Research Article

Relationship Between Vaginal Electrical Resistance and Follicular Dynamics During $PGF_2\alpha$-Induced Estrus Synchronization in Aceh Cattle

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Abstract | This study examined the relationship between vaginal mucus electrical resistance (ERVM), dominant follicle diameter, and estrus score in Aceh cattle after PGF2α-induced estrus synchronisation. A total of 15 adult female Aceh cattle aged 3–5 years with regular estrous cycles were used in this study. Estrus synchronization was performed using a single intramuscular injection of 25 mg $PGF_2\alpha$. Estrus signs, ERVM values, and dominant follicle diameter were observed at 0, 24, 48, and 72 h after injection. ERVM was measured using a Draminski estrus detector, while dominant follicle diameter was evaluated by transrectal ultrasonography. Data were analyzed using Friedman test, Spearman correlation, and multiple linear regression analysis. The proportion of cattle showing estrus after PGF2α synchronisation was 80% (12 out of 15 animals). ERVM values fell significantly ($P < 0.05$), reaching their lowest point at 48 hours post-injection (262.22 ± 9.06 Ω), then rose again by 72 hours. Although this value remained above the manufacturer's recommended estrus threshold, it coincided with the largest dominant follicle diameter and peak estrus expression, suggesting possible breed-specific physiological variation in Aceh cattle. In contrast, dominant follicle diameter grew significantly ($P < 0.05$), peaking at 48 hours (10.88 ± 0.66 mm), before decreasing at 72 hours. Estrus score increased at 48 h but did not differ significantly among observation times ($P>0.05$). Correlation analysis showed positive but non-significant relationships between estrus score and ERVM ($r = 0.466$, $p = 0.127$), and between estrus score and follicle diameter ($r = 0.383$, $p = 0.219$). Multiple linear regression analysis showed that ERVM and follicle diameter together accounted for 38.5% of the variation in estrus score ($R^2 = 0.385$), although the overall model was not statistically significant ($p = 0.112$). In conclusion, changes in ERVM and dominant follicle diameter reflected physiological estrus dynamics following $PGF_2\alpha$ synchronization in Aceh cattle. Integration of ERVM measurement and ovarian ultrasonography might contribute to improved estrus detection and reproductive management in Aceh cattle, although further validation is required.

Keywords | Aceh cattle, Dominant follicle, ERVM, Estrus synchronization, $PGF_2\alpha$

Received | May 23, 2026; **Accepted** | June 26, 2026; **Published** | July 28, 2026
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Citation | Melia J, Budiyanto A, Sari MK, Leliana L, Jauhari J, Husnurrizal H, Armansyah T, Agung NP, Hafizuddin H, Thasmi CN, Siregar TN, Telaumbanua M, Sirat MMP, Ermawati R (2026). Relationship between vaginal electrical resistance and follicular dynamics during PGF$_2\alpha$-induced estrus synchronization in Aceh cattle. Adv. Anim. Vet. Sci., 14(8):1651-1659.
DOI | https://dx.doi.org/10.17582/journal.aavs/2026/14.8.1651.1659
ISSN (Online) | 2307-8316

INTRODUCTION

Aceh cattle are one of the four recognized Indonesian indigenous cattle breeds, alongside Bali, Madura, and Pesisir cattle, as well as Peranakan Ongole (PO) cattle, which are also classified as local breeds. These cattle show good adaptation to local conditions such as limited feed and water, tropical climates, and disease pressure. Therefore, local cattle are considered highly suitable for development in Indonesia, although their productivity is generally lower than that of imported breeds (Lubis *et al*., 2025). One of the approaches widely implemented to overcome this limitation is artificial insemination (AI), which has been proven effective in improving the genetic quality of livestock. However, the success of AI is highly dependent on accurate estrus detection, which remains a major challenge under smallholder farming conditions (Mikkola *et al*., 2024). In Aceh cattle, estrus intensity, assessed using a behavioral estrus scoring system, has been reported to be lower in repeat-breeding cows than in fertile cows, with mean scores of 2.9 ± 1.1 and 4.0 ± 1.0, respectively (Thasmi *et al*., 2017). Similarly, Melia *et al*. (2024) reported that estrus intensity in Aceh cattle remained relatively low even after GnRH administration during estrus synchronization, where the estrus intensity score increased only slightly from 1.67 ± 1.15 in the control group to 1.80 ± 0.84 following GnRH treatment. Therefore, an effective method capable of controlling and synchronizing the timing of estrus is needed to improve the precision and efficiency of insemination timing.

One of the most commonly used methods for estrus synchronization in cattle is prostaglandin F$_2\alpha$ (PGF$_2\alpha$), which induces luteolysis and is widely applied in synchronization programs (López-Gatius, 2022). The mechanism of luteolysis following PGF$_2\alpha$ administration is considered similar to the natural luteolytic process occurring during the late luteal phase in cattle. Luteolysis is initiated by uterine PGF$_2\alpha$ release and involves interactions among oxytocin, PGF$_2\alpha$, and other mediators such as TNF-α, which contribute to corpus luteum regression (Okuda *et al*., 2002). Structural luteal regression has also been associated with activation of cell death pathways, particularly necroptosis, during PGF$_2\alpha$-induced luteolysis (Jonczyk *et al*., 2019). This process results in a decline in progesterone concentrations and an increase in estrogen secretion, leading to the expression of estrus (Dias Da Silva *et al*., 2024). Furthermore, higher estradiol concentrations have been associated with larger dominant follicles during ovulation (Perry *et al*., 2023).

Unlike ovulation synchronization protocols that do not require estrus observation to determine insemination timing (Sales *et al*., 2025), estrus synchronization using PGF$_2\alpha$ still relies heavily on accurate estrus detection (Setiawati *et al*., 2026). Consequently, reliable physiological indicators that can complement behavioural observations are needed to improve estrus monitoring and reproductive management in Aceh cattle. Therefore, evaluating the relationship between ERVM and follicular dynamics may provide useful information for understanding estrus-associated physiological changes in this breed.

Based on reports by Thasmi *et al*. (2017) and Melia *et al*. (2024), visual observation alone may not provide accurate estrus detection in Aceh cattle because of their relatively low estrus intensity. Widyastuti *et al*. (2025) reported that, during peak estrus following double PGF$_2\alpha$ injections administered at a 14-day interval, estrus detection using electrical resistance of vaginal mucus (ERVM) was consistent with visual estrus observations in Pasundan cattle. Peak estrus was characterized by maximum vulvar swelling (7.27 ± 1.15 cm), highest mucus viscosity (14.9 ± 3.00 mm), and the lowest vaginal electrical resistance value (198.67 ± 29.61 Ω). In goats, the characteristics of the proestrus, estrus, and metestrus phases based on vaginal cytology were also reported to correlate with ERVM readings obtained using an estrus detector (Meydilasari *et al*., 2020). The development of the dominant follicle is associated with increased estradiol secretion, which subsequently induces physiological changes in the reproductive tract, including a reduction in ERVM values. Therefore, ERVM has been proposed as an effective physiological indicator for estrus detection and reproductive status monitoring in cattle (Tadesse *et al*., 2011).

Although behavioral estrus assessment, vaginal electrical resistance, and ultrasonographic evaluation of follicular dynamics have previously been used for estrus monitoring in cattle, information regarding the relationship among these parameters in Aceh cattle remains limited. Therefore, this study aimed to evaluate the association between ERVM, dominant follicle diameter, and estrus score following $PGF_2\alpha$-induced estrus synchronization in Aceh cattle. We hypothesized that changes in electrical resistance of vaginal mucus are associated with dominant follicle development and estrus expression following $PGF_2\alpha$-induced estrus synchronization in Aceh cattle.

MATERIALS AND METHODS

Experimental animals

This study was conducted at the Balai Pembibitan Ternak Unggul-Hijauan Pakan Ternak (BPTU-HPT) Indrapuri, Kabupaten Aceh Besar, Provinsi Aceh. We used 15 adult female Aceh cattle aged 3-5 years, weighing 150-250 kg, with a history of previous calving, a body condition score of at least 2.5 on a 5-point scale, and at least two regular oestrous cycles before the study. Only cows with a history of at least two consecutive regular estrous cycles, based on farm reproductive records and information provided by animal caretakers, were included in the study. Only cows with a body condition score (BCS) ≥ 2.5 (on a 5-point scale) were included to minimize the potential effects of poor nutritional status on reproductive performance and response to synchronization treatment. Body condition scores were determined using a standard 5-point scoring system based on visual assessment and palpation of specific anatomical landmarks prior to enrolment in the study. Before selection, we checked for a corpus luteum and confirmed non-pregnancy by rectal palpation. Only cows with a functional CL and confirmed non-pregnant status were selected as experimental animals. The presence of a corpus luteum was determined by rectal palpation rather than ultrasonography during animal selection, which may have reduced the accuracy of corpus luteum identification. The cows were fed fresh forage and had free access to drinking water throughout the study period.

Experimental procedures

Estrus synchronization

Each cow received 25 mg $PGF_2\alpha$ (5 mL Lutalyse®, Zoetis, USA) intramuscularly, following protocols previously validated in Aceh cattle (Siregar *et al*., 2017; Hafizuddin *et al*., 2024). The injections were administered intramuscularly at 08:00 a.m. Administration of $PGF_2\alpha$ was intended to induce corpus luteum regression (luteolysis), resulting in decreased progesterone concentrations in the bloodstream, which subsequently stimulated dominant follicle development and increased estrogen secretion, ultimately triggering estrus.

Estrus observation and vaginal resistance measurements

Following $PGF_2\alpha$ injection, animals were observed for estrus behaviours for 30 minutes at 24-hour intervals over a period of 3 days. Measurements were performed at D0 and subsequently repeated at 24-hour intervals for 72 hours (D1, D2, and D3). Estrus scoring was determined according to the method developed by Van Eerdenburg with several modifications. In this study, modifications were made by excluding the use of teaser bulls to stimulate behavioral responses; therefore, the parameter "standing to be mounted" (standing heat) was not included in the scoring system (Table 1). Frequent vocalization/decreased appetite was recorded as present when animals exhibited noticeably increased vocalization and/or reduced feed intake relative to their usual behavior during the observation period. Although standing heat is considered the most reliable behavioral indicator of estrus, it was excluded because it could not be consistently assessed under the management conditions of the present study. Consequently, the behavioral estrus scores should be interpreted as a modified estimate of estrus expression rather than a complete representation of the original Van Eerdenburg scoring system.

Total estrus scores were categorized as strong (>15), moderate (10–14), weak (5–9), and non-estrus (<5).

Table 1: Estrus observation scoring system.

No	Observed Parameter	Criteria	Score
1	Mounting other cows	Active	10
		Absent	0
2	Increased activity/ restlessness	Clearly increased	5
		Normal	0
3	Vulval mucus discharge	Abundant, clear, hanging	5
		Slight/cloudy	2
		Absent	0
4	Vulval redness and swelling	Evident	3
		Slight	1
		Absent	0
5	Frequent vocalization/ decreased appetite	Present	2
		Absent	0

Electrical resistance of vaginal mucus (ERVM) was measured using a Draminski estrus detector (Draminski Electronic in Agriculture™, 17 Owocowa, 10-860 Olsztyn, Poland). Prior to measurement, the cattle were restrained and the vulva was cleaned using a mild antiseptic solution. The Draminski probe was also disinfected with a mild antiseptic before being inserted through the vulva until it reached the cervix. ERVM values were determined according to the manufacturer's protocol, with measurements performed in triplicate and averaged for each observation (Husnurrizal *et al.*, 2024). ERVM values >300 Ω were categorized as non-estrus, values between 221–300 Ω were considered proestrus/metestrus, values between 181–220 Ω were considered the period of maximum physiological estrus-related changes, and values <180 Ω were classified as peak estrus.

Measurement of dominant follicle diameter

Transrectal ultrasonographic examinations were performed using an ultrasound system (Mindray DP10 Vet, 5 MHz) at the time of $PGF_2\alpha$ injection (D0) and subsequently repeated at 24 h intervals for 4 days (D1, D2, and D3). All ultrasonographic examinations were conducted by the same operator to ensure data consistency. The dominant follicle was defined as the follicle that reached the largest diameter during the observation period (Sirois and Fortune, 1988). All examinations were performed while the animals were restrained in a standing position.

Data analysis

Data were analyzed using descriptive statistics and presented as mean ± standard deviation (SD). Normality of data distribution was assessed using the Shapiro–Wilk test. Changes in ERVM values, follicle diameter, and estrus score over time were analyzed using Friedman test, followed by appropriate post hoc tests. Correlations among variables were analyzed using Spearman correlation coefficients. Multiple linear regression analysis was performed to determine the effect of ERVM and follicle diameter on estrus score. Statistical significance was set at $p<0.05$. Statistical analyses were performed using IBM SPSS Statistics version XX (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Changes in estrus score, ERVM, and dominant follicle diameter following $PGF_2\alpha$ administration

Of the 15 cows, 12 showed estrus signs after a single PGF2α injection, giving a response rate of 80%. This rate was lower than the 100% response reported with double PGF2α injections in Aceh cattle (Hafizuddin *et al.*, 2024). The difference in estrus response was likely associated with the synchronization protocol used. In double-injection protocols, the second $PGF_2\alpha$ administration is intended to ensure that a greater proportion of animals are in the luteal phase with a functional corpus luteum responsive to $PGF_2\alpha$, thereby producing a more synchronized estrus response. Similar findings were reported in Boran cattle, in which estrus response following the second $PGF_2\alpha$ injection reached 91.01% (Dodicho *et al.*, 2024). A single $PGF_2\alpha$ injection was selected because the study focused on physiological changes associated with estrus synchronization in cows previously confirmed to possess a functional corpus luteum, rather than on maximizing synchronization efficiency across animals at different stages of the estrous cycle.

Estrus scores increased from 0 h and reached the highest value at 48 h (4.00 ± 1.79), before declining again at 72 h. However, the changes in estrus score were not statistically significant (p=0.097), as presented in Table 2. The non-significant estrus scores may reflect our modifications to the scoring method. In the original method proposed by Van Eerdenburg *et al.* (2002), standing heat is considered one of the most sensitive behavioral indicators of estrus. However, this parameter was excluded in the present study because teaser bulls were not used to stimulate behavioral responses. The exclusion of this parameter may have reduced the sensitivity of the scoring system, resulting in smaller variations in estrus score among observation periods and consequently non-significant statistical differences. In addition, estrus expression is influenced by various individual and environmental factors, making behavioral estrus more variable than physiological parameters. Factors such as milk production, parity, health status, housing system, season, and herd size may influence estrus intensity and duration (Reith and Hoy, 2018; Van Eerdenburg *et al.*, 2024). Behavioral indicators such as vocalization and appetite changes were assessed qualitatively and may have been influenced by observer interpretation and individual animal variation.

Table 2: Changes in estrus score, ERVM values, and dominant follicle diameter following estrus synchronization using $PGF_2\alpha$ in Aceh cattle.

Variable	0 (D0)	24 (D1)	48 (D2)	72 (D3)	p value
ERVM score (Ω)	336.11 ± 31.15^a	287.78 ± 10.85^{ab}	262.22 ± 9.06^b	330.56 ± 24.32^a	0.006
Dominant Follicle diameter (mm)	7.85 ± 0.43^a	9.37 ± 0.50^{ab}	10.88 ± 0.66^b	7.08 ± 1.35^a	0.001
Estrus score	0.25 ± 0.25	2.58 ± 0.84	4.00 ± 1.79	0.50 ± 0.34	0.097

Different superscript letters (a, b, and ab) within the same row indicate significant differences among observation times ($P < 0.05$). Values are presented as mean ± SD (n = 12 cows exhibiting oestrus signs).

The relatively low estrus scores observed in the present study may be attributed to the limited observation period (30 min per observation). During such a short observation window, Aceh cattle rarely exhibited all behavioral estrus signs simultaneously, resulting in lower cumulative estrus scores despite clear physiological evidence of estrus based on ERVM and follicular dynamics. Behavioural estrus scores did not differ significantly among observation times ($P>0.05$), although the highest mean score was observed at 48 h post-injection. In contrast, ERVM and dominant follicle diameter changed significantly over time, indicating the period of maximum physiological estrus-related changes during this period. The present study demonstrated that ERVM values decreased significantly ($P<0.05$) 48 h after $PGF_2\alpha$ injection to 262.22 ± 9.06 Ω and increased again 24 h later to 330.56 ± 24.32 Ω (Table 2). These findings are consistent with the report of Maquivar *et al.* (2019), who demonstrated that ERVM values vary according to the estrous cycle phase. ERVM values were significantly lower during the follicular/estrus phase compared to the luteal phase and were significantly associated with corpus luteum diameter and dominant follicle diameter during estrus.

The decline in ERVM values following $PGF_2\alpha$ administration was consistent with physiological changes commonly associated with luteolysis and subsequent follicular development, although progesterone and estradiol concentrations were not measured in the present study. Luteolysis induces regression of the corpus luteum and decreases progesterone concentrations, thereby shifting hormonal dominance towards estrogen produced by the dominant follicle. This hormonal shift alters the physiological condition of the reproductive tract, including increased mucosal hydration and vaginal mucus secretion, which enhance electrical conductivity and reduce vaginal electrical resistance. Melia *et al.* (2013) reported that corpus luteum regression in Aceh cattle observed by ultrasonography showed a gradual decline in corpus luteum diameter following $PGF_2\alpha$ administration, decreasing from 6.25 ± 2.71 mm to 4.50 ± 1.77 mm and 3.25 ± 0.89 mm.

The decrease in ERVM values at 48 h after $PGF_2\alpha$ injection indicated that the cows had entered the period of maximum physiological estrus-related changes, although the standard estrus threshold provided by the device was lower than the values observed in this study. Although ERVM values decreased significantly after $PGF_2\alpha$ administration, the minimum value observed (262.22 ± 9.06 Ω) remained above the manufacturer's recommended oestrus threshold (181–220 Ω). An important finding of the present study is that the lowest ERVM value observed (262.22 ± 9.06 Ω) remained above the manufacturer's recommended oestrus range of 181–220 Ω. Consequently, the present results do not validate the manufacturer's ERVM classification for Aceh cattle. Several explanations are possible, including breed-specific physiological differences, limitations of applying generalized threshold values across cattle breeds, or incomplete agreement between ERVM measurements and other indicators of oestrus. Because the lowest ERVM values coincided with the largest dominant follicle diameter and the highest mean oestrus score, the findings may indicate that Aceh cattle exhibit oestrus-associated physiological changes at ERVM values higher than those proposed by the manufacturer. Further studies incorporating hormonal measurements and ovulation confirmation are needed to establish breed-specific ERVM reference values. Therefore, the present study does not validate the manufacturer's ERVM threshold for oestrus detection in Aceh cattle. Instead, the findings indicate that physiological indicators commonly associated with oestrus, including the largest dominant follicle diameter and the highest mean oestrus score, occurred at ERVM values higher than the currently recommended threshold.

The reduction in ERVM values was likely associated with increased estrogen secretion during dominant follicle development following $PGF_2\alpha$-induced luteolysis approximately 48 h after injection. Besides affecting the physiological condition of the reproductive tract, the reduction in ERVM values during this period may also be related to luteolysis characterized by declining progesterone concentrations. In Aceh cattle, $PGF_2\alpha$ administration has been reported to induce corpus luteum regression, resulting in decreased progesterone concentrations followed by increased follicular activity and estrus expression (Hafizuddin *et al.*, 2024; Thasmi *et al.*, 2017). Estrogen increases hydration and mucus secretion within the reproductive tract, thereby enhancing electrical conductivity and lowering ERVM values.

The increase in ERVM values at 72 h likely indicated the end of the estrus phase and the transition toward the subsequent luteal phase. This increase may reflect the occurrence of ovulation followed by declining estrogen concentrations and increasing luteal activity during the next estrous cycle. Tadesse *et al.* (2011) reported that $PGF_2\alpha$-induced estrus in dairy cattle was associated with decreased ERVM values accompanied by increased dominant follicle diameter, and a negative correlation was observed between ERVM and follicle size.

Dominant follicle diameter changed significantly following $PGF_2\alpha$ administration, reaching the largest diameter at 48 h after injection (10.88 ± 0.66 mm), before decreasing again at 72 h (7.08 ± 1.35 mm), as presented in Table 2. Previous studies have reported that larger dominant follicles are generally associated with higher oestradiol concentrations (Perry *et al.*, 2023). However, because oestradiol was not measured in the present study, this mechanism remains speculative. Melia *et al.* (2024) reported complete regression of the corpus luteum, with no measurable luteal structure detected at the final observation period. Although dominant follicle diameter reached its maximum value at 48 h post-injection, ovulation was not confirmed by subsequent ultrasonographic examination. Therefore, these follicles should not be definitively classified as pre-ovulatory, and their ovulatory status remains unknown.

This condition indicates that $PGF_2\alpha$ effectively induced luteolysis, thereby promoting ovarian activity through dominant follicle development toward the preovulatory stage. These findings are consistent with the report of Putro (2013), who stated that the corpus luteum rapidly regressed following $PGF_2\alpha$ administration and reached its minimum size during estrus approximately three days later. The reduction in follicle diameter observed at 72 h after injection was also in agreement with previous findings showing that dominant follicles in Aceh cattle disappeared on day 4 after $PGF_2\alpha$ administration due to ovulation (Melia *et al*., 2024). It is likely that if observations had been continued until day 4 in the present study, a similar pattern would have been observed. Although dominant follicle diameter reached its maximum value at 48 h post-injection, ovulation was not confirmed by subsequent ultrasonographic examination. Therefore, these follicles should not be definitively classified as pre-ovulatory, and their ovulatory status remains unknown

$PGF_2\alpha$-induced luteolysis decreases progesterone concentrations, thereby promoting dominant follicle development and increasing estradiol production. Elevated estradiol concentrations play an important role in inducing estrus, enhancing reproductive tract function, and preparing an optimal uterine environment for fertilization and embryo development. Furthermore, cows with higher estradiol concentrations during ovulation have been reported to possess larger dominant follicles and higher progesterone concentrations after ovulation, indicating a close relationship among follicular development, luteal function, and reproductive success (Perry *et al*., 2023).

Changes in ERVM values and dominant follicle diameter in Aceh cattle following $PGF_2\alpha$ administration during the 72 h observation period are presented in Figure 1. ERVM values gradually declined and reached the lowest point at 48 h post-injection before increasing again at 72 h. In contrast, dominant follicle diameter increased and reached the maximum size at 48 h before declining at the end of the observation period. The opposite pattern observed between these two parameters indicates a physiological relationship between dominant follicle development and changes in vaginal electrical resistance during estrus following $PGF_2\alpha$ synchronization. The increase in ERVM observed at 72 h may indicate a return toward the post-oestrus physiological state following the period of maximum follicular development observed at 48 h. However, because endocrine profiles and ovulation status were not evaluated, this interpretation should be considered tentative.

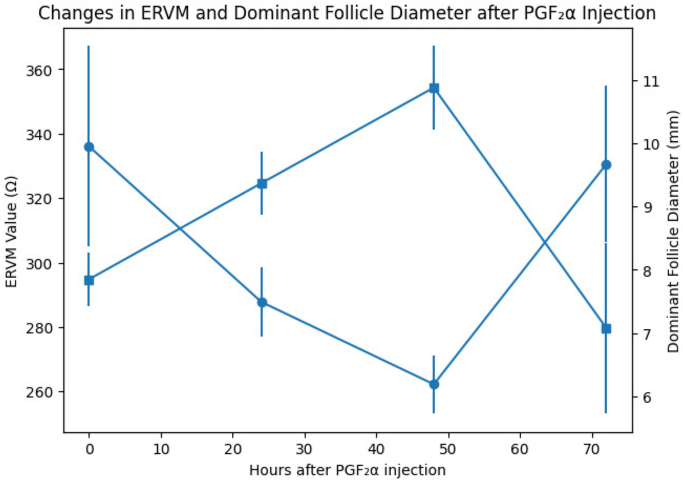

Figure 1: Temporal changes in ERVM values and dominant follicle diameter in Aceh cattle following estrus synchronization using $PGF_2\alpha$.

Correlation and linear regression analysis of estrus score, ERVM, and dominant follicle diameter

Table 3 presents the correlation analysis among estrus score, ERVM values, and follicle diameter in Aceh cattle. The results showed that estrus score had a moderate positive correlation with ERVM (r= 0.466) and follicle diameter (r= 0.383), although these relationships were not statistically significant ($p > 0.05$). These findings indicate that increases in ERVM values and follicle diameter tended to be accompanied by increased estrus expression in Aceh cattle.

Table 3: Correlation analysis between estrus score, ERVM, and dominant follicle diameter in $PGF_2\alpha$-synchronized Aceh cattle.

Variable	Estrus Score		ERVM		Follicle diameter	
	r	p-value	r	p-value	r	p-value
Estrus score	1.000	–	0.466	0.127	0.383	0.219
ERVM	0.466	0.127	1.000	–	-0.158	0.623
Follicle diameter	0.383	0.219	-0.158	0.623	1.000	–

ERVM = Electrical Resistance of Vaginal Mucus.

Although a positive correlation was observed between oestrus score and dominant follicle diameter, the relationship was not statistically significant ($P>0.05$). Therefore, the present study does not provide sufficient evidence to support an association between follicle diameter and behavioural oestrus score. Physiologically, optimally developed follicles produce higher concentrations of estrogen, thereby inducing more pronounced estrus signs (Perry *et al*., 2023). Meanwhile, the positive correlation between estrus score and ERVM indicates that changes in vaginal mucus electrical resistance are associated with physiological reproductive changes during the estrous phase.

On the other hand, ERVM showed a very weak negative correlation with follicle diameter (r=-0.158; p=0.623), indicating that changes in ERVM values in the present study were not directly associated with follicle size. The absence of statistically significant correlations among variables was likely influenced by the relatively small sample size (n=12), resulting in substantial biological variation among individuals.

Nevertheless, the tendency toward positive relationships between estrus score, ERVM, and follicle diameter suggests that both parameters still possess biological potential as reproductive biomarkers for estrus detection in Aceh cattle. The present study demonstrated temporal changes in both ERVM and follicular dynamics following $PGF_2\alpha$ administration, but did not evaluate the comparative effectiveness of combining these methods for oestrus detection.

Table 4 presents the results of multiple linear regression analysis among ERVM, estrus score, and dominant follicle diameter in Aceh cattle following $PGF_2\alpha$-induced estrus synchronization. This analysis was conducted to evaluate the relationships among reproductive parameters during the estrous period and to determine the association between ERVM changes, dominant follicle development, and estrus expression.

Table 4: Multiple linear regression analysis of ERVM and dominant follicle diameter associated with estrus score in Aceh cattle.

Predictor variables	B	SE	β	t	p value
Constant	-32.458	17.016	–	-1.907	0.089
ERVM	0.103	0.059	0.462	1.754	0.113
Dominant follicle diameter	1.116	0.622	0.472	1.794	0.106
Model parameters	Value				
R	0.62				
R^2	0.385				
Adjusted R^2	0.248				
Standard error of estimate	4.739				
F-value	2.816				
p-value (model)	0.112				
n	12				

Note: Dependent variable= estrus score; B= unstandardised regression coefficient; SE= standard error; β= standardised regression coefficient; t= t-statistic; R= correlation coefficient; R^2= multiple coefficient of determination; F= F-statistic; ERVM= Electrical Resistance of Vaginal Mucus.

The exploratory regression analysis indicated that ERVM and dominant follicle diameter were associated with the model; however, the overall model was not statistically significant (P= 0.112). The regression equation obtained was as follows: Estrus Score=−32.458+0.103 (ERVM)+1.116 (Follicle Diameter)

The regression analysis indicated that increases in ERVM values and follicle diameter tended to be followed by increased estrus response. Quantitatively, each one-unit increase in ERVM value was estimated to increase estrus score by 0.103 units, whereas each 1 mm increase in follicle diameter was predicted to increase estrus score by 1.116 units, assuming other variables remained constant.

The standardized regression coefficient (β) demonstrated that maximum follicle diameter (β=0.472) contributed slightly more than minimum ERVM (β=0.462) to variations in estrus score. These findings indicate that dominant follicle development plays an important role in enhancing estrus expression in Aceh cattle. Physiologically, increased follicle diameter is associated with enhanced folliculogenesis and estrogen secretion, which subsequently influence estrus behavior and vaginal mucus characteristics.

Although the model yielded an R^2 value of 0.385, the overall regression was not statistically significant (P=0.112), indicating that the observed explanatory power should be interpreted cautiously, particularly given the limited sample size. Although non-parametric approaches were considered, regression analysis was retained to provide an initial assessment of the joint contribution of ERVM and follicular diameter. The results are presented as exploratory and interpreted with caution. These findings suggest the biological potential of both parameters as reproductive biomarkers for selecting Aceh cattle as embryo transfer recipients. Therefore, integration of ERVM measurements and ovarian ultrasonographic evaluation may improve the accuracy of identifying animals with optimal reproductive readiness for artificial insemination.

Several limitations should be considered when interpreting the findings of this study. The relatively small sample size (n= 12) may have reduced statistical power and contributed to the non-significant correlation and regression results. Behavioural oestrus assessment was based on a modified scoring system that excluded standing heat and relied on limited observation periods, potentially underestimating oestrus intensity. Hormonal parameters such as progesterone and oestradiol were not measured, and ultrasonographic observations were terminated at 72 h post-treatment, preventing confirmation of ovulation and subsequent corpus luteum formation. In addition, reproductive outcomes, including conception and pregnancy rates, were not evaluated. The absence of an untreated control group further limits the ability to distinguish treatment effects from natural cyclic variation. Although ERVM measurements were obtained in triplicate, formal assessment of measurement repeatability was not performed, and the lowest ERVM value observed remained above the manufacturer's recommended oestrus threshold, indicating that standard ERVM reference values may not be directly applicable to Aceh cattle. Therefore, the findings should be interpreted with caution, and further studies involving larger sample sizes, hormonal profiling, ovulation confirmation, appropriate control groups, and reproductive performance measurements are needed to validate the biological and practical significance of ERVM and follicular dynamics in Aceh cattle.

CONCLUSION

$PGF_2\alpha$ administration induced significant temporal changes in electrical resistance of vaginal mucus and dominant follicle diameter in Aceh cattle. The lowest ERVM values and the largest dominant follicle diameter were observed at 48 h post-injection, indicating marked physiological changes during the peri-oestrus period. However, the non-significant statistical findings and small sample size mean that the practical value of combining these measurements remains uncertain and requires further validation. Because hormonal concentrations, ovulation, and reproductive outcomes were not evaluated, further studies are required to validate the physiological significance and practical application of these parameters in Aceh cattle. In addition, behavioural assessments were conducted by a single non-blinded observer, and formal evaluation of observer reliability was not performed, which may have introduced observer-related bias.

ACKNOWLEDGEMENTS

The authors are grateful to the Rector of Syiah Kuala University and Indonesia Endowment Fund for Education (LPDP), Ministry of Finance of the Republic of Indonesia for the funding support through the Penelitian Program Riset Kolaborasi Indonesia Equity Skema B1 for the fiscal year 2025–2026 under contract number 2609/UN11.2.4/WCU.01.12/RKI-E/2025.

NOVELTY STATEMENT

This study provides the first integrated evaluation of vaginal mucus electrical resistance (ERVM), dominant follicle dynamics, and estrus expression following $PGF_2\alpha$-induced estrus synchronization in Aceh cattle. The findings indicate that ERVM values associated with physiological estrus are higher than the standard reference range recommended by the manufacturer, suggesting breed-specific characteristics and providing baseline information for improving estrus detection in Aceh cattle.

AUTHOR'S CONTRIBUTION

JM and TNS designed the study, conducted the experiment, collected and analyzed the data, and drafted the manuscript. AB and TNS conceived and supervised the research. MKS, LL, JJ, HH, TA, NPA, H, and CNT assisted with the experimental work and data collection. MT, MMPS, and RE contributed to data interpretation and manuscript revision. All authors reviewed, approved, and agreed to the final version of the manuscript.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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