



## TEMPORAL CHANGES IN MILK YIELD AND COMPOSITION OF EARLY-LACTATION MUTURU COWS UNDER SMALLHOLDER TROPICAL PRODUCTION SYSTEMS

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### ABSTRACT

The temporal variations in milk yield and composition of early lactation Muturu cows in their first parity over 12 weeks were investigated in this study. Twenty Muturu cows were chosen from a mixed herd on a smallholder farm. Milk samples were collected early in the morning (0700 to 0800 hours) and documented every day. Lactose was measured in milk samples on a daily basis, while protein, total solids, fat, solid non-fat, and ash were evaluated in bulked samples using established procedures. The animals were given a diet of natural grasses and shrubs. They were given 16% CP concentrates for six weeks before and after calving. The results demonstrated that there was a statistically significant difference ( $P < 0.05$ ) in both the quantity of milk produced and the nutritional content of the milk throughout the study. Overall, milk production by the Muturu breed cows increased weekly from an average of 3.65 kg during week one through an average of 5.51 kg of milk per animal during week nine, and continued to decrease as lactation progressed. As lactation progressed, the percentage of protein in the milk increased from an initial value of 3.75 percent during week one to a high value of 4.71 percent by week nine; whereas, the percentage of butter fat in the milk decreased from an initial value of 4.30 percent during week one to 3.70 percent by week seven, before increasing again. The overall trend in total solids and solid/non-fat content in the milk followed the same pattern. Simple linear regression was used to evaluate the relationship between milk yield and each component of the milk. There was a highly positive correlation between milk yield and total solids in the milk ( $r = 0.96$ ,  $P < 0.01$ ); likewise, there was a high positive correlation between milk yield and milk protein ( $r = 0.88$ ,  $P < 0.01$ ); however, there was a negative and non-statistically significant correlation between milk yield and butterfat values ( $r = -0.29$ ,  $P < 0.01$ ).

**Keywords:** Lactation, Butterfat, Variation, Pattern, Nutrients.

### INTRODUCTION

Cow milk is the most widely consumed milk globally and has many uses in dairy products (Bekere *et al.*, 2022). The majority of Nigerian cattle are raised by extensive methods (about 82.1%), but approximately 58.2% of Muturu farmers use semi-intensive techniques to raise their cattle. In spite of the fact that pastoralists produce 95% of all milk consumed in Nigeria, they currently do not meet the 1.45-billion-liter demand for this product from consumers (CSIRO, 2021; Oyekale *et al.*, 2023). The Muturu (*Bos taurus brachyceros*) is a humpless shorthorn breed that is trypanotolerant, robust, and hardy. It is mostly found in western Africa, notably in Nigeria, where it is utilized in smallholder agricultural systems (Ajayi *et al.*, 2022). The ease of rearing and the ability of the Muturu breed to survive on low-quality feed and limited water supply have made it a choice breed for many smallholder farmers in Nigeria (Adoligbe *et al.*, 2020). The Muturu cattle, adjudged the smallest cattle breed in Nigeria, are considered sacred because their milk is used for medicinal purposes in many tropical regions. (Ahozonlin *et al.*, 2022).

The many different influences of intrinsic and extrinsic factors that affect both milk quantity and quality include breed, lactation phase, climate and seasonality, feed intake and diet, and farm management systems (Rúa-Giraldo *et al.*, 2024; Gelaye *et al.*, 2025; Nasir *et al.*, 2025); these various impacts produce considerable differences in milk production. In regions where tropical climates prevail, variation in forage quality, availability, and management methods can also impact milk production and its components and require additional studies to examine the long-term variability in native breeds of cattle (Hayes *et al.*, 2023).



Proximate milk composition, including fat, proteins, lactose, total solids, and ash content, has an extremely important function in defining milk quality or suitability for use as a beverage or processed product (Kasapidou *et al.*, 2023; Abou Ayana *et al.*, 2025). Also, milk composition defines both infant and adult nutritional needs and dairy process yields (Hayes *et al.*, 2023), further emphasizing the importance of studying milk composition in local cattle breeds that serve as the foundation for rural economies. Milk samples taken weekly provide valuable information for evaluating changes in cow feeding and health status as well as milk quality (Siberski-Cooper and Koltes, 2021), whereas milk yield and composition continue to be used as the primary indicator(s) of dairy profitability (Gorelik *et al.*, 2021). In Africa, milk production levels vary significantly among indigenous breeds (Ema *et al.*, 2018); however, approximately 90 percent of all milk produced comes from low input/low yielding systems. These findings highlight the need to evaluate them in order to improve how they are managed. As one of the most important genetic resources in Africa, the Muturu breed has lower-than-average milk yields (Adoligbe *et al.*, 2022) but has declining populations and reduced productivity as a result of increased competition from other breeds (Ajayi *et al.*, 2022). Extensive research has focused on the major dairy breeds (Holsteins and Jerseys) (Busanello *et al.*, 2025; Hauser *et al.*, 2025), but there is limited documentation regarding the milk-producing abilities of Muturu cattle (Ngere, 1990), although genetic progress relies on both increases in population size and productivity improvements (Gobel *et al.*, 2021). Therefore, understanding the potential nutritional and dairy production value of these cattle will help characterize and document their productive value in order to develop strategies to improve milk quality and quantity for small-scale farmers in Africa. This project provides preliminary scientific data regarding lactation patterns and milk composition in Muturu cattle to maintain their genetic identity, help selection and breeding programs, and ultimately support achieving sustainable production and food security in West Africa.

## **MATERIALS AND METHODS**

### **Study Area**

This study was undertaken in the Deborah Cattle Farm village in Ado Ekiti, Ekiti State, Nigeria. The area is located at (7° 37'N, 5° 13'E) at an elevation of 455m above sea level in a tropical climate with distinct wet and dry seasons, an average annual temperature of 32°C, and a relative humidity range of 60–85%. The major vegetation is lowland tropical grasslands, which provide natural grazing pastures for cattle. This research was conducted during the rainy season, which lasted from May to July.

### **Experimental Animals and Feeding**

Twenty lactating Muturu cows in their first parity, raised under a semi-intensive system, were selected for this study. The experimental animals were grazed daily on natural and mixed grasses and shrubs (*Penisetum purpureum*, *Panicum maximum*, *Talinum triangulare*, and *Gliricidia sepium*, etc.) from 0900 hours to 1600 hours. The in-dams were also given some concentrate feeds of 16% CP (consisting of brewers' dried grain, cassava peels, maize offal, cottonseed cake, etc.), a few weeks before and after calving. The cows grazed freely with supervision by the herdsmen, after which they were retired to their pens at night to rest. They were routinely vaccinated against diseases. Freshwater and salt lick were provided *ad libitum* throughout the study.

### **Milk Collection and Yield Measurements**

Fresh milk samples were collected daily from each cow. Lactating animals were milked between 7:00hr and 8:00hr once daily by hand milking technique starting from the eighth day after calving. The values obtained were adjusted for two-milking-a-day production. Daily milk yield was recorded per cow per day, and the yield data were averaged weekly for statistical comparisons. Before cow milking, each teat was washed, wiped with an udder towel, disinfected and allowed to dry, and thereafter milked until the udder was empty. However, the first squirts of milk were rejected. Collected milk (5 mL) from each lactating cow was poured into sterile, labeled sample bottles with no preservatives and stored in a deep freezer at -20°C until needed for laboratory analysis.



### **Milk Sample Analysis**

Milk samples were collected on a daily basis from each cow for milk lactose determination before bulking, using the Marrier and Boulet (1959) colorimetric method. Every week, the milk samples were labeled and transported to the laboratory in an ice cooler. The milk samples were evaluated for proximate composition, including milk fat using the Gerber extraction technique (AOAC, 2006), protein using the Kjeldahl (Kjeldahl, 1883) method, and lactose using Marrier and Boulet's enzymatic colorimetric method (1959). Total solids were determined by gravimetric drying at 105°C for 24 hours in accordance with AOAC (2012), ash by incineration in a muffle furnace at 550°C, while solids-non-fat was calculated by subtracting butter fat from total solids.

### **Statistical Analysis**

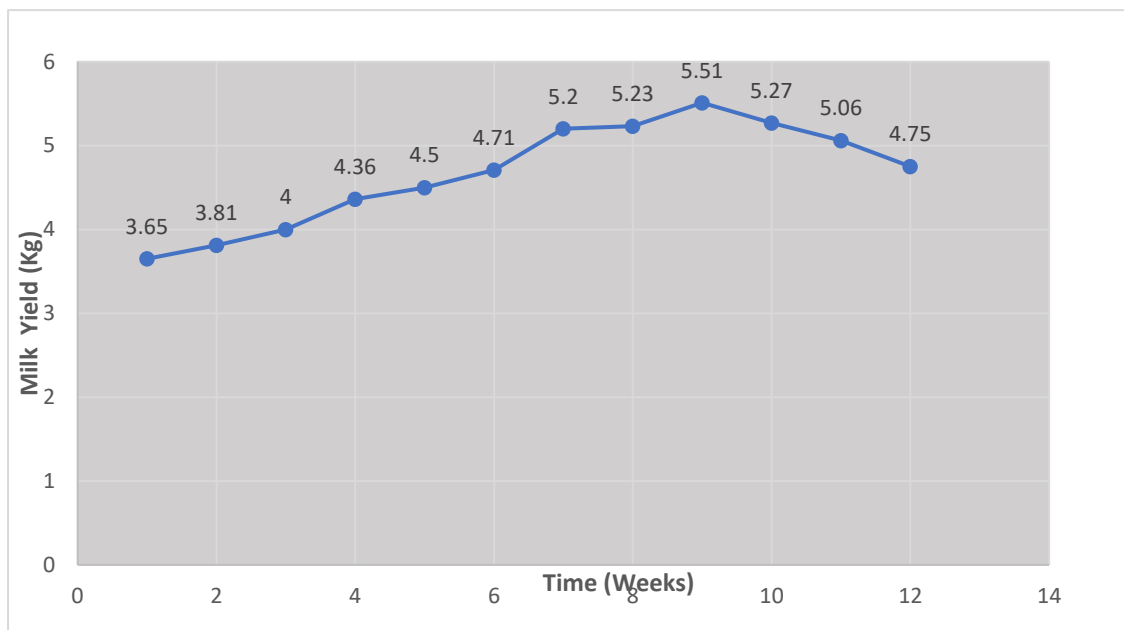
The analysis of variance (ANOVA) and the simple linear regression analysis of the recorded data were done using SPSS Version 15.0 (SPSS Inc., Chicago, IL, USA). The standard deviation and coefficient of variation were calculated, and where significant differences were found, Tukey's HSD post hoc tests (Tukey, 1953) were used to separate treatment means. For all statistical analyses, significance was accepted at  $p < 0.05$ .

## **RESULTS AND DISCUSSION**

The longitudinal assessment of temporal shifts in milk yield and composition among semi-intensively managed Muturu cattle offers valuable insights into their dairy performance within low-input systems. The results indicated prominent variations in both milk quantity and composition throughout the lactation cycle due to the cows' normal biological rhythms' intricate interaction with the environment as well as the management practices associated with extensive farming systems.

### **Milk Yield**

The average milk yield of the Muturu cattle breed is relatively low; however, significant variations in milk yields were observed among individual cows. Milk yields increased gradually immediately post-calving and reached their peak between weeks seven and nine (Table 1). This is consistent with previous reports that milk yields in dairy breeds usually reach their peak at mid-lactation (Chaudhary, 2021). While the week six peak identified by Ezekwe and Machebe (2021) does not agree with the observed data in this study, the findings, however, agree with reports by Ahamefule and Ibeawuchi (2008), which indicated that milk output peaked at week seven in Muturu cattle. The initial increase in milk yields depicts the cow's physiological transition into lactation, including the development of her mammary gland and hormonal changes related to parturition. Conversely, the latter decrease represents the normal decline in milk production that occurs as the cow transitions out of lactation (Hannan *et al.*, 2023). Pasture quality and quantity also affect the shape of a cow's lactation curve, particularly when cows are grazed extensively. Seasonal variability in nutrient content in pastures typically results in similar seasonal variability in milk yields and is a trait commonly seen in pasture-based dairy operations (Timlin *et al.*, 2021). Tactically supplementing cows' diets during the dry seasons of poor-quality pasture can assist in steadying milk yields and reducing the degree of fluctuation between peaks and troughs.



**Fig 1:** Lactation curve of the early-lactation tropical Muturu cattle.

### Milk Composition

Milk Protein Content showed an upward trend throughout this study; it reached its peak in week 8 (Table 1). These findings support prior studies which stated that protein concentration generally increases as lactation continues, largely because of a decrease in milk volume (Ezekwe and Machebe, 2021). A higher protein concentration during the mid-lactation stage is critical to ensure calf growth and development with adequate nutrients being supplied (Zhang *et al.*, 2015). Improved nutritional planning to meet the needs of dams during the mid-lactation stage may further improve the protein content of their milk for the benefit of both dam and calf. (Brunner, 1981). Butterfat Content in Muturu milk was relatively high (especially at 4.63% in week 12); when compared to the butterfat values obtained in other breeds (Ezekwe and Machebe, 2021), these values are useful nutritionally. Butterfat content followed a varying trend, with a decline observed from week 2 to week 7 (See Table 1). The observed butterfat values were comparable to those found by Ezekwe and Machebe (2021) as a mean value (4.72%). The inverse relationship between milk yield and butterfat observed in this study agrees with reports of Ahamfule and Ibeawuchi (2008) and Ezekwe and Machebe (2021). Several factors such as dietary fat composition, ruminal fermentation profiles, and metabolic responses influence variation in butterfat levels (Toral *et al.*, 2018). Grazing systems provide extensive variety in diets, thereby influencing the fatty acid profile of milk fat, and potentially affecting the synthesis of milk fat. Additionally, seasonal fluctuations in pastures available to animals can result in energy deficits and affect milk fat production. (Chaidanya, 2015). This highlights the importance of providing a reliable source of quality forage or supplemental energy.

Fat content in milk affects flavor and energy (Garhwal *et al.*, 2023), whereas the nutritional value and functional characteristics of milk depend on protein content for the manufacture of dairy products (ALKaisy *et al.*, 2023).

Lactose is the principal carbohydrate of cattle's milk and serves as an essential source of energy, which defines the stability of milk (Costa *et al.*, 2019; Portnoy and Barbano, 2021). The lactose content generally improved throughout the study, peaking along with total solids during weeks 7 to 9 (Table 1). This study recorded a positive relationship between lactose and milk protein, which is similar to reports by Ahamfule and Ibeawuchi (2008). Lactose serves primarily as an osmotic regulatory compound for milk (Carasca, 2023); therefore, any changes to lactose could indicate that there are possibly some concerns related to the mammary gland or other udder-related health issues (Zigo *et al.*, 2021), thereby



providing a means by which milk quality and udder health may potentially be evaluated. (Auldist *et al.*, 1995) reported a decline in lactose concentration as lactation progressed in his study; however, this trend was inconsistent with data from the current study.

The ash and solid non-fat (SNF) content of the milk samples also demonstrated considerable temporal variation (Table 1). The SNF content, which reflects the protein, mineral, and lactose components in milk, increased throughout the study. This finding supports recent research that has suggested that milk's nutritional value increases with time (Kailasapathy, 2015). Together, these components provide a comprehensive view of Muturu's milk nutritional worth and economic significance. The disparities in milk yield between Muturu and other breeds may be attributed to the high genetic potential and varying levels of management supplied by various farmers (Innocent *et al.*, 2023). However, the milk constituents were within the values reported for other Muturu tropical breeds (Ahamefule and Ibeawuchi, 2008).



**Table 1:** Weekly Milk Yield and Composition in Early-Lactation Tropical Muturu Cattle

| Week | Milk Yield (kg)           | Protein (%)               | Butter Fat (%)            | Ash (%)                  | Lactose (%)               | Total Solid (%)           | Solid Non-Fat (%)        |
|------|---------------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------|--------------------------|
| 1    | 3.65 ± 0.09 <sup>a</sup>  | 3.75 ± 0.07 <sup>a</sup>  | 4.30 ± 0.45 <sup>a</sup>  | 0.81± 0.01 <sup>b</sup>  | 3.75 ± 0.04 <sup>a</sup>  | 9.47 ± 0.08 <sup>a</sup>  | 5.17 ± 0.55 <sup>a</sup> |
| 2    | 3.81 ± 0.08 <sup>a</sup>  | 3.71 ± 0.05 <sup>ab</sup> | 4.22 ± 0.46 <sup>a</sup>  | 0.86± 0.31 <sup>a</sup>  | 3.81 ± 0.04 <sup>a</sup>  | 9.77 ± 0.07 <sup>b</sup>  | 5.55 ± 0.53 <sup>b</sup> |
| 3    | 4.00 ± 0.08 <sup>ab</sup> | 3.79 ± 0.05 <sup>b</sup>  | 4.10 ± 0.43 <sup>ab</sup> | 0.76 ± 0.07 <sup>c</sup> | 3.85 ± 0.05 <sup>ab</sup> | 10.04 ± 0.08 <sup>c</sup> | 5.94 ± 0.53 <sup>c</sup> |
| 4    | 4.36 ± 0.08 <sup>bc</sup> | 4.10 ± 0.08 <sup>c</sup>  | 4.04 ± 0.46 <sup>bc</sup> | 0.74± 0.01 <sup>c</sup>  | 3.94 ± 0.04 <sup>bc</sup> | 10.41 ± 0.07 <sup>d</sup> | 6.37 ± 0.53 <sup>d</sup> |
| 5    | 4.50 ± 0.09 <sup>c</sup>  | 4.30 ± 0.07 <sup>d</sup>  | 4.00 ± 0.46 <sup>c</sup>  | 0.72±0.11 <sup>cd</sup>  | 4.00 ± 0.05 <sup>c</sup>  | 10.90 ± 0.09 <sup>e</sup> | 6.90 ± 0.54 <sup>e</sup> |
| 6    | 4.71 ± 0.08 <sup>cd</sup> | 4.39 ± 0.07 <sup>d</sup>  | 3.91 ± 0.46 <sup>c</sup>  | 0.67± 0.01 <sup>d</sup>  | 4.22 ± 0.04 <sup>d</sup>  | 11.00 ± 0.08 <sup>e</sup> | 7.09 ± 0.54 <sup>e</sup> |
| 7    | 5.20 ± 0.08 <sup>de</sup> | 4.45 ± 0.07 <sup>e</sup>  | 3.70 ± 0.46 <sup>d</sup>  | 0.75 ± 0.02 <sup>c</sup> | 4.45 ± 0.06 <sup>e</sup>  | 11.34 ± 0.08 <sup>f</sup> | 7.64 ± 0.54 <sup>f</sup> |
| 8    | 5.23 ± 0.08 <sup>e</sup>  | 4.66 ± 0.07 <sup>f</sup>  | 3.93 ± 0.96 <sup>c</sup>  | 0.77± 0.01 <sup>c</sup>  | 4.50 ± 0.06 <sup>e</sup>  | 11.70 ± 0.08 <sup>g</sup> | 7.77 ± 1.04 <sup>g</sup> |
| 9    | 5.51 ± 0.08 <sup>ef</sup> | 4.71 ± 0.05 <sup>f</sup>  | 4.01± 0.44 <sup>bc</sup>  | 0.80± 0.06 <sup>b</sup>  | 4.30 ± 0.04 <sup>d</sup>  | 12.06± 0.08 <sup>h</sup>  | 8.05 ± 0.89 <sup>h</sup> |
| 10   | 5.27 ± 0.08 <sup>e</sup>  | 4.60 ± 0.07 <sup>f</sup>  | 4.18 ± 0.43 <sup>b</sup>  | 0.80± 0.01 <sup>b</sup>  | 4.11 ± 0.04 <sup>cd</sup> | 12.50 ± 0.08 <sup>i</sup> | 8.32 ± 0.66 <sup>i</sup> |
| 11   | 5.06 ± 0.08 <sup>de</sup> | 4.20 ± 0.07 <sup>dc</sup> | 4.35 ± 0.44 <sup>a</sup>  | 0.76 ± 0.03 <sup>c</sup> | 4.00 ± 0.04 <sup>c</sup>  | 11.72 ± 0.08 <sup>g</sup> | 7.32 ± 0.66 <sup>e</sup> |
| 12   | 4.75 ± 0.08 <sup>cd</sup> | 3.83 ± 0.05 <sup>b</sup>  | 4.63 ± 0.45 <sup>a</sup>  | 0.68 ± 0.01 <sup>d</sup> | 3.82 ± 0.04 <sup>ab</sup> | 11.00 ± 0.08 <sup>e</sup> | 6.37 ± 0.01 <sup>d</sup> |

\*a, b, c, d, e, f, g, h... Means that different superscripts in the same column are significantly different (P<0.05). SEM = Standard error of the mean.



### Relationship between Milk Yield and its Components

The simple linear regression analysis in the Muturu breed revealed statistically significant relationships between milk yield and vital milk components, notably total solids (TS) and crude protein (CP). The milk yield record was found to have a high positive and statistically significant ( $P < 0.01$ ) correlation with total solids ( $r = 0.96$ ), indicating that higher milk yield in Muturu cattle leads to higher solids in their milk. Previous research has noted similar relationships among various dairy systems in the tropics (Park *et al.*, 2007; Olanrewaju *et al.*, 2021). A similar trend was observed between milk yield and protein content ( $r = 0.88$ ,  $P < 0.01$ ), which is an indication of the role of protein synthesis in the process of lactation. Conversely, the relationship between milk yield and butter fat (BF) was weakly negative and insignificant, indicating that greater volume may not have a direct influence on fat content. This is consistent with Santos *et al.*'s (2016) findings, which relate it to dilution effects during peak lactation.

Strong correlations existed between total solids and SNF ( $r = 0.97$ ,  $P < 0.01$ ), total solids and protein ( $r = 0.86$ ,  $P < 0.01$ ), as well as between total solids and lactose ( $r = 0.68$ ,  $P < 0.05$ ). It would appear therefore that SNF and protein are primary components contributing to the total solids content of Muturu milk. These findings are in line with previous research by Fox & McSweeney (1998) who identified protein and lactose as two of the most important solid contributors in cow's milk. A negative relationship exists between BF and Protein ( $r = -0.59$ ,  $P < 0.05$ ), which could be indicative of a metabolic trade-off for nutrient distribution, such as those previously reported for indigenous cattle breeds raised in low-input systems (McDermott *et al.*, 2010). These findings indicate that there is a direct correlation between milk yield and both the amount of solids and protein present in the milk of the Muturu cattle breed; thereby providing evidence of potential for improvement through selection or nutrition. The information provided by these data will aid in the development of feeding practices and breeding programs aimed at improving milk quality in indigenous cattle breeds.

**Table 2:** Regression Equations and Correlation Coefficients between Milk Yield and Constituents of Early-lactation Tropical Muturu Cattle.

| Parameter      | Regression Equ.     | SE   | r     | Significance |
|----------------|---------------------|------|-------|--------------|
| Yield and TS   | $Y = 4.16 + 1.46x$  | 0.13 | 0.96  | **           |
| Yield and BF   | $Y = 4.64 + -0.11x$ | 0.12 | -0.29 | ns           |
| Yield and CP   | $Y = 1.74 + 0.53x$  | 0.09 | 0.88  | **           |
| TS and CP      | $Y = 0.46 + 0.34x$  | 0.06 | 0.86  | **           |
| TS and SNF     | $Y = -4.60 + 1.04x$ | 0.08 | 0.97  | **           |
| TS and Lactose | $Y = 2.02 + 0.19x$  | 0.06 | 0.68  | *            |
| TS and Ash     | $Y = 0.85 + -0.01x$ | 0.02 | -0.14 | ns           |
| BF and CP      | $Y = 7.88 + -0.89x$ | 0.39 | -0.59 | *            |
| BF and Ash     | $Y = 0.74 + 0.01x$  | 0.07 | 0.03  | ns           |

\*=  $P < 0.05$ ; \*\*= $P < 0.01$ , ns = not significant.

### CONCLUSION AND RECOMMENDATIONS

The 12-week study revealed clear shifts in Muturu cattle milk yield and composition, highlighting the breed's resilience and strong nutritional value under semi-intensive management. Although they are a relatively small breed of cow, the Muturu cows have the ability to provide an excellent source of well-balanced milk that is beneficial for small-scale farmers. Additionally, changes during different phases of lactation indicate the importance of providing targeted feeding based on lactation phase as well as supplementation with high-energy foods at the beginning of lactation. Similar to other popular breeds, the Muturu cattle can also deliver enhanced productivity and offer long-term dairy possibilities for tropical smallholder farmers. Targeted nutrition, optimal breeding, and lactation-specific treatment are consequently recommended. However, there is a need for further integrated, long-term research that connects milk composition, metabolic condition, and environmental adaptability, which is critical to developing sustainable breed-specific production strategies.



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