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Full Length Article

Evaluation of Reproductive Performance of Semen from Algerian Rembi Sheep through Artificial Insemination in Ewes in a Semi-Arid Region of Algeria

Ahmed Redha Benia[1,3*] and Naceur Benamor[2]
[1]*Department of Biomedicine, Institute of Veterinary Sciences, University of Tiaret, Tiaret 14000, Algeria*
[2]*Department of Natural Sciences and Life, Faculty of Natural Sciences and Life, University of Tiaret, Tiaret 14000, Algeria*
[3]*Farm animal reproduction laboratory, Institute of Veterinary Sciences, University of Tiaret, Tiaret 14000, Algeria*
[*]For correspondence: arbveto@yahoo.fr
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Abstract

Our objective of this study was to determine the effect of age on the success of artificial insemination (AI) and on certain numerical reproductive parameters of Rembi sheep in a semi-arid region in Algeria. During the semen collection, we divided 10 rams that were well trained into two groups (young and adult). After semen was collected, sperm was subjected to the usual controls (volume, mass motility and concentration) and then diluted and packaged in straws. Moreover, 126 ewes were divided into three groups (ewe hoggets, young and adult ewes). Then, they were synchronized with Controlled Internal Drug Release (CIDR) + Pregnant Mare Serum Gonadotropin (PMSG), and each group was subdivided into two batches of 21 heads. After the appearance of estrus, the ewes of the two batches of each group were inseminated cervically with straws of fresh semen according to the age group of the rams. Statistical analysis indicated that the andrological values studied were higher in adult than in young rams with a very significant ($P < 0.001$) difference in mass motility and concentration. Reproductive performance was higher in ewes (3 years and over) inseminated with semen from adult rams compared to young ones with no statistically significant difference. Otherwise, the lowest rates were recorded among the ewe hoggets. The present research revealed that AI can be considered as a possible strategy in Rembi sheep genetic improvement programs and allow us to better preserve this breed known for its great productive than reproductive capacities.

Keywords: Rembi sheep; Semen; Artificial insemination; Reproductive parameters; Algeria

Introduction

Artificial insemination (AI) is the most widely used reproductive biotechnology in the world for the implementation of breeding schemes (Arranz *et al.* 2008). In sheep farms, it is an essential technical tool for the creation and dissemination of genetic progress, despite constraints that are specific to this sheep such as the need to synchronize heat, the use of fresh semen and high relative cost of acts (Thibault and Levasseur 2001; Fatet *et al.* 2008). The development of artificial insemination and the consequent genetic improvement of farm animals have led to a remarkable increase in the productivity of livestock (Najafi *et al.* 2014).

In Algeria, the artificial insemination has not been used very widely in the sheep farms, despite sheep farming is of great economic, social and environmental interest in all countries with a Mediterranean climate (Rancourt *et al.* 2006). Despite a large number of sheep that is estimated at 29 million heads (MARD 2021) yet breeding techniques at farm level are till now-a-days basic and traditional based on pasture (Atigui and Chniter 2022), which is subjected to the current issue of global warming, which causes severe rangeland degradation (Elloumi *et al.* 2011; Bengoumi and Ameziane-Hassani 2013), hence the low productivity of sheep (Dekhili 2014). The first step must be increasing the numerical productivity of animals of "good genetic quality" by improving reproductive performance. In this regard, artificial insemination can help solve this issue.

Intracervical artificial insemination with fresh semen is the most used AI technique in sheep (Anel *et al.* 2006). Its weak application in Algeria as well as the lack of knowledge about its effects on sheep, especially the Rembi, pushed us to shed light on it (Allaoui *et al.* 2014; Atigui and Chniter 2022). The success of this biotechnology is affected by many factors (intrinsic and extrinsic) related to female (age, handling, seasonality, genital morphology, interval last lambing-AI, etc.), male (age, seasonality, sperm quality, etc.), timing and number of inseminations, Controlled Internal Drug Release (CIDR) protocol, dose of Pregnant

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Mare Serum Gonadotropin (PMSG), the diluter used, the concentration of sperm used in the straws, technique itself (vaginal, cervical, cervicouterine, laparoscopy), technician, type of breeding, environmental conditions (region, climate, etc.) and feeding are important for the process (Shackell et *al.* 1990; Donovan *et al.* 2004; Anel *et al.* 2006; Grimard *et al.* 2006; Garcia-Ispierto *et al.* 2007; Ingrid *et al.* 2008; Raoul *et al.* 2008). The CIDR device has been compared with various other progesterone-releasing devices and has been found to have a better sustained release of progesterone over time (Hamra *et al.* 1989). This technique has been recently applied in Algeria as a heat synchronization treatment of the sheep (Benia *et al.* 2022).

No study on the impact of these biotechnologies on the control of Rembi sheep reproduction has been reported. Therefore, this work presents a different strategy to improve AI efficiency with fresh semen as a function of Rembi sheep age on some reproductive parameters.

Materials and Methods

Study area

This study was conducted on a private sheep farm (35°10'43.4" N, 2°11'55.4" E) in coordination with the Livestock Technical Institute of Ksar Chellala, Tiaret province, North-western Algeria. Our study area was located 260 km south of the capital Algiers. The habitat was located in the steppe region, which is characterized by a semiarid Mediterranean climate. The mean annual temperature was 17.1°C, while the mean annual rainfall varies from 170 to 260 mm (Benamor *et al.* 2021). The Institute is under the supervision of the Ministry of Agriculture and Rural Development and aims at the implementation of national agricultural development plans.

Selection of animals

The study began in April (Spring) in the middle of breeding season of Rembi sheep. Ten Rembi rams were selected for the study. The sample animals were aged between 18 months and 6 years at the beginning of the experiments. Then, they were divided into two lots: the first included five young rams aged 18 to 24 months while the second included five adult rams aged between 5 and 6 years (Benia *et al.* 2018). These males were trained for sperm collection biweekly using two ewes. This step is very necessary in the training of rams intended for semen production.

Three groups of Rembi ewes (n = 126, with a last lambing-IA interval greater than 80 days) ranging from 18 months to 6 years of age were arranged for AI using straws prepared from fresh semen collected from rams. Each of the three groups was composed of 42 ewes (group 1: ewe hoggets aged 18 to 24 months; group 2: young ewes aged 3 to 4 years; group 3: adult ewes aged 5 to 6 years). Then, each group was subdivided into two small batches of 21 heads intended for AI by straws prepared according to the age range of the inseminating rams (young and adult).

The evaluation with Body Condition Scoring method showed that the used sheep had states of bodies between 3.0 and 3.5 so that they could have the maximum ardor. These sheep were identified and separated from the rest of the herd while receiving a feed ration based on specialized commercial concentrate that is recommended for breeders one month before the start of mating and 3 weeks later for females (flushing). Prophylactic treatments were recommended and only healthy subjects were retained.

Experimental protocol

The semen harvest was carried out using an artificial vagina. The semen is instantly subjected to the usual controls (volume, mass motility and concentration) then diluted in Laiciphos W488 (this diluter allows the preservation of sperm for 8 to 10 h) before being packaged in straws (IMV Technologies, France) labeled with information about the rams collected. These straws were kept in thermos at a temperature of 15°C. Each 0.25 mL in the straw contained 400 million sperm cells (fresh semen) with a mass motility equal to or greater than 3 (Faigl *et al.* 2012).

The estrus of the sheep was induced and synchronized through the application of CIDR for 12 days (CIDR® Ovis, Zoetis, France: T-shaped device consisting of an inert nylon support on which is molded a silicone elastomer impregnated with natural progesterone 0.35 g) (Table 1). The treatment is completed with an intramuscular injection of 400 IU of PMSG (Folligan 1000 IU: lyophylisat injection + solvent) in each ewe at the time of withdrawal of CIDRs (Benia *et al.* 2022). Estrus was checked 24 h after the CIDR was withdrawal using rams equipped with marking harnesses. The sheep in our study have not undergone any hormonal program of heat synchronization before.

About 30 to 40 h after the injection of PMSG, each estrus ewe is inseminated with two straws 24 h apart. The insemination practice was of the cervical type because the straw of fresh semen harvested from the rams of the two age categories (young or adult) is deposited with care and slowness by an experienced inseminator at the entrance of the cervix using a speculum (equipped with a light source) and a Cassou insemination gun (Najafi *et al.* 2014).

Gestations were diagnosed with ultrasound after approximately 60 days of artificial inseminations. Moreover, the lambing data were collected through direct observation on the farm. We used individual records related to the information of our experiments for each subject of our study.

Parameters studied

Based on the study of Craplet and Thibier (1984), we have chosen the following zootechnical parameters to evaluate the numerical performance of reproduction, and consequently the success of AI:

$$\text{Fertility rate} = \frac{\text{Number of ewes that have lambing}}{\text{Number of ewes put to breed}} \times 100 \quad (1)$$

$$\text{Fecundity rate} = \frac{\text{Number of lambs born "dead and alive"}}{\text{Number of ewes put to breed}} \times 100 \quad (2)$$

$$\text{Prolificacy rate} = \frac{\text{Number of lambs born "dead and alive"}}{\text{Number of ewes that have lambing}} \times 100 \quad (3)$$

Statistical analysis

In our study, we used descriptive statistics such as the mean and standard deviation to interpret the results. The data were subjected to the Shapiro-Wilk normality test at $P < 0.05$. We used the nonparametric test (Mann Whitney test) to compare quantitative variables with a significance threshold of 5%. Moreover, principal component analysis (PCA) was used to demonstrate the effect of the age of inseminating rams and ewes to determine the significant changes in the reproductive performance (fertility, fecundity, and prolificity) and AI using PAST 4.08 software (Hammer *et al.* 2001).

Results

The data in Table 1 indicate that all females subjected to estrus synchronization responded favorably to hormone treatment, showing signs of estrus. In this line, we did not observe any loss of this intravaginal device in all the ewes on the day of withdrawal of the CIDR.

Data show that all harvested semen values (*i.e.*, volume, mass motility, concentration and number of straws) were higher in the adult group of rams than the young group with overall averages of 1.27 ± 0.22 mL; 4.08 ± 0.17; 4.15 ± 0.21 10^9/mL and 10.38 ± 1.07 respectively (Table 2). The results of the analysis of variance indicate that the age range of rams had a very highly significant ($P < 0.001$) influence on the parameter of mass motility and a highly significant ($P = 0.0053$) influence on semen concentration (Table 2). On the other hand, the statistical treatment showed no significant ($P > 0.05$) difference for the other two andrological parameters (volume and number of straws).

Reproductive performance data showed that the inseminated females by the semen of adult rams were more fertile, more fecund, and more prolific compared to those inseminated by the semen of young rams (Table 3). In addition, there was no statistically detectable significant difference. The best rates of fertility (95.23 ± 2.18%), fecundity (138.09 ± 6.69%) and prolificacy (145 ± 6.04%) were obtained in the group of adult ewes aged 5 to 6 years (group 3), which were artificially inseminated by the fresh semen harvested from adult rams. On the other hand, the lowest rates of these three parameters were recorded in females in group 1 (aged 18 to 24 months) inseminated by the semen of young rams (Table 3). Our results revealed the significant, highly significant, and very highly significant differences between the females of groups 1 and 3 in the variables of prolificacy ($P = 0.0111$), fertility ($P = 0.0037$) and fecundity ($P = 0.0002$). For the latter parameter, a significant difference ($P = 0.0199$) was observed between the ewes of groups 1 and 2. On the other hand, the analysis of variance revealed no statistically detectable ($P > 0.05$) effect of age on the numerical reproductive factors of the artificially inseminated ewes of groups 2 and 3.

Principal Component Analysis clearly showed the relationship between the age of the males and females and different reproductive parameters (Fig. 1). The ascending hierarchical classification is represented by two categories. The first category was reflected mainly by ewes aged 3 years and older (groups 2 and 3), which were artificially inseminated by fresh semen harvested from adult rams (G2A and G3A) and young rams for the ewes of group 3 (G3Y). This category was correlated positively with reproductive parameters (fertility, fecundity and prolificacy). The second category consisting of all the ewe hoggets of group 1 (G1Y and G1A) as well as the young ewes of group 2 which were artificially inseminated by fresh semen harvested from the young rams (G2Y) where we recorded fairly low numerical production rates compared to the rest of the ewes.

Discussion

In our study, a 100% estral response was observed in all females in all three age groups (ewe hoggets, young ewes and adults) treated with a 12-day intravaginal CIDR device combined with an intramuscular injection of 400 IU of PMSG on the day of withdrawal. These results corroborated the report of Dogan and Nur (2006) and Simonetti *et al.* (2002) who showed estral responses of 88.9 and 80.87%, respectively, using 60 mg of progesterone (CIDR) combined with 500 IU of PMSG in the off-season in ewes aged 2 to 6 years. Moreover, higher estrus reactions (100%) were reported by Hashemi *et al.* (2006) in their study involving the use of 60 mg progesterone and 500 IU PMSG in Karakul ewes aged 3–7 years outside the breeding season. However, other authors have reported lower heat induction rates ranging from 46 to 96% following CIDR treatments in ewes older than 18 months (Naderipour *et al.* 2012). The observed distinction between these studies can be explained by the differences in sheep breed, season, environment, diet and hormone treatment protocol. The action of PMSG (400 IU) injected on the day of withdrawal of CIDR after 12 days of treatment is the main cause of the manifestation of estrus treatment protocol. The action of PMSG (400 IU) injected on the day of withdrawal of CIDR after 12 days of treatment is the main cause of the manifestation of estrus, which allows ewes to obtain more precise and predictable synchronizations of ovulatory heat thanks to its effects on follicular growth after the faster stimulation of pituitary-ovarian responses which positively promote the secretion of estrogen (Simonetti *et al.* 2008).

Results indicated that set of andrological parameters

Table 1: Chronology of the experimental protocol

Experimental protocol	Group 1 (Ewe hoggets aged 18 to 24 months)	Group 2 (Young ewes aged 03 to 04 years)	Group 3 (Adult ewes aged 05 to 06 years)
Number of synchronized ewes	42	42	42
Date of CIDR installation	04/14/2021	04/19/2021	04/24/2021
CIDR withdrawal date	04/26/2021	05/01/2021	05/06/2021
Dose of PMSG (UI)	400	400	400
Number of ewes that lost CIDR	00	00	00
Number of ewes in estrus	42	42	42
Dates of artificial inseminations	04/28 to 04/29/2021	05/03 to 05/04/2021	05/08 to 05/09/2021
Lambing period	09/30 to 10/07/2021	10/02 to 10/09/2021	10/04 to 10/11/2021
Number and rate of lambing ewes	26 (61.90%)	33 (78.58%)	38 (90.47%)

Table 2: Effect and degrees of significance of the age category of rams (young and adults) on spermatic production parameters

Andrological parameters	Young rams (18-24 months)	Adult rams (Aged 5 to 6 years)	Overall average	Significance (U test)
Volume (mL)	1.21 ± 0.32	1.33 ± 0.23	1.27 ± 0,22	0.738
Mass motility	3.68 ± 0.18	4.48 ± 0.11	4.08 ± 0.17	0.0001***
Concentration (10^9/mL spermatozoa)	3.74 ± 0.22	4.57 ± 0.17	4.15 ± 0.21	0.0053**
Number of straws	9.35 ± 1.01	11.42 ± 1.11	10.38 ± 1.07	0.093

Mean ± standard deviation. P<0.05: (*) Significant; P<0.01: (**) Highly significant; P<0.001: (***) Very highly significant

Table 3: Effect and degrees of significance of the semen of inseminating rams (young and adult) on the reproductive performance of the ewes studied

Reproduction parameters	group of ewes	Semen of rams			Significance (U test)
		Youngs	Adults	Overall average	
Fertility rate (%)	Group 1	52.38 ± 5.11	71.42 ± 4.62	61.90 ± 4.91	0.2147
	Group 2	76.19 ± 4.36	80.95 ± 4.02	78.57 ± 4.15	0.7234
	Group 3	85.71 ± 3.58	95.23 ± 2.18	90.47 ± 2.97	0.3106
Fecundity rate (%)	Group 1	52.38 ± 5.11	80.95 ± 6.01	66.67 ± 5.7	0.1294
	Group 2	85.71 ± 5.73	109.52 ± 7.01	97.61 ± 6.43	0.2407
	Group 3	109.52 ± 6.24	138.09 ± 6.69	123.81 ± 6.55	0.1957
Prolificacy rate (%)	Group 1	100.00 ± 0.00	113.33 ± 3.51	106.67 ± 2.71	0.1957
	Group 2	112.5 ± 3.41	135.29 ± 4.92	123.9 ± 4.35	0.1390
	Group 3	127.77 ± 4.6	145 ± 6.04	136.39 ± 5.41	0.3963

Mean ± standard deviation

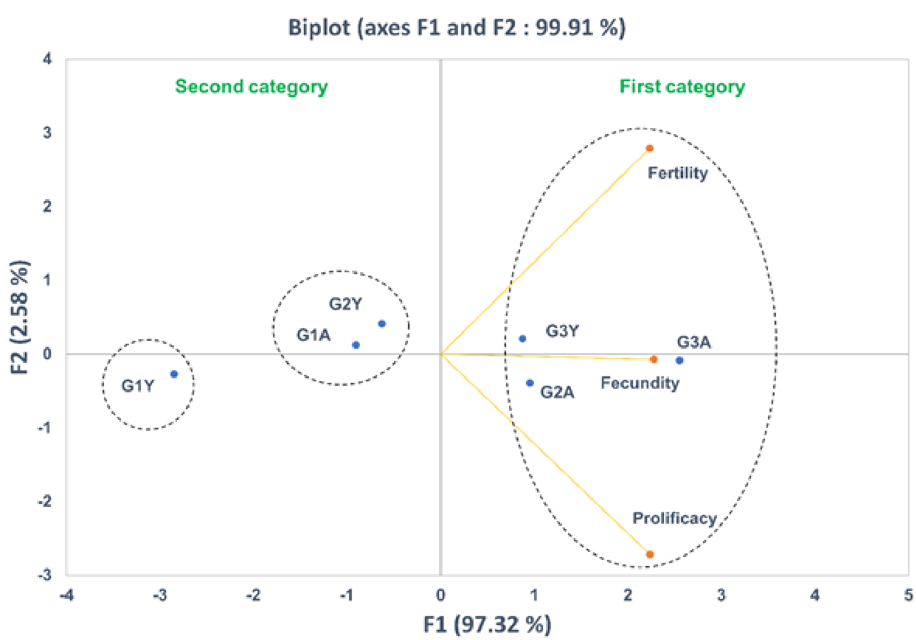

Fig. 1: Principal Component Analysis (PCA) of the relationship between the age of the males and females and the different reproductive parameters (G1A: ewe hoggets inseminated by semen from adult rams; G1Y: ewe hoggets inseminated by semen from young rams; G2A: young ewes inseminated by semen from adult rams; G2Y: young ewes inseminated by semen from young rams; G3A: adult ewes inseminated by semen from adult rams; G3Y: adult ewes inseminated by semen from young rams)

Table 4: Degrees of significance of the age of ewes inseminated by the fresh semen of young and adult rams on their reproductive parameters

Reproduction parameter	Group of ewes		Significance (U test)
Fertility rate (%)	Group 1	Group 2	0.1218
	Group 1	Group 3	0.0037**
	Group 2	Group 3	0.1024
Fecundity rate (%)	Group 1	Group 2	0.0199*
	Group 1	Group 3	0.0002***
	Group 2	Group 3	0.0567
Prolificacy rate (%)	Group 1	Group 2	0.0827
	Group 1	Group 3	0.0111*
	Group 2	Group 3	0.3430

$P < 0.05$: (*) Significant; $P < 0.01$: (**) Highly significant; $P < 0.001$: (***) Very highly significant

of the semen collected from the males in our study were higher in the adult age group compared to the young with significant differences in the variables of sperm concentration and mass motility (Table 2). Benia *et al.* (2018) reported that the effect of the age range on the rams of the Ouled Djellal breed was found to be a factor of variation since quantitative semen production is greater in adults than the young ones. This difference was significant for mass motility and concentration. The mean values of mass motility (4.08 ± 0.17) and concentration (4.15 ± 0.21 × 10^9 spermatozoa/mL) obtained are very acceptable (Table 2) in comparison with the standards of 4 and 2 to 6 × 10^9 spermatozoa/mL respectively, from which semen is considered very good and very favorable for artificial insemination according to Baril *et al.* (1993) who confirmed that when the motility score and the concentration of the ejaculate increase, the probability of success of the AI rises.

The success rate of AI in sheep is quite variable depending on several factors such as breeding season, region, breed, age of couples, the conduct (hormonal treatment or natural estrus), type of semen (fresh, chilled, frozen), time and number of inseminations, site (cervical, uterine, laparoscopy), and operator competence (Palacín *et al.* 2012).

Variations in fertility, fecundity and prolificacy of inseminating rams have already been observed in ewes inseminated with fresh semen (Anel *et al.* 2006; Palacín *et al.* 2012). In the present study, no significant differences in these parameters between young and adult inseminating rams were observed (Table 3). This could be due to the strict selection of rams and ejaculates used and the homogeneous management of males and/or the low number of AIs performed per ram.

The reproduction performance of our study is within a satisfactory range and is consistent with those reported in the literature. According to Allaoui *et al.* (2014), fertility rates vary from 60 to 100% in Ouled Djellal sheep and are favorable performances. In the present study we found that the implementation of AI (cervical type with fresh semen) in Rembi sheep in semi-arid areas as a genetic improvement tool could be a solution to accelerate genetic progress in order to achieve sufficiently high selection intensity.

The best rates of fertility, fecundity, and prolificacy in our work were obtained in adult ewes while the lowest are recorded in ewe hoggets. Our results are contradictory to those found by (Stalhammar *et al.* 1994; Anel *et al.* 2006; Grimard *et al.* 2006), which showed that in some sheep breeds the probability of success of AI decreases with the advanced age of the sheep. This may be related to a decrease in the response of ewes to synchronize by an anti-PMSG antibody production resulting from previous treatments (Bodin *et al.* 1999), decrease in the quality of female gametes, or a disruption of the luteal phase (Garcia-Ispierto *et al.* 2007). Given that the heat synchronization program is being used for the first time in the Rembi ewes in our study. In crux this single treatment did not yet reach a threshold that could prompt an immune response to synchronize and subsequently, affect AI success.

The existence of a highly significant difference between the fertility of groups 1 and 3 (ewe hoggets and adult ewes) is similar to the one found by Levasseur and Thibault (1980) who observed a progressive fertility reaching its maximum values around the age of 4 to 6 years. The values decrease little in older ewes; here it is the embryonic mortality that increases from the age of 6 years. The low fertility rate observed in ewe hoggets is probably due to impaired spermatozoa transport combined with low mucus production in the cervical ducts during estrus.

According to Boujenane and Chikhi (2006), the age of Boujaâd and Sardi ewes in Morocco has a highly significant effect ($P < 0.001$) on fertility. In this regard, 3-year-old ewes have a higher fertility rate (97%) while 4-year-old ewes have the lowest rate (77.5%). Ewes aged 2, 5 and 6 years have intermediate rates.

Anel *et al.* (2005) reported that the best fecundity rates of Churra ewes are recorded between 3.5 and 4.5 years; beyond this age, fecundity declines remarkably. Moreover, Santolaria *et al.* (2011) concluded that the ewes selected for AI should be 2 to 5 years old. On the other hand, younger and older ewes should be used for natural mating.

According to Arbouche *et al.* (2013), the age of Ouled Djellal ewes had a significant effect ($P < 0.05$) on fecundity, 3-year-old ewes had a high rate (112.5%), the lowest rate was attributed to 6-year-old ewes (83.3%), while ewes aged 2, 4 and 5 years had a fecundity of 91.4, 85 and 96.4%, respectively. For the Rembi ewes in our research, the highest fecundity rates are obtained in the age group of 5 to 6 years (123.81%) while the lowest is in ewe hoggets (66.67%); with very highly significant differences ($P = 0.0002$). According to results, the recorded fecundity rate reflected a very high proportion of ovulatory heat (Table 3). This follows the injection of PMSG (400 IU) at the end of progestin treatment which increases the dynamic development of new follicular waves, the duration of estrus, the ovulation rate, and advances at the beginning of the onset heat (Koyuncu and Altiçekiç 2010).

Our recorded results on the overall fertility and fecundity rates are fairly comparable to the values reported by Najafi *et al.* (2014) and Fornazari *et al.* (2018), respectively, in Ghezel and Assaf ewes synchronized with CIDR and are cervically inseminated with diluted fresh semen. However, our data are higher than those cited by Olivera-muzante *et al.* (2011) who reported fertility and fecundity rates of 51 and 56%, respectively, for multiparous Australian Merino ewes, which are synchronized with two doses of PGF2α seven days apart and are cervically inseminated with fresh semen 48 h after hormone administration.

Prolificacy is considered an essential zootechnical parameter for the profitability of sheep farms. The use of AI in Rembi ewes in our work has resulted in satisfactory percentages of prolificacy (Table 3). The higher rates are obtained in ewes of groups 2 and 3 (young 123.9% and adults 136.39%) compared to the percentage of 115% recorded in a previous study on multiparous ewes of the same breed and age group in natural mating (Benia *et al.* 2022). Females aged 5 to 6 years showed a very high prolificacy rate (136.39%) with a significant difference compared to ewe hoggets (106.67%) (Tables 3 and 4). These two rates are considered very good according to the standards of this breed (105 to 115%) (Laoun *et al.* 2015). According to Dekhili (2014), the prolificacy of Ouled Djellal ewes in Algeria is closely related to age. Contrary to what we observe in our study, this author says that the youngest subjects (1.5 to 3.5 years) are the most prolific and that it is the effect of the environment that is questioned. Scaramuzzi *et al.* (2006) showed the existence of a positive correlation between the prolificacy of ewes and its physical state in relation to age; thus, in addition to the pastures, the feeding of the animals in our work was mainly based on flushing during the reproduction season. This factor has a positive impact on the prolificacy of the lambing ewes, as previously observed by Chikhi and Boujenane (2003).

Ingrid (2008) reported that the time interval between the last lambing and AI is paramount to the success of this biotechnology. Even if the trend is less clear than in dairy sheep, the author noted for lactating sheep, an improvement in the probability of success of AI when the time interval with the previous lambing increases. Again, it is possible to consider this factor as causal. A very short time interval does not allow the female to replenish the body reserves and causes a poor success of the AI. This time period was more than 80 days for the ewes in our study, representing a very favorable margin to succeed in this act (Baril *et al.* 1993).

Conclusion

Results confirmed that estrus could be effectively synchronized with CIDR to obtain homogeneous and concentrated lambing in Rembi sheep. The application of AI biotechnology showed adequate success rates according to different age groups of sheep. This success involved intrinsic factors related to males and females, and extrinsic factors related to the environment and the mode of breeding. The age of rams significantly affected the parameters of mass motility and concentration of the harvested semen. Moreover, the andrological values were higher in adults and ewes inseminated with their semen were more fertile, fecund and prolific compared to those inseminated by the semen of the young ones. The best fertility, fecundity, and prolificacy rates were recorded in ewes aged 5 to 6 years while the lowest rates were noted in ewe hoggets. Thus, the best rates of AI and reproductive performance were grouped in multiparous ewes aged 5–6 years and were artificially inseminated with fresh semen harvested from rams of the same age group. AI proved as a possible strategy in Rembi sheep genetic improvement programs. In order to increase genetic gain, AI could also be a solution to import fewer exotic genotypes and allows to better preserve this breed known for its great productive than reproductive capacities and the challenge remains to extrapolate this AI technique to field conditions at a large-scale.

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Author Contributions

ARB planned, performed the experiments and interpreted the results, NB applied data analysis and manuscript writeup. All authors read and approved the final manuscript.

Conflicts of Interests

All the authors declare that they have no competing interests

Data Availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request

Ethics Approval

This study was conducted in full accordance with ethical principles. All experimental protocols were carried out in accordance with the relevant guidelines and regulations

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