VERTICAL DISTRIBUTION IN GRASS SWARDS: INTERACTIONS BETWEEN DRY MATTER AND NUTRITIONAL QUALITY

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ABSTRACT
A field experiment was conducted to study the distribution of mass and quality over plant height throughout the growing season in a pure stand of orchardgrass (*Dactylis glomerata* L.). When plant density (expressed as kg DM/ha per cm height) is plotted against a height of strata, all treatments show a similar linear shape distribution. ADF and NDF concentrations declined with sward height. Fall treatments had lower ADF and NDF concentrations than summer treatments. Conversely, CP concentrations showed an increase with plant height. Fall treatments showed higher CP than spring and summer treatments. Defoliation management did not affect orchardgrass quality. Correlation between orchardgrass height and herbage mass and quality were presented. In addition, the results from this study can be used in pasture models to estimate animal intake and assist in model validation and calibration.

KEYWORDS
Grass, grazing, management, quality, sward mass, vertical distribution

INTRODUCTION
As grazing becomes increasingly popular as a method to reduce feed costs for producing milk, fine tuning the pasture system becomes more important. Maximizing pasture productivity requires a thorough understanding of the dynamic relationships between herbage and intake parameters and how they can be affected by grazing management and seasonal variability. The interface between the plant and animal components of the pasture system and potential animal intake (as estimated by neutral detergent fiber — NDF) also plays an important role (Stakelum and Dillon, 1991).

Vertical distribution of dry matter and quality have an impact on the animal bite size and, therefore, pasture intake. The vertical distribution of mass and the grazing frequency that can be simulated by mechanical cutting of the sward can also affect growth rate and the plantís light interception efficiency (Hodgson, 1990).

The objectives of this study were to determine the distribution of mass and forage quality over the plant height throughout the growing season in a pure stand of orchardgrass (*D. glomerata* L.), and to explore implications of vertical distributions of mass and forage quality. Relationships between orchardgrass height and herbage mass and quality from this study can be used in pasture models to estimate animal intake and assist in model validation and calibration (Mohtar et al., 1996a).

METHODS
A 0.2 ha (0.5 acre) of established orchardgrass pasture in State College, Pennsylvania, was used for a replicated trial of 28 treatments. About 84 kg N/ha (75 lb N/acre) of nitrogen was applied.

Treatments. The experimental treatments were combinations of these variables: 1) ceiling height (14, 21, or 28 cm), the height at which the sward was cut during the maintenance period, 2) harvest height (12, 17, 22, or 28 cm), the height at which cutting was initiated and stratification began, and 3) growing season, (spring, summer, or fall). The residual height was kept at 7 cm as much as possible during the maintenance period. The residual height is defined as the height to which a particular treatment was cut when its ceiling height was reached.

During the spring growth cycle, there was no previous management variable. Therefore, the total number of plots in the experiments were 112, each with an area of 0.26 m^2. Sixteen treatments occurred in the spring (four harvest heights x four replicates), 48 treatments in the summer (three residual heights x 12 x four harvest heights * four replicates), and 48 treatments in the fall (three residual heights x four harvest heights x four replicates). The 96 plots of the summer and fall were maintained during the spring season as described below. The fall treatments were also maintained through the summer.

Sample Collection. A special vacuum clipper was designed for uniform and quick sample collection. All samples were mechanically harvested using an electric clipper powered from a generator. To ensure uniform samples from all treatments, sliding wheels were framed to the clipper shear that slides in the guiding frame track. The frame has height adjustable legs that hold in place by inserting a pin in the desired hole punched in the legs at 5 cm intervals.

Quality Analysis. Quality measurements were made for all samples. Quality constituents measured were acid detergent fiber (ADF), neutral detergent fiber (NDF) (Van Soest and Robertson, 1979) and Kjeldahl nitrogen crude protein (CP). After drying, the samples were ground with a Udy mill (Fort Collins, CO) to pass through a 1 mm screen. Ground samples were scanned with a NIR Systems 6500 instrument operated by Center Select program (Infrasoft International, Port Matilda, PA).

RESULTS AND DISCUSSION
Vertical Distribution of Sward Mass. Mohtar et al. (1996b) evaluated dry matter distribution by modeling dry matter density as a function of plant height variables:

$$\rho = 453 - 91.3 \cdot I_{summer\ or\ fall} - 3.69 \cdot H - 153 \cdot \left(\frac{h}{H}\right)$$

where:
ρ = dry matter density, kg DM/ha per cm of plant height
$I_{summer\ or\ fall}$ = 1 if not spring growth, 0 otherwise
h = strata level, cm from ground
H = plant height, cm

Plant density decreased as strata level (distance from the ground) increased. There was a linear effect of height on dry matter density and a density at a certain strata level was higher for spring growth than later growth.

Vertical Distribution of Sward Forage Quality. Regression models of forage quality over plant height were developed by Mohtar et al. (1996b).

$$ADF\% = 28.5 + 8.15 \cdot I_{summer} - 3.14 \cdot I_{fall} + 1.68 \cdot I_{28cm} - .49 \cdot h$$
$$NDF\% = 52.7 + 13.8 \cdot I_{summer} - 7.64 \cdot I_{fall} - .84 \cdot h$$
$$CP\% = 16.8 - 5.72 \cdot I_{summer} + 1.97 \cdot I_{fall} + .43 \cdot h$$

where:
ADF% = ADF concentration, % of DM
NDF% = NDF concentration, % of DM
CP% = CP concentration, % pf DM
I_{summer} = 1 if summer growth, 0 otherwise
I_{fall} = 1 if fall growth, 0 otherwise

I_{s28cmr} = 1 if previous ceiling was 28 cm, 0 otherwise

Integration of dry matter density times nutrient concentrations over the plant height yields expressions for cumulative nutrient mass to a strata level of interest. Figures 1 and 2 illustrate the integration results for CP and NDF for the spring growth condition.

Several implications are evident from Figures 1 and 2. If grazing is to be terminated once a certain level of CP is reached, a strata level (residual height) can be determined. For example, spring forage below 7 cm is lower than 20% CP; while this is not likely a factor for spring growth since an 8 cm residual is common, for summer growth the forage below 20 cm is lower than 20% CP. For summer growth, the adjusting residual height to maintain sufficient quality in pasture intake may be necessary for high producing lactating dairy cows. Similarly, a 40% NDF threshold is reached at a 14 cm strata level. For spring growth, grazing below this 14 cm level results in lower quality forage intake which may lead to physical fill limiting milk production. Assuming an 8 cm lower limit to residual height, it is interesting to note that of the 5400 kg DM/ha available in a 30 cm sward (integrating density over height from 8 to 30 cm), 30% falls between the 8 and 14 cm strata levels. In other words, the top 70% of mass is lower than 40% NDF, but the lower 30% of the mass (more difficult to graze) is higher in NDF. An understanding of these interactions between dry matter distribution and nutritive quality can be very important for high producing cows.

While the relationships presented and used for orchardgrass may not be relevant for other species, the approaches used should be widely applicable. Simple models of vertical distribution of mass and quality can give insight to practical grazing management as well as improve intake prediction models.

SUMMARY AND CONCLUSIONS

A field experiment was conducted to study the distribution of mass and quality over the plant height throughout the growing season in a pure stand of orchardgrass. The study aimed to evaluate the vertical distributions of mass and quality. The vertical distribution of mass for all treatments was somewhat uniform, but a slightly higher percentage of mass was in the bottom 50% of canopy height. Models of dry matter density and nutrient concentrations over canopy height were presented.

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Figure 1
Cumulative dry matter, cumulative crude protein, and crude protein concentration over the plant height for spring-growth orchardgrass at 20 (a) and 30 (b) cm total height.

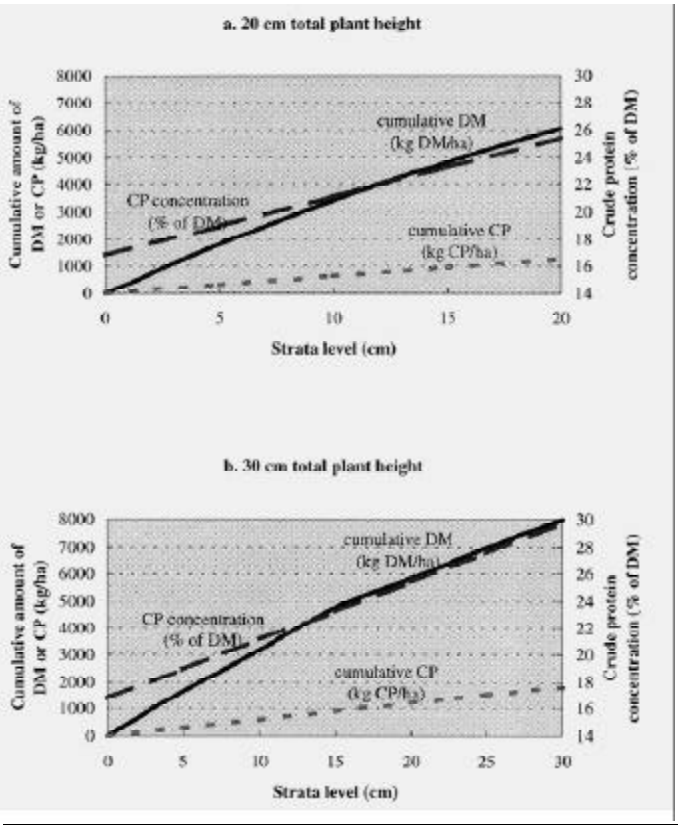

Figure 2
Cumulative dry matter, cumulative neutral detergent fiber, and neutral detergent fiber concentration over the plant height for spring-growth orchardgrass at 20 (a) and 30 (b) cm