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Determinant factors of economic performance of goat meat production systems in arid rangelands of Mendoza, Argentina

Factores determinantes del rendimiento económico de los sistemas de producción de caprinos para carne en pastizales naturales áridos de Mendoza, Argentina

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Summary

This study identified and quantified the relevance of the variables affecting the annual income of meat goat production systems in arid rangelands of north-eastern Mendoza plain. It was hypothesized that the number of kid produced per year is the main factor that influences the economic performance of production systems. Ordinary linear, semi-log and Cobb-Douglas functions were estimated based on data from a cross section of 20 representative producers of the study area. Dependent variable was farm income and independent variables were number of kids and calves produced, manure sold, off-farm income, labor used for animal management (all the previous variables expressed at annual terms), farm available infrastructure, and distance of the farm to the main path. Producer size, on the basis of the number of goats and cows that they had, was divided into two categories: C_1 with no more than 130 animals and C_2 with more than this amount. Linear equation was a good one because it had the highest R^2 (0.99). Production elasticity was higher for off-farm income than that of kid production in C_1 producers. The contrary was verified for C_2 producers. Optimal policy for incrementing significantly the farm annual income would be to increase the producer size when the available natural resources and others farm characteristics would permit it.

Resumen

Este estudio identificó y cuantificó la importancia de las variables que afectan el ingreso anual de los sistemas de producción de caprinos para carne en pasturas naturales del noreste de la llanura de Mendoza. Se hipotetizó que la cantidad de cabritos producidos anualmente es el factor principal que influye sobre los resultados económicos de dichos sistemas. Se estimaron las funciones lineal ordinaria, semi logarítmica y Cobb-Douglas sobre la base de la información de una sección

cruzada de 20 productores representativos del área. La variable dependiente fue el ingreso anual de la explotación. Las variables independientes fueron: cantidad de cabritos y terneros producidos, estiércol comercializado, ingreso extrapredial, mano de obra usada para manejo de los animales (todas las variables anteriores expresadas en términos anuales), infraestructura disponible en la explotación y distancia de esta a la ruta principal. El tamaño de los productores, sobre la base de la cantidad de cabras y vacas que poseían, fue dividido en dos categorías: C_1 con no más de 130 animales y C_2 con mayor cantidad de animales. La ecuación lineal ordinaria fue la de mejor ajuste ($R^2 = 0,99$). La elasticidad de producción fue más alta para los ingresos extraprediales que para la producción de cabritos en los productores C_1. Lo contrario se verificó para los productores C_2. Para incrementar significativamente el ingreso anual de los productores se debería aumentar su tamaño cuando los recursos naturales disponibles y otras características de la explotación lo permitieran.

Key words: production functions, rangelands, Mendoza plain, farm income, kids, off-farm income, production elasticity

Palabras clave: *funciones de producción, pastizales naturales, llanura de Mendoza, ingreso de la explotación, cabritos, ingreso extrapredial, elasticidad de producción*

Introduction

The total world goat population in 2014 was estimated at 1,008 million and included a total of 570 breeds (FAO, 2014). Goats are distributed across all regions and ecosystems of the world, but arid environments are favored. Meat production is the principal function of goats throughout the developing countries. Generally low level of production in these countries is associated with inefficient feeding and management, inadequate use of the indigenous goat genetic resources, and disease constraints (Devendra, 2010). Goats play an important role for the provision of animal protein and as source of income to small holders in marginal rural areas of the world (Castel et al., 2010; Devendra, 2010; Mahgoub, 1997).

The existence of goats in Argentina was 4.2 million in 2011 (MAGYP, 2010). In Mendoza province there are more than 800,000 goats and 3,500 producers who engage in this activity (MATM, 2012).

The prevailing production system is that called "rangeland-based system", found in the semiarid and arid regions of the world, where sparse vegetation, containing mainly native grasses and shrubs, is characteristic in these regions. These plants are important source of feed (Devendra, 2010).

Goats are the predominant livestock species in the rangelands of northeastern Mendoza plain (Guevara, 1991). In 2002, this area of 10,244 km^2 had 96,750 goats, which represented 14.4% of the Mendoza goat herd (Bernard, 2007). Goat production is undertaken by 608 small stockmen (PlaNet Finance, 2011). Goats have been traditionally kept for meat production.

The most extensive feeding system is continuous grazing without fencing, which is the most practical way for exploiting the natural vegetation; goats are herder or are free roaming to graze what they can find (Allegretti et al., 2012). The stockman, who lives in the production site, provides all or most of the necessary labor. The cultural and socioeconomic conditions of the inhabitants and their limited access to improved technology

have led to overgrazing and its consequent impact on vegetation, soil and future productivity. Goat herders generally occupy communally or state-owned land (Guevara et al., 2009). In general, goat production is associated with the activity of many subsistence farming families when natural resources do not permit to generate other profitable economic activity (MATM, 2012). As occurred in other areas of the world (Zaibet et al., 2004) generally there is no record keeping or selection programs in the study site except for a natural selection towards survival more than production.

To our knowledge, there were not studies related to the estimation of production functions for meat goat production systems in Argentina. In other areas of the world, the studies of production functions are referred to dairy goats (Kipserem et al., 2011), livestock milk (cattle, sheep, goats, camel and horses) in Pakistan (Ishaq et al., 2007) or the characterization of dairy goat production systems using ANOVA (Capote et al., 2006). Cobb-Douglas function and other models were used to investigate technical efficiency of goat producers in the Sultanate of Oman (Zaibet et al., 2004).

The purpose of this study was to identify the variables that affect the annual income of meat goat production systems and quantify their relevance. It was hypothesized that the number of kids produced annually is the main variable that influences the economic performance of production systems.

Material and Methods

Study site

Most of the study area is comprised by a desert of dunes (Roig et al., 1992). Saline depressions are present along the eastern border of the area (Guevara et al., 1997). The vegetation is typical of the Monte phytogeographic province (Roig et al., 1992). Shrublands and open woodlands play an important role because they provide forage for grazing animal throughout the year. Vegetation communities of major foraging importance with regard to floristic composition, forage species cover and carrying capacity are: a) semiclosed woodlands of *Prosopis flexuosa* DC. (algarrobo dulce) with *Atriplex lampa* Gillies ex Moq. (zampa) in interdune valleys, and b) open woodlands of *P. flexuosa* with *A. lampa* and *Tricomaria usillo* Hook. & Arn. (usillo) on dunes (Alvarez et al., 2006; Passera et al., 2004).

Mean annual rainfall in the area is 175 mm (S.D.= 77.4) (Guevara et al., 1996), most of which falls during the spring-summer period. The bioclimatic conditions are considered "warm-arid" with a mean annual temperature of 20 °C. The precipitation/potential evapotranspiration (Penman standard) ratio is about 0.08 (Guevara et al., 2006). Soils are mainly sandy with undifferentiated horizons (Entisols and Aridisols). Estimated rangeland carrying capacity was 45.5 ha cow^{-1} or 7.3 ha $goat^{-1}$ (Guevara et al., 1996).

Animals and production systems

The "Criollo" goats, the most common breed in the study area, descended from goat breeds transported by the Spanish and Portuguese colonizers from the Canary Islands (Amills et al., 2009). Goat parturition occurs in two periods of the year: spring-summer (November-December) and fall–winter (May–July). About 70% of goats kid in the latter pe-

riod, in which there is no kid production in other goat husbandry zones of Mendoza (Guevara et al., 1997). The mean annual kid crop for the "Criollo" biotype was 1.0 goat^{-1}. Kids are sold alive on the farm at 40–65 days old with a live weight ranging from 7 to 12 kg from which a 4 to 6 kg carcass is obtained (Paez Lama et al., 2013).

The handling of animals consists in releasing goats in the morning to go to grazing and by late afternoon they return to the farm and are kept in pens. This habit of locking protects kids from predators and permits that kids suck goat milk, drink water, and also collecting manure, which is sold to agricultural enterprises (Robles et al., 2007).

Producers also carried out other economic activities such as lambs, doe and kid skins, handicraft and bee honey production and rural tourism, among others.

Data collection

Data for estimating the production function came from a cross section of 20 representative producers, representing 20% of the total existing in the study area. They were located around the Telteca Flora and Fauna Reserve (32º 23' 27"S, 68º 01' 30"W) and occupied about 110,600 hectares. The information was obtained through direct producer surveys conducted in June 2013, using a structured questionnaire which contained a total of 40 items grouped into personal and household data, production structure and activities, labor, technological structure, marketing and income hierarchy and off-farm activities.

Estimated models

The ordinary linear, Cobb-Douglas (double-log) and semi-log functions were used to determine which of them would best fit the relationship between annual income and the explanatory variables.

The implicit form of regression model for this analysis was given as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, u),$$

where:

Y: Total income in Argentine $ ($ 7.95 = U$U 1.0 at the end of January 2014). It was calculated on the basis of data provided by farmers of the marketed products (kids, calves, manure) and off-farm income. All incomes were valued at current local market prices.

X_1: Number of kids obtained per year (most of them are for marketing and the rest for the producer and his family consumption).

X_2: Number of calves produced per year.

X_3: Manure sold per year (Argentine $).

X_4: Total labor used for animal management expressed in Man Equivalents. It was taking into account only the dedication of the producer and his family who performed tasks on the farm because some of this labor is used out of farm.

X_5: Infrastructure for livestock available in the farm (pens, watering points, troughs, shelters, etc.). This variable was quantified through an arbitrary index with maximum score of 20 points (0: null; 5: scarce; 20: complete).

X_6: Distance of farm to the main road (km). Consideration was given to this variable under the assumption that the price paid to farmers for some products sold, such as manure, decreased by increasing the distance to the main path and as a consequence the farm income decreases. This assumption was based on the fact that the

farm household is often located in a highly risky environment where markets do not operate perfectly. Thus, the road infrastructure is poor (roads linking the farmers with the main roads are unpaved and almost inaccessible) which makes difficult the communications and arrival of buyers to farms.

X_7: Off-farm income per year (Argentinian $). This includes retirement or pension of farmer family, off-farm work (rural schools, municipalities, farming, domestic, agricultural harvest, Renewable Natural Resources Division, etc.) and perception of the Universal Child Allowance (UCA) which is a state subsidy.

u: Error term

The number of lambs produced per year was not included in the production function because only two producers marketed this product and the number of existing sheep is reduced (4 and 20, respectively). Producers do not increase it for the losses caused by the tendency of this species to spread and the difficulty of controlling the animals by the absence of fencing (Guevara et al., 1993). Similarly, production of honey, skin, handicraft and rural tourism were not considered in annual income because these activities are performed occasionally and the producers did not provide enough information for their quantification.

To test the proposed hypothesis the three functions utilizing the stepwise selection method and the maximum p-value to enter and to retain = 0.1 were used.

Producer size, on the basis of the number of goats and cows that they possessed, was divided into two categories: C_1, small producers, with no more than 130 animals, and C_2, largest producers, with more than this amount, using the probabilistic method assigning categories by intervals (Di Rienzo et al., 2014).

Data used for estimating the production functions are listed in **Table 1**.

The estimation of the parameters of the production functions was performed by least squares, by the linear regression program InfoStat version 2014 (Di Rienzo et al., 2014).

Results and Discussion

The livestock (adult animal head total, in animal units) that the producers had was as follows: goats: 55.0%, cattle: 28.5% and horses: 16.5%. The mean number of goats and cows per farm and their standard deviations were 191.8 ± 180.5 and 16.7 ± 21.9, respectively. Producers complement goats with cattle rather than compete with them for feed because of the ability of these livestock species to use a wide variety of plant species (Lebbie, 2004). Goat owners in rural areas do not usually have access to banking facilities and thus have come to rely on investment in their stock, with goats serving as "current accounts" and cattle serving as "savings accounts" (Lebbie, 2004).

The estimated functions are presented in **Table 2.**

The values of R^2 (**Table 2**) indicate that linear equation was a good one compared to the other two functional forms because it has the highest R^2. This form shows that number of kids and calves obtained annually and annual off-farm income have significant statistically effect on annual income. Coincident partially with this result, number of kids and off-farm income were also significant variables for explaining the annual income in semi-log and Cobb-Douglas equations. The values of "F" were significant at $p<0.001$ for the linear and Cobb-Douglas equations and $p<0.05$ for the semi-log form.

Table 1.Data from the production systems of the north-eastern Mendoza plain
Tabla 1. Información de los sistemas de producción del noreste de la llanura de Mendoza

AI[a]	K[b]	C[c]	M[d]	OFI[e]	TL[f]	AI[g]	DP[h]
135,382	450	2	7,514	79,118	2.0	20	3.0
53,274	180	0	2,312	30,802	1.75	15	0.25
75,349	450	8	6,000	16,549	2.5	12	4.0
37,686	180	2	2,400	6,336	2.0	10	3.0
19,625	190	1	2,500	100	2.0	20	10.0
7,656	65	0	1,156	150	1.0	10	0.15
48,374	240	8	4,046	9,648	3.0	10	22.0
9,857	15	1	578	6,624	2.0	12	20.0
95,960	190	20	2,800	56,060	3.0	20	0.25
187,750	700	25	11,000	81,600	5.0	20	25.0
59,016	100	18	2,500	24,466	2.5	20	32.0
69,193	30	15	578	50,630	3.0	15	12.0
55,299	200	10	2,000	16,549	1.0	20	1.0
65,248	400	0	4,624	6,624	3.0	20	1.0
53,048	150	2	1,200	33,098	3.0	15	2.0
39,578	48	0	50	33,098	2.5	15	4.0
40,957	20	1	289	37,393	2.5	10	3.0
94,157	140	15	1,743	65,598	3.0	10	5.0
45,784	100	0	2,100	33,284	1.5	5	6.0
59,000	95	15	3,071	35,000	2.0	20	10.0

[a]Annual income; [b] Number of produced kids; [c] Number of obtained calves; [d] Manure sold; [e] Off-farm income; [f] Total labor; [g] Available infrastructure; [h] Distance of farm to main path
[a]Ingreso anual; [b] Número de cabritos producidos; [c] Número de terneros obtenidos; [d] Estiércol vendido; [e] Ingreso extra predial; [f] Mano de obra total; [g] Infraestructura disponible; [h]Distancia del predio a la ruta principal

Table 2. Regression equations for farm annual income in the north-eastern Mendoza plain
Tabla 2. Ecuaciones de regresión para el ingreso anual de los predios en el noreste de la llanura de Mendoza

Production function	Constant	X_1	X_2	X_3	X_4	X_5	X_6	X_7	R^2	Adj. R^2	F-value
		Kids	Calves	Manure	Labor	Infrastructure	Distance to road	Off-farm income			
Linear	-741.7	137.2**	844.8**	-1.27	-249.0	193.4	115.5	0.98***	0.99	0.99	215.90
	(4,992.9)	(36.2)	(206.8)	(2.4)	(2,289.6)	(262.0)	(207.9)	(0.1)			
Semi-log	179,906.4	15,822.3*	1,292.8	3,406.5	23,113.2	12,897.3	-200.7	10,493.2**	0.78	0.65	6.09
	(61,465.7)	(8,813.5)	(4,033.0)	(5,892.7)	(19,966.4)	(17,521.2)	(4,602.8)	(3,782.0)			
Cobb- Douglas	5.91	0.38**	0.02	-0.03	0.24	0.17	-0.003	0.27***	0.93	0.88	21.22
	(0.77)	(0.12)	(0.02)	(0.10)	(0.21)	(0.19)	(0.05)	(0.04)			

*, **, *** Values significant at p<0.1, P<0.05 and p<0.001, respectively. Figures in parentheses are standard errors
, **, * Valores significativos a p<0.1, P<0.05 y p<0.001, respectivamente. Los números entre paréntesis son errores estardar*

In the Cobb-Douglas production function, production elasticity was higher for off-farm income (0.37) than that of kid obtained (0.34) in C_1 producers. The contrary was verified for C_2 producers (0.26 and 0.37 for off-farm income and kid produced, respectively). Our results are coincident with that found in goat production systems in Oman where off-farm income was the major source of income for flocks ranged between 10 and 100 heads (Zaibet et al., 2004). These authors reported that in this area off-farm income helps the community, at least partly, to meet expenses incurred in raising the livestock and improving living conditions of the rural people. The significance of non-farm income over farm revenue indicates an important issue for the development of the community, primarily for the smaller producers (Leones & Feldman, 1998).

In the Cobb-Douglas function the sum of elasticity of the five positive regression coefficients gave a value of 1.08, which reveals that the production system is characterized by increasing return to scale. The Cobb-Douglas production function estimated for small ruminant farming in Pakistan (Ishaq et al., 2007) gave an increasing return to scale of similar value (1.19). Higher value of return to scale was found (1.946) in dairy goat farming in Kenya (Kipserem et al., 2011). For wintering in farms of the northeast of La Pampa, Argentina, the production is located in an area of constant returns to scale (1.002) (García et al., 2007). The same was verified in meat sheep production systems in Aragón, Spain (Pérez et al., 2007).

Distance of the farm to the main road was not a significant variable for explaining the farm annual income due to the price paid to farmers for the manure sold represents only 9.2% of the sold products. On the other hand, marketing of kid (70% of the products sold) has its own and complex characteristic. Indeed, kids are usually sold "standing" in the producer's exploitation to buyers who attend, often extra-provincial and in some cases sent by meat processing plants or intermediaries, and pay with money or goods (barter). The price is set for the whole lot and several factors are involved in fixing the price such as number, age and body conditions of kids, and competition among processing plants (PlaNet Finance, 2011).

The weaknesses of the goat sector in the study area are, in addition to others cited previously, the following: lack of horizontal and vertical integration of producers, kid seasonal production, furtive slaughter, and lower promotion of goat products and absence of national health plan (Bernard, 2007). Complementary to the above, the overriding challenge calls for the definition of policies that can: a) ensure the survival and improvement of the livelihoods of small farmers and the landless who own goats, b) foster greater institutional involvement and investments in target agro-ecosystems; c) promote increased adaptive Research and Development programs involving productivity enhancing technology application, and d) vigorous scale up production and post-production systems, linkages and market access (Devendra, 2010).

Conclusion

As a consequence of the higher return to scale of kid production in the producers with more than 130 animals, the

optimal policy for incrementing significantly the farm annual income would be to increase the producer size in the cases where the available natural resources and others farm characteristics would permit it. The significance of off-farm income over farm revenue indicates important an issue for the development of the community. Farmers must develop strategies to mitigate risk which are economically rational. These include production diversification and off-farm work.

It is considered essential to continue the action plan implemented by the Goat Provincial Advisory Committee in 2004 to mitigate the weaknesses of the goat sector in the study area.

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