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Sheep production systems in the semi-arid zone: Changes and simulated bio-economic performances in a case study in Central Chile

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ABSTRACT

A sheep farm typology was developed to describe the evolution of sheep farming between the censuses of 1997 and 2007 in the semiarid zone of Central Chile. The typology yielded three groups (I–III) that accounted for 81, 17 and 2.5% of the farms respectively, differing in farm size and in the ratio of sheep to cattle and other agricultural activities. Sheep represented 80–86% of the livestock units in small farms, as opposed to 53% in the larger, more diversified, ranches. Farm-based technical and economic parameters were not available. Stochastic mathematical simulation of bioeconomic performance for prototype farms representative of each of the three groups showed differences accounted for by farm size, farm diversification and animal breed. Large between-farms within group variation in performance suggest the existence of room for incorporation of technology. Smaller flock sizes in I and II were associated with larger production costs and less income per lamb and per kg live weight. Larger farms carrying Merino produced more lambs per ewe and had lower unitary costs. Unaccounted for costs of family labor in the smaller farms, together with some evidence of their gradual decapitalization, explain the continued existence of the small sheep farm sector. Implications for the future development of these farms are discussed.

1. Introduction

The Mediterranean region of Chile extends for about 1000 km between 30° and 37°S, ranging from arid areas in the N to humid in the S (Le Houerou, 2004), and covers some of the most important agricultural regions of the country. Within this area, the central, most populated, semi-arid portion includes a variety of land uses, and has a long history of agricultural occupation (Cáceres, 2010). The valleys and flatlands are dedicated to intensive, irrigated horticulture, viticulture and pomology, whereas hilly lands are typically dominated by a woody savanna (Moreira-Muñoz, 2011), and are largely in the hands of family farms whose main source of income is meat and wool sheep raised in extensive, input–low output systems. These dry lands, degraded by decades of cereal monocropping (Brunel et al., 2011; Kapur and Ersahin, 2014), are covered by low yielding naturalized annual pastures (Ovalle and Squella, 1996) thus resulting in low animal and per ha performance (Vera et al., 2013). Grassland-based sheep production systems are of historical, social, environmental and economic importance throughout the world's Mediterranean regions (Cosentino et al., 2014). Sheep systems are frequently based on subhumid to semiarid degraded rangelands that limit physical productivity and are highly seasonal (Specht et al., 1988), but may also be associated with multifunctionality characteristics (Hadgigeorgiou et al., 2005), including conservation of the landscape and biodiversity (Baumont et al., 2014; Casasús et al., 2012; García-Martínez et al., 2011; Winkler, 1999). The forage resources of Mediterranean environments and the environmental services that they provide have been the subject of numerous reviews (e.g. Arroyo et al., 1995; Baumont et al., 2014), but their future is uncertain (de Rancourt et al., 2006).

Not surprisingly, between-farm variability is large in Mediterranean regions, compounded by changes in policies, national and international market opportunities, and variable institutional support over time (Carmona et al., 2010).

Numerous authors have advanced the view that government policies should ideally consider this wide variation so as to skew policies towards the weaker sectors (Boyazoglu and Morand-Fehr, 2001; Boyazoglu, 2002; Daskalopoulou and Petrou, 2002), but neither the EU subsidies (Caballero, 2001) nor the credits and policies available in Chile differentiate between production systems. In consequence, the importance of sheep production systems in the Mediterranean continues to decrease (Bernués et al.,

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2011), a trend replicated in Chile where sheep farms decreased 17% in the 1997–2007 period (INE, 2007, 1997). Sheep flocks in Central Chile are mostly based on Suffolk and Merino, and are owned mostly by small and medium farmers. Reduction in wool prices, particularly for medium wool, have forced farmers to favor meat production via the gradual introduction of new breeds that give rise to larger, easier to cut carcasses, and with larger added value. This process further increased between-farms variability, and modified their production and profitability. In this context the development of farm typologies constitutes a tool to identify structural features of production systems, generate a framework within which policies may address the needs of specific farm categories, and identify farms with a need or potential to adopt new technologies.

Targeting policies, technical assistance, and innovative technologies for fragile environments can be helped through the identification of farms clusters and recommendation domains as carried out by typological studies (Barrantes et al., 2009; Cortez-Arriola et al., 2015; Daskalopoulou and Petrou, 2002; Girard et al., 2008; Madry et al., 2013; Ripoll-Bosch et al., 2014) together with a variety of information technologies (Blackmore and Apostolidi, 2011; Carmona et al., 2010; Dalgliesh et al., 2009) to support farmer decision making. For example, Meyland et al. (2013) recognizing the ecosystem importance of soils, combined a farm typology with a conceptual cropping system with the purpose of identifying system-appropriate alternatives to promote soil conservation. Similarly, Bohnet et al. (2011a) developed a farm typology of cattle systems in the Bowen–Broken watershed, to understand the relationships between ranchers, land, and the capacity to incorporate sustainable practices in order to decrease the rate of sedimentation and nutrient loading of the Great Barrier Reef.

Mathematical modeling techniques that integrate economic and agro-ecological information allow the early assessment of possible policies and technical interventions, due to their ability to rapidly focus on specific farm types and production systems at low cost, as exemplified among others by Bohnet et al. (2011b), Buysse et al. (2007), Cacho et al. (1995), Catrileo et al. (2009), Dalgliesh et al. (2009), Ruben et al. (1998), Toro et al. (2009) and Zimmermann et al. (2009).

Thus, the joint use of these tools allows prioritization of support policies for farm groups based on technical and economic indicators. They also permit to value environmental services and societal values, including the generation of opportunities for farm labor (Olaizola et al., 2015), so that marginal farms may reach profitability levels compatible with their continuing existence.

The objective of the present paper was to develop a typology of sheep production systems in the Mediterranean area of Central Chile to identify and quantify changes that have taken place in the interval between the last two agricultural surveys, in terms of structural, and aggregated economic and technological variables. Since surveys do not identify technical and economic parameters for production systems, nor was data available elsewhere, the bioeconomic performance of prototype farms representative of each typological group was simulated to identify groups of farms marginally profitable, and to assess interventions that would increase their performance and continued livelihood.

2. Materials and methods

2.1. Study area

The study was carried out in the central, semi-arid zone of Chile (33° to 35°01'S, 70°02'W to the Pacific Ocean). The surface area is 16,387 km^2, 29.5% of which is under native forests, 24% in rangelands, 17% croplands and 9% forestry (INE, 2007). The topography is varied, with altitudes varying between 0 and 5135 masl, and encompasses four agro-ecological regions: Coastal areas, a Central Valley with ocean influences, an interior Valley, and the Andean foothills. The average yearly rainfall varies between 518 mm in the interior Valley and 580 mm in the foothills (Santibañez and Uribe, 1993) but annual rainfall has been decreasing over the last 20 years (IPPC, 2014). Winter rainfall predominates, and June and July are the wettest months but with a highly erratic rainfall ranging between 100 and 300 mm per month (Pizarro, 2007).

2.2. Data selection and population

Farms that raise ruminant animals cover 1.6 million ha in the study region, and 18% of them carry sheep (INE, 2007). Data available in the 1997 and 2007 surveys for sheep farms include dimensional and social variables, land tenure, and farmer-related characteristics. Survey data were then processed to obtain derived quantitative and qualitative variables (Ruiz et al., 2008). The number of farms carrying at least some sheep was 3466 in 1997, and 2793 in 2007 (INE, 2007, 1997). Some farms had nominal numbers of sheep and therefore only sheep farms with a minimum of 5 ha, stocking rates of at least 0.1 sheep LU/ha and a minimum of 40% of the LU as sheep were kept for further analysis. Initially, farms were grouped into four classes, according to the number of sheep animal units in each, as shown in Table 1. Subsequently, noncommercial farms with less than 5 LU were excluded from the analysis. These farms represented a large proportion of the total, but with a trend towards decreasing absolute numbers. The number of farms classified as T1 increased over the period 1997–2007, whereas that of T0 decreased, possibly due to increases in flock size of the latter that allowed them to reclassify as T1 farms in 2007. Excluding category T0 from the study population left a total (T1+T2+T3) of 352 farms for 1997 and 395 for 2007 (Table 1).

To characterize sheep production systems, quantitative variables extracted and/or generated from the 2007 Census were classified into three categories as follows: dimensional, intensity and diversification, and social variables. The dimensional variables showed a wide range of variation in terms of crop area and flock size (Table 2). Variables related to intensification and diversification were relatively less variable. Sheep numbers as proportion of total livestock, and the area covered by natural grasslands, showed coefficients of variation less than 50%. Although with a high coefficient of variation, 95% of the farm population had sheep stocking rates ranging between 0.25 and 0.32 sheep LU/ha. The persistence of extensive sheep systems in the region is evidenced by variable, but low, sheep stocking rates, large proportion of native pastures, and low areas of sown annual and perennial forages. Social variables showed a high percentage of tenured areas, advanced age of farmers, and low permanent and total labor use, all of which coincide with the extensive nature of these systems.

The geographical location of sheep farms (Fig. 1) showed larger concentrations in the Coastal area and Central Valley. The municipalities of Litueche, La Estrella and, Marchigüe had 65 and 67% of the commercial farms reported for 1997 and 2007 respectively, and showed an increasing number of farms owning 30–100 LU.

2.2.1. Typological classification and Inter-census evolution

The method proposed by Escobar and Berdegué (1990) and used by Guillem et al. (2012), Toro-Mujica et al. (2012) and Gaspar et al. (2011) was applied to farm classification. It includes three stages, as follows: review and selection of variables, factor analysis, and cluster analysis. This approach was applied to the 2007 data yielding a number of farm types as well as equations to estimate factors for each farm. Quantitative variables included dimension, land use and tenure, and the composition of the farm crop and