THE CORRELATION OF
BODY SIZE AND BODY WEIGHT
IN ONGOLE GRADE CATTLE

UNDERGRADUATE THESIS

By:

Ega Rosalinda
SIN. 165050100111010

ANIMAL SCIENCE STUDY PROGRAM
FACULTY OF ANIMAL SCIENCE
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An Undergraduate Thesis presented as
partial fulfilment of the requirements for the
Bachelor Degree Faculty of Animal Science
University of Brawijaya

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On Date: Thursday, 9th July 2020

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BIOGRAPHY

The author was born in Probolinggo, May 22nd, 1998. The third child of Mr. Hariyono and the late Mrs. Odah. The author starts her education in SDN Lumbang 1 and graduated in 2010, continued to Junior High School in SMPN 1 Lumbang and graduated in 2013, then graduated from SMAN 1 Tongas in 2016. In 2016, the author accepted in Faculty of Animal Science University of Brawijaya through *Seleksi Bersama Masuk Perguruan Tinggi Neger*i (SBMPTN).

In 2015, the author was a part of *Pasukan Pengibar Bendera* (PASKIBRA) of Probolinggo Regency. The author also actived in faculty organization that focused on scientific paper named *Kelompok Ilmiah Mahasiswa* (KIM) for 2017-2019 and joined the scientific paper competition for student orientation at university level, Rektor Cup in 2017 and achieved an award as the first winner with the title of the paper was PROFIT. The author has also joined World Invention and Technology Expo (WINTEX) in 2018 at Bandung Institute of Technology and achieved a Silver Medal with the title of the innovation was BIT-TURNER. In 2019, The author joined social dedication with KIM *Mengabdi* V in Nongkojajar Village, Pasuruan Regency with the activities were focused on milk processing training and scientific paper writing for senior high school students in the location. In 2019, the author joined an internship program at PT. Japfa Comfeed Indonesia Tbk., Poultry Breeding – Hatchery Unit, Subang, West Java.

ACKNOWLEDGMENTS

Alhamdulillah by the grace of God Almighty for His blessings, so the author was able to accomplish this undergraduate thesis entitled "**The Correlation of Body Size and Body Weight in Ongole Grade Cattle**". The author expresses great gratitude to all parties who helped in the completion of the undergraduate thesis from the beginning to the end especially to:

1. My Parents, Mr. Hariyono and the late Mrs. Odah, Mama Rena Susanti, my beloved brother and sister, Hendri Hananta and Fransisca Agustin, and my beloved Niece Gabriella Andrea Munk who always pray and support me in every step I take,
2. Prof. Dr. Ir. V. M. Ani Nurgiartiningsih, M.Sc., as the advisor who gives advice and guidance from the beginning until the end of my writing,
3. Prof. Dr. Ir. Gatot Ciptadi, DESS., IPU., ASEAN Eng. and Dr. Ir. Marjuki, M.Sc., as the examiners who spend their time and give advice for my writing,
4. Prof. Dr. Sc. Agr. Ir. Suyadi, MS., IPU., ASEAN Eng., as Dean of Animal Science Faculty University of Brawijaya,
5. Dr. Khotibul Umam Al Awwaly, S.Pt., M.Si., as Head of Animal Science Major Animal Science Faculty University of Brawijaya,
6. Dr. Herly Evanuarini, S.Pt., MP., as Head of Animal Science Study Program Animal Science Faculty University of Brawijaya,
7. Ir. Nur Cholis, M.Si., IPM., ASEAN Eng., as Head of Animal Production Department Animal Science Faculty University of Brawijaya,

8. Department of Agriculture and Food Security of Probolinggo City, especially Mr. Agung Widodo, Bangu Jaya and Progo Jaya Farmer Group, and *Badan Kesatuan Bangsa, Politik, dan Perlindungan Masyarakat* (BAKESBANGPOL) of Probolinggo City who give permission, help, and tuition during research,
9. My friends, Btari, Chaida, Fitri, Liza, Nay, and Rohida who always give supports and helps,
10. All member of English Class 2016 who gives the meaning of kinship and togetherness, and
11. All my friends and relatives who give support for my study.

Malang, July 2020

Author

THE CORRELATION OF BODY SIZE AND BODY WEIGHT IN ONGOLE GRADE CATTLE

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ABSTRACT

The objectives of this research were to analyze the body performance in various groups of age and to estimate the correlation between body size and body weight in Ongole Grade cattle. This research was conducted in two sub-districts (Kedopok and Wonoasih) of Probolinggo City started from 21st February to 21st March 2020. Materials used were 70 heads of Ongole Grade cattle consisted of 6–12, 18–24, and 25–36 months old. Variables observed were wither height (WH), body length (BL), chest girth (CG), and body weight (BW) at 6–12, 18–24, and 25–36 months old. Data were analyzed by using unpaired t-test, coefficient of correlation, coefficient of determination, and simple linear regression. The results of unpaired t-test showed that means of body performance between male and female was significantly different ($P<0.05$) on wither height at 6–12 months old (110.80$\pm$10.73 cm and 101.87$\pm$7.31 cm, respectively). The phenotypic correlations between chest girth and body weight at 6–12, 18–24, and 25–36 months old showed the positive highest result in each group of age with the values of 0.87, 0.95, and 0.85, respectively, and the results for coefficients of determinations were 75.71 %, 89.46%, and 72.38%, respectively. The simple linear regression equations for estimated body weight (Y) based on chest girth (X) in Ongole Grade cattle at 6 – 12, 18 – 24, and 25 – 36 months old were: $Y = -159.24 + 2.51X$, $Y = -462.97 + 4.92X$, and Y= – 358.77 + 4.22X, respectively. It indicated that chest girth could be considered as the best estimator to estimate body weight in Ongole Grade cattle.

Keywords: Whiter height, body length, chest girth, simple linear regression

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SUMMARY

Ongole Grade cattle is one of local Indonesian beef cattle breeds that has been determined based on Decree of Agriculture Ministry of Republic Indonesia (*Keputusan Menteri Pertanian Republik Indonesia*) No. 2841/ Kpts/ Lb.430/ 8/ 2012. Ongole Grade cattle is a grading up of Java cattle as an indigenous breed with Ongole cattle around the year 1930. Ongole Grade cattle is one of local cattle breeds that have physical characteristics and genetic compositions that suitable with Indonesia's climate. It also has good productivity in Indonesia and can be used for draught power and meat production because of its high adaptability and resistance to bad climate. Thus, Ongole Grade cattle have an important role to fulfil the requirement of meat for the community. The objectives of this research were to analyze the body performance in various groups of age and to estimate the correlation between body size and body weight in Ongole Grade cattle.

This research was conducted from 21st February to 21st March 2020 in two sub-districts (Kedopok and Wonoasih) of Probolinggo City with guidance of The Department of Agriculture and Food Security of Probolinggo City. Materials

used in this research were 70 heads of Ongole Grade cattle consisted of 6–12, 18–24, and 25–36 months old. Variable observed were wither height (WH), body length (BL), chest girth (CG), and body weight (BW) at 6–12, 18–24, and 25–36 months old. The age of cattle was determined by the number of permanent incisors. Data were analyzed using unpaired t-test, coefficient of correlation, coefficient of determination, and simple linear regression.

The results of this research showed that body performance between male and female was significantly different ($P<0.05$) on wither height at 6–12 months old (110.80 ± 10.73 cm and 101.87 ± 7.31 cm, respectively). Body performance of male Ongole Grade cattle at 18 – 24 months were categorized in Grade I for $BL_{18\text{-}24}$, Grade II for $CG_{18\text{-}24}$, and below the standard of Indonesian National Standard (SNI) for $WH_{18\text{-}24}$. Female Ongole Grade cattle at 18 – 24 months were categorized in Grade I for $WH_{18\text{-}24}$, $BL_{18\text{-}24}$, and $CG_{18\text{-}24}$. Body performance of male Ongole Grade cattle at 25 – 36 months old were categorized in Grade I for $WH_{25\text{-}36}$ and Grade II for $BL_{25\text{-}36}$ and $CG_{25\text{-}36}$. Body performance of female Ongole Grade cattle at 25 – 36 months old were categorized in Grade I for $WH_{25\text{-}36}$ and $BL_{25\text{-}36}$ and Grade III for $CG_{25\text{-}36}$ according to SNI. The correlations between body size and body weight at 6–12, 18–24, and 25–36 months old in Ongole Grade cattle ranged from 0.43–0.95 and categorized as moderately positive to very highly positive correlation. The coefficients of correlations for $WH_{6\text{-}12}$ – $BW_{6\text{-}12}$, $BL_{6\text{-}12}$ – $BW_{6\text{-}12}$, and $CG_{6\text{-}12}$ – $BW_{6\text{-}12}$ were 0.78, 0.81, and 0.87, respectively, and the values for coefficients of determinations were 61.09 %, 65.18 %, 75.71 %, respectively. The results of coefficients of correlations for $WH_{18\text{-}24}$ – $BW_{18\text{-}24}$, $BL_{18\text{-}24}$ – $BW_{18\text{-}24}$, and $CG_{18\text{-}24}$ – $BW_{18\text{-}24}$ respectively were

0.70, 0.71, and 0.95, with the values for coefficients of determinations were 49.00 %, 49.98 %, and 89.46 %, respectively. The coefficients of correlations for WH_{25-36} – BW_{25-36}, BL_{25-36} – BW_{25-36}, and CG_{25-36} – BW_{25-36} were 0.57, 0.43, and 0.85, respectively, and the values for coefficients of determinations were 33.03 %, 18.39 %, and 72.38 %, respectively. The simple linear regression equations for estimated body weight (Y) based on body size (X) in Ongole Grade cattle at 6 – 12 months old were Y= – 142.08 + 2.66X, Y= – 88.93 + 2.15X, and Y= – 159.24 + 2.51X, respectively for WH_{6-12} – BW_{6-12}, BL_{6-12} – BW_{6-12}, and CG_{6-12} – BW_{6-12}. The results of linear regression equations for WH_{18-24} – BW_{18-24}, BL_{18-24} – BW_{18-24}, and CG_{18-24} – BW_{18-24} were Y= – 232.82 + 3.88X, Y= – 250.75 + 3.98X, and Y= – 462.97 + 4.92X, respectively. The linear regression equations for WH_{25-36} – BW_{25-36}, BL_{25-36} – BW_{25-36}, and CG_{25-36} – BW_{25-36} were Y= – 238.99 + 4.09X, Y= – 46.56 + 2.49X, and Y= – 358.77 + 4.22X, respectively.

In conclusion, male Ongole Grade cattle at 18 – 24 months old were categorized in Grade I and II of SNI for BL_{18-24} and CG_{18-24} and at 25 – 36 months old were categorized in Grade I for WH_{25-36} and Grade II for BL_{25-36} and CG_{25-36}. Female Ongole Grade cattle at 18 – 24 months old were categorized in Grade I for all body performance and at 25 – 36 months old were categorized in Grade I for WH_{25-36} and BL_{25-36} and Grade III for CG_{25-36} according to SNI. The correlation between chest girth and body weight showed the highest value in all groups of age. Therefore, the value of chest girth could be considered as the best estimator to estimate the body weight in Ongole Grade cattle due to the highest correlation value in each group of age.

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LIST OF ABBREVIATIONS

BBIB	= *Balai Besar Inseminasi Buatan*
BL	= Body Length
BSN	= *Badan Standardisasi Nasional*
BW	= Body Weight
CG	= Chest Girth
PI	= Permanent Incisors
SNI	= *Standard Nasional Indonesia*
WH	= Wither Height

CHAPTER I
INTRODUCTION

1.1 Background

Livestock sector in Indonesia is one of sectors that have primary roles in the form of food. It has several leading commodities used as animal protein sources, one of them is beef cattle. Indonesia has high genetic resources of local beef cattle. According to Directorate General Livestock and Animal Health (2018) the total population of beef cattle in 2017 was 16.4 million heads, increasing 2.70 percent when compared to the population in 2016 with a total of 15.9 million heads. Meanwhile, beef consumption per capita in 2017 was 0.469 kg or increasing by 12.50 percent of beef consumption per capita in 2016 with a value of 0.417 kg. However, Directorate General Livestock and Animal Health (2018) stated that Indonesia still needs to import about 28,638 kg of beef. Therefore, the government continues the increase of beef production in Indonesia to fulfil the needs of meat for the community.

Ongole Grade cattle is one of local Indonesian beef cattle breeds that has been determined based on Decree of Agriculture Ministry of Republic Indonesia No. 2841/ Kpts/ Lb.430/ 8/ 2012. Indonesian National Standard (SNI) (2015) stated that Ongole Grade cattle have an important role to fulfil the requirement of meat in Indonesia. The characteristics of Ongole Grade cattle are predominantly white-to-gray body-color, grayish-white legs and buttocks, black nose, white tail color and black at its tips, black horns, and grayish wither. Ongole Grade cattle is suitable to be bred in the area with temperature ranges from 17 – 27°C and 60 – 80% of humidity

(Anggraeny, Sulistya, Sukmasari, and Wandasari, 2016). Therefore, Ongole Grade cattle already have good environmental adaptation with Indonesia's climate. Due to its high productivity and adaptive ability, Ongole Grade cattle are preferred by the farmer and breeder in Indonesia.

In the field, the high interest in Ongole Grade cattle breeding mostly not supported with good breeding management. This condition could decrease the number of Ongole Grade cattle populations. The role of government is very important in this problem. Therefore, through SNI (2015), the government has standardized Ongole Grade cattle breed includes the minimum quantitative requirement for performance of wither height (WH), body length (BL), and chest girth (CG). The quantitative requirements categorized into three Grades (Grade I, II, and III) in Ongole Grade cattle at 18 – 24 and >24 – 36 months old. In addition, weaning age also can be used to evaluate the performance production of cattle because weaning weight in beef cattle is a trait of major economic importance as the weaned calf is the end product and total output of the relation between calf and the dam. Hence, there is need good breeding management to increase the availability of Ongole Grade cattle stock with good quality of genotypes and phenotypes. The genetic quality of livestock can be determined based on its phenotype which analyzed through its performance of production. According to Hardjosubroto (1994), the performance of production is determined by genetic and environmental factors. Genetic factors in livestock are more difficult to analyze. Thus, it needs to be estimated based on their quantitative traits such as wither height, body length, chest girth, and body weight (Supartini and Darmawan, 2014).

Body weight of livestock is one of indicators for livestock productivity. The value of body weight affected by the growth of body size. The correlation between body size and body weight in livestock can be known from the coefficient of correlation. The correlations of production performance are important for estimating future livestock productivity based on current productivity records (Karnaen, 2008). On the other hand, the information on body size can be used as a parameter to estimate the body weight in livestock through simple linear regression. Simple linear regression can be used to predict the value of body weight as the dependent variable (Y), by using the value of body size as the independent variable (X) (Sugiyono, 2007).

Probolinggo City has been determined as one of the breeding center areas for Ongole Grade cattle. Kedopok and Wonoasih are two sub-districts in Probolinggo City that used as the area for Ongole Grade cattle breeding because it showed good potential for breeding activities. Breeding activities in Probolinggo City has been done by the farmer groups under the guidance of The Department of Agriculture and Food Security of Probolinggo City. Based on the important breeding program to improve the performance of Ongole Grade cattle, this study is done to analyze the body performance in various groups of age and to estimate the correlation between body size and body weight in Ongole Grade cattle.

1.2 Research Problems

The problems of this research were:

1. How is the body performance of Ongole Grade cattle in the various groups of age?

2. How is the correlation between body size and body weight in Ongole Grade cattle?

1.3 Research Objectives

The objectives of this research were:

1. To analyze the body performance of Ongole Grade cattle in the various groups of age.
2. To estimate the correlation between body size and body weight in Ongole Grade cattle.

1.4 Research Benefits

The benefits of this research were to provide information about body size and body weight in Ongole Grade cattle that can be used as a parameter to estimate body weight and to improve the performance of Ongole Grade cattle in associations and/or farmer groups.

1.5 Research Framework

Ongole Grade cattle is one of local Indonesian beef cattle breeds that has been determined based on Decree of Agriculture Ministry of Republic Indonesia No. 2841/ Kpts/ Lb.430/ 8/ 2012. Ongole Grade cattle have good productivity, high adaptability, resistance to bad climate, and can be used for draught power and meat production (Wiyatna, 2007). Based on those conditions, farmers in Indonesia have a high interest in Ongole Grade cattle breeding. It is necessary to improve the quality of Ongole Grade cattle through quantitative traits to support the conservation and improvement of Ongole Grade cattle performance as local genetic resources of Indonesia.

The genetic quality of livestock can be estimated through its phenotype, which usually expressed from its quantitative and qualitative traits. According to Kaswati, Sumadi, and Ngadiyono (2013), the quantitative trait is one of the traits that show the appearance of individual animals that are controlled by genetic and environmental factors. The importance of quantitative traits in beef cattle are body size and body weight. The increase in body size is followed by the increase in body weight. Thus, grouping a population of livestock based on age can show the difference in the growth process and can be used as a parameter of selection.

Chest girth has a relation with the growth of body weight in livestock because body tissues and ribs inside the chest girth were growing as the cattle get older. The growth of chest girth shows the growth of ribs and the growth of body tissues that attached to ribs (Ni’am, Purnomoadi, and Dartosukarno, 2012). Meanwhile, the correlation of wither height and body length with body weight affected by the growth of muscle and bone formation. The growth of muscle affected by the growth of the skeletal body. It is because of the muscle attached to the skeletal body, which makes the muscle and the skeletal body grow simultaneously. Soeparno (2005) also explained that the growth in livestock is a change of the body size which includes changes in shapes, dimensions, and compositions of the body.

The correlation between body size and body weight can be measured by the value of coefficient of correlation. The coefficient of correlation is an abstract value between a negative one (–1) until a positive one (+1) which has no units (Nurgiartiningsih, 2017). Correlation can be positive if changes of one trait lead to the changes of other trait in the same direction. A negative correlation indicates the changes in opposite directions in two traits. The relationship between two traits occurs due to the presence of a pleiotropy gene. This gene associated one trait with the other traits that correlated (Karnaen, 2008).

The results regarding the correlation between body size with body weight in different local cattle breeds have been reported in several studies. The research done by Ikhsanuddin, Nurgiartiningsih, Kuswati, and Zainuddin (2018) reported that the correlation between body size (chest girth, wither height, and body length) with body weight in Aceh cattle at post weaning age were 0.64, 0.56, 0.65, respectively. Nisa (2017) reported that the correlation between body size (chest girth, wither height, and body length) with body weight at 18 – 24 months old of Ongole Grade cattle were 0.99, 0.97, and 0.98, respectively. Meanwhile in Bali cattle, the correlation between body size (chest girth, wither height, and body length) with body weight at 25 – 36 months old were 0.84, 0.65, 0.78, respectively (Ni'am et al., 2012).

The information about body size can be used to estimate body weight in livestock through linear regression equation. Body weight of livestock is one of indicators for livestock productivity because it showed the growth process of the livestock. Anggraeni and Triwulaningsih (2007) explained that estimating body weight of livestock could be done by measuring the body size of livestock as the dependent variable for body weight estimation in the linear regression equation. The advantage of using linear regression equation to estimate body weight is easier to be measured. In addition, the value of coefficient of correlation is in line with the value of coefficient of regression. In general, if the value of coefficient of correlation is negative (–), the value of coefficient of regression is also negative (–), and vice versa (Sugiyono, 2007). Based on those explanations, this research conducted to analyze the body performance in various groups of age and to estimate the correlation between body size and body weight in Ongole Grade cattle due to the importance of the breeding program for the improvement of performance in Ongole Grade cattle.

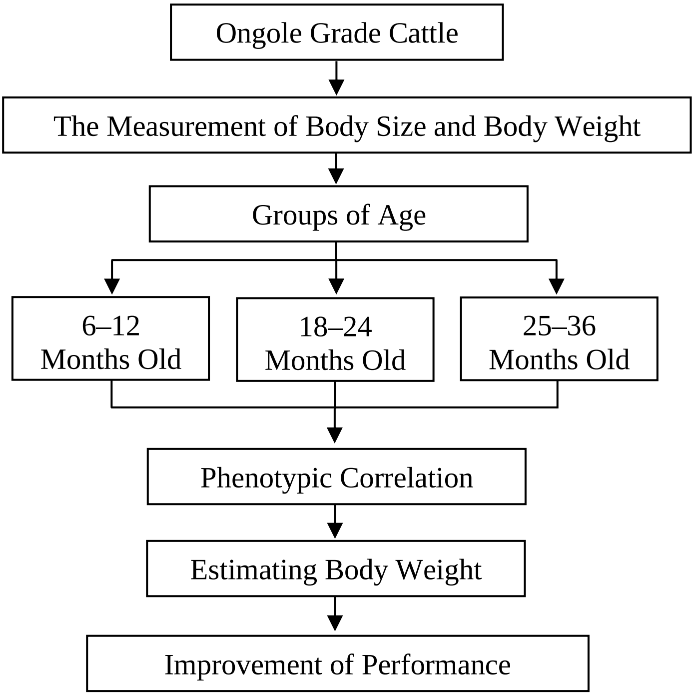


Figure 1. Research framework

1.6 Hypothesis

Hypothesis in this research was there is a significant correlation between body size and body weight in Ongole Grade cattle.

CHAPTER II
LITERATURE REVIEW

2.1 General Situation of Research Location

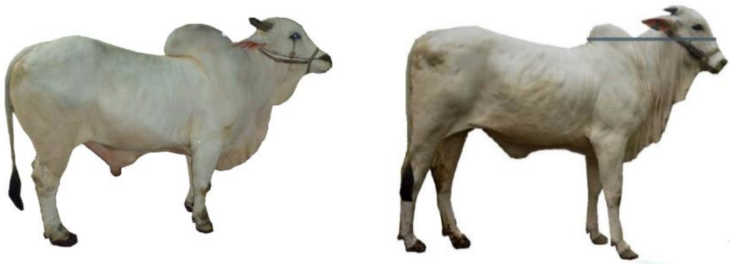
Probolinggo City is one of cities in East Java Province. It has average height of 18 meter above sea level. The average temperature of Probolinggo City is 28°C, with a minimum temperature is 21°C, and the maximum temperature is 34°C. The average humidity is 76%. This average temperature is suitable for Indonesian beef cattle breeds to be bred. The ideal maintenance temperature for beef cattle ranges from 17 – 27ºC with 60 – 80% of humidity (Anggraeny et al., 2016). Indonesian local beef cattle breed that suitable in Probolinggo City are Ongole Grade cattle and Madura cattle. Bali cattle are not suitable to be bred in Probolinggo City because there are sheep which are carriers of the Malignant Catarrhal Fever (MCF) disease (Khatimah, Berata, and Supartika, 2014).

Probolinggo City has been determine as one of breeding center areas for Ongole Grade cattle. In Probolinggo City, there are some farmer groups that focused on Ongole Grade cattle breeding named Bangu Jaya and Progo Jaya. The breeding activities of those farmer groups are under the guidance of The Department of Agriculture and Food Security of Probolinggo City. The mating system of Ongole Grade cattle in Probolinggo City is by artificial insemination to guarantee that the sire is pure Ongole Grade cattle. The semen for insemination are from *Balai Besar Inseminasi Buatan* (BBIB) Singosari. The insemination done by the inseminator from The Department of Agriculture and Food Security of Probolinggo City for free as one of incentives for the farmers who breed pure Ongole Grade cattle. Ongole Grade cattle that have good productivity and good recording system will be keep as replacement stock.

2.2 Ongole Grade Cattle

Ongole Grade cattle is one of beef cattle breeds that has been determined based on Decree of Ministry of Agriculture No. 2841/ Kpts/ Lb.430/ 8/ 2012, as one of Indonesian local cattle breeds and has been spread in most parts of Indonesia. Ongole Grade cattle is a grading up of Java cattle as an indigenous breed with Ongole cattle around the year 1930. Ongole cattle is a domesticated-cattle in the group of Zebu cattle from India. Ongole cattle categorized as *Bos indicus* and dual-purpose cattle. Meanwhile, Java cattle is a crossbreed between wild bull (*Bos javanicus*) with Zebu cattle (*Bos indicus*) (Hartatik, 2014). Ongole Grade cattle is one of local breed cattle breeds which have physical characteristics and genetic compositions that suitable with Indonesia's climate. Ongole Grade cattle showed the superiorities as tropical cattle such as have high adaptive ability in tropical climate, resistance to high temperature, resistance to parasites such as mosquito and louse, and has good tolerant to feed that containing high crude fiber (Astuti, 2004).

Ongole Grade cattle have a large and long body, large hump, and white hair around the head, neck, knees, and tail. Male Ongole Grade cattle has larger wither compared to female Ongole Grade cattle. This cattle have whips from the bottom of the neck to the back of the front legs, the size of the head is relatively short, has a convex forehead profile, and short horns (Hartatik, 2014). Body proportion and body weight of Ongole Grade cattle are smaller than Ongole cattle. The color of its hair is various but generally is white or grayish-white. The black color also appeared on other body parts such as on snout and nails. The black color of the snout is a phenotypic characteristic that commonly found in Ongole Grade cattle. Another color of the snout, such as red is inherited from Simmental or Limousine cattle (Trifena, Budisatria, and Hartatik, 2011).



(a) (b)

Figure 2. (a) Male Ongole Grade cattle and
(b) Female Ongole Grade cattle
Source: *Badan Standardisasi Nasional* (BSN) (2015)

2.3 Body Weight

Body weight is one of the important factors to determine the productivity of livestock. Philips (2010) explained that knowing the body weight of livestock is important to estimate and evaluate the meat production and percentage of the carcass that has been produced, selling price, choosing the breed, the need for feed, and medical treatment. The best method to know the body weight of livestock is weighing the livestock by using a weighing scale. In the field, weighing large livestock such as cattle requires more effort, especially in the area with bad topography which difficult in transportation (Priyanto, 1994). Suranjaya and Wiyana (2011) also explained that the knowledge and skill of the farmers in measuring body weight and the increase of body weight gain are important aspects in the management of beef cattle breeding.

Body weight and body size of livestock determine the growth of livestock, which can be used as the criteria of selection (Margawati, Noor, Rahmat, Indriawati, and Ridwan, 2011). The growth of livestock is manifested by the change of body size and body weight at the same time. Herring (2014) stated that as the livestock becoming older, the body weight of livestock could be decreased, the change of body size such as body length and wither height is same with sigmoid curve of body weight. According to Field and Taylor (2012), when the livestock has reached the body maturity, it will allow the irregularities in the body weight of livestock.

2.4 Body Size

Body size is one of factors that can be used to express the performance of livestock production. The information about body size can be used as the criteria to estimate the body weight in livestock efficiently and accurately. According to Isroli (2001), body size has an important contribution to estimate body weight in livestock about 90% from the actual body weight. Body sizes that commonly used to estimate body weight in livestock are wither height, body length, and chest girth. Trisnawanto, Adiwinarti, and Dinaga (2012) explained that the increase of body weight is followed by the increase of body size.

The measurement of chest girth is the best estimator for body weight estimation in livestock. It has high accuracy as the parameter to estimate the body weight of livestock. It is because the growth of chest girth shows the growth of ribs and the growth of body tissues that attached to ribs (Ni'am et al., 2012).

According to Nugraha, Maylinda, and Nasich (2015), measuring the body sizes in livestock can be done by following explanation below:

1. Wither Height (WH), measured from the surface of the ground to the highest point of the wither in the unit of cm.
2. Body Length (BL), measured by making horizontal line from the front edge of the shoulder (*Tuberculum humeralis lateralis*) to the back edge of sitting bone (*Tuberculum ischiadum*) in the unit of cm.
3. Chest Girth (CG), measured by following a chest or body circle behind the shoulder through to the wither or behind *Os scapula* in the unit of cm.

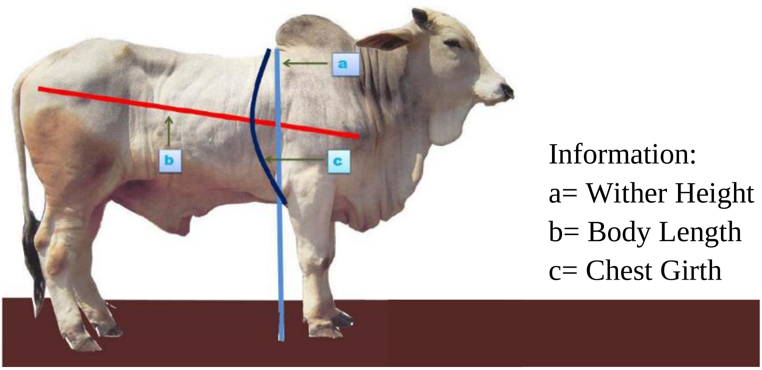


Figure 3. Body size measurement in Ongole Grade cattle
Source: BSN (2015)

According to SNI (2015), government has certified the quantitative requirements for Ongole Grade cattle breed that presented in Table 1.

Table 1. Quantitative requirements for Ongole Grade cattle breed

Sex	Age (Months)	Parameter	Unit	Class		
				I	II	III
Male	18-24	WH	cm	128	125	122
		BL	cm	134	127	124
		CG	cm	152	148	144
	>24-36	WH	cm	133	130	127
		BL	cm	139	133	129
		CG	cm	175	160	149
Female	18-24	WH	cm	119	116	113
		BL	cm	120	118	117
		CG	cm	138	134	130
	>24-36	WH	cm	129	125	121
		BL	cm	132	129	127
		CG	cm	161	156	139

Source: BSN (2015)

2.5 Sex

Sex can cause the difference of growth rate in the livestock. Male livestock has a higher growth rate than female livestock. The difference in growth rate caused by the hormonal factors. In male livestock, there is an androgen, which is a sex hormone that regulates the growth of male livestock. Androgen is produced by interstitial cells and adrenal glands. One of the androgen steroids is testosterone. The presence of testosterone produced by testis in male livestock caused the growth of male livestock is faster than female livestock. It is because testosterone take a role in stimulating the growth of body tissue, muscle, and bone formation (Suranjaya, Ardika, and Indrawati, 2010).

Furthermore, Endah (2007) said that body weight and sex has a highly significant effect on the weight and percentage of carcass. The change in body weight of both male and female cattle will affect the change of weight and percentage of carcass. In the increasing of body weight, there were the indications of fattening, fat percentage, kidney fat, and pelvic fat also increase.

2.6 Prediction of Age

The Age of cattle can be determined by checking the recording data or the number of permanent incisors. Cattle that have a pair of permanent incisors is 1,5 – 2 years old, cattle with two pairs of permanent incisors is 2,5 – 3 years old, cattle with three pairs of permanent incisors is 3,5 – 4 years old, while cattle with four pairs of permanent incisors meaning that the cattle is above four years old (Pradana, Rudyanto, and Suada, 2014).

Cattle have eight incisors that grow only on its mandible. The incisors will be replaced with permanent incisors as the cattle getting older. Prediction of age in cattle based on the number of permanent incisors were presented in Table 2.

Table 2. Prediction of age based on the number of permanent incisors

Term	Permanent Incisors	Age Prediction (Months)
PI 0	0 pair	<18
PI 1	1 pair	18 – 24
PI 2	2 pairs	>24 – 36

Source: Raines, Dikeman, Unruh, Hunt, and Konck (2008)

2.7 Correlation between Body Size and Body Weight

The correlation between body size and body weight of livestock could be calculated by using the coefficient of correlation. The coefficient of correlation is an abstract value between negative one (–1) until positive one (+1) which has no units (Nurgiartiningsih, 2017). Correlation can be positive if increases in one trait lead to increases the other trait, and vice versa. A negative correlation indicates changes in the opposite directions in two traits. The correlation of two traits or more in livestock caused by the pleiotropy gene, this gene associated one trait with another that correlated (Karnaen, 2008). According to Sugiyono (2007), the level of coefficient of correlation divided into five categories, there are very low (r = 0.00 – 0.19), low (r = 0.20 – 0.39), moderate (r = 0.40 – 0.59), high (r = 0.60 – 0.79), and very high (r = 0.80 – 1.00).

The results of previous studies regarding the correlation between body size with body weight in various beef cattle breed mostly showed positive values. The research done by Nurgiartiningsih (2011) reported that the correlation between body size (chest girth, wither height, and body length) with body weight at 5 months old of Madura cattle were 0.68, 0.46, and 0.15, respectively. Nisa (2017) reported that the correlation between body size (chest girth, wither height, and body length) with body weight at 18 – 24 months old of Ongole Grade cattle were 0.99, 0.97, and 0.98, respectively. Meanwhile in Bali cattle, the correlation between body size (chest girth, wither height, and body length) with body weight at 25 – 36 months old were 0.84, 0.65, 0.78, respectively (Ni'am et al., 2012).

Body size can be used to estimate body weight of livestock by using simple linear regression equation. Anggraeni and Triwulaningsih (2007) explained that estimating body weight of livestock could be done by measuring the body size of livestock as the independent variable for body weight estimation in the linear regression equation. In addition, the advantage of using the value of body size to estimates body weight in livestock through linear regression equation is because it easy to be measured. Simple linear regression also can be used to make a decision whether the change in the value of dependent variable (body weight) can be determined by the increase of the value of independent variable (body size) or not (Sugiyono, 2007).

CHAPTER III
MATERIALS AND METHODS

3.1 Research Location and Time

This research was conducted from 21st February to 21st March 2020 in two sub-districts (Kedopok and Wonoasih) of Probolinggo City with guidance of The Department of Agriculture and Food Security of Probolinggo City.

3.2 Research Methods

Methods used in this research were case study and direct observation in the field by measuring of wither height and body length by using a measuring stick "Bravo" (1 cm of accuracy), chest girth by using a measuring tape "Animeter" (0.1 cm of accuracy), and weighing of body weight by using a weighing scale "Thunderbird" (0.1 kg of accuracy and 500 kg of maximum weight capacity). The documentations of the measuring tools are in Appendix 9. The samples were taken purposively, which were Ongole Grade cattle at age of 6 – 12, 18 – 24, and 25 – 36 months old. The age of cattle was determined by the number of permanent incisors. The collected data were wither height, body length, chest girth, and body weight at 6 – 12, 18 – 24, and 25 – 36 months old. The comparison between two means of body performance based on sex was analyzed by using unpaired t-test. The correlation between body size and body weight was calculated by using coefficient of correlation and the estimation of body weight which predicted by the size of linear body was calculated by using simple linear regression equation.

3.3 Research Variables

Variables used in this research consisted of:

1. Wither height, measured from the surface of the ground to the highest point of the wither by using a measuring stick in unit of cm.
2. Body length, measured by making horizontal line from the front edge of the shoulder (*Tuberculum humeralis lateralis*) to the back edge of sitting bone (*Tuberculum ischiadum*) by using a measuring stick in unit of cm.
3. Chest girth, measured by following a chest or body circle behind the shoulder through to the wither or behind *Os scapula* by using a measuring tape in unit of cm.
4. Body weight, weighed by using a weighing scale in unit of kg.

3.4 Research Materials

Materials used in this research were 70 heads of Ongole Grade cattle consisted of three groups of age (6 – 12, 18 – 24, and 25 – 36 months old).

3.5 Data Analysis

3.5.1 Unpaired t-Test

The comparison between two means of body performance based on sex was analyzed by using unpaired t-test. According to Sugiyono (2014), the formula was:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 + n_2) - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Information:

t = t distribution

$\overline{X_1}$	=	average of body performance in male Ongole Grade cattle
S_1^2	=	variance of body performance in male Ongole Grade cattle
n_1	=	number of sample in male Ongole Grade cattle
$\overline{X_2}$	=	average of body performance in female Ongole Grade cattle
S_2^2	=	variance of body performance in female Ongole Grade cattle
n_2	=	number of sample in female Ongole Grade cattle

3.5.2 Coefficient of Correlation

Correlation between body size and body weight was calculated by using coefficient of correlation. According to Nurgiartiningsih (2017), the formula was:

$$r = \frac{cov_{XY}}{\sqrt{\sigma_X^2 \sigma_Y^2}} = \frac{cov_{XY}}{\sigma_X \sigma_Y}$$

Information:

r	=	coefficient of correlation
cov_{XY}	=	covariance of two traits (body size and body weight)
σ_X^2	=	variance of body size
σ_Y^2	=	variance of body weight
σ_X	=	standard deviation of body size
σ_Y	=	standard deviation of body weight

The result for coefficient of correlation divided into five categories which presented in Table 3.

Table 3. The categories for coefficient of correlation

Interval of Coefficient	Category of Correlation
0.00 – 0.19	Very Low
0.20 – 0.39	Low
0.40 – 0.59	Moderate
0.60 – 0.79	High
0.80 – 1.00	Very High

Source: Sugiyono (2007)

3.5.3 Signification Test for Coefficient of Correlation

The significance of correlation between body size and body weight was calculated by using signification test. The formula according to Maylinda (2010) was:

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Information:

t	=	t distribution
r	=	coefficient of correlation
n	=	number of sample

3.5.4 Coefficient of Determination

The effect of variance of body size on variance of body weight was calculated by using coefficient of determination. According to Sugiyono (2007), the formula was:

$$R^2 = r^2 \times 100\%$$

Information:

R^2	=	coefficient of determination
r	=	coefficient of correlation

3.5.5 Simple Linear Regression

The estimation of body weight predicted by the measurement of body size will be shown in linear regression equation by using simple linear regression. The calculation for simple linear regression was done by using data analysis on Microsoft Excel 2013.

3.6 Terminology

Ongole Grade cattle	:	Ongole Grade cattle is a grading up of Java cattle with Ongole cattle around the year 1930 (Hartatik, 2014).
Performance	:	The appearance of phenotypic trait in the individual animals.
Wither height	:	Measured from the surface of the ground to the highest point of the wither using a measuring stick in the unit of cm (Nugraha et al., 2015).
Body length	:	Measured by making horizontal line from the front edge of the shoulder (*Tuberculum humeralis lateralis*) to the back edge of sitting bone (*Tuberculum ischiadum*) by using a measuring stick in the unit of cm (Nugraha et al., 2015).
Chest girth	:	Measured by following a chest or body circle behind the shoulder through to the wither or behind *Os scapula* using a measuring tape in the unit of cm (Nugraha et al., 2015).
Body weight	:	Weighed by using a weighing scale in the unit of kg.

CHAPTER IV
RESULTS AND DISCUSSIONS

4.1 Body Size and Body Weight of Ongole Grade Cattle

The body performance measured in this research were wither height, body length, chest girth, and body weight. The results and the discussions are showed below.

4.1.1 Ongole Grade Cattle at 6 – 12 Months Old

Means and standard deviations of wither height, body length, chest girth, and body weight in Ongole Grade cattle at 6 – 12 months old based on sex were presented in Table 4. The calculations of the means are in Appendix 2.

Table 4. Means and standard deviations for wither height (WH_{6-12}), body length (BL_{6-12}), chest girth (CG_{6-12}), and body weight (BW_{6-12}) in Ongole Grade cattle at 6 – 12 months old based on sex

Parameter	N	Male Ongole Grade cattle	N	Female Ongole Grade cattle
WH_{6-12} (cm)	5	110.80 ± 10.73^{a}	15	101.87 ± 7.31^{b}
BL_{6-12} (cm)	5	107.20 ± 14.08	15	103.13 ± 10.72
CG_{6-12} (cm)	5	122.00 ± 13.77	15	116.07 ± 9.35
BW_{6-12} (kg)	5	138.80 ± 30.54	15	134.03 ± 31.28

Note: * different superscripts in the same row indicated significantly different (P<0.05)

According to the results, the effect of sex in Ongole Grade cattle at 6 – 12 months old was significantly different ($P<0.05$) on WH_{6-12}. In contrast, it gives no significant effect ($P>0.05$) on BL_{6-12}, CG_{6-12}, and BW_{6-12}.

However, male tended to be higher in value compared to female. It may be caused by hormonal factors. Suranjaya et al. (2010) explained that sex affected the growth of livestock. The presence of testosterone produced by testis in male caused the growth of male is faster than female livestock. It is because testosterone take a role in stimulating the growth of body tissue, muscle, and bone formation.

The means of $WH_{6\text{-}12}$, $BL_{6\text{-}12}$, $CG_{6\text{-}12}$, and $BW_{6\text{-}12}$ for male Ongole Grade cattle were 110.80$\pm$10.73 cm, 107.20$\pm$14.08 cm, 122$\pm$13.77 cm, and 138.80$\pm$30.54 kg, respectively. The means for female Ongole Grade cattle were 101.87$\pm$7.31 cm, 103.13$\pm$10.72 cm, 116.07$\pm$9.35 cm, and 134.03$\pm$31.28 kg, respectively. These results were higher than the means of body performance reported by Kusuma, Ngadiyono, and Sumand (2016), which were the means of $WH_{0\text{-}10}$, $BL_{0\text{-}10}$, $CG_{0\text{-}10}$, and $BW_{0\text{-}10}$ for male Ongole Grade cattle at 0 – 10 months old in Kebumen Regency were 101.40$\pm$9.58 cm, 89.54$\pm$12.71 cm, 110.62$\pm$15.15 cm, and 120.50$\pm$40.93 kg, respectively. The same research also reported the means for female Ongole Grade cattle were 99.98$\pm$10.38 cm, 88.50$\pm$11.45 cm, 110.01$\pm$12.15 cm, and 119.53$\pm$34.36 kg, respectively for $WH_{0\text{-}10}$, $BL_{0\text{-}10}$, $CG_{0\text{-}10}$, and $BW_{0\text{-}10}$. The difference of the results may be caused by the differences in age ranges, location, and population. The difference in age range showed the level of variation in a population. In addition, body performance is commonly in line with the age of the cattle. Ikhsanuddin et al. (2018) explained that the increasing of body weight in cattle have a relative correlation on the growth of the body size dimension.

Besides, the higher means of this research also might be due to the better performance and genetic potency of Ongole Grade cattle in Probolinggo City. Probolinggo City is one of breeding center area for Ongole Grade cattle which make the breeding activities in Probolinggo City might be more focused and well planned.

Furthermore, the value of body performance can be affected by environmental conditions and nutritional factors. Panoga, Suherman, and Brata (2018) explained that the productivity and production of livestock could be different due to the difference of the environmental conditions. In addition, Hartati and Dicky (2008) stated that the difference in body performance of post-weaning calf can be caused by mothering ability. The dam with good mothering ability will produce good quality and quantity of milk for growth of the calf. The performance of post-weaning stage is affected by nutritional factors during pre-weaning age.

4.1.2 Ongole Grade Cattle at 18 – 24 Months Old

The results of means and standard deviations for wither height, body length, chest girth, and body weight in Ongole Grade cattle at 18 – 24 months old based on sex were presented in Table 5. The calculations of the means are in Appendix 3.

Table 5. Means and standard deviations for wither height (WH_{18-24}), body length (BL_{18-24}), chest girth (CG_{18-24}), and body weight (BW_{18-24}) in Ongole Grade cattle at 18 – 24 months old based on sex

Parameter	N	Male Ongole Grade cattle	N	Female Ongole Grade cattle
WH_{18-24} (cm)	2	119.50±19.09	18	122.50±10.75
BL_{18-24} (cm)	2	143.00±7.07	18	121.39±9.02
CG_{18-24} (cm)	2	148.00±15.56	18	142.72±11.83
BW_{18-24} (kg)	2	268.00±115.97	18	238.22±57.97

The means of WH_{18-24}, BL_{18-24}, CG_{18-24}, and BW_{18-24} for male Ongole Grade cattle were 119.50±19.09 cm, 143±7.07 cm, 148±15.56 cm, and 268±115.97 kg, respectively. The results in female Ongole Grade cattle in this research for means of WH_{18-24}, BL_{18-24}, CG_{18-24}, and BW_{18-24} were 122.50±10.75 cm, 121.39±9.02 cm, 142.72±11.83 cm, and 238.22±57.97 kg, respectively. The results for WH_{18-24}, CG_{18-24}, and BW_{18-24} either in male or female Ongole Grade cattle were lower than the results reported by Rasyid and Luthfi (2017) that the means of WH_{18-24}, BL_{18-24}, CG_{18-24}, and BW_{18-24} for male Ongole Grade cattle at Beef Cattle Research in Grati, were 128.90±2.30 cm, 121.90±8.30 cm, 157.30±7.90 cm, and 306.80±44.00 kg, respectively. The same research reported the means of body performance in female Ongole Grade cattle were 125.30±3.00 cm, 117.60±3.30 cm, 148.90±10.00 cm, and 261.70±37.70 kg, respectively for WH_{18-24}, BL_{18-24}, CG_{18-24}, and BW_{18-24}. Feeding management seems affected the result of the research. The research from Rasyid and Luthfi (2017) was used the same feeding management for the individual in the population, giving supplement as the additional feed, and applying intensive system for rearing which make it easier to control the dietary for the cattle. On the other hand, the cattle in this research are reared by the smallholder farmer that may have different feeding management. Sandi, Desiarni, and Asmak (2018) stated that feeding management affects the production of the livestock because it is related to feed quality and frequency, method of feeding, and diseases prevention. The optimum physical condition will be obtained with good genetic quality and supports with good environmental conditions (Panoga et al., 2018). In addition, Rasyid and Luthfi (2017) said that livestock should have an optimal growth rate until obtained the specific target age. Therefore, good breeding practice also important to be applied in rearing management.

The means of BL_{18-24} of male Ongole Grade cattle in this research was categorized in Grade I, CG_{18-24} in Grade II, and WH_{18-24} was below the SNI for quantitative requirements of male Ongole Grade cattle breed at 18 – 24 months old. The minimum values for BL_{18-24} in Grade I and CG_{18-24} in Grade II were 134 cm and 148 cm, respectively. On the other hand, means of female Ongole Grade cattle were higher than Grade I for all body performance. The minimum quantitative requirements for WH_{18-24}, BL_{18-24}, and CG_{18-24} in female Ongole Grade cattle which categorized in Grade I were 119 cm, 120 cm, and 138 cm, respectively. These indicated that means of body performance of female Ongole Grade cattle in this research has obtained the minimum standard of the quantitative requirements for Ongole Grade cattle breed in Grade I. However, there still needs the improvement of management for cattle that have a lower value of quantitative traits than the minimum quantitative requirements of SNI. Therefore, the knowledge and the skill of the farmers are important. The knowledge of the farmers in line with management skill to improve the productivity of the livestock (Priady, Wiyatna, and Firman, 2016). Suranjaya and Wiyana (2011) also explained that the knowledge and skills of the farmers is one of the important aspects in management of beef cattle breeding.

4.1.3 Ongole Grade Cattle at 25 – 36 Months Old

Means and standard deviations of wither height, body length, chest girth, and body weight in Ongole Grade cattle at 25 – 36 months old based on sex were presented in Table 6. The calculations of the means are in Appendix 4.

Table 6. Means and standard deviations for wither height (WH_{25-36}), body length (BL_{25-36}), chest girth (CG_{25-36}), and body weight (BW_{25-36}) in Ongole Grade cattle at 25 – 36 months old based on sex

Parameter	N	Male Ongole Grade cattle	N	Female Ongole Grade cattle
WH_{25-36} (cm)	2	137.00±2.83	28	129.18±5.56
BL_{25-36} (cm)	2	137.50±4.95	28	135.89±7.23
CG_{25-36} (cm)	2	166.50±2.12	28	153.18±7.77
BW_{25-36} (kg)	2	350.25±38.54	28	287.21±38.26

The means of WH_{25-36}, BL_{25-36}, CG_{25-36}, and BW_{25-36} for male Ongole Grade cattle were 137±2.83 cm, 137.50±4.95 cm, 166.50±2.12 cm, and 350.25±38.54 kg, respectively. These results were higher than the previous study from Hamdani, Husni, and Setyawan (2018), where the means for WH_{25-36}, BL_{25-36}, CG_{25-36}, and BW_{25-36} of male Ongole Grade cattle in Wawasan Village, South Lampung Regency were 131±7.81 cm, 129.4±10.14 cm, 152.6±12.56 cm, and 22 7.4±64.19 kg, respectively. On the other hand, the means of WH, BL, CG, and BW_{25-36} for female Ongole Grade cattle in this research were 129.18±5.56 cm, 135.89±7.23 cm, 153.18±7.77 cm, and 287.21±38.26 kg, respectively. The results of this research were higher than Hartati, Sumadi, and Hartatik (2009), where the means for WH_{25-36}, BL_{25-36}, CG_{25-36}, and BW_{25-36} of female Ongole Grade cattle in Tuban Regency respectively were 119.9±8.8 cm, 124.3±7.1 cm, 151,8±10.2 cm, and 284.2±54.5 kg. The different results of the researches may be caused by the different location of the research, such as height, temperature, and humidity. The effect of the environment will cause the expression of genetic variation. Hardjosubroto (1994) also stated that the effect of environmental factors on an individual of livestock in a population will be caused variation of genetic.

The means of this research compared to SNI for quantitative requirements of Ongole Grade cattle breed at 25 – 36 months old for male Ongole Grade cattle were categorized in Grade I for WH_{25-36} and Grade II for BL_{25-36} and CG_{25-36}. The minimum value for wither height in Grade I was 133 cm and for BL_{25-36} and CG_{25-36} in Grade II respectively were 133 cm and 160 cm (SNI, 2015). Means of WH_{25-36} and BL_{25-36} in female Ongole Grade cattle were categorized in Grade I and CG_{25-36} in Grade III. The minimum values of WH_{25-36} and BL_{25-36} for female Ongole Grade cattle at 25 – 36 months old in Grade I respectively were 129 cm and 132 cm and for CG_{25-36} was 139 cm (SNI, 2015). Although the quantitative traits of Ongole Grade cattle in this research has obtained the requirements, there still need better maintenance to improve the quality to obtain the higher category of SNI.

4.2 Correlation between Body Size and Body Weight in Ongole Grade Cattle

Correlation between body size and body weight were calculate by using coefficient of correlation and simple linear regression. The results and discussions are explained below.

4.2.1 Correlation between Body Size and Body Weight in Ongole Grade Cattle at 6 – 12 Months Old

The coefficients of correlations (r) and coefficients of determinations (R^2) between body sizes (wither height, body length, and chest girth) with body weight in Ongole Grade cattle at 6 – 12 months old were presented in Table 7. The calculations are in Appendix 6.

Table 7. Coefficients of correlations and coefficients of determinations for the correlations of wither height – body weight (WH_{6-12} – BW_{6-12}), body length – body weight (BL_{6-12} – BW_{6-12}), and chest girth – body weight (CG_{6-12} – BW_{6-12}) in Ongole Grade cattle at 6 – 12 months old

Parameter	N	r	R^2
WH_{6-12} – BW_{6-12}	20	0.78**	61.09 %
BL_{6-12} – BW_{6-12}	20	0.81**	65.18 %
CG_{6-12} – BW_{6-12}	20	0.87**	75.71 %

Note: ** highly significant (P<0.01)

The results showed that coefficients of correlations for WH_{6-12} – BW_{6-12}, BL_{6-12} – BW_{6-12}, and CG_{6-12} – BW_{6-12}

were highly significant ($P<0.01$). The correlations for $WH_{6-12} - BW_{6-12}$, $BL_{6-12} - BW_{6-12}$, and $CG_{6-12} - BW_{6-12}$ were 0.78, 0.81, and 0.87, respectively. Sugiyono (2007) explained that the level for coefficient of correlation were divided into five categories, there are very low ($r = 0.00 – 0.19$), low ($r = 0.20 – 0.39$), moderate ($r = 0.40 – 0.59$), high ($r = 0.60 – 0.79$), and very high ($r = 0.80 – 1.00$). Therefore, the correlations for $BL_{6-12} - BW_{6-12}$, and $CG_{6-12} - BW_{6-12}$ were categorized as very highly positive value and the correlation for $WH_{6-12} - BW_{6-12}$ was categorized as highly positive value. Positive value indicated that the value of BW_{6-12} will increase as the increasing value of WH_{6-12}, BL_{6-12}, and CG_{6-12}, and vice versa. The correlation between $CG_{6-12} - BW_{6-12}$ in Ongole Grade cattle showed the highest result compared to $WH_{6-12} - BW_{6-12}$ and $BL_{6-12} - BW_{6-12}$. It can be caused by the body tissues and ribs inside the chest girth were growing as the cattle get older. It is supported by the explanation from Ni'am et al. (2012) that the growth of chest girth shows the growth of ribs and the growth of body tissues that attached to ribs. The coefficient of determination for correlation between $CG_{6-12} - BW_{6-12}$ was 75.71%, which means that the variation of chest girth influences the variation of body weight about 75.71% and 24.29% remains were influenced by other factors.

The correlation between $WH_{6-12} - BW_{6-12}$ showed the lowest result with the value was 0.78. However, this result categorized as highly positive value with the coefficient of determination was 61.09%, which means that the variation of BL_{6-12} influences the variation of BW_{6-12} about 61.09% and 38.91 remains were influenced by other factors. The high correlation values of $WH_{6-12} - BW_{6-12}$, $BL_{6-12} - BW_{6-12}$, and CG_{6-12} – BW_{6-12} may be caused the growth rate at this age is fast. Sampurna and Suatha (2010) explained that the growth of the livestock is divided into two stages, there were fast and slow. The fast growth is before the livestock obtained sex maturity, and the growth of livestock getting slower after the livestock obtained body maturity.

The linear regression equations to estimate body weight in Ongole Grade cattle at 6 – 12 months old were presented in Table 8. The calculations are in Appendix 6.

Table 8. Linear regression equations to estimate BW_{6-12} in Ongole Grade cattle at 6 – 12 months old

Parameter	Regression Equation
WH_{6-12} – BW_{6-12}	Y= – 142.08 + 2.66X*
BL_{6-12} – BW_{6-12}	Y= – 88.93 + 2.15X*
CG_{6-12} – BW_{6-12}	Y= – 159.24 + 2.51X*

Note: * significant ($P<0.05$)

The linear regression equations to estimate BW_{6-12} in Ongole Grade cattle showed significant results ($P<0.05$). This indicated that using the regression equations, body size can be used as the estimator for BW_{6-12} in Ongole Grade cattle range from 87 to 195 kg. The results of linear regression equations for WH_{6-12} – BW_{6-12}, BL_{6-12} – BW_{6-12}, and CG_{6-12} – BW_{6-12} were Y= – 142.08 + 2.66X, Y= – 88.93 + 2.15X, and Y= – 159.24 + 2.51X, respectively, with the values for coefficients of regressions were 2.66, 2.15, and 2.51, respectively. Those indicated that the increasing of 1 cm of WH_{6-12} followed with the increasing of 2.66 kg of BW_{6-12}; the increasing of 1 cm of BL_{6-12} followed with the increasing of 2.15 kg of BW_{6-12}; and the increasing of 1 cm of CG_{6-12} followed with the increasing of 2.51 kg of BW_{6-12}, respectively. According to the results, the linear regression equation for CG_{6-12} – BW_{6-12} could be used as the best estimator to predict the body weight in Ongole Grade cattle at at 6 – 12 months old due to the highest value of correlation.

4.2.2 Correlation between Body Size and Body Weight in Ongole Grade Cattle at 18 – 24 Months Old

The coefficients of correlations (r) and coefficients of determinations (R^2) between body sizes (wither height, body length, and chest girth) with body weight in Ongole Grade cattle at 18 – 24 months old were presented in Table 9. The calculations are in Appendix 7.

Table 9. Coefficients of correlations and coefficients of determinations for the correlations of wither height – body weight (WH_{18-24} – BW_{18-24}), body length – body weight (BL_{18-24} – BW_{18-24}), and chest girth – body weight (CG_{18-24} – BW_{18-24}) in Ongole Grade cattle at 18 – 24 months old

Parameter	N	r	R^2
WH_{18-24} – BW_{18-24}	20	0.70**	49.00 %
BL_{18-24} – BW_{18-24}	20	0.71**	49.98 %
CG_{18-24} – BW_{18-24}	20	0.95**	89.46 %

Note: ** highly significant (P<0.01)

The correlations of WH_{18-24} – BW_{18-24}, BL_{18-24} – BW_{18-24}, and CG_{18-24} – BW_{18-24} in Ongole Grade cattle were showed highly significant results (P<0.01). Indicated that the value of BW_{18-24} will increase as the increasing of the value of WH_{18-24}, BL_{18-24}, and CG_{18-24}. The correlations of WH_{18-24} – BW_{18-24}, BL_{18-24} – BW_{18-24}, and CG_{18-24} – BW_{18-24}

respectively were 0.70, 0.71, and 0.95. The highest correlation was the correlation between $CG_{18\text{-}24}$ – $BW_{18\text{-}24}$, which is categorized as very highly positive value with the value of correlation was close to one. The value of coefficient of correlation is negative one (-1) until positive one (+1) (Nurgiartiningsih, 2017). If the coefficient of correlation between two variables is high (close to one), it means that there is a strong correlation between those variables. The coefficient of determination for correlation between $CG_{18\text{-}24}$ – $BW_{18\text{-}24}$ was 89.46%, it means that the variation of $BW_{18\text{-}24}$ affected by 89.46% of the variation of $CG_{18\text{-}24}$ and 10.54% remains were caused by other factors.

The correlation between $WH_{18\text{-}24}$ – $BW_{18\text{-}24}$ showed the lowest result. The value of correlation between $WH_{18\text{-}24}$ – $BW_{18\text{-}24}$ was 0.70. However, this result categorized as highly positive correlation with the result for coefficient of determination was 49%. It means that variation of $BW_{18\text{-}24}$ affected by variation of $WH_{18\text{-}24}$ about 49% and 51% remains were affected by other factors. The high value of the results can be caused by the growth process of the cattle. The growth process defined as the ability of the individual in the population to show its genetic potency and the development of the body until the livestock has obtained body maturity (Karnaen, 2007). The cattle in this group of age were in the phase of preparing for the first mating which make the growth process of the cattle is continuing.

The linear regression equations to estimate body weight in Ongole Grade cattle at 18 – 24 months old were presented in Table 10. The calculations are in Appendix 7.

Table 10. Linear regression equations to estimate BW_{18-24} in Ongole Grade cattle at 18 – 24 months old

Parameter	Regression Equation
$WH_{18-24} – BW_{18-24}$	Y= – 232.82 + 3.88X*
$BL_{18-24} – BW_{18-24}$	Y= – 250.75 + 3.98X*
$CG_{18-24} – BW_{18-24}$	Y= – 462.97 + 4.92X*

Note: * significant (P<0.05)

The linear regression equations to estimate body weight at 18 – 24 months old in Ongole Grade cattle showed significant results (P<0.05). This indicated that using the regression equations, body size can be used as the estimator for BW_{18-24} in Ongole Grade cattle range from 148.5 to 350 kg. The results of linear regression equations for WH_{18-24} – BW_{18-24}, BL_{18-24} – BW_{18-24}, and CG_{18-24} – BW_{18-24} respectively were Y= – 232.82 + 3.88X, Y= – 250.75 + 3.98X, and Y= – 462.97 + 4.92X, respectively, with the results for coefficients of regressions were 3.88, 3.98, and 4.92, respectively. Those indicated that the increasing of 1 cm of WH_{18-24} followed with the increasing of 3.88 kg of BW_{18-24}; the increasing of 1 cm of BL_{18-24} followed with the increasing of 3.98 kg of BW_{18-24}; and the increasing of 1 cm of CG_{18-24} followed with the increasing of 4.92 kg of BW_{18-24}. Based on those results, the linear regression equation of CG_{18-24} – BW_{18-24} could be used as the best estimator to estimate the body weight in Ongole Grade cattle at at 18 – 24 months old due to the highest value of correlation.

4.2.3 Correlation between Body Size and Body Weight in Ongole Grade Cattle at 25 – 36 Months Old

The coefficients of correlations (r) and coefficients of determinations (R^2) between body sizes (whiter height, body length, and chest girth) with body weight in Ongole Grade cattle at 25 – 36 Months Old were presented in Table 11. The calculations are in Appendix 8.

Table 11. Coefficients of correlations and coefficients of determinations for the correlations of wither height – body weight ($WH_{25\text{-}36}$ – $BW_{25\text{-}36}$), body length – body weight ($BL_{25\text{-}36}$ – $BW_{25\text{-}36}$), and chest girth – body weight ($CG_{25\text{-}36}$ – $BW_{25\text{-}36}$) in Ongole Grade cattle at 25 – 36 months old

Parameter	N	r	R^2
$WH_{25\text{-}36}$ – $BW_{25\text{-}36}$	30	0.57**	33.03 %
$BL_{25\text{-}36}$ – $BW_{25\text{-}36}$	30	0.43**	18.39 %
$CG_{25\text{-}36}$ – $BW_{25\text{-}36}$	30	0.85**	72.38 %

Note: ** highly significant ($P<0.01$)

Correlations of $WH_{25\text{-}36}$ – $BW_{25\text{-}36}$, $BL_{25\text{-}36}$ – $BW_{25\text{-}36}$, and $CG_{25\text{-}36}$ – $BW_{25\text{-}36}$ were showed highly significant results ($P<0.01$). Indicated that the value of $BW_{25\text{-}36}$ will increase as the increasing of the value of $WH_{25\text{-}36}$, $BL_{25\text{-}36}$, and $CG_{25\text{-}36}$. The correlations of $WH_{25\text{-}36}$ – $BW_{25\text{-}36}$, $BL_{25\text{-}36}$ – $BW_{25\text{-}36}$, and $CG_{25\text{-}36}$ – $BW_{25\text{-}36}$ were 0.57, 0.43, and 0.85, respectively. Correlation of $CG_{25\text{-}36}$ – $BW_{25\text{-}36}$ showed the highest result with the value was 0.85. This result included as very highly positive value, indicated that there is a high correlation between $CG_{25\text{-}36}$ and $BW_{25\text{-}36}$. Afolayan, Adeyinka, and Lakpini (2006) explained that chest girth is getting bigger as the livestock getting older because it is close to vital organs that also grow as the livestock grow. The coefficient of determination for correlation between CG_{25-36} – BW_{25-36} was 72.38%, which means that the variation of BW_{25-36}, 72.38% were affected by the variation of CG_{25-36} and 27.38% remains were affected by other factors.

The lowest correlation in Ongole Grade cattle at 25 – 36 months old was the correlation between BL_{25-36} – BW_{25-36} with the value was 0.43. This result was categorized as moderately positive value (0.4< r <0.59) with the coefficient of determination was 18.39%, which means that the variation of BW_{25-36} influenced by the variation of BL_{25-36} about 18.39% and 81.61% remains were affected by other factors. Compare to the results in Ongole Grade cattle at 6 – 12 and 18 – 24 months old, the results in this group of age was the lowest due to the lowest variation of the data. Furthermore, the value of lower correlation at this age can be affected by the slower growth process of the cattle. Pane (1993) explained that the growth process of cattle will be faster until the calf reaches the weaning age and continuing until the cattle reached maturity. The growth process will be decreased and constant as the cattle getting older. It is because of the process of duplicating protoplasm and enlarging of cellular structure in the body tissues already obtained the maximum growth (Karnaen, 2007). The cattle at this group of age are in the early phase of adult age where the growth rate is started to decrease.

The linear regression equations to estimate body weight at in Ongole Grade cattle 25 – 36 months old were presented in Table 12. The calculations are in Appendix 8.

Table 12. Linear regression equations to estimate BW_{25-36} in Ongole Grade cattle at 25 – 36 months old

Parameter	Regression Equation
$WH_{25-36} – BW_{25-36}$	Y= – 238.99 + 4.09X*
$BL_{25-36} – BW_{25-36}$	Y= – 46.56 + 2.49X*
$CG_{25-36} – BW_{25-36}$	Y= – 358.77 + 4.22X*

Note: * significant (P<0.05)

The linear regression equations to estimate body weight at 25 – 36 months old in Ongole Grade cattle showed significant results ($P<0.05$). This indicated that by using the regression equations, body size can be used as the estimator for BW_{25-36} in Ongole Grade cattle range from 232 to 377.5 kg. The results of linear regression equations for WH_{25-36} – BW_{25-36}, BL_{25-36} – BW_{25-36}, and CG_{25-36} – BW_{25-36} were Y= – 238.99 + 4.09X, Y= – 46.56 + 2.49X, and Y= – 358.77 + 4.22X, respectively, with the coefficients of regressions were 4.09, 2.49, and 4.22, respectively. Those indicated that the increasing of 1 cm of WH_{25-36} followed with the increasing of 4.09 kg of BW_{25-36}; the increasing of 1 cm of BL_{25-36} followed with the increasing of 2.49 kg of BW_{25-36}; and the increasing of 1 cm of CG_{25-36} followed with the increasing of 4.22 kg of BW_{25-36}. Body weight of livestock is one of indicators for livestock productivity, which can be predicted by the size of linear body of the cattle. The highest correlation between CG_{25-36} – BW_{25-36} indicated that chest girth could be used as the best estimator to estimate BW_{25-36} of Ongole Grade cattle. Afolayan et al. (2006) explained that chest girth has high accuracy to estimate body weight about 90%, better than body length and wither height.

CHAPTER
CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the results of the research it can be concluded that:

1. Body performance of male Ongole Grade cattle at 18 – 24 months old were categorized in Grade I for $BL_{18\text{-}24}$, Grade II for $CG_{18\text{-}24}$, and below the standard of SNI for $WH_{18\text{-}24}$ and female Ongole Grade cattle were categorized in Grade I for $WH_{18\text{-}24}$, $BL_{18\text{-}24}$, and $CG_{18\text{-}24}$. Body performance of male Ongole Grade cattle at 25 – 36 months old were categorized in Grade I for $WH_{25\text{-}36}$ and Grade II for $BL_{25\text{-}36}$ and $CG_{25\text{-}36}$, and body performance of female Ongole Grade cattle were categorized in Grade I for $WH_{25\text{-}36}$ and $BL_{25\text{-}36}$ and Grade III for $CG_{25\text{-}36}$.
2. The correlations between body sizes (wither height, body length, and chest girth) and body weight at 6 – 12, 18 – 24, and 25 – 36 months old in Ongole Grade cattle were categorized as moderately positive to very highly positive correlation and ranged from 0.43 to 0.95. The correlation between chest girth and body weight showed the highest value in all groups of age with the values for the coefficients of correlations ranged from 0.85 to 0.95.
3. The simple linear regression equations for estimated body weight (Y) based on chest girth (X) in Ongole Grade cattle at 6 – 12, 18 – 24, and 25 – 36 months old were: $Y = -159.24 + 2.51X$, $Y = -462.97 + 4.92X$, and $Y = -358.77 + 4.22X$, respectively.

4. The value of chest girth could be considered as the best estimator to estimate the body weight in Ongole Grade cattle due to the highest correlation value in each group of age.

5.2 Suggestion

According to the research, it is suggested to use chest girth as estimator for body weight in Ongole Grade cattle. However, there need to conduct further research on phenotypic correlation and regression of body size and body weight using more data to get more accurate results.

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APPENDIXES

Appendix 1. Observed data for WH, BL, CG, and BW at 6 – 12, 18 – 24, and 25 – 36 months old of Ongole Grade cattle

1. Observed data for WH_{6-12}, BL_{6-12}, CG_{6-12}, and BW_{6-12} of Ongole Grade cattle

No.	Identity/Owner	Sex	Age (Month)	WH_{6-12} (cm)	BL_{6-12} (cm)	CG_{6-12} (cm)	BW_{6-12} (kg)
1	Buali 1	F	8	94	91	106	99
2	Buasin 1	F	12	114	124	131	195
3	Hatib	F	7	115	87	100	131.5
4	Kawi 1	F	7	92	92	103	87
5	Muklas 1	F	7	93	96	110	95
6	Mukram	F	6	98	91	108	108.5
7	Mursadi 1	M	7	112	100	118	130
8	Nihat 1	F	8	101	100	115	120
9	Nihat 2	F	9	101	110	120	133
10	Nihat 3	F	9	101	110	118	131.5

11	Nihat 4	M	7	101	89	111	119.5
12	Pandi 1	F	6	98	106	122	140
13	Sibrin 1	M	12	127	127	146	192
14	Siyo 1	F	8	101	109	117	138
15	Siyo 2	F	12	113	120	131	192
16	Slamet	F	8	100	106	115	135
17	Sunar	F	10	100	104	121	147
18	Suparman 1	M	9	113	109	119	134.5
19	Tuman	M	6	101	111	116	118
20	Warlin 1	F	12	107	101	124	158
Total				**2082**	**2083**	**2351**	**2704.5**
Average				**104.10**	**104.15**	**117.55**	**135.23**
Standard Deviation				**8.91**	**11.39**	**10.55**	**30.36**
Coefficient of Variation				**8.56**	**10.94**	**8.97**	**22.45**

2. Observed data for WH_{18-24}, BL_{18-24}, CG_{18-24}, and BW_{18-24} of Ongole Grade cattle

No.	Identity/Owner	Sex	Age (Month)	WH_{18-24} (cm)	BL_{18-24} (cm)	CG_{18-24} (cm)	BW_{18-24} (kg)
1	Aziz	F	18	115	118	134	206
2	Buang 1	F	24	124	133	161	333
3	Buasin 2	F	18	108	113	122	148.5
4	Ibrohim	F	18	105	116	139	217
5	Minali	F	24	136	135	156	343
6	Muklas 2	F	18	121	120	132	186
7	Muklas 3	F	18	126	123	133	193
8	Muklas 4	F	24	134	127	157	326
9	Munajib	F	24	132	134	149	277.5
10	Mursadi 2	M	18	133	148	159	350
11	Nihat 5	F	18	129	122	143	239
12	Rohim 1	F	18	107	113	131	200
13	Rohim 2	F	18	107	109	136	190
14	Sadi	F	18	115	112	132	185

15	Sagi 1	M	18	106	138	137	186
16	Samad	F	18	131	110	151	239
17	Samin 1	F	18	120	115	133	200
18	Siyo 3	F	24	126	127	160	302
19	Wahid	F	18	132	137	154	275
20	Warlin 2	F	24	137	121	146	228
Total				**2444**	**2471**	**2865**	**4824**
Average				**122.2**	**123.55**	**143.25**	**241.2**
Standard Deviation				**11.11**	**10.94**	**11.86**	**61.63**
Coefficient of Variation				**9.09**	**8.86**	**8.28**	**25.55**

3. Observed data for $WH_{25\text{-}36}$, $BL_{25\text{-}36}$, $CG_{25\text{-}36}$, and $BW_{25\text{-}36}$ of Ongole Grade cattle

No.	Identity/Owner	Sex	Age (Month)	$CG_{25\text{-}36}$ (cm)	$BL_{25\text{-}36}$ (cm)	$WH_{25\text{-}36}$ (cm)	$BW_{25\text{-}36}$ (kg)
1	13490	F	36	144	134	121	235
2	Buali 2	F	30	149	131	126	262
3	Buang 2	F	36	156	144	141	327
4	Edi 1	F	30	148	136	131	232
5	Edi 2	F	36	150	134	126	266
6	Hasun 1	F	30	155	142	130	293
7	Hasun 2	F	30	152	150	127	300
8	Kawi 2	F	36	149	130	126	258
9	Misnaji	F	30	159	147	145	345
10	Muklas 5	F	36	145	131	122	241
…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…
21	Salawi	F	36	151	122	130	268

22	Samin 2	F	36	155	119	124	270
23	Satugi	F	30	165	135	123	334.5
24	Sibrin 2	F	36	159	129	131	321
25	Sibrin 3	F	30	147	133	128	270
26	Sudi	F	30	162	138	132	350
27	Suparman 2	F	30	147	132	133	240
28	Suyoto	F	36	147	134	131	283
29	Tris 1	F	30	146	144	131	285
30	Tris 2	F	36	161	130	127	303
Total				**3891**	**4080**	**4622**	**8742.5**
Average				**129.7**	**136**	**154.07**	**291.42**
Standard Deviation				**5.74**	**7.05**	**8.24**	**40.86**
Coefficient of Variation				**4.43**	**5.18**	**5.35**	**14.02**

Appendix 2. Calculations for means, standard deviations, and coefficients of variations for WH_{6-12}, BL_{6-12}, CG_{6-12}, and BW_{6-12} in Ongole Grade cattle at 6 – 12 months old

1. Total Data

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$
$$= \frac{2082}{20} = 104.10$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$
$$= \sqrt{\frac{218244 - \frac{2082^2}{20}}{20-1}}$$
$$= \sqrt{\frac{1507.8}{19}} = 8.91$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$
$$= \frac{8.91}{104.10} = 0.0856$$

Body Length
Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$
$$= \frac{2083}{20} = 104.15$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$
$$= \sqrt{\frac{219409 - \frac{2083^2}{20}}{20-1}}$$
$$= \sqrt{\frac{2464.55}{19}} = 11.39$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$
$$= \frac{11.39}{104.15} = 0.1094$$

Chest Girth
Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$
$$= \frac{2351}{20} = 117.55$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{278473 - \frac{2351^2}{20}}{20-1}}$$

$$= \sqrt{\frac{2112.95}{19}} = 10.55$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{10.55}{117.55} = 0.0897$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2704.5}{20} = 135.23$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{383230.3 - \frac{2704.5^2}{20}}{20-1}}$$

$$= \sqrt{\frac{17514.24}{19}} = 30.36$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{30.36}{135.23} = 0.2245$$

2. Male Ongole Grade Cattle

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{554}{5} = 110.8$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{61844 - \frac{554^2}{5}}{5-1}}$$

$$= \sqrt{\frac{460.8}{4}} = 10.73$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{10.73}{110.8} = 0.0969$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{536}{5} = 107.2$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{58252 - \frac{536^2}{5}}{5-1}}$$

$$= \sqrt{\frac{792.8}{4}} = 14.08$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{14.08}{107.2} = 0.1313$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{610}{5} = 122$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{75178 - \frac{610^2}{5}}{5-1}}$$

$$= \sqrt{\frac{758}{4}} = 13.77$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{13.77}{122} = 0.1128$$

Body Weight
Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{694}{5} = 138.8$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{100059 - \frac{694^2}{5}}{5-1}}$$

$$= \sqrt{\frac{3731.3}{4}} = 30.54$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{30.54}{138.8} = 0.2200$$

3. Female Ongole Grade Cattle
Whiter Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{1528}{15} = 101.87$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{156400 - \frac{1528^2}{15}}{15-1}}$$

$$= \sqrt{\frac{747.7}{14}} = 7.31$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{7.31}{101.87} = 0.0717$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{1547}{15} = 103.13$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{161157 - \frac{1547^2}{15}}{15-1}}$$

$$= \sqrt{\frac{1609.7}{14}} = 10.72$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{10.72}{103.13} = 0.1040$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{1741}{15} = 116.07$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{203295 - \frac{1741^2}{15}}{15-1}}$$

$$= \sqrt{\frac{1222.9}{14}} = 9.35$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{9.35}{116.07} = 0.0805$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2010.5}{15} = 134.03$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{283171.8 - \frac{2010.5^2}{15}}{15-1}}$$

$$= \sqrt{\frac{13697.7}{14}} = 31.28$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{31.28}{134.03} = 0.2334$$

Appendix 3. Calculations for means, standard deviations, and coefficients of variations for WH_{6-12}, BL_{6-12}, CG_{6-12}, and BW_{18-24} in Ongole Grade cattle at 18 – 24 months old

1. Total data

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2444}{20} = 122.2$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{301002 - \frac{2444^2}{20}}{20-1}}$$

$$= \sqrt{\frac{2345.2}{19}} = 11.11$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{11.11}{122.2} = 0.0909$$

Body Length
Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2471}{20} = 123.55$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{307567 - \frac{2471^2}{20}}{20-1}}$$

$$= \sqrt{\frac{2274.95}{19}} = 10.94$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{10.94}{123.55} = 0.0886$$

Chest Girth
Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2865}{20} = 143.25$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{413083 - \frac{2865^2}{20}}{20-1}}$$

$$= \sqrt{\frac{2671.75}{19}} = 11.86$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{11.86}{143.25} = 0.0828$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{4824}{20} = 241.2$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{1235718.5 - \frac{4824^2}{20}}{20-1}}$$

$$= \sqrt{\frac{72169.7}{19}} = 61.63$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{61.63}{241.2} = 0.2555$$

2. Male Ongole Grade Cattle

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{239}{2} = 119.5$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{28925 - \frac{239^2}{2}}{2-1}}$$

$$= \sqrt{\frac{364.5}{1}} = 19.09$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{19.09}{119.5} = 0.1598$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{286}{2} = 143$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{40948 - \frac{286^2}{2}}{2-1}}$$

$$= \sqrt{\frac{50}{1}} = 7.07$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{7.07}{143} = 0.0494$$

Chest Girth
Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{296}{2} = 148$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{44050 - \frac{296^2}{2}}{2-1}}$$

$$= \sqrt{\frac{242}{1}} = 15.56$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{15.56}{148} = 0.1051$$

Body Weight
Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{536}{2} = 268$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{157096 - \frac{536^2}{2}}{2-1}}$$

$$= \sqrt{\frac{13448}{1}} = 115.97$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{115.97}{268} = 0.4327$$

3. Female Ongole Grade Cattle

Whiter Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2205}{18} = 122.05$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{271077 - \frac{2205^2}{18}}{18-1}}$$

$$= \sqrt{\frac{1964.5}{17}} = 10.75$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{10.75}{122.50} = 0.0878$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2185}{18} = 121.39$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{266619 - \frac{2185^2}{18}}{18-1}}$$

$$= \sqrt{\frac{1384.3}{17}} = 9.02$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{9.02}{121.39} = 0.0743$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{2569}{18} = 142.72$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{369033 - \frac{2569^2}{18}}{18-1}}$$

$$= \sqrt{\frac{2379.61}{17}} = 11.83$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{11.83}{142.72} = 0.0829$$

Body Weight
Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{4288}{18} = 238.22$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{1078622.5 - \frac{4288^2}{18}}{18-1}}$$

$$= \sqrt{\frac{57125.6}{17}} = 57.97$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{57.97}{283.22} = 0.2433$$

Appendix 4. Calculations for means, standard deviations, and coefficients of variations for $WH_{25\text{-}36}$, $BL_{25\text{-}36}$, $CG_{25\text{-}36}$ and $BW_{25\text{-}36}$ in Ongole Grade cattle at 25 – 36 months old

1. Total data

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$
$$= \frac{3891}{30} = 129.7$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$
$$= \sqrt{\frac{505619 - \frac{3891^2}{30}}{30-1}}$$
$$= \sqrt{\frac{956.3}{29}} = 5.74$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$
$$= \frac{5.74}{129.7} = 0.0443$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{4080}{30} = 136$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{556322 - \frac{4080^2}{30}}{30-1}}$$

$$= \sqrt{\frac{1442}{29}} = 7.05$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{7.05}{136} = 0.0518$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{4622}{30} = 154.07$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{714064 - \frac{4622^2}{30}}{30-1}}$$

$$= \sqrt{\frac{1967.9}{29}} = 8.24$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{8.24}{154.07} = 0.0535$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{8742.5}{30} = 291.42$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{2596133 - \frac{8742.5^2}{30}}{30-1}}$$

$$= \sqrt{\frac{48422.5}{29}} = 40.86$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{40.86}{291.42} = 0.1402$$

2. Male Ongole Grade Cattle

Wither Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{274}{2} = 137$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{37546 - \frac{274^2}{2}}{2-1}}$$

$$= \sqrt{\frac{8}{1}} = 2.83$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{2.83}{137} = 0.0206$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{275}{2} = 137.5$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{37837 - \frac{275^2}{2}}{2-1}}$$

$$= \sqrt{\frac{24.5}{1}} = 4.95$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{4.95}{137.5} = 0.0360$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{333}{2} = 166.5$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{55449 - \frac{333^2}{2}}{2-1}}$$

$$= \sqrt{\frac{4.5}{1}} = 2.12$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{2.12}{166.5} = 0.0127$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{700.5}{2} = 350.25$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{246835.25 - \frac{333^2}{2}}{2-1}}$$

$$= \sqrt{\frac{1485.12}{1}} = 38.54$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{38.54}{350.25} = 0.110$$

3. Female Ongole Grade Cattle

Whiter Height

Mean for wither height

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{3617}{28} = 129.18$$

Standard deviation for wither height

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{468073 - \frac{3617^2}{28}}{28-1}}$$

$$= \sqrt{\frac{834.1}{27}} = 5.56$$

Coefficient of variation for wither height

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{5.56}{129.18} = 0.043$$

Body Length

Mean for body length

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{3805}{28} = 135.89$$

Standard deviation for body length

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{518485 - \frac{3805^2}{28}}{28-1}}$$

$$= \sqrt{\frac{1412.7}{27}} = 7.23$$

Coefficient of variation for body length

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{7.23}{135.89} = 0.0532$$

Chest Girth

Mean for chest girth

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{4289}{28} = 153.18$$

Standard deviation for chest girth

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{658615 - \frac{4289^2}{28}}{28-1}}$$

$$= \sqrt{\frac{1632.1}{27}} = 7.77$$

Coefficient of variation for chest girth

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{7.77}{153.18} = 0.0508$$

Body Weight

Mean for body weight

$$\bar{X} = \frac{\sum X}{n}$$

$$= \frac{8042}{28} = 287.21$$

Standard deviation for body weight

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

$$= \sqrt{\frac{2349297.5 - \frac{8042^2}{28}}{28-1}}$$

$$= \sqrt{\frac{395520.2}{27}} = 38.26$$

Coefficient of variation for body weight

$$CV = \frac{SD}{\bar{X}}$$

$$= \frac{38.26}{287.21} = 0.1332$$

Appendix 5. Unpaired t-test analysis for effect of sex on $WH_{6–12}$, $BL_{6–12}$, $CG_{6–12}$, and $BW_{6–12}$ in Ongole Grade cattle at 6 – 12 months old

Whiter Height

t-Test: Two-Sample Assuming Equal Variances ($P_{0.05}$)

	$WH_{6–12}$ (Male)	$WH_{6–12}$ (Female)
Mean	110.8	101.87
Variance	115.2	53.41
Observations	5	15
Pooled Variance	67.14	
Hypothesized Mean Difference	0	
Df	18	
t Stat	2.11	
P(T<=t) one-tail	0.02	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.10	

t-Test: Two-Sample Assuming Equal Variances ($P_{0.01}$)

	$WH_{6–12}$ (Male)	$WH_{6–12}$ (Female)
Mean	110.8	101.87
Variance	115.2	53.41
Observations	5	15
Pooled Variance	67.14	
Hypothesized Mean Difference	0	
Df	18	
t Stat	2.11	
P(T<=t) one-tail	0.02	
t Critical one-tail	2.55	
P(T<=t) two-tail	0.05	
t Critical two-tail	2.88	

Body Length

t-Test: Two-Sample Assuming Equal Variances ($P_{0.05}$)

	$BL_{6–12}$ (Male)	$BL_{6–12}$ (Female)
Mean	107.2	103.13
Variance	198.2	114.98
Observations	5	15
Pooled Variance	133.47	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.68	
P(T<=t) one-tail	0.25	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.50	
t Critical two-tail	2.10	

t-Test: Two-Sample Assuming Equal Variances ($P_{0.01}$)

	$BL_{6–12}$ (Male)	$BL_{6–12}$ (Female)
Mean	107.2	103.13
Variance	198.2	114.98
Observations	5	15
Pooled Variance	133.47	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.68	
P(T<=t) one-tail	0.25	
t Critical one-tail	2.55	
P(T<=t) two-tail	0.50	
t Critical two-tail	2.88	

Chest Girth

t-Test: Two-Sample Assuming Equal Variances ($P_{0.05}$)

	$CG_{6–12}$ (Male)	$CG_{6–12}$ (Female)
Mean	122	116.07
Variance	189.5	87.35
Observations	5	15
Pooled Variance	110.05	
Hypothesized Mean Difference	0	
Df	18	
t Stat	1.10	
P(T<=t) one-tail	0.14	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.29	
t Critical two-tail	2.10	

t-Test: Two-Sample Assuming Equal Variances ($P_{0.01}$)

	$CG_{6–12}$ (Male)	$CG_{6–12}$ (Female)
Mean	122	116.07
Variance	189.5	87.35
Observations	5	15
Pooled Variance	110.05	
Hypothesized Mean Difference	0	
Df	18	
t Stat	1.10	
P(T<=t) one-tail	0.14	
t Critical one-tail	2.55	
P(T<=t) two-tail	0.29	
t Critical two-tail	2.88	

Body Weight

t-Test: Two-Sample Assuming Equal Variances ($P_{0.05}$)

	BW_{6-12} (Male)	BW_{6-12} (Female)
Mean	138.80	134.03
Variance	932.83	978.41
Observations	5	15
Pooled Variance	968.28	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.30	
P(T<=t) one-tail	0.39	
t Critical one-tail	1.73	
P(T<=t) two-tail	0.77	
t Critical two-tail	2.10	

t-Test: Two-Sample Assuming Equal Variances ($P_{0.01}$)

	BW_{6-12} (Male)	BW_{6-12} (Female)
Mean	138.80	134.03
Variance	932.83	978.41
Observations	5	15
Pooled Variance	968.28	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.30	
P(T<=t) one-tail	0.39	
t Critical one-tail	2.55	
P(T<=t) two-tail	0.77	
t Critical two-tail	2.88	

Appendix 6. Calculations for coefficient of correlation, coefficient of determination, signification test, and simple linear regression for the correlations of $WH_{6–17}$ – BW_{6-12}, $BL_{6–17}$ – BW_{6-12}, and $CG_{6–17}$ – BW_{6-12} in Ongole Grade cattle at 6 – 12 months old

1. Wither Height – Body Weight

n	= 20 heads	σ_{X1}	= 8.91
$\Sigma X1..$	= 2082	σ_{Y1}	= 30.36
$\Sigma Y1..$	= 2704.5		
$\Sigma X1^2..$	= 218244		
$\Sigma Y1^2..$	= 383230.3		
$\Sigma X1Y1..$	= 323207		

$$\boldsymbol{SS_{X1} = \sum X1^2.. - \frac{(\Sigma X1..)^2}{n}}$$

$$SS_{X1} = 218244 - \frac{2082^2}{20} = 1507.8$$

$$\boldsymbol{SS_{Y1} = \sum Y1^2.. - \frac{(\Sigma Y1..)^2}{n}}$$

$$SS_{Y1} = 383230.3 - \frac{2704.5^2}{20} = 17514.24$$

$$\boldsymbol{SCP_{X1Y1} = \sum X1Y1.. - \frac{(\Sigma X1..)(\Sigma Y1..)}{n}}$$

$$SCP_{X1Y1} = 323207 - \frac{(2082)(2704.5)}{20} = 4016.55$$

$$\boldsymbol{cov_{X1Y1}} = \frac{\boldsymbol{SCP_{X1Y1}}}{\boldsymbol{n-1}} = \frac{4016.55}{19} = 211.40$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X1Y1}}}{\boldsymbol{\sigma_{X1}\sigma_{Y1}}} = \frac{211.40}{8.91 \times 30.36} = 0.78$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \mathbf{100}\% = 0.78^{\mathbf{2}} \times 100\% = 61.09\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t} = \boldsymbol{r}\sqrt{\frac{\boldsymbol{n} - \mathbf{2}}{\mathbf{1} - \boldsymbol{r^2}}} = 0.78\sqrt{\frac{20 - 2}{1 - 0.78^2}} = 7.72$$

The result of t_{cal} (7.72) was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between WH_{6-12} – BW_{6-12} was highly significant (P<0.01).

Simple linear regression

Regression Statistics	
Multiple R	0.78
R Square	0.61
Adjusted R Square	0.59
Standard Error	19.46
Observations	20

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	10699.48	10699.48	28.26	0.00
Residual	18	6814.76	378.60		
Total	19	17514.24			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-142.08	52.35	-2.71	0.01	-252.05	-32.12	-252.05	-32.11
WH (cm)	2.66	0.50	5.32	0.00	1.61	3.72	1.61	3.72

$\boldsymbol{Y = a + bX}$

$Y = -142.08 + 2.66X$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $WH_{6-12} - BW_{6-12}$ was significant.

2. Body Length – Body Weight

n	= 20 heads	σ_{X2}	= 11.39
$\Sigma X2..$	= 2083	σ_{Y1}	= 30.36
$\Sigma Y1..$	= 2704.5		
$\Sigma X2^2..$	= 219409		
$\Sigma Y1^2..$	= 383230.3		
$\Sigma X2Y1..$	= 286978		

$$\boldsymbol{SS_{X2}} = \sum \boldsymbol{X2^2}.. - \frac{(\boldsymbol{\Sigma X2}..)^2}{\boldsymbol{n}}$$

$$SS_{X2} = 219409 - \frac{2083^2}{20} = 2464.55$$

$$\boldsymbol{SS_{Y1}} = \sum \boldsymbol{Y1^2}.. - \frac{(\boldsymbol{\Sigma Y1}..)^2}{\boldsymbol{n}}$$

$$SS_{Y1} = 383230.3 - \frac{2704.5^2}{20} = 17514.24$$

$$\boldsymbol{SCP_{X2Y1}} = \sum \boldsymbol{X2Y1}.. - \frac{(\boldsymbol{\Sigma X2}..)(\boldsymbol{\Sigma Y1}..)}{\boldsymbol{n}}$$

$$SCP_{X2Y1} = 286978 - \frac{(2083)(2704.5)}{20} = 5304.33$$

$$\boldsymbol{cov_{X2Y1}} = \frac{\boldsymbol{SCP_{X2Y1}}}{\boldsymbol{n-1}} = \frac{5304.33}{19} = 279.18$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X2Y1}}}{\boldsymbol{\sigma_{X2}\sigma_{Y1}}} = \frac{279.18}{11.39 \times 30.36} = 0.81$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.81^{\boldsymbol{2}} \times 100\% = 65.18\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.81\sqrt{\frac{20-2}{1-0.81^2}} = 8.43$$

The result of t_{cal} (8.43) was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between BL_{6-12} – BW_{6-12} was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.82
R Square	0.65
Adjusted R Square	0.63
Standard Error	18.41
Observations	20

ANOVA

	Df	SS	MS	F	Sig. F
Regression	1	11416.23	11416.23	33.69	0.00
Residual	18	6098.01	338.78		
Total	19	17514.24			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-88.93	38.83	-2.29	0.03	-170.52	-7.35	-170.52	-7.35
BL (cm)	2.15	0.37	5.81	0.00	1.37	2.93	1.37	2.93

$$\boldsymbol{Y = a + bX}$$
$$Y = -88.93 + 2.15X$$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $BL_{6\text{-}12}$ – $BW_{6\text{-}12}$ was significant.

3. Chest Girth – Body Weight

n	= 20 heads	σ_{X3}	= 10.55
$\Sigma X3..$	= 2351	σ_{Y1}	= 30.36
$\Sigma Y1..$	= 2784.5		
$\Sigma X3^2..$	= 278473		
$\Sigma Y1^2..$	= 383230.3		
$\Sigma X3Y1..$	= 323207		

$$\boldsymbol{SS_{X3}} = \sum \boldsymbol{X3^2}.. - \frac{(\boldsymbol{\Sigma X3}..)^{\boldsymbol{2}}}{\boldsymbol{n}}$$

$$SS_{X3} = 278473 - \frac{2351^2}{20} = 2112.95$$

$$\boldsymbol{SS_{Y1}} = \sum \boldsymbol{Y1^2}.. - \frac{(\boldsymbol{\Sigma Y1}..)^{\boldsymbol{2}}}{\boldsymbol{n}}$$

$$SS_{Y1} = 383230.3 - \frac{2704.5^2}{20} = 17514.24$$

$$\boldsymbol{SCP_{X3Y1}} = \sum \boldsymbol{X3Y1}.. - \frac{(\boldsymbol{\Sigma X3}..)(\boldsymbol{\Sigma Y1}..)}{\boldsymbol{n}}$$

$$SCP_{X3Y1} = 323207 - \frac{(2351)(2704.5)}{20} = 5293.03$$

$$\boldsymbol{cov_{X3Y1}} = \frac{\boldsymbol{SCP_{X3Y1}}}{\boldsymbol{n-1}} = \frac{5293.03}{19} = 278.58$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X3Y1}}}{\boldsymbol{\sigma_{X3}\sigma_{Y1}}} = \frac{278.58}{10.55 \times 30.36} = 0.87$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.87^{\boldsymbol{2}} \times 100\% = 75.71\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.87\sqrt{\frac{20-2}{1-0.87^2}} = 10.88$$

The result of t_{cal} (10.88) was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between CG_{6-12} – $BW_{6-12}$was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.87
R Square	0.75
Adjusted R Square	0.74
Standard Error	15.37
Observations	20

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	13259.24	13259.24	56.09	0.00
Residual	18	4255.00	236.39		
Total	19	17514.24			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%

Intercept	-159.24	39.47	-4.03	0.00	-242.16	-76.32	-242.16	-76.32
CG (cm)	2.51	0.33	7.49	0.00	1.80	3.21	1.80	3.21

$$\boldsymbol{Y = a + bX}$$

$$Y = -159.24 + 2.51X$$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $CG_{6\text{-}12} - BW_{6\text{-}12}$ was significant.

Appendix 7. Calculations for coefficient of correlation, coefficient of determination, signification test, and simple linear regression for the correlations of WH_{18-24} – BW_{18-24}, BL_{18-24} – BW_{18-24}, and CG_{18-24} – BW_{18-24} in Ongole Grade cattle at 18 – 24 months old

1. Wither Height – Body Weight

n	= 20 heads	σ_{X4}	= 11.11
$\Sigma X4..$	= 2444	σ_{Y2}	= 61.63
$\Sigma Y2..$	= 4824		
$\Sigma X4^2..$	= 301002		
$\Sigma Y2^2..$	= 1235719		
$\Sigma X4Y2..$	= 598590		

$$\boldsymbol{SS_{X4} = \sum X4^2.. - \frac{(\Sigma X4..)^2}{n}}$$

$$SS_{X4} = 301002 - \frac{2444^2}{20} = 2345.2$$

$$\boldsymbol{SS_{Y2} = \sum Y2^2.. - \frac{(\Sigma Y2..)^2}{n}}$$

$$SS_{Y2} = 1235719 - \frac{4824^2}{20} = 72169.7$$

$$\boldsymbol{SCP_{X4Y2} = \sum X4Y2.. - \frac{(\Sigma X4..)(\Sigma Y2..)}{n}}$$

$$SCP_{X4Y2} = 598590 - \frac{(2444)(4824)}{20} = 9097.2$$

$$\boldsymbol{cov_{X4Y2} = \frac{SCP_{X4Y2}}{n-1}} = \frac{9097.2}{19} = 478.8$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X4Y2}}}{\boldsymbol{\sigma_{X4}\sigma_{Y2}}} = \frac{478.8}{11.11 \times 61.63} = 0.70$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.70^{\boldsymbol{2}} \times 100\% = 49\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t} = \boldsymbol{r}\sqrt{\frac{\boldsymbol{n-2}}{\boldsymbol{1- r^2}}} = 0.70\sqrt{\frac{20-2}{1-0.70^2}} = 6.03$$

The result of t_{cal} (6.03) was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between $WH_{18\text{-}24}$ – $BW_{18\text{-}24}$ was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.70
R Square	0.49
Adjusted R Square	0.46
Standard Error	45.27
Observations	20

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	35288.70	35288.70	17.22	0.00
Residual	18	36881	2048.94		
Total	19	72169.70			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-232.82	114.67	-2.03	0.06	-473.73	8.09	-473.73	8.09
WH (cm)	3.88	0.93	4.15	0.00	1.92	5.84	1.92	5.84

$$\boldsymbol{Y = a + bX}$$
$$Y = -232.82 + 3.88X$$

The result of significance F was 0.00 (P<0.05). Indicated that the linear regression equation for $WH_{18\text{-}24}$ – $BW_{18\text{-}24}$ was significant.

2. Body Length – Body Weight

n	= 20 heads	σ_{X5}	= 10.94
$\Sigma X5..$	= 2471	σ_{Y2}	= 61.63
$\Sigma Y2..$	= 4824		
$\Sigma X5^2..$	= 3075567		
$\Sigma Y2^2..$	= 1235719		
$\Sigma X5Y2..$	= 605064		

$$\boldsymbol{SS_{X5}} = \sum \boldsymbol{X5^2}.. - \frac{(\boldsymbol{\Sigma X5}..)^2}{\boldsymbol{n}}$$

$$SS_{X5} = 3075567 - \frac{2471^2}{20} = 2274.95$$

$$\boldsymbol{SS_{Y2}} = \sum \boldsymbol{Y2^2}.. - \frac{(\boldsymbol{\Sigma Y2}..)^2}{\boldsymbol{n}}$$

$$SS_{Y2} = 1235719 - \frac{4824^2}{20} = 72169.7$$

$$\boldsymbol{SCP_{X5Y2}} = \sum \boldsymbol{X5Y2}.. - \frac{(\boldsymbol{\Sigma X5}..)(\boldsymbol{\Sigma Y2}..)}{\boldsymbol{n}}$$

$$SCP_{X5Y2} = 605064 - \frac{(2471)(4824)}{20} = 9058.3$$

$$\boldsymbol{cov_{X5Y2}} = \frac{\boldsymbol{SCP_{X5Y2}}}{\boldsymbol{n-1}} = \frac{9058.3}{19} = 476.75$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X5Y2}}}{\boldsymbol{\sigma_{X5}\sigma_{Y2}}} = \frac{476.75}{10.94 \times 61.63} = 0.71$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.71^{\boldsymbol{2}} \times 100\% = 49.98\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.71\sqrt{\frac{20-2}{1-0.71^2}} = 6.16$$

The result of t_{cal} 6.16 was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between $BL_{18\text{-}24}$ – $BW_{18\text{-}24}$ was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.71
R Square	0.49
Adjusted R Square	0.47
Standard Error	44.78
Observations	20

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	36067.96	36067.96	17.98	0.00
Residual	18	36101.74	2005.652		
Total	19	72169.7			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-250.75	116.44	-2.15	0.05	-495.37	-6.12	-495.37	-6.12
BL (cm)	3.98	0.94	4.24	0.00	2.01	5.95	2.01	5.95

$$\boldsymbol{Y = a + bX}$$
$$Y = -250.75 + 3.98X$$

The result of significance F was 0.00 (P<0.05). Indicated that the linear regression equation for $BL_{18\text{-}24}$ – $BW_{18\text{-}24}$ was significant.

3. Chest Girth – Body Weight

n	= 20 heads	σ_{X6}	= 11.86
$\Sigma X6..$	= 2865	σ_{Y2}	= 61.63
$\Sigma Y2..$	= 4824		
$\Sigma X6^2..$	= 413083		
$\Sigma Y2^2..$	= 1235719		
$\Sigma X6Y2..$	= 704172		

$$\boldsymbol{SS_{X6}} = \sum \boldsymbol{X6^2}.. - \frac{(\boldsymbol{\Sigma X6}..)^2}{\boldsymbol{n}}$$

$$SS_{X6} = 413083 - \frac{2865^2}{20} = 2671.75$$

$$\boldsymbol{SS_{Y2}} = \sum \boldsymbol{Y2^2}.. - \frac{(\boldsymbol{\Sigma Y2}..)^2}{\boldsymbol{n}}$$

$$SS_{Y2} = 1235719 - \frac{4824^2}{20} = 72169.7$$

$$\boldsymbol{SCP_{X6Y2}} = \sum \boldsymbol{X6Y2}.. - \frac{(\boldsymbol{\Sigma X6}..)(\boldsymbol{\Sigma Y2}..)}{\boldsymbol{n}}$$

$$SCP_{X6Y2} = 04172 - \frac{(2865)(4824)}{20} = 13133.5$$

$$\boldsymbol{cov_{X6Y2}} = \frac{\boldsymbol{SCP_{X6Y2}}}{\boldsymbol{n-1}} = \frac{13133.5}{19} = 691.24$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X6Y2}}}{\boldsymbol{\sigma_{X6}\sigma_{Y2}}} = \frac{691.24}{11.86 \times 61.63} = 0.95$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.95^{\boldsymbol{2}} \times 100\% = 89.46\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.95\sqrt{\frac{20-2}{1-0.95^2}} = 17.96$$

The result of t_{cal} (17.96) was higher than the level of signification 5% (1.73406) and 1% (2.55238), indicated that correlation between $CG_{18\text{-}24}$ – $BW_{18\text{-}24}$ was highly significant (P<0.01).

Simple linear regression

Regression Statistics	
Multiple R	0.95
R Square	0.89
Adjusted R Square	0.89
Standard Error	20.56
Observations	20

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	64560.24	64560.24	152.72	0.00
Residual	18	7609.46	422.75		
Total	19	72169.70			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%

Intercept	-462.97	57.17	-8.10	0.00	-583.08	-342.87	-583.08	-342.87
CG (cm)	4.92	0.40	12.36	0.00	4.08	5.75	4.08	5.75

$$\boldsymbol{Y = a + bX}$$
$$Y = -462.97 + 4.92X$$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $CG_{18\text{-}24} – BW_{18\text{-}24}$ was significant.

Appendix 8. Calculations for coefficient of correlation, coefficient of determination, signification test, and simple linear regression for the correlations of $WH_{25\text{-}36}$ – $BW_{25\text{-}36}$, $BL_{25\text{-}36}$ – $BW_{25\text{-}36}$, and $CG_{25\text{-}36}$ – $BW_{25\text{-}36}$ in Ongole Grade cattle at 25 – 26 months old

1. Wither Height – Body Weight

n	= 30 heads	σ_{X7}	= 5.74
$\Sigma X7..$	= 3891	σ_{Y3}	= 40.86
$\Sigma Y3..$	= 8742.5		
$\Sigma X7^2..$	= 505619		
$\Sigma Y3^2..$	= 2596133		
$\Sigma X7Y3..$	=		1137813

$$\boldsymbol{SS_{X7}} = \sum \boldsymbol{X7^2}.. - \frac{(\boldsymbol{\Sigma X7}..)^2}{\boldsymbol{n}}$$

$$SS_{X7} = 505619 - \frac{3891^2}{30} = 956.3$$

$$\boldsymbol{SS_{Y3}} = \sum \boldsymbol{Y3^2}.. - \frac{(\boldsymbol{\Sigma Y3}..)^2}{\boldsymbol{n}}$$

$$SS_{Y3} = 2596133 - \frac{8742.5^2}{30} = 48422.54$$

$$\boldsymbol{SCP_{X7Y3}} = \sum \boldsymbol{X7Y3}.. - \frac{(\boldsymbol{\Sigma X7}..)(\boldsymbol{\Sigma Y3}..)}{\boldsymbol{n}}$$

$$SCP_{X7Y3} = 1137813 - \frac{(3891)(8742.5)}{30} = 3910.75$$

$$\boldsymbol{cov_{X7Y3}} = \frac{\boldsymbol{SCP_{X7Y3}}}{\boldsymbol{n-1}} = \frac{3910.75}{29} = 134.85$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X7Y3}}}{\boldsymbol{\sigma_{X7}\sigma_{Y3}}} = \frac{134.85}{5.74 \times 40.86} = 0.57$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \mathbf{100}\% = 0.57^{\mathbf{2}} \times 100\% = 33.03\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t} = \boldsymbol{r}\sqrt{\frac{\boldsymbol{n-2}}{\mathbf{1}-\boldsymbol{r^2}}} = 0.57\sqrt{\frac{30-2}{1-0.57^2}} = 5.35$$

The result of t_{cal} (5.35) was higher than the level of signification 5% (1.70113) and 1% (2.4671), indicated that correlation between $WH_{25\text{-}36}$ – $BW_{25\text{-}36}$ was highly significant (P<0.01).

Simple linear regression

Regression Statistics	
Multiple R	0.57
R Square	0.33
Adjusted R Square	0.31
Standard Error	34.03
Observations	30

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	15992.85	15992.85	13.81	0.00
Residual	28	32429.69	1158.20		
Total	29	48422.54			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-238.99	142.87	-1.67	0.11	-531.65	53.67	-531.65	53.67
WH (cm)	4.09	1.10	3.72	0.00	1.84	6.34	1.84	6.34

$$\boldsymbol{Y = a + bX}$$
$$Y = -238.99 + 4.09X$$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $WH_{25\text{-}36}$ – $BW_{25\text{-}36}$ was significant.

2. Body Length – Body Weight

n	= 30 heads	σ_{X8}	= 7.05
$\Sigma X8..$	= 4080	σ_{Y3}	= 40.86
$\Sigma Y3..$	= 8742.5		
$\Sigma X8^2..$	= 556322		
$\Sigma Y3^2..$	= 2596133		
$\Sigma X8Y3..$	= 1192564		

$$\boldsymbol{SS_{X8}} = \sum \boldsymbol{X8^2}.. - \frac{(\boldsymbol{\Sigma X8}..)^2}{\boldsymbol{n}}$$

$$SS_{X8} = 556322 - \frac{4080^2}{30} = 1442$$

$$\boldsymbol{SS_{Y3}} = \sum \boldsymbol{Y3^2}.. - \frac{(\boldsymbol{\Sigma Y3}..)^2}{\boldsymbol{n}}$$

$$SS_{Y3} = 2596133 - \frac{8742.5^2}{30} = 48422.54$$

$$\boldsymbol{SCP_{X8Y3}} = \sum \boldsymbol{X8Y3}.. - \frac{(\boldsymbol{\Sigma X8}..)(\boldsymbol{\Sigma Y3}..)}{\boldsymbol{n}}$$

$$SCP_{X8Y3} = 1192564 - \frac{(4080)(8742.5)}{30} = 3583.5$$

$$\boldsymbol{cov_{X8Y3}} = \frac{\boldsymbol{SCP_{X8Y3}}}{\boldsymbol{n-1}} = \frac{3583.5}{29} = 123.57$$

Coefficient of correlation

$$\boldsymbol{r} = \frac{\boldsymbol{cov_{X8Y3}}}{\boldsymbol{\sigma_{X8}\sigma_{Y3}}} = \frac{123.57}{7.05 \times 40.86} = 0.43$$

Coefficient of determination

$$\boldsymbol{R} = \boldsymbol{r^2} \times \boldsymbol{100}\% = 0.43^{\boldsymbol{2}} \times 100\% = 18.39\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.43\sqrt{\frac{30-2}{1-0.57^2}} = 3.62$$

The result of t_{cal} (3.62) was higher than the level of signification 5% (1.70113) and 1% (2.4671), indicated that correlation between $BL_{25\text{-}36}$ – $BW_{25\text{-}36}$ was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.43
R Square	0.18
Adjusted R Square	0.15
Standard Error	37.57
Observations	30

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	8905.32	8905.32	6.31	0.02
Residual	28	39517.22	1411.33		
Total	29	48422.54			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%

Intercept	-46.56	134.72	-0.35	0.73	-322.52	229.41	-322.52	229.41
BL (cm)	2.49	0.99	2.51	0.02	0.46	4.51	0.46	4.51

$$\boldsymbol{Y = a + bX}$$
$$Y = -46.56 + 2.49X$$

The result of significance F was 0.00 ($P<0.05$). Indicated that the linear regression equation for $BL_{25\text{-}36} - BW_{25\text{-}36}$ was significant.

3. Chest Girth – Body Weight

n	= 30 heads	σ_{X9}	= 8.24
$\Sigma X9..$	= 4622	σ_{Y3}	= 40.86
$\Sigma Y3..$	= 8742.5		
$\Sigma X9^2..$	= 714064		
$\Sigma Y3^2..$	= 2596133		
$\Sigma X9Y3..$	= 1355233		

$$\boldsymbol{SS_{X9} = \sum X9^2.. - \frac{(\Sigma X9..)^2}{n}}$$

$$SS_{X9} = 714064 - \frac{4622^2}{30} = 1967.87$$

$$\boldsymbol{SS_{Y3} = \sum Y3^2.. - \frac{(\Sigma Y3..)^2}{n}}$$

$$SS_{Y3} = 2596133 - \frac{8742.5^2}{30} = 48422.54$$

$$\boldsymbol{SCP_{X9Y3} = \sum X9Y3.. - \frac{(\Sigma X9..)(\Sigma Y3..)}{n}}$$

$$SCP_{X9Y3} = 1355233 - \frac{(4622)(8742.5)}{30} = 8304.67$$

$$\boldsymbol{cov_{X9Y3} = \frac{SCP_{X9Y3}}{n-1}} = \frac{8304.67}{29} = 286.37$$

Coefficient of correlation

$$\boldsymbol{r = \frac{cov_{X9Y3}}{\sigma_{X9}\sigma_{Y3}}} = \frac{286.37}{8.24 \times 40.86} = 0.85$$

Coefficient of determination

$$\boldsymbol{R = r^2 \times 100}\% = 0.85^2 \times 100\% = 72.38\%$$

Signification test for coefficient of correlation

$$\boldsymbol{t = r\sqrt{\frac{n-2}{1-\ r^2}}} = 0.85\sqrt{\frac{30-2}{1-0.85^2}} = 12.33$$

The result of t_{cal} (12.33) was higher than the level of signification 5% (1.70113) and 1% (2.4671), indicated that correlation between $CG_{25\text{-}36}$ – $BW_{25\text{-}36}$ was highly significant ($P<0.01$).

Simple linear regression

Regression Statistics	
Multiple R	0.85
R Square	0.72
Adjusted R Square	0.71
Standard Error	21.86
Observations	30

ANOVA

	df	SS	MS	F	Sig. F
Regression	1	35046.83	35046.83	73.37	0.00
Residual	28	13375.71	477.70		
Total	29	48422.54			

	Coef.	SE	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%

Intercept	-358.77	76.01	-4.72	0.00	-514.47	-203.06	-514.47	-203.06
CG (cm)	4.22	0.49	8.57	0.00	3.21	5.23	3.21	5.23

$\boldsymbol{Y = a + bX}$

$Y = -358.77 + 4.22X$

The result of significance F was 0.00 (P<0.05). Indicated that the linear regression equation for $CG_{25\text{-}36} – BW_{25\text{-}36}$ was significant.

Appendix 9. Documentation