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# Chest Girth, Body Weight, and Body Condition Score of Female Swamp Buffaloes at Different Altitudes in West Sumatra, Indonesia

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## ABSTRACT

The purpose of this study is to analyze the variation of chest girth, body weight, and body condition score (BCS) of female swamp buffaloes raised in areas with different altitudes in West Sumatra. Factors such as temperature humidity index (THI) and forage quality were also analyzed as supporting factors. This study was conducted using a survey method at three regions: lowland (Lubuk Basung Regency, Agam Regency, 26–46 m above sea level), moderate land (Akabiluru Regency, Lima Puluh Kota Regency, 570–632 m above sea level), and highland (Matur Regency, Agam Regency, 851–1190 m above sea level). The study sample comprises 104 adult, non-pregnant female buffaloes, selected using purposive sampling. The results showed that chest girth, body weight, and BCS differed significantly among the three regions ($p<0.05$). Water buffalo reared in moderate land performed the highest chest girth (187.45 cm), body weight (522.6 kg), and BCS (3.16), followed by buffalo reared in highland and lowland areas. Better body performance in the moderate land was supported by more comfortable environmental conditions and relatively higher forage quality in that area. In conclusion, environmental altitude influences variations in chest girth, body weight, and BCS in female swamp buffalo, with moderate and highland areas providing the most favorable conditions for optimal body performance.

**Keywords:** body measurements, temperature-humidity index, feed quality, comfort environment, tropical livestock

## INTRODUCTION

The swamp buffalo (Bubalus bubalis) is a ruminant livestock species that plays an important role in community economies, particularly in rural areas. This livestock is typically raised to serve as a family's savings and is also still widely used as working livestock in several traditional industries, such as sugarcane processing and brick production (Reswati and Putra 2023). However, buffalo husbandry systems in Indonesia are still largely traditional, resulting in inadequate production. This condition affects buffalo growth and productivity, which have not yet reached their optimal production potential (Reswati et al. 2024a). In addition to management factors, environmental factors also influence livestock performance and production characteristics, particularly feed availability and environmental comfort (Vale et al. 2019).

Buffaloes in Indonesia inhabit a variety of geographic conditions, ranging from lowlands and moderate lands to highlands, each with distinct characteristics related to temperature, humidity, precipitation, and solar radiation. Reswati et al. (2024b) reported that highland areas had lower ambient temperatures compared to the lowland areas, resulting in differences in livestock comfort levels. Comfort livestock is commonly evaluated using the Temperature-Humidity Index (THI), which is an indicator of hot or cold stress that affects the

physiological balance of livestock (Habeeb et al. 2018). An environment with an optimal THI supports livestock growth and productivity, while an extreme THI can cause thermal stress, disrupt physiological balance, and lower production performance (Patriani et al. 2018).

In addition to thermal conditions, environmental characteristics also influence the growth and nutritional quality of forage. According to a study by Purnomo et al. (2024), there are differences in the dry matter and crude protein contents of gamal (*Gliricidia sepium*) leaves grown in areas with varying agroecological characteristics. Specifically, gamal leaves grown in highland areas have higher dry matter and crude protein contents. Indriani et al. (2020) report that field grasses grown in lowland and medium areas have higher content of NDF, cellulose, and hemicellulose than in highlands. These findings suggest that altitude influences forage quality, leading to variations in livestock nutritional intake depending on rearing location.

Based on the information above, differences in environmental conditions influenced by altitude are believed to affect buffalo body measurements and body condition, particularly chest girth, body weight, and body condition score (BCS). Chest girth and body weight are widely used indicators of physical growth and production potential in buffaloes, while BCS reflects the nutritional and energy status of the animal (Komariah et al. 2018). The Indonesian National Standard 7706-1:2020 on Buffalo Breeds-Part 1: Swamp Buffalo establishes minimum requirements for several body measurement parameters, including a minimum shoulder height of 116 cm in buffaloes, both male and female, a chest girth of at least 172 cm in adult male buffaloes, and a minimum chest girth of 165 cm in adult female buffaloes.

Several previous studies have reported variations in buffalo body size and body weight across regions. Komariah et al. (2015) reported that the body size of buffalo in the highlands was better than that of the buffalo in the lowlands. Hadi et al. (2020) found that the body weight of buffaloes in the highlands was generally lower than in the lowlands, which was closely associated with differences in feed quality and availability. However, previous research has generally been limited to one or two agroecosystem zones, thereby failing to provide a comprehensive understanding of how altitude affects variations in chest girth, body weight, and BCS in swamp buffaloes. Moreover, studies that simultaneously compare chest girth, body weight, and BCS of female swamp buffalo across three different altitude levels (lowland, moderate, and high) remain limited.

Therefore, this study aims to evaluate variations in chest girth, body weight, and BCS of female swamp buffalo reared in lowland, moderate-land, and highland areas, while accounting for differences in feed quality and environmental thermal comfort, as indicated by THI at each location. The results of this study are expected to provide valuable scientific information to support the improvement of swamp buffalo quality in accordance with SNI standards, and to contribute to the development of buffalo management practices that are more adaptive to environmental conditions.

## MATERIAL AND METHODS

### Method, location, tools, and materials of the research

This research was carried out by survey method in three areas in West Sumatra with different altitudes, namely Lubuk Basung District, Agam Regency (lowland, 26–46 m above sea level), Akabiluru District, Lima Puluh Kota Regency (moderate land, 570–632 m above sea level), and Matur District, Agam Regency (highland, 851–1190 m above sea level). The population in this study was buffalo owned by smallholder farmers in the three research locations. Sample selection employed purposive sampling, with the inclusion criterion that adult female buffalo were not pregnant. The number of selected samples was 104, comprising 24 from the lowland, 44 from the moderate land, and 36 from the highlands. The average age of buffalo in the lowlands was 6.64±2.57 years, the moderate land was 6.68±2.13 years, and

the highland was 6.24±2.24 years. The chest girth of buffaloes was measured with a Rondo measuring tape, and ambient temperature and humidity were measured with a digital thermometer and hygrometer.

### Parameters and data analysis

The parameters measured in this study include the main parameters and supporting parameters. The main parameters were chest girth (cm), body weight (kg), and Body Condition Score (BCS). Supporting parameters include: Temperature Humidity Index (THI) and feed quality. THI was calculated from ambient temperature (T) and humidity (RH) data using the formula THI = 0.8T + RH (T–14.4) + 46.4 (Hahn et al., 2009). Forage samples were randomly taken three times at each research location from the pastures that are the primary source of feed for buffaloes. The samples were then dried, ground, and analyzed in the Biochemistry and Biotechnology laboratory at IPB University to determine the contents of dry matter, crude protein, crude fiber, crude fat, ash, and nitrogen-free extract.

Chest girth was measured using a tape measure on the largest circle around the chest, just behind the front leg. Body weight (BW) was estimated using the Schoorl formula, namely BW = $(LD+22)^2/100$, where LD is the chest circumference. Body Condition Score (BCS) was assessed using a scale of 1 to 5 with visual and palpation methods (Singh et al. 2017). The collected data were statistically analyzed using descriptive statistics for each parameter at each altitude region, and were tested using analysis of variance (ANOVA) and a Duncan's Multiple Range Test (DMRT) follow-up test.

## RESULTS AND DISCUSSION

### Temperature Humidity Index (THI)

The value of the Temperature Humidity Index (THI) in areas with different altitudes is presented in Figure 1. The highest THI value was obtained in the lowland area at 81.88, followed by the moderate area at 76.19, and the lowest value was observed in the highland area at 73.10. This result indicates a decrease in THI with increasing altitude.


Figure 1. Temperature Humidity Index in lowlands, moderate lands, and highlands in West Sumatra

Dash et al. (2016) reported that an environment with a THI ≤ 72 represents optimal conditions for buffaloes. At the THI value of 72-78, buffaloes begin to experience mild heat stress, characterized by an increase in rectal temperature and respiratory frequency. The THI value of 79-88 causes moderate heat stress, resulting in a significant increase in respiratory frequency, decreased dry matter intake, and increased water consumption in buffaloes. The THI

value of 89-98 causes severe heat stress, characterized by symptoms of excessive panting and restlessness, decreased rumination and urine secretion, and negative impact on reproductive performance in buffalo. Meanwhile, at THI levels exceeding 98, buffaloes experience extreme heat stress, which can be fatal. Based on this classification, the THI value in the lowlands indicates that buffalo experiences moderate heat stress, while in the moderate land and highlands areas, buffalo experiences mild heat stress.

The decrease in THI in higher-altitude areas is associated with lower air temperature and more stable humidity. This condition provides better thermal comfort for livestock, thereby supporting physiological activities such as feed consumption, growth, and reproduction (Reswati et al. 2024b). Thus, buffalo raised in the highlands tend to have a lower risk of *heat stress* than those raised in lowland areas. This difference in THI is also one of the environmental factors that may influence body performance, including chest girth, body weight, and BCS, which will be discussed in the following parameter.

**Feed Quality**

The quality of grazing field feed across the study site's different altitudes is presented in Table 1. The highest value of dry matter (DM) was found in the lowland at 25.53%, followed by the moderate land (17.83%) and highland (16.69%). The highest crude protein content was observed in the moderate land (13.50%), followed by the highlands (11.12%), and the lowest in the lowlands (8.57%). The crude fiber content in all three regions ranged from 25.52% to 29.25%, while the crude fat content ranged from 1.31% to 1.58%. The highest Nitrogen-Free Extract (NFE) content was observed in the lowlands (53.64%), indicating a greater predominance of non-structural carbohydrates in these areas.

Table 1. Feed quality of grazing fields in lowland, moderate, and highland areas in West Sumatra

| Region | Dry Matter | Ash | Crude Fat | Crude Protein | Crude Fiber | Nitrogen Free Extract |
|---|---|---|---|---|---|---|
| Lowland | 25.53 | 8.31 | 1.58 | 8.57 | 27.90 | 53.64 |
| Moderate land | 17.83 | 12.69 | 1.31 | 13.50 | 25.52 | 46.98 |
| Highland | 16.69 | 12.47 | 1.56 | 11.12 | 29.25 | 45.60 |

The differences in feed quality among the three regions demonstrate the impact of environmental conditions on the nutritional composition of grazing pastures. The high dry matter (DM) content in the lowlands reflects warmer ambient temperatures and high evapotranspiration, resulting in lower plant moisture content. This finding aligns with the results of Fibriana et al. (2018), who reported that evapotranspiration increases with rising temperatures, solar radiation, humidity, and wind speed. In contrast, forage in the moderate and high land areas had lower DM content due to cooler, more humid air, resulting in higher water content in plant tissues.

These results are corroborated by the study of Purnomo et al. (2024), who reported a similar pattern in forage growth in areas with different environmental characteristics. Similar findings were also reported by Indriani et al. (2020), who noted that field grasses in low and moderate land areas have higher content of NDF, cellulose, and hemicellulose than those in highlands. The study of Rochana et al. (2016) Showed that the quality of field grass in the highlands in the dry season tended to be better, characterized by higher crude protein, NFE, and Total Digestible nutrients (TDN) and lower crude fiber compared to lowland and moderate land areas. In contrast, dry matter and phosphorus contents were relatively similar across elevations.

This finding suggests that altitude influences forage nutrient composition, which, in turn, affects the quality and nutritional value for livestock, depending on the rearing location.

Furthermore, the highest crude protein content in the moderate land indicates that the region's agroclimatic conditions support the vegetative growth of nitrogen-rich forage. According to Septian (2023), the increases in crude protein content are influenced by the amount of nitrogen elements absorbed by plants, which in turn increases protein accumulation in plant tissues. The protein content of 13.50% found in moderate land is sufficient to support rumen microbial activity and the growth performance of ruminant livestock.

Overall, the data indicate that the moderate land area has relatively better feed quality in terms of nutritional composition, particularly due to its higher crude protein content combined with crude fiber levels that remain within an optimal range. This condition is likely to support better growth and body condition in buffaloes than in those raised in other regions.

## Chest girth

The average chest girth of female swamp buffalo in areas with different heights in West Sumatra is presented in Figure 2. The highest average chest girth value was found in buffalo in the moderate land (187.45 cm), followed by the buffalo in the highlands (182.14 cm), and the lowest in the lowlands buffalo (167.27 cm). The results of the ANOVA showed that the difference in altitude of the area had a significant effect ($P < 0.05$) on the chest girth of buffaloes. Based on Duncan's Multiple Range Test (DMRT) follow-up test, the chest girth of buffalo in the moderate land is significantly different from that of buffalo in the lowlands, but not substantially different from that of buffalo in the highlands. These results indicate variation in chest girth across regions and altitudes, suggesting that environmental conditions influence the development of swamp buffalo body size.

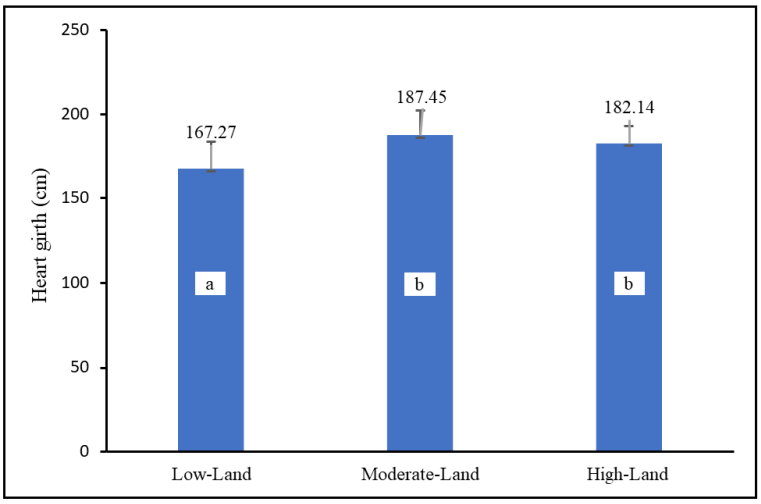


Figure 2. Buffalo chest girth in the lowland, moderate land, and highland areas in West Sumatra; Values followed by different letters indicate significant differences among regions ($p<0.05$) according to Duncan's Multiple Range Test (DMRT)

The chest girth of buffaloes kept in lowlands, moderate, and highlands has all met or exceeded the minimum standard of chest girth set in SNI 7706-1:2020, which is 165 cm (SNI 2020). Nevertheless, buffaloes reared in moderate and highland areas exhibit greater chest girth values compared to lowland buffaloes. This suggests that environmental conditions in areas with medium to high altitudes are more conducive to the morphometric development of buffaloes.

This difference is influenced not only by temperature and humidity but also by variations in feed quality across regions. Based on the results of feed analysis (Table 1), forage from moderate land has the highest crude protein content (13.50%) and crude fiber content (25.52%) that remain within the optimal limits. In comparison, in the lowlands, the protein content is only 8.57%, with the highest NFE (53.64%). The high protein content of feed in the moderate land supports muscle growth and increases body mass, thereby directly contributing to a larger chest girth. On the other hand, low-protein feeds in lowlands result in slower growth. This is consistent with the view of Wihelmina et al. (2023), who stated that muscle mass formation requires proteins that stimulate muscle protein synthesis and prevent muscle tissue damage.

The chest girth of buffalo in the moderate and highland areas shows a larger number than the chest girth of buffalo in Cirebon Regency, West Java Province (Syifauddin 2019), in Kampar District, Riau Islands Province (Rahmad et al. 2025), and in Talang Empat District, Bengkulu Province (Setiawan 2022). Meanwhile, the lowland buffaloes showed a smaller chest girth compared to the buffalo in all three locations. This difference is thought to be related to environmental conditions and greater feed availability in moderate- and highland areas, thereby supporting more optimal body growth.

Chest girth is one of the essential morphometric parameters with a robust correlation (r=0.9) with body weight (Niam et al. 2012; Said and Rusdin 2025). So that it can be used as an indicator of the nutritional condition and productivity of buffaloes. The difference in chest girth between altitude zones is influenced not only by feed quality but also by environmental conditions, as reflected in the Temperature Humidity Index (THI) value. As explained earlier, buffalo in lowland areas are located in areas with high THI, which causes heat stress that impacts feed consumption, resulting in slow growth of muscle tissue, including the chest. In moderate land, the balance between relatively good feed quality and more comfortable thermal conditions allows metabolic efficiency to be optimized without heat-stress disturbances, resulting in a larger chest girth. Although the quality of feed in the highlands is relatively good and THI is lower, the colder ambient temperature diverts some of the body's energy to thermoregulatory processes, resulting in suboptimal tissue growth and a slightly smaller chest girth than on the temperate plains.

**Body weight**

The body weight of buffalo in the lowland, moderate land, and highland in West Sumatra is presented in Figure 3. The average body weight of female swamp buffaloes showed a significant difference ($P < 0.05$) between altitude regions. The highest body weight is found in buffalo in the moderate land (440.92 kg), followed by the highlands (417.87 kg), and the lowest in the lowlands (360.74 kg). This pattern aligns with variation in chest girth, indicating that differences in environmental conditions and feed quality across regions affect the growth performance of buffaloes.

The difference in body weight is closely related to the nutritional quality of forage and environmental thermal conditions. Based on the results of feed analysis (Table 1), forage in the moderate land has the highest crude protein content (13.50%), followed by the highlands (11.12%) and the lowlands (8.57%). Research results Mariani et al. (2016) showed that the provision of rations with the highest protein content (15.42%) and gross energy of 4.02 Mcal/kg of dry matter resulted in a higher increase in daily body weight of Bali cattle and a lower feed conversion ratio (FCR) value compared to rations with lower protein content. It indicates that the adequacy of protein in the ration plays a crucial role in supporting nutrient utilization efficiency and promoting optimal growth in livestock. In addition, the crude fiber content in the moderate land (25.52%) is medium, so the digestibility of feed is better than in the lowlands with higher crude fiber (27.90%). Crude fiber in rations that are too high can lower the consumption rate (Aling et al. 2020), which will affect buffalo growth.

In contrast, forage in lowlands has the highest NFE (53.64), but with low protein levels. This imbalance between energy and protein hinders the formation of body tissues, even when sufficient energy is available. This condition is exacerbated by the highest THI value in the lowlands (81.88), indicating heat stress. According to Dash et al. (2016) heat stress reduces feed intake, impairs energy metabolism efficiency, and ultimately decreases livestock growth performance. Buffalo in the moderate and highland areas have a greater body weight because the environment with more moderate temperatures and better quality feed supports an optimal energy-protein balance for growth.

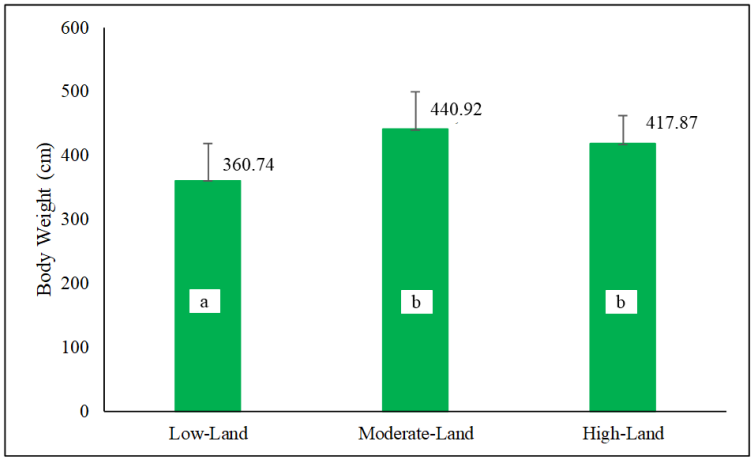


Figure 3. Body weight of the buffalo in the lowland, moderate land, and highland areas in West Sumatra; Values followed by different letters indicate significant differences among regions ($p<0.05$) according to Duncan's Multiple Range Test (DMRT).

However, the body weight of buffalo in the highlands is slightly lower than in the temperate plains. This is thought to be due to lower ambient temperatures at high altitudes, requiring additional energy for thermoregulation. This is in accordance with the opinion of Nuriyasa et al. (2015), which states that livestock raised in environmental conditions with THI values that deviate from the comfort zone experience increased energy requirements for basic life, resulting in a decrease in the energy available for growth.

Overall, these results indicate that the combination of thermal conditions (THI) and feed quality significantly influences the growth efficiency of swamp buffaloes. The moderate land is the region with the most favorable thermal environment (moderate THI) and relatively balanced feed nutrient composition, resulting in significantly higher body size and body weight ($P<0.05$).

## Body Condition Score (BCS)

The BCS scores of buffaloes across different altitudes in West Sumatra are shown in Figure 4. The analysis showed that altitude differences in the area significantly influenced the BCS of female swamp buffalo ($P<0.05$). The highest average BCS score was found in the buffalo at moderate land (3.16), followed by the highland (3.08), while the lowest value was found in the lowland (2.98). The different letters on the graph indicate the significant differences between regions based on Duncan's Multiple Range Test (DMRT).

Based on Singh et al. (2017), the body condition of buffalo in the lowlands is categorized as medium, while that of buffalo in the moderate and highland areas is categorized as ideal. This pattern is consistent with variations in body weight (Figure 4), in which the buffalo on the moderate land exhibit better body performance. This indicates that an environment with moderate temperatures and high-quality feed supports optimal energy and metabolic balance, thereby maintaining body condition. BCS is a quick and practical method for evaluating

livestock energy reserves by describing the relationship between fat and energy metabolism (Saqib et al., 2022). A higher BCS indicates that cattle can store energy reserves in the form of subcutaneous and intramuscular fat tissue, which is an indicator of nutritional adequacy.

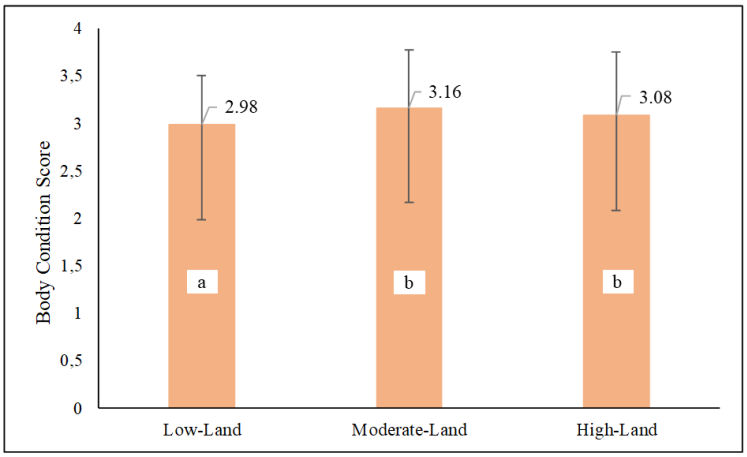


Figure 4. BCS buffalo in the lowland, moderate land, and highland areas in West Sumatra; Values followed by different letters indicate significant differences among regions ($p<0.05$) according to Duncan's Multiple Range Test (DMRT).

Lower BCS values in the lowland are thought to be related to the region's high THI (81.88) and low forage crude protein content (8.57%). This high THI condition can lead to decreased appetite and digestive efficiency due to heat stress (Dash et al. 2016), so that energy and protein intake are insufficient to maintain optimal body condition. In contrast, plains buffalo thrive in environments with lower THI and feed on a diet with balanced nutritional composition, particularly with the highest crude protein content (13.50%) and medium crude fiber (25.52%), which supports the body's nutritional status and energy balance.

The BCS of buffalo in the highland is slightly lower than in the moderate land, likely due to the use of additional energy for the thermoregulatory process at lower temperatures (Nuriyasa et al. 2015). Although the feed in this region is relatively good, some metabolic energy is allocated to maintaining body temperature rather than to storing fat reserves.

## CONCLUSION

Altitude differences in West Sumatra significantly affect the performance of female swamp buffaloes, as indicated by variations in chest girth, body weight, and BCS. Buffaloes reared in moderate land show the best chest girth, body weight, and BCS, while the lowest values are generally found in lowland. These performance differences are influenced by environmental conditions, particularly thermal comfort and feed quality, which affect the efficiency of energy and nutrient utilization. Thus, the moderate land area most supports optimal body performance in female swamp buffaloes in West Sumatra.

## CONFLICT OF INTEREST

The author states that there is no conflict of interest in the implementation of the research or the writing of this article.

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