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Food selection by ruminants

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Farm animals can be considered as machines which process raw materials, food and water into products—wool, meat, milk, hides or even tractive power. The basic limiting factors in the process are the potential converting power of the animal and what we are chiefly concerned with in this paper—the potential input and how it is determined. This paper discusses some of the factors which determine whether and to what extent a ruminant animal accepts and ingests its food.

The ruminant has no incisor teeth in the upper jaw; instead, these six teeth are replaced by a 'dental pad'. The six chisel-like incisors of the lower jaw bear against the dental pad in the upper jaw and form, together with the lips, a very efficient mechanism for prehension.

Sheep at pasture are specially noted for their ability to select a diet which is, theoretically, distinctly better than is the average herbage available. On grass, the sheep is known to ingest a diet with a considerably greater nitrogen content than is apparent from a general sampling procedure (e.g. Weir & Torell, 1969). According to Fels, Moir & Rossiter (1959), this occurs only when the nitrogen concentration in the pasture organic matter is about 3·0% or less. Selection can vary with time of day and with breed, age, and previous history (Langlands, 1965, 1969). This ability to select has been explained on the basis that the narrow muzzle of the sheep, together with its split upper lip, allows the animal to pick out portions of herbage very precisely. However, we need not jump to conclusions. The domestic cow is usually considered to be a patch selector. It uses its long prehensile tongue to sweep a bunch of fodder into the mouth. This herbage is then clamped between the incisors and the dental pad and is torn off. Apparently this should not allow of anything other than a very crude selectivity. And yet it has been found that cattle do select extremely well (e.g. Hardison, Reid, Martin & Woolfolk, 1954; Topps, 1962; Tayler, 1965) and in one instance they selected so well on a poor sparse winter pasture as to cause scouring (Garner, 1944). It has been suggested that, when cattle and sheep are grazing together, the sheep show the greater selectivity but are not actually more successful than are cattle (Anonymous, 1963). And, the two species differ so markedly in taste and food selection that they are not in competition for nutrients. This is partly because cattle, although they selected fodder 25% higher in cellulose than that eaten by sheep, have a possibly much greater ability to digest cellulose.

Since cattle and sheep, and possibly all ruminants, can and do select effectively from natural grazing, one wonders what determines the animal's recognition of what to select. Obviously the senses must play a large part. First of all we will consider vision.

It appears that domestic ruminants do not have colour vision. For example Tribe & Gordon (1949) were unable to set up a conditioned reflex in sheep relating the presence of desirable food and light of a specific colour. Had these animals possessed colour vision this relationship would have been quickly and easily learned. It appears that cattle do not have colour vision and neither do deer. But in any case it may be anthropomorphic to consider that colour vision could be important. One other aspect of vision could conceivably play a part in food intake. Ungulates, in general, have a highly developed power to react to movement in the visual field. I do not know whether this power plays any part in food selection. Ruminants will graze in very dark conditions and will eat readily even in complete darkness. This may indicate that vision is relatively unimportant, but the true role of vision in food intake is not known.

The sense of smell, on the other hand, does appear to be important, although Tribe (1949) has shown that with penned animals adaptation to smells such as faeces or carbon disulphide can occur very rapidly. Contamination by the faeces of its own species renders herbage unacceptable (Plice, 1951; Marten & Donker, 1964*a*). It may be that the defaecation patterns of some animals such as the horse (Taylor, 1954) are an avoidance of smell rather than a purposive avoidance of parasitic infection (Michel, 1955, 1964). However D. B. Johnstone-Wallace, quoted by Taylor (1954), found that when grass was removed from a contaminated area it was then accepted, although it had previously been refused. Although Huffman (1939) has argued that taste is unimportant, both Plice (1951) and Taylor (1954) have suggested that taste may be the real reason for refusal of grass from contaminated pasture. This taste may be related to a low-sugar level in the herbage (Plice, 1951; Marten & Donker, 1964*b*).

One recent piece of work on the contamination of pasture by faeces is that of Greenhalgh & Reid (1969). In this experiment, cattle given a herbage allowance of either 11 or 20 kg dry matter per cow/d were allowed to strip-graze fouled pasture. On an area which had 2·8% of its surface covered by faeces, digestible organic-matter intake was affected more by grazing intensity than by fouling and this was true also for milk yield, milk composition and live-weight change. There was no evidence of rejection of grass from fouled areas other than that attributable direct to the fouling.

In his review of the composition of a sheep's natural diet, Tribe (1950) quoted the work of Charles Linnaeus, the Swedish systematist, who investigated which plants are consumed by well-fed livestock, which are ignored and which are avoided. Linnaeus believed that the answer to this question was 'of fundamental importance both for private owners of livestock and for animal husbandry as a whole'. Goats and sheep showed the least discrimination. Tribe took a list of 473 plants used by Linnaeus, which can be found in Great Britain, and examined Linnaeus's result in relation to such things as the presence of aromatic compounds, hairs, succulence etc. There was no apparent common factor which could be used to forecast the acceptability of a given plant.

Tribe dealt only with Linnaeus's data for sheep and these could be different for cattle. But it is of interest to consider that these plants apparently varied considerably in smell, touch, taste and tensile strength, and yet it was not possible to forecast which would be eaten. This is strange since sheep do select effectively and intake, even of hays, is related direct to digestibility, among other things. This has been shown, for example, by Reid & Jung (1965), and Troelsen & Campbell (1969). However, Greenall (1958) found that, although sheep selected from a pure stand of rape a diet which was different from the pure stand in composition, because they preferred leaf to stem, the composition of the selected rape was slightly worse than that of the pure stand. Also, when grazing is intense, selectivity is reduced (Pieper, Cook & Harris, 1959).

One might also mention the ability which the camel has to enable it to browse on unlikely material. To quote Leese (1927); 'the mouth of the camel is almost impervious to injury by the many wicked-looking thorns which are so characteristic of the vegetation of arid tracts; to see a camel briskly running its mouth along a branch of Acacia with its $\frac{3}{4}$ inch thorns is enough to make one squirm'. The explanation of the camel's selection of *Acacia* is in part mechanical—having thick lips it suffers little discomfort. And, a mechanical effect may be the reason for the apparently wise selection of herbage by sheep, cattle and deer (Swift, 1948). The lower the fibre, the better is the nutritive value and the easier it is to pluck (Tayler, 1965). But this theory will not always hold good. It does not explain the findings of Auld (1962) who pointed out that Merino sheep select roughages when forced to eat high-protein feed. I think it probable that any sheep receiving a 'low rumination' diet will go for anything chewable whether it be hay, wood or even another sheep's fleece. However, in the same paper, Auld also reported that, given the right selection, sheep were the best judges of what they required, giving exceptional results in body growth and wool production. It should be added that Huffman (1939) argued that a low breaking strength meant low palatability.

Is there some innate or learned ability on the part of livestock which enables them to select what they need? In discussing this question of so-called 'appetite instinct' in the human infant, Le Magnen (1951) pointed out that such a concept would involve avoidance of harmful materials. He suggested that KCN should have been offered! If we accept this we need only look at Linnaeus's results again to see that of seventy-three poisonous plants offered to well-fed sheep, forty-five were eaten and nine sometimes eaten. Only nineteen (26%) were refused. However, small amounts of a poisonous material may be quite different, in effect, from large amounts.

Cattle and, possibly, sheep when grazing phosphorus-deficient herbage tend to eat foreign material. They show a pica which may take the form of osteophagia, i.e. bone-eating or, in worse cases, allotrophagia, the eating of any apparently abnormal material such as decaying flesh, apparently to get at the bones (Theiler, Green & du Toit, 1924). Green (1925) tells of an extreme craver which crunched a living tortoise while blood dripped from its jaws. But is this abnormal? What, after all, is an herbivore? There are accounts of various herbivores observed taking flesh food. Roast chicken is very attractive to weanling wild rabbits. And, therefore, might not the cattle have eaten these things anyway? According to Darling (1937), phosphorous deficiency is the reason for the consumption of dead frogs and cast horns by red deer. Or is it? Can we really classify these things at all neatly?

Some years ago we tested this hypothesis concerning the ability of cattle and sheep to select phosphorus. On phosphorus-deficient grazings on the Isle of Skye, 90 cattle and 500 sheep were present. The cattle suffered from phosphorus deficiency and there was evidence of oesteophagia; allotrophagia was also alleged. These cattle and sheep failed to consume phosphorus to any significant extent from depots of a dicalcium phosphate–ground limestone mixture (Gordon, Tribe & Graham, 1954). They failed to 'recognize' an easy source of phosphorus. Possibly we were anthropomorphic in assuming that a clean powder would be more acceptable than would an old bone. Perhaps the mineral was gritty. Or perhaps it should have been flavoured with something which would nauseate our prejudices. It is of interest that Stewart (1953) found that, whereas on cobalt-deficient grazing top-dressing with cobalt sulphate resulted in sheep selecting the dressed pasture, he could not induce the sheep to accept cobalt-rich mineral mixtures. On the other hand, Todd, Scally & Ingram (1966) successfully used molasses in self-selection studies of magnesium with dairy cows at pasture.

We also investigated the question of whether grazing cattle browsed on coarse herbage, weeds, shrubs and the like to provide some dietary component missing in the pasture. We found that neither the growth nor the behaviour of young growing stock was affected by the eating of browse–plantain, yarrow, gorse, broom and coarse grasses (Tribe, Gordon & Gimingham, 1952).

An indoor experiment using eight pregnant Cheviot sheep bearing twins (Gordon & Tribe, 1951) was also done. The ewes were housed in roomy individual pens and were offered water, mineral salt licks, chopped hay, a carbohydrate concentrate, either yellow maize meal or crushed oats, and a protein supplement, either linseed-cake meal or white fish meal. All these components were expected to be palatable to sheep with the exception of white fish meal. In fact, neither linseed-cake meal nor white fish meal was eaten to any extent. The sheep failed to select an adequate diet. Food intake also fell a few weeks before lambing and three ewes died of pregnancy toxaemia; one ewe developed eversion of the vagina before and after lambing. All the lambs were weak, over half died and some did not feed. Only one ewe had a satisfactory milk supply but she produced small lambs. These sheep had previously been pregnant and produced a satisfactory crop of lambs.

Nevens (1927), with cattle, also found a failure to select correctly their own diet in an indoor experiment but Moore & Dolling (1961) found that, when housed Merinos were offered a diet of roughage only, they behaved like animals at pasture and selected more nitrogen than was present in the original mixture. It may be that the conditions of the experiments are important. Cunningham (1949) failed to show any relationship between intake of minerals and what had already been ingested, whereas Beilharz & Kay (1963) found that some sheep drank just enough sodium bicarbonate solution to balance their sodium deficit. Denton & Sabine (1961, 1963) showed that, when in positive sodium balance, considerable amounts of sodium salts may be drunk by sheep but, when in negative balance, there was a large increase in sodium appetite, sufficient to regain balance in some but still giving some degree of sodium deficiency in others. The sheep generally corrected their intake of solution according to the concentration of sodium offered and the time during which it was offered. The same type of result was obtained with Baldwin (1968) using trained goats. Cattle have also been observed to show 'salt hunger' (Smith & Aines, 1959) and when sodium-depleted they maintained a salivary Na:K ratio by selection for sodium (Bell & Williams, 1960).

Thus, to sum up this question; domestic ruminants generally show a power to select their own diet when at pasture or when suffering from sodium depletion. Other mineral needs such as cobalt, magnesium or phosphorus do not necessarily give rise to a selection of the right materials for ingestion even when these are easily available.

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Food preference in domestic pets

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Introduction

Domestic animals, whether on the farm or in the home, have only limited freedom to select their own diets and are to a substantial degree dependent on the judgement, prejudice or whim of their owners. Whereas the selection of a feedstuff for farm animals is strongly influenced by experience, or reports of weight gain and feed conversion, such yardsticks are not applicable to foods for household pets. The cost is still a factor, but more in the context of the standard of living of the family.

The other criteria which apply to the choice of food for dogs and cats are also more akin to those for human food than to those for farm animal feeds. The pet shares many of the foods which his owner enjoys, and the owner assumes that there is much in common between his own likes and dislikes and those of his dog. The food must therefore satisfy a critical organoleptic assessment from the owner as well as the dog. It is clear that the owner's assessment of these properties is more influential than the animal's—for how many owners would offer horse dung or rotten meat to their dogs, even though these commodities are often attractive to the canine palate? It is not, however, within the scope of this paper to discuss the organoleptic properties which man considers important in pet foods and we shall thus confine our attention to the responses of the dog and cat.

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