

# A Review of Browse in the Nutrition of Grazing Animals

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## Highlight

Literature on the chemical analyses, animal preference, digestibility, and intake of browse and on the production of animals grazing on browse is examined. It is concluded that browse has not yet been shown to make a major contribution to the nutrition of domestic or most game animals and further study of browse-grass comparisons is needed.

## Revision Bibliografica de los Arbustos en la Nutricion de los Animales en Pastoreo

### Resumen<sup>1</sup>

Este artículo revisa el progreso que se ha logrado en las evaluaciones de arbustos respecto a: análisis químicos, preferencia para pastoreo, digestibilidad y consumo, y su producción medida en animales.

Se concluyó que no se ha mostrado todavía que los

arbustos tengan una contribución importante en la nutrición de los animales domésticos o animales silvestres mayores. En algunas zonas áridas se ha estado demostrando que no tienen contribución, pero existen otras situaciones climáticas y vegetales en las cuales pueden ser importantes forrajeras. Conformarse con estos estudios en la evaluación de solo la calidad puede ser engañoso porque los arbustos tienen deficiencias en materia seca la cual persiste con el pastoreo. Discusiones sobre el diseño de las investigaciones futuras relativas a evaluaciones de arbustos son presentadas.

In areas of low or intermittent rainfall, the leaves of shrubs and trees (browse) are often regarded as important for the nutrition of grazing animals. Browse provides supplements of protein and energy when grasses are mature and of low value and a reserve of feed that can be utilized in time of drought. Experimental support for these views comes principally from chemical analyses of browse and grasses and from pen feeding trials and there is surprisingly little supporting evidence in the form of production response by grazing animals.

The purpose of this article is to assess the progress that has been made in browse evaluation and to make suggestions for the future direction of this work. Some reference is made to game animals, but the principal conclusions refer to use of browse by domesticated sheep, cattle, or goats.

<sup>1</sup> Por Ing. Edmundo L. Aguirre, Dep. de Zootecnia, ITESM, Monterrey, N. L., Mexico.

The reader is also referred to articles in Joint Publication No. 10 of the Imperial Agricultural Bureau (1947) and to a review on range research in the dry tropics by Naveh (1966). For a description of some browse plants the reader is referred to Dougall and Bogdan (1958) (Kenya), Sampson and Jespersen (1963) (California), and Knowles (1951), Condon and Knowles (1952) and Stannard and Condon (1958) (Australia).

### Chemical Analyses

There are many reports of the chemical analyses of browse plants, either on the Weende system of proximate analysis or for crude protein alone. Many of these have been gathered together by the Imperial Agricultural Bureau (1947, 894 entries) and some of the recent analyses are listed in articles by Hellmers (1940), Cook and Harris (1950), Bissell and Strong (1955), Innes and Mabey (1964a), and Khajuria (1965). Because of the great variety of results, it is difficult to draw any conclusions from these. However, one may concur with the conclusion of Bohman and Lesperance (1967) that, in general, browse has a more consistent crude protein content than grasses, which are typically high in protein at the beginning of the growing season and low in protein when mature. On the other hand, browse consistently has a higher fiber and lignin content than grasses. Leguminous shrubs differ from other shrubs in that they often contain more than 20% crude protein (Hutton and Bonner, 1960; Innes and Mabey, 1964a).

However, all these analyses have been done on hand-collected material. A recent observation with esophageal fistulated cattle showed that the diet contained 66% more crude protein than hand-collected samples (Bredon et al., 1967) and this has been the consistent observation of other workers (Weir and Torell, 1959; Arnold, 1960). With browse, it is probable that the same selectivity occurs since Reynolds and Sampson (1943) observed a range of 7 to 17% crude protein between the old and young leaves of the one species. Furthermore, many of these analyses do not consider seasonal and maturity variations which are known to occur in some browse species (Gordon and Sampson, 1939).

On the basis of crude protein content, browse can be considered as a supplement to protein-deficient grasslands and, in pens, responses to the supplementation of roughages with browse have been obtained (Wilson, 1966). However, no reports can be cited in which responses were obtained to the supplementation of grazing animals with naturally occurring browse. In future work on supplementation with browse, it would be of value to make comparisons with alternative protein sources, such as protein concentrates (Harris et al.,

1956), or introduced legumes (Jones and Winans, 1967; Shaw, 1961).

Browse may also be of value as a source of vitamin A. Cook et al. (1954) analyzed 8 species of browse and found that they contained a mean of 7.2 mg/lb of carotene. Gartner and Anson (1966) found that the leaves of mulga (*Acacia aneura*) contained from 5 to 38 mg/lb of B-carotene and that sheep maintained on mulga for 3 to 16 months had adequate vitamin A reserves.

In terms of mineral composition browse may be deficient in phosphorus (Cook et al., 1954; Innes and Mabey, 1964a) and responses to phosphorus supplementation on an arid range containing browse have been obtained (Harris et al., 1956). However, this does not necessarily apply to all species as Sampson and Jespersen (1963) found that deciduous trees and shrubs were adequate in phosphorus (0.8% in spring, declining to 0.2% in fall), whereas nondeciduous shrubs were low in phosphorus (0.22% in spring, declining to 0.11% in fall). Cook and Harris (1950) noted that the leaves of browse are higher in phosphorus than the stems.

In calculating energy values for browse, it should be noted that the essential oils contained in some species are poorly utilized by animals and are largely excreted in the urine (Cook et al., 1952).

### Animal Preference

Studies of the proportion of browse in the diet of grazing animals have been conducted with cattle (Connor et al., 1963; Payne and MacFarlane, 1963; Cook et al., 1967), sheep (Leigh and Mulham, 1966, 1967; Cook et al., 1967), goats (Knight, 1965), antelope (Ferrel and Leach, 1950) and deer (Leach, 1956; Browning and Lauppe, 1964; Allen, 1968). The methods used have included esophageal and rumen fistulae, observation of grazing time, and examination of rumen contents. It is possible that browse intake is overestimated when examining the rumen contents of slaughtered animals, because of the high fiber and slower digestion of browse, but there is not yet any experimental evidence on this point.

The above studies show that the intake of browse varies widely with the season, the alternative vegetation, and the type of animal, and because of variation in the availability and palatability of the ground flora it is often not possible to predict from past observations, the proportion of browse that will be eaten. In each locality, the availability of browse and herbaceous material is important in determining the relative intakes of these two classes of forage. For instance, Biswell et al. (1952) observed that deer ate 95 to 99% browse in heavy brush areas, but only 3 to 50% in open brush areas. It can generally be concluded that browse

is eaten in greatest quantity at the height of the dry season when green grasses and herbs are sparse, although in areas with severe winters the reverse may be true.

The various species of livestock and game also differ in the amounts of browse that they eat. Goats eat more browse than sheep, which in turn eat more than cattle (Staples et al., 1942; Campbell et al., 1962; Cook et al., 1967) and these animals may be ranked in the same order for effectiveness in reducing heavy brush. Wild animals, such as deer and elk, and some of the wild ruminants of Africa, also eat much browse. There is a similarity in the preferences of all these animals (Julander, 1958), but there are important differences that have relevance in studies on competition between wild and domesticated animals. For instance, Severson and May (1967) found that antelope ate more of the shrubs rabbitbrush (*Chrysothamnus viscidiflorus*) and sagebrush (*Artemisia tridentata*) than did sheep and Griffiths and Barker (1966) found that kangaroos never ate the leaves of mulga and berrigan (*Eremophila longifolia*) which are browsed by sheep. However, evidence of consumption of browse should not be equated with a requirement for browse, nor be used as an indication of nutritive value.

Many differences, some large, exist in the relative palatabilities of the many browse species and no attempt has been made in this review to list these. Little is known of the basis of these differences in palatability and the recent attempts by Longhurst and Jones (1967) to define the chemical factors affecting palatability in browse plants are of considerable interest. It has been found that the unpalatable factors in Douglas fir (*Pseudotsuga menziessii*), blue gum (*Eucalyptus globulus*) and bay (*Umbellularia californica*) are associated with the essential oils contained in the leaves and further work is proceeding on the separation of the unpalatable volatile components.

### Inhibition of Digestion

The leaves of a number of shrubs and trees contain poisonous compounds and others contain a high proportion of sodium chloride, but no attempt has been made to tabulate these. A more recent discovery has been that the essential oils contained in the leaves of some browse species inhibit digestion in the rumen (Nagy et al., 1964; Oh et al., 1967). Oh et al. (1967) have isolated the various essential oils in Douglas fir needles and examined their effect on the rate of digestion in vitro. The oxygenated monoterpenes were the principal group inhibiting digestion. However, after continued ingestion, there was some evidence that the rumen microorganisms became adapted to these inhibitory essential oils, so that the field im-

portance of these observations remains to be determined.

### Digestibility and Intake

In a number of studies, the leaves or twigs of individual browse species have been harvested and fed to penned deer, sheep or cattle. Of the species from temperate climates, intakes of chamise (*Adenostoma fasciculatum*), live-oak (*Quercus wislizenii*), aspen (*Populus grandidentata*), balsam (*Abies balsamea*) and jack pine (*Pinus banksiana*) (Bissell et al., 1955; Ullrey et al., 1964, 1967, 1968) were extremely low and to achieve higher intakes, Bissell and Weir (1957) mixed chamise and live-oak with alfalfa. Nevertheless, the highest digestibility of dry matter recorded was 56%. The intakes of northern white cedar (*Thuja occidentalis*), scrub oak (*Quercus gambelii*), curl leaf mahogany (*Cercocarpus ledifolius*), bitterbrush (*Purshia tridentata*) and juniper (*Juniperus utahensis*) by deer were found to be more satisfactory (1.2 to 2.0 lb/100 lb body weight), but with the exception of curl leaf mahogany (60%) digestibilities were below 50% (Smith, 1952, 1959; Ullrey et al., 1967, 1968). These trials underestimate value, because of the restriction of selectivity, and this may be more important with small-leaved species, such as chamise, than with larger-leaved species.

Higher intakes have been recorded with sheep fed on the arid-area species sagebrush (1.9 to 2.5 lb/100 lb, Smith, 1950) and bladder saltbush (*Atriplex vesicaria*) (3.3 lb/100 lb, Wilson, 1966). A digestibility of 70% was recorded with oldman saltbush (*Atriplex nummularia*) (Wilson, 1966), although intake was only 1.8 lb/100 lb. The association of low intake with high digestibility could occur frequently with browse, owing to the occurrence of unpalatable and inhibitory factors mentioned earlier. With tropical browse plants, Mabey and Innes (1966a, 1966b) found digestibilities up to 70% and intakes of up to 2.3 lb/100 lb in cattle feeding studies with *Antiarus*, *Grewia*, *Baphia*, and *Griffonia*. In India, Mia et al. (1960a, 1960b) and Majumdar and Momin (1960) fed a number of tree fodders (*Ficus* spp.) to goats and recorded intakes as high as 5.2 lb/100 lb body weight and organic matter digestibilities up to 61%. However, when fed to bullocks, the highest intake recorded was 2.0 lb/100 lb. Joshi and Ludri (1966) fed kharik (*Celtis tetrandia*) leaves to sheep and found intake to be 4.1 lb/100 lb and organic matter digestibility to be 51%.

These results suggest that arid and tropical browse plants have more potential as ruminant feeds than those from temperate areas, although such a generalization may merely reflect the difficulties of collecting samples representative of grazed forage in some species.

With grazing animals, the diet is rarely 100% browse. Nevertheless, there have been several measurements of the food intake of sheep on arid shrublands which were made when browse was essentially the whole diet. In these instances, intake was measured by total fecal collection, together with estimates of digestibility made by lignin ratio (Cook et al., 1952, 1967) or by in vitro digestibility of esophageal fistula samples.<sup>2</sup> The intake of digestible dry matter was generally sufficient for maintenance of the animals in question, which is preferable to the loss of weight that often occurs in the dry season. A report that the intake by cattle eating a combination of *Griffonia* and grass (40 : 60) was 40% higher than that of cattle eating grass alone (Innes and Mabey, 1964b) may not be reliable, as the grass alone comparisons were pen fed.

### Production Measurements on Grazing Animals

There are a few experiments in which the long-term productivity of animals on browse areas has been compared to that on neighboring areas without browse. Leigh, Wilson, and Mulham (1968) could find no production response (body weight and wool growth) to the presence of small amounts of cottonbush (*Kochia aphylla*) in an arid grassland. Larger amounts of oldman saltbush were also generally without effect on body weight or wool growth, although a small improvement in body weight was obtained in a year of low rainfall. These results were explained on the basis that at no time were these grasslands deficient in protein and that the dry matter contribution of the bushes was small. Yearlong grazing on a bladder saltbush shrubland and on a grassland pasture (*Danthonia caespitosa*) at 0.5 sheep/acre<sup>2</sup> showed that productivity in the first year was slightly higher on the shrub pasture than on the grassland, but in the second year it was considerably lower. This arose because at the grazing intensity used, the shrubs died, but the grassland remained in good condition. Long-term carrying capacity on the grassland was twice that of the shrub pasture. In a similar climate, Cook (1966) recorded a four-fold increase in carrying capacity following the replacement of sagebrush with grasses, although later there was difficulty with invasion by other poor-quality woody plants.

These observations emphasize the need for information on browse productivity and persistence under grazing, as well as the more common measurements of quality. A few studies of browse production have been made (Hubbard et al., 1960; Hutton and Bonner, 1960; Oakes and Skov, 1962), but these cover few of the plants under consideration and present no comparisons with grasses

grown under the same conditions. This is probably because of the difficulty of measuring growth where the establishment of a baseline by complete defoliation may significantly reduce growth or kill the plant, but it could be argued that a plant that will not withstand defoliation has no place in a grazing system.

These observations also emphasize that browse evaluation should be made comparative to the alternative vegetations of that area. Browse is generally not of high quality, but owing to its retention of protein or digestible energy in dry seasons, it may be higher in quality than the alternative grasslands. However, the improvement of grasslands is generally achieved by the introduction of legumes and there is, as yet, no support for the contention of Innes (1965) that for tropical-savanna areas grass-browse combinations have greater promise than grass-legume combinations.

The leaves of some trees are used as a drought reserve in arid areas, but there is little information available on the amounts of fodder accumulated or its nutritive value. In Australia, the leaves of mulga have been successfully used to maintain sheep over long droughts (Gartner and Anson, 1966).

### Methodology of Evaluation

It has not yet been shown that browse has an important contribution to make to the nutrition of domestic or most game animals. In some arid areas browse has been shown to make no contribution, but there remain many other plant and climatic situations in which a place for browse may be found. These studies have also shown that evaluation in terms of quality alone can be misleading, since many browse plants have deficiencies in dry matter production and persistence under grazing.

At this point it would be appropriate to examine the design of future work on browse evaluation. Until it has been shown that browse, as a whole, has a place in grazing systems, it would seem appropriate to direct attention to comparisons of browse and grassland areas, rather than to comparisons between browse species. Since browse is used as a grazed plant, the most important information will come from grazing studies and from grazing studies that use the system of grazing appropriate to the region. Ideally these studies would involve paired areas, one with browse and the other without, although such trials present certain difficulties. The development of a stable grassland in areas previously occupied by shrubs or trees may take many years and grazing studies can be both costly and time consuming. Consequently, the breakdown of browse-grass comparisons into quality and quantity measurements on

<sup>2</sup> Wilson, A. D., J. H. Leigh, and W. E. Mulham. 1968. Australian J. Agr. Res.

small areas and over shorter periods of time would be desirable.

Studies of quality require sampling by fistulated animals at various levels of utilization and encompassing the range of seasons in which browse use occurs. Evaluation of these samples should include analysis for nitrogen and estimates of digestibility. The latter may be obtained by in vitro digestion (Tilley and Terry, 1963) or in vitro digestion of cell-wall constituents (Van Soest, 1967), which have given good estimates for forages. However, there is a need to evaluate the validity of these methods for browse by in vivo-in vitro comparisons. Quantitative studies of dry matter production and of browse persistence under grazing are also required. Studies such as those of Lay (1965) which measure dry matter production under various intensities of defoliation, with the addition of measurements on alternative grasslands, should be attempted.

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