us assume that each 10 kg of herbage eaten by jackrabbits is worth a
kg of beef. If beef is worth about
66 cents per kg the value is about
$9.35 per hectare per year (about
$3.70/acre/year). There are about
2 × 10^6 acres of range classified as
“deep sand” and “sandy plains” in
eastern Colorado. Therefore, the
loss of forage to jackrabbits might
have been worth 7.4 million dol-
ners for the years 1968–1970 had
yearling steers been used to har-
vest the forage instead of jackra-
bbits. The value that jackrabbits
contribute to esthetics and hunting
recreation should be subtracted to
obtain a net value of the jackrab-
bbits’ worth to Colorado.

Literature Cited
ARNOLD, J. F. 1942. Forage consump-
tion and preferences of experimen-
tally fed Arizona and antelope jack-
rabbits. Univ. of Arizona Agr. Exp.
ARNOLD, J. F., AND H. G. REYNOLDS.
1943. Droppings of Arizona antele-
lope jackrabbits and the pellet cen-
sus. J. Wildlife Manage. 7:322–327.
COOK, C. W. 1971. Why not say it
the way it is? J. Range Manage. 24:
320–321.
COOK, C. W., AND L. E. HARRIS. 1968.
Nutritive value of seasonal ranges.
Utah State Univ. Agr. Exp. Sta. 
Bull. 472. 55 p.
HANSEN, R. M., AND D. N. UECKERT.
1970. Dictary similarity of some
primary consumers. Ecology 51: 
640–648.

Evaluating Animal Forage Preference

WILLIAM C. KRUEGER
Assistant Professor, Rangeland Resources Program Oregon State 
University, Corvallis.

Highlight

Four relative preference indices were used to rank sheep preference for
twelve plant species in a tall-forb community of a summer range in southwestern
Montana. Ranking of preference values for the plant species was different
by all four indices. Frequency measurements of plant species both in the diet
and on the range were found useful in interpreting forage preference. Diet
frequency values measure consistency of intake while range frequency values
measure plant distribution within a community. These values when incorpo-
rated into a relative preference index increase its sensitivity, but do not sub-
stitute for measurements of diet composition or forage availability on the range-
land studied.

Numerous factors influence pre-
ference of grazing animals for indi-
vidual plant species. Preference
for any plant varies according to
season of use, ecotypic differences,
animal function, changes in plant
community structure, and many
other plant and animal modifiers.
While the interactions of these
preference modifying factors are
important in determining which
plant species a grazing animal will
consume, most of them are not
suitable for inclusion as part of a
relative preference index. Interpre-
tation of preference index values
should integrate numerical values
with other influential factors not
incorporated into the index. Absol-
ute preference index values for
a particular plant species may indi-
cate whether that plant is pre-
ferred or rejected, but the primary
value of preference indices is to
rank various plants with regard to
their palatability under a specified
set of circumstances.

Bartlett (1958) rated palatability
by the difference between utiliza-
tion of a plant and average utiliza-
tion of all plants on the range.
Recognizing the influence of avail-
ability on forage preference, he
computed the palatability index
for high, medium, and low avail-
ability classes, which were ex-
amined independently. Van Dyne
and Heady (1965) developed a
relative preference index (RPI)
which allowed all availability
classes to be considered simultane-
ously. Their index was a ratio of
the percent of a plant in the diet
to the percent availability of the
plant. Chamrad and Box (1968)
modified Van Dyne and Heady’s
index to include frequency of oc-
currence of a plant in the diet.

Diet frequency measurements
can be important in determi-
ning relative preference of animals for
specific plants because the index
then includes not only the quantity
of a plant the animals eat but also
the consistency with which they
select the plant. However, con-
sistency of selection may be influ-
enced by plant distribution, i.e.,
uniformly distributed plants might
be more frequent in the diet than
plants with irregular distribution.
Allowance can be made for this by
using frequency of the plant on the

1 Received for publication October 7, 
1971.
Table 1. Average RPI and relationship of frequency components for twelve plants studied.

<table>
<thead>
<tr>
<th>Species</th>
<th>RPI₁</th>
<th>RPI₂</th>
<th>RPI₃</th>
<th>RPI₄</th>
<th>% frequency in diet</th>
<th>% frequency on range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickleaf groundsel (Senecio crassulus)</td>
<td>47.85</td>
<td>6.08</td>
<td>5.93</td>
<td>48.12</td>
<td>2.79</td>
<td></td>
</tr>
<tr>
<td>Spike trisetum (Trisetum spicatum)</td>
<td>12.71</td>
<td>11.50</td>
<td>7.45</td>
<td>20.16</td>
<td>.96</td>
<td></td>
</tr>
<tr>
<td>Mountain sorrel (Rumex paucifolius)</td>
<td>10.90</td>
<td>3.24</td>
<td>3.07</td>
<td>11.41</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>Yampa (Perideridia gairdneri)</td>
<td>8.39</td>
<td>3.46</td>
<td>1.68</td>
<td>17.21</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>Alpine leafybract aster (Aster foliacus)</td>
<td>4.42</td>
<td>3.13</td>
<td>3.13</td>
<td>4.42</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>Mountain brome (Bromus marginatus)</td>
<td>3.93</td>
<td>3.66</td>
<td>3.66</td>
<td>3.93</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>Pale agoseris (Agoseris glauca)</td>
<td>3.46</td>
<td>2.53</td>
<td>2.13</td>
<td>4.14</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>Alpine timothy (Phleum alpinum)</td>
<td>2.74</td>
<td>2.30</td>
<td>2.15</td>
<td>2.92</td>
<td>1.21</td>
<td></td>
</tr>
<tr>
<td>Western valerian (Valeriana occidentalis)</td>
<td>1.95</td>
<td>1.51</td>
<td>1.11</td>
<td>2.70</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Northwest cinquefoil (Potentilla gracilis)</td>
<td>1.29</td>
<td>1.39</td>
<td>1.25</td>
<td>1.34</td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Mountain knotweed (Polygonum montanum)</td>
<td>.57</td>
<td>.78</td>
<td>.57</td>
<td>.78</td>
<td>.65</td>
<td></td>
</tr>
<tr>
<td>Sticky geranium (Geranium viscosissimum)</td>
<td>.006</td>
<td>.12</td>
<td>.006</td>
<td>.012</td>
<td>.51</td>
<td></td>
</tr>
</tbody>
</table>

RPI₁ = \(\frac{\% \text{ diet frequency} \times \% \text{ diet composition}}{\% \text{ range frequency} \times \% \text{ range composition}}\)

RPI₂ = \(\frac{\% \text{ diet frequency} \times \% \text{ diet composition}}{\% \text{ range composition}}\)

RPI₃ = \(\frac{\% \text{ diet composition}}{\% \text{ range composition}}\)

RPI₄ = \(\frac{\% \text{ diet frequency}}{\% \text{ range frequency}}\)

Methods

The study was conducted on the U.S. Sheep Experiment Station summer range in southwestern Montana within a tall-forb vegetation type. Two esophageally fistulated sheep per pasture were grazed in two separate 0.5 acre pastures. The fistulated sheep were used to collect forage samples for approximately one hour shortly after sunrise for five days during the early summer of 1968.

The fistula samples were analyzed by the microscopic point method under 15x magnification (Van Dyne and Heady, 1965). Plants that could not be identified at this low power were mounted on slides with Hoyer's solution and identified with a compound microscope at 125x magnification (Ward, 1970). One hundred points were examined for each sample to yield percent diet composition. The fistula collection from each sheep on each day was considered as one sample. Frequency in the diet for each plant species was determined as the percent of samples in which the species occurred.

Plant species within 30 4.8 ft² plots per pasture were clipped and weighed to give an estimate of the available green weight production. The weight of each plant species present in each pasture was divided by the total weight of forage produced in the pasture to yield percent range composition. Percent frequency on the range was computed for each plant species as the percentage of plots in which the species occurred.

Relative preferences for 12 plant species representative of varying levels of dietary composition were determined with four different indices.

RPI₁ = \(\frac{\text{id} \times \text{D}}{\text{fr} \times \text{R}}\)

RPI₂ = \(\frac{\text{D}}{\text{R}}\)

RPI₃ = \(\frac{\text{fd} \times \text{D}}{\text{R} \times 100}\)

RPI₄ = \(\frac{\text{D} \times 100}{\text{fr} \times \text{R}}\)

where:

id = % frequency in diet
D = % diet composition
fr = % frequency on range
R = % range composition

All of the relative preference indices included the ratio of percent diet composition to percent range composition for each plant species. RPI₁ included, in addition, the ratio of frequency in the diet to frequency on the range. No frequency measurements were used in RPI₂. Both RPI₃ and RPI₄ included only one measure of frequency. RPI₅ was a ratio of diet composition to range composition modified by frequency of the plant species in the diet, thus it accounted for the effects of consistency of selection but not for effects of plant species distribution within the community. RPI₆ included the ratio of diet composition to range composition modified by percent frequency on the range so it accounted for effects of plant species distribution but not consistency of selection. RPI₃ and RPI₄ both included constants in order to
maintain the computed values of all four indices in the same order of magnitude.

The relative preference index values were computed for each sheep each day. Preference rankings for the plants were determined from overall average values. Each index was correlated with RP1, to determine the linear relationship.

**Results**

The sheep in this study showed varying degrees of preference for different species of plants. Thick-leaf groundsel (Senecio crassulifolius) was most preferred, according to RP1 and RP2, but not according to RP3 or RP4. Sticky geranium (Geranium viscosissimum) was least preferred of the twelve plants used to evaluate the different indices (Table 1). All plants except mountain knotweed (Polygonum montanum) and sticky geranium were preferred species, i.e., RP > 1.0. This was probably a result of high production of unpalatable geranium which made up 46% of the total production.

RP1, more closely approximated RP1 than the other indices. It showed a high correlation to RP1 (r = .97). RP2 and RP3 were similar to each other but greatly different from RP1. The correlation of RP3 with RP1 was low (r = .69) and RP2 showed an even lower correlation with RP1 (r = .51).

The relative ranking of animal preference for the twelve plants was different for all indices. RP1 showed 50% agreement with RP1, RP2 agreed with RP1 for 42% of the plants, and RP1 ranked 67% of the plants in the same order as RP1.

**Discussion**

The primary benefit received from calculating relative preference indices is comparison of preference by animals for forage plants. Comparison of animal preference for different plant species is more meaningful if every plant has the same value when selection by animals is completely random. The index proposed by Van Dyne and Heady incorporating only diet and availability (range composition) and an index using frequency measurements for both diet and availability in conjunction with these factors meet this criterion. Indices using diet composition and range composition in combination with either frequency measurements of occurrence in the diet or occurrence on the range but not both, do not meet this criterion. For these indices, the value at completely random selection would vary for each plant species according to the frequency measurement used.

In order to illustrate the relationship of plant frequency on the range to the four relative preference indices examined, a hypothetical plant community was developed (Table 2). Plant species A comprised 50% of the total vegetation and was irregularly distributed. Species B also comprised 50% of the vegetation present and was uniformly distributed. It animals grazed this community and forage selection was completely random, the diet composition and frequency values would be equal to the range composition and frequency values for each plant species. Using the information from this hypothetical situation, the four relative preference indices were computed for both plant species (Table 3). Indices using neither or both frequency values had a base value at random selection of 1.00 for both plant species. When the index incorporating frequency in the diet but not frequency on the range was used and the plants had an irregular distribution, the index base value at random selection was low. The index value would approach and then equal the value for indices with uniform range frequency at completely random selection (1.00) as diet frequency approaches and then equals 100%. Conversely, when the index incorporating frequency on the range but not frequency in the diet was used, the base value at random

**Table 2. Hypothetical plant community and expected diets for completely random animal selection. Species A is irregularly distributed and species B is uniformly distributed.**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Diet composition (%)</th>
<th>Frequency in diet (%)</th>
<th>Range composition (%)</th>
<th>Frequency on range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 3. Relative preference indices for an irregularly distributed plant (species A) and a uniformly distributed plant (species B) when animal selection is completely random.**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>RP1</th>
<th>RP2</th>
<th>RP3</th>
<th>RP4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.00</td>
<td>1.00</td>
<td>.20</td>
<td>5.00</td>
</tr>
<tr>
<td>B</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

1. $RP_1 = \frac{\% \text{ diet frequency} \times \% \text{ diet composition}}{\% \text{ range frequency} \times \% \text{ range composition}}$
2. $RP_2 = \frac{\% \text{ diet composition}}{\% \text{ range composition}}$
3. $RP_3 = \frac{\% \text{ diet frequency} \times \% \text{ diet composition}}{\% \text{ range composition} \times 100}$
4. $RP_4 = \frac{\% \text{ diet composition}}{\% \text{ range frequency} \times \% \text{ range composition}}$
selection for scattered plants was high. This index value would decrease to the value for the plants with uniform distribution (1.00) as range frequency increases to 100%.

Frequency measurements can be useful in determining relative preference of sheep. Since consistency of selection and distribution of plants are related to animal preference, an index incorporating both of these factors (RPI$_1$) is more sensitive in ranking preference values compared to indices lacking one or both of these factors. It was decided RPI$_1$ was the most useful index because it has the same value for all plant species when selection is completely random (1.00); it provides a wider spread of values than the indices not incorporating range frequency, so preference differences are more obvious; and it considers more factors related to preference than the other indices.

Frequency measurements are dependent on plot size. As the size of a plot increases the frequency of occurrence of a plant species would be expected to increase. If plot sizes are equal, comparison of frequency values is straightforward. If plot sizes are unequal, comparison of frequency values becomes more complex. To facilitate the use of range frequency data a plot size should be selected that provides a fairly wide range in values so differences in distribution of various plant species can be identified. In this study percent frequency on the range of the twelve plant species studied ranged from 22 to 100%.

Diet frequency values are a measure of consistency of selection. These values are primarily dependent on distribution of the various plant species on the range and animal preference. While a sheep is grazing it will more frequently encounter the plants with more uniform distribution and less frequently encounter plants with an irregular distribution. So, if percent frequency on the range is 20% for a particular plant species a sheep would find and be able to graze that plant one-fifth as often as a plant with 100% range frequency. Consequently, the range in values for percent frequency in the diet would be expected to be modified by percent frequency of species within a plant community and according to the relative palatability of the various plant species. Length of time spent grazing can also influence the frequency of a plant species in the diet. Enough time should be allowed so the fistulated animals can adequately cover the area to be sampled, but short enough so frequency differences can be identified. The number of microscopic points examined per sample will also influence the diet frequency value. As more points are examined the possibility of recording a very sparse plant in the sample increases. This influence can be minimized by setting a lower limit on values to be included in the frequency calculation, e.g., any plant making up less than 1% of the composition could be recorded as absent in determining frequency in the diet. In this study the range of diet frequency values was 30 to 100%, with most of the values above 60%.

In theory, the ratio of percent frequency of a plant in the diet and percent frequency on the range should give some insight into the animal's preference for the plant. If the ratio is less than one it would indicate the animal rejected the plant when it was encountered on the range. If the value is very close to one it would indicate the animal consumed some of the plant whenever the animal discovered its presence. If the ratio is greater than one it would indicate the animal was actively seeking the plant and thus enhancing the possibility of grazing preferred vegetation.

Because of the dependency of frequency measurements on plot size and time spent grazing, it is difficult to interpret the ratio of diet and range frequency from field data. However, if it is assumed that the proper plot size was selected and frequency measurements of the range and diet are satisfactory, then comparisons of the two different frequency measurements can be considered. In this study the ratio of the frequency measurements tended to decline as preference for the different plants declined (Table 1). Plants that were highly preferred had a high ratio and plants that were rejected had a ratio value much less than one.

Spike trisetum (Trisetum spicatum) was evaluated as highly preferred by all of the relative preference indices used, yet, the ratio of frequency measurements was almost one. Based on the frequency ratios for other plant species, the value for spike trisetum indicated it should have been of low to moderate palatability. But, as previously indicated, preference is not based on frequency of selection and distribution alone. The amount of the plant consumed in relation to the amount available must also be considered. In the case of spike trisetum, frequency measurements added little to preference evaluation. The animals apparently did not seek it out but did consume a large proportion of the plant when it was encountered. Thus, it appeared that animal preference for different plant species was related to composition of intake and availability as well as frequency of intake and plant distribution.

The four preference indices were computed for twelve representative plant species and then compared with RPI$_1$ which was accepted as the standard evaluation. The index that did not incorporate any frequency measurements (RPI$_2$) did have a constant value for all plant species when selection was completely random (Table 3) but did not have as wide a spread of index values as RPI$_1$ (Table 1) and did not consider the effects of plant distribution or consistency of intake. This index had the lowest correlation with RPI$_1$ and ranked
the plant species in the same order as RPI, only 50% of the time. Because of the low level of agreement of these two indices and difference in sensitivity RPI2 was considered to be less useful.

The index incorporating diet frequency but not range frequency (RPI5) did not have a constant value when selection was completely random, it did not have as wide a spread of index values as RPI1, and did not consider the effects of plant distribution. This index ranked the preference values the same as RPI1 least frequently of the indices studied and showed a low correlation with RPI1. When ranking preference values for unpalatable plants, RPI1 values were the same as those of RPI1, but in these cases range frequency equaled 100%, so mathematically the indices were identical. It appeared the addition of diet frequency measurements alone added very little to the usefulness of the index.

The index using range frequency measurements but not diet frequency did not have a constant value when selection was completely random, it did provide as wide a spread of index values as RPI1, but did not consider the effects of consistency of intake. This index (RPI4) agreed most frequently with RPI1 in ranking preference values for plants and had a high correlation with RPI1. The preference index values for RPI3 and RPI4 were very similar. RPI4 tended to rate plants higher as in the model (Table 3) and agreed with RPI1 when diet frequency equaled 100%. If diet frequency measurements cannot be obtained, as in determining diet from utilization and production estimates, RPI4 can be a satisfactory substitute for RPI1 on this range.

Summary and Conclusions
Four different relative preference indices were compared and the contribution of frequency measurements was evaluated. The preference indices incorporating both frequency of occurrence in the diet and on the range or neither frequency measurement had the same base value for all plants when selection was completely random, while preference indices using either diet or range frequency, but not both, did not have a common base value. The index that included diet and range composition and diet and range frequency not only had a common base value at random selection but also more clearly showed preference differences than indices not using range frequency and considered more factors related to preference than the other indices, so it was considered to be the most useful of the four relative preference indices studied.

While frequency ratios do provide added information concerning animal preference for many plants, they are not a satisfactory substitute for composition measurements of the diet and available forage. For some plant species frequency measurements would not be expected to modify preference values and for other plant species frequency measurements may raise or lower preference values, as determined from composition ratios.

Literature Cited


The Beneficence of Promptness

In spite of constantly rising operating costs, as well as an expanded program, the Society for Range Management has been able to hold the line on membership dues for the last five years. Whether or not we are able to maintain the present modest dues schedule will depend largely on two things: (1) on-time dues payments, and (2) a continued increase in membership.

Concerning the first, everyone is probably aware that dues are on a calendar year basis and, in accordance with the bylaws, are payable on or before January 1 of each year—in other words, dues for 1978 should be remitted by this coming first day of January. In the past only about 55%–60% of the membership has renewed by the specified time and, consequently, it has been necessary to send out second notices, perform additional clerical work, and frequently engage in some fancy footwork with the budget for the coming year (which is not a particularly desirable activity). Since SRM's income—mostly from membership dues—is seasonal while expenses are fairly constant throughout the year, it is most important to have operating money in hand before a firm program can be established. Thus, payment of dues on or before January 1 can be of significant help in achieving a steady state with regard to Society activities—fewer contingencies, less stop-and-go in getting things done, and less likelihood of some future dues increase.

On-time dues payments are, therefore, of great benefit not only to SRM as an organization but to you, the individual member.

Between July 31, 1971, and July 31, 1972, SRM registered a 10% increase in total membership and we should work diligently for similar increases in the years immediately ahead. Membership applications are available from time to time in Rangeman's News, from the Executive Secretary's office, or from your Section membership chairman. There are literally thousands of people who would benefit from SRM membership; each present member should bring in at least one.

Incidentally, the number of people who have elected to provide additional support to the Society by becoming an Individual Sustaining member has roughly doubled each year since 1969. Won't you please consider adding your name to this list for 1973?