Pasture Mass Estimation by the C-DAX Pasture Meter: Regional Calibrations for New Zealand

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ABSTRACT

Accurate estimation of pasture mass is essential for managing farm systems for top performance. The C-DAX Pasturemeter has the potential to provide fast, accurate estimates of pasture mass. However, the Pasturemeter has been calibrated for 'typical' temperate dairy pastures and its suitability for use on the range of pastures present in New Zealand is unknown. This study determined the accuracy of the technology for estimation of pasture mass on dairy pastures from Northland, Waikato, Taranaki, Lincoln and Southland. Monthly Pasturemeter and rising plate meter (RPM) measurements were made over a year and compared with quadrat cut data. Large seasonal variations in the Pasturemeter calibrations reflected changes in pasture composition. Both the Pasturemeter and the RPM benefit from the use of different seasonal calibration equations, specific to the region. The Pasturemeter and RPM show similar accuracies for estimation of dry matter yield across all regions.

Keywords: pasture mass estimation; dairy; calibration**.**

INTRODUCTION

A fast and accurate method of pasture mass estimation has long been seen as valuable for the agricultural industry (Earle & McGowan, 1979). However, use of pasture mass estimation technologies is limited and formal feed budgeting is used on only around 20% of New Zealand dairy farms (Clark *et al.,* 2006). The low acceptance is due to perceived inaccuracies and the time and effort required for their regular use (Lile *et al.,* 2001). The rising plate meter (RPM) is, perhaps, the most widely used pasture mass estimation technology although there are other methods, such as calibrated visual estimations or pasture capacitance probes, with similar accuracy (L'Huillier & Thomson, 1988).

The C-DAX Pasturemeter (Lawrence *et al.* 2007, www.Pasturemeter.co.nz) is a tow-behind attachment for a quad bike that determines average pasture height as the sward breaks the light path of a light emitting and sensing photodiode array at 20 mm spacing. The Pasturemeter can take numerous pasture cover readings (200 per second) across a paddock and can be used at speeds up to 20 km/h. Pasture mass is calculated from sward height with manufacturer-supplied or user-defined equations.

The Pasturemeter could reduce the time required to obtain paddock level estimates of pasture mass and has low inter-operator variation due to minimal operator input. Other mass estimation methods can show large variation between operators due to technique or subjectivity. Minimal operator training is necessary to ensure a representative paddock sampling. However, the manufacturer-supplied Pasturemeter calibration equations have been developed using ryegrass/white clover (*Lolium perenne/Trifolium repens*) pastures at a limited number of localities.

There is a considerable range of pasture types present on dairy farms in New Zealand. While all of the pastures utilised in this study were based on perennial ryegrass and white clover, dairy pastures can have a highly variable weed flora and a very different seasonality of growth across the country. This has the potential to affect the height vs. mass correlation used by the Pasturemeter. For example, the warm temperate Northland climate has allowed the widespread establishment of kikuyu (*Pennisetum clandestinium*), a C_4 grass. While kikuyu stolons contribute little to grazeable mass, they can have a highly variable effect on pasture mass estimation technologies (Fulkerson & Slack 1993). Other C_4 grasses can occur in Waikato (e.g. *Paspalum digitatum*) but may be completely absent from pastures elsewhere in New Zealand where C_3 grass weeds are more common.

The aim of this study was to assess the accuracy of the C-DAX Pasturemeter and the rising plate meter (RPM) in dairy pastures across the country using manufacturer-supplied calibrations and then to develop region-specific calibrations specifically for those pastures.

METHODS

A single farm in each of five locations was selected: Northland Agricultural Research Farm (NARF) at Dargaville; Greenfields Farm at Newstead, Waikato; Taranaki Agricultural Research Station, Hawera; Lincoln University Dairy Farm, Canterbury; Southland Agricultural Research Farm, Invercargill. Six paddocks, on one farm in each region were sampled roughly monthly between November 2007 and December 2008. Different paddocks were used each month due to variation in time since grazing. Two recently grazed paddocks of low pasture cover (< 2000 kg DM/ha), two of intermediate pasture cover (2000-3000 kg DM/ha) and two paddocks of high pasture cover (pre-grazing, 3000 kg DM/ha, depending on farm pasture cover) were chosen each month. At each sampling event the paddocks on each farm, consisted of established pastures of unknown age, similar in botanical composition, differing only in length of time since grazing. In each paddock, eight locations were subjectively chosen so as to cover a range in pasture heights. At each location the following was conducted in order:

1. C-DAX Pasturemeter measurement of pasture height, with a 28cm × 100cm quadrat placed over the measured area after the C-DAX pass.
2. RPM measurement of the pasture height (three measurements per quadrat).
3. Visual estimation of the pasture composition on the basis of total dry mater: % legume, % broadleaved species, % grass, % dead material and % bare ground by comparison with Pasture Quality Calibration Sheets (developed by Meat NZ). The two major grass and legume species were noted.

The quadrat was then cut to ground level. The pasture sample was washed to remove soil contamination before drying at 80°C for a minimum of 24 h and recording the dry weight.

In addition, a strip of pasture adjacent to the long axis of each quadrat (viz. 8 × 100 cm) was cut as close as possible to ground level (< 1 cm) without collecting any soil and was bulked for each paddock to give a 'paddock average' sample for dissection into grass leaf, grass stem, legume, weeds and dead material. These samples were dried at 80°C for a minimum of 24 h before weighing and determination of botanical composition. In total, cut samples from 480 paddocks were collected across the five regions.

Statistical methods

Pasture biomass (dry matter yield) estimations were predicted over the year using the mixed model smoothers of Upsdell (1994). The daily varying calibration equations were calculated within the model from the smoothed data.

RESULTS

Pasture composition

With the exception of the Northland samples, the botanical composition of the pastures was broadly similar across regions: dominated by perennial ryegrass (> 70%). In Northland, however, kikuyu became a major component (up to 50%) of the sward during summer-autumn. White clover contents were low but variable throughout the country e.g. clover averaged 10% in Waikato while Taranaki pastures had less than 5%. Some additional grass species, including cocksfoot and prairie grass, occurred as minor sward components (< 5%) in Taranaki. In Canterbury, white clover averaged 15% through late spring/summer while Southland pastures contained 5-10% clover on average. Both Canterbury and Southland pastures contained a common but minor component of Poa annua.

Estimation of pasture mass

Standard calibration equations

Pasture mass was estimated using the seasonal calibrations supplied with the Pasturemeter and RPM (Table 1). These were compared with the pasture mass determined by quadrat cutting to ground level and drying. Over the measurement period both techniques showed substantial errors, ranging from 439 to 1126 kg DM/ha.

TABLE 1: Manufacturer or industry-supplied calibration equations for the CDAX Pasturemeter and the Rising Plate Meter.

	Pasturemeter		RPM	
Month	Multiplier	Constant	Multiplier	Constant
Winter	18.6	1117	140	500
October	15.3	1358	115	850
November	16.0	1530	120	1000
December	18.6	1818	140	1200
January	21.9	1978	165	1250
February	24.6	2017	185	1200
March	22.6	1850	170	1100

Regional re-calibration

The relationship between the raw Pasturemeter or RPM output (pasture height) and the measured mass of the pasture was used to determine daily calibration factors for the linear equation, *pasture* = m *reading* + c.

For both devices, the variation of the calibration constant (c) throughout the year was within the standard error of a single constant. In addition, the inclusion of a variable constant did not significantly improve the fit of the whole equation. A single constant was therefore used for each region (Table 2). These constants were substantially lower than the manufacturer supplied values (Table 1).

The calibration equation multiplier range showed greater variation than the manufacturer-supplied multipliers through the year and there can be substantial daily changes (Figure 1).

Using these new, region-specific, daily calibrations resulted in a decrease in the prediction errors for both the Pasturemeter and the RPM (Table 3), significantly so for almost all regions for at least some of the year (Figure 2).

TABLE 2: Calibration constants (with standard error) for each region.

Region	Pasture meter		RPM	
	Constant	Std error	Constant	Std error
Northland	809	89	501	105
Waikato	654	86	385	101
Taranaki	67	84	521	99
Lincoln	731	82	355	96
Southland	825	79	517	92

TABLE 3: Prediction errors (RMS, kg DM/ha) for the CDAX Pasturemeter and the Rising Plate Meter (RPM) using manufacturer-supplied or custom, region-specific calibration equations.

		Region				
		Northland	Waikato	Taranaki	Canterbury	Southland
Pasturemeter	Supplied	900	1326	665	1234	924
	Custom	655	530	668	520	576
Rising Plate Meter	Supplied	828	803	1127	660	439
	Custom	552	487	773	493	441

DISCUSSION

Pasture height measurement has previously been shown to be no more precise than other indirect pasture estimation technologies, such as the plate and probe (Piggot, 1986). Some of the inherent disadvantages of using sward height to estimate pasture mass also apply to the Pasturemeter. Over-estimation of herbage mass with increasing sward height is common due to a high proportion of the mass being concentrated in the lower layers (Frame, 1993). However, unlike other techniques based on pasture height, such as the sward stick, with the Pasturemeter it is not possible to distinguish stem or seed head height from the more important free standing leaf height (Webby & Pengelly, 1986; Litherland *et al.,* 2008).

The RPM can estimate herbage mass of sample plots with similar reliability to properly calibrated visual assessments. On a whole-farm scale, however, the RPM may underestimate herbage mass (Thomson *et al.,* 2001). The Pasturemeter samples much larger areas and may therefore show similar or better accuracy in the estimation of pasture biomass compared with the RPM over the whole farm. Pasturemeter operator input is minimal and therefore low operator error and inter-operator variation would also be expected.

In this study, both the C-DAX Pasturemeter and the RPM showed large pasture mass prediction errors when using manufacturer-supplied seasonal calibrations (Table 2, Figure 2). During summer, the Pasturemeter can overestimate pasture mass by more than 1000 kg DM/ha (Northland, Waikato, Canterbury). The RPM can underestimate by a similar amount in autumn (Northland) and overestimate in spring (Taranaki). Across all regions and through the whole year, however, the error was similar for the two methods. These figures reflect both the variation and the bias within the predictions and demonstrate broad comparability between the two methods.

These considerable, systematic errors in the pasture mass estimations using industry-supplied calibration equations (large deviation between estimated and actual dry matter) indicate the need for region-specific calibration equations for both the Pasturemeter and the RPM. The calibrations developed here have the potential to provide more accurate pasture mass estimates than the industry supplied standards. They appear to be robust to

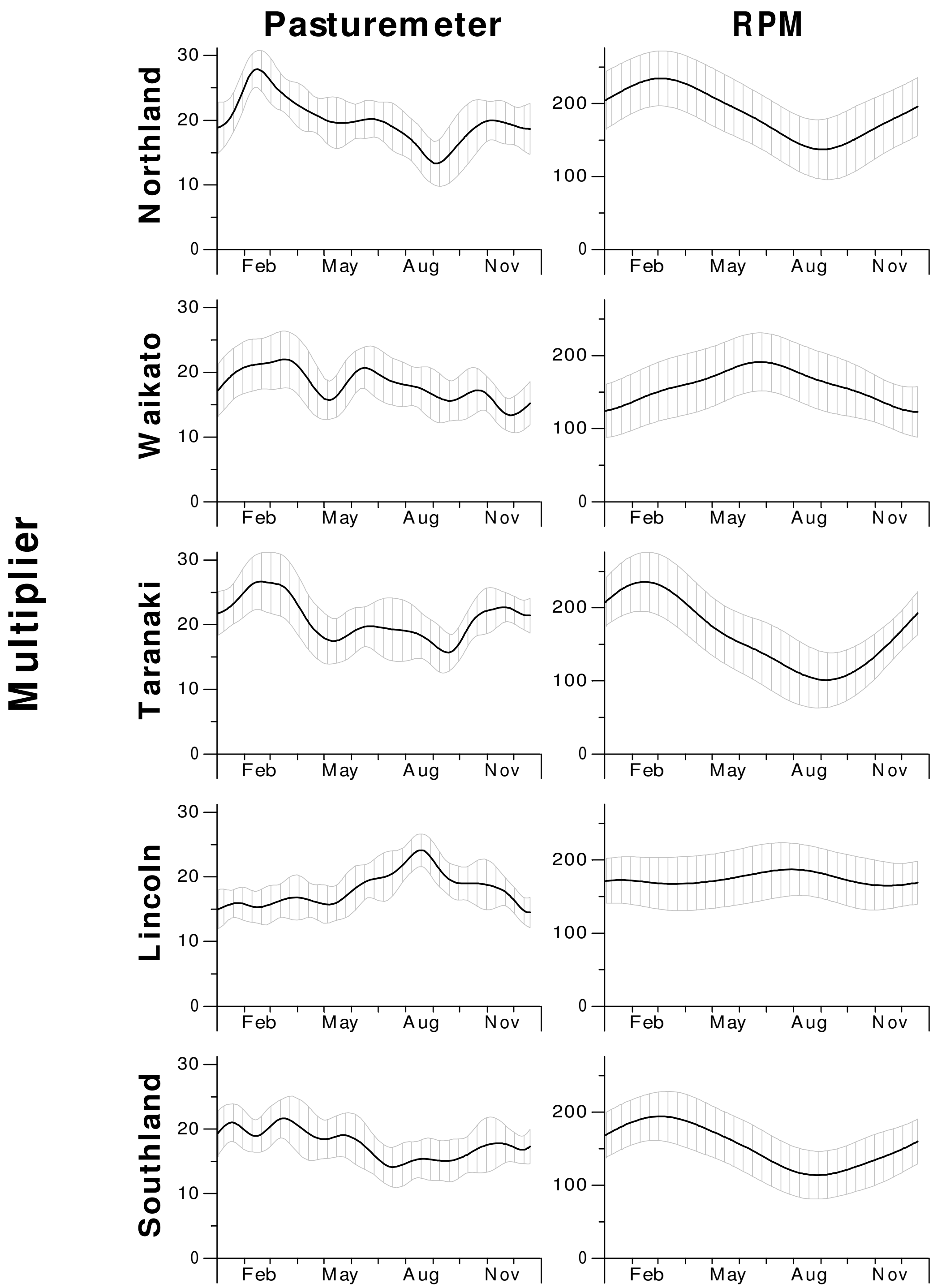

FIGURE 1: Multipliers derived from region-specific calibrations for the CDAX Pasturemeter and the Rising-Plate Meter (RPM). The bands are the 95% confidence intervals for the estimates.

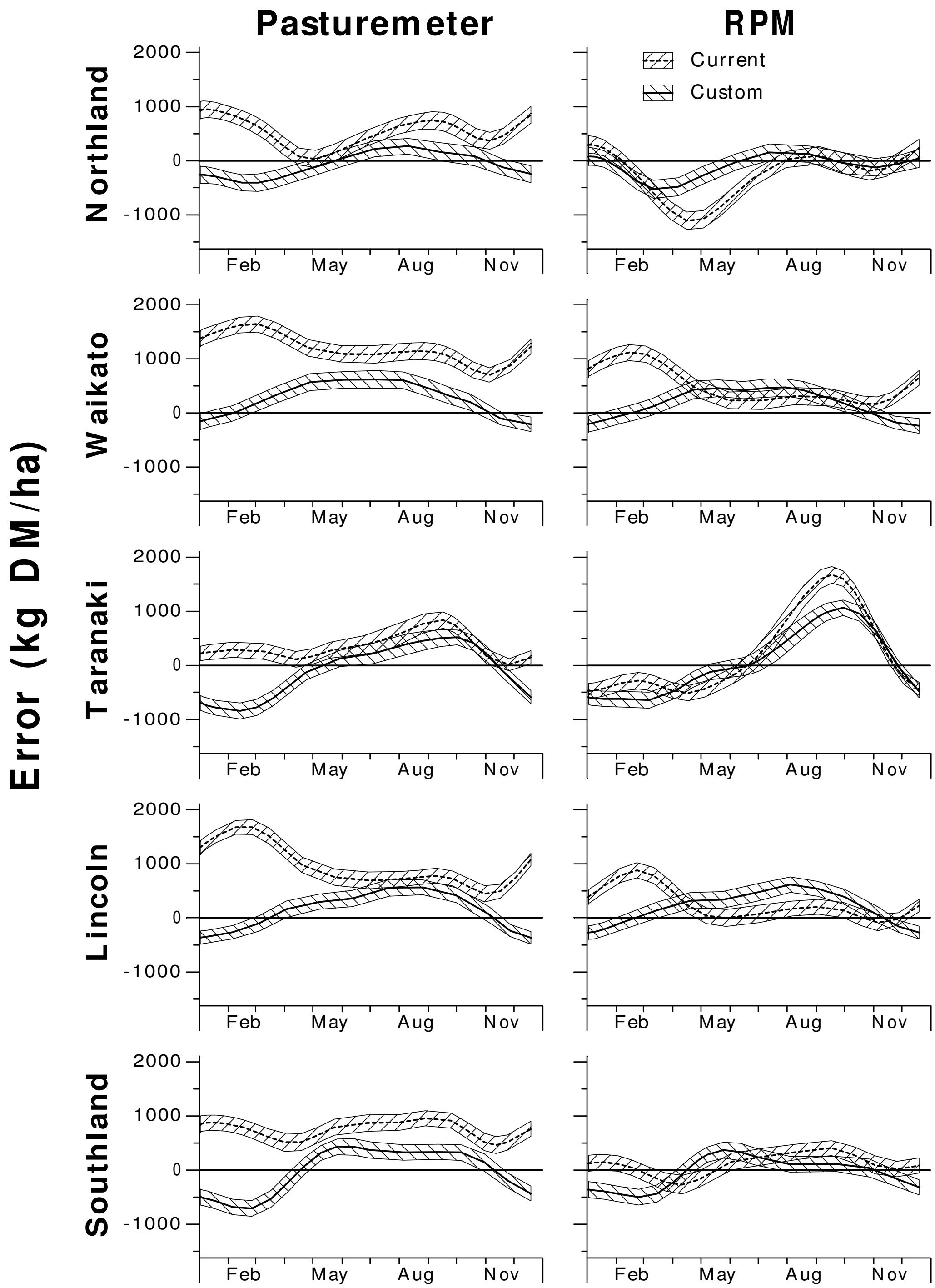

FIGURE 2: Errors in pasture mass prediction throughout the year using manufacturer-supplied calibrations ("Current") and region-specific calibrations ("Custom"). The bands on the graph are the 95% LSD intervals for differences in the means. The curves are significantly different where the bands do not overlap.

quite large changes in pasture composition (Rennie *et al.,* 2009) and will allow for more accurate feed budgeting, better pasture utilisation and, ultimately, better pasture quality and production.

The choice of pasture estimation method will also be influenced by cost, convenience and personal preference (L'Huillier & Thomson, 1988). The cost of the C-DAX Pasturemeter is considerably greater than the RPM. The Pasturemeter also has potential drawbacks such as wheel or skid marks on wet pasture and loss of sward familiarity. However, reduced labour cost, ease of use and convenience of the Pasturemeter could greatly increase the frequency of use compared with the RPM.

The trial was run for one year on one farm in each region; therefore further validation of these equations on other dairy properties is required before stronger recommendations on their widespread use can be made.

CONCLUSION

Large errors can occur when estimating the pasture mass if commonly-used calibration equations are applied to data from the C-DAX Pasturemeter and the rising plate meter (RPM). The new calibration equations reported here should be a better choice when using either of these technologies for pasture mass estimation. However, further validation is required to ensure the robustness of the new calibration equations within each region and across years.

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