FORAGE ANALYSES FOR DEER MANAGEMENT STUDIES

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This paper describes methods and reasons for chemically analyzing selected plant tissue and discusses procedures for processing plant samples so that the results will be meaningful in deer food and habitat evaluation studies.

COLLECTING PLANT SAMPLES

Deer food—as the term is used by wildlife biologists—designates those items actually selected and ingested. The chemical analysis of deer foods therefore implies a thorough understanding of feeding habits and consequently a very careful selection of plant material for sampling. In contrast, habitat evaluation studies suggest that the plant tissue collected for analysis can seldom be identified precisely with that eaten by deer. Plant tissue in these studies is routinely and objectively chosen to provide a more general type of information.

Deer Food Evaluation

In evaluating deer foods the surest way to get a representative sample is to let the test animal select the forage for analysis. Rumen contents of deer killed while foraging on range have been frequently used to assay food habits. Undigested portions of rumen contents—recognizable leaves, twigs, fruits, acorns—should be thoroughly washed as soon as possible to remove digestive secretions and other stomach contaminants. Finely masticated plant parts should not be used, since their chemical composition has been altered. Neither should chyme from the rumen-reticulum be analyzed—it may include metabolites secreted into the rumen.

Plant tissue can be obtained from living deer through stomach tubes and rumen fistulas. As the ingested material is usually layered and poorly mixed it is very important that samples be collected throughout the rumen-reticulum. Even then the often fibrous nature of rumen contents and the small diameter of the delivery devices may render the sample unrepresentative. Too, such forcibly applied procedures are very traumatic to the deer—sometimes also to the biologist. Esophageal cannulas have been successfully installed in sheep and cattle so that the eaten foods are collected before reaching the stomach and before any degradation occurs. This procedure, which may have good potential, has not been tried for deer.

If it is impossible to use the test animal as a collecting device, the researcher must do the collecting. One way is to follow a tame deer and attempt to gather plant tissue identical to what is observed eaten. McMahan (1964) followed tame sheep, cows, goats, and deer to compare their food habits, and found that the presence of the observer occasionally influenced the animal's behavior. However, the procedure seemed to provide a reliable index of stable and preferred foods.

The researcher may also try to duplicate the deer's diet by collecting food items that appear similar to those previously eaten by deer. Short and Remmenga (1965) sampled plant tissue like that eaten by captive deer which were allowed to forage for a short time in two small range pens each containing a pure stand of browse. The researchers measured the diameter of each browsed twig, computed a frequency distribution of the total number of browsed twigs, and then sampled unchewed stems accordingly. This procedure probably provided a good tissue sample, but it was very time-consuming and expensive.

That great care must be exercised in sampling plant tissue is ap-

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parent from a study by Blair and Epps (1967). These authors measured the protein and phosphorus content of different portions of the current annual growth of rusty blackhaw (*Viburnum rufidulum*). The terminal inch contained 40% more crude protein than did the second inch, and the second inch 20% more than the third inch. Thus, if the exact tissue eaten by the deer is not known, the analysis may be very misleading.

Habitat Evaluation

Tissue from identical parts of two plants of the same species may vary because of the effects of soil composition, soil moisture levels, and degree of overstory competition. Sampling different phenological stages of development will also produce compositional differences.

If the intention is to compare plant composition values between treatments or locations the sampling rules should be sufficiently explicit so that identical plant tissue is obtained. For example, a work plan might specify an early-morning sample of leaves from the first five feet (the "deer zone") of each of three thrifty yaupon (*Ilex vomitoria*) plants collected during winter dormancy in mid-January, from each of several study areas.

When plants are large, sufficient tissue for analysis can be obtained from one plant, but enough collections should be made from a plot or range type to provide an estimate of composition and variance. When individual plants are small, several plants within a plot should be composited and several plots located within a forage type to provide a statistical statement of composition.

Time of Day and Season of Sampling

When amino acids, vitamins, and other constituents of protoplasm are to be measured, plant tissue should always be collected at approximately the same time of day. The sucrose content of corn leaves, by way of example, is 300% greater at 4 p.m. than at 4 a.m. (Bonner and Galston, 1952). Structural components like cellulose and lignin should not vary much throughout the day, but individual minerals may differ from less than 5% to as much as 40% of their mean daily levels (Goodall and Gregory, 1947).

Some plants grow very rapidly during a short period in early spring and then cease to elongate and form terminal buds. Other plants grow rapidly in early spring and sporadically thereafter when moisture is available. Obviously more changes in composition occur during rapid growth than during apparent dormancy. When chemical assays are used to help describe phenological development, plant samples should be collected at weekly or shorter periods during times of rapid growth and at monthly or longer intervals thereafter.

PROCESSING PLANT MATERIAL

Unless the biological pocesses within the plant are halted soon after the sample is taken, many labile constituents—such as pigments, volatile substances, starches, and sugars—will be metabolized or lost.

When very labile constituents are to be measured the plant tissue should be quick-frozen. One acceptable procedure is to place bagged samples in contact with dry ice, and later dry the samples in a cold low-pressure system. Freeze-drying maintains soluble carbohydrates better than does oven-drying (Burns *et al.*, 1964). *In vitro* studies to determine the nutritive value of pasture have indicated higher micro-digestion values of dry matter and cellulose from freeze-dried than from oven-dried materials (Reid *et al.*, 1964).

Drying in forced-air ovens at 80°C and above will halt metabolic activity, but Van Soest (1965) has indicated that oven-drying above 50° C causes significant increases in yield of lignin and fiber and some degradation of vegetable protein. Each of these constituents is of nutritional significance, and drying temperatures of 40-50° C are better when cell constituents, cell wall components, ether extractives, protein, and minerals are to be measured. However, these temperatures will not quickly halt metabolic processes within the plant cell, and hence the carotenoids which are vitamin A precursors, other plant pigments, and

various soluble carbohydrates may be underestimated in the subsequent determinations.

When neither freeze-drying nor oven-drying facilities are available, plant material can be air-dried for ether extract, crude protein, cell wall constituents (lignin, cellulose), gross energy, and mineral content—in short, for all constituents except those readily affected by enzymatic activity or metabolic processes. Air-drying requires several days, and air must pass completely through the sample if heating and spoilage are to be avoided. Adequate air-drying is difficult in warm and humid climates.

After drying, the plant tissue should be ground or milled in ball or hammer mills, placed in tightly-stoppered glass bottles, and stored out of heat and light—if possible under refrigeration.

WHAT DO CHEMICAL ANALYSES INDICATE?

Chemical analyses may be very meaningful if the measurements can be related to the physiology of game animals and forage plants. Unfortunately, in the South most forage analyses have been restricted to the proximal analysis—an empirical assessment of water, crude protein, crude fat, crude fiber, ash, and nitrogen-free extract. These constituents are apparently sensitive enough to reflect broad changes in habitat conditions or plant physiology throughout the calendar year. But because crude fiber and nitrogen-free extract are not definitive structural components of forage, the proximal analysis has not successfully predicted forage quality to game animals. Forage analysis studies should in general consider measurements of structural and metabolic factors important to the plant and either of nutritional significance to the animal or of diagnostic importance in understanding the environment.

Future deer management may utilize food plots extensively. If plant tissue samples collected regularly according to some statistical design and analyzed for some diagnostic agent indicate mineral deficiencies, then game managers will know how to fertilize the food plots. Analysis for diagnostic agents of plant protoplasm may help to interpret the effects on forage of such management practices as fertilization, controlled burning, herbicide spraying, and mechanical cutting.

A noteworthy structural component of forage plants is cellulose. Cellulose is apparently less well digested by deer than by cows (Short, 1963) and has been shown to restrict energy and dry-matter digestibility by mule deer (Short, 1966). Certainly one reason why overgrazed ranges and woody forages restrict deer productivity is the inability of deer to metabolize fibrous forages extensively.

The available carbohydrate content of plants is a metabolic constituent that provides useful information in forage studies. McConnell and Garrison (1966) list the seasonal variations in available carbohydrate content of bitterbrush (*Purshia tridentata*) on western deer ranges. Starches and sugars produced by photosynthetic processes during the growing season are stored at relatively high levels in twigs and roots during the autumn and winter. These reserves provide the energy that allows the plant to leaf out, flower, and grow until photosynthetic processes begin during the next summer. Grazing during autumn and winter, when carbohydrate reserves are high, presumably is not as harmful to the plant as heavy grazing during the early spring, when important carbohydrate reserves are low. Possibly heavy livestock use of browse plants during spring and early summer, when deer are foraging on succulents, would reduce shrub vigor during later seasons.

Forage testing laboratories occasionally develop new procedures for expressing plant quality. They attempt to fraction tissue into structural items that can be determined easily and consistently and that have nutritional importance to the plant and animal. Van Soest and Moore (1965) have developed a simple and rapid procedure that differentiates cell contents, cell wall constituents, and a lignocellulose fraction. Although the procedure is somewhat empirical, the plant portions seem to have nutritional significance. Ellis (1962), working with plant carbohydrates, has developed a sequential partition according to the dif-

ferential solubility of these carbohydrates in acid. These analytical procedures have not yet been applied to wild forages, so it is difficult to assess their usefulness in game management.

SUMMARY

In summary, plant materials have been collected and analyzed in many deer management studies. The importance and usefulness of forage analyses are directly dependent on four collection criteria. One, the plant parts collected must rigorously duplicate food items ingested or the design of the research must allow for adequate sampling replication. Two, forage collections may have to be made at specific times of day, and rate of sampling throughout the year may vary between periods of rapid growth and development and those of plant dormancy. Three, collected plant material should be quickly processed to kill biological activity while minimizing chemical degradation of the sample. Four, careful consideration should be given initially to obtaining those measurements which best assess forage quality to the animal or which indicate desired criteria of habitat quality.

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