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Improving sustainability in livestock family farm systems based on natural grasslands in Uruguay implementing a co-innovation process

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1 – Introduction

Livestock production in Uruguay involves the management of C4-species dominated natural grasslands, which cover almost 65% of the country's surface area. Almost 75% of the farms specialized in beef and wool production are family farms. The farm systems exhibit low sustainability due, together with other factors, to low family income and grassland overgrazing caused by poor management of pasture-herd interaction. Therefore, grassland productivity is low, affecting animal productivity. Experimental data show that management of the pasture-herd interactions by seasonal modulation of animal density improves natural grassland growth and increases meat production while improving environmental impact. However, the significant progress in scientific knowledge obtained on several production system components did not result in increases in on-farm sustainability. The challenge of translating research knowledge and techniques to real production systems was left to farmers themselves. To test results when working in real farms, a co-innovation process was implemented in seven pilot farms in the east of Uruguay with the aim of improving family productivity and income while reducing natural resource degradation.

2 – Materials and methods

A co-innovation process (Dogliotti et al., 2014; Albicette et al., 2017) was implemented during three years in seven pilot farms located in the East of Uruguay. The approach involved characterization and diagnosis of systems sustainability, followed by cycles of redesign, implementation and monitoring. Proposals of redesign were based on changes in management practices without adding external inputs and without increasing costs. Re-design plans were discussed between scientists and farmers, and adapted till an agreement was reached. Productivity (meat production per ha, % of pregnancy, kg of weaning calf per breeding cow, forage allowance) and economic (net income) indicators were estimated for three years before starting the project to define a baseline. After starting the project, forage height was measured twice per season in all farms. Use of technologies and detailed records were kept during the whole project (Aguerre et al., 2018). Labour time was estimated following the "Work assessment" approach (Dedieu and Servière, 1999). The Ecosystem Integrity Index (EII) (Blumetto et al., 2019) was applied at the beginning (spring 2013) and the end of project (spring 2015).

3 – Results – Discussion

We found the weakest points of the farms to be associated with productive and economic results. On average for the seven pilot farms, baseline equivalent meat was 99.6±28 kg, % of pregnancy 75.8±3.2 and net income 31.2±43 U$S.ha^{-1}. The use of technologies at the beginning of the project varied a lot among farmers (from 9 to 91%; Table 1). The average forage height (FH) for all farms in the first summer of the project (summer 2013/14) was 6.1±1.6 cm and in the first autumn (autumn 2014) was 6.6±1.9 cm. Those values were lower than those suggested by literature for maximizing growth rate and animal productivity (12 cm and 9 cm for summer and autumn respectively; Soca & Orcasberro, 1992). Baseline herbage allowance (HA) (three years average) was estimated to be 3.3±1.2 kg DM kg $^{-1}$ LW, which was significantly lower than the suggested literature value of 10 kg DM kg $^{-1}$ LW (Soca et al., 2013). The inadequate forage mass availability at key moments of the animal productive cycle was affecting animal intake and consequently meat productivity. This was reflected in the low number and weight of weaning calves and low number and weight of replacement animals. Information obtained in experiments (Soca et al., 2013; Quintans & Scarsi, 2013) was taken as a base for redesign plans and those plans were agreed considering objectives of farmers and technicians.

Table 1. Use of technology per pilot farm at the beginning (initial) and at the end of the project (final)

	Farmer													
	1		2		3		4		5		6		7	
Technology	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Stocking rate adjustment	1	1	0	1	0	1	0	1	0	1	0	1	1	1
Breeding period	1	1	0	1	0	1	0	1	1	1	0	1	1	1
Management considering body condition	1	1	0	1	0	1	0	1	0	1	0	1	1	1
Ovarian activity diagnosis	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Pregnancy diagnosis	1	1	0	1	0	1	0	1	1	1	0	1	1	1
Weaning control	1	1	0	1	0	1	1	1	0	1	0	1	1	1
Definitive weaning at 6 months	1	1	1	1	0	1	0	1	1	1	0	1	1	1
Differenciate management for young females	1	1	0	1	0	1	0	1	0	1	0	1	1	1
First matting at 2 years	1	1	1	1	1	1	1	1	1	1	0	1	1	1
Paddock asignation cosidering forage height and anim	0	1	0	1	0	1	0	1	0	1	0	1	1	1
Use of records	1	1	0	0	0	0	0	1	1	1	1	1	1	1
Use of technologies (%)	**81**	**100**	**18**	**91**	**9**	**91**	**18**	**100**	**45**	**100**	**9**	**100**	**91**	**100**
0: no use; 1: uses														

The main objective in all farms was to increase productivity and income without affecting the environment and without increasing labour time. In all farms the redesign focused on increasing forage production (native grasslands) and stabilizing year-round availability (improved pastures) and increasing and stabilizing meat productivity. At the end of the project, on average for the seven pilot farms, 97% of the proposed technologies were applied (Table 1). During the project, stocking rate was reduced, on average on all farms by 9% (from 0.92±0.05 to 0.84±0.03 LU ha^{-1}) and the sheep to cattle ratio by -46% (from 2.71±0.44 to 1.27±0.25). Forage height increased from 6.1±1.6 to 9.2±1.2cm (summer 2013 vs summer 2015, respectively) and from 6.6±1.9 to 8.1±1.8cm (autumn 2013 vs autumn 2015 respectively). Forage allowance increased from 3.3±0.2 to 5.6±1.7 kg DM kg $^{-1}$LW. As a consequence, equivalent meat production (i.e. meat + wool) increased by 22% (from 99.5±5.9 to 121.5±2.6 kg) and % of pregnancy increased from 76% to 91% (initial vs final respectively), kg of weaning calf per breeding cow increased by 31%

(from 106.4±13.7 to 139.9±11.9 kg ha^{-1}). Comparing baseline results with the average after three years of redesign net income increased from 31.3±18.9 to 59.5±15.8 US$ ha^{-1}. Labour time decreased by 24% after implementation of the project while labour productivity increased by 97%. The EII increased slightly from 3.6 to 3.7 and was always more than 3.5, which is the value considered acceptable for this type of systems.

4 – Conclusions –

The co-innovation process was effective to improve productive and economic results without affecting the environment and without complexifying the management of livestock grazing systems. This process was also successful in improving researcher's perspective since it required adaptation of the research knowledge considering farmers experience and farms reality.

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