Improvement of reproductive performances with a combined strategy (Sementusa®) in sheep farms in Sicily

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SUMMARY

Introduction - In the era of the global economic crisis and according to the human demographic increase that will lead to a wider food demand in few decades, farming industries need to be improved through sustainable strategies especially in those countries where animal breeding could represent a relevant part of national economy and food source. Dairy sheep farming in Sicily has a good productive potential but poor and traditional breeding systems represent the main impairs for its development.

Aim - The aim of this study was to evaluate the efficacy of a combined strategy named Sementusa®, in a group of sheep farms in Sicily.

Material and methods - About 4,000 sheep of Valle del Belice and Comisana breeds, reared in five farms that satisfied the inclusion criteria such as the presence of more than 200 animals in reproduction, the pasture-based breeding, the electronic and visual system of animal identification, were enrolled in the study and monitored during a whole reproductive season. For each farm, once data related to management for instance welfare, identification system, feeding, parasite control and reproductive strategies, were obtained, corrective actions have been undertaken when applicable. According to the Sementusa® protocol, 4 ultrasound checks after the mating period or synchronization were also performed.

Results and discussion - A total of 3,947 sheep were followed and 430 non-pregnant ewes were successfully managed to get gravid. The application of the Sementusa® strategy allowed to obtain a significant increase of fertility rate of 14.4% compared to the previous year; furthermore an extra income of about 100,000 Euros from milk and meat production was also gained. Findings of this study suggest that the Sementusa® strategy could be regarded as a reliable and sustainable management technique for the improvement of herd fertility and production without any further investment.

KEY WORDS

Sheep, reproduction, production, ultrasound, Sementusa®.

INTRODUCTION

The Island of Sicily is the second region in Italy, after Sardinia, for abundance of sheep (over 1,000,000 heads). Sicilian sheep farms are featured by a traditional mixed cereal- and pasture-based farming system with an average flock size of 100 animals (www.agri.istat.it). The extensive breeding system does not encourage care for housing and milking facilities. Autochthonous breeds such as Valle del Belice, Pinzirita and Comisana and their inbreeds have high genetic potential to produce milk in severe environmental conditions (dry and hot). Milk is generally processed to produce several types of local cheeses like Vastedda del Belice, Pecorino Siciliano and Piacentino Ennese and most of them have a Protected Designation of Origin (PDO) in order to protect breeds, system of breeding, environment, cultural tradition and production technology. Lamb’s meat market has two moment peaks of commercial request, at Christmas and Easter festivities. During these periods the mean price of the lamb meat is about 5 Euros per kilo, while, in the rest of the year, it decreases to half or even less. The traditional breeding system does not allow high productive performances and farmers are generally refractory to new investments. The net result is that farms are progressively closing. In Sicily, veterinary activities in sheep farms are mainly represented by surveillance programmes for infectious diseases proposed by National Veterinary Service. Indeed, in past decades, farmers have experienced numerous outbreaks of infectious diseases such as brucellosis, catarrhal fever and toxoplasmosis, which caused compulsory prophylactic actions due to their zoonotic concerns1,2. These actions, however, have caused a significant economic loss in sheep farms of the Island. According to the extensive breeding system and to the questionable control strategies adopted in several farms, parasitic infestations such as gastrointestinal nematodes, metacestodosis and myiasis are frequent and massive in Sicilian sheep and may impair reproductive and productive performances3-5. The breeding season may be influenced by several factors, including the male effect, the presence of cycling ewes or female effect, availability of pasture, climate and latitude6. In temperate areas like Sicily and Sardinia, seasonality is not so evident;
therefore farmers encourage mating in spring in order to obtain lambing in autumn. In these ewes, lactation lasts for 220-240 days. The new-born female lambs are kept as replacements while the male lambs are sold for meat production during Christmas celebrations. Mating of the replacement ewes is planned generally for the following autumn. Ewes lambing later in February, March and April present a short lactation period of about 150 days and all lambs are sold for meat production at Easter. Non-pregnant and short lactating ewes are considered the main indicators of low fertility in dairy sheep. Different factors may be related to a low fertility, including season, inadequate social stimulii, diseases, poor welfare and feeding; nutrition can either inhibit (low energy intake) or improve (nutritional supplementation or flushing diet) ovarian activity and consequent ewe fecundity. Hormonal and non-hormonal systems have been described to stimulate reproductive activity, but the risk of overestimating the percentage of pregnant ewes is real for the presence of poor signs of oestrus and pregnancy in the sheep. Sensitivity and specificity of ultrasonography increase along with the progression of the pregnancy, reaching approximately 100% after day 45. Pregnancy may be established at day 25-30 due to embryonic or foetal death. By using the trans-abdominal approach, pregnancy may be established at day 25-30 after breeding. Sensitivity and specificity of ultrasonography increase along with the progression of the pregnancy period, reaching approximately 100% after day 45. Sementusa®, which name originated from a Sardinian dialectal word that means “two year old ewe”, is a combined strategy that covers several aspects of sheep production including welfare, nutrition, parasites and reproduction. It has been suggested that this strategy might improve sheep production without substantial economical efforts. The aim of the present study was to investigate the effectiveness of the Sementusa® strategy in five sheep farms in Sicily.

MATERIALS AND METHODS

The study was carried out in 5 sheep farms rearing Valle del Belice and Comisana breeds. Each enrolled farm had the following characteristics: more than 200 animals and pasture-based breeding system. The adopted management system named Sementusa®, included the following 5 phases.

Phase 1. Focus on welfare evaluation and classification of the farm. For this phase, an already existent welfare checklist developed for cattle (Measure 215 of Sicilian Rural Plan 2007-2013) was employed once adapted for sheep. It consisted in a checklist to be filled according to breeding system; housing; facilities for parturition and for isolation; type of milking system (i.e., manual or mechanical); feed and drink facilities; hygiene; health and behaviour; personnel; environment control. The farm welfare was then classified according to the checklist with the following scores: 1 = unacceptable; 2 = poor; 3 = sufficient; 4 = moderate; 5 = good; 6 = optimal. Only the farms with a score over 3 were enrolled and considered for phase 2.

Phase 2. Implementation of electronic identification of animals. During this phase, all animals were electronically identified. Phase 3. Evaluation of feed and feeding. This phase included evaluation of the vegetables available in the pasture, the rotation system of the pasture, the presence and variety of forage and concentrate. Corrective actions included improvement of the pasture management, obligatory forage supply before pasture, and choice of the better concentrate, in relation to the season and to the pasture, in order to reach an appropriate ratio. Farmers received information on the animal group's requirements in relation to their different alimentary needs. Milk analysis was encouraged and especially evaluation of urea, to balance the protein intake. This phase may have a cost varying from 0 to 1,500 Euros/year for each farm depending on the study and the required analyses.

Phase 4. Evaluation of parasites and treatments. This phase included a reorganization of the treatment against parasites. Representative faecal samples were collected from each enrolled farm and tested for parasites presence by FLOTAC® copro-microscopical technique. Briefly, faecal samples were pooled at the laboratory in order to obtain 4 composites of 5 individual samples of the same weight, for each tested farm. Pooled samples were processed using the FLOTAC® technique with a sucrose flotation solution (s.g. 1,250 N/m³) ensuring an analytic sensitivity of 2 eggs per gram of faeces. In each enrolled farm anti-parasitic treatments were designed after copro-microscopical diagnosis and performed preferring peri-partum (August) for adult animals and pre-pubertal (November) time for young animals. Costs for diagnosis and treatment, estimated in about 2 Euros per head, were covered by farmers.

Phase 5. Reproductive strategies. It starts from the reproductive anamnesis of the flock including fertility rate, prolificacy, replacement rate, monthly distribution of lambing (lambing curve) and male/female ratio. Fertility of 95%, replacement rate of 20%, male/female ratio of 1:30, prolificacy of 1.25 and mortality less of 5% were considered the optimal parameters for sheep farm. Based on these indexes, the economic loss for each enrolled farm was estimated, considering a non-pregnant ewe as a lost, accounting milk and lamb, of about 200 Euros per year and a late lambing as about 1 Euro for each lost day. According to the anamnesis of the flock and the existing condition of the sheep farm (recorded during the phase 1), including the reproductive parameters, an increase of the farmer's income was hypothesized. The salary of the team, which includes at least 2 vets and 1 agronomist, was previewed as a percentage of this increase ranging between 5% (in case of the worst acceptable condition) and 20% (in case of the best farm condition). The reproduction phase of Sementusa® began with the management of rams and aimed to adjust the male/female ratio (1:30 but always in an odd number) and to exclude animals with ultrasound signs of testicular pathology (e.g., mineralization, oedema, abscesses) or other factors that could impair the spermatic output (stress, hyperthermia, drugs). Rams were tested by ultrasonography technique at least 2 months (i.e., January) before mating season; once selected, they were isolated, kept in artificial negative photoperiod (8 hours per day), subjected to flushing food and never sheared. During the same period, ewes were evaluated by means of Body Condition Score (BCS) (accepted range 2.75 - 3.25) and eventually corrected by feeding. Before the mating season, they were subjected to flushing food with vitamins and minerals. Rams were placed with ewes from March to October to induce oestrus and mating (male effect).
In May (about 30 days after mating), a first ultrasonographic check was performed for all the adult ewes. A portable scanner with a 3.5-6 MHz convex transducer was the equipment of choice for trans-abdominal ultrasound, while a 6-9 MHz linear endo-cavitary transducer with a support for rectal insertion was utilized for trans-rectal evaluation. The ultrasound procedure was realized in the farm during housing or milking. Trained vets were capable to perform up to 100 ultrasound evaluations in 1 hour. Ewes were firstly tested with a trans-abdominal probe, to identify and register the pregnant ones. The non-pregnant ewes were then re-tested with the trans-rectal scan in order to visualize early pregnancies and ovarian structures. Pregnant ewes were not more evaluated further unless signs of abortion occurred. In this case, ewes were carefully examined and isolated or treated as a non-pregnant.

Non-pregnant ewes were re-evaluated for BCS and diet adjusted when applicable. When the number of non-pregnant ewes was high, allowing a concrete risk of economic loss, and according to other circumstances such as a low number of rams, farmer request, demand of lamb meat, a synchronization plan was performed. This consisted in the administration of intra-vaginal sponges containing 40 mg of fluorogestone acetate (FA) followed by 300 IU Equine Chorionic Gonadotropin (eCG) (Cronogest, Intervet). After 40 hours, natural service was allowed giving rams in a ratio 1:9. In July, the May non-pregnant ewes were re-checked by ultrasound. The procedure was repeated, but the July non-pregnant ewes were joined with rams and with the young ewes (replacements). In September, the July non-pregnant and the replacements were re-checked by ultrasound. The September non-pregnant ewes were re-evaluated and eventually synchronized as above. In November, the last group of non-pregnant ewes were re-checked. In December, data were analyzed (chi-square test) and a strategy for the following year was proposed.

RESULTS

Farm 1 had 750 adult ewes, 250 replacement ewes (24%) and 50 rams (ratio 1:20); it was classified as a high standard farm (welfare score: 5). It had mechanical milking system, a cheese factory, 250 hectares of pasture, with a good management and auto-sufficient for the production of forage and concentrates. Fertility in the previous year was 82%. Applying the combined strategy, corrective actions were done for welfare, feeding and parasites. Feeding was re-organized increasing the quantity of forage and adding amounts of barley especially in late spring and summer. No synchronization was necessary after the ultrasound checks. At the end of the year, fertility was 92.5% with a high significant increase (10.5%, p<0.01), while the lambing curve was irregular as shown in Figure 1 as consequence of the incorrect male/female ratio. Strategies for the following year included the acquisition of 40 rams and a better management of the replacements.

Farm 2 had 950 adult ewes, 250 replacement ewes (21%) and 14 rams (ratio 1:70); it was classified as a high standard farm (welfare score: 5). It had manual milking, a cheese factory, 240 hectares of pasture, with a good management and auto-sufficient for the production of forage and concentrates. Fertility in the previous year was 82%. Applying the combined strategy, corrective actions were done for welfare, feeding and parasites. During the first year it was not possible to correct the number of rams. After the ultrasound controls in May, 50 non-pregnant ewes were synchronized obtaining 60 lambs (50% of twins). At the end of the year, fertility was 95.9% with a high significant increase (6.9%, p<0.01) while the lambing curve was not still optimized as shown in Figure 1, as consequence of the incorrect male/female ratio. Strategies for the following year included the acquisition of 40 rams and a better management of the replacements.

Farm 3 had 800 adult ewes, 200 replacement ewes (20%) and 13 rams (ratio 1:92); it was classified as a high standard farm (welfare score: 5). It had manual milking, a cheese factory, 280 hectares of pasture, with a discrete management and no auto-sufficient for the production of forage and concentrates. Fertility in the previous year was 79%. Applying the combined strategy, corrective actions were done for welfare, feeding and parasites. During the first year it was not possible to correct the number of rams. After the ultrasound controls in May, 50 non-pregnant ewes were synchronized obtaining 60 lambs (50% of twins). At the end of the year, fertility was 95.9% with a high significant increase (6.9%, p<0.01) while the lambing curve was not still optimized as shown in Figure 1, as consequence of the incorrect male/female ratio. Strategies for the following year included the acquisition of 40 rams and a better management of the replacements.

Farm 4 had 290 adult ewes, 80 replacement ewes (21%) and 12 rams (ratio 1:31; it was classified as a high standard farm (welfare score: 4). It had manual milking, no cheese factory, 20 hectares of pasture, with a discrete management and no auto-sufficient for the production of forage and concentrates. Fertility in the previous year was 79%. Applying the combined strategy, corrective actions were done for welfare and parasites. Feeding was re-organized increasing the quantity of forage and adding amounts of barley especially in late spring and summer. No synchronization was necessary after the ultrasound checks. At the end of the year, fertility was 94.6% with a high significant increase (15.6%, p<0.01), while the non-pregnant ewes were represented mainly (80%) by the replacements. The lambing curve was irregular as shown in Figure 1. Strategies for the following year included a better management of the replacements.

Figure 1 - Lambing curves obtained applying the Sementusa® system in 5 sheep farms in Sicily.
Farm 5 had 220 adult ewes, 60 replacement ewes (21%) and 8 rams (ratio 1:30); it was classified as a medium standard (welfare score: 3) farm. It had manual milking and no cheese factory. Pastures were in rent and moderately managed but the farm was not auto-sufficient for the production of forage and concentrates. Fertility in the previous year was 71.5%. Applying the combined strategy, corrective actions were done for welfare and parasites. Feeding was re-organized increasing the quantity of forage and adding amounts of barley especially in late spring and summer. No synchronization was necessary. At the end of the year, fertility was 97.5% with a high significant increase (26%, \( p < 0.01 \)) while the non-pregnant ewes were represented mainly (80%) by the replacements. All results defined above are summarized in Tables 1 and 2. The lambing curve was reasonable but the high amount of late lambing still persisted in all included farms (Figure 1).

Considering all the farms, 3,915 sheep were managed allowing productive mating of 430 non-pregnant ewes. The combined approach allowed an extra-income for all farmers of about 100,000 Euros.

**DISCUSSION**

The control of reproduction in sheep is poorly applicable without a complete evaluation of the management system. The modern trend is to improve productivity, profitability and, simultaneously, promote a "clean, green and ethical production". Valle del Belice and Comisana breeds include robust sheep able to feed in severe environmental conditions and to cycle all the year; hence it is not so difficult to have pregnancy and laming in the desired periods. Extensive breeding system has great advantages for animal welfare, especially when a wide well-managed pasture is available, but they may face a range of compromises related to nutritional stress, inadequate water supply, climatic extremes, parasites and lameness. In this kind of breeding, housing facilities are used only for the night and when grazing is not feasible. It is fundamental to ensure maintenance of good hygiene conditions, associated with correct dimensioning of structural parameters. Unfortunately, Mediterranean sheep often have shelters that are not appropriate, in terms of design, materials and size but, fortunately, grazing in Sicily is practicable almost all the year.

The most frequent miscalculation for Sicilian sheep flocks is a bad management of nutrition and alimentary needs. In autumn, winter and spring, the pasture is able to give sufficient protein intake, but fibres are generally insufficient. In late spring and summer, there is poor grass availability and palatability but also a marked reduction of protein intake. Therefore, grazing animals in extensive rearing can face nutritional unbalance during these periods, with alteration of rumen fermentation, which compromises their welfare and negatively influences fertility and lactation performances.

Applying the Sementusa® strategy, three corrective actions were employed in this study: analysis of milk and evaluation of urea, administration of supplement of forage or adequate amount of concentrate in case of pasture lacking of fibres or protein, respectively.

Pasture favours the development of endoparasitism; intestinal parasites are regarded as a common cause of reduction in feeding efficiency and alteration in reproduction performances. Enrolled farms were used to treat their animals with wide-spectrum drugs without a previous diagnosis of para-

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**Table 1** - Characteristics of the farms at the time of inclusion enrolled to evaluate the new reproductive management strategy (Sementusa®).

<table>
<thead>
<tr>
<th>ID</th>
<th>Farm</th>
<th>Adult ewes</th>
<th>Replacements</th>
<th>Rams</th>
<th>Ram: Ewe Ratio</th>
<th>Farm quality score</th>
<th>Milking technique</th>
<th>Pasture (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>750</td>
<td>250 (24%)</td>
<td>50</td>
<td>1:20</td>
<td>5</td>
<td>Mechanical</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>950</td>
<td>250 (21%)</td>
<td>13</td>
<td>1:92</td>
<td>5</td>
<td>Mechanical</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>800</td>
<td>200 (20%)</td>
<td>14</td>
<td>1:70</td>
<td>5</td>
<td>Mechanical</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>290</td>
<td>80 (21%)</td>
<td>12</td>
<td>1:31</td>
<td>4</td>
<td>Manual</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>220</td>
<td>60 (21%)</td>
<td>8</td>
<td>1:30</td>
<td>3</td>
<td>Manual</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2** - Summary of results of the reproductive performances in the sheep farms obtained following the application the new reproductive management system (Sementusa®).

<table>
<thead>
<tr>
<th>ID farm</th>
<th>Fertility in the previous year (%)</th>
<th>Corrective actions</th>
<th>Ewes synchronized in May (n)</th>
<th>Lambs obtained after synchronization (n)</th>
<th>Twins (%)</th>
<th>Fertility obtained in the study (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82</td>
<td>Welfare</td>
<td>100</td>
<td>85</td>
<td>20</td>
<td>92.5</td>
</tr>
<tr>
<td>2</td>
<td>89</td>
<td>Feeding</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>95.9</td>
</tr>
<tr>
<td>3</td>
<td>82</td>
<td>Parasites</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>95.8</td>
</tr>
<tr>
<td>4</td>
<td>79</td>
<td>Welfare</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>94.6</td>
</tr>
<tr>
<td>5</td>
<td>71.5</td>
<td>Parasites</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>97.5</td>
</tr>
</tbody>
</table>
site species and load; in addition the timing of treatments against parasites was irrationally scheduled with negative consequences for production and reproductive performances. Subsequently to the adoption of the combined strategy, the use of anthelmintic drugs was rationalized and leaded, for selection of molecules based on copro-microscopical diagnosis. As regard to timing of treatments these were mainly performed in August and November in order to avoid withdrawal time and optimize production. Once welfare, nutrition and parasites problems were solved, the combined strategy was focused on reproduction. The potential increase of income to farmers was estimated based on reproductive performances of the previous years. Interesting enough, it was really appreciated by farmers that the salary of the team was calculated as a percentage of the reliable increase of profit.

A common reproductive problem encountered was the management of rams. Farmers are used to buy rams of high genetic value as they believe that this can improve fertility and productions. The prize for these animals is strongly high; therefore they are bought in low number resulting in an inappropriate male/female ratio. In our experience, genetic improvement is a further phase, which does not represent a priority in flocks with welfare, feeding, health and reproductive problems. Ram management plays a main role in the Sementusa® strategy. The male/female ratio was the main problem in farms 2 and 3. The intensity of sexual stimulation experienced by the ewes results from the number of rams present. The literature reports a wide range of ram to ewe ratios under different production systems and all are assumed to be sufficient to stimulate females, from 1:1 to 1:100. However, Signoret et al. recorded a significant increase in the number of ewes ovulating when this ratio was changed from 1:100 to 1:20. In our experience, ratio under 1:30, especially if not clinically evaluated and if not adequately managed (isolation and photoperiod), are not able to induce oestrus cycles in all the ewes and are not able to mate them during spring. As result, a high number of non-pregnant ewes and a distended lambing curve are the characteristic of this kind of problem. Timing of ultrasound checks was another strength point of the Sementusa® strategy. Established pregnancy (over 30 days) were registered using the trans-abdominal technique, that is easier and faster than the trans-rectal one. Early pregnancy should be always confirmed, as there is the risk of embryonic resorption. Trans-rectal scans are able to reveal the ovarian status and this is the basis to choose the corrective treatment of approximately 100,000 Euros. The encouraging results herein reported, are even better than those recently obtained in Sardinia on Sarda sheep breed. Findings of this study suggest that the Sementusa® strategy could be regarded as a reliable and sustainable management technique for the improvement of sheep herd fertility and productions without any further economic investment.

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