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Short communication

Growth and economic performance of kid production under different rearing systems and slaughter ages in arid areas of Argentina☆

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ABSTRACT

This paper evaluated the growth performance of Criollo kids under three different rearing systems and determine the economic profit of each rearing systems with slaughter at two different ages. Forty-eight kids were distributed randomly into three groups ($n = 16$). Two groups of kids were naturally reared with their mothers, suckling goat milk until weaning at 30 and 45 days of age (groups N30 and N45, respectively). In the remaining group, kids were artificially reared on milk replacer until 45 days of age (group A45). Between 30 and 90 days, all groups were ad libitum offered with a ration of alfalfa hay and ground corn. Kids from each group were slaughtered at 60 ($n = 8$) and 90 ($n = 8$) days old. The growth performance of kids was acceptable achieving average daily gain (ADG) values ranging between 115.9 and 129.5 g d^{-1}, with no major differences between rearing systems at the end of the study. The natural rearing systems showed low values of gross return, which ranged from −0.60 to 5.67 US\$ kid^{-1}, while the artificial rearing system was not economically viable due to the high cost of milk replacer and high demand of labor. The price of milk replacer should not exceed 20% of meat value so that artificial rearing becomes economically feasible. The average gross return of the two natural rearing groups slaughtered at 90 days (3.96 ± 1.46 US\$ kid^{-1}) was three times higher than the animals slaughtered at 60 days (1.25 ± 0.93 US\$ kid^{-1}). On the basis of the economic results it would be advisable to raise the kids naturally with goat milk and increase the age of slaugther, as long as consumers accept these older animals without decreasing the selling price of meat.

1. Introduction

The Criollo goats, most common breed in Argentina, descended from goat breeds transported by the Spanish and Portuguese colonizers from the Canary Islands (Amills et al., 2009). Traditionally, these goats have been kept for meat production and the main product obtained are kids raised with goat milk until slaughter (Guevara et al., 2009). Generally, the kids are sold alive on the farm, between 45 and 60 days old with a live weight ranging from 7 to 12 kg. The buyers come from the city (often from other provinces) and are employees of the slaughterhouse companies or intermediaries who sell directly to companies (MinAgri, 2007). A limited bargaining power of producers and a concentrated demand allow buyers to set the price of kids. The selling price is set taking into account factors as: the number of kids, the state of body fatness, accessibility and distance to the farmer household, competition with other buyers, etc.

Most of goat production systems are extensive under continuous grazing on rangelands, without stockmen

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Table 1
Chemical composition of feedstuffs offered to kids during trials.

	Composition, dry matter basis (%)			
	Goat milk[a]	Milk replacer	Starter	Ration
Dry matter	12.9	95.2	92.1	90.5
Crude protein	3.9	23.5	25.8	14.1
Crude fiber		0.5	3.3	21.2
Ether extract or fat	3.7	26.7	8.6	2.6
Ash	0.8	7.6	5.9	9.0
ME MJ kg^{-1}	2.96	19.2	17.6	8.4

[a] Milk composition expressed per kg of fresh milk.

control and with little or no feed supplementation to animals (Allegretti et al., 2012). For this reason, the production and supply of suckling kids are highly dependent on rainfall and forage availability in the field. A great constraint of this production system is that supply of kids is concentrated in December and January while market demand is stable throughout the year (MinAgri, 2007). Under these conditions, it is necessary to develop alternative rearing systems, to support the production of kids in years with adverse weather conditions and low forage availability. On the other hand, increasing the slaughter age would allow to produce more meat for market, off-time of the higher supply, achieving a better sale price with a higher profitability of production.

This study aimed to: (1) evaluate the growth performance of Criollo kids under three different rearing systems and (2) determine the economic profit of each rearing systems with slaughter at two different ages (60 and 90 days old).

2. Materials and methods

2.1. Animals, rearing systems and measurements

All experimental procedures and animal handling were performed according to animal welfare regulations of the National Animal Health Service of Argentina (Servicio Nacional de Sanidad y Calidad Agroalimentaria, SENASA).

Forty-eight Criollo male kids of single birth from the farmer household of “La Majada” (32°19′39′S, 67°54′36′W) were selected to perform this study. Kids were kept with their mothers during the first three days of life and then were assigned to three treatments ($n = 16$), balancing the groups according to the liveweight (LW). Two groups of kids were naturally reared with their mothers suckling goat milk until weaning at 30 and 45 days of age (groups N30 and N45, respectively). These kids had free access to suckling during the day (16 h day^{-1}) and were separated from goats at night. In the remaining group, kids were artificially reared on milk replacer until 45 days of age (group A45). Milk replacer was prepared at a concentration of 16% (w/v) and was ad libitum offered by bottle during 1 h at 08:00 and 16:00 h. A commercial starter diet was ad libitum offered only to N30 group from the beginning of the trials until 45 days of age. Between 30 and 90 days, all groups were ad libitum offered with a ration consisting of alfalfa hay (80%) and ground corn (20%) (on dry matter basis).

The chemical composition of different feedstuffs offered to kids is shown in Table 1. Kids from each group were slaughtered at 60 ($n = 8$) and 90 ($n = 8$) days old after a 12 h fasting with free access to water.

The intake of milk and milk replacer was measured twice a week. The kids from natural rearing groups were weighed before and after suckling, and the milk intake was calculated as the difference between the two weights. The milk replacer intake was determined by the difference between the weight of bottle before and after feeding. Starter and ration intake were measured weekly by difference between offered and refused. Kids were weighed each week, and the average daily gain (ADG) and feed efficiency (FE, intake/gain) were calculated.

2.2. Economic analysis of rearing systems and slaughter ages

The economic analyses were made taken into account the USA dollar value at October of 2011 (US$ 1 ≈ 4.22 argentinian pesos). To compare the economic profit of the different rearing systems and slaughter ages, the gross return (GR) was calculated by the difference between total income and total operating costs. Income and operating costs were individually calculated for each kid. Feeding costs included milk, milk replacer, starter and ration. In Argentina, there is not a quality payment system to set the milk price as occurs in other countries. This leads to the lack of a official and well established market price. However, is possible to state that the milk price has remained around 0.45 US$ L^{-1} in last recent years (MinAgri, 2009). Prices paid for milk replacer, starter and ration were 4.502, 2.654 and 0.220 US$ kg^{-1}, respectively. Labor costs were calculated by multiplying the price of a farmer working hour (3.01 US$ h^{-1}) by the number of hours employed per kid in the different rearing systems (RMLA, 2011). Also sanitary costs (vaccination and deworming, 0.47 US$ kid^{-1}) and building and equipment maintenance costs (0.11 US$ kid^{-1}) were included. Income included: carcass (5.431 US$ kg^{-1}) and skin (valued in local tanneries at 0.592 US$ per unit). Income from manure during trial period revealed insignificant values and were excluded from the analysis.

2.3. Statistical analysis

Data were statistically analyzed using the GLM procedure of InfoStat statistical software (InfoStat, 2011).

The LW, ADG, milk replacer intake and FE data were analyzed with a repeated measures design according to the following model: $Y_{ijk} = \mu + BW + R_i + T_j + RT_{ij} + \epsilon_{ijk}$.

The total DM intake data were analyzed according to the following lineal model: $Y_{ijk} = \mu + R_i + T_j + RT_{ij} + \epsilon_{ijk}$.

The costs, income and gross retun data were analyzed according to the following lineal model: $Y_{ijk} = \mu + R_i + ST_j + \epsilon_{ijk}$ where Y_{ijk} = dependent variable, μ = overall mean, BW = birth weight as a covariable, R_i = fixed rearing system effect, T_j = time effect, RT_{ij} = rearing system × time interaction effect, ST_j = slaughter age effect and ϵ_{ijk} = experimental error.

When effects of treatment, time or treatment x time interaction were significant, differences between means were determined by Fisher LSD test, considering differences statistically significant at $p < 0.05$.

3. Results and discussion

3.1. Intake and growth performance

Total dry matter intake and growth performance of Criollo kid according to rearing system are shown in Table 2. The average milk replacer intake recorded in artificial rearing group (220.2 g DM d^{-1}) was similar to those observed in Criollo–Saanen (193.1 g DM d^{-1}; Tacchini et al., 2006) and Angora kids (218 g DM d^{-1}, calculated from data published by Davis et al., 1998). Although all groups were ad libitum fed, the average consumption of milk replacer (220.2 g DM d^{-1}) was greater ($p < 0.001$) than the average consumption of goat milk (147.7 and 150.9 g DM d^{-1}, for N45 and N30, respectively). This could be because perhaps Criollo goats did not produce enough quantity of milk to achieve the satiety of these kids, despite the diet offered meets the theoretical nutrient requirements of goats according to NRC (2007). However, further studies should be performed to verify this assumption.

After weaning, the dry feed intake of N30 group was low (104.7 g d^{-1} of total DM intake between 30 and 45 days), probably due to their early age at weaning and the ad libitum supply of milk during the period prior to the weaning. Goetsch et al. (2001) reported that during the preweaning phase, a restriction in the supply of milk can stimulate dry feed consumption.

Table 2
Effects of rearing systems on intake and growth performance of kids.

Item	Age (d)	Rearing systems				Effect		
		N45	N30	A45	S.E.	*R*	*T*	*R* × *T*
Total DM intake, g d^{-1}						***	***	***
	3–15	149.8[a]	149.0[a]	179.7[b]	6.19			
	15–30	142.9	165.7	219.3	8.25			
	30–45	198.0[a]	104.7[b]	288.1[a]	7.95			
	45–60	167.0	250.9	151.3	26.02			
	60–75	278.1	399.5	225.9	81.66			
	75–90	484.4	521.6	441.4	80.29			
ADG, g d^{-1}						**	***	***
	3–15	214.1[a]	218.4[a]	100.2[b]	10.1			
	15–30	126.7	144.4	157.7	10.1			
	30–45	119.6[a]	57.9[b]	92.8[a]	10.1			
	45–60	85.9[a]	105.6[a]	45.2[b]	10.2			
	60–75	98.6	113.1	99.1	12.0			
	75–90	109.4[a]	141.8[ab]	163.2[b]	12.5			
	Overall	119.4	129.5	115.9	10.5			
FE (intake/gain)						***	***	**
	3–15	0.77[a]	0.77[a]	1.96[b]	0.13			
	15–30	1.22	1.23	1.49	0.13			
	30–45	1.73	2.08	3.25	0.39			
	45–60	2.69	2.60	2.50	0.72			
	60–75	3.36[a]	4.26[b]	3.30[a]	0.73			
	75–90	4.96[a]	4.18[a]	3.08[b]	0.56			

Means in the same row with different letter (a and b) differ statistically ($p < 0.05$).
** $p \leq 0.01$.
*** $p \leq 0.001$.

The ADG of A45 kids during the milk replacer feeding period (mean from 3 to 45 days) was 118.1 g d^{-1}, very similar to 120 g d^{-1} achieved in Criollo–Saanen kids (Tacchini et al., 2006), and to 115–138 g d^{-1} in Angora kids (Davis et al., 1998), but lower than 151 g d^{-1} of Alpine kids (Genandoy et al., 2002). Whereas, for the same period, kids from N45 fed with goat milk showed a mean ADG of 149.1 g d^{-1}, values very close to 150 g reported for Criollo kids by Lanari et al. (2007), and to 147 g for Alpine kids (Goetsch et al., 2001). It is notable that the growth performance of the three groups throughout the whole study was very acceptable, since their overall ADG values are somewhat lower than 132–160 g d^{-1} reported for Boer breed (Zhang et al., 2009). During the first two weeks of study, the A45 kids showed the lowest ADG, even though these animals had the highest total DM intake during the same period. This was clearly due to the lower feed efficiency achieved with the milk replacer and is consistent with Morand-Fehr et al. (1982) and Perez et al. (2001), who affirm that the lower feed efficiency of milk replacer may be due to a lower nutritional quality and a slower digestive utilization.

In N30 kids, the post-weaning ADG (30–45 d period) decreased by 59.9% compared to the pre-weaning ADG (15–30 d period). In contrast, the post-weaning ADG (45–60 d period) of N45 kids decreased by only 28.2% with respect to the pre-weaning ADG (30–45 d period). This agrees with Morand-Fehr et al. (1982), who argue that whereas earlier it is performed the weaning more pronounced is the weaning shock.

Between 15 and 90 days old, the liveweight of artificially reared kids (A45 group) was always significantly lower ($p < 0.05$) than the liveweight of N30 and N45 groups (Fig. 1). Other authors also found a higher growth in kids raised with goat milk, which may be attributable to a higher digestibility of milk and to milk growth promoters that are not present in milk replacers (Argüello et al., 2007; Delgado-Pertíñez et al., 2009a).

The LW of N30 kids at 45 days (8.40 ± 0.33 kg) was similar to that of A45 kids (7.99 ± 0.26 kg), but significantly lower ($p < 0.05$) than that of N45 kids (9.20 ± 0.26 kg), this may be caused by the negative effect of early weaning on the growth performance of N30 kids. However, no differences were found between the LW of N30 and N45 groups from 60 days until the end of the trial. Many authors (Morand-Fehr et al., 1982; Goetsch et al., 2001; Sanz Sampelayo et al., 2003) have reported a phenomenon known as compensatory growth in animals that have

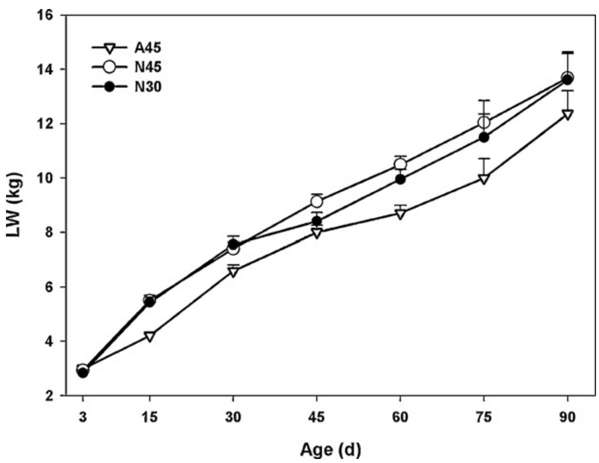

Fig. 1. Liveweight of kids according to age and rearing system.

Table 3
Costs, income and gross return according to rearing systems and slaughter age of kids.

Item	Slaughter age (d)	Rearing systems			
		N45	N30	A45	S.E.
Operating cost, US$ kid^{-1}					
Total feeding cost	60	22.49^{a}	16.07^{b}	43.12^{c}	0.65
	90	24.77^{a}	20.73^{b}	44.68^{c}	0.65
	Mean	23.63^{a}	18.40^{b}	43.90^{c}	0.80
Labor	60	7.53^{a}	6.96^{a}	14.45^{b}	0.40
	90	9.78^{a}	9.22^{a}	17.46^{b}	0.49
	Mean	8.65^{a}	8.09^{a}	15.95^{b}	0.55
Total operating cost, US$ kid^{-1} §	60	30.60^{a}	23.61^{b}	58.15^{c}	3.16
	90	35.13^{a}	30.51^{b}	62.72^{c}	3.04
	Mean	32.87^{a}	27.07^{b}	60.44^{c}	2.20
Total income, US$ kid^{-1}	60	30.00^{a}	26.71^{b}	24.02^{c}	0.50
	90	37.37^{a}	36.20^{a,b}	32.30^{b}	2.19
	Mean	33.69^{a}	31.46^{a}	28.16^{b}	1.12
Gross return, US$ kid^{-1}	60	−0.60^{a}	3.11^{b}	−34.13^{c}	3.56
	90	2.24^{a}	5.67^{a}	−30.42^{b}	3.58
	Mean	0.82^{a}	4.39^{b}	−32.27^{c}	1.24

Means in the same row with different letter (a–c) differ statistically ($p < 0.05$).
§ Sanitary and maintenance costs are included (0.58 US$ kid^{-1}).

undergone a dietary restriction that negatively affected their growth rate. It is probable that N30 kids came into nutritional restriction after 30 days old, due to the anatomical and physiological changes that involves the weaning and the transition from pre-ruminant to ruminant. These animals clearly showed a compensatory growth, which allowed them to reach the same LW ($p > 0.05$) that N45 kids at the end of the trial (13.61 ± 1.02 kg and 13.68 ± 0.90 kg, for N30 and N45, respectively). Compensatory growth is achieved through an increased intake and/or a more efficient use of food (Sanz Sampelayo et al., 2003). The N30 kids had the worst feed efficiency from 60 to 75 days. Probably in our study, compensatory growth has been achieved by an increased intake, because from 45 days until the end of study, the total DM intake of N30 kids was always numerically ($p > 0.05$) greater than the other two groups. According to Ugur et al. (2004), this is because the early weaned kids are more experienced in the consumption of solid food, which provides a significant advantage to the animals for a better development.

3.2. Economic performance

Costs, income and gross return are shown in Table 3. Feeding costs comprised 72.7, 71.9 and 68% of total operating costs for groups A45, N45 and N30, respectively. This coincides with Amaral et al. (2005) who reported that in intensive production systems the cost of feed corresponds to 55–75% of the total production costs. Mean total operating costs of kids raised on milk replacer were significantly higher ($p < 0.001$) than the costs of kids raised with goat milk. In Mexico, Galina et al. (1995) also found that feeding with milk replacer was more expensive than goat milk, whereas Delgado-Pertíñez et al. (2009b) found no major differences between natural and artificial rearing. However, contrary to our results, other authors (Perez et al., 2001; Delgado-Pertíñez et al., 2009a) found that rearing with goat milk was between 30 and 40% more expensive than milk replacer rearing. This is mainly due to different market prices of goat milk and milk replacer. In our work, the price paid for the milk replacer (0.74 US$ L^{-1}) was unreasonably higher than the market price of goat milk (0.45 US$ L^{-1}). In addition, mean labor costs of artificial rearing system were significantly higher ($p < 0.001$) than those of natural rearing, without differences between N45 and N30 groups. In agreement with these results, Delgado-Pertíñez et al. (2009a,b) found that artificial rearing with milk replacer required twice more labor than the natural raising.

Given that the mean total income of the groups fed with milk replacer was 28.16 US$ kid^{-1}, and that the sum of ration, labor and sanitary plus maintenance costs was 18.26 US$ kid^{-1}, is possible to estimate that can not be spend more than 9.9 US$ kid^{-1} (28.16–18.26 US$ kid^{-1}) in buying the milk replacer to achieve a positive gross return in the artificial rearing system. This means that milk replacer should not cost more than 1.06 US$ kg DM^{-1} (9.9 US$ divided by the total consumption of milk replacer, 9.37 kg DM kid^{-1}). This shows that the price of milk replacer should not exceed 20% of meat value so that artificial rearing becomes economically feasible (1.06 US$ kg DM^{-1} divided by meat value, 5.431 US$ kg^{-1}).

Early weaning reduced feeding costs by 22.1% compared to the traditional weaning age of 45 days. With early weaning, 16.3 L of milk were saved per kid (milk consumption of N45 – milk consumption of N30, 48 – 31.7 L = 16.3 L saved, equivalent to 7.34 US$ kid^{-1}), with an additional cost on solid food of only 2.13 US$ kid^{-1} (difference between cost of starter plus ration of N30 and N45 = 4.16 – 2.03 US$ kid^{-1}).

The highest gross returns were obtained with the natural rearing system and weaning at 30 days followed by weaning at 45 days. While, the artificial rearing system always showed negative values. The mean gross returns of both natural rearing groups were low, this is consistent with Perez et al. (2001) who found that in Chile it was not economical to raise kids with the market conditions at that time. The mean gross return per kid for all groups slaughtered at 60 days was not significantly different ($p > 0.05$) from those slaughtered at 90 days old. However, it can be seen that the average gross return of the two natural rearing groups slaughtered at 90 days (3.96 ± 1.46 US$ kid^{-1}) was three times higher than the animals slaughtered at 60 days (1.25 ± 0.93 US$ kid^{-1}). This occur because the slaughter at 90 days allowed to raise animals for longer periods with a solid ration, which cost considerably less than the liquid diet and achieved an acceptable feed efficiency. Therefore, slaughter older animals allow to diversify the production and get more marketable meat, off-time of the higher supply (probably with a better selling price), reaching higher gross returns and improving the profitability of current rearing systems. However, the goat market in Argentina presents certain characteristics that could make difficult the inclusion of older animals in the market. As in other Latin American countries like Mexico (Aréchiga et al., 2008) and Brazil (Madruga and Bressanb, 2011) there is heterogeneity in the quality of the product reaching the market. In Argentina, this is due to the lack of a system for assessment, classification and pricing the carcasses of goats, leading to distrust and unwillingness of consumers to purchase unknown goats products (MinAgri, 2007). On the other hand, similar to the situation of Mexico, the cost of intermediary is high, the value added to the primary product is low, there are no specialized marketing channels and commercial promotion of goat products is very poor (Aréchiga et al., 2008; MinAgri, 2007). Perhaps, the efforts to improve the association between producers, evaluation and qualification of the carcasses and commercial promotion of the product have better effects on the profitability of goat production systems than changes in production management.

4. Conclusion

The Criollo kids showed a very acceptable growth performance, with no major differences in average daily gains among the three rearing systems at the end of the study. The shock effect of weaning was most marked in the early-weaned kids, but these animals showed a compensatory growth that enabled them to regain the bodyweight lost. To achieve the economic feasibility of artificial rearing system, the price of milk replacer should not exceed 20% of the meat value of kids. Therefore, at current market conditions, the artificial rearing of kids is not economically. Based on economic results, it would be advisable to raise the kids with goat's milk and then with solid food until slaughter at an older age to the traditional. As long as these older animals can be incorporated into the market and consumers accept them without reducing the selling price.

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