Scientific Paper

Evaluation of two methods for estimating dry matter availability in mixed pastures in the Amazon region, Peru

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Abstract

Objective: To evaluate two methods to estimate dry matter availability in mixed pastures in the Amazon region, Peru.

Materials and Methods: The traditional method and the electronic capacitance method with *Grass Master Pro* equipment were used. A complete randomized block design was used, with two sources of variation: five pastures, three evaluation periods (20, 40 and 60 days) and the average of 15 observation units per pasture. A variance analysis and multiple comparisons of means were performed using Tukey's test: 5 % probability to compare the existence of significant differences among means. Linear and polynomial regression were also used to estimate the relationship between the two methods. For data processing and analysis, the statistical program R was used.

Results: Actual dry matter values were obtained using the quadrat method. The traditional method and the electronic capacitance method showed significant differences ($p < 0,05$). Dry matter availability by the traditional method was 3 530,3 kg DM/ha and by the capacitance method 3 942,4 kg DM/ha. With the linear regression, a determination coefficient of $R^2 = 0,87$ was obtained and with the polynomial regression, of $R^2 = 0,93$.

Conclusions: The electronic capacitance method reported average dry matter measurements in the pasture, significantly higher than the traditional method, and showed desirable and concordant characteristics for its use in animal husbandry activity.

Keywords: stocking rate, animal husbandry, pastures

Introduction

According to Lerma-Lasso *et al*. (2020), the largest percentage of agricultural land in the world is used for animal husbandry. In Peru, it is developed in the three regions (Coast, Highlands and Jungle), with its own characteristics according to each type of farming. Livestock production accounts for 40 % of the country's gross income (MINAGRI, 2017). Pasture is the main feeding source for ruminants, and one of the main components of animal husbandry (Santos *et al*., 2021; Te Pas *et al*., 2021). However, little is known about methods for estimating dry matter (DM) availability as a feedstuff source.

The Amazon region has a rural population that is generally economically dependent on agriculture and animal husbandry as the main income sources (Chizmar *et al*., 2020). In the main animal husbandry basins, managed (silvopastoral and forage systems) and natural pastures are based on feeding with associations of *Lolium multiflorum* Lam. (ryegrass) and *Trifolium repens* L. (white clover) (Oliva-Cruz, 2016). These associations of grasses and legumes constitute a cheap and reliable source of feedstuffs for dairy cows and increase animal production, in addition to ensuring good profitability in animal husbandry (Dickhoefer *et al*., 2018). Specifically in the Molinopampa district, livestock production is the main source of economic income for the villagers, being the most extensive in the Amazon region, in terms of pasture production, mostly *L. multiflorum* + *T. repens* associations (Oliva-Cruz *et al*., 2016; Rojas-Briceño *et al*., 2020).

The need to evaluate dry matter (DM) yield in pasture associations, commonly grown in the district, arises because livestock farmers do not value the DM availability of their pastures, an indicator that allows adjusting systems and establishing pasture management criteria (Hepp *et al*., 2017), as well as determining energy and

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nutrient efficiency (Rombach *et al*., 2019). Also, because of the importance of knowing the goodness of pastures, so that they cover the nutritional requirements of animals, it allows determining the stocking rate per hectare.

There are several techniques to determine DM availability in pastures by direct and indirect methods (Serrano *et al*., 2020; Cruz *et al*., 2021). An easy and reliable technique for evaluation is electronic capacitance using *Grass Master Pro* equipment, which is considered an indirect method. This piece of equipment, generally composed of an electronic circuit, produces a signal of a certain frequency, and then measures the capacitance of the air-grass mixture (Serrano *et al*., 2020).

With this technique, the farmer could know the stocking rate per pasture and the correct grazing age. Thus, pasture can be used more efficiently. Also commonly used is the quadrat (square meter) method, known as the traditional method, which is considered a direct method. This is highly costly, destructive, laborious and slow to obtain biomass properties at a high sampling density (López-Guerrero *et al*., 2011; Cruz *et al*., 2021).

Natural and cultivated pastures constitute a fundamental factor in animal husbandry, and it is necessary to know the DM availability in pastures. This is achieved through the use of existing sampling methods.

Therefore, the objective of this study was to evaluate two methods to estimate dry matter availability in mixed pastures in the Amazon region of Peru.

Materials and Methods

This study was conducted in the Santa Cruz del Tingo population center, located in the Molinopampa district, Chachapoyas province, south of the Amazonas region, in the northeastern zone of Peru (6° 13' 25.134'' South latitude and 77° 37' 15.095'' West longitude), between altitudes of 2 300 to 2 500 masl (fig. 1), with average temperature of 16 ºC and average precipitation of 1 200 mm/year (Oliva-Cruz *et al*., 2018; Huaman *et al*., 2018).

To compare DM availability between the two evaluation methods, a complete randomized block design with the additive linear model with two sources of variation (five pastures and three evaluation periods as intervals (20, 40 and 60 days), was used. Five units were sampled (15 samples per block). The selection of the sample was based on criteria, i.e., it was taken into account that the pasture had a homogeneous cover of *L. multiflorum* (ryegrass) + *T. repens* (white clover), as well as the resting period (20, 40 and 60 days after grazing).

The direct (traditional) method is used in research works, because it allows comparing the real quantity of DM with an indirect or non-destructive method (Canseco *et al*., 2007). A square frame (0,5 x 0,5 m) was used for the evaluations. The location of the sampling site consisted in randomly throwing the ½-inch PVC pipe frame over the pastureland.

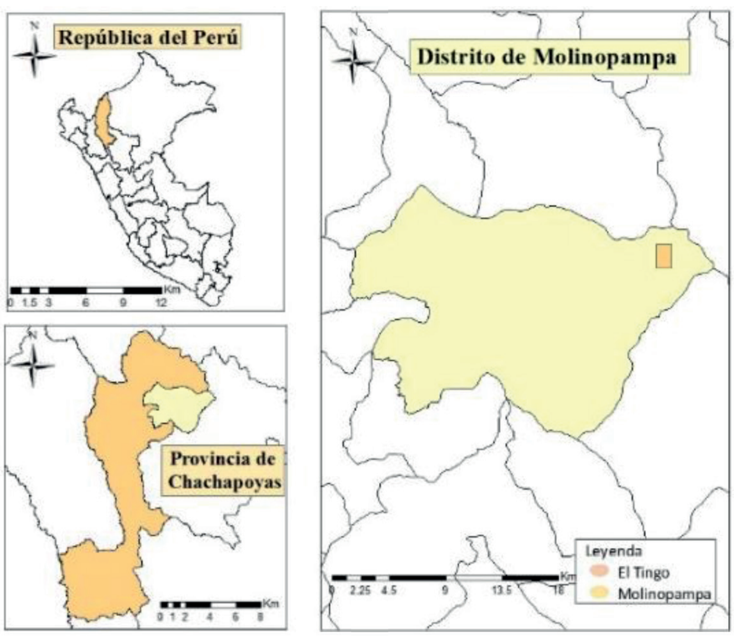

Figure 1. Location of the study area.

Subsequently, all the matter found in the square was cut at 3 cm from the ground (Serrano *et al*., 2011). The cut forage was collected in plastic bags and the samples were labeled (date, paddock name or number, sample number).

For DM analysis, the samples were taken to the animal nutrition and food bromatology laboratory of the National University Toribio Rodríguez de Mendoza (UNTRM, for its initials in Spanish). For the determination of this indicator, forced ventilation stoves were used, at a temperature of 105 ºC for 24 hours, until constant weight was obtained.
The following formula was used for the calculation:

$$DM = \frac{\text{final weight}}{\text{initial weight}} \times 100$$

For the electronic capacitance method, the commercial Grass Master Pro meter was used, with a probe that extends into the pasture. It is easy to use, equipped with an electronic processor, and an indicator that shows dry matter availability (Serrano *et al*., 2011; Serrano *et al*., 2016). With this piece of equipment, the forage availability of up to 200 paddocks can be determined, with a maximum of 250 readings per paddock (López-Guerrero *et al*., 2011).

The Grass Master Pro meter was placed horizontally, 50 centimeters from the ground, so that it was far from the reader's feet or any object that could hinder the reading, since this instrument sends an electric charge through the forage with a frequency of 1 500 Hz by means of a hose (Teuber, 2004). Once the reading was finished, the instrument was ready to start the walk, following a random pattern. To perform the sampling, the stick was positioned touching the ground, and a small force was applied to indicate to the equipment to take the reading. The instrument was then lifted to the next point. This procedure was carried out until the 150 samples collected in this study were completed.

To check the data normality and homogeneity, the Shapiro-Wilk and Levene tests were used (Zar, 1999). Once these assumptions were met, the variance analysis was carried out. Tukey's HSD test was applied to determine the statistical differences between the means obtained by both methods. Subsequently, linear and polynomial regression analysis was performed. The data were subject to a comparison test between the actual DM value obtained with the traditional method and the data recorded with Grass Master Pro. The results were presented using simple linear and polynomial regression tables and graphs. The analyses were performed with the aid of the statistical program R-version 4.1.2 (R Core Team, 2021).

Results and Discussion

Table 1 shows the results of the variance analysis. There were significant differences ($p < 0,05$) among the variables (evaluation period, pastureland and used method).

The multiple comparison with an alpha of 5 % indicated that there were significant differences among the measurements with the application of the electronic capacitance method and those obtained by the quadrat method. Serrano *et al*. (2016) stated that the capacitance method is crucial in the evaluation of pasture mass, because reliable data are obtained in the samplings. DM availability by the traditional method was 3 530,3 kg DM/ha, and by the electronic capacitance method it was 3 942,4 kg DM/ha (table 2). This showed that there were significant differences between the evaluation methods ($p = 0,0002$).

In mixed pastures, in terms of kg of DM/ha, the results showed from Duncan's test that the electronic capacitance method with the *Grass Master Pro* equipment was the one that reported a higher average measurement than the traditional method, with a difference of 412,1 kg DM. This difference may have been influenced by the methodology used at the time of processing the samples with the quadrat method.

In the evaluation intervals carried out in this study (table 3), there were significant differences ($p < 0,05$)

Table 1. Variance analysis for dry matter.

Variation source	Degrees of freedom	Mean squares	P - value
Model	7	3511068,83	0,0001***
Evaluation period	2	10971248,98	0.0001***
Pastureland	4	340388,41	0.0034**
Method	1	1273430,22	0.0002***
Error	22	62910,94	

Table 2. Dry matter, according to each evaluation method (kg DM/ha).

Method	Mean	N	P - value
Quadrat	3 530,4	15	0,0002
Electronic capacitance	3 942,4	15	

Table 3. Dry matter content per day of evaluation (kg/ha).

Evaluation[¥]	Mean[1]	N	P - value
20 days	2 795,9[a]	10	0,0001
40 days	3 548,1[b]	10	
60 days	4 865,2[c]	10	

Equal letters indicate non-significant differences ($p < 0,05$).
[¥]days after grazing

and the highest amount of DM was obtained in pastures with 60 days of post-grazing rest. These notorious differences in each evaluation interval may be due to different soil fertility conditions and climate (Serrano *et al*., 2020), which are not very favorable in the Molinopampa district, where there is constant rainfall throughout the year.

These intervals of days of evaluation help to know the most suitable age of the pastures for DM calculation. In this study, DM calculation evaluations were performed at 20, 40 and 60 days after grazing (table 3).

The average DM at 40 days is within the range reported by Villalobos and Sánchez (2010), who in their research indicated that at 45 days an average of 3 787 kg DM/ha is obtained in *L. multiflorum*. Vázquez *et al*. (2017) reported 4 200 kg DM/ha at 36 days of evaluation, which shows remarkable difference. These authors agree that environmental characteristics influence DM production of forages. Phenological age is fundamental in forage matter, and has a direct relationship with the climatology of the study area.

In this study, results using regressions (linear and polynomial) indicated that DM availability kg/ha between the quadrat method and electronic capacitance with equipment showed a positive correlation, with a determination coefficient of $R^2 = 0,87$. This indicates that 87 % of the variability of the data obtained between the methods is explained (fig. 2).

To corroborate the obtained information, López-Guerrero *et al*. (2011) reported values of $R^2 = 0,72$ to 0,89. However, they reported no significant differences ($p = 0,815$). Murphy *et al*. (1995) compared a quadrat with a capacitance meter, and obtained a correlation coefficient of 0,65. Meanwhile, in the research conducted by Jones *et al*. (1977) values from 0,57 to 0,75 were reported. Martín *et al*. (2005) reported values lower than 0,63 in grazing pastures. In this research, a high degree of significance was found between both methods ($p < 0,05$).

The polynomial regression fitted for both methods corresponds to $y=-0,0005x^2 + 4,8177x - 6370,5$, with a determination coefficient of $R^2 = 0,93$ (figure 3). This indicates that 93 % of the data variability is explained by the evaluated methods.

López-Guerrero *et al*. (2011) refer their linear model of $Y=1,240 + 13,8 X$, with determination coefficient of $R^2 = 0,86$. Teuber (2004) obtained an $R^2=57,4$ %. These authors concluded that the use of electronic capacitance is useful for monitoring pastures when doing intensive sampling. However, Millapán (2006) mentions that the quadrat method provides higher accuracy for the calculation of forage and in smaller areas. These variations are basically due to the calibration of the equipment at the time of sampling, the forage type and environmental conditions, mainly temperature and humidity (Murphy *et al*., 1995; Pérez-Argotti, 2017).

Both methods have advantages and disadvantages. The quadrat method is economically cheaper, compared with the electronic capacitance method and the use of the commercial Grass Master Pro meter. For the quadrat method, in addition to the square, other complementary tools are necessary for cutting and weighing the forage, such as the portable scale and cutting scissors (Santos *et al*., 2021). These tools are very accessible and easy to obtain. The commercial Grass Master Pro meter in its current version would cost an average of US$1 150 (Serrano *et al*., 2020). This disadvantage makes this equipment difficult to be accessed for small independent animal husbandry farmers.

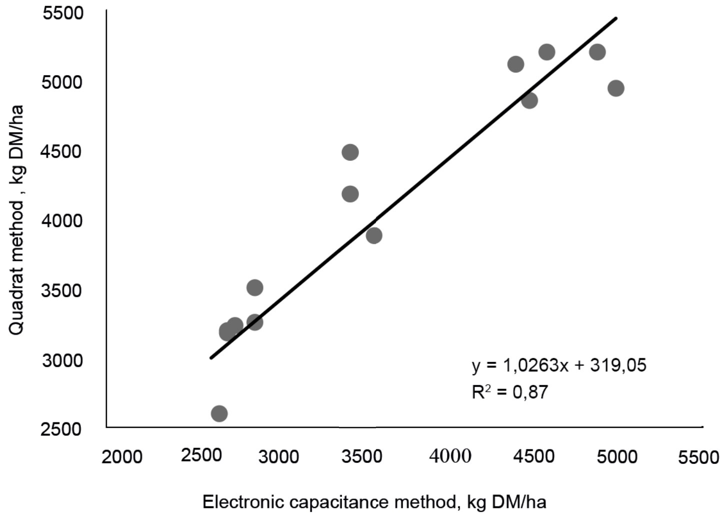

Figure 2. Linear relationship of dry matter availability between the quadrat method and the electronic capacitance method..

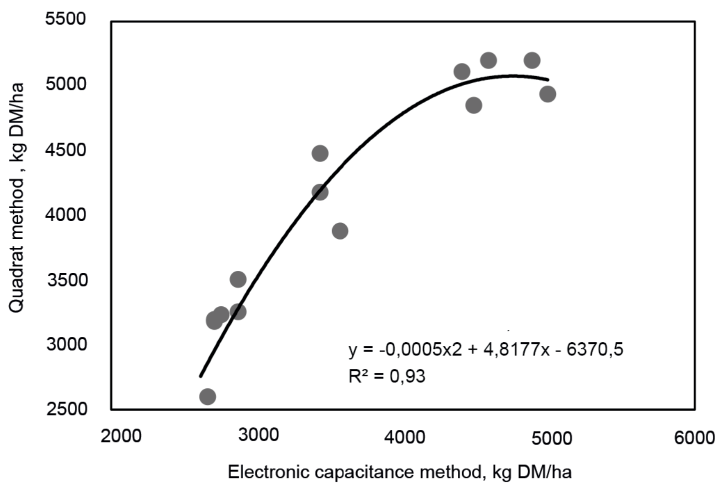

Figure 3. Polynomial relationship of dry matter availability between the quadrat method and the electronic capacitance method..

Conclusion

The electronic capacitance method is recommended for the evaluation of DM of pastures with paddocks of extensive areas, due to its efficiency in the speed of sample processing, obtaining the results and reduction of labor, unlike the quadrat method, which demands more time and labor.

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Conflicts of interest

The authors declare that there is no conflict of interest among them.

Authors' contribution

- Walter Mas-Portocarrero. Research design and set-up, data curation.
- Erik Cuzco-Mas. Data curation and first draft.
- Marco Antonio Mathios-Flores. Manuscript writing and revision.
- Carlos Darwin Angulo-Villacorta. Data analysis and interpretation, manuscript writing and revision.

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