Sward structural characteristics and selective foraging behaviour in dairy cows

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We know what we are, but know not what we may be

Shakespeare – Hamlet, Act IV. Sc. 5

ABSTRACT

This thesis sought to further the understanding of foraging behaviour in the context of the manner in which dairy cattle graze in a complex dietary environment, and incorporated an evaluation of the trade-offs cattle make between criteria for selection between alternative patches of vegetation. A series of five experiments at the patch scale were carried out with four trained dairy cows, using a novel methodology of patches arranged in linear sequence. Observations of preferential behaviour (grazing bites, residence time and the mass of herbage removed) were related to choices involving combinations of sward physical, structural and morphological characteristics, and where possible were related to phenomena defining the components of ingestive behaviour, primarily bite depth and bite mass.

Swards in a vegetative phase of growth were offered to animals in Experiment 1, with sward height a stronger patch cue than bulk density, although the relative importance of density within the selection criteria could not be ascertained. Green leaf mass, however, was strongly associated with sward height (Experiments 1 and 2). When sward maturity was added to the heterogeneity of the offered choices, increasing the complexity of decisions the cattle faced, patch reward was no longer always associated with sward height as a cue (Experiments 3 and 4). Cattle then sampled all sward choices in the appraisal phase of foraging to gain information about their potential value. The preferential grazing of the short immature swards in Experiment 3 indicated that the initial approach cue of sward height was strongly conditioned by the information gathered about sward maturity upon patch appraisal. The selective response for short immature swards could not be accounted for by variations in leaf mass or the depth of regrowth, which suggested that the distribution of leaf mass within the canopy, and the intermingling of leaf and stem within the grazed stratum strongly modified patch residence time. The results from Experiment 3 suggested clearly the need to separate out the effects of sward height and maturity on foraging decisions. In Experiment 4, cattle strongly used the handling cue of depth of regrowth rather than sward height as a basis for patch appraisal, and because of the decline in the depth of regrowth with increasing

sward height, sward height was negatively associated with patch preference. The strength of the effect of maturity over that of sward height as a selection cue was a particularly significant finding from the programme. The final experiment (Experiment 5) investigated the role of the spatial distribution of patches relative to patch area and sward height on foraging behaviour. When foraging responses were adjusted for per unit area effects, the current patch distance strongly influenced patch selection as measured by the preferential indices of grazing bites and residence time. In this study preference was greater for the short sward treatment but, within sward height treatments, preference was linearly related to sward height. Animals showed strong evidence for the monitoring of patch area.

Analysis of the patch grazing cycle showed an asymptotic relationship between bite depth and bite number (Experiment 4) which indicated a clear adjustment phase where animals increased the depth of penetration as they gained information and appreciated the opportunity value of the patch. The structure and composition of sward strata were found to be important regulators of bite penetration. When the contrast between the stubble and regrowth strata reflecting variations in biting resistance were small (Experiment 2) cattle readily penetrated into the stubble stratum comprising leaf and pseudostem (Experiment 2). At the opposite end of the continuum, when the contrast between the two strata was greater (Experiment 4), the depth of bite penetration was strongly influenced by the vertical position of the regrowth:stubble interface. The response in terms of deeper penetration into the stubble stratum with increasing sward height (Experiment 4) led to the conclusion that the interface was only a partial regulator of bite penetration, although it strongly influenced patch residence time, indicating the relative importance of this structural feature on patch ingestion. The sward combinations used throughout this thesis covered a wide range of sward heights. There was, however, a lack of consistency for the significance of the proportionality concept, a result strongly emphasised when choices comprised controlled variations in the proportions of regrowth and stubble (Experiment 4). This generalised finding raises concerns over the theoretical assumption that bite depth can be modelled as a constant proportion of sward height.

The absence of any consistent relationship for within and between patch behaviour across Experiments 1 to 5, and the absence for evidence of rate of intake control with increasing inter-patch distance (Experiment 5), and increasing number of bites removed per patch (Experiments 4 and 5) calls into question the underlying

assumptions and constraints that characterise linear style foraging models such as the marginal value theorem.

The novel methodology used throughout this thesis demonstrated its potential to examine trade-off decisions, but greater effort will need to be focussed on separating many of the naturally confounding sward characteristics and their effects on foraging behaviour.

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There is a potential source of confusion in the description of sward state characteristics, particularly with reference to the tendency to use the terms horizon and stratum interchangeably. Throughout this thesis the terminology as defined below has been adhered to. Accordingly when quoting from published material, the terminology has been changed to maintain this consistency.

Stratum/strata	A depth of sward canopy confined between two distinct lines.
Horizon	A distinct line separating two strata.
Sward height	The average height of the uppermost surface of leaves in an undisturbed sward canopy.
Stubble height	The mean height from ground level of the cut surfaces of tillers following a defoliation or series of defoliations.
Regrowth depth	Depth of a stratum of regrowth. The difference between sward height and stubble height.
Pseudostem height	The height from the base of a tiller to the ligule of the youngest mature leaf.