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Implantation of STAR© accelerated system in extensive "dehesa" merino breed farms

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Abstract. The aim of this study was to improve lamb yield in Merino breed farms in extensive systems by using the STAR© accelerate lambing system. A model farm with lamb production as principal activity from *El Valle de Los Pedroches* (38.45ºN; 4.9ºW; Cordoba, Spain) was selected for this purpose. During the 9 year period of the field assay, the reproductive rhythm was gradually intensified. Until the year 2003, a natural mating system without control was carried out. From 2004 to 2007, traditional mating system of three lambings in two years in combination with hormonal management was applied. Finally, from 2008 until the present day, the STAR© lambing system was implemented in addition to hormonal treatment. Breeding was carried out every 73 days. Pregnancy diagnosis was performed by ultrasound 43 days after the mating period. Non-pregnant ewes were relocated directly to the breeding-group and pregnant animals were separated. Melatonin (Melovine®) and vaginal sponges (Sincropart® 30 mg) were used in anoestrus mating (March). The results showed that the benefits of the STAR© accelerated lambing system in a medium herd (n = 380), improve work planning (in advance), which increases the farmer's quality of life and permits labour for other activities, whilst maintaining high productivity. In addition, perinatal mortality during lambing was reduced as a consequence of shortening the mating period (30 days), and production per ewe was improved (flock averages 1.80 lambs per ewe per year). Lastly, an elimination of seasonality on lamb production was achieved, ensuring incomes when prices in the lamb market are higher.

Keywords. Lambing systems – Merino breed farms – Extensive systems – Sheep.

L'implantation du Star system accélérée en élevages extensifs de race Mérinos dans la "dehesa"

Résumé. *Le but de cette étude était d'améliorer la production d'agneaux dans les fermes élevant des moutons de race mérinos en régime extensif par le biais de l'intensification du programme de reproduction, en utilisant le système STAR©. Pour ce faire, on a choisi une exploitation modèle de la vallée des Pedroches (38,45° N, 4,9° W, Cordoue, Espagne) dont l'activité principale est la production d'agneaux. Pendant neuf ans le taux de reproduction a été intensifié de manière progressive. Jusqu'à l'année 2003, un système d'accouplement naturel sans contrôle avait été effectué. De 2004 à 2007, le système d'accouplement traditionnel de trois agnelages en deux ans a été suivi. Finalement, à partir de 2008, le système STAR© a été appliqué (5 mises-bas/3 ans), en combinaison avec des méthodes hormonales. L'accouplement a eu lieu tous les 73 jours. Le diagnostique de grossesse a été réalisé par écographie 43 jours après chaque accouplement, et au moment de l'anœstrus (mars), de la mélatonine et des éponges vaginales ont été utilisés. Finalement, les brebis non gestantes ont été renvoyées directement au groupe d'élevage et les femelles gestantes ont été isolées. Les résultats obtenus montrent que la mise en œuvre de STAR© dans une exploitation ovine de taille moyenne (n = 380) permet d'améliorer la planification du travail suffisamment à l'avance, ainsi que la qualité de vie des producteurs. En outre, la réduction de la période d'accouplement à 30 jours a permis de réduire la mortalité périnatale, tout en améliorant les résultats de fertilité et de prolificité (moyenne des troupeaux 1,80 agneaux par brebis et par an). Enfin, l'élimination de la saisonnalité de la production d'agneaux assure des revenus quand les prix des agneaux sont plus elevés.*

Mots-clés. *Systèmes d'agnelage – Fermes de race mérinos – Systèmes extensifs – Ovins.*

I – Introduction

In Andalousia, as in the rest of Spain, lamb price fluctuates over the year, reaching the highest values in the second half of the year due to the increasing demand for lamb meat in those days (the Christmas period), and due to the reproductive seasonality. Spreading lambing throughout the year has resulted in higher profits since overlap between two lambings is avoided. Therefore, a lambing management system could be a useful tool for the farmer, in order to achieve a better lamb delivery distribution over the year.

One way of providing a less condensed, more evenly spread supply of lamb throughout the year, is to breed ewes more frequently than once yearly, by means of accelerated lamb production systems. These systems include breeding ewes so that individual animals have the opportunity to lamb twice in one year, three times in two years, five times in three years or even more[1]. In addition to providing a constant year-round supply of lambs, the method could be used to achieve a greater number of lambs per ewe and per year.

The STAR© system (Lewis *et al.*, 1996) is an accelerated lambing production system that has five breeding and lambing periods within a year, in which individual ewes have the opportunity to breed five times in three years. Therefore, the objective of this study was to introduce STAR© accelerated system to extensive Merino breed farms under pastoral conditions in the South of Spain (Latitude: 38º 30' 01'' N; Longitude: 5º 08' 53'' W).

The STAR© system has already been used in small ruminant farms, especially in intensive dairy systems (Palacios *et al.*, 2005; Martín *et al.*, 2009a, 2009b; Mantecón *et al.*, 2010a; Martín *et al.*, 2010a, 2010b), but not in extensive systems. The novelty of this project lies in its use in extensive dehesa systems with merino sheep. The final objective is to reduce livestock density and optimize feeding, therefore it is necessary to know the reproductive efficiency of ewes and eliminate unproductive periods, and infertile or subfertile animals.

II – Material and methods

1. STAR© accelerated lambing system

The STAR© system (Fig. 1) was developed at Cornell University (USA) by Brian Magee, manager of a sheep farm, and Dr. Doug Hogue (Lewis *et al.*, 1996). The model is based on finding a high reproductive rate that's compatible with the ewe biology. The STAR© system is presented as a reproductive schedule whose objective is to obtain five lambings per ewe in three years. Considering that the gestation length is 146 days, the interval between lambing and next fertile mating must be: 219-146 = 73 days. In practice, 5 periods of 30 days mating-lambing are generated among the year with an interval of 43 days between each one. Each year will follow the same STAR© schedule, so the mating-lambing periods will occur on the same dates.

2. Flock management

A model farm with lamb production as principal activity from *El Valle de Los Pedroches*[2] (38.45ºN; 4.9ºW; Cordoba), in the north of Cordoba (Andalusia, Spain), was chosen to conduct this study. The average flock has around 380 sheep, of merino breed, with a livestock density of 2.43 animals/ha, feed by extensive pasture (the "dehesa" ecosystem).

[1] For instance, the CAMAL system, that is, Cornell Alternate Month Accelerated Lambing, which includes lambing six times in three years (Thonney, 2010).

[2] The evolution and current situation that farms located in *El Valle de Los Pedroches* are facing is developed in (Villegas and Arrebola, 2011).

Fig. 1. STAR© accelerated lambing system. Source: Thonney (2005) (http://www.sheep.cornell.edu/management/breeding/star/description.html)

Sheep farms in this region are traditionally managed by the conventional three lambings/year system, or continuous mounting. Some areas are partially cultivated for grain production. The delivery performance of feedlot production is usually 1 to 1.2 lambs per ewe per year. There is a significant seasonal effect on lamb production, so that in the last six months of the year only 30% of the lambs are delivered to the feedlot.

The management of the flock was overseen by the same farm manager. Guidelines were given to ensure flock size, animal welfare, sheep condition and pasture cover were maintained. Ewes were shorn in May. At the beginning of each mating-lambing period, three distinct groups of ewes were present together not physically separated: open ewes, ewes that conceived in the preceding period and were in early gestation, and ewes that became pregnant two periods earlier and were in late gestation. A proportion of the open ewes had just weaned lambs, whereas others were open because of failure to conceive at earlier opportunities. Ewes in late gestation were identified by visual assessment and palpation of the developing mammary glands, and separated from the rest of the flock. Mating ewes were placed with breeding rams for 30 days at the start of the period. Pregnancy diagnosis was performed by ultrasound 43 days after the mating period, hence the 73 days interval between groups of ewes. In these lots, replacement ewes were added.

In each mating-lambing season, ewes were exposed to Merino rams (1 ram per 20 ewes), and if some ewes failed to conceive after three consecutive exposures, they were culled. Melatonin (Melovine®) and vaginal sponges (Sincropart® 30mg) were used during the March mating period to induce oestrous behaviour in spring. Flushing two weeks before mating and “ram-effect” was also applied.

The STAR© program consisted of five 30-day concurrent breeding and lambing periods per year, beginning on January 13, March 26, June 7, August 20, and November 1. This schedule was repeated every year since 2009. These dates are similar to the STAR© system described by Lewis *et al.* (1996).

The implantation of the STAR accelerated system was in two stages, as the reproductive rhythm was gradually intensified. Until the year 2003, a natural mating system without control was carried out. From 2004 to 2007, traditional mating system of three lambing in two years in combination with hormonal management was applied. Finally, from 2008 until today, STAR© lambing has been implemented in addition to hormonal treatment, although 2008 could be considered as a transition year.

Feeding in extensive systems like the "dehesa" ecosystem is based on pasture intake and supplementing this with a mixture of cereals (wheat, oats, and corn) during the months of June to October, according to rainfall. Lambs are weaned from their mothers 75-80 days after birth, and are fed with fodder and hay (up to 20-22 kg live weight) before slaughter. In general, the body condition of the sheep under study was good and ranged between 2.5 and 3.5, within an excellent sanitary status.

3. Lamb data

Lambing records for Merino ewes mated from year 2003 to November 2012 were used (RAEA, 2004-2012). In addition, lambs sold to the cooperative-feedlot named *Dehesas Cordobesas* during the 9 year period considered are also included.

Descriptive statistical analysis was carried out using the IBM SPSS Statistics package version 19. An average production analysis has been performed, considering annual values of the different production systems studied and a seasonality index in delivering lambs, using a one-way analysis of variance.

III – Results and discussion

The sequence of lambing in the 5 periods outlined above, typical of the STAR© program, is graphically shown in Fig. 2; this curve is very similar for all years considered in the study. Moreover, the number of ewes bred was also similar, although for some years the number of lambs born in August was the largest. This seasonality in lamb births contrasts with the sales to the cooperative, where 60% of lambs were delivered to the feedlot in the first semester while 40% occured in the second half of the year. August lambings follows the typical pattern of the hormonal treatments carried out in the anoestrus season. In the beginning of the field assay, Melatonin (Melovine®) was used in March mating (unfavorable season). An earlier work (Arrebola *et al.*, 2005) indicated that the use of melatonin was able to produce a significant improvement of reproductive performance, maintaining the easy management of the flock (30 days of mating periods and 42 days after to perform pregnancy diagnosis). This allowed planning of advanced improvements to the quality of life of farmers, so they can organize for other activities (shearing, haying, etc.) without excessive workload and bottlenecks, including their leisure time. In addition, perinatal mortality during lambing was reduced as a consequence of shortening the mating period (30 days) and diarrhoeas (Scours).

These results shown in Table 1 and 2 remark, as observed in other studies (Abecia *et al.*, 2003; Pontes *et al.*, 2003; Gutierrez *et al.*, 2004; Abecia *et al.*, 2007), the importance of using hormonal treatments in the anoestrus period, which have shown remarkable effectiveness in a variety of situations, with a good mean litter size all along the year (1.30, $p<0.05$).

On the other hand, in Fig. 3, we can observe the reproductive results over the 9 year period of the field assay: until 2003, a continuous mating where the males remained with the females throughout the year; from 2004 to 2007, three lambings in two years in combination with hormonal management was applied, and, finally, since 2008, the STAR© system was implemented in addition to hormonal treatment. As a consequence, we can remark how the distribution of lambings has been

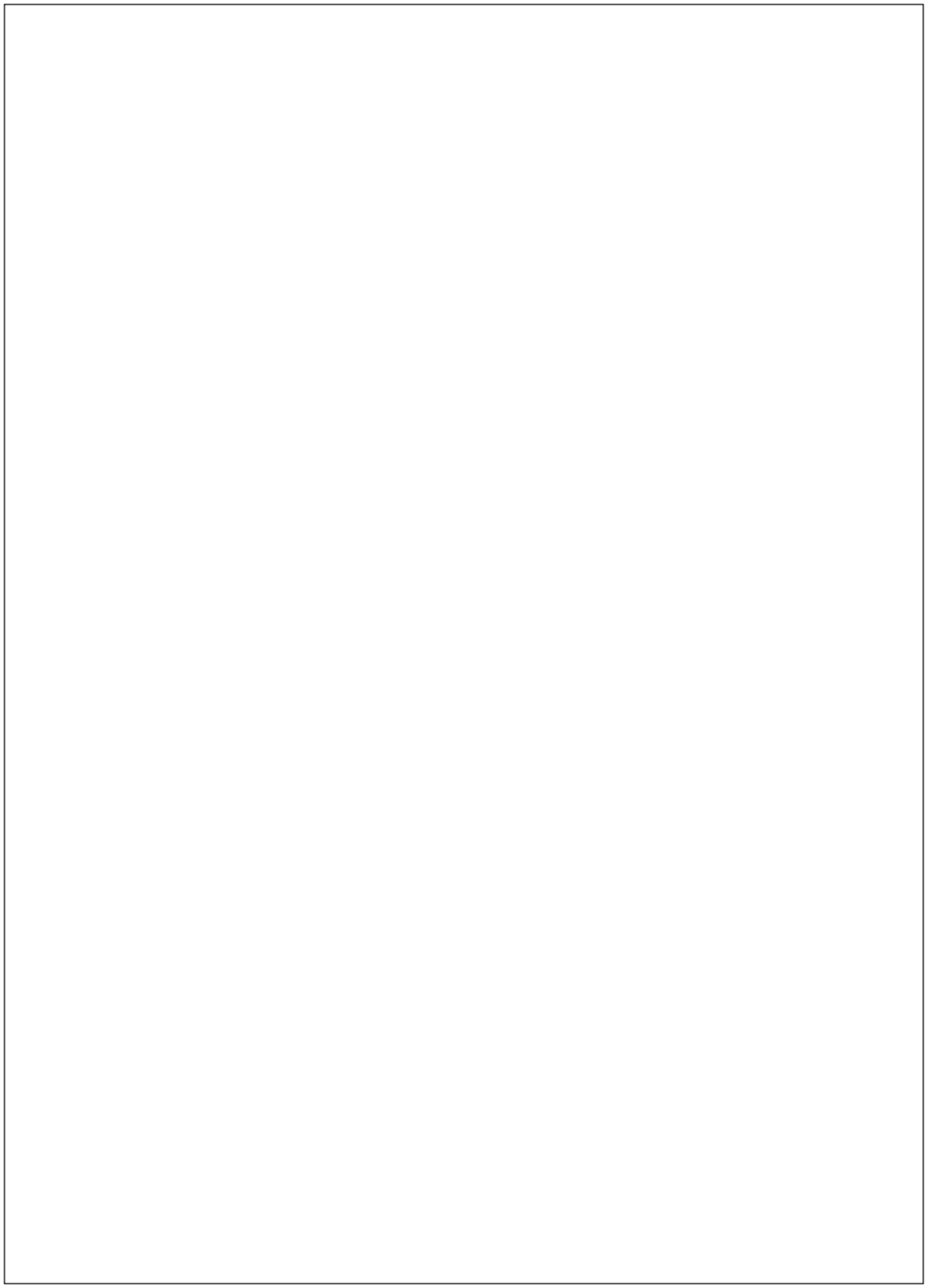

Fig. 2. STAR© system lambing curve pattern. Source: Data from a model farm with Merino breed in *El Valle de Los Pedroches Region* (years 2009-2012).

Table 1. Merino breed extensive farms: flock evolution with STAR© System (years 2009-2012)

Year	Ewes (nº)	Rams (%)	Replacement ewes (%)	Lambings	Lambings/ ewe/year	Lambs born	Lambs born/ Lambing	Lambs born/ ewe/year
2009	413	4.84	10.65	589	1.43	731	1.24	1.77
2010	374	4.81	17.38	468	1.25	635	1.36	1.70
2011	372	4.57	14.25	540	1.45	737	1.36	1.98
2012	360	5.00	6.39	503	1.40	635	1.26	1.76
Mean 2009-2012	**380**	**4.81**	**12.18**	**525**	**1.38**	**685**	**1.30**	**1.80**

Table 2. STAR© System reproductive season lambing-mating indicators average data for period 2009-2012

	Lambings		Little size (type of lambings)				Nº of lambs born		Nº lambs born per lambings	
			Singletons		Multiple lambs††					
Mating season	**Mean**	***St. Dev.***	**Mean**	***St. Dev.***	**Mean**	***St. Dev.***	**Mean**	***St. Dev.***	**Mean**	***St. Dev.***
January	**114**	*15*	**81**	*15*	**33**	*12*	**148**	*23*	**1.29**	*0.11*
March	**124**	*54*	**88**	*35*	**37**	*22*	**161**	*75*	**1.28**	*0.09*
June	**94**	*40*	**75**	*33*	**20**	*8*	**114**	*48*	**1.22**	*0.04*
August	**103**	*42*	**54**	*22*	**50**	*28*	**154**	*68*	**1.48**	*0.13*
November	**89**	*39*	**71**	*31*	**18**	*8*	**108**	*47*	**1.21**	*0.02*
Total†	**525**	*52*	**368**	*61*	**157**	*28*	**685**	*57*	**1.30***	*0.06*

† The Total is the total number of individuals represented across all seasons.

†† Multiple lambs/per ewe, almost 99% are twins.

* Significance level ($p<0.05$).

more uniform throughout the year since 2008. For instance, in 2003, when natural mating was the reproduction system, no lamb was delivered to the cooperative in the third quarter, and the following quarter only yields 8.07% of total lambs sold, bearing in mind that at this time of the year (near Christmas) lamb prices start increasing. In order to ensure incomes when prices in the lamb market are higher, homogeneous yearly lamb production is encouraged by means of the STAR© lambing system (see also Table 3). This figure shows the significant reduction achieved in lambings in the first quarter (from 56.08 up to 18.38; $p<0.001$) and how they became virtually 50/50 in the two halves of the year. Significant differences in prices per kilogram and prices per lamb sold by the cooperative, 2.26 €/kg and 59.44 €/lamb on average respectively, were found considering the implantation of the STAR© system ($p<0.000$ and $p<0.05$, respectively) (see Table 3).

In addition, if we study the evolution of the STAR© system within the different mating-lambing seasons (Tables 1 and 2), and how the flock has evolved with numbers of ewes, n = 413 in 2009 to n = 380 in 2012 (Table 1), while production per ewe improved (flock averages until 1.98 lambs born per ewe per year). This 12.83% reduction in livestock census producing practically the same lamb crop per year is related to a higher reproductive efficiency. By reducing livestock density, a better use of grazing resources is made, which results in more profits if we take into account that feeding represents the 60% of the production costs of a commercial farm (RAEA, 2012). Moreover, considering the total lambs delivered per year, a significant increase of 70.43% ($p<0.05$) has evolved since 2002, from 301 lambs to 513 in 2012, while the total numbers of animals has decreased (Table 3).

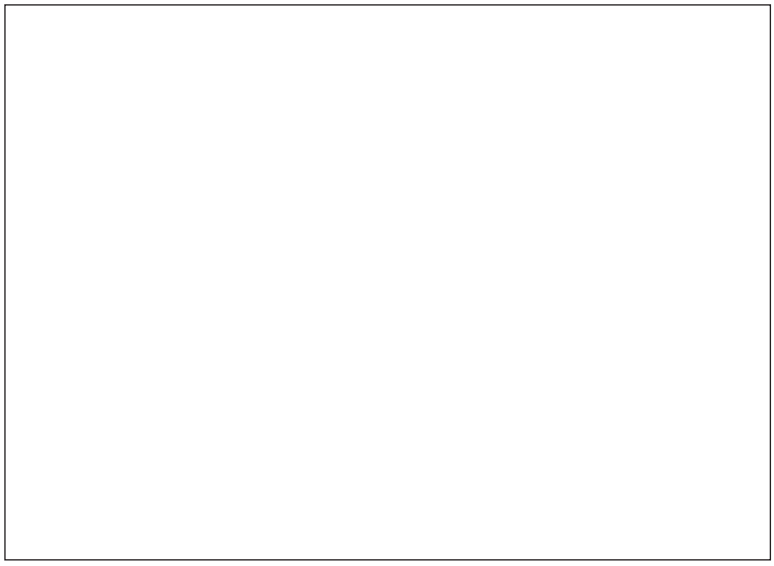

Fig. 3. STAR© System seasonality in the delivery of lambs to the cooperative Dehesas Cordobesas SCA (years 2002-2012). Source: Dehesas Cordobesas Cooperative, SCA. (Years 2002-2012).

Table 3. STAR© System seasonality in the delivery of lambs to the cooperative Dehesas Cordobesas SCA (years 2002-2012)

	Total lambs delivere		**Weight (kg)**		**Price/kg (€/kg)**		**Price/lamb (€/lamb)**	
	Mean	***Std. Deviation***	**Mean**	***Std. Deviation***	**Mean**	***Std. Deviation***	**Mean**	***Std. Deviation***
Natural mating (2002-2003)	301	*110*	50.98	*0.63*	1.11	*0.01*	56.46	*1.50*
3 lambings in 2 years (2004-2008)	441	*64*	23.98	*0.39*	2.36	*0.10*	56.47	*2.24*
STAR© System (2009-2012)	513	*69*	23.92	*0.14*	2.71	*0.20*	64.64	*4.61*
Total	**442***	*101*	**28.87****	*10.93*	**2.26****	*0.60*	**59.44***	*5.06*

* Significance level (p<0.05), ** significance level (p<0.000).
Source: Dehesas Cordobesas Cooperative, SCA. (Years 2002-2012).

V – Conclusion

In this study we implemented a reproductive management system known as STAR© system to merino sheep herds in areas converted to extensive pasture ("dehesa" ecosystem) in the north of Cordoba, with the aim of optimizing the production of lambs, the individual control of each animal and finally the profitability of the farm. Spreading lambings throughout the year has resulted in higher profits. Therefore, an accelerated lambing management system could be a useful tool for farmers, in order to achieve a better lamb delivery distribution over the year, more lambs produced per ewe per year and better average prices for the lambs.

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