Seasonal changes in pasture quality in Mediterranean regions of Australia

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Abstract

This paper presents a new simple model describing the seasonal change in in-vitro digestibility (DMD) and crude protein (CP) content of annual pastures. Datasets were constructed from 995 pasture samples collected at 14 sites in 11 seasons in the south-west of Western Australia, and at 7 sites in 8 seasons in Victoria. The decline in quality was related to the cumulative temperature sum (TS). A three-stage linear regression model was fitted. The R^2 values in annual pastures ranged between 0.76-0.87 and 0.34-0.70 with a RMSE of 4.2-5.6% and 2.7-3.8% for DMD and CP respectively. Differences between pasture types and data-sets were small for DMD in contrast to CP. It is concluded that TS can be used to describe seasonal changes in DMD for extensively grazed pastures in Mediterranean regions of Australia. However, for CP this approach can only be used for annual clover and weed dominant pastures.

Key Words

pasture quality, dry matter digestibility, crude protein, temperature sum

Introduction

One of the key decisions in a grazing enterprise is how to manage the feed available in order to minimise costs and maximise output of animal products (wool, milk or meat). Setting stocking rate to annual pasture production and matching feed available to animal requirements are the key elements to ensure that this is achieved. For animal nutrition, the most important components of pasture quality are dry-matter digestibility (DMD) and crude protein (CP) contents. The nutritional value of pastures declines by 0.03 and 0.06 MJ ME/kg DM/day for leaves and stems respectively at 18?C, but this decline is negligible at 12?C (Lambert and Litherland, 2000). The ratio between stems and leaves is determined by plant development which is also a function of temperature (Goudriaan and Van Laar, 1994). For our analyses, therefore, an empirical regression model is proposed to quantify seasonal changes in quality as function of temperature sum (TS). It is hypothesised that the main changes in pasture quality occurs in the generative growth stage at a steady rate per degree TS. The objective of this paper is to test this hypothesis on DMD and CP contents of samples collected from pastures in the Mediterranean climate zones of Western Australia and Victoria.

Methods

Four pasture quality datasets were compiled. The WA-annuals dataset contained data collected from annual pastures in the Mediterranean region of south-west Western Australia. Only samples from un-stocked or extensively set-stocked pastures (e.g. a target food on offer > 2000 kg DM/ha) were included. This dataset included samples collected over 11 years from 14 sites. The VIC-annuals was comprised of data collected from annual pastures in the Mediterranean region of Victoria over 8 years from 3 sites. The VIC-mix was made up of mixtures of annuals and perennials collected over 3 years from 5 sites. The meta-dataset contains all available data of annual pastures only. A simple three-phase linear model was fitted to the data, estimating the DMD or CP in the vegetative and senesced growth stages, the moment when quality decline commences and ends and the decline-rate as function of TS, see figure 1.

The TS is calculated as the cumulative positive mean daily temperature above 4.5?C from mid-winter onwards (optimized values). The parameters of this model were estimated by minimizing the root mean squared error (RMSE).

Results

The meta-model for DMD explained 78% of the variation with a RMSE value of 5.3% DMD (Table 1). For CP, the meta-model explained 53% of the variation with a RMSE of 3.5% CP. The TS1 and TS2 values are 35 and 17 days lower for CP than for DMD. This may indicate that decline starts and ends about 35 and 17 days earlier for CP than for DMD in an average year. For DMD, model parameters were very similar between pasture types and data-sets. For example, R values were between -0.022 and -0.035. The model for CP performed poorly for grass dominated pastures, in contrast to clover and other pastures. For CP, the model parameters differed considerably between pasture types. For example, values for R were between -0.006 and -0.011 for different pasture types and between -0.006 and -0.020 for different data-sets.

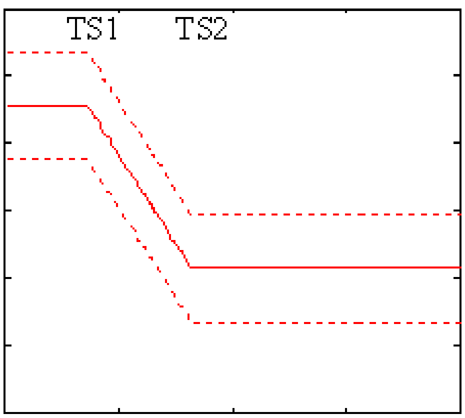

Figure 1. Example of the regression model fitted. Dotted lines indicate the 90% confidence intervals of a new sample.

Table 1. R^2 and root mean squared error (RMSE) values for the fitted regression models for various data-sets.

Variable	dataset	n	R^2	RMSE
		#		%
DMD	Meta	789	0.78	5.3
CP	Meta	995	0.53	3.5
	Meta-dataset differentiated to species			
DMD	Grass	92	0.87	4.2

DMD	Sub-clover	241	0.82	4.7
DMD	Other	456	0.76	5.6
CP	Grass	403	0.34	2.7
CP	Sub-clover	225	0.65	3.1
CP	Other	367	0.69	3.2
	Meta-dataset differentiated to data-sets			
DMD	WA-ann	466	0.82	3.7
DMD	VIC-ann	182	0.84	3.4
DMD	VIC-mix	141	0.60	3.4
CP	WA-ann[1]	297	0.70	3.5
CP	VIC-ann[1]	154	0.48	3.8
CP	VIC-mix	141	0.66	3.3

[1]Samples from pastures dominated by grass were excluded

Conclusion

The optimized value of 4.5?C matches with the base temperature for plant development for C3 species in Mediterranean climates (Schapendonk et al., 1998). The effects of pasture type or source of data were small for DMD, in contrast to CP. Models for CP in grass dominant pastures performed poorly, probably due to the strong CP response to fertiliser application. There was no evidence that the DMD changes strongly either before TS1 or after TS2. On average, decline rates were 0.032% DMD/?C and 0.013% CP/?C . When converted to ME, this DMD decline rate is in-between values for leaves and stems (Lambert and Litherland, 2000). The models developed only apply to extensive grazing systems. Intensive grazing systems do affect quality significantly, but these have not been accounted for in our models. We hypothesise that intensive grazing will mainly shift TS1 and TS2 to higher values as the vegetative growth stage is extended. It is concluded that TS can be used to describe DMD seasonality for Mediterranean climates of Australia. For CP, this approach can only be used for annual clover and weed dominated pastures where different models need to be used for different regions.

References

Goudriaan, J., and H.H. Van Laar. 1994. Modelling potential crop growth processes: textbook with exercises Kluwer Academic Publishers, Dordrecht, the Netherlands.

Lambert, M.G., and A.J. Litherland. 2000. A practioner's guide to pasture quality. p. 111-116. *In* Anonymus, ed. Grasslands. Proceedings of the New Zealand Grassland Association, Invercargill, NZ. New Zealand Grassland Association.

Schapendonk, A.H.C.M., W. Stol, D.W.G. Van Kraalingen, and B.A.M. Bouman. 1998. LINGRA, a sink/source model to simulate grassland productivity in Europe. Eur. J. Agron. 9:87-100.