B-5577
[1-6]

RESEARCH ARTICLE Indian Journal of Animal Research

Comparative Studies on the Effect of Synchronization Protocols on Estrus Response, Ovulation Time and Conception Rate in Boer Goats during Early Breeding Season in Odisha

A.D. Barik[1], S.S. Biswal[1], B.K. Patra[1], H. Behera[1], S. Sathapathy[2], S.S. Behera[3], A.K. Sahoo[3], S. Kanungo[4]

10.18805/IJAR.B-5577

ABSTRACT

Background: Estrus synchronization is a reproductive technique which used in livestock species to enhance the reproductive performances. The present experiment was conducted to investigate the effect of CIDR (EAZI-BREED CIDR®) and Prostaglandin ($PGF_{2\alpha}$) on estrus response, ovulation time and conception rate during early breeding season of Boer goats.

Methods: A total of 20 non-pregnant does (10 for CIDR based and 10 for double $PGF_{2\alpha}$ based protocol) were used for the present experiment. For CIDR based protocol (Group I), does were inserted with EAZI-BREED CIDR intravaginally containing 0.3 mg progesterone and kept for 11 days. A single dose of 125 microgram $PGF_{2\alpha}$ was injected before 24 hrs of EAZI-BREED CIDR removal and 4 µg Buserelin acetate on day of implant removal. For prostaglandin ($PGF_{2\alpha}$) protocol (Group II), does were injected intramuscularly with two doses of 125 µg cloprostenol at 11-day intervals. In both the groups teaser buck was used for estrus detection and mated by selected bucks.

Result: Estrus response was hundred per cent in both the groups. The duration of onset of estrus (hours) was shorter (28.80±1.20) in CIDR treated protocol than double $PGF_{2\alpha}$ protocol (40.20±1.30), where as the duration of estrus was longer in Group I (37.70±0.75) hour as compared to group II (33.60±0.54) does. Serum progesterone levels on day 0, on day 12 (24 hrs after completion of protocol) and day 35 after mating were1.31±0.13, 0.70±0.12 and 5.94±1.29 respectively for Group I, where as 1.13±0.13, 0.96±0.14 and 3.73±0.53 (ng/ml) were observed for Group II does. A significant difference was observed between day 12 and day 35 in both the groups but no significant difference was observed between the groups for day 0, 12 and 35. LH concentrations on the day of estrus did not vary significantly in both groups. Conception rates were 80 percent and 60 percent for group I and II respectively. In conclusion, the CIDR protocol provided better estrus synchronization and higher conception rates compared to the double $PGF_{2\alpha}$ protocol, making it a more effective and reliable for estrus synchronization in Boer goats.

Key words: Boer goats, Estrus synchroinization, Protocols.

INTRODUCTION

Goats (*Capra hircus*) are important domestic animals in many parts of the world (Molale *et al.*, 2017). Nowadays, goat meat is among the imported and exported Halal commodity (Sanchez *et al.*, 2020). Goat farming in Odisha is the most important source of house hold income in rural farmers. Increasing human population, urbanization and incomes, coupled with changing consumer preferences, are creating more demand for these animals and their products (Bolacali *et al.*, 2017). The success of the farming depends on the percent of Kids, multiple birth rates and the viability of kids (Zarkawi and Ai-Daker, 2013). But the breeding and management programme in small ruminants especially in goats are more difficult due to poor estrus expression and in adequate heat detection technique.

Estrus synchronization in livestock is a reproductive management technique aimed at regulating the timing of estrus by manipulating the follicular and luteal phases of the estrous cycle. Estrus is a short period of sexual receptivity during which the female exhibits specific behavioral and physiological changes, facilitating mating with the male. In goats, the average estrus duration is approximately 36 hours (Nogueira *et al.*, 2015), though it can range from 19 to 48 hours (Nogueira *et al.*, 2015).

[1]Department of ARGO, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India.
[2]Department of Anatomy and Histology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India.
[3]Department of Veterinary Surgery and Radiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India.
[4]Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India.

Corresponding Author: S.S. Biswal, Department of ARGO, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, Odisha, India. Email: ssbiswal@ouat.ac.in

How to cite this article: Arik, A.D., Biswal, S.S., Patra, B.K., Behera, H., Sathapathy, S., Behera, S.S., Sahoo, A.K. and Kanungo, S. (2025). Comparative Studies on the Effect of Synchronization Protocols on Estrus Response, Ovulation Time and Conception Rate in Boer Goats during Early Breeding Season in Odisha. *Indian Journal of Animal Research*. **1-6.** doi: 10.18805/IJAR.B-5577.

Submitted: 03-03-2025 **Accepted:** 07-07-2025 **Online:** 21-07-2025

Efficient synchronization of estrus can significantly improve breeding efficiency by aligning the reproductive cycles of the female herd, enabling more predictable and controlled mating.

The use of the Controlled Internal Drug Release (CIDR) device, which contains progesterone, is a widely utilized method for estrus synchronization in various livestock species, including goats (Knights and Knights, 2016). The CIDR is inserted into the vagina for a set period (typically 5, 7, 9, or 12 days), during which it releases progesterone to inhibit estrus. Upon removal, a hormonal protocol such as prostaglandin ($PGF_{2\alpha}$) is often administered to induce estrus. Understanding the periovulatory events, such as the luteinizing hormone (LH) surge and follicular maturation, is crucial for optimizing synchronization protocols, as ovulation in goats typically occurs 20-26 hours after the LH surge. In addition to hormonal treatments, assisted reproductive technologies (ARTs), including the use of progestogens, estrogens, $PGF_{2\alpha}$, PMSG, HCG and GnRH, are employed to regulate estrus and ovulation, making breeding more efficient and predictable. Progesterone assays and real-time ultrasonography are valuable tools for monitoring estrus and early pregnancy detection, providing quick, non-invasive and reliable methods for assessing reproductive status.

While CIDR-based protocols have been well established in some species, their use in goats, particularly in tropical regions, remains relatively under explored. Gaining a deeper understanding of CIDR-based estrus synchronization could greatly benefit goat farming by improving estrus detection, reducing labor costs and enhancing the uniformity of offspring. This could lead to more efficient breeding programs and higher productivity in goat production systems. Therefore, this study was carried out with the objective of comparing two estrus synchronization protocols on estrus response, ovulation time and conception rate in Boer goats during early breeding season in Odisha.

MATERIALS AND METHODS

Study area and animal selection

The experiment was conducted between mid-July to late September 2024, in a private goat farm located in Bhadrak district of Odisha with gps coordinates of 21°3′4.2552″ N and 86°29′8.6928″ E. Animals were first screened by ultrasonography and healthy breedable non-pregnant does within first to third parity were selected for the present study. Deworming and mineral supplementation were done 15 days before the start of experiment. At the initial stage of experiment, basic information regarding reproductive and productive traits of goats was ascertained from the owner.

Experimental design

A total of 20 pure Boer breed does were selected for present study. The goats selected were reared under same managemental practices. Synchronization of estrus was carried out using 2 different protocols. Does were equally allotted to 2 experimental groups and were subjected to various hormonal treatments randomly.

Group 1 (n=10): Does were synchronized for estrus using controlled internal drug releasing devices (EAZI-BREED CIDR®) *inserted intravaginally and kept for 11 days. The animals received a single dose of *i.e.*- 125 microgram of Clostenol** a day before (10^{th} day) device removal and 4 µg Buserelin acetate (Gynarich) IM on day of implant removal.

Group 2 (n=10): Does were synchronized by double $PGF_2\alpha$ protocol (Clostenol**, 125 mg, IM) at an interval of 11 days.

Experimental procedures

CIDR insertion

The hind quarter of the animal was cleaned thoroughly with soap solution and the vaginal area was again disinfected using the Chlorhexidine spray. A lubricating jelly (Lubitas gel) * was then applied over the applicator and distributed evenly to ease the insertion process. Finally, the tail of the animal was lifted and external vaginal lips were exposed to insert the applicator to full length. The pistol of the applicator was then pushed completely and applicator was removed slowly. A thin nylon tail was seen hanging from the vagina which indicated that the device was successfully inserted.

Estrus response, onset and duration

After the end of the treatment protocols , teaser buck was used to detect the estrus signs such as tail wagging, bleating, mounting, frequent urination ,contraction of vulva and vaginal mucus discharge. The efficacy of different estrus synchronization protocols in the present study were expressed in terms of estrus response, time taken for onset of estrus and duration of estrus. The estrus response was calculated by the number of does in estrus divided by number of does treated and expressed in percentage. The time of onset of estrus was calculated after CIDR removal and last $PGF_{2\alpha}$ injection to the time of first appearance of estrus symptoms for group I and group II does. The duration of estrus was calculated from the time of first acceptance of mating to time of last acceptance of mating by buck.

Progesterone and LH estimation

Blood samples were collected on the day 0 (start of protocol), day 12 (after 24 hrs of end protocol) and day 35 (from day of mating) from the experimental animals. The blood for estimation of hormone concentrations was taken from jugular vein of boer goats using a 5 ml disposable syringe. The centrifuge was carried out at 2500rpm for 15 minutes and serum was extracted into a micro tube. The serum was stored in freezer of -20° until further analysis. Progesterone concentrations of the does were measured on the day 0, day 12 and day 35 by enzyme linked immunosorbent assay (ELISA) using progesterone kits. The LH concentrations were measured on day 0 and day 12 by using ELISA commercial kits.

Pregnancy diagnosis

Does after coming to the estrus were mated twice with an interval of 24 hrs. Pregnancy was assessed individually in each experimental animals, that did not return to estrus by ultrasonography method. Ultrasonographic examination was performed transabdominally after 35 days post breeding.

Conception rate

The conception rate was calculated using the following formula:

$$\text{Conception rate} = \frac{\text{Number of animals conceived}}{\text{Number of animals bred}} \times 100$$

Statistical analysis

The time for onset of estrus, duration of estrus, progesterone and LH concentration at various days of sampling, pregnancy diagnosis and conception rate data were collected and analysed by using IBM SPSS 29.0 software.

RESULTS AND DISCUSSION

Estrus response, onset and duration

The estrus response for both group I and group II animals were similar (100%) *i.e* all thedoes came to estrus. The onset of estrus in CIDR treated group was (28.80±1.20 hours) which was significantly earlier than that of double $PGF_{2\alpha}$ treated group (40.20±1.30 hours).The duration of estrus (hrs) was observed to be longer in group I animals (37.70±0.75) in comparison to group II animals (33.60±0.54) (Table 1).

The behavioural and physical signs of estrus were observed by visual examination as well as by using teaser bucks. Vocalization and tail wagging was observed in almost all animals but clustering around buck was observed in 70 per cent of animals in group I whereas only 50 per cent of animals showed that symptom in group II. Frequent urination was observed in 90 percent of animals while the buck teasing was observed in 80 per cent of animals for CIDR treated group. For $PGF_{2\alpha}$ treated group frequent urination and buck teasing was observed in 60 and 70 per cent of does respectively. Oedema of vulva was observed in 80 and 50 per cent of animals for group I and II respectively. Vaginal discharge was observed in more number of does (80%) in $PGF_{2\alpha}$ treated group in comparison to CIDR treated group (70%).

The serum progesterone concentration (ng/ml) was observed to be 1.31±0.13 on day 0, 0.70±0.12 after 24 hrs of CIDR removal and 5.94±1.29 on day 35 post breeding for group I does. A significant decrease ($p<0.05$) in progesterone level was observed between day 0 to day 12 but the concentration of progesterone increases significantly ($p<0.01$) between day 0 and day 35 as well as day 12 and day 35. For group II does the progesterone concentration was found to be 1.13±0.13, 0.96±0.14 and 3.73±0.53 on day 0, 12 and 35 respectively. Though there was a decrease in progesterone concentration observed between day 0 to day 12 but the difference was not significant. A significant increase in progesterone concentration ($p<0.01$) was observed between day 0 to day 35 and day 12 to day 35 post breeding. The serum Leutinizing Hormone (LH) concentration (ng/ml) was estimated on day 0 and day 12. The concentration of LH was found to be 1.96±0.16 and 11.15±0.543 on day 0 and 12 respectively for CIDR treated group whereas 1.96±0.09 and 11.03±0.58 values were observed for double $PGF_2\alpha$ treated group. A significant ($p<0.01$) increase in values for LH concentration were observed between day 0 and day 12 for both the groups but no significant differences were observed between the groups for day 0 and day 12.

Ultrasonographic examination was conducted after 35 days of post breeding to rule out the pregnant does. Eight out of ten does (80%) were found to be pregnant for CIDR treated protocol group whereas six out of ten does (60%) were found to be pregnant with double $PGF_2\alpha$ protocol.

Table 1: Comparison of reproductive performances between two different synchronization protocols in boel goats.

Variables	Synchronization protocol	
	CIDR based protocol	Double $PGF_{2\alpha}$ protocol
No. of goats	10	10
Esrus response	10 (100%)	10 (100%)
Duration of onset of estrus (hours)	28.80±1.20[a]	40.20±1.30[b]
Duration of estrus (hours)	37.70±0.75[a]	33.60±0.54[b]
Progesterone concentration (ng/ml)		
Day 0	1.31±0.13[a]	1.13±0.13[a]
Day 12	0.70±0.12[b]	0.96±0.14[a]
Day 35	5.94±1.29[c]	3.73±0.53[b]
LH concentration (ng/ml)		
Day 0	1.96±0.16[a]	1.96±0.09[a]
Day 12	11.15±0.54[b]	11.03±0.58[b]
Conception rate	80%	60%

[a,b,c]Means bearing different superscripts differ statistically ($p<0.05$).

Both the synchronization protocols were equally effective in inducing estrus in boer goats during early breeding season. The result of the present study where does were treated with CIDR corroborates with result of Motlomelo *et al.* (2002) and Gore *et al.* (2020) who studied on estrus response of boer and toggenburg breeds. However greling and van der nest (2000) reported lower estrus response (85%) in boer goats. The estrus induction rate was 100 per cent in the present study using double $PGF_2\alpha$ protocol. The result was comparable with the results of Compton (2009), Fonseca *et al.* (2018) and Parmar *et al.* (2020) using similar protocol. However lower estrus response (79.30 and 81.25%) was observed by Sumeldan *et al.* (2015) and Abera (2017) as compared to the present finding. These differences in estrus response might be attributed to variations in genotype, breed, age, parity and individual animal responses.

The mean onset of estrus interval following CIDR withdrawal was observed to be 28.80±1.20 hours, This onset of estus interval is shorter than 53.2±27.5 as reported by Greyling and Van der Nest (2000) on Boer goats. However shorter period (27.2±0.4) of onset of estrus was observed by Motlomelo *et al.* (2002) in Boer goats. In the present study comparatively longer (40.20±1.30 hours) onset of estrus interval was observed for double $PGF_{2\alpha}$ protocol than CIDR protocol. On contrary to the present study Parmar *et al.* (2020) observed a longer onset of estrus period (52.33±1.15 hr) in Sruti goats and El-Sherry *et al.* (2012) reported shorter onset of estrus (37.2± 5.3 hr). The duration of estrus for group I was observed to be 37.70±0.75 hr. The shorter duration of estrus 35.2±0.7 hours and 31.32±0.53 hr were observed by Motlomelo *et al.* (2002) in boer goats and Gore *et al.* (2020) in toggenburg goats. For group II duration of estrus was 33.60±0.54 hr. The findings of the present study contradicts the finding of Parmar *et al.* (2020) who observed 28±0.54 hr in Sruti goats and Wondim *et al.* (2022) reported 40±1.24 hr in Abergele goats. The differences in the above parameters might be due to breed, nutrition and season (Ahmed *et al.*, 1998).

The behavioural signs observed in the present study were similar to those reported by Oleforuh-Okoleh *et al.* (2021), Salleh *et al.* (2021) and Patel *et al.* (2023). The continuous slow release of progesterone from CIDR controls optimal coordination of endocrine events and triggered pronounced estrus signs following the rebound phenomenon after CIDR withdrawal. Vaginal discharge and vulvar edema were noted in both experimental groups, with Group I showing the highest response. Salleh *et al.* (2021) reported vulval discharge and vulvar edema rates of 52.38% and 71.43%, respectively. These discrepancies in physical characteristics may be attributed to variations in estrogen profiles, genotype, induction effects and observation methods. Additionally, the physical signs in the experimental groups may have been influenced by the administration of exogenous hormones.

The increase in progesterone concentration was noticed from day 12 (0.70 ng/ml) to day 35 post breeding (5.94 ng/ml). Al-Sobaiyl (2010) reported a progesterone concentration of 0.5 ng/ml, 48 hours post CIDR removal and 3.75 ng/ml on day 30 post mating. Similar findings to the present was observed by Kanduri *et al.* (2022) who reported a concentration of1.83±0.21 on day 0 and 0.78±0.04 on day of estrus following sponge treatment. He also reported a concentration of 1.38±0.12 and 0.77±0.02 on day 0 and day of estrus respectively following double $PGF_2\alpha$ protocol which is in agreement with the present study. Panjaitan *et al.* (2020) reported a progesterone concentration of (5.05±7.75) on day 21 after mating in comparison to the present study (3.73±0.53) for double $PGF_2\alpha$ protocol which corroborates the present study.

In the present study, the serum LH level was not affected by the protocol used for synchronization *i.e.* 11.15±0.54 Vs 11.03±0.58 in group I and group II respectively. But Greyling and Van Niekerk (1990) mentioned in their report that after onset of estrus the mean interval to LH peak is constant irrespective of the method used for estrous synchronization. Martínez-Alvarez *et al.* (2007) found highest concentration of LH was 19.8±2.9 ng/ml, which was higher than the present findings. This variation might be due to the timing of sampling in our study (24 hours after end of protocol). They also mentioned that average interval between estrus to LH peak was 14.9±1.8 hrs. The interval between the end of treatment and sequence of events such as signs of estrus, pre-ovulatory LH peak and ovulation will be affected by types of progestogen, its route of administration, dose and duration of treatment Martínez-Alvarez *et al.* (2007).

During ultrasongraphic examination, the conception rate with CIDR protocol and double $PGF_{2\alpha}$ protocol were 80 percent and 60 percent respectively. Motlomelo *et al.* (2002) and Gore *et al.* (2020) reported low conception rate of 47 per cent and 79 per cent using CIDR protocols in Boer and Toggenberg breeds respectively, which contradicts the present study. Andrabi *et al.* (2015) and Bowdridge *et al.* (2013) using double $PGF_{2\alpha}$ protocol reported a conception rate of 71 and 68 per cent respectively, which was higher than the present study. Lower conception rate of 44 per cent was reported by Parmar *et al.* (2020). Abera (2017) showed 61 per cent conception rate which was similar to that of present finding. Higher conception rate of 77 per cent and 75 per cent was reported by Compton (2009) and Pujar *et al.* (2016) using double $PGF_{2\alpha}$ protocol.

CONCLUSION

From the current study, it was concluded that the CIDR based protocol and double $PGF_2\alpha$ protocol were more or less equally efficient in synchronization of estrus during early breeding season in Boer goats. However, in CIDR based protocol, shorter interval of estrus induction and better conception was observed indicating more effectiveness and reliability of this protocol during early breeding season.

ACKNOWLEDGEMENT

The authors wish to acknowledge Prof. Lionel Dawson, department of theriogenology, boren veterinary teaching hospital, oklahoma state university, USA for providing EAZI-BREED CIDR® for goats to undertake this study.

Conflict of interest

There is no conflict of interest among the authors.

REFERENCES

Abera, A.G. (2017). Effect of Estrus and Ovulation Synchronization Protocols in Local Goats during the Breeding Season. M.Sc. Thesis. Mekelle University, Ethiopia.

Ahmed, M.M., Makwi, S.E. and Jabura, A.S. (1998). Synchronisation of oestrus in Nubian goats. *Small Ruminant Research*. **30:** 113-120.

Al-Sobaiyl, K.A. (2010). Effect of breeding season and pregnancy status on serum progesterone, sodium, potassium, copper and iron of estrous synchronized Aradi goat does. *Saudi Journal of Biological Sciences*. **17:** 259-263.

Andrabi, S.M.H., Anwar, M. and Mehmood, A. (2015). Efficacy of short term estrus synchronization protocols and timed artificial insemination in sub-tropical goats. *Journal of Animal and Plant Science*. **25:** 298-300.

Bolacali, M., Ozturk, Y., Yilmaz, O., Kucuk, M. and Karsli, M.A. (2017). Effect of genotype and non-genetic factors on growth traits and survival rates in Turkish indigenous hair goats and their first cross with boer bucks. *Indian Journal of Animal Research.* **51(6):** 975-981. doi: 10.18805/ijar.B-716.

Bowdridge, E.C., Knox, W.B., Whisnant, C.S., Farin, C.E. and Synch, N.C. (2013). A novel, progestagen-free protocol for ovulationsynchronization and timed artificial insemination in goats. *Small Ruminant Research*. **110:** 42-45.

Compton, E.C. (2009). Ovulation Synchronization and Timed Artificial Insemination in Goats. M.Sc. Thesis. Faculty of North Carolina State University, Raleigh, North Carolina, USA.

El-Sherry, T.M., Derar, D.R., Hayder, M., Hamdon, H. and Saifelnasr, E. (2012). Effect of progesterone and prostaglandin analogue based synchronization programs on the follicular dynamics and conception rate at two different breeding seasons in subtropical ewes. *Assiut Veterinary Medical Journal*. **58(135):** 88-95.

Fonseca, J.F., Torres, C.A.A., Costa, E.P., Maffili, V.V., Carvalho, G.R. and Alves, N.G. (2018). Progesterone profile and reproductive performance of estrus-induced Alpine goats given hCG five days after breeding. *Animal Reproduction*. **2:** 54-59.

Gore, D.L.M., Mburu, J.N., Okeno, T.O. and Muasya T.K. (2020). Short-term oestrous synchronisation protocol following single fixed-time artificial insemination and natural mating as alternative to long-term protocol in dairy goats. *Journal of Small Ruminant Research*. **192:** 106207.

Greyling, J.P.C. and Van Der Nest, M. (2000). Synchronisation of oestrus in goats: Dose effect of progestagen. *Small Ruminant Research*. **36:** 201-207.

Greyling, J.P.C. and Van Niekerk, C.H. (1990). Ovulation in the boer goat doe. *Small Ruminant Research.* **3:** 457-464.

Kanduri, A.K.R., Reddy, K.C.S., Venkata Ramana, K., Venkateshwarlu, M., Swathi, B. and Kannegundla, U. (2022). Study on estrus traits and progesterone profile during different estrus synchronization protocols in local goats. *The Pharma Innovation Journal*. **11(7):** 2052-2059.

Knights, M. and Knights, D.S. (2016). Use of controlled internal drug releasing (CIDR) devices to control reproduction in goats: A review. *Animal Science Journal.* **87(9):** 1084-1089.

Martınez-Alvarez, L.E. andez-Ceron,J. H.,Alez-Padilla, E.G., Perera-Marın, G. and Valencia, J. (2007). Serum LH peak and ovulation following synchronized estrus in goats. *Small Ruminant Research*. **69:** 124-128.

Molale, G., Antwi, M.A., Lekunze, J.N. and Luvhengo, U. (2017). General linear model analysis of behavioural responses of boer and tswana goats to successive handling. *Indian Journal of Animal Research.* **51(4):** 781-784. doi: 10.18805/ijar.10986.

Motlomelo, K.C., Greyling, J.P.C. and Schwalbach, L.M.J. (2002). Synchronisation of oestrus in goats: The use of different progestagen treatments. *Small Ruminant Research*. **45:** 45-49.

Nogueira, D.M., Cavalieri, J., Gummow, B. and Parker, A.J. (2015). The timing of the commencement of the breeding season in Boer and rangeland goats raised in the tropics of Queensland, Australia. *Small Ruminant Research*. **125:** 101-105.

Oleforuh-Okoleh, V.U., Laven, R., Obianwuna, U.E., Olorunleke, S.O. and Emeka, O.C. (2021). Influence of short-term synchronization protocol and fixed timed AI on oestrus synchronization response, oestrus behaviour and pregnancy rate of two breeds of Nigeria indigenous goats. *Nigerian Journal of Animal Science*. **23(3):** 53-59.

Panjaitan, B., Dewi, A., Nasution, F.F., Adam, M., Siregar, T.N. and Thasmi, C.N. (2020). Comparison of estrus performance and progesterone level of kacang goats induced by $PGF_{2\alpha}$ versus ovsynch protocol. *In E3S Web of Conferences*. **151:** 1-45.

Parmar, C.P., Dhami, A.J., Patel, J.A. and Belsare, V.P. (2020). Efficiency of different estrus synchronization protocols in Surti goats. *The Indian Journal of Veterinary Sciences and Biotechnology*. **15:** 21-23.

Patel, S., Chaudhary, S., Puri, G. and Singh, V.K. (2023). Effect of progestin based estrussynchronization protocol on estrus parameters, hormonal profile and vaginal cytology in surti goats. *Indian Journal of Veterinary Sciences and Biotechnology*. **19(1):** 57-60.

Pujar, C., Puro, N.A., Markandeya, N.M., Mali, A.B. and Kumawat, B.L. (2016). Studies on efficacy of selectsynch and ovsynch protocols for induction and synchronization of estrus in Osmanabadi goats. *International Journal of Science Environment and Technology*. **5:** 4069-4073.

Salleh, S.M., Basri, A.M.I.H. and Yaakub, H. (2021). Study of sexual behaviours with different types of estrus synchronization protocols in boer goats. *Animal Reproduction*. **18(3):** 202-208.

Sumeldan, J.D., Ocampo, L.C., Atabay, E.P., Celestino, E.F., Lazaro, J.V. and Ocampo, M.B. (2015). Comparison on the efficiency of estrus synchronization methods for artificial insemination in goats. *Journal of Agricultural Technology.* **11(8):** 2489-2497.

Sanchez, C.B., Salvana, F.R.P., Sepelagio, E.G. and Cardenas, L.B. (2020). Challenges in goat production faced by halal goat raisers in region XII (SOCCSKSARGEN), philippines. *Indian Journal of Animal Research*. **40(1):** 77-83. doi: 10.18805/ag.D-209.

Wondim, B., Taye, M., Alemayehu, K., Rouatbi, M., Getachew, T. and Haile, A. (2022). The efficiency of estrus synchronization protocols and artificial insemination in the Abergelle goat on-station and on-farm conditions of Northern Ethiopia. *Journal of Applied Animal Research*. **50:** 518-525.

Zarkawi, M. and Al-Daker, M.B. (2013). Determination of certain reproductive and productive parameters in female mountain (Jabali) and crossbred goats during different age stages. *Archiva Zootechnica*. **16(2):** 15-30.