

## Factors that influence ovulation in animal reproduction: A literature review

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### Abstract

Ovulation is a complex process influenced by various genetic, hormonal, and environmental factors. This study aims to conduct a literature review of factors affecting ovulation, focusing on their correlation with contraception, assisted reproductive technology, and reproductive efficiency in livestock. The research method follows a literature review approach, with sources obtained from Scopus-indexed journals between 2015 and 2024. The analysis results indicate that genetic mutations, particularly in the leptin receptor gene (LEPR), can affect delayed puberty and reduced ovulation rates. Additionally, hormonal regulation through pre-synchronization of ovulation and artificial insemination increases reproductive success rates in cattle. Environmental factors, such as seasonal reproductive patterns and delayed implantation, also play a significant role in reproductive efficiency in certain species. This study highlights the importance of understanding ovulation regulation to develop more effective reproductive strategies in both livestock farming and wildlife conservation.

**Keywords:** Ovulation; Hormonal Regulation; Genetic Factors; Artificial Insemination.

### 1. Introduction

Reproduction in animals is a crucial factor in population sustainability and production efficiency, both in the livestock industry and in the conservation of wild species. Research on reproductive mechanisms encompasses various aspects, including genetic, hormonal, and environmental factors that influence ovulation, fertilization, and pregnancy success rates. Ovulation is a complex process controlled by various hormonal factors and plays a crucial role in human and animal reproduction. Timing ovulation regulation is an essential strategy in multiple fields, including contraception, assisted reproductive technology, and artificial insemination efficiency in livestock. Several studies have highlighted how hormonal manipulation can delay or inhibit ovulation, which can be utilized for various reproductive purposes. Genetic factors play a vital role in regulating the fertility of reproductive organs in animals. Mutations in the leptin gene affect reproductive efficiency, associated with delayed puberty, reduced ovulation rates, and decreased pregnancy success.

Other factors include pre-synchronization ovulation techniques to increase artificial insemination success with sex-sorted semen. The importance of hormonal regulation in ovulation synchronization aims to enhance reproductive efficiency, particularly in modern livestock production systems (Oosthuizen et al., 2021). Another factor is the seasonal reproductive patterns in various carnivorous species, considering geographical factors, delayed implantation, and induced ovulation. Studies indicate that reproductive mechanisms in wild animals heavily depend on environmental factors and physiological adaptations that allow them to sustain species survival. Hormonal contraception is a primary method for inhibiting ovulation. The effectiveness of progestin-only contraceptive pills (drospirenone/DRSP) compared to combination pills (ethinyl estradiol-gestodene/EE-GS) in inhibiting ovulation and affecting cervical mucus permeability is analyzed (Ratanasaengsuang et al. (2024).

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In the context of assisted reproductive technology, ovulation delay also has significant benefits. Progestin-based ovarian stimulation (PPOS) can suppress luteinizing hormone (LH) levels and progesterone receptor (PGR) expression, contributing to ovulation delay (Xie et al. (2023)).

These studies are interconnected in terms of ovulation regulation for various purposes. Whether in contraception, assisted reproductive technology, or artificial insemination efficiency, hormonal manipulation of ovulation timing provides significant benefits. With a better understanding of these mechanisms, new strategies can be developed to improve contraception effectiveness, IVF success, and reproductive efficiency in the livestock industry.

## 2. Methods and searching strategies

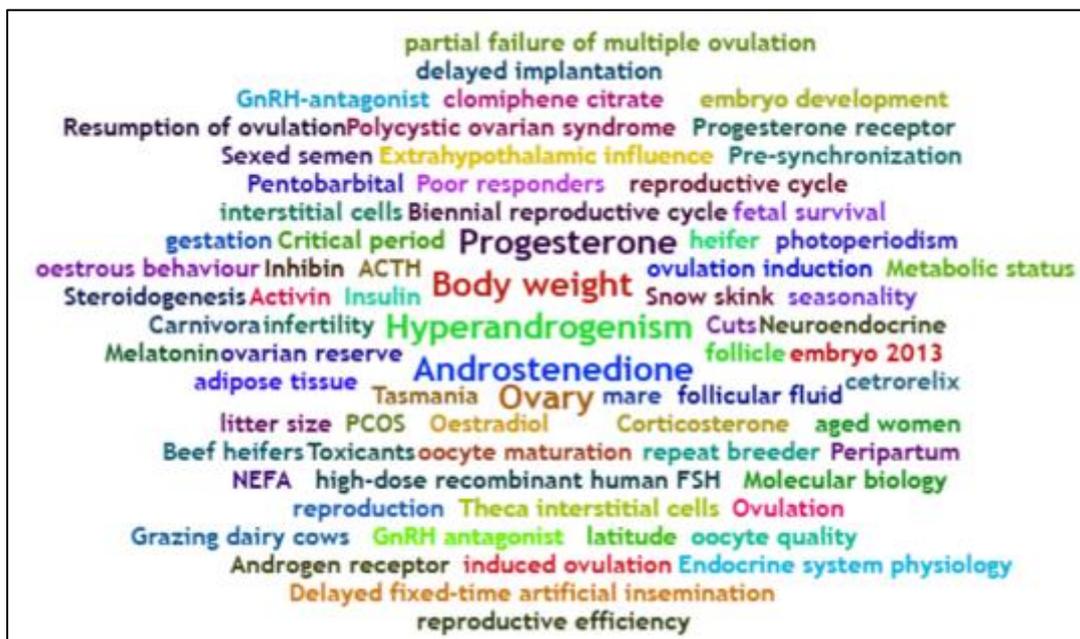
This research follows the literature review guidelines using the Watase Uake website. All searches were limited to the years 2015 to 2024. To ensure that only materials written in English were included, several restrictions were applied. Journals indexed in Scopus formed the basis of the database. The Watase Uake website was systematically used to assist in finding papers. Researchers felt that other sources could improve the study quality, so additional materials were included besides those obtained from Watase Uake. A total of five papers were considered for inclusion in this review after all full texts were obtained.

### 2.1. Criteria

Publications included were articles written in English discussing reproductive mechanisms, including genetic, hormonal, and environmental factors influencing ovulation and fertilization. Exclusion criteria included studies conducted before 2015, data unrelated to reproductive mechanisms, and missing data, which were considered disqualifying factors for this study.

### 2.2. Article data extraction

Of the fifty-three publications examined using titles and abstract keywords, five articles were deemed suitable for study after reading the full text. A brief review of the data included a word cloud generated from the Scopus database search, the distribution of countries where the research was conducted, a table listing authors and publication years, study objectives, and conclusions.



**Figure 1** The Word cloud generated using Watase Uake website from Scopus database search

## 3. Discussion

Based on the review of the three journals, several connections can be concluded regarding reproductive regulation in animals, both in livestock and wild populations.

### 3.1. Genetic and Hormonal Factors in Reproductive Regulation

According to Juengel et al. (2015), mutations in the leptin receptor gene can affect puberty, ovulation, and pregnancy rates in sheep. Female sheep homozygous for the LEPR mutation have an ovulation rate 15% lower than wild-type or heterozygous sheep. The conception rate at first service decreased by 12% in homozygous sheep compared to wild-type or heterozygous ones. The number of lambs born also declined, averaging 0.2 fewer per birth compared to non-mutated sheep.

Oosthuizen et al. (2021) demonstrated that hormonal regulation through pre-synchronization of ovulation and artificial insemination with sex-sorted semen can increase pregnancy success rates in cattle. Pregnancy rates were higher in the PRE72-SEX group (46.1%) compared to the CTRL54-SEX group (36.9%). No significant difference was found between the CTRL54-CNV (50.4%) and PRE72-SEX (46.1%) groups, indicating that this method can improve the efficiency of sex-sorted semen use.

Heldstab et al. (2018) highlighted how some carnivore species have reproductive mechanisms influenced by environmental factors, including delayed implantation, which allows them to have more flexible reproductive seasons by postponing embryo development until environmental conditions are more favorable. Additionally, induced ovulation is found in some species, meaning ovulation only occurs when a mating partner is available, increasing reproductive success rates. This indicates that besides genetic and hormonal factors, the environment also plays a role in reproduction.

Animal reproduction is influenced by a combination of genetic factors (mutations in the leptin receptor), hormonal factors (ovulation synchronization and artificial insemination), and environmental factors (seasonal reproductive patterns and delayed implantation).

### 3.2. Ovulation Synchronization and Reproductive Efficiency

Juengel et al. (2015) noted that mutations in the leptin receptor gene could lead to delayed puberty and reduced ovulation rates in sheep, ultimately affecting fertility.

Oosthuizen et al. (2021) proved that with pre-synchronization of ovulation, pregnancy rates could increase, especially with the use of sex-sorted semen. This shows that ovulation timing regulation is crucial in ensuring reproductive success.

Heldstab et al. (2018) observed that some carnivore species have induced ovulation mechanisms, meaning they ovulate only when there is a mating stimulus. This suggests an evolutionary strategy to ensure reproductive efficiency.

These three studies discuss how ovulation timing regulation, whether through genetic interventions, hormonal control, or natural evolutionary mechanisms, can influence reproductive success rates.

### 3.3. Implications for Reproductive Management in Livestock and Conservation

Juengel et al. (2015) provide insights into how genetic selection can be used to improve reproductive efficiency in sheep farming.

Oosthuizen et al. (2021) show that pre-synchronization techniques can be applied in cattle farming to increase pregnancy rates and productivity.

Heldstab et al. (2018) reveal that reproductive patterns in wild animals heavily depend on environmental conditions, which can aid in the conservation management of endangered species.

### 3.4. Ovulation Regulation in Hormonal Contraception

A study by Ratanasaengsuang et al. (2024) examined the effectiveness of progestin-only pills (DRSP 4 mg) compared to a combination of ethinyl estradiol-gestodene (EE/GS) in inhibiting ovulation. The results showed that DRSP inhibited ovulation in 88.9% of participants, while EE/GS inhibited ovulation in 77.8% of participants. Cervical mucus changes: Most participants experienced changes that did not support fertilization within the first 7 days, indicating contraceptive effectiveness. Side effects: DRSP caused higher rates of unscheduled bleeding (55.56%) compared to EE/GS (10%). This study suggests that ovulation inhibition through progestin can be an effective contraception strategy, which is relevant to other research by Xie et al. (2023) that also highlights how LH suppression in progestin-based ovarian stimulation (PPOS) protocols can delay ovulation, even in the context of in vitro fertilization (IVF).

### 3.5. Delayed Ovulation in Assisted Reproductive Technology

Xie et al. (2023) studied how Progestin-Primed Ovarian Stimulation (PPOS) protocols suppress ovulation by reducing Luteinizing Hormone (LH) levels and progesterone receptor (PGR) expression. Key findings include a decrease in LH levels before ovulation trigger (hCG) in the PPOS group compared to the control group. A significant reduction in PGR expression in preovulatory follicles in the PPOS group. Increased fertilization success due to more mature oocytes obtained.

This principle was also found in Oosthuizen et al. (2021), where delaying insemination timing in young heifers that underwent pre-synchronization of ovulation increased the chances of fertilization success with sex-sorted semen.

### 3.6. Ovulation Synchronization for Livestock Reproductive Efficiency

This study confirms that controlled ovulation delay can improve pregnancy rates when artificial insemination is performed closer to the actual ovulation time.

Research findings indicate Pregnancy success rates (PR/AI) were higher when insemination was performed 72 hours after CIDR removal compared to 54 hours. Estrus expression rates were higher in groups that experienced delayed TAI. The success rate of sex-sorted semen was lower than conventional semen but could be improved with pre-synchronization of ovulation.

This supports the findings of Xie et al. (2023), which show that ovulation timing regulation can provide more optimal fertilization outcomes. Additionally, the principles of LH inhibition and hormonal changes observed in Ratanasaengsuang et al. (2024) are also relevant in this context, as LH level regulation can be used to adjust ovulation timing.

**Table 1** Summary of Selected Articles

No	Author and year	Aim of the study	Conclusion
1	Juengel et, al. (2015)	Investigating whether mutations in the leptin receptor gene (LEPR), known to be associated with delayed puberty onset, also impact decreased ovulation rates, first conception, and the number of lambs born in Davigdale sheep flocks.	The research findings indicate that sheep carrying specific mutations in the LEPR gene experience significant reductions in ovulation rates, first-service conception rates, and the number of lambs born. Thus, these mutations contribute to decreased reproductive efficiency in productive sheep.
2	Oosthuizen et, al. (2021)	Evaluating the impact of pre-synchronization of ovulation and delayed timed artificial insemination (TAI) on pregnancy rates in female cattle, particularly when using sex-sorted semen.	Pre-synchronization strategies to align ovulation timing, when followed by delayed TAI, have been shown to increase pregnancy rates (PR/AI) in female cattle. These findings indicate that adjusting insemination timing, especially when using sex-sorted semen, can optimize reproductive outcomes in cattle farming systems.
3	Heldstab et, al. (2018)	Identifying and analyzing the key factors influencing seasonal reproduction in carnivores, with a focus on the role of geographical origin, delayed implantation, and ovulation type (induced or spontaneous).	This study concludes that variations in seasonal reproductive patterns in carnivores can be explained by factors such as latitude of origin, delayed implantation strategies, and ovulation mechanisms. Species that adapt to delayed implantation or induced ovulation tend to adjust their reproductive cycles to align with optimal environmental windows, increasing the chances of offspring survival.
4	Ratanasaengsuang et, al. (2024)	Investigating the effectiveness of progestin-only pills (4 mg drospirenone/DRSP) compared to combination pills (ethinyl estradiol	The research findings indicate that DRSP pills have an ovulation inhibition rate comparable to EE-GS, with success rates of 88.9% and 77.8%, respectively. However, the DRSP group

		0.02 mg + gestodene 0.075 mg/EE-GS) in inhibiting ovulation and affecting cervical mucus permeability. This study also evaluates whether DRSP use in a "delayed-start" method can still effectively inhibit ovulation compared to EE-GS.	experienced a higher incidence of unscheduled bleeding compared to EE-GS. Thus, DRSP-only pills can be an effective contraceptive alternative, although some side effects need to be considered.
5	Xie, Yating et, al. (2023)	Investigating how the Progestin-Primed Ovarian Stimulation (PPOS) protocol can delay ovulation by suppressing luteinizing hormone (LH) levels and progesterone receptor (PGR) expression. This study aims to understand the mechanisms of ovulation regulation in ovarian stimulation procedures that may influence oocyte retrieval timing in in vitro fertilization (IVF).	This study found that PPOS can delay ovulation by suppressing LH receptor and PGR expression in preovulatory follicles, inhibiting progesterone production after ovulation trigger (hCG). This ovulation delay can increase the maturation rate of oocytes obtained during the IVF procedure, ultimately potentially improving fertilization and implantation success rates.

#### 4. Conclusion

Each of these articles is interconnected in understanding the factors influencing animal reproduction. Juengel et al. (2015) highlighted the role of genetic factors in sheep reproduction, Oosthuizen et al. (2021) emphasized the importance of hormonal manipulation to enhance reproductive efficiency in cattle, and Heldstab et al. (2018) discussed how environmental factors and evolutionary strategies influence reproductive patterns in carnivores. By understanding the relationship between genetic, hormonal, and environmental factors, we can optimize reproductive strategies in livestock farming and support conservation efforts for wild species.

These three journals demonstrate that regulating ovulation timing through hormonal manipulation significantly impacts reproductive success, whether in preventing pregnancy (contraception), improving in vitro fertilization (IVF) outcomes, or enhancing reproductive efficiency in livestock. The biological mechanisms examined in each study show a strong correlation between LH inhibition, progesterone receptor (PGR) expression, and effects on oocyte maturation and ovulation timing.

Overall, these studies lead to the conclusion that ovulation control can be utilized for various medical and industrial purposes, including developing more effective contraception, improving IVF success rates, and optimizing reproductive systems in livestock.

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