

SHORT COMMUNICATION



Ewes giving birth to female lambs produce more milk than ewes giving birth to male lambs

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ABSTRACT

A total number of 23,271 parturitions were studied from two sheep farms of the Churra (CH) and Lacaune (LA) breeds. CH lambs were kept with their mothers during the first 30 days of age; from that moment onwards, ewes were machine-milked. LA lambs were not allowed to suckle their mothers, and ewes were machine-milked from parturition. Milking length (ML), total milk yield (TMY) and daily milk yield (DMY) (TMY/ML) were calculated. For the CH breed, there was an effect ($p < .001$) of prolificacy on ML, TMY and DMY and of offspring gender on TMY and DMY. For the LA breed, prolificacy and offspring gender had an effect ($p < .001$) on ML, TMY and DMY. Ewes giving birth to twin lambs produced more milk (CH: +0.15 l/d and +27.5 l/ewe; LA: +0.15 l/d and +11 l/ewe), than ewes giving birth to single lambs. For single parturitions in the CH breed, ewes giving birth to females produced more milk (+0.04 l/d and +5.2 l/ewe) ($p < .0001$) than ewes giving birth to males. In this breed, this effect of female offspring on milk production was similar for those ewes giving birth to twin lambs. In conclusion, ewes presenting twin parturitions produced more milk than single parturitions and the presence of female lambs had a positive effect on milk yield. These results open new possibilities to increase profitability of dairy sheep farms through a selection of the offspring gender.

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Introduction

Sheep and goat production are important economic, environmental and sociological issues for Mediterranean countries and particularly milk production in sheep is an important component of the livestock sector of this geographical area (de Rancourt et al. 2006). As reviewed by these authors, the high diversity of the Mediterranean countries for the dairy sheep sector leads to an important diversity of production systems, differences that are mainly based in the breeds, flock management, milking systems and lamb weaning modalities found in farms. Indeed, apart from breed, milk production in sheep can be affected by several non-genetic factors, such as nutrition, type of lambing or weaning (Pulina and Nudda 2004). The number of lambs suckling their dams has a direct effect on milk secretion (Ploumi and Emmanouilidis 1999). Multiple births induce a higher milk yield in meat sheep breeds throughout the lactation period (Snowder and Glimp 1990). In dairy breeds, it has been reported that ewes rearing more than one lamb

present higher milk production than ewes rearing single lambs, but this is evident only in early lactation (Gonzalo et al. 1994), when, in traditional systems, lambs are still with their mothers and the suckling effect is evident.

In dairy cattle, an effect of offspring sex on milk production has been reported. Thus, milk production in Holstein dairy cows in the USA present a sex-biased milk production in favour of female calves (Hinde et al. 2014) and, in New Zealand, the birth of a female rather than a male calf was associated with a 0.33–1.1% higher milk yield ($p < .05$) (Hess et al. 2016). In sheep, references in the literature on the effect of the number of lambs and their gender on milk production of their dams are scarce. In meat breeds, just a few works have described an absence of effect of offspring gender on milk production (Wilson et al. 1970; Wohlt et al. 1981).

In high-yield dairy sheep breeds such as Assaf or Lacaune, lambs are not allowed to suckle their mothers, and they are given colostrum through a stomach

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tube and then artificially reared, in order to intensify milk production from the first day after lambing. However, a traditional system in which the suckling period of the lamb is about one month, followed by a milking period of variable length (120–204 d) after lambs are weaned, can be found in Mediterranean dairy breeds such as Latxa, Churra, Sarda or Chios in countries as Spain, Italy or Greece. The aim of this study was to determine the effects of the number and sex of lambs, artificially reared or not from birth, on the milk production of their mothers.

Materials and methods

Animals and milking periods

A total number of 13,063 parturitions with their corresponding milking periods were studied from a Churra (CH) sheep farm, recorded from 1995 to 2016, and 10,208 parturitions from 2007 to 2016 from a Lacaune (LA) sheep farm, both in Spain.

Gender of the offspring of the ewes was identified at lambing, and CH lambs were kept with their mothers during the first 30 days of age, when they were weaned and slaughtered as suckling lambs. From that moment onwards, CH ewes were machine-milked. On the other hand, LA lambs were not allowed to suckle their mothers, and they were given colostrum through a stomach tube; their mothers started being milked 24 h after parturition. Milking length (ML), total milk yield (TMY) and daily milk yield (DMY) (TMY/ML) were calculated based on the Spanish Official Recording System, which has been approved by the International Committee for Animal Recording (ICAR 2016). Individual TMY was calculated based on up to four (CH) or five (LA) consecutive monthly records, recorded by electronic milk metres inserted in the milking equipment. Thus, data included 40,163 (CH) and 50,339 (LA) monthly milk controls. Since data were obtained from pre-existing databases, the study was not subject to ethics approval.

The CH sheep is a Spanish breed located at Castilla y Leon (Northern Spain), with approximately 450,000 heads (Yanes and de La Fuente 2011). The LA breed was originated in France and has been spread throughout Spain in the late eighties, with a census of around 90,000 breeding ewes.

Statistical analysis

Milk yield was evaluated statistically by a multifactorial model with a fixed effect of litter size (single or twin births) or offspring sex (male, female or

male + female), using the Least Squares Method of the GLM procedure in SPSS v.22 (IBM Corp. Released, 2013). In a second step, milk production was compared between litters where 'there were' or 'there were not females' by analysis of variance. The general representation of the model is as follows: $y = xb + e$, where y is $N \times 1$ vector of records, b denotes the fixed effect in the model within the association matrix x , and e is the vector of residual effects. The *post hoc* Fisher's least significant difference (LSD) test was performed to compare type of lambing. Only single and twin parturitions were considered, since the proportion of triplets and quadruplets was very low (0.73%).

Results and discussion

Churra breed

Average prolificacy was 1.23 lambs/lambing, with 77% singles and 23% twins. Table 1 summarises mean ML, TMY and DMY values, taking into consideration number of lambs born and their gender. There was a significant effect ($p < .001$) of prolificacy on ML, TMY and DMY and of offspring gender on TMY and DMY. Thus, ewes giving birth to twin lambs produced more milk ($+0.15$ l/d and $+27.5$ l/ewe), than ewes giving birth to single lambs. In the case of single parturitions, those ewes giving birth to females produced more milk ($+0.04$ l/d and $+5.2$ l/ewe) ($p < 0.0001$) than ewes giving birth to males. This effect of female offspring was similar for those ewes giving birth to twin lambs,

Table 1. Milking length (ML), total milk yield (TMY) and daily milk yield (DMY) (mean \pm S.E.M.) of Churra and Lacaune ewes, depending on litter size (single vs. twin births) or offspring gender.

	<i>n</i>	ML (d)	TMY (l)	DMY (l/d)
Churra				
Single	10,016	134 \pm 1 ^x	97.4 \pm 0.5 ^x	0.71 \pm 0.01 ^x
Females	4741	134 \pm 1	100.1 \pm 0.8 ^b	0.73 \pm 0.02 ^b
Males	5275	134 \pm 1	94.9 \pm 0.7 ^a	0.69 \pm 0.01 ^a
Twins	3047	141 \pm 1 ^y	124.8 \pm 1.1 ^y	0.86 \pm 0.01 ^y
Female + Female	740	141 \pm 1	123.3 \pm 2.3 ^a	0.86 \pm 0.01 ^a
Males + Male	623	141 \pm 1	118.9 \pm 2.4 ^c	0.83 \pm 0.01 ^c
Female + Male	1684	142 \pm 1	127.6 \pm 1.6 ^b	0.88 \pm 0.08 ^b
Total	13,063	136 \pm 1	103.8 \pm 0.5	0.74 \pm 0.01
Lacaune				
Single	7440	143 \pm 1	167 \pm 1 ^x	1.17 \pm 0.01 ^x
Females	3704	146 \pm 2	168 \pm 2	1.18 \pm 0.01
Males	3736	139 \pm 1	168 \pm 2	1.17 \pm 0.01
Twins	2768	143 \pm 2	178 \pm 1 ^y	1.32 \pm 0.08 ^y
Female + Female	809	140 \pm 3 ^b	176 \pm 4 ^a	1.29 \pm 0.01 ^a
Males + Male	750	142 \pm 3 ^a	173 \pm 5 ^a	1.30 \pm 0.01 ^a
Female + Male	1209	144 \pm 3 ^a	182 \pm 4 ^b	1.35 \pm 0.01 ^b
Total	10,208	141 \pm 3	178.6 \pm 4	1.31 \pm 0.01

Churra breed: lambs were with their mothers during the first 30 days of age, and after that, ewes were machine-milked; Lacaune breed: lambs were not allowed to suckle their mother and ewes were machine-milked from parturition.

^{a,b,c}Indicate significant differences between genders.

^{x,y}Indicate significant differences between litter size.

but only in the case of 'female + female' versus 'male + male' parturitions ($+0.03$ l/d and $+4.2$ l/ewe for 'only-females' lambings; $p < .0001$). When the ewe gave birth to a male and a female together, they produced more milk than in the other two cases ($p < .0001$), with similar ML. Thus, the presence of female litters in single or twins parturitions produced 6% and 3.4% more milk, respectively, than did ewes lambing males, although the best option was a mixture of males and females in the same parturition (9% and 3% more milk compared with 'only-males' and 'only-females' twin parturitions, respectively) (Table 2).

Lacaune breed

Average prolificacy was 1.28 lambs/lambing (73% singles and 27% twins). Prolificacy and offspring sex had a significant effect ($p < .001$) on TMY and DMY, and the interaction effect was significant ($p < .0001$). Thus, ewes giving birth to multiple lambs produced more milk (Table 1), especially if one of the offspring was female. Milk yields did not differ significantly between male-only and female-only litters, but considering all the lambing records, the effect of the presence of females on milk production was evident (Table 1). Thus, the presence of female litters produced 9% more milk than did ewes producing no females at all ($p < .0001$) (Table 2).

Our two studies using CH and LA sheep are the only works demonstrating an effect of both litter size and offspring sex on milk yield in sheep, either under the absence of the lamb from parturition or with the lambs suckling the mothers for 30 days before being milked. This indicates that the differences must have originated during pregnancy and acted on the growth and development of the mammary gland of the dam. Mammary gland development is regulated, in part, by the neuroendocrine system through the exposure to oestrogen, progesterone, placental lactogen, prolactin,

and oxytocin (Lérias et al. 2014). Thus, a higher secretion of placental lactogen, due to high placental weight, stimulates greater development of the mammary gland in sheep: maternal serum concentrations of placental lactogen and progesterone during late gestation in sheep are directly correlated with the number of foetus and placental mass (Butler et al. 1981). This relationship between prolificacy and placental lactogen concentrations might explain, at least in part, the high milk production by ewes that bear multiple offspring. It seems that female and male foetuses differ in the expression of the hormones that affect secretion milk synthesis, as has been demonstrated in cows presenting sex-biased milk yields (Hess et al. 2016). Moreover, the bovine foetus secretes INSL3, which is the first sex-specific foetal hormone identified with potential to influence placental and maternal physiology (Anand-Ivell et al. 2011). This different expression of hormones from male and female foetuses, and their interaction on the mammary gland of the mother may be responsible of the variation of milk production when male and female foetuses are gestated together.

In conclusion, CH and LA ewes presenting twin parturitions produced more milk than ewes giving birth single lambs. In both cases, the presence of female lambs had a positive effect on milk yield, especially when ewes gave birth to males and females together. These results confirm our previous works and open new possibilities to increase profitability of dairy sheep farms through a selection of the offspring gender, as the use of sexed semen provides. On the other hand, genetic evaluation programmes should consider sex of the lamb as a source of variation when an animal is given a genetic index, since its milk production can be modified by this factor.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Table 2. Milking length (ML), total milk yield (TMY) and daily milk yield (DMY) (mean \pm S.E.M.) of Churra and Lacaune ewes, depending on the presence ('There are') or not ('There are not') of female offspring.

	<i>n</i>	ML (d)	TMY (l)	DMY (l/d)
Churra				
There are females	5566	135 \pm 1	103 \pm 1	0.75 \pm 0.01 ^a
There are not females	7591	136 \pm 1	104 \pm 1	0.74 \pm 0.01 ^b
Lacaune				
There are females	5722	145 \pm 1 ^a	196 \pm 2 ^a	1.35 \pm 0.01 ^a
There are not females	4486	140 \pm 1 ^b	172 \pm 2 ^b	1.23 \pm 0.01 ^b

Churra breed: lambs were with their mothers during the first 30 days of age, and after that, ewes were machine-milked; Lacaune breed: lambs were not allowed to suckle their mother and ewes were machine-milked from parturition.

^{a,b}Indicate significant differences.

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