Research Article

Efficacy of Vaginal Electrical Resistance Measurement in West African Dwarf Goats Synchronized using Ovsynch and Double PG Protocol

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Abstract | One of the major constraints to good reproductive performance in West African dwarf (WAD) goats is low estrus detection, this study investigates the use of vaginal electrical resistance (VER) as estrus detection in WAD goats. Thirty-six (36) WAD does were randomly divided into two synchronization protocols and a control; Group 1 was the control without hormonal treatment, Group 2, was administered with double prostaglandin, and Group 3 Ovsynch protocols. The results revealed that does in the control group (G1) showed an unpredictable pattern in the onset of estrus. The mean VER values of treatment groups are within the normal range. The onset of estrus correlated with the lowest VER reading post-treatment, observed 24 to 36 hours in 40% of does in both groups. Blood progesterone and estradiol revealed distinct but synchronized patterns in both groups. Group 2 displayed a consistent decline in blood progesterone from day 0 to 7, and a spike on days 7-11, attributed to the second prostaglandin analogue administration. The subsequent decline on days 12-13 signalled impending estrus, accompanied by a rise in blood estradiol. Group 3 exhibited a progesterone spike on day 10, with a corresponding decrease in estradiol. The study demonstrates that regardless of synchronization protocol, the lowest mean VER reading post-treatment corresponds to high blood estradiol and low progesterone concentrations. This consistent pattern highlights the reliability of VER measurements in predicting estrus, while no significant difference in VER means the two protocols offer flexibility to goat farmers in choosing synchronization methods based on specific breeding objectives.

Keywords | Small ruminant, Reproduction, Estradiol, Progesterone, Estrus, Goat

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INTRODUCTION

The West African Dwarf (WAD) goats are a remarkable breed known for their distinctive dwarfism and adaptability to the humid regions of West and Central Africa. This breed is distributed across 15 countries, including Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Mali, Burkina Faso, Cote d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, and the Central African Republic (Chiejina and Behnke, 2011). WAD goats are integral to the local economy and culture, providing meat, milk, and skin, and playing a vital role in the livelihoods of millions of people, particularly in the rainforest belt of southern Nigeria (Oseni et al., 2014). Women, in particular, are deeply involved in the value chains associated with WAD goats, highlighting the breed's socio-economic significance in rural communities across West and Central Africa. This involvement is pivotal not only for household livelihoods but also for broader economic stability and development within these regions. Women, who are often the primary caregivers for small livestock, manage a substantial portion of the WAD goat population. Their involvement spans various stages of the value chain, including breeding, feeding, healthcare, marketing, and processing of goat products (Adewumi et al., 2020; Ayoade et al., 2014).

Physically, WAD goats are distinguished by their resilient nature, short legs, and variable body colours, ranging from white to black or black with white spots. Mature WAD goats often have beards, and both sexes possess horns, with the males' horns typically curving outwards and backwards. The average height of WAD goats ranges from 30 to 50 cm, with weight varying between 20 and 30 kg for mature individuals (Azeez et al., 2018). Compared to other breeds, WAD goats are notably smaller, which contributes to their unique adaptability to the region's environment.

One of the most renowned traits of WAD goats is their scavenging ability and trypanotolerance, which refers to their resistance to trypanosomiasis, a parasitic disease prevalent in their native regions (Chiejina and Behnke, 2011). This adaptability is supported by studies showing their superior survival rates in tsetse-infested areas compared to non-indigenous breeds (Chiejina and Behnke, 2011). Despite these advantages, WAD goats have relatively slow growth rates, a term that requires clarification. Typically, WAD goats reach sexual maturity at about 12 to 15 months, and their growth rate is considered slow compared to commercial breeds like the Boer goat, which reach market weight more quickly (Fakae et al., 1999).

Economically, WAD goats offer significant advantages due to their lower nutrient requirements and reduced capital costs per head compared to larger livestock such as cattle, pigs, or poultry (Fakae et al., 1999). These attributes make WAD goats an attractive option for smallholder farmers and contribute to their potential in poverty alleviation programs. However, the potential of WAD goats in such programs is still largely untapped, despite their recognized benefits (Oseni et al., 2014).

The productivity of WAD goats faces several challenges. One major issue is the seasonal fluctuation in nutritional quality, which is influenced by low-input management systems and inadequate feeding practices. Additionally, WAD goats are susceptible to endemic diseases such as Peste *des* Petits Ruminants (PPR) and gastrointestinal (GI) helminths, including *Haemonchus contortus* and *Trichostrongylus colubriformis* (Fakae et al., 1999; Chiejina and Behnke, 2011). The prevalence of GI parasites can reach 100% in traditionally managed goats, leading to significant losses in kid survival, live weight gain, milk/meat production, and reproductive performance (Chukwuka et al., 2010). Addressing these health and environmental challenges is critical for improving the productivity and economic viability of WAD goat farming.

Given these challenges, it is essential to explore innovative methods to enhance reproductive efficiency in WAD goats. One promising technique is the measurement of electrical resistance of vaginal mucus (ERVM) during estrus to determine the optimal timing for artificial insemination (AI). Accurate estrus detection is crucial for improving reproductive performance, yet it remains a significant constraint due to environmental and physiological factors (Arakawa, 2020). Techniques such as vaginal electrical resistance (VER) measurement offer a non-invasive method to detect estrus by monitoring changes in the electrical conductivity of vaginal mucus, which correspond to various stages of the oestrous cycle (O'Connor, 2007).

VER measurement has shown promise in several species, including cattle, buffalo, pigs, camels, and sheep, for detecting estrus and timing insemination (Meena et al., 2003; Tadesse et al., 2011; Zuluaga et al., 2008; Gupta and Purohit, 2001; Yamauchi et al., 2009; Purohit et al., 2020; Vyas et al., 2009; Bartlewski et al., 1999; Talukder et al., 2018). Recent studies have demonstrated that cyclic changes in vaginal impedance are closely related to estrus behaviour in goats (Křivánek, 2008; Murtaza et al., 2020). Thus, this study aims to evaluate the efficacy of VER measurement in WAD does synchronized using the Ovsynch and Double PG protocols. By investigating the relationship between VER patterns and key reproductive events, such as estrus onset and ovulation, we seek to provide valuable insights that can enhance reproductive efficiency and success rates in WAD doe breeding programs.

MATERIALS AND METHODS

Experimental Site

The research was conducted at the Small Ruminant Unit of the RPC Cattle Hub Farm in Iwo, Osun State, Nigeria. The experimental site is situated at approximately 4.1770° E latitude and 7.6401° N longitude, with an average temperature of 28.4°C and an average annual precipitation of 206.63 mm (Ugwumba, 2008). This site falls within the Derived Savanna agroecological zone, characterized by a tropical climate that serves as a transitional area between the Rain Forest and Savanna Grassland biomes (Oguntunji et al., 2019). The climate at the experimental site is typical of tropical regions, featuring double maxima rainfall patterns and a mix of deciduous trees and tall grasses. This interspersed vegetation is crucial for the sustenance of WAD goats, which thrive in environments that offer both browsing and grazing opportunities. The presence of diverse flora supports the nutritional needs of WAD goats, which is essential for their reproduction and overall health (Adewumi et al., 2020).

The area experiences two principal seasons: the wet season (April to September) and the dry season (October to March). These main seasons are further divided into four sub-seasons: the early rainy season (April to June), the late rainy season (July to September), the early dry season (October to December), and the late dry season (January to March) (Oguntunji et al., 2015). The early rainy season (April to June) marks the onset of rainfall, which replenishes water sources and stimulates the growth of fresh vegetation. For WAD goats, this season provides abundant nutritional resources, crucial for lactation and kidding, enhancing reproductive success. During the late rainy season (July to September), the vegetation is at its peak, providing optimal foraging conditions. The sustained availability of high-quality forage supports the nutritional needs of pregnant and lactating does, promoting healthier offspring. As rainfall diminishes in the early dry season (October to December), water sources and fresh forage begin to decline. WAD goats rely more on residual vegetation and stored feeds. Nutritional stress during this period can impact reproductive performance if not properly managed. The late dry season (January to March) is marked by the lowest availability of natural forage and water. The nutritional stress is at its peak, and the reproductive activities of WAD goats may be adversely affected unless supplementary feeding strategies are implemented to maintain their body condition and reproductive capabilities (Chiejina and Behnke, 2011).

The seasonal variations in climate and vegetation at the experimental site significantly influence the reproductive cycles of WAD goats. Adequate nutrition during the wet seasons supports higher fertility rates and healthier pregnancies, while the dry seasons necessitate effective management practices to mitigate nutritional deficits.

Experimental Animals and Management

For this study, thirty-six (36) West African Dwarf (WAD) does, each with a history of having kidded once or twice, were selected. This selection was intentional to ensure consistency and reliability in the experimental outcomes. Choosing does with proven reproductive capability eliminates variability associated with first-time breeders and ensures the study accurately assesses reproductive interventions. These does are typically in the prime of their reproductive lives, ensuring stable hormonal cycles and consistent performance. Using animals with similar reproductive histories reduces data variability, crucial for clear statistical analysis. The healthy WADs does were purchased from individual farmers and local markets around Iwo. Following their purchase, the WADs does were routinely treated for ectoparasites using the acaricide cypermethrin. They were dewormed with albendazole, and prophylactic antibiotics, specifically 20% oxytetracycline, were administered. These procedures were conducted following the protocols described by Fakae *et al.* (1994). Furthermore, they were also vaccinated against Peste *des* Petits Ruminant (PPR) using tissue culture rinderpest vaccine (TCRV, NVRI, Vom, Nigeria). The WAD does were housed and managed intensively and were fed with grasses and supplemented with concentrate while water was provided *ad libitum*. Routine sanitation and strict biosecurity were adhered to throughout the study.

Experimental Design

Following the acclimatization for two weeks, the WAD does were ear-tagged and randomly assigned to the three groups by balloting. Group 1 (G1) comprised 12 does that served as the control, Group 2 (G2) comprised 12 does which were treated with two doses of prostaglandin analog (PGF2α) administered 11 days apart while Group 3 (G3) comprised 12 does that were synchronized using the Ovsynch protocol (Day 1 – GnRH, Day 7 - PGF2α and Day 9 – GnRH). The Ovsynch protocol was selected for its precise control of ovulation timing, while the double PGF2α protocol was chosen for simplicity and cost-effectiveness (Patrik et al., 2022, Jae-kwon et al., 2022).

Data Collection

Determination of VER reading: To determine the vaginal electrical resistance (VER) reading, we used the Draminski oestrous detector designed for sheep and goats, Model EDs. Each doe was gently restrained, and the vulva was opened using the index finger and thumb. Before insertion, the heat detector was disinfected with Savlon and dried with a paper towel to ensure cleanliness. The detector was then inserted into the vagina at a 45-degree angle until it reached the fornix part. After insertion, the probe was rotated twice, and the VER reading was recorded. This procedure was conducted every 12 hours, both in the morning (6 - 7 AM) and in the evening (6 - 7 PM), throughout the experiment period. This method was chosen for its accuracy, hygiene, and ability to capture fluctuations in estrus activity over time.

Blood collection: Blood samples were collected from WAD does in Group 1 on days 0, 7, 11, 12, 13, and 14, and from Group 2 on days 0, 7, 9, 10, and 11. The procedure began by restraining the WAD doe, followed by swabbing the neck area with cotton wool soaked in methylated spirit to ensure cleanliness. The jugular vein was then located using digital pressure, and 5 ml of blood was drawn using a sterile syringe and needle. The blood was immediately dispensed into a vacutainer tube without anticoagulant and tilted at a 30° angle to facilitate serum collection before centrifugation. After centrifuging at 1,500 rpm for 15 minutes, the serum was collected and stored at -80°C. Before analysis, the serum samples were equilibrated at room temperature for 30 minutes. The standard procedure for detecting progesterone and estradiol concentrations in blood was then followed using enzyme-linked immunosorbent assay (ELISA) kits (NovaTec Immundiagnostica GmbH, Germany). These kits were used to quantify the concentrations of progesterone and estradiol in each blood sample, providing crucial data for hormonal analysis and monitoring of reproductive activity.

Data Analysis

Data collected for VER were subjected to a one-way analysis of variance (ANOVA) using the fixed effect model. Duncan's multiple range test was used to test for the significance of variance ($P<0.05$) for all recorded and calculated data between different treatments using SAS 1999 version 12.

$Y_{ij}=\mu +T_i +e_{ij}$

Where Y_{ij}=individual observation

μ=general mean

T_i=fixed effect of treatment (i=1…..3)

e_{ij}=expected error

Hormonal (progesterone and estradiol) concentrations were compared using a t-test (0.05%) by IBM SPSS version 26 software. and values for individual ewes were presented as a line graph.

RESULTS AND DISCUSSION

The study investigated the effectiveness of vaginal electrical resistance (VER) measurements and hormonal profiles in determining estrus onset in West African Dwarf (WAD) does under different synchronization protocols. The mean values of VER for all does are illustrated in Figure 1, and a comparison between the mean VER for groups G2 and G3 is shown in Figure 2. Initially, the control group (G1) displayed an unpredictable pattern of estrus onset, underscoring the necessity for synchronization interventions. Contrarily, does in the treatment groups (G2 and G3) exhibited clear signs of estrus following hormonal treatments, suggesting successful synchronization. The control group's mean VER readings ranged from 337 ± 26 to 633 ± 122, while Group 2 (double PG) exhibited readings from 405 ± 39 to 788 ± 160, and Group 3 (Ovsynch) from 352 ± 25 to 1098 ± 166. Estrus onset was determined by the lowest VER reading post-treatment. In Group 2, 40% of does displayed estrus 36 hours post-treatment, another 40% after 48 hours, and the remaining 20% after 72 hours. In Group 3, 40% of does exhibited estrus signs 24 hours post-treatment, with the rest showing signs between 36 and 60 hours post-treatment. ANOVA revealed a significant difference ($p<0.05$) between the control and treatment groups, but no significant difference ($p>0.05$) in mean VER readings between Groups 2 and 3. An independent t-test corroborated these findings, showing no significant difference in VER readings between Group 2 and Group 3 ($t(53) = 1.206$, $p = 0.462$).

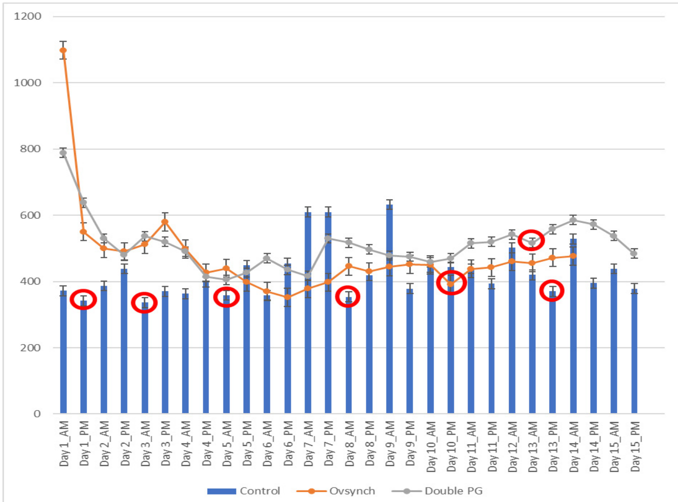

Figure 1: Mean vaginal resistance reading for does in the control and experimental group. The red rings signify the onset of estrus (standing heat) in the does. WAD does in the control group (n=12) was observed to come on heat at different intervals.

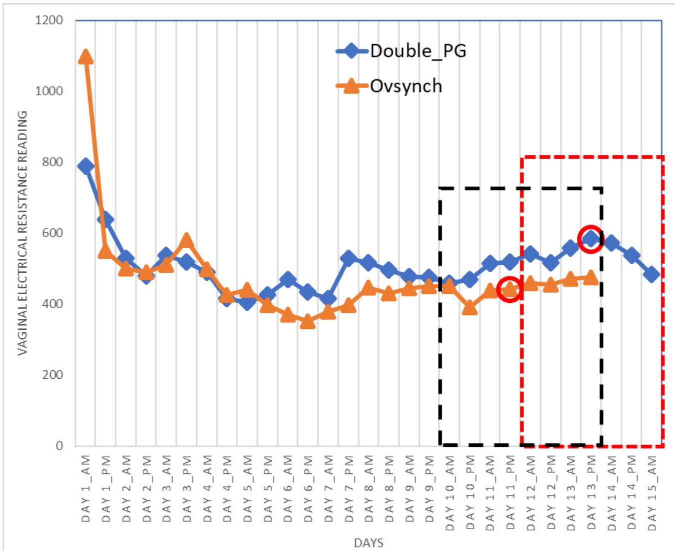

Figure 2: Average vaginal electrical resistance reading for does in groups 2 and 3. The orange and blue arrows indicate the last hormonal treatment. The red and black dotted boxes show the duration of the estrus periods post the last hormonal treatment. The chart showed that at the beginning of the experiment, the does were at different stages of the oestrous cycle. The VER post-hormonal treatment chart is however indicated in the dotted box (red for group 2 and black for group 3). The red rings indicate the likely time of ovulation after the completion of the hormonal treatment.

Hormonal profiles, shown in Figures 3 and 4, were assessed through blood progesterone and estradiol concentrations. In Group 2, progesterone levels initially declined (3.1 ± 1.0 ng/ml), peaked around day 11 (7.8 ± 2.6 ng/ml), and then sharply decreased post-treatment. Conversely, estradiol concentrations increased as progesterone declined, indicating an inverse relationship. Similarly, in Group 3, progesterone remained low (4 ng/ml) until day 9, spiked on day 10 (7.8 ± 5.7 ng/ml), and decreased afterward, with estradiol levels mirroring these changes. The mean blood estradiol concentration in Group 2 ranged from 90.3 ± 25.4 μmol/l on day 0 to 190.6 ± 31.4 μmol/l on day 13, while in Group 3, it ranged from 84.3 ± 17.4 μmol/l on day 0 to 167.0 ± 26.3 μmol/l on day 9. These findings underscore the hormonal dynamics associated with synchronization protocols. Regardless of the synchronization method, the lowest VER readings post-treatment corresponded with elevated estradiol and decreased progesterone levels, indicating successful synchronization of estrus behavior and hormonal changes in WAD does.

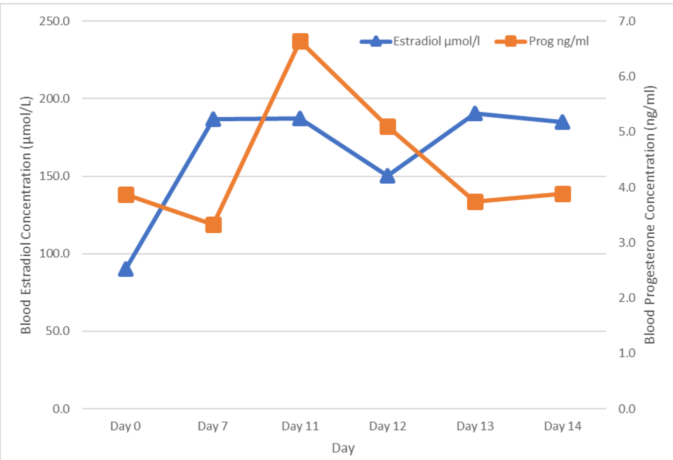

Figure 3: Hormonal profile of WAD does subject to the double does of prostaglandin (group 2).

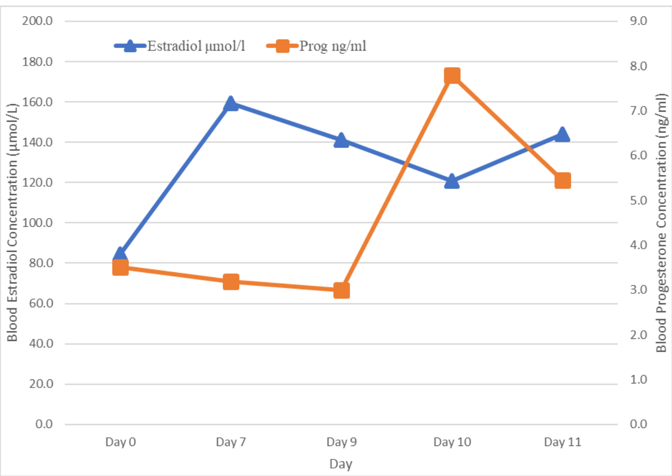

Figure 4: The hormonal profile of WAD does subject to the Ovsynch protocol (group 3).

VER measurements have proven to be a practical and reliable non-invasive method for detecting estrus in various animal species (Rafiqul et al., 2018). This study represents the first use of VER measurement in WAD goats to determine estrous onset. The synchronization protocols effectively induced estrus behavior in WAD does, as evidenced by consistent VER values within the expected range for both treatment groups. Approximately 40% of does in both treatment groups exhibited signs of estrus within 24 to 36 hours post-treatment, consistent with previous studies (Oleforuh-Okoleh et al., 2021; Omontese et al., 2016). Comparative analysis with existing literature revealed similarities in VER measurements during estrus in sheep (Rafigul et al., 2018), though with slight variations (370.0 ± 82.0 to 416.7 ± 51.3 Ω). The lack of significant difference in VER means between the two treatment groups suggests that both synchronization protocols were equally successful in inducing estrus behavior. This finding provides practical implications for goat farmers, offering flexibility in selecting suitable synchronization methods for their breeding objectives.

Further examination of hormonal profiles in the treatment groups revealed distinct yet complementary patterns. In Group 2, blood progesterone levels showed an initial decline followed by a sudden spike between days 7 and 11, before declining again. This fluctuation aligns with expected hormonal changes during pre-estrus and ovulation phases (Levy et al., 2000; Wen et al., 2020). The decline could be attributed to the administration of the second prostaglandin analogue, a critical component of the synchronization protocol (Wen et al., 2020). Prostaglandins induce a sudden decline in progesterone secretion, likely due to corpus luteum regression (Vu et al., 2012, Ayoola et al., 2020). The declining blood progesterone concentration on days 12 and 13 signifies the impending onset of estrus, as progesterone levels drop to facilitate ovulation (Sirois and Fortune, 1990; Duchens et al., 1994). In Group 3, progesterone levels remained relatively low until day 9, followed by a sharp increase on day 10, accompanied by a decrease in estradiol concentration. This pattern emphasizes the intricate interplay between progesterone and estradiol during the estrous cycle (Derar et al., 2022). The synchronization protocols effectively manipulated the balance between these hormones, creating an optimal environment for successful breeding outcomes. This study's results align with previous research demonstrating the efficacy of synchronization protocols in managing estrus and enhancing reproductive efficiency in livestock (Sirois and Fortune, 1990b; Stock and Fortune, 1993; Chasombat et al., 2014; Ding et al., 2022).

The observed consistency between VER readings and hormonal profiles across different synchronization protocols underscores the robustness of these physiological indicators in predicting estrus onset in WAD does. This convergence of physiological processes offers valuable insights for optimizing reproductive management strategies in goat production. Future research should explore additional synchronization protocols and their impacts on estrus behavior and hormonal profiles in WAD goats. Investigating variations in hormone administration timing or dosage could enhance synchronization efficacy. Moreover, comparative studies across different goat breeds could provide insights into breed-specific responses to synchronization protocols, thereby enriching our understanding of reproductive physiology and management strategies.

CONCLUSION

In conclusion, the findings of this study underscore the importance of VER measurements and hormonal profiling in predicting estrus onset and optimizing reproductive management in WAD goats. By elucidating the relationships between these physiological indicators and synchronization protocols, this research contributes to the advancement of goat reproductive science. Implementing these findings in practice could lead to improved breeding efficiency and profitability in WAD goat production.

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AUTHOR CONTRIBUTIONS

All authors contributed to the study's conception and design. Olagbaju Olawole and Ayoola Mathew: Conceptualization, Methodology, Software. Olagbaju Olawole and Olorunleke Solomon: Data curation, Writing, Original draft preparation. Ayoola Mathew: Visualization, Investigation. Lawal Tunde, Alabi Olufemi, Aderemi Foluke: Supervision. Ajayi Abimbola, Oladejo Opeyemi and Oguntunji Abel: Software, Validation. Ayoola Mathew, Olorunleke Solomon and Olagbaju Olawale: Writing-Reviewing and Editing. All authors read and approved the final manuscript.

Statement of Animal Rights

The methods/procedures used in this study were concomitant with those outlined in the Animals Scientific Procedures Act of 1986 for the care and use of animals for research purposes. Approval was obtained from the Research Ethics Committee of the Faculty of Agriculture, BOWEN University, Iwo Osun State (BUREC/COAES/AGR/0001).

Limitations of this study

This study was carried out with limited resources within a short time frame, hence constraining the hormonal assay to WAD does in the treatment groups only. Although we understand that a larger population of WAD does will be needed to validate our findings and strengthen their reliability, this study established the efficacy of vaginal electrical resistance in determining the onset of oestrous and prediction of the time of ovulation.

Conflicts of Interest Statement

The authors declare that no financial/personal interest or belief could affect the objectives, aims and results of this study.

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