FEEDING VALUE AND UTILIZATION OF PASTURE

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Summary

Research into the feeding value and use of pasture has concentrated mainly on plants and animals outside the context of the pastoral system. From this considerable fund of information, assumptions have been made regarding species and practices for the pastoral system, but few have been experimentally tested in that system. Where grazing experiments have been done, the annual animal production figures do not always confirm the assumptions.

There would thus seem to be a need for greater active collaboration between plant, animal and grazing system investigators. Studies in depth as to the precise effect on the functioning of the whole system of various species and practices over a range of stocking rates should help define the influence of various plant and animal characteristics and mechanisms on animal productivity. At a few locations, at least, such conjoint studies within the same experiments would seem warranted.

I. INTRODUCTION

For most regions of the world, the fluctuations in the daily growth rate of plants both within and between years are wider than the fluctuations in the potential daily consumption rate of their livestock populations. The figure of 80 per cent of the total annual growth occurring in 12 weeks (Moore, Barrie and Kipps 1946) is probably a common circumstance. As a consequence, where livestock graze year-round, they experience considerable changes in the amount and quality of food presented to them. For economic reasons, a large proportion of the world’s livestock, including virtually all the sheep and cattle in Australia, depend on year-round grazing. A large proportion of the world’s land surface, including over 96 per cent of the agriculturally occupied land in this country, is used for this purpose.

A further restriction applying to livestock production in Australia and in many other places is the absence of nomadism or transhumance. Each flock of relatively constant size throughout the year is confined in its grazing to a fixed area of land, viz., the area within the boundaries of a property. Within each property, the objective of the livestock owner is to have as high a number of animals as possible consistent with a satisfactory quantity and quality of saleable

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product per head, and with minimal recourse to hand-feeding, to enforced uneco-
nomic sale or to agistment of livestock. This form of animal production is com-
monly referred to as the pastoral system.

II. RESEARCH FOR THE NON-PASTORAL FORMS
OF ANIMAL PRODUCTION

Most research into the feeding value and use of plants is concerned with
plants which are mechanically harvested on a few occasions during the year when
the quantity and quality are at or near their maximum, with animals which are
hand-fed on that harvested material either directly or from storage, or with animals
grazing plants at high levels of utilization when plant growth is rapid and quality
is high.

The information gained from these types of research is relevant to the feed-
lot situation or to those forms of animal production where grazing can be limited
to the periods of rapid pasture growth, and where the area of pasture or the
number of livestock can be altered from time to time during the grazing periods
so as to achieve high levels of pasture utilization. Means employed for adjusting
pasture use to pasture growth include transferring the livestock to and from
other regions, hand feeding, making other use, e.g., conservation or cropping,
of areas not currently required for grazing, etc. By contrast, in the pastoral
system, these adjustments can be made only between portions of the system so
that, for example, when pasture growth is rapid and its utilization is consequently
low, increased utilization can be attained only on some portions by confining the
livestock thereon, and then only at the expense of decreased utilization on the
ungrazed remainder.

The concentration of research into these non-pastoral forms of animal pro-
duction may be ascribed to such research having originated and having developed
in countries where the climatic conditions make year-round grazing difficult or
where cropping is a profitable adjunct to animal production. From these develop-
ments, the plant and animal sciences relevant to animal production have been
founded, and these have been used as a basis for the establishment throughout
the world of separate plant and animal institutes, frequently administratively and
geographically separated.

Such concentration of research into plants and animals largely as separate
entities has led to the development of new species and procedures which have
markedly improved animal production from the non-pastoral industries. The adop-
tion of many of these species and procedures in non-pastoral countries has been
assisted by often considerable subsidies from Governments. However, despite the
substantial improvements in the non-pastoral forms, the pastoral system for con-
siderable areas of the world remains the more economic. For instance, even in the
U.S.A., grain-feeding in dry lots has been calculated to be less profitable for beef
production than grazing (McClyod 1966). There would thus appear to be a
good case for more of the world’s research to be directed towards increasing the
efficiency of the pastoral system.
III. RESEARCH FOR THE PASTORAL SYSTEM OF ANIMAL PRODUCTION

In Australia there is a general appreciation that research into feeding value and pasture use should be concerned with the pastoral system. Morley (1962) has indicated the features of this system and the determinants of animal output in contrast to the non-pastoral forms. He has listed plant breeding objectives for increased numbers of livestock, increased production per head, freedom from harmful structures or substances, improved adjustment to the climatic and agricultural environment, etc. Morley has stressed the need for “clear and realistic objectives”, and for “more work in plant and animal physiology as well as plant and animal breeding, and the co-ordination of these in the design and management of highly productive plant-animal complexes”.

Considerable work has been accomplished in the separate fields of plant and animal physiology, and plant and animal breeding. At the Australian Grasslands Conference, 1968, under the general title of “Evaluation of Herbage Plants”, reviews were given by Lazenby (1969) on plant selection, Rossiter (1969) on agronomic data, Minson (1969) on plant quality, Lamboume (1969) on evaluation by measurement of animal production, and Hutton (1969) on the evaluation of herbage plants. These, together with the recent reviews by McWilliam (1969) on the introduction, evaluation and breeding of new pasture species, by McDonald (1968) on the nutrition of grazing ruminants, and by Corbett (1969) on the nutritional value of grassland herbage, give a thorough coverage of these subjects and no attempt will be made in this paper to extend the detailed survey thus provided.

Much of this work, however, has been conducted by scientists working as individuals in separate plant or animal institutes or departments, and “co-ordination (of the results) into the design and management of highly productive plant-animal complexes” (Morley 1962) is generally lacking. Indeed, though Axelsen and Morley (1968) have stated that “ultimate discrimination demands tests under grazing”, most recommended species and practices have been based on assumptions from unco-ordinated programmes.

The conviction that grazing tests are essential indicates a suspicion that there is inadequate knowledge of the functioning of the pastoral system and how it might react to changes in species or practices. Lambourne (1969) shares this uncertainty in his statement that “one major justification for large-scale factorial grazing experiments is that they can reveal inconsistencies or unexpected results which then can be explored in greater depth”. He doubts the validity of extrapolating from grazing experiments to other circumstances until more is known of the specific reasons for the results obtained.

One alternative to resolving the dilemma that grazing is the ultimate test, but that insufficient is known to extrapolate from such tests to other situations, would be to conduct grazing experiments in every environment and situation, each covering a range of species, practices, types of animal production, and stocking rate — a colossal undertaking! The other alternative, as Mc Donald (1868) has pointed out, is “to study the many interactions between soil, plant, animal and climate so that the mechanisms governing the animal’s response within the ecosystem can be elucidated”.

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IV. THE FUNCTIONING OF THE PASTORAL SYSTEM

Basic to incorporating a new species or practice into the pastoral system with the objective of improving its animal output is as complete an understanding as possible of how the total system functions and which are the component mechanisms to be improved. In brief, a pastoral property is a closed system involving soils, plants and animals in continuous association, each influencing the other, and all under the influence of the climatic and managerial environment. The fact that there are situations where it is economically advantageous to deviate from the closed system, e.g., by exporting plant material such as a crop, or by importing plant material to supplement the animal feed grown within the property, alters the levels of; but does not eliminate, the interacting influences operating within the system. Except where plant production is completely separated from animal production, as in feed-lots, knowledge of the structure and functioning of the system is a necessary prerequisite to its improvement.

In the pastoral system, the total forage within the property can be regarded as a food pool in which there are continual changes in quantity and quality due to the following influences:-

(a) The Growth of the Plants

The growth rate of the plants varies markedly throughout the year due to variations in climate and to the age and amount of plant material present, the latter being the result of prior growth, ageing and intake. New growth is generally high in apparent digestibility and this is probably the most useful single measure of the nutritive value of a feed because digestibility is a major determinant of intake and intake is a major determinant of animal production (Corbett 1969). Thus, plant growth, when it occurs, increases the quantity and generally increases the quality of the food pool.

(b) Intake by the Grazing Animal

The amount of pasture consumed on any one day depends on the number of animals and their intake per head. During the year, the number of animals may change or be changed due to births, deaths, purchases and sales, and the potential intake per head may change due to variations in the weight of the animals (the outcome of prior intake), their ages and physiological state (dry, pregnant, lactating). The animals deliberately select the young material, i.e., leaf rather than stem, green rather than dry or dead material, these being the more highly digestible portions (Corbett 1969). But whether each animal or the flock or herd as a whole achieves the potential intake on any one day depends on the quantity and quality of the food presented. Above certain quantitative and qualitative levels which may differ for different plants and for different animal circumstances, there is no increase in intake. Below these levels intake falls at an increasing rate (Willoughby 1959).

There are thus upper limits to the amount of food that the flock or herd can remove from the pasture pool on any one day, and there are lower limits fixed by the survival needs of the animal. The less the intake potential of the flock or herd is fulfilled the less is the current animal production. Though total intake per day is of the order of only 1 to 2 per cent of the total pool, the effect is to reduce the quantity and quality of the pool.
(c) Ageing and Decomposition of Plants

In general, as plants pass through their various stages of growth, their digestibility decreases. The longer the period of time that plant material remains unconsumed the lower becomes its quality, and additionally it is increasingly exposed to loss in quantity through decomposition. Consequently, when the plant pool is inadequate to provide the livestock with their potential needs, i.e., when the quantity of forage is low, there is little opportunity for ageing or decomposition to occur. The greater the ability of the pasture pool to provide or exceed the requirements of the livestock, the greater are the opportunities for losses in quantity and quality.

The variations in the rate of increments to the plant pool in quality and quantity due to growth (which may be at zero for long periods) are far wider than the variations in the rates of decrement in quality and quantity due to intake. These, together with the variations in the rates of decrement due to ageing and decomposition, lead to wide fluctuations throughout the year in the quantitative and qualitative status of the pool. These fluctuations would not appear to be greatly affected by the location of the animals within the food pool. As between allowing the livestock continuous access to the whole or confining them to portions at a time, only minor differences have been recorded in the total amount of pasture (Moore, Barrie and Kipps 1946; Willoughby 1959) or in total animal production (Arnold 1968). Apparently, any diminution of the incremental or decremental rates in one portion of the pool is largely compensated by relatively equivalent increases in the remainder.

V. THE PHASES OF PASTURE QUANTITY AND QUALITY

As a result of the above interactions between pasture (or food pool) and animal, the pasture relative to animal production at any one time is in one or other of the phases shown in Figure 1.

These include not only the phases when all the material in the pool is of the same quality and quantity but also those where there is a mixture of different quantities and qualities. The transitional phases when the pasture exactly provides the maximal requirements for the animal are usually very brief and have been omitted.

There are periods, as illustrated, when improving the quantity or amount of the pasture will have no effect on current animal production. In general, these coincide with the periods on which much research has been and is being done, and which has more relevance to the non-pastoral situation. For the pastoral situation, plant measurements made at this time indicate the quantity of material in excess of that required by the animal, and exposed to loss. The greater the excess the greater the risk of loss (Willoughby 1959).

Such excess in amount may aggravate the problem of pasture use. Pasture species selected on the basis of higher quantity when quantity is already in excess may create the very conditions which the pastoral industry seeks to escape, namely, an increase in the disparity between the patterns of pasture production and pasture use. This may lead the livestock producer to reduce the disparity by high cost methods such as fodder conservation. On the other hand there could be merit
Fig. 1.-Possible phases of a pasture at any one time relative to the requirements of the livestock population for maximum animal productivity at that time.

\[ A = \text{Amount more than sufficient} \]
\[ a = \text{Amount insufficient} \]
\[ Q = \text{Quality high} \]
\[ q = \text{Quality low} \]

Two sets of symbols in any one phase indicate a mixture, e.g., \( Aq \), \( aQ \) = a more than sufficient amount of low quality material and an insufficient amount of high quality material. The brief transitional phases where the pasture exactly provides the livestock with their maximal needs are omitted.

in a species which gives higher quantity when this is already in excess if current quality is not reduced and if the species has greater resistance to losses due to ageing and decomposition to the extent that subsequent deficiency periods are alleviated.

Greater research attention should be directed to these deficiency periods, namely those illustrated in Figure 1, which limit the size of the animal population which can be supported year-round, or their production per head, or birth. Here the critical aspects are the levels of forage deficit below the animal requirements at that time, and the length of time that these conditions persist. The lower the deficit or the longer its duration, the greater is the restriction on current animal production. The severity and duration of these deficiency periods is influenced by the grazing activities and, therefore, cannot be measured, at least presently, other than in the grazing situation.
Studies aimed at alleviating these deficiency periods and their effect must nevertheless have relevance to the year-long and year-to-year situation under which the pastoral system operates. The current status of the pasture and of the animal is an outcome not only of current but also of prior conditions. Again, because there are circumstances under which the animal can withstand, or subsequently compensate for, temporary periods of sub-optimal nutrition, alleviation of the deficiency periods may not necessarily give economic increases in annual animal production. As McDonald (1968) has indicated, knowledge of all the mechanisms governing animal response is “essential to permit the effective application of scientific findings to practical husbandry pastoral systems”.

VI. REFERENCES