Endocrine, Nutritional and Photothermal Modulation of Gestation Length in Crossbred Goats (Capra hircus): A Controlled Trial of Hormonal Induction, Metabolic Markers and Environmental Management to Optimize Parturition Timing and Kid Viability

[1]Manan E. Undong, [1]Taskier S. Musa, [1]Shiela Mae A. Dionaldo, [1]Sittie Aina B. Mohamad, [1]Ma. Fe G. Cordon, [2] Lumina D. Cabilo

[1]Mindanao State University Maguindanao, Datu Odin Sinsuat, Maguindanao del Norte, Philippines
[2]Cotabato Foundation College of Science and Technology, Doroluman Arakan Cotabato, Philippines

Abstract
This study evaluated the feasibility of shortening gestation length in crossbred Anglo-Nubian × native goats (Capra hircus) through endocrine induction, while monitoring maternal metabolic status, natural photothermal conditions, and neonatal viability under tropical conditions. Twenty pregnant does were randomly assigned to a control group (natural parturition) and an induced group receiving prostaglandin $F_2\alpha$ (15 mg) and dexamethasone (10 mg) on day 144 of gestation. Gestation length, parturition timing, maternal endocrine and metabolic biomarkers (progesterone, cortisol, IGF-1, leptin, glucose, β-hydroxybutyrate), ambient temperature and light conditions, and neonatal outcomes were assessed.
Hormonal induction significantly reduced gestation length by approximately four days ($p < 0.01$) and synchronized parturition without increasing maternal stress or metabolic imbalance. Progesterone declined rapidly following induction, mimicking natural luteolysis, while cortisol responses were comparable between groups. Metabolic biomarkers remained within physiological ranges, indicating adequate nutritional support. Birth weights, neonatal vigor, and survival to weaning did not differ between induced and control kids. The findings demonstrate that controlled endocrine induction near term can safely modulate gestation length in crossbred goats without compromising neonatal viability, offering a practical reproductive management strategy for tropical smallholder and institutional goat production systems.

Keywords: Gestation length modulation; Prostaglandin $F_2\alpha$; Dexamethasone induction; Endocrine biomarkers; Photothermal environment; Neonatal viability; Metabolic profiling

Introduction

Gestation in goats (Capra hircus) normally lasts about 145–155 days (≈150 days). Maintaining this pregnancy depends on high progesterone from the corpus luteum, which drops sharply 12–24 h before kidding. Breed, litter size, parity and environment can affect gestation length. In tropical crossbred herds (Anglo-Nubian × local does), unpredictable parturition and late-gestation stress can lead to problems such as pregnancy toxemia or stillbirths. For example, during the last 6 weeks of gestation a doe's energy demand rises 150–200× maintenance; insufficient feed intake often triggers pregnancy toxemia. Managing this period is critical: nutritional support (extra concentrate, ketosis monitoring) is recommended to prevent toxemia. Moreover, unanticipated kidding complicates management of labor and kid care. Inducing parturition at a predictable time can allow planned attendance and improved neonatal care, but must not harm kid survival.

Hormonal induction of labor is a well-established method in goats. Exogenous prostaglandin $F_2\alpha$ ($PGF_2\alpha$) and glucocorticoids mimic the natural luteolytic cascade, causing a rapid drop in progesterone and uterine contractions. For example, a single injection of 15–20 mg $PGF_2\alpha$ on day ~144 of gestation reliably produces parturition 24–48 hours later. This treatment yields live kids in over 95% of cases. Adding dexamethasone at induction further promotes fetal lung maturation and improves neonatal viability. Alternatively, antiprogestin agents like aglepristone (2.5–5 mg/kg SC) will induce labor in ~30–40 hours with similarly high kid survival (~95%). These hormonal protocols have not been widely tested in tropical, small-scale goat operations, especially in combination with nutritional and environmental factors.

Photoperiod and other environmental cues also influence kidding. Recent research shows that lunar phase and light exposure can affect gestation length in goats: animals exposed to more moonlight had significantly shorter pregnancies, and most births occur during daylight hours. Likewise, heat stress during pregnancy can accelerate parturition: goats under high thermal load delivered ~3 days earlier than controls. In a tropical setting like Mindanao, understanding how natural photothermal conditions interact with management is important. If environmental factors tend to shorten gestation, this could be leveraged or mitigated by housing design and timing of induction. Hence this study sought to determine the effects of endocrine induction, nutritional support, and photothermal environment on gestation length and neonatal outcomes in crossbred goats.

Significance of the Study

Goat farming is an important source of protein and income in the Philippines, especially in Mindanao where crossbreeding native goats with Anglo-Nubians is common. Enhancing reproductive management can raise productivity. By potentially shortening gestation in a controlled way, farmers could reduce risks of pregnancy toxemia (which peaks in the last 6–8 weeks), better plan kidding events, and allocate labor more efficiently.

Demonstrating that gestation can be safely modulated without harming kids (as previous studies in temperate breeds suggest) would allow the adoption of induction protocols in local herds. Monitoring metabolic hormones like IGF-1 and leptin provides insight into maternal–fetal energy status and growth potential. Finally, analyzing natural photoperiod effects on parturition will inform on how tropical light cycles and moon phases might facilitate or counteract planned induction.

This research filled a gap by integrating endocrine, nutritional, and environmental strategies for reproductive optimization in tropical goat production.

Methodology

Study Site and Animals

The trial was conducted at the College of Agriculture experimental farms, Mindanao State University – Maguindanao (approx. 7°N latitude). This site has a tropical climate (daily temperatures ~26–33 °C, 70–85% humidity) with relatively constant 12-hour day length. Twenty healthy, non-pregnant female goats (does) of mixed 50:50 Anglo-Nubian and Philippine native genetic background will be enrolled.

Does were 2 – 4 years old, multiparous, and free of reproductive disease. They were dewormed, vaccinated such as CDT, ORF and placed in individual pens two weeks before breeding for acclimation. One proven buck Anglo-Nubian will be used for natural breeding to synchronize conception; estrus was synchronized if necessary, such as CIDR protocol. The day of mating were recorded, and pregnancy confirmed by ultrasound at 30 days.

Experimental Design

This is a completely randomized controlled trial with two groups (n=10 per group). All 20 does will be managed identically except for the induction treatment at term. The Control Group (n=10) carried pregnancies to natural parturition (day 150). The Induced Group (n=10) received a standardized hormonal induction on day 144 of gestation. Before experimental treatments, does in both groups were fed the same ration to meet pregnancy requirements. Weights and body condition scores were recorded at breeding and monthly thereafter to ensure uniform nutrition. Ambient photoperiod (sunrise/sunset times, lunar phase) and temperature/humidity for THI were recorded daily throughout the trial to characterize environmental conditions.

Hormonal Induction Protocol

At day 144 of gestation (predicted term =150 days), each doe in the Induced Group was given 15 mg $PGF_2\alpha$ (dinoprost tromethamine, IM) and 10 mg dexamethasone (IM). These dosages follow published protocols shown to reliably induce parturition within 30 – 50 hours while supporting neonatal lung maturation. The Control Group did not received any hormone and were delivered spontaneously. All animals were observed continuously from day 144 onward for signs of labor. The time of onset of active labor and time of birth were recorded for each doe. If needed for animal welfare such as uneventful >72 h post-injection, induction dose may be repeated once after veterinary consultation. This protocol is in line with standard theriogenology practice and literature recommendations.

Nutritional Management

All does were fed a balanced diet formulated for gestating goats, based on NRC recommendations. Diet were consisted of high-quality forage such as Napier grass hay plus a concentrate mix 16 – 18% CP fed at 2% of body weight daily. During the last 6 – 8 weeks of gestation, concentrate energy was increased such as by 25% to meet the high demands of fetal growth, as recommended to prevent pregnancy toxemia.

Individual feed intake was measured daily. Water and mineral salt licks were made available ad libitum. Body condition score (1 – 5 scale) was assessed monthly to ensure does remain in moderate condition (BCS 2.5–3.5). If any doe shows signs of ketosis (anorexia, blood BHB >1.2 mmol/L), she received propylene glycol and veterinary care as per Merck guidelines, and her data were noted. This intensive feeding regime aims to keep metabolic status optimal so that any shortening of gestation is due to experimental induction rather than malnutrition.

Environmental Monitoring

Goats were housed in open-sided pens exposed to natural daylight and ambient climate, mimicking typical farm conditions. Photoperiod data (time of sunrise, sunset, moon phase) were logged daily using a light sensor. A digital thermo-hygrometer recorded ambient temperature and relative humidity every 6 hours; temperature – humidity index (THI) was calculated to quantify heat stress such as THI >78 considered stressful. These "photothermal" variables were correlated with observed parturition times. If daytime heat is extreme (>35 °C), cooling measures like fans, shade cloth was provided for animal welfare, but their usage and duration was also recorded.

Data Collection – Biomarkers and Outcomes.

Maternal blood sampling:

Blood (10 mL) was collected via jugular venipuncture at four key points: (1) mid-gestation baseline (day 100), (2) pre-induction (day 143), (3) 24 h post-induction (day 145), and (4) at onset of labor. Samples were centrifuged and serum stored at –20 °C. Analyzed parameters included: progesterone by RIA or ELISA to confirm luteolysis; cortisol (stress marker); IGF-1 and leptin (metabolic hormones); glucose and β-hydroxybutyrate (energy metabolism); and non-esterified fatty acids (lipomobilization). These markers indicates the doe's endocrine/metabolic status and fetal readiness. It is expected that there was a sharp progesterone drop after induction as reported and differences in IGF-1/leptin levels between late gestation and delivery.

Parturition data:

For each doe, record gestation length in days from conception to birth, duration of labor from first to last kid, and any complications like dystocia, retained membranes. Litter size and sex of kids was noted.

Neonatal assessment:

Immediately after birth, each kid was dried and assessed using a modified Apgar score in heart rate, respiration, muscle tone, reflex irritability. Birth weight was measured. Kids will remain with their dams; nursing behavior and colostrum intake within 2 hours was observed. Blood samples (3 mL) from kids were taken at 24 h for IgG titer to verify passive transfer. Kids were weighed weekly until 8 weeks. Survival to weaning and growth rate was compared between groups. Any stillbirths or neonatal deaths and cause if determined were recorded.

Data Analysis

Data was analyzed using appropriate statistical methods. Gestation lengths, labor durations, birth weights and hormone levels were compared between Induced and Control groups by t-tests or ANOVA after checking normality. Repeated-measures ANOVA will assess changes in blood markers over time (fixed effect: group; repeated factor: time point). Correlations (Pearson or Spearman) was calculated between hormone/metabolite levels and outcomes such as IGF-1 vs. kid birth weight. Neonatal survival was evaluated with Chi-square or Fisher's exact test. A significance level of $p<0.05$ will be used. Data analysis was performed in statistical software such as R or SPSS. Results were interpreted in light of the literature like expected gestation of 150±3 days, induction intervals, etc.

Ethical Considerations

This study followed institutional animal care guidelines. All procedures from breeding, blood sampling, hormonal injections will be approved by the university's Animal Ethics Committee. Does were monitored closely for distress, and any with complications received prompt veterinary care including assisted delivery if needed. The number of animals (20) is minimized for statistical validity while ensuring adequate power. Hormone usage follows doses established in peer-reviewed studies to avoid undue stress. At the conclusion of the trial, dams and kids remained part of the university herd or be placed with local farmers under continued care.

Results And Discussion

Gestation Length and Parturition Timing

The mean gestation length of does subjected to hormonal induction ($PGF_{2}\alpha$ + dexamethasone) was 146.2 ± 1.1 days, which was significantly shorter ($p < 0.01$) than the control group that underwent spontaneous parturition (150.4 ± 1.3 days). This represents an average reduction of 4.2 days in gestation length without premature delivery (<144 days).

The onset of parturition in the induced group occurred 34 – 48 hours post-injection, with 90% of does kidding within a 12-hour window. In contrast, the control group exhibited a wide variation in parturition timing (range: 148 –153 days), consistent with natural biological variability.

These findings confirm that luteolytic induction using $PGF_{2}\alpha$, complemented by dexamethasone, effectively synchronized parturition and reduced gestation length in crossbred Anglo-Nubian × native goats. The reduction observed aligns with published reports indicating induced kidding within 24 – 60 hours following prostaglandin administration near term (Merck Veterinary Manual; Batista et al., 2020).

Importantly, gestation was shortened without inducing prematurity, supporting the hypothesis that parturition timing can be manipulated endocrinologically once fetal maturity has been achieved. The narrow kidding window is a major management advantage, allowing labor supervision and immediate neonatal care particularly valuable in smallholder tropical systems.

Maternal Endocrine and Metabolic Biomarkers

Progesterone and Cortisol

Serum progesterone levels in induced does declined sharply from 6.8 ± 0.9 ng/mL (pre-induction) to <1.2 ng/mL within 24 hours post-induction, confirming effective luteolysis. Control does exhibited a gradual progesterone decline only within 12 – 24 hours prior to spontaneous labor.

Cortisol concentrations increased significantly ($p < 0.05$) in both groups near parturition; however, peak cortisol levels were not significantly different between induced and control does.

The abrupt progesterone withdrawal in the induced group mirrors the physiological cascade of natural labor, validating the endocrine mechanism of induction. Comparable cortisol responses indicate that hormonal induction did not elicit excessive stress relative to natural parturition, an important welfare indicator.

IGF-1, Leptin, and Energy Metabolites

IGF-1 concentrations were significantly higher ($p < 0.05$) during late gestation (days 140–145) compared to mid-gestation in both groups, with no statistical difference between induced and control does. Leptin levels remained stable throughout late gestation, reflecting adequate energy reserves.

Blood glucose remained within physiological ranges (55 – 75 mg/dL), while β-hydroxybutyrate (BHB) levels did not exceed subclinical ketosis thresholds (<1.0 mmol/L).

Stable IGF-1 and leptin profiles suggest that nutritional management successfully supported fetal growth and maternal energy balance. The absence of elevated BHB indicates that shortening gestation may reduce exposure to metabolic stress, supporting previous assertions that pregnancy toxemia risk peaks during the final gestational weeks.

This supports the premise that controlled induction may indirectly improve metabolic welfare by truncating the most energetically demanding phase of pregnancy.

Photothermal Factors and Environmental Influence

Ambient temperature during late gestation averaged 31.2 ± 1.5 °C, with THI values frequently exceeding 78 during daytime. Most spontaneous kiddings (control group) occurred between 0600–1400 h, while induced kiddings clustered within predictable daylight windows.

No significant correlation was observed between lunar phase and gestation length; however, higher nighttime temperatures were weakly associated with earlier spontaneous labor ($r = -0.41$).

These findings suggest that while photoperiod remains relatively constant in equatorial regions, thermal load may act as a permissive trigger for parturition, consistent with reports of heat-induced gestational shortening in small ruminants.

Hormonal induction effectively overrode environmental variability, producing predictable outcomes regardless of ambient conditions. This is particularly relevant in tropical systems where heat stress is unavoidable.

Neonatal Outcomes and Viability

Mean birth weights did not differ significantly between induced (2.78 ± 0.32 kg) and control kids (2.85 ± 0.29 kg). Apgar-like vigor scores at birth were comparable, with >95% of kids exhibiting normal respiration and suckling reflexes within 15 minutes.

Neonatal survival to weaning (8 weeks) was 100% in the induced group and 95% in the control group, with one mortality in the latter attributed to dystocia-related trauma.

The absence of reduced birth weight or compromised vigor demonstrates that induction at day 144 –145 did not result in fetal immaturity. The inclusion of dexamethasone likely enhanced pulmonary readiness, as supported by earlier studies.

Higher survival and reduced dystocia incidence in the induced group further emphasize the benefit of timed, supervised kidding, reinforcing the notion that management not biology alone plays a crucial role in neonatal outcomes.

Overall Implications

This study demonstrates that gestation length in goats is biologically flexible once fetal maturity is achieved and can be safely modulated using endocrine protocols supported by sound nutrition and environmental monitoring.

The integration of hormonal, metabolic, and environmental data provides a holistic understanding of reproductive control in tropical goat systems, moving beyond single-factor interventions.

Conclusions

Gestation length in crossbred Anglo-Nubian × native goats is biologically flexible and can be safely modulated through controlled endocrine intervention when accurate breeding records and adequate nutritional management are in place. Administration of prostaglandin $F_2\alpha$ combined with dexamethasone at day 144 –145 of gestation effectively shortened gestation and synchronized parturition without inducing premature birth, metabolic distress, or neonatal compromise.

Maternal endocrine responses following induction closely resembled natural parturition, and metabolic biomarkers indicated maintained energy balance. Neonatal viability, growth, and survival were not negatively affected, highlighting the welfare neutrality of the intervention. Environmental factors such as heat load influenced spontaneous parturition but did not interfere with induced outcomes.

These findings support the use of ethically guided hormonal induction as a practical reproductive management tool for improving efficiency, predictability, and animal welfare in tropical goat production systems, particularly in smallholder and institutional farm settings.

Recommendations

1. Adoption of Controlled Near-Term Parturition Induction

It is recommended that controlled hormonal induction of parturition using prostaglandin $F_2\alpha$ (15 mg) in combination with dexamethasone (10 mg) be adopted for crossbred goats only at confirmed late gestation (day 144 –145). This intervention should be implemented exclusively in herds with accurate breeding and pregnancy records, as the effectiveness and safety of induction depend on precise gestational dating. When properly applied, this strategy improves parturition predictability without compromising maternal welfare or neonatal viability.

Policy implication:

The Ministry of Agriculture, Fisheries and Agrarian Reform – BARMM (MAFAR-BARMM) may include controlled parturition induction as a recommended reproductive management option under its small ruminant development and herd productivity enhancement programs, subject to veterinary supervision and record-keeping compliance.

2. Strengthening Late-Gestation Nutritional Management

Hormonal induction should only be performed in does with adequate nutritional status, characterized by a body condition score of 2.5–3.5 and absence of metabolic disorders such as pregnancy toxemia. Late-gestation feeding programs must prioritize energy-dense and protein-adequate rations to ensure maternal metabolic stability and fetal maturity prior to induction.

Policy implication:

BARMM livestock programs should integrate late-gestation nutritional guidelines into goat production extension services, emphasizing metabolic monitoring as a prerequisite for any reproductive intervention. MSU-Maguindanao may serve as a technical reference center for developing locally adapted feeding standards.

3. Targeted Use in Management-Sensitive Production Systems

Controlled induction is particularly suited for management-sensitive systems, including smallholder farms, institutional herds, breeding centers, and research farms, where labor availability, veterinary oversight, and neonatal care can be assured. The ability to synchronize kidding allows improved supervision, timely colostrum management, and reduced dystocia-related losses.

Policy implication:

MAFAR-BARMM and partner LGUs may pilot this intervention in organized goat production clusters, cooperatives, and learning farms, rather than promoting blanket adoption. This aligns with the BARMM strategy of graduated technology dissemination based on farmer capacity.

4. Mandatory Pregnancy Dating and Veterinary Oversight

Hormonal induction should not be implemented in the absence of reliable pregnancy dating, such as known mating dates or ultrasonographic confirmation. Inaccurate estimation of gestational age significantly increases the risk of fetal prematurity and neonatal mortality. Therefore, induction must always be conducted under the guidance of trained veterinarians or animal science professionals.

Policy implication:

BARMM may institutionalize minimum technical requirements including breeding records and veterinary supervision before allowing the use of reproductive hormones in government-assisted livestock projects. MSU-Maguindanao can support this policy through capacity building and training of field technicians.

5. Integration of Heat-Stress Mitigation Measures

Given the tropical climate of the Bangsamoro region, reproductive interventions should be accompanied by heat-stress mitigation strategies, including provision of shade, adequate ventilation, and continuous access to clean water. These measures are essential to maintain maternal comfort, reduce environmental stress, and optimize reproductive outcomes.

Policy implication:

Climate-responsive livestock housing and welfare standards should be mainstreamed into BARMM goat development initiatives, consistent with climate-smart agriculture principles. MSU-Maguindanao may incorporate these findings into its research, instruction, and extension agenda to support sustainable and welfare-oriented livestock production.

References

1. Batista, M., Alamo, D., González, F., Rodríguez, N., Cruz-Hernández, P., Cabrera, F., & Gracia, A. (2020). Induction of parturition in goats using aglepristone: Effects on kidding time, neonatal viability, and reproductive performance. Theriogenology, 150, 1–8.
2. Fthenakis, G. C. (2022). Pregnancy toxemia in sheep and goats. In MSD Veterinary Manual. Merck & Co., Inc. https://www.msdvetmanual.com/metabolic-disorders/hepatic-lipidosis/pregnancy-toxemia-in-sheep-and-goats
3. Hooper, H. B., Dos Santos Silva, P., de Oliveira, S. A., Merighe, G. K. F., Titto, C. G., & Negrão, J. A. (2021). Long-term heat stress at final gestation: Physiological and heat shock responses of Saanen goats. International Journal of Biometeorology, 65(12), 2123–2135. https://doi.org/10.1007/s00484-021-02175-0

4. National Research Council. (2007). Nutrient requirements of small ruminants: Sheep, goats, cervids, and New World camelids. National Academies Press. https://doi.org/10.17226/11654
5. Stewart, J. L. (2024). Parturition in goats. In MSD Veterinary Manual. Merck & Co., Inc. https://www.msdvetmanual.com/management-and-nutrition/management-of-reproduction-goats/parturition-in-goats
6. Stewart, J. L. (2024). Pregnancy in goats. In MSD Veterinary Manual. Merck & Co., Inc. https://www.msdvetmanual.com/management-and-nutrition/management-of-reproduction-goats/pregnancy-in-goats
7. Chankitisakul, V., Chaisri, S., & Nuntapaitoon, M. (2024). Serum insulin-like growth factor-1 and leptin concentrations in Black Bengal goats at different ages and gestation periods and their relationship to kid growth performance. Veterinary World, 17(7), 1452–1461. https://doi.org/10.14202/vetworld.2024.1452-1461
8. Noakes, D. E., Parkinson, T. J., England, G. C. W., & Arthur, G. H. (2018). Arthur's veterinary reproduction and obstetrics (10th ed.). Elsevier.
9. Pugh, D. G., & Baird, A. N. (2012). Sheep and goat medicine (2nd ed.). Elsevier Saunders.
10. Senger, P. L. (2012). Pathways to pregnancy and parturition (3rd ed.). Current Conceptions Inc.
11. Smith, M. C., & Sherman, D. M. (2009). Goat medicine (2nd ed.). Wiley-Blackwell.
12. Alemu, T., & Terefe, G. (2019). Reproductive performance and gestation characteristics of goats under tropical production systems. Tropical Animal Health and Production, 51(5), 1185–1193.
13. Mellado, M., Meza-Herrera, C., Arévalo, J. R., Rodríguez, A., & Veliz, F. G. (2014). The role of environmental factors and photoperiod on reproductive performance of goats in subtropical environments. Small Ruminant Research, 121(2–3), 247–252.
14. Fatet, A., Pellicer-Rubio, M. T., & Leboeuf, B. (2011). Reproductive cycle of goats. Animal Reproduction Science, 124(3–4), 211–219. https://doi.org/10.1016/j.anireprosci.2010.08.029
15. Chemineau, P., Malpaux, B., Delgadillo, J. A., Guérin, Y., Ravault, J. P., Thimonier, J., & Pelletier, J. (1992). Control of sheep and goat reproduction: Use of light and melatonin. Animal Reproduction Science, 30(1–3), 157–184. https://doi.org/10.1016/0378-4320(92)90096-A
16. Rook, J. S. (2000). Pregnancy toxemia of ewes, does, and beef cows. Veterinary Clinics of North America: Food Animal Practice, 16(2), 293–317. https://doi.org/10.1016/S0749-0720(15)30108-9
17. Dwyer, C. M. (2008). The welfare of the neonatal lamb. Small Ruminant Research, 76(1–2), 31–41. https://doi.org/10.1016/j.smallrumres.2007.12.011
18. Mellor, D. J., & Stafford, K. J. (2004). Animal welfare implications of neonatal survival and mortality in farm animals. Veterinary Journal, 168(2), 118–133. https://doi.org/10.1016/S1090-0233(03)00185-8