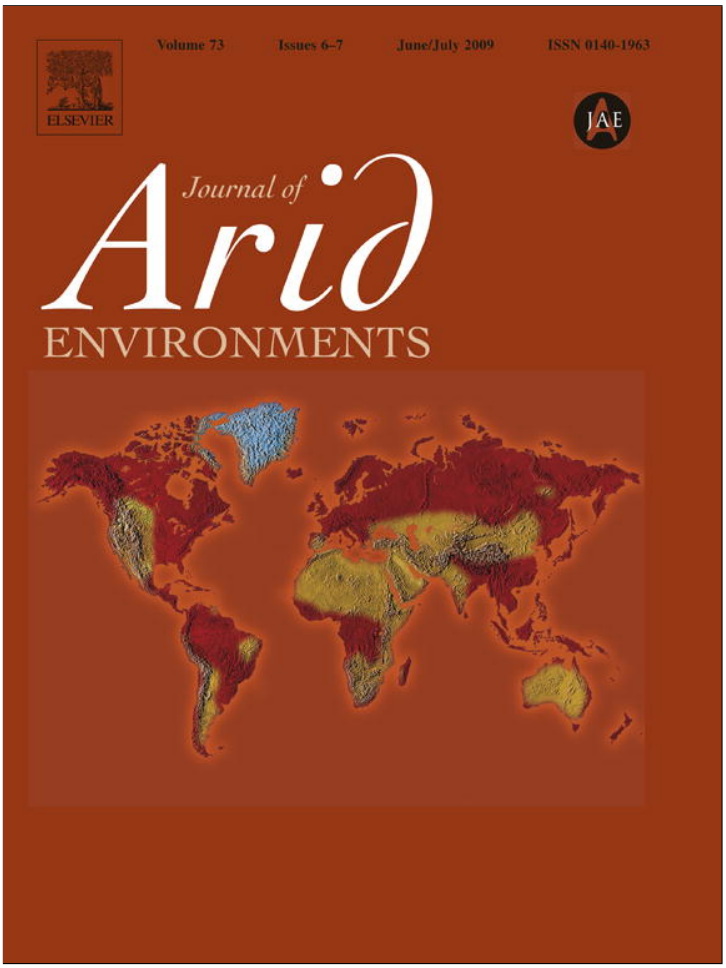

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Cover is a good predictor of aboveground biomass in arid systems

Harvest methods used to estimate plant biomass can be replaced by non-destructive methods, which are cost effective and allow for multiple estimates of biomass in the same location (Catchpole and Catchpole, 1993; Sala and Austin, 2000). Flombaum and Sala (2007) developed a method based on a model relating plant cover and aboveground biomass of dominant grass species of the Patagonian steppe. The study enlarged the range of cover and biomass by removing portions of individual tussock grasses and obtained significant relationships between cover and biomass data for all categories (Flombaum and Sala, 2007). Montès (2009) pointed out that reducing the area of a tuft could lead to an overestimation of the relationship between grass cover and grass biomass because the growth of tussock grasses follows isometric relationships and an increase in area would be accompanied by an increase in tuft height, hence in tuft volume and biomass.

Here, we demonstrate the conceptual mistake in Montès statement and provide two new sets of data that clearly show that experimentally enhancing the cover–biomass range does not affect the cover–biomass relationship. The mistake in Montès statement resides in confounding individual mass with ecosystem biomass. While it is true that individuals with small area are shorter; it is not true that ecosystems with low biomass are made up of smaller, shorter and younger individuals. Low biomass patches have low density of adult individuals but are not made up of smaller individuals (McIntyre, 1953; Yahdjian and Sala, 2006). Montès (2009) overestimation statement implied that within an ecosystem, low cover patches are made up of small tussock grasses, and high cover patches are made up of large tussock grasses. On the contrary in Patagonia, tussock size distribution is unrelated to grass cover (Yahdjian and Sala, 2006).

Our first study demonstrating that enhancing cover and biomass range does not affect the cover–biomass relationship consisted in progressively reducing plant cover by removing portions of individual tussock grasses (Table 1). We sequentially reduced plots cover from 90 to 0%. We found that the slope of the relationship between grass cover and biomass did not differ among reduction cover treatments (Table 1). In addition, there was no trend in the slope with changes in cover range. We compared slopes with the Tukey–Kramer test for multiple unplanned comparisons (Sokal and Rohlf, 1995) and no difference was found. These slopes had no relationship with the reduction treatment imposed ($P = 0.65$).

Our second study to demonstrate that the Flombaum and Sala (2007) model accurately predicts aboveground grass biomass consisted in comparing eight independent biomass harvest estimates with estimates using the model (Table 2). Biomass and cover data were collected in an area located close to Río Mayo, Argentina (45°S, 70°W), where vegetation is typical of the Patagonian steppe with 50% of vegetation cover (Soriano and Sala, 1983). We estimated biomass simultaneously using i) a harvest method in 10 20×500 cm plots (Fernández Alduncin et al., 1991), and ii) using vegetation cover method (Flombaum and Sala, 2007) in 10 2×1.9 m plots (2000–01), 90 5×5 m plots (2002), 6 5×5 m plots (2003–04), and 10 3×3 m plots (2005–07) containing 5.5 m, 20 m, 20 m and 6 m long interception lines (Canfield, 1941), respectively. We performed *t*-test comparison between harvest and line interception estimates of aboveground net primary production (ANPP). ANPP estimates did not differ between harvest and vegetation cover ($P = 0.28$; Table 2).

We conclude, based on our analysis of the conceptual mistake in Montès (2009) statement and two independent tests, that tuft isometric growth does not bias the relationship between grass

Table 1
Slope of the relationship between grass cover and biomass for an experimental gradient of grass cover.

Reduction treatment [%]	Slope ± 1SE between cover and biomass [g m^{-2} percentage^{-1}]
0	87.2 ± 12.6
10	97.0 ± 5.2
20	76.5 ± 17.0
30	71.4 ± 7.9
40	50.7 ± 7.4
50	78.0 ± 10.4
60	63.5 ± 10.1
70	109.4 ± 24.4
80	118.0 ± 10.7
90	72.9 ± 20.1

Table 2
Aboveground net primary production (ANPP) estimated using direct harvest and the Flombaum and Sala (2007) method for the Patagonian steppe.

Year	ANPP ± 1SE [g m^{-2} yr^{-1}]	
	Harvest	Flombaum & Sala
2000	21.3 ± 2.0	18.1 ± 1.6
2001	21.9 ± 1.9	26.5 ± 2.4
2002	19.6 ± 1.5	17.6 ± 0.4
2003	22.6 ± 2.8	16.2 ± 1.6
2004	19.6 ± 1.6	13.7 ± 1.9
2005	22.6 ± 1.7	23.4 ± 1.7
2006	26.6 ± 2.2	20.9 ± 1.2
2007	21.7 ± 1.6	21.5 ± 1.4
Average	22.0 ± 0.8	19.7 ± 1.6

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cover and ecosystem biomass, and that the Flombaum and Sala (2007) model does not overestimate biomass. Moreover, the Flombaum and Sala (2007) method accurately predicts aboveground biomass, allows for sequential estimates of biomass in the same plots because it is not destructive and it is much less expensive allowing for larger number of replicates.

References

Canfield, R., 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39, 388–394.
Catchpole, W.R., Catchpole, E.A., 1993. Stratified double sampling of patchy vegetation to estimate biomass. Biometrics 49, 295–303.
Fernández Alduncin, R.J., Sala, O.E., Golluscio, R.A., 1991. Woody and herbaceous aboveground production of a Patagonian steppe. Journal of Range Management 44, 434–437.
Flombaum, P., Sala, O.E., 2007. A non-destructive and rapid method to estimate biomass and aboveground net primary production in arid environments. Journal of Arid Environments 69, 352–358.
McIntyre, G.A., 1953. Estimation of plant density using line transects. Journal of Ecology 41, 319–330.
Montès, N., 2009. A non-destructive method to estimate biomass in arid environments: a comment on Flombaum and Sala (2007). Journal of Arid Environments 73, 599–601.
Sala, O.E., Austin, A.T., 2000. Methods of estimating aboveground net primary productivity. In: Sala, O.E., Jackson, R.B., Mooney, H.A., Howarth, R.W. (Eds.), Methods in Ecosystem Science. Springer-Verlag, New York, Berlin, Heidelberg, pp. 31–43.
Sokal, R.R., Rohlf, F.J., 1995. Biometry, third ed. Freeman, New York, Oxford.
Soriano, A., Sala, O.E., 1983. Ecological strategies in a Patagonian arid steppe. Vegetatio 56, 9–15.
Yahdjian, L., Sala, O.E., 2006. Vegetation structure constrains primary production response to water availability in the Patagonian steppe. Ecology 87, 952–962.

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