COMPARATIVE EVALUATION OF SHORT- AND LONG-TERM ESTRUS SYNCHRONIZATION PROTOCOLS ON REPRODUCTIVE PERFORMANCE AND COST-EFFECTIVENESS OF BARKI EWES

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SUMMARY

The objective of this study was to assess the effectiveness of short- and long-term estrus synchronization protocols in Barki sheep. A total of sixty-four multiparous Barki ewes, aged between 2.5 and 4 years with an average body weight of 44±0.36 kg, were selected for this study. The ewes were randomly assigned to eight groups, with eight ewes per group, for the purpose of evaluating different hormonal estrus synchronization protocols. Each group was subjected to one of four distinct estrus synchronization protocols. The first protocol, designated PG-SHORT-TERM, involved the administration of double injections of prostaglandin $F_2\alpha$, with an interval of seven days between each injection, followed by the administration of 400 IU PMSG on the seventh day. The second protocol, designated PG-LONG-TERM, was similar to the first but with an interval of 14 days between injections. (3) FGA sponge - SHORT-TERM: This protocol involved the insertion for a period of seven days, followed by the administration of 400 IU PMSG at the time of sponge removal. (4) FGA sponge - LONG-TERM: This protocol was similar to the third one but entailed the retention of the sponges for duration of 14 days. Furthermore, the P4 and Ovsynch protocols were evaluated in both short- and long-term variations. The measurements in the experiment included estrus characteristics, estrus response rate, reproductive performance, progesterone concentration, and cost-effectiveness of the protocols. A one-way analysis of variance was conducted. Significant differences were identified among the protocols with regard to reproductive performance parameters. In general, long-term synchronization protocols demonstrated superior outcomes compared to their short-term counterparts. Notwithstanding the overall efficacy of the tested protocols, the FGA sponge protocols, irrespective of their duration, were identified as the most cost-effective means. This study recommends the implementation of FGA sponge protocols to optimize reproductive efficiency and economic returns in sheep.

Keywords: Estrus synchronization, progestogens, $PGF_2\alpha$, PMSG, GnRH

INTRODUCTION

In arid regions, traditional reliance on natural estrus in sheep and goats has persisted until recently. However, the rise of large-scale commercial farming in these areas has highlighted the need for reproductive techniques like estrus synchronization. This method is crucial for enhancing reproductive efficiency in ewes by shortening the generation interval, increasing conception and lambing rates, and mitigating the effects of seasonal breeding patterns. By extending the breeding season and optimizing lambing times, estrus synchronization enables more frequent deliveries, reduces breeding costs, and maximizes economic returns. A variety of estrus synchronization protocols have been developed and used, with varying degrees of success. Some protocols have demonstrated notable improvements in estrus response, pregnancy rates, and overall fertility, whereas others have exhibited limited efficacy. The most commonly utilized hormonal treatments for estrus synchronization in sheep include progestogen vaginal sponges (FGA), prostaglandins (PG), progesterone injection, and gonadotropin-releasing hormone (GnRH) analogs. These protocols can be included into two categories: long-term treatments (9-16 days) and short-term treatments (5-7 days) with such hormones. Each category has distinct advantages and disadvantages. For instance, long-term sponge treatments have been shown to significantly increase conception rates, while short-term protocols offer managerial ease, reduced infection risks, and improved fertility (Wei *et al*., 2016).

Also, pregnant mare serum gonadotropin (PMSG) or GnRH are another widely used agent in estrus synchronization (Eppleston *et al*., 1991; Koyuncu and Ozis, 2010).

Long-term progesterone treatment has been demonstrated to effectively result in estrus synchronization; however, the resulting pregnancy rates have been observed to vary. For example, Contreras-Solis *et al*. (2008) demonstrated that subcutaneous progesterone injection with olive oil could maintain plasma progesterone at a high level for 41 hours. Administration of a high dose of progesterone in reproductive protocols for a brief period could enhance the regulation of follicular dynamics and pregnancy rate in small ruminants (Ungerfeld and Rubianes, 2002).

Reproductive performance represents a fundamental aspect of the productivity and profitability of livestock enterprises (Martin *et al.*, 2004). Prior research has demonstrated that suboptimal reproductive performance in sheep can be enhanced through the administration of exogenous hormones, particularly progestogen-impregnated

sponges, either independently or in conjunction with PMSG treatment (Abdalla *et al*., 2014; Eldomany *et al*., 2023). The objective of this research is, therefore, to study the impact of short- and long-term synchronization on reproductive and economic return of Barki ewes.

MATERIALS AND METHODS

Study region:

This study was conducted at the Siwa Research Station, specifically the Tegzerty Experimental Farm for Animal Production, Desert Research Center. This research station is situated 300 kilometers southwest of the Mediterranean coastline and 60 kilometers east of the Libyan border, within the Siwa Oasis.

Animals, feeding, and management:

A total of sixty-four multiparous Barki ewes, aged between 2.5 and 4 years with an average body weight of 44±0.36 kg, were selected for this study. Animals were housed in semi-open, freely ventilated pens. All animals were clinically healthy and treated for internal and external parasite infestations. The ewes were provided with a concentrate mixture according to their body weight requirements of National Research Council (NRC, 2007). The concentrate mixture contained 14% crude protein, 15% crude fiber, 9% ash, 2% crude fat, and 65% total digestible nutrients. Additionally, Egyptian clover (*Trifolium alexandrinum*) hay was provided ad libitum as a roughage ration. Fresh underground water was supplied twice daily at 08:00 am and 02:00 pm.

Estrus synchronization protocol:

The ewes were randomly assigned to eight groups, eight animals each group, for the purpose of evaluating different hormonal estrus synchronization protocols. The experimental design for the various hormonal protocols is illustrated in Fig. 1, and the treatment details are as follows:

- **PG-SHORT-TERM:** Ewes received two injections (1 ml each) of prostaglandin $PGF_2\alpha$ (Estrumate, 263 µg Cloprostenol/ml, Schering-Plough Animal Health, Germany) 7 days apart, followed by an injection of 400 IU pregnant mare serum gonadotropin (PMSG) (Gonaser, Laboratories HIPRA, S. A.-Avoda. Laselva, Spain) on day 7.
- **PG-LONG-TERM:** Ewes received two injections (1 ml each) of prostaglandin $PGF_2\alpha$ 14 days apart, followed by an injection of 400 IU PMSG on day 14.
- **FGA Sponge-SHORT-TERM:** Ewes received an intravaginal progestagen-impregnated sponge (20 mg fluorogestone acetate, FGA, Chronogest, Intervet International, B.V. Manufactured in the European Union) for 7 days. Upon sponge removal, each ewe received an intramuscular injection of 400 IU PMSG.
- **FGA Sponge-LONG-TERM:** Ewes received an intravaginal progestagen-impregnated sponge for 14 days. Upon sponge removal, each ewe received an intramuscular injection of 400 IU PMSG.
- **P4-SHORT-TERM:** Ewes were intramuscularly injected with 20 mg progesterone acetate in oil [0.8 mL Lutone (Misr, Egypt)] every other day for 6 days, followed by 400 IU PMSG on day 6.
- **P4-LONG-TERM:** Ewes were intramuscularly injected with 20 mg progesterone acetate in oil [0.8 mL Lutone (Misr, Egypt)] every other day for 12 days, followed by 400 IU PMSG on day 12.
- **Ovsynch-SHORT-TERM:** Ewes received two intramuscular injections of 8 µg buserelin acetate (Receptal, GnRH agonist, Intervet International, Netherlands) 7 days apart, with an additional injection of 1 ml prostaglandin $PGF_2\alpha$ (Estrumate) on day 5.
- **Ovsynch-LONG-TERM:** Ewes received two intramuscular injections of 8 µg buserelin acetate 9 days apart, with an additional injection of 1 ml prostaglandin $PGF_2\alpha$ on day 7.

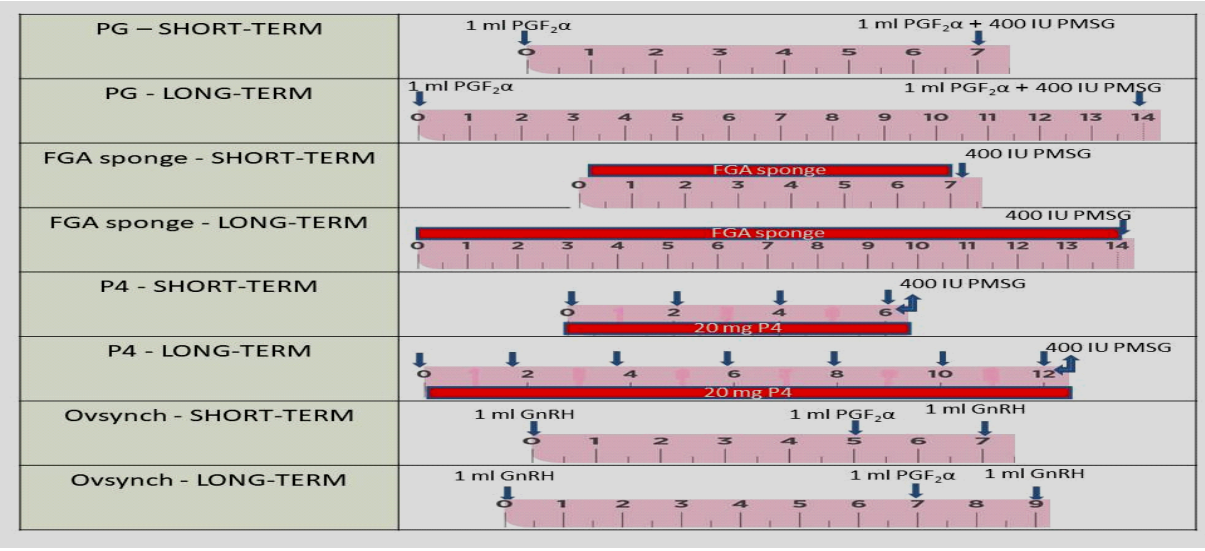

Figure 1: A schematic presentation of the estrus synchronization protocols employed in this study.

Estrus detection and breeding:

Throughout the course of the treatment, the ewes were observed twice daily (morning and evening) to ascertain the continued placement of the sponges. Fertile Barki rams in good body condition were used for estrus detection twice daily (morning and evening) for a period of one hour each session. The onset of estrus was determined by observing paint marks on the ewes' rumps. Ewes were considered in estrus and ready for mating when the raddle mark was heavy and evenly distributed or when copulation was directly observed. The onset of estrus was defined as the time when a ewe first showed mounting behavior toward the ram. Estrus duration was measured from the onset of estrus signs to when the ewe no longer accepted mounting. Rams were allowed to mate with the ewes for 96 hours and were rotated among different groups to avoid sire and group confounding effects.

Reproductive performance:

The reproductive performance of the ewes was evaluated based on the following parameters: estrus rate (calculated as the number of ewes exhibiting signs of estrus divided by the total number of ewes in each group multiplied by 100), conception rate (defined as the number of ewes that became pregnant divided by the number of ewes that were mated multiplied by 100), lambing rate (calculated as the number of ewes that gave birth to lambs divided by the number of ewes that were mated multiplied by 100), and prolificacy (defined as the number of lambs born per ewe that lambed).

Blood sampling for progesterone assay:

To assess serum progesterone concentrations among the experimental groups, blood samples were collected from the jugular vein into 5 mL coagulant-free centrifuge tubes. Blood samples were obtained from all ewes (n= 64) at the commencement of the experiment (day 0) and on days 6, 7, 9, 12, and 14 (at the initiation and conclusion of each protocol). The samples were allowed to clot at room temperature for one hour before being subjected to centrifugation at 1,500 × g for 15 minutes. The sera were harvested into 2 mL capacity Eppendorf vials and stored frozen at -30 °C until laboratory analysis. The serum progesterone levels were analyzed using commercial ELISA kits (Monobind, USA), with intra- and inter-assay coefficients of variation (CVs) of 9.3% and 9.7%, respectively.

Statistical analysis:

The onset and duration of estrus, as well as progesterone concentrations, were analyzed using the General Linear Model Procedure (SAS, 2004). A one-way analysis of variance was performed, and the Duncan Multiple Range Test (Duncan, 1955). was employed to test for significant differences among means. Reproductive performance data were analyzed using the Chi-square test.

RESULTS AND DISCUSSION

Estrus characteristics:

The onset of estrus exhibited notable variability ($P<0.05$) across all synchronization protocols, as detailed in Table 1. The FGA sponge-LONG-TERM protocol resulted in the earliest onset of estrus (27.47 hours), while the P4-SHORT-TERM protocol had the latest onset (65.07 hours). In general, long-term synchronization protocols induced estrus at an earlier time point than their short-term counterparts, with the exception of the Ovsynch protocol. This discrepancy can be attributed to the physiological response to progesterone removal. In short-term protocols, the developing follicle requires time to stimulate ovulation, resulting in delayed estrus onset (Oliveira *et al*., 2016). Conversely, in long-term protocols, progesterone levels decline rapidly following device removal, prompting an earlier onset of estrus and ovulation (Nakafeero *et al*., 2020).

Table 1. Impact of short- and long-term estrus synchronization protocols on the characteristics of estrus behavior in Barki ewes under desert conditions

Experimental groups	Treated ewes (N)	Ewes in estrus (N)	Onset of estrus (h)	Duration of estrus (h)
PG – SHORT-TERM	8	7	52.26 ± 0.18^{c}	25.78 ± 0.40^{g}
PG - LONG-TERM	8	8	44.15 ± 0.07^{e}	28.13 ± 0.11^{f}
FGA sponge - SHORT-TERM	8	8	53.15 ± 0.05^{b}	34.16 ± 0.12^{b}
FGA sponge - LONG-TERM	8	8	27.47 ± 0.19^{h}	35.43 ± 0.12^{a}
P4 - SHORT-TERM	8	6	65.07 ± 0.27^{a}	29.18 ± 0.10^{e}
P4 - LONG-TERM	8	7	38.20 ± 0.28^{g}	32.41 ± 0.13^{c}
Ovsynch - SHORT-TERM	8	3	42.17 ± 0.06^{f}	30.26 ± 0.12^{d}
Ovsynch - LONG-TERM	8	5	49.26 ± 0.06^{d}	32.38 ± 0.15^{c}
Overall mean			46.47±1.33	30.97±0.38

a, b until h: Means denoted within the same column with different superscripts are significantly different at $P<0.05$; N: number; h: hours.

These findings are in accordance with those reported in previous studies. Das *et al*. (2000) and Vinoles *et al*. (2001) observed the onset of estrus within a period of 24–144 hours following the withdrawal of progestagen or progesterone. In our study, the FGA sponge-LONG-TERM protocol

resulted in the onset of estrus at 27.47 hours, a time point that is shorter than the 37.2 hours reported by Kulaksiz *et al*. (2013) in fat-tailed ewes using the same protocol. With regard to the FGA sponge-SHORT-TERM protocol, the onset of estrus occurred at 53.15 hours, which is slightly later than the 49.7 hours reported by Kulaksiz *et al*. (2013). The onset of estrus with the Ovsynch-LONG-TERM protocol was 49.26 hours, which is in close alignment with the 50.5 hours reported by the same study. These discrepancies in estrus onset may be attributed to variations in breed and management conditions. These findings are corroborated by the observations of Martinez-Ros *et al*. (2019), they noted that PMSG treatment is more effective in advancing estrus onset in long-term progestagen treatments than in short-term ones. The administration of PMSG following the removal of a vaginal sponge has been shown to increase the size of antral follicles, leading to elevated estrogen concentrations and potentially contributing to an earlier onset of estrus (Barrett *et al*., 2004).

The results for Barki ewes are consistent with those reported by Almadaly *et al*. (2023) for Ossimi ewes, except for the Ovsynch protocol, where estrus onset occurred earlier in their study compared to the current findings. Furthermore, Abu El-Ella *et al*. (2016) discovered that the combination of sponges or CIDR with PMSG resulted in a reduction in the interval to estrus onset. This is likely attributable to the PMSG-induced enhancement of follicular growth and acceleration of pituitary endocrine responses and estradiol secretion.

As indicated in Table 1, the duration of estrus observed in our study falls within the physiological range of 24–36 hours, as previously reported by Jainudeen *et al*. (2000). The longest duration of estrus was observed in the FGA sponge-LONG-TERM protocol (35.43 hours), followed closely by the FGA sponge-SHORT-TERM protocol (34.16 hours). In contrast, the PG-SHORT-TERM protocol resulted in the shortest estrus duration (25.78 hours), which was statistically significant ($P < 0.05$). These findings are consistent with those of Farrag (2019), who reported 29.80 hour estrus duration in Abou-Delik ewes using double injections of $PGF_2\alpha$. However, Mohan and Kumar (2023) found a longer estrus duration (48.0 hours) in ewes treated with two $PGF_2\alpha$ injections, thereby underscoring the variability across studies.

A comparison of long-term and short-term protocols revealed that the former resulted in longer estrus durations. This finding aligns with the results reported by Abu El-Ella *et al*. (2016), they observed that progestagen-based hormonal treatments resulted in longer estrus durations compared to other methods. Additionally, Nasser *et al*. (2012) proposed that elevated blood estrogen levels, in conjunction with breed variations, age, and geographical influences, may contribute to prolonged estrus duration. In contrast, Kulaksiz *et al*. (2013) reported a shorter estrus duration (24 hours) in ewes treated with the Ovsynch protocol compared to FGA sponge + PMSG protocols. Our findings for Ovsynch protocols are similar to the 29.2-hour duration reported by Mohan and Kumar (2023).

Estrus response rate:

As demonstrated in Table 2, the estrus response rate was markedly elevated ($P<0.05$) in the FGA sponge-SHORT-TERM, FGA sponge-LONG-TERM, and PG-LONG-TERM protocols, each attaining a 100% response rate. In contrast, the Ovsynch-SHORT-TERM and Ovsynch-LONG-TERM protocols exhibited the lowest estrus response rates, at 50% and 62.5%, respectively. The Ovsynch-SHORT-TERM protocol yielded the lowest estrus response rate (50%), a result that aligns with the findings of Waheeb *et al*. (2017). The latter study reported a similar 50% estrus response in Barki ewes using the Ovsynch protocol. This finding is consistent with the conclusions of Almadaly *et al*. (2016), who reported that the Ovsynch-SHORT-TERM protocol was ineffective in inducing estrus in Rahmani ewes.

In contrast to progesterone-based protocols, $PGF_2\alpha$ regimens are typically less efficacious during the non-breeding season due to the absence of a functional corpus luteum (CL). However, the PG-LONG-TERM protocol demonstrated a high estrus rate of 100%, while the PG-SHORT-TERM protocol also exhibited a notable performance, with an estrus rate of 87.5%. These outcomes are in line with the findings reported by Abdalla *et al*. (2014), who observed a 90.91% estrus response rate in Barki ewes using a PG protocol.

The efficacy of short-term progestogen sponge protocols (5-7 days) in inducing and synchronizing estrus in ewes has been demonstrated in both breeding and non-breeding seasons (Ataman *et al*., 2006). The reduction in sponge insertion time in short-term protocols may assist in maintaining elevated progesterone levels following the removal of the pessary, while simultaneously reducing the risk of vaginal contamination. In this study, all long-term synchronization protocols exhibited higher estrus response rates in comparison to their short-term counterparts.

An additional benefit of these long-term protocols is their greater capacity for prolificacy in comparison to short-term protocols. This may be attributed to the extended exposure of the ewe ovaries to progesterone, which enables the optimal selection of dominant follicles, resulting in the development of larger CLs capable of sustaining pregnancy until full term (Sánchez *et al*., 2018). This hypothesis is further corroborated by the elevated serum progesterone concentrations observed at the conclusion of the long-term protocols in this study.

Table 2. Reproductive performance of Barki ewes in experimental protocols

Experimental groups	Treated ewes (N)	Ewes in estrus (N)	Estrus Rate (%)	Conception rate (%)	Lambing rate (%)	Lambs born(N)	Prolificacy rate (%)
PG–SHORT-ERM	8	7	87.50^{ab} (7/8)	71.42 (5/7)	71.42 (5/7)	5	1.00
PG- LONG-TERM	8	8	100.00^{a} (8/8)	87.50 (7/8)	87.50 (7/8)	8	1.14
FGA sponge-SHORT- TERM	8	8	100.00^{a} (8/8)	100.00 (8/8)	100.00 (8/8)	10	1.25
FGA sponge-LONG-TERM	8	8	100.00^{a} (8/8)	100.00 (8/8)	87.50 (7/8) (1 ewe aborted)	9	1.28
P4 - SHORT-TERM	8	6	75.00^{ab} (6/8)	50.00 (3/6)	50.00 (3/6)	3	1.00
P4 - LONG-TERM	8	7	87.50^{ab} (7/8)	85.71 (6/7)	71.42 (5/7) (1 ewe aborted)	6	1.20
Ovsynch - SHORT-TERM	8	4	50.00^{b} (4/8)	50.00 (2/4)	50.00 (2/4)	2	1.00
Ovsynch - LONG-TERM	8	5	62.50^{ab} (5/8)	60.00 (3/5)	60.00 (3/5)	3	1.00
P value			0.04	0.12	0.34		0.81
Chi value			13.94	11.29	8.13		32

Means bearing different superscript within columns differ significantly (P<0.05); N: number

Reproductive performance:

The findings of the study indicate that the FGA sponge-LONG-TERM and FGA sponge-SHORT-TERM protocols resulted in the highest conception rates, both at 100%, among ewes exhibiting estrus. Subsequently, the PG-LONG-TERM and P4-LONG-TERM protocols exhibited conception rates of 87.5% and 85.71%, respectively. The superior conception rates observed with the FGA sponge, PG, and P4 protocols in comparison to the Ovsynch protocol can be attributed to the use of exogenous gonadotropins (PMSG), which promote efficient follicle development and advance ovulation. These findings are consistent with those reported by Miljkovic *et al*. (1989), who observed an 85% conception rate in ewes treated with vaginal sponges containing 30-40 mg of FGA and 80 IU of PMSG. Similarly, Akoz *et al*. (2006) documented a 100% conception rate in Akkaraman crossbred ewes treated with FGA and 700 IU of PMSG.

The efficacy of gonadotropin-releasing hormone (GnRH) administration in inducing ovulation is dependent on the stage of the estrous cycle at which it is administered (Alminer *et al*., 2005). In contrast, the observed conception rate in our study was higher than the 66.6% reported by Almadaly *et al*. (2016) for FGA sponge short-term treatment and the 66.67% reported by Abu El-Ella *et al*. (2016) for MAP sponge long-term treatment.

The highest lambing rate (100%) was observed in the FGA sponge-SHORT-TERM protocol. The FGA sponge-LONG-TERM and PG-LONG-TERM protocols exhibited the second-highest lambing rates, although one ewe in the FGA sponge-LONG-TERM protocol aborted shortly before lambing. In the FGA sponge-SHORT-TERM protocol, all ewes successfully conceived and gave birth, resulting in a prolificacy rate of 1.25. Conversely, the FGA sponge-LONG-TERM protocol achieved a 100% conception rate, but a lower lambing rate of 87.5% due to one abortion, with a prolificacy rate of 1.28. Our findings are consistent with those of Waheeb *et al*. (2017), who reported comparable pregnancy and lambing rates. Similarly, Akoz *et al*. (2006) observed an 85.7% lambing rate in Akkaraman crossbred ewes treated with FGA and 700 IU PMSG.

Ashmawy (2011) discovered that administering GnRH on days 0 and 7 with $PGF_2\alpha$ on day 5 and GnRH on days 0 and 9 with $PGF_2\alpha$ on day 7 during the breeding season resulted in lambing rates of 60% and 40%, respectively. Similarly, Kulaksiz *et al*. (2013) observed lower estrus, conception, and lambing rates with the Ovsynch synchronization protocol in comparison to long- and short-term progesterone sponge + PMSG protocols. Ustuner *et al*. (2007) reported higher lambing rates and fertility with short-term progestogen treatments combined with PMSG compared to long-term protocols. The Ovsynch protocol primarily acts as a source of exogenous GnRH, which mainly stimulates endogenous LH release, while PMSG serves as a source of exogenous FSH, which may be more beneficial compared to LH alone.

The highest prolificacy was observed in ewes treated with FGA sponge protocols, with a rate of 1.28 for long-term and 1.25 for short-term. In contrast, the lowest prolificacy was observed in ewes treated with the PG-SHORT-TERM, P4-SHORT-TERM, Ovsynch-SHORT-TERM, and Ovsynch-LONG-TERM protocols, with a value of 1.00. In a

study conducted by Boscos *et al*. (2002), it was observed that the administration of PMSG following progestogen treatments resulted in enhanced ovarian response, increased rates of conception, and a notable rise in the proportion of multiple births. Safdarian *et al*. (2006) observed a prolificacy rate of 1.40 in Karakul ewes treated with a MAP sponge and PMSG, and a rate of 1.25 in those treated with PG protocols. The results of this study indicate that the P4-LONG-TERM protocol is more efficacious than the P4-SHORT-TERM protocol, which is consistent with the findings of Almadaly *et al*. (2023), who reported a 55.55% lambing rate. The pregnancy rate was 1.75 with a 12-day P4 treatment, compared to a 33.33% lambing rate and a prolificacy rate of 1.0 with a 6-day P4 treatment.

The superior reproductive performance observed in the PG-LONG-TERM protocol can be attributed to its more favorable hormonal profile in comparison to the PG-SHORT-TERM protocol. The longer intervals between $PGF_2\alpha$ injections result in sustained higher plasma progesterone levels before mating, as evidenced by increased progesterone concentrations in this study. This finding is consistent with that reported by Besufkad *et al*. (2020), who observed greater conception rates and prolificacy with double $PGF_2\alpha$ injections spaced 11 days apart compared to 7 days apart.

In summation, long-term synchronization protocols yielded higher estrus response rates, conception rates, lambing rates, and prolificacy compared to short-term protocols, except for the lambing rate observed in the FGA sponge protocol. The variability in estrus rate and reproductive performance across studies may be attributed to differences in ewe breeds, climatic conditions, and the dosages and combinations of protocols employed.

Progesterone concentration:

Table 3 illustrates the serum progesterone concentrations across various estrus synchronization protocols. At the conclusion of the protocols, progesterone levels were significantly elevated ($P<0.05$) relative to the initial baseline measurement. It is noteworthy that the P4-LONG-TERM protocol exhibited the highest progesterone concentration, reaching 2.60 ng/mL, while the P4-SHORT-TERM protocol demonstrated a concentration of 2.22 ng/mL on days 12 and 6, respectively. Both the P4 and FGA sponge protocols resulted in elevated progesterone concentrations by the end of the treatment period, indicating effective exogenous progesterone provision, irrespective of pregnancy status.

Table 3. Mean±SEM of serum progesterone concentrations (ng/ml) in Barki ewes during estrus synchronization by short- and long-term experimental protocols

Experimental groups	Serum progesterone concentrations (ng/ml)							
	0 day	Day 6	Day 7	Day 9	Day 12	Day 14	Overall mean	P value
PG–SHORT-TERM	0.62±0.003		1.62±0.003				1.12±0.13	P<0.001
PG- LONG-TERM	0.92±0.003					1.85±0.003	1.39±0.12	P<0.001
FGA sponge - SHORT-TERM	0.81±0.003		1.89±0.023				1.35±0.14	P<0.001
FGA sponge - LONG-TERM	1.19±0.027					2.16±0.026	1.68±0.13	P<0.001
P4-SHORT-TERM	0.51±0.003	2.23±0.037					1.37±0.22	P<0.001
P4 - LONG-TERM	0.54±0.003				2.60±0.071		1.57±0.27	P<0.001
Ovsynch - SHORT-TERM	0.82±0.003		1.06±0.026				0.94±0.03	P<0.001
Ovsynch - LONG-TERM	0.36±0.003			1.14±0.003			0.75±0.1	P<0.001

The considerable elevation in progesterone levels documented in protocols that employ progesterone (FGA sponge and P4 injection) can be ascribed to the sustained release of progesterone from the vaginal sponge or injection, which ensures the maintenance of elevated progesterone levels throughout the protocol (Kusina *et al.*, 2000). In contrast, the Ovsynch protocol exhibited the lowest progesterone concentrations relative to other protocols upon completion of the treatment. This observation is in contrast with the findings of Ashmawy (2011), who reported higher plasma progesterone concentrations following GnRH treatment.

The higher progesterone levels in PMSG-treated ewes compared to those in the Ovsynch protocol can be explained by the increased ovulation rates and formation of additional corpora lutea due to the gonadotropic effects of PMSG (Greyling *et al*., 1988).

Cost-effectiveness of drugs estrus synchronization:

The cost-effectiveness analysis of estrus synchronization protocols reveals significant variations in production costs, which are crucial for assessing their efficiency in sheep management (Table 4). The FGA sponge protocols, both short-term and long-term, demonstrated the lowest costs

per lamb production at 240 LE and 267 LE, respectively. This cost-effectiveness can be attributed to the lower expense of FGA sponges and their effectiveness in achieving high reproductive outcomes. Consequently, FGA sponge protocols reduce the per-lamb production cost, making them advantageous for sheep farmers.

In contrast, the Ovsynch protocols incurred higher costs, totaling 968 LE for short-term and 645 LE for long-term applications. These elevated costs stem from the use of GnRH and the necessity for precise timing and management. The higher costs associated with GnRH treatment, combined with lower reproductive performance as indicated by reduced conception and lambing rates, further exacerbate the cost per lamb. This renders Ovsynch protocols less cost-effective compared to FGA sponge protocols.

The use of PMSG, particularly in FGA sponge and PG protocols, is linked to enhanced reproductive efficiency and reduced costs per lamb production. PMSG improves follicular development and ovulation, leading to increased conception rates and prolificacy. Abd El-Rafaa *et al*. (2022) noted that while GnRH treatments were more expensive and less effective, PMSG provided a more cost-effective option with superior reproductive outcomes. These findings align with previous studies by Abd El-Rafaa *et al*. (2022) and Miljkovic *et al*. (1989), emphasizing the importance of selecting cost-effective synchronization protocols that optimize reproductive outcomes. Overall, FGA sponge protocols, especially when combined with PMSG, present a cost-effective and efficient approach to estrus synchronization in sheep, facilitating informed decision-making to maximize profitability in sheep farming.

Table 4. Cost-effectiveness of drugs used for short- and long-term estrus synchronization in Barki ewes under desert conditions

Experimental groups	Total of Ewes	Ewes lambed	Lambs alive born	Total cost of hormonal protocol (LE)	Cost of lambs born(LE)	%
PG – SHORT-TERM	8	5	5	8*(120 + 160)= 2240	448	20
PG - LONG-TERM	8	7	8	8*(120 + 160)= 2240	280	12.5
FGA sponge - SHORT-TERM	8	8	10	8*(140 + 160)= 2400	240	10
FGA sponge - LONG-TERM	8	7	9	8*(140 + 160)=2400	267	11.12
P4 - SHORT-TERM	8	3	3	8*(26 + 160)= 1488	496	33.33
P4 - LONG-TERM	8	5	6	8*(45.5 + 160)=1644	274	16.66
Ovsynch - SHORT-TERM	8	2	2	8*(182 + 60)= 1936	968	50
Ovsynch - LONG-TERM	8	3	3	8*(182 + 60)= 1936	645	33.31

Price of drugs hormone: 1 ml Estrumate = 60 LE, 400 IU PMSG = 160 LE, one sponge = 140 LE, 0.8 mL Lutone (P4) = 6.5 LE, 1 ml GnRH = 91 EP.

CONCLUSION

The study finds that long-term estrus synchronization protocols significantly enhance estrus response rates and reproductive performance in Barki ewes compared to short-term methods, particularly those using FGA sponges. Conversely, GnRH-based protocols were less effective and require further optimization. Overall, FGA sponge protocols are more financially feasible and effective for Barki sheep in desert conditions, emphasizing their advantages for enhancing reproductive efficiency and cost-effectiveness. These findings highlight the advantages of utilizing FGA sponge protocols for improving reproductive efficiency and cost-effectiveness in Barki sheep.

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تقييم مقارن لبروتوكولات التزامن الشبقى قصيرة وطويلة المدى على الأداء التناسلي وفعالية التكلفة للنعاج البرقي

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هدف الدراسة هو تقييم فعالية بروتوكولات التزامن الشبقى قصيرة وطويلة المدى لتحسين التكاثر في الأغنام البرقي. تم إختيار أربعة وستين نعجة برقي متعددة الولادات، تتراوح أعمارها بين 2.5 و 4 سنوات بمتوسط وزن للجسم 44 كجم. تم توزيع النعاج عشوائياً الى ثماني مجموعات، مع ثماني نعاج لكل مجموعة، بغرض تقييم بروتوكولات التزامن الشبقى المختلفة. خضعت كل مجموعة لأحد بروتوكولات مزامنة الشبق الأربعة المميزة. تمثل البروتوكول الأول، المعروف بإسم PG-SHORT-TERM، في إعطاء حقنتين من البروستاجلاندين $F_2\alpha$ بفاصل زمني قدره سبعة أيام بين كل حقنة، متبوعاً بإعطاء 400 وحدة دولية من PMSG في اليوم السابع. أما البروتوكول الثاني، المعروف باسم PG-LONG-TERM ، فقد كان مشابهاً للبروتوكول الأول ولكن بفاصل زمني قدره 14 يوماً بين الحقنتين. البروتوكول الثالث (إسفنجة FGA - قصيرة المدى) تضمن إدخال إسفنجة مهبلية لمدة سبعة أيام، متبوعاً بإعطاء 400 وحدة دولية من PMSG عند إزالة الإسفنجة. أما البروتوكول الرابع (إسفنجة FGA - طويلة المدى) ، فقد إستلزم الإحتفاظ بالإسفنجة المهبلية لمدة 14 يوماً مع حقن 400 وحدة دولية من PMSG عند إزالة الإسفنجة. بالإضافة إلى ذلك، تم تقييم بروتوكولات P4 وOvsynch في كل من النماذج قصيرة وطويلة المدى. تضمنت القياسات في التجربة خصائص الشبق ومعدل إستجابة الشبق والأداء التناسلى وتركيز البروجسترون والفعالية من حيث التكلفة للبروتوكولات المستخدمه. تم إجراء تحليل التباين أحادي الإتجاه.

أظهرت النتائج وجود فروق معنوية بين البروتوكولات من حيث الأداء التناسلي. وبشكل عام تفوقت بروتوكولات التزامن طويلة المدى مقارنةً بالبروتوكولات قصيرة المدى، ورغم الفعالية العامة للبروتوكولات المختبرة فقد تبين أن بروتوكولات إسفنجة FGA وبغض النظر عن مدتها هي الأكثر كفاءة من حيث التكلفة. لذا توصي الدراسة بتطبيق بروتوكولات إسفنجة FGA لتعزيز الكفاءة التناسلية وتحقيق عوائد إقتصادية أفضل للأغنام.