THE PLACE OF TREES AND SHRUBS AS SOURCES OF FORAGE IN TROPICAL AND SUBTROPICAL PASTURES

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ABSTRACT

The relative roles of browsing and grazing in the evolution of herbivorous animals are traced briefly from the Mesozoic era to the present time. The concept of browse as merely a useful stand-by for dry times is shown to give an underestimation of the full potential value of this class of plant. It is pointed out that some browse species exist which have a high potential value as sources of protein-rich forage, especially in tropical and subtropical regions, and that these should receive greater attention from agronomists.

EVOLUTION OF HERBIVOROUS ANIMALS

Long before there were grassy pastures there were trees. Browsing preceded grazing by a good many millions of years. In the Mesozoic era, the land was dominated by the dinosaurs, many of which were herbivorous. *Diplodocus* and its allies that were probably the largest land animals that have ever lived, fed on trees and shrubs. Another group of dinosaurs, exemplified by *Stegosaurus,* were known as the beaked dinosaurs, and were distinguished by a beak sheathed with horn carried in front of the tooth-set jaw, and presumably used to strip the leaves and twigs off trees and shrubs.

The Cretaceous and early Tertiary periods were times of comparatively rapid evolution both of angiosperms and of mammals. In the later Tertiary period grasses became abundant, providing new food for herbivorous animals, and in parallel with this came the evolution of grazing animals—elephant, horse, deer, cattle, sheep, goat, bison.

Climatic changes in the Northern Hemisphere in the later Tertiary period favoured the parallel development of grassland and grazing animals. As the climate became cooler, much of the forest and woodland disappeared, being replaced by savannah and savannah-woodland.

The symbiotic relationship that developed between natural grasslands and grazing animals persisted without much change in the temperate parts of the earth throughout the long period of time in which further evolution in the mammals took place, leading eventually to the appearance of man, a million or more years ago. At the same time, in many parts of the earth, both temperate and tropical, other herbivorous mammals continued to live in forests or woodlands, browsing on leaves and stems from trees and shrubs. Special features such as the well known long neck of the giraffe served as adaptive features in this mode of living. Thus browsing and grazing continued as alternative ways of feeding on vegetation, and undoubtedly some animals practiced some of both methods.

MAN'S INFLUENCE

The appearance of man made little difference at first to the ecological scene. Later when he left the forests and became a plain dweller, he became a direct competitor with the carnivores preying on grazing animals. Further changes converted him from a hunter to a nomadic herdsman, and later on to a grower of crops. Each of these changes had repercussions on the grassland-grazing animal relationship, the most important of which was that much of the best land was gradually converted from

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grazing to cropping, and pastures became relegated to inferior land. Modern agriculture, with the introduction of mechanization and the use of fertilizers for crops, at first intensified this situation. But in the present century has come the concept of pasture improvement and sown pastures, in which grassland is no longer regarded as inferior to cropping, but is given adequate consideration as a crop. This development has taken place mainly in the temperate regions but is now being extended to the tropics and subtropics. Here some radical concepts may be needed. The turf-forming grasses and herbaceous legumes that form the basis of temperate pastures are not necessarily the only type of pasture plants for the tropics. It is here that the browse trees and shrubs may have a vital place.

TREES AND SHRUBS AS DROUGHT RESERVES

The value of certain trees and shrubs for fodder reserves in times of stress has been widely recognized (Everist, 1969) but in most instances the discovery of this kind of use has been made more or less fortuitously, and has had relatively local application. This practice has come about both in regions of highly developed and long-standing agriculture, and in regions where natural vegetation or range is utilized for grazing.

In semi-arid tropical and subtropical regions, the role of indigenous trees in providing reserve fodder in times of drought has been widely recognized. In Australia, the kurrajong (*Brachychiton populneum*) has been very popular as drought feed, and a number of other native species, including wilga (*Geigera parviflora*) and mulga (*Acacia aneura*) have been widely used for the same purpose (Everist, 1969). In South Africa, Rhodesia, and Kenya, many native trees and shrubs, including several species of *Acacia,* are recognized (Bonsma 1942, West 1950, Dougall and Bogdan 1958). In South Africa also a number of introduced species including carob (*Ceratonia siliqua*), honey locust (*Gleditsia triacanthos*), and Mexican hawthorn (*Crataegus pubescens*) are appreciated as fodder trees (Jurriaanse 1950).

TREES AND SHRUBS FOR PERMANENT FORAGE

Many species of trees and shrubs are recognized as a source of reserve fodder for use in time of drought. This very useful concept, however, tells only a small portion of the full story of the potential usefulness to man of this class of fodder plant. While edible trees and shrubs have undoubted value from the point of view of drought reserves, their full usefulness for animal feeding will only be achieved if trees and shrubs are looked upon as a permanent normal source of fodder, in good seasons as well as in bad.

In a critical appraisal of this concept, the first question that comes to mind is—do these plants meet the criteria of a good pasture plant? In other words, do they possess the productivity, the acceptability to stock, the nutritive value, and the degree of persistency and sustained productivity under stocking, that would stand comparison with high quality pastures of the conventional sward type?

Consideration should also be given to any direct advantages that the tree or shrub might have over the herbaceous grass or forb that grows in the conventional sward. The fact that the climax vegetation in many tropical and subtropical regions, even when there is a moderately high population of herbivorous animals, is frequently in the form of woodland or savannah-woodland, rather than pure savannah, suggests that the tree or shrub may have an ecological advantage over the herbaceous sward.

In an environment where intermittent moisture stress occurs, the more extensive permanent root system of the tree or shrub would in general confer an advantage in comparison with many herbaceous grasses or legumes, enabling them to exploit the soil area more effectively. The tree or shrub in general would also have much higher food reserves stored in root systems or in woody stems, that would enable

these plants to resume growth and productivity very rapidly after the return of favourable growing conditions. The large number of latent growing points in the stem tissues of trees and shrubs also gives there plants the ability to make rapid recovery after being cropped by the browsing animal. Damage by grazing to potential growing points is one of the major weaknesses of many herbaceous pasture plants, especially among the legumes, but the tree or shrub usually has in its stem cambium a virtually unlimited source of new growing points that are completely protected from damage by browsing.

The tree or shrub, however, is not without some disadvantages. Most of the animal species used by man are adapted to feeding close to ground level, whereas trees and some shrubs tend to grow beyond their reach unless some form of management can be imposed on the stand to keep the production of edible material within reach of the animal. A further disadvantage of the tree or shrub is the high proportion of inedible woody tissue that these plants produce.

FEED VALUE OF BROWSE PLANTS

Yield

Very little critical experimentation has been done that would permit direct yield comparisons between woody and herbaceous plants for animal feeding. Most of the studies made on browse trees and shrubs have been limited to the concept of drought reserves and have not been planned to show whether trees and shrubs can be regarded as an adequate source of feed in all years. Relatively low production by browse plants may be of considerable economic value if it is a means of saving the lives of animals in danger of starvation, but this level of production may not warrant the use of the plant as a normal means of forage production. Nevertheless, sufficient data have been obtained in several countries with one promising species, namely *Leucaena leucocephala,* to demonstrate the high yielding ability of this browse tree. Using cutting techniques, this plant has yielded eight to nine tons of dry matter per acre per annum in Hawaii (Takahashi and Ripperton, 1949), five tons in Queensland (Hutton and Bonner, 1960), and up to eight tons in the Virgin Islands (Oakes and Skov, 1967). Hutton and Bonner concluded that the productivity of this plant in Queensland compared favourably with that of good crops of irrigated lucerne, and was comparable with the yield from high quality clover-rye grass pasture in New Zealand.

Quality

Wilson (1969) recently reviewed the role of browse plants in the nutrition of grazing animals. After examining chemical analyses, animal preferences, digestibility, and intake of browse, and the production of animals feeding on browse, he concluded that browse has not yet been shown to make a major contribution to the nutrition of domestic animals, and that further study of browse-grass comparisons is needed. However, most of the work reviewed by Wilson relates to admittedly poor classes of roughage that have a place only as a supplement under drought conditions. The reviewer significantly stated, however, that leguminous shrubs differ from other shrubs in that they often contain more than 20 percent crude protein.

No critical work seems to have been done to compare browse trees and shrubs with herbaceous swards in regard to stocking rates, effects on soil and vegetation conservation, or on the relative use by the two kinds of vegetation of soil moisture, nutrients, or solar energy.

MANAGEMENT

West (1950), writing of indigenous tree crops for Southern Rhodesia, stated: "If these trees were regarded as crop producing plants, and if they were to receive a

fraction of the care devoted to the breeding, selection, and improvement of the staple annual crops, they might be capable of revolutionising the entire agriculture of the semi-arid tropics." West's paper draws attention to the fact that present knowledge of how these and similar trees should be grown and managed is very meagre.

The optimal use of edible trees and shrubs in farming systems requires consideration of three alternative functions that these plants may serve in the overall pattern of animal feeding. These are (1) use as drought reserves, (2) use as seasonal reserves, and (3) use in year-round forage systems.

Drought Reserves

The traditional use as drought reserves implies that the edible material is kept intact during good times and only used in emergencies when the normal sources of forage are not available. It is necessary that stock are denied access to the material in normal times; this restriction may occur automatically in the case of the taller trees through the inaccessibility of the edible produce. This type of reserve will require lopping when it is to be fed. Shorter growing shrubs would need to be fenced.

Seasonal Reserves

In areas where there are regularly recurring dry periods when the normal sources of forage are inadequate, such as in southern Queensland in winter and spring, browse reserves can be used to help overcome the deficiency. For this purpose an area of trees or shrubs may be reserved for use at this particular season only each year, being kept unstocked at other times to enable the plants to recover. Bryan (1966) has suggested the use of *Desmodium gyroides* in this way, although he pointed out that it would need to be browsed sufficiently at other times of the year as well, to prevent unruly growth. *Leucaena leucocephala* could be used in a similar manner.

Year-round Forage

The high yielding ability of high-protein forage possessed by some of the better browse plants adapted to good rainfall conditions indicates clearly that this type of forage has a vital role to play in the up-grading of animal production in the tropics and subtropics. It remains to be shown how the better types of browse can be integrated into year-round forage systems as opposed to their use merely as drought feed. Here there is currently a need for much research of an ad hoc nature, because each species of browse and each situation present their own particular problems. But some general principles can be indicated.

The objective in incorporating browse into a normal farming system is to provide animals with a protein-rich supplement in addition to their other feed. Browse plants are probably best grown in areas separate from those devoted to grass, although not necessarily in pure stands. Stocking of browse and grass areas can then be controlled to secure the optimal use of both kinds of forage. This approach is being studied in south-eastern Queensland with *Leucaena leucocephala* in conjunction with native pasture plus Townsville stylo (Shaw, 1968). The increased weight gains obtained in this trial have demonstrated the feasilibity of using *Leucaena leucocephala* as a supplementary crop in this way. But experimentation on an extended scale is needed to work out the best combinations of the many factors involved, such as size and arrangement of paddocks, stocking rates, plant spacing, time and frequency of browsing, use of fertilizers, and so on.

It was mentioned above that the browse plant need not necessarily be in a pure stand. Indeed in many circumstances it would probabaly be better in a mixture. Although it would generally be difficult to incorporate a browse species into an existing herbaceous pasture, it is not difficult with appropriate spacing to add an herbaceous pasture to an established stand of browse plants by over sowing. This leads

to the concept of a two-storied pasture, with suitably spaced browse trees or shrubs and an understorey of grass or grass plus legume. Systems of this kind would not only provide an appropriate mixed diet for the stock but would also maximize the utilization of solar energy and soil moisture.

THE RANGE OF BROWSE PLANTS

The number of tree and shrub species being widely used as browse plants in the tropics and subtropics is at present small, although there are undoubtedly many more species that could be used in this way that have not yet become widely recognised, or that require further study before being accepted.

There has been an increasing interest in recent years in the use of the legume *Leucaena leucocephala.* Information contained in the literature about the use of this plant for forage has been reviewed by Takahashi and Ripperton (1949), Hutton and Gray (1959), Oakes (1968), and Gray (1968).

Some genera of tropical legumes include both herbaceous and shrubby species. Bryan (1966) has grown a number of the shrubby species of *Desmodium* in coastal southern Queensland. Some of them, such as *D. nicaraguense,* are deciduous in winter under Queensland conditions, but another species, *D. gyroides,* retained its leaves in winter. Bryan found that this species persisted under grazing for five years and thrived under soil conditions which were unsuitable for *Leucaena leucocephala.* He concluded that *D. gyroides* has a place as a high-protein feed for use in autumn and winter.

The carob bean (*Ceratonia siliqua*) comes from the Mediterranean, but has been grown successfully in parts of coastal southern Queensland, and deserves more widespread trial. Jurriaanse (1950) pointed out that this fodder tree has been disappointing in many areas in South Africa where it has been introduced, mainly because of its sensitivity to severe cold, but that in areas where it thrives it merits greater attention, especially in regard to the development of improved varieties.

West (1950) described a number of leguminous trees indigenous to Southern Rhodesia, which produce large crops of edible pods that fall to the ground as they mature. Many of these belong to the genus *Acacia,* e.g. camel thorn (*A. giraffae*), umbrella thorn (*A. litakunensis*), *A. albida, A. woodii,* and *A. subalata.* Many additional species of *Acacia* useful as browse occur in Kenya, according to Dougall and Bogdan (1958). In Australia, several species of *Acacia,* including mulga (*A. aneura*) have been used as browse plants (Everist 1969).

Two other notable leguminous trees, both of North American origin, are the honey locust (*Gleditsia triacanthos*) and mesquite (*Prosopis* spp.). The former has been found to be adaptable to dry areas under irrigation in South Africa (Jurriaanse 1950) and is cultivated mainly for its pods. A good deal of variation occurs, and improvement by selection and breeding is considered desirable. Mesquite is very variable, some types being quite useful but others tending to be unproductive. This species has a tendency to spread rapidly and become weedy, so some selection of types would be necessary.

SEARCH FOR NEW SPECIES

Can the available range of browse plants for the tropics and subtropics be extended? The most likely source of additional species would probably be among the relatives of species already recognised as pasture plants for these regions.

The close relatives of *Leucaena leucocephala,* however, are not particularly promising. *Leucaena* is a small genus with about nine species, most of which have been tested in Queensland, but are generally unpromising as forage plants, with the possible exception of *L. pulverulenta* and *L. diversifolia.* The much larger genera *Mimosa* and *Acacia* are more likely to contain new species of interest.

The sub-family *Caesalpineaceae* includes many trees and shrubs, mainly tropical, but few of these have been considered as forage plants. Many species in this group of legumes contain toxic principles, but a search among such large groups would probably disclose some exceptions. An intriguing possibility would be to find a non-toxic species of *Cassia* or some similar genus, or to develop non-toxic strains by breeding.

In the remaining groups of legumes there are many large genera containing recognised tropical pasture plants, which also include species that are trees or shrubs, that could furnish additions to the range of potential browse species. *Desmodium* has been mentioned above in this connection, but many other genera such as *Sesbania, Dolichos, Pueraria, Erythrina, Crotalaria,* and *Indigofera* would probably repay further investigation.

Finally it should be mentioned that in common with other tropical legumes, many of the potential browse plants present problems for the plant breeder in order to improve their adaptation and usefulness as pasture plants. The development and testing of genetic variation within potential species should add appreciably to the range of browse material.

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