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BITE DEPTH PENETRATION PATTERNS OF DAIRY COWS FORAGING ON COMPLEX SWARDS

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Abstract

Sward height was the dominant cue used by dairy cattle to determine the depth of penetration on young vegetative swards. On more complex swards, bite depth penetration was controlled by variations in the depth of regrowth. Evidence showed that cattle grazed to the pseudostem:lamina interface, but sward height exerted a stronger effect on bite depth than pseudostem height. Modelling efforts to predict how the herbivore places bites in space in the vertical dimension across sward states are currently being restricted by the absence of detailed canopy structure descriptions. We argue that the contrast between strata is an important determinant of bite depth penetration through the conditioning effect on biting resistance, and that the "constant proportionality" concept of bite depth control should be treated with caution. Furthermore, we demonstrate that bite depth penetration is continuously being conditioned through information gained on a bite-by-bite basis, and that patch appraisal begins a new cycle at every patch.

Keywords: Bite depth penetration, foraging strategy, proportionality, regrowth depth, stubble height, sward height.

Introduction

The "constant proportionality" concept is now widely used in modelling bite depth (Demment et al., 1995), but there has been little critical examination of the consistency of proportionality of bite depth to sward height across a range of sward structures. Furthermore, there is little data to document the patterns of bite depth penetration within a patch. We present a summary of results collected from a series of three studies which evaluated bite depth placement in response to variations in sward structural maturity contrasts. These studies formed a component of a broader programme focussing on selective foraging behaviour in dairy cows.

Material and Methods

Three studies using a field design involving linear sequences from 12 to 27 patches in a perennial ryegrass (*Lolium perenne* L, cultivar Yatsyn) sward, and offering balanced variations in two or three sward variables at a time (Griffiths et al., 1996), were conducted over the period June 1996 to December 1997. Four mature Friesian cross dairy cows were each allowed to traverse one sequence of patches at a time with their preferential behaviour monitored according to the number of grazing bites removed per patch. In Experiment 1, cattle were offered nine combinations of variations in vegetative stubble height and regrowth depth, in Experiment 2 nine combinations of regrowth depth and sward height, and in Experiment 3 eight combinations of two sward heights across two patch areas and two inter-patch distances.

We use the term 'stubble height' to represent the mean height from ground level of the cut surfaces of tillers following a series of defoliations and 'regrowth depth' as the difference between stubble height and sward height. Pseudostem height is defined as the height from the base of a tiller to the ligule of the youngest mature leaf. Ranges of values are shown in Table 1.

Sets of sward height readings were taken from each patch prior to grazing (10 for Experiment 1, 15 for Experiment 2 and 15 or 30 for small and large patches respectively in Experiment 3), and from grazed areas. For Experiment 3, 7 and 14 pseudostem height readings were taken for small and large patches respectively.

Biting resistance was measured in Experiment 1 as the shear strength of test samples of five tillers at defined stratum heights using a Warner Bratzler meat shear-test apparatus (Wright and Vincent, 1996). In Experiment 2, force to fracture was measured using a universal testing machine fitted with a 1 kN load cell (Bench-top Model 4502 Instron Limited, High Wycombe, Buckinghamshire, UK), and test samples of three tillers severed at defined heights in the regrowth and stubble strata. Further details of procedures are given in Griffiths et al. (1996) and Griffiths (1999). Results for each experiment were analysed using the SAS General Linear Models procedure (SAS Institute, 1995) and a model fitting effects of sequences, blocks within sequences and treatments.

Results and Discussion

When the choices comprised swards in a vegetative growth stage (Experiment 1), depth of bite penetration was linearly related to sward height (F=504.91; P=0.0001). The combined sum of squares for the separate effects of regrowth depth and stubble height showed sward height was the strongest cue impacting on penetration patterns. By contrast, for swards in a reproductive growth phase (Experiment 2), bite depth penetration was strongly and positively related to the depth of regrowth (F=477.96; P=0.0001), and negatively related to sward height (F=37.62; P=0.0001).

These results clearly indicate that the relative importance of the stubble and regrowth strata was determined by the degree of maturity and resistance of stem material. The magnitude of the contrast in biting resistance (stubble:regrowth) in Experiment 2 approximated

3:1 while in Experiment 1 the corresponding value was only 2:1, indicating the possibility of an interaction between stem maturity and the positioning of the regrowth:stubble interface which combine to impact on both within-and between-patch choice. Information on the magnitude of contrast that is required to elicit variations in bite penetration responses would enhance our understanding of the mechanisms governing the vertical positioning of bites in space.

In Experiment 3, depth of grazing was also positively and linearly related to sward height but the height at which grazing settled was also strongly correlated with the interface between lamina and pseudostem. While there were strong indications that pseudostem height was a persuasive cue in conditioning the depth of penetration, the effect was not absolute as the effect of sward height (F=138.21; P=0.0001) on bite penetration was more dominant than that of pseudostem height (F=81.04; P=0.0001).

Across the three studies there was no consistent evidence to support the constant proportionality concept (Demment et al., 1995) of control of bite depth (Table 1). In Experiment 1 the bite depth/sward height proportionality range was 44.4 – 55.0 % (P=0.0011). The corresponding range in Experiment 2 was 20.7 – 45.6 % (P=0.0001), and in Experiment 3 was 41.6 – 48.4 % (P=0.2060). In Experiment 3, the across-treatment evidence in support of a constant proportion of sward height removed with each bite largely reflected the observation that the cattle grazed close to the interface between pseudostem and lamina on all treatments.

Recently there has been consistent evidence for within and between stratum depression in bite area and bite mass as patches are depleted (Laca et al., 1994; Wallis DeVries et al., 1998; Ungar and Ravid, 1999), but there appears to be no comparable data documenting the patterns of adjustment in bite depth penetration on a new patch. This question was addressed by examining the relationship between bite depth and bite number from the pooled field records for individual patches in Experiment 2 (Figure 1). Log relationships improved the fit between bite number and bite depth within treatments, implying that the relationships were not linear. Fitted curves for the three sward height levels overlapped, but curves for the three regrowth depths were distinct and parallel (Figure 1).

Changes in bite depth in the early stages of grazing on a new patch (Figure 1) appear to be too great to be explained simply in terms of increasing overlap of basically bowl-shaped bites (Ungar, 1996). Rather, we suggest that these changes are indicative of an inherently cautious pattern of behaviour in which animals gradually increase bite penetration as they build up an appreciation of the grazing opportunity on a patch, followed by an "adjusted" phase where bite depth shows little change (in this case over a substantial range from 20 to 65 bites per patch, or 32 to 106 bites per m^2).

The relationships shown in Figure 1 appear to be largely independent of any impact of patch depletion (Ungar, 1996), but they provide further evidence of the need for caution in drawing conclusions about bite dimensions from limited series of bites. Further research on the rationale behind bite depth penetration should be encouraged.

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Table 1 - **Absolute range of values for sward height, regrowth depth, stubble height, pseudostem height, bite depth and biting resistance where applicable for each of the three experiments.**

	Experiment 1	Experiment 2	Experiment 3
Sward height (cm)	8.3 – 21.2	15.4 – 22.3	16.6 – 23.3
Regrowth depth (cm)	2.2 – 7.3	0.0 – 10.5	11.6 – 18.3
Stubble height (cm)	4.0 – 16.0	6.2 – 22.0	5.0
Pseudostem height (cm)	*	*	9.2 – 13.9
Bite depth (cm)	3.7 – 10.6	3.8 – 8.2	8.1 – 10.0
Biting resistance (N) Regrowth	22.9 – 36.7	8.5 – 13.1	*
Stubble	48.4 – 66.0	29.8 – 34.8	*

* not measured

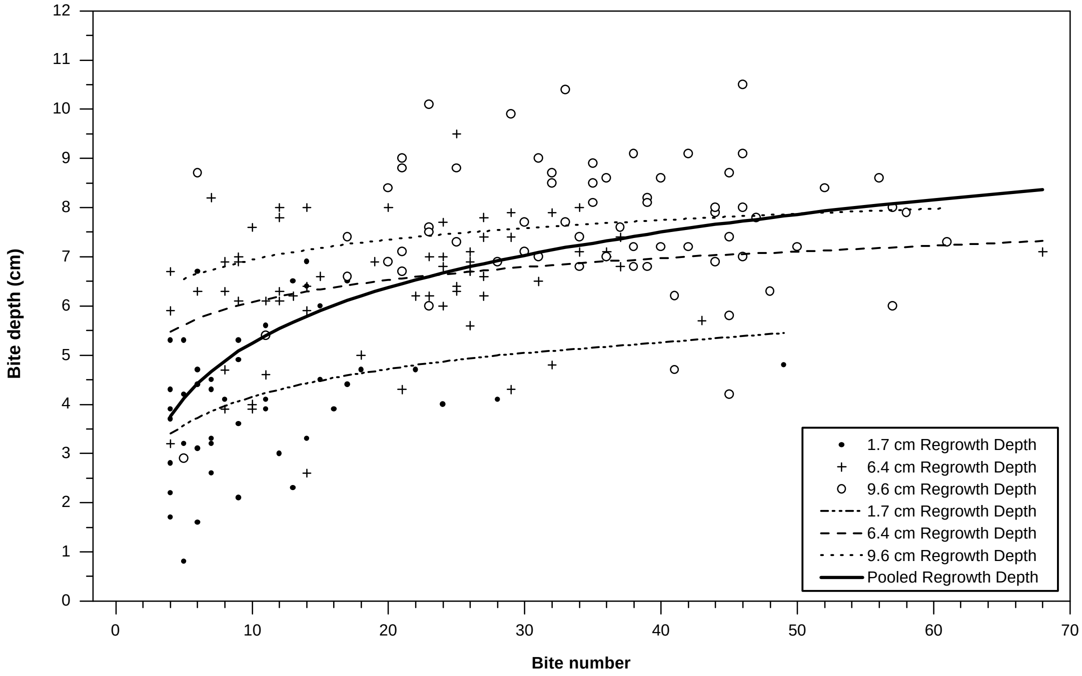

Figure 1 - Experiment 2: relationship between bite depth and bite number for the three regrowth depths. Pooled relationship: Bite depth=1.50 (±0.41) + 3.74 (±0.32)Log Bite number; 1.7 cm regrowth depth: Bite depth=2.26 (±0.71) + 1.89 (±0.72)Log Bite number; 6.4 cm regrowth depth: Bite depth=4.58 (±0.67) + 1.49 (±0.53)Log Bite number; 9.6 cm regrowth depth: Bite depth=5.63 (±1.16) + 1.32 (± 0.76)Log Bite number.