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QUALITATIVE IDENTIFICATION OF FORAGE REMNANTS IN DEER FECES

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Abstract: Seventeen tree, shrub, and herbaceous plant species were individually fed to captive mule and white-tailed deer (*Odocoileus hemionus* and *O. virginianus*). Remnants in feces were identified for all species by magnification varying from 7× to 100×. At best, only low percentages of recognizable material were found despite a single species diet. Unstained epidermal mounts prepared from fresh plant material and photomicrographs required less time and proved superior to staining techniques for identification.

Ruminant food habit studies have emphasized direct observation of feeding and analyses of stomach contents and samples taken from esophageal fistulas. Fecal analysis, with the advantage of unlimited sampling, could supplement these methods. This study adapts and extends to deer, procedures developed for fecal studies of birds and small mammals. Specifically, this study reports on forage plant structures that can be qualitatively identified in deer feces, and the development of a useful technique for such analyses.

Foremost among the several cooperators who have contributed to this study are D. J. Neff, Arizona Game and Fish Department, Flagstaff, and J. L. Tinker of the Phoenix Zoo.

REVIEW OF THE LITERATURE

Fecal studies of mammalian carnivores and birds have been used for many years to determine diet composition. These studies largely restricted identification to gross undigested structures, such as chitinous insect exoskeletons, fur, bones, seeds, and pine needles.

Herbivorous mammals often masticate and degrade food items so finely that histological microtechniques are necessary for species identification. The first widely-used technique was developed for analysis of squirrel stomach contents (Baumgartner and Martin 1939). Material in stomachs was compared with permanent reference slides of stained leaf and stem epidermis from plants in the study area. Later, Dusi (1949, 1952) adapted this technique for fecal analysis of cottontail rabbits (*Sylvilagus floridanus*).

Adams (1957) modified a technique used by Scott (1941) on red fox (*Vulpes* sp.) for analysis of snowshoe hare (*Lepus americanus*) diets. Hares were fed a stock diet plus a forage plant. A species constant for the forage plant was ascertained as a factor correlating the number of "recognition items" in the excreta to the amount of forage plant eaten. More sophisticated statistical methods of analysis were later developed (Adams et al. 1962).

Gross items have been recognized in deer feces. Adams (1957:156) found bitterbrush (*Purshia tridentata*) leaf and stem fragments in mule deer pellets. Remains of various acorns and seeds were identified from white-tailed deer fecal material in Texas (Lay 1965). A European study of deer damage to forest trees utilized fecal examination (Burckhardt 1959).

Storr (1961), in Australia, fed perennial

[1] Forest Service, U. S. Department of Agriculture. Central headquarters maintained in cooperation with Colorado State University, Fort Collins. Research reported here was conducted at Tempe, in cooperation with Arizona State University.

and annual dicotyledonous plants to penned quokkas (*Setonix brachyurus*), marsupials with ruminant-like digestive systems. He concluded (p. 161) that epidermis survived digestion by virtue of the encasement of entire cell walls in cutin, and that perennial dicots showed no differential breakdown. Succulent annuals, however, survived digestion very poorly.

Hegg (1961) made microscopic counts of cuticle and epidermal fragments found in red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and chamois (*Rupicapra rupicapra*) fecal samples collected in the Swiss National Park. He found that such counts gave satisfactory data on diet composition. However, a more thorough study in Uganda and Kenya by Stewart (1967) contests this conclusion. He fed perennial grasses to a number of wild ungulates. Stewart (1967) questions the validity of remnant counts because some species fragment more readily than others and consequently would appear more important, although intake was the same or less. Statistical support is presented for using point quadrat or area cover to estimate frequency-of-species occurrence. He further states (p. 100) that perennial grasses consistently forming more than 5 percent of the diet can be quantitatively identified in any fecal sample with standard errors within 10 percent of the expected mean.

Kiley (1966) used epidermal characteristics to qualitatively identify individual grass species and some dicotyledonous plants from waterbuck (*Kobus* sp.) feces in Uganda and Kenya. Difficulties in quantitative analysis were implied but not discussed.

PROCEDURE

Feeding

Two mule and one white-tailed deer were confined in small pens and fed selected plant material. The stock diet consisted of rolled barley, commercial pelleted feed, and alfalfa. Feces from deer fed the stock diet were examined for structures that survived digestion to distinguish these from forage plant remnants. Subsequently, an individual forage species treated with a red marker dye (basic fuchsin) and granulated salt (Kindel 1960) was offered alone and in abundance. Only stained droppings were collected for identification of forage plant structures.

Analysis

Approximately 20 pellets from each composite sample were soaked overnight or boiled for 15 minutes in 10 percent sodium hydroxide to dissolve the exterior mucus coat. Vigorous stirring then reduced the pellets to a pulpy mass. This material was allowed to settle, removed from the supernatant fluid, rinsed, and examined wet at 7× with a binocular microscope. If no recognizable structures were evident at 7×, the material was examined under progressively higher magnification to 100×.

Identification of fecal remnants was based on comparison with epidermal mounts and photomicrographs. Epidermal mounts were prepared by boiling fresh leaf and stem tissue in an aqueous solution of 10 percent nitric acid and 10 percent chromic acid for 10 minutes. The excized epidermis was stored in glycerin between slides. Photomicrographs were made with pan-x film, focused at infinity, and exposed from 0.5 to 1.0 second (the time varying with light intensity).

In addition, verified remnants from fecal samples were stored in small vials of 10 percent formalin as an aid to identification of wild deer diets.

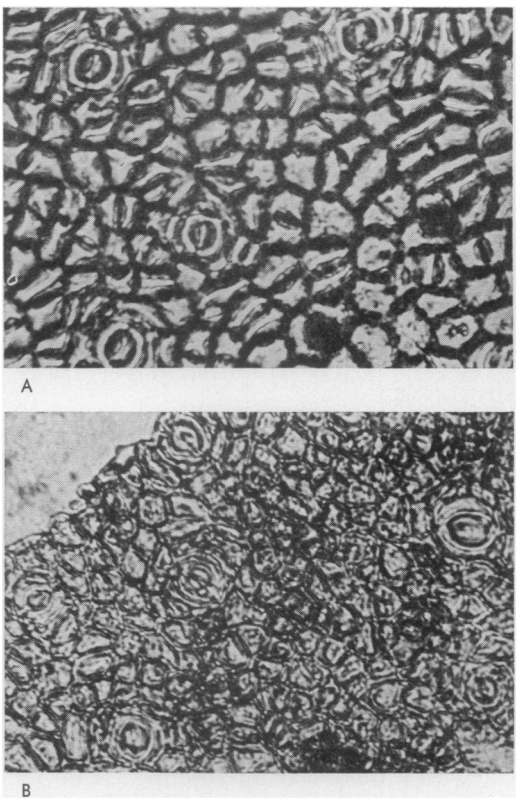

Fig. 1. Photomicrographs of *Simmondsia chinensis* epidermis (*A*, epidermal mount; *B*, fecal remnant) showing the distinctive stomatal pattern and small cells with thick walls.

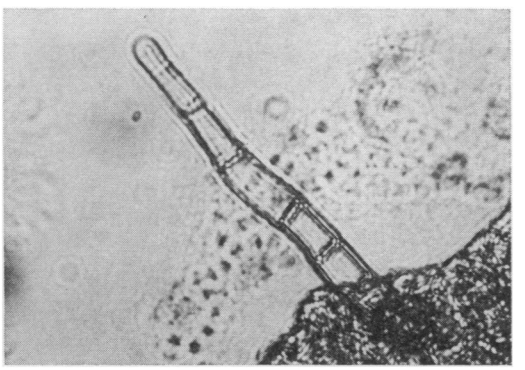

Fig. 2. Photomicrograph of *Simmondsia chinensis* showing partitioned trichome that has remained intact through the digestive process.

RESULTS AND DISCUSSION

Seventeen forage species were fed to two mule deer at Flagstaff and one white-tailed deer at the Phoenix Zoo. Species fed to mule deer included crested wheatgrass (*Agropyron cristatum*), mountain muhly (*Muhlenbergia montana*), alfalfa (*Medicago sativa*), horse cinquefoil (*Potentilla hippiana*), dandelion (*Taraxacum* spp.), cliffrose (*Cowania mexicana*), true mountain-mahogany (*Cercocarpus montanus*), Gambel oak (*Quercus gambelii*), and quaking aspen (*Populus tremuloides*). Browse plants fed the white-tailed deer included desert ceanothus (*Ceanothus greggii*), hollyleaf buckthorn (*Rhamnus crocea*), jojoba (*Simmondsia chinensis*), birchleaf mountain-mahogany (*Cercocarpus betuloides*), shrub live oak (*Quercus turbinella*), Wright silktassel (*Garrya wrightii*), yellowleaf silktassel (*G. flavescens*), and mistletoe (*Phoradendron villosum*).

Recognition items were found for all plants examined. Degree of magnification (7× to 100×) varied with species. Magnification greater than 7× (Adams 1957) increases the percentage of classifiable material—an important consideration in developing quantitative analyses (Chamrad and Box 1964, Dusi 1952).

Characters useful in identification included: (1) leaf venation–pattern, extension of main veins to leaf margins, and density of secondary vascular tissue; (2) trichomes–presence or absence, density or distribution, and morphology; (3) epidermal cell morphology; and (4) gross structures–leaf fragments, buds, flower parts, seeds, and woody tissue.

The grasses were easily distinguished from dicots by parallel venation, rectangular epidermal cells, and by stomata with two guard cells and two accessory cells. Classification of grasses by epidermal characters has been reported (Prat 1932). Epidermal

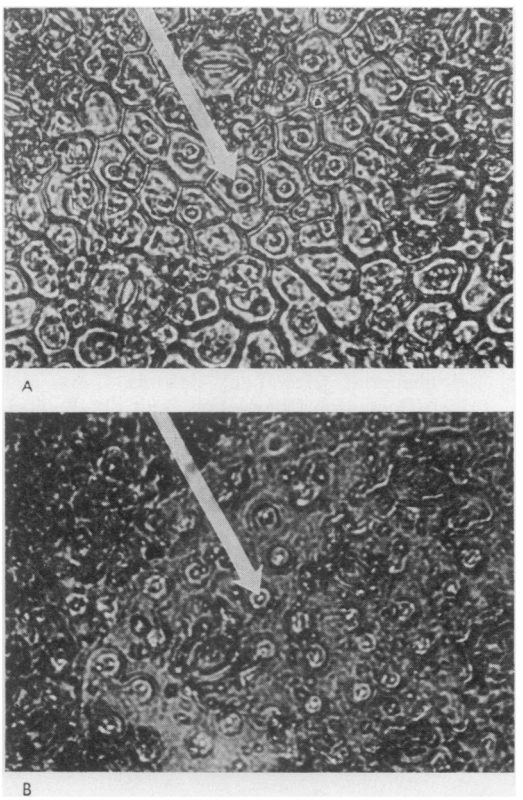

Fig. 3. Photomicrographs of *Garrya wrightii* (*A*, epidermal mount; *B*, fecal remnant) showing the characteristic epidermal cell glands.

cells of dicots are usually irregular in outline, and the stomata are enclosed by two guard cells only.

Some plants such as Wright silktassel and jojoba have unique characters that readily distinguish them (Figs. 1–3). Other species require careful examination and comparison with epidermal mounts prepared from fresh material.

Permanent reference slides, as used in stomach analysis (Baumgartner and Martin 1939, Dusi 1949), proved unsatisfactory for fecal remnant studies because: (1) a large number of slides per individual plant was necessary to represent adequately the possible structures that survived digestion; and (2) the numerous structures in fecal remnants were stain specific; hence, mounts required an exorbitant amount of time to prepare.

Fecal remnants for analysis were difficult to obtain for some forages. Deer frequently refused to eat certain plants when offered alone, although these same species are common items in diets of free-ranging deer. Starvation up to 3 days was required before deer would accept these species. This problem was alleviated slightly by placing granulated salt on the moistened forage.

The normal time lapse from feeding to evacuation, as indicated by presence of basic fuchsin dye, proved to be about 36 hours. Pellets collected at shorter intervals contained few remnants of the forage species. Peak amounts of forage remnants in the feces usually appeared after 36 hours because the forage was not immediately eaten in quantity when offered; coarse browse apparently passes through the digestive tract more slowly than concentrate and herbaceous feeds.

To increase the percentage of classifiable remnants, it is recommended that: (1) magnification not be restricted to low power (7×) in microscopic examination; (2) reference material consisting of preserved, positively identified fecal remnants be used as standards rather than prepared mounts; and (3) a file of good photomicrographs be developed. Color slides are particularly helpful for identifying unstained material.

Seldom did fecal samples contain more than a low percentage of recognizable items, although intake had been satisfactory. This fact will seriously limit development of a reliable quantitative analysis of deer feces for diet-composition determinations, especially for samples from free-ranging deer whose feeding behavior favors ingesting small amounts of many species (McCulloch 1965).

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