilization and nutrients ingested were calculated.

By the use of the lignin-ratio technique, daily consumption of dry matter and digestion coefficients were determined.

Big sagebrush furnished an adequate diet for pregnant ewes and compared favorably with alfalfa. However, this
species is high in essential oils which yield high energy values that are not indicative of digestible energy available to the animal. This species was considered the least palatable of the species studied but was believed a good feed when occurring in only minor quantities with other forage plants.

Shadscale was slightly deficient in digestible protein and energy and markedly deficient in phosphorus. However, sheep ate the plant readily on all areas and gained weight during the grazing trials.

Winterfat was not outstandingly high in any particular nutrient and most nutrients were only average in digestibility. However, this species was considered deficient only in energy supplying substances. Winterfat was highly preferred by sheep in all plant mixtures and was readily eaten throughout the season.

Nuttall saltbush was highly relished and animals consumed an average of about 4 pounds per day. This plant was markedly low in phosphorus, furnished less than one-half the protein requirement, and was seriously deficient in energy material. Yet, all animals gained weight during this grazing trial.

Black sage was comparable to big sagebrush in chemical composition but most constituents were not as highly digested. Black sage furnished most of the recommended nutrient allowances except possibly digestible protein which was slightly low. Black sage was moderately palatable and sheep consumed an average of 3.24 pounds of dry matter daily. However, sheep began to tire of a pure diet of this species before the grazing trial ended.

Squirreltail grass was highly relished and sheep consumed an average of 4.36 pounds of dry matter daily. It was extremely low in both digestible protein and phosphorus but comparatively high in energy supplying substances particularly cellulose which yielded a high digestible energy value. In spite of the deficiencies in protein and phosphorus, animals gained weight during the grazing trial.

Diets composed of mixtures of various species gave digestion coefficients which were about average for the species when grazed individually except for cellulose. Animals prefer mixtures to pure diets but when plants vary materially in palatability, animals will graze the more preferred species to the extent that both animal and plant welfare are affected.

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LITERATURE CITED


