EVALUATION OF WORKABILITY TRAITS ASSOCIATED WITH HANDLING AND MILKING OF BUNAJI COWS

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN ANIMAL SCIENCE

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FEBRUARY, 2022

DECLARATION

I declare that the work in this dissertation entitled EVALUATION OF WORKABILITY TRAITS ASSOCIATED WITH HANDLING AND MILKING OF BUNAJI COWS has been performed by me in the Department of Animal Science. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

LOT HGYAB SUNDAY (P16AGAN8035)	____________________ Signature	____________________ Date

CERTIFICATION

This dissertation entitled EVALUATION OF WORKABILITY TRAITS ASSOCIATED WITH HANDLING AND MILKING OF BUNAJI COWS by LOT HGYAB SUNDAY meets the regulations governing the award of the degree of Masters in Animal Science (Animal Breeding and Genetics) of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to the all sufficient God who gave me the enablement to successfully carry out the study.

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ABSTRACT

The study was carried out to explore the phenotypic relationships and dependencies among workability traits (temperament and milkability) that significantly affect the function of Bunaji cows. Fifty-one (51) multiparous, non-pregnant, lactating cows were used for this study. These cows in their third stage of lactation were sorted from four different herds of the same farm. The cows were tagged and certified clinically fit by animal health personnel. The techniques implored to assess the animals' workability traits were average milk flow-rate and subjective milkability score for milkability trait; and milking, pen, chute, chute exit score and chute exit speed for temperament traits. Data of milkability, temperament, udder and body linear measurements in the experiment were analysed using SAS (9.0) version. Computations using means procedure were done to: determine the means and standard error for each trait; and coefficients of variation (CV) to determine the variability in the population sample. Significant differences in means were compared using the Duncan Multiple Range Test (DMRT). Pearson correlation coefficients were computed to determine the degrees of relationship among and between variables for all animals within each temperament and milkability groups. Further exploration using principal components analysis (PCA) was used to determine the relationships of the traits. The result of these findings showed that: majority of the cattle handles perceived the temperament of Bunaji cattle to be moderately reactive. Milk yield (MY), rear udder height (RUH), rear udder width (RUW); udder depth (UD); central ligament (CL), fore teat-placement (FTP), tail lengths (TL2), were significantly ($p<0.05$) affected by milkability (AFR). Temperament traits had significant ($p<0.05$) effect on exit speed, milk yield, milkability and body measurements. Milkability was significantly correlated with RUH, TL, FTP, UD, CL and milking duration (D). Chute temperament score (CT), chute exit score (CES) and chute exit speed (FS) were highly ($P< 0.01$) correlated temperament traits as they had high significant loadings on only one principal components (PCs); similarly the milk flow-rate traits and milkability score (AMS). The correlations between temperament and milkability traits were not significant ($p>0.05$). The conclusions were: Bunaji cows with very fast milkability scores (MS1) had the highest flow-rate and milk yield; Bunaji cows with milking temperament score 1 (very calm) produced more milk than those of the milking temperament score 3 (moderately calm). Bunaji cows that jump while exiting the chute at a higher speed (score 5) were more reactive and dangerous than those that ran (score 3), trot (score 2) and walked (score 1). PCA could be used for the reduction in the number of type traits used in selection for subjective and objective milkability and temperament. An improvement on milkability traits would significantly reduce the total time of milking. It is thus recommended that: Farmers and dairy producers should be encouraged to rear cows that have high milk flow trait; handlers need to be conscious of temperaments of cattle to ensure safety. This study should be replicated for other breeds of cattle.

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CHAPTER ONE

1.0 INTRODUCTION

Functional traits such as measures of reproductive performance, health and disease resistance, feed consumption, longevity, adaptation to local breeding conditions, milkability and temperament among many others have been coined to refer to the phenotypic characteristics that affect or are indicators of cow's well-being (Boettcher, 2010). Milkability and temperament traits have been classified as functional traits associated with workability by the Genetic Information of Functional Traits (GIFT, 1999). Workability probably could be best described as the suitability of an animal to carry out a purpose on the farm (Ellen, 2013).

Milkability, evaluated as milk flow-rate or milking speed and duration (Gray *et al*., 2012) is the aptitude of the cow to let-down milk from the udder and to be fully milked (Lee and Choudhary, 2006). Milkability is greatly determined by the milking technique employed such as the traditional as well as the robotic or the modern technique (Ellen, 2013). Milkability could influence involuntary culling as superior cattle with major milk protein genes that serves as markers for both milk yield and composition are retained in the breeding flock (Sammy*et al.*, 2018). The trait is affected by milk yield, resistance from the teat canal, strength of the hormonal let-down reflex (Carlstrom, 2014), herd-year season, calving and parity as well as factors with inestimable effects such as infectious diseases and parasitic infestations (Tshilate, 2017).

Cattle temperament on the other hand describes individual behavioural and physiological differences with regard to a stressor or an environmental challenge that is consistent over time or over contexts (Sutherland and Dowling, 2014; Louise and Hanne, 2015). Cattle temperament varies and comprises of behavioural characteristics like shyness to boldness, exploration, avoidance, activity, sociability, aggressiveness and emotionality such as fearfulness which constitute an important aspect of behavioural genetics (Friedrich *et al*., 2015). Like milkability, cattle temperament could also influence selection as the genetic basis such as moderate heritability estimates, vast variations in the major handling temperament traits and the identification of quantitative trait loci – QTL has been investigated (Haskell *et al*., 2014). Temperament traits that have received most attention are generally those that have adverse production, welfare or human safety consequences, the foremost of which is the handling temperament and the impacts of poor temperament on farm management efficiency and animals (Burrow, 1997; Barrozo *et al*., 2012; Turner *et al.,* 2013). Other temperament traits that are important from an animal welfare or human safety stand point are: maternal aggressiveness, resource-based aggression and social motivation or sociability, which is the willingness to be in close proximity to group-mates (Turner *et al*., 2013).

Improvement of the workability traits from economic standpoint are important because cattle which are safer to handle during routine management, several human contact (Haskell *et al.*, 2014; Adedibu and Musa, 2017) have a higher average daily gain in terms of meat quality and quantity (Voisinet *et al.,*1997; Dorgan and Demirci, 2012), and higher milk yield because more number of cows can be milked within the shortest possible time and with minimal labour (Lee and Choudhary, 2006) which invariably influence the farmer's profit (Schick, 2009; Gray *et al.*, 2012).

1.1 Statement of Problem

Numerous subjective and objective techniques of assessing cattle workability (temperament and milkability) traits have been developed. Yet the extents to which workability traits are quantified by these techniques are not certain (Jones, 2013) in many breeds of dairy cattle from review in literatures. The uncertainty of data often used for evaluation of functional traits due to inconsistency, inaccuracy, and high cost associated with collection and collation has made functional traits difficult to analyse and be justified economically (Boettcher, 2010). However human- cattle contact cannot be avoided (Adedibu and Musa, 2017). Thus far cattle with poor workability traits would often time negatively influence their response to husbandry and handlings.

1.2 Justification of the Study

The key goals of reducing the cost associated with animal handling and increase economic efficiency in dairy production are necessary to make livestock production sustainable. These can be achieved by increasing the animal wellbeing. In view of these the significance of this study would reveal the impact of temperament and milkability traits on animal welfare, animal handler's safety and production attributes to animal scientist, veterinary workers and dairy farmers and recommend areas for further research on workability traits.

1.3 Objective of the Study

The broad objective of this study was to explore the phenotypic relationships and dependencies among workability traits (temperament and milkability) that significantly affects the function of Bunaji cows reared under extensive system of management. The specific objectives were to:

1. Test the knowledge and perception of handlers to temperament trait in Bunaji cattle;
2. Evaluate the effect of milkability traits on milk yield, udder and body linear measurements;
3. Evaluate the effect of temperament on exit speed, milk yield, milkability, udder and body linear traits;

4. Determine the relationship of milkability traits with milk yield, milking duration and udder characteristics;
5. Determine the relationship between temperament traits with milkability, milk yield, milking duration, udder and body linear measurements.

1.4 Hypotheses

H_0: Cattle handlers do not differ significantly in the test of knowledge and perception to temperament traits of Bunaji cattle;

H_a: Cattle handlers differ significantly in the test of knowledge and perception to temperament traits of Bunaji cattle;

H_0: Milkability has no significant effect on milk yield, udder and body linear traits of the Bunaji cows;

H_a: Milkability has significant effect on milk yield, udder and body linear traits of the Bunaji cows;

H_0: Temperament has no significant effect on exit speed, milk yield, milkability, udder and body linear traits of the Bunaji cows;

H_a: Temperament has significant effect on exit speed, milk yield and milkability, udder and body linear traits of the Bunaji cows;

H_0: The relationship between milkability with milk yield, milking duration and udder traits of the Bunaji cows is not significant;

H_a: Milkability has significant relationship with milk yield, milking duration and udder traits of the Bunaji cows;

H_0: Temperament has no significant relationship with milkability, milk yield and duration, udder and body linear traits of the Bunaji cows;

Ha: Temperament has significant relationship with milkability, milk yield and duration, udder and body linear traits of the Bunaji cows.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Functional Traits

The term "functional" traits generally refer to those traits that increase biological and economic efficiencies through reduced cost of production; these include measures of reproductive performance, health and disease resistance, feed consumption, and longevity, adaptation to local breeding conditions, milkability and temperament among many others (Groen *et al.*,1997; Boettcher, 2010). The term "functional" traits have been coined to refer to the phenotypic characteristics that affect or indicate a cow's well-being (Boettcher, 2010). For years, functional traits were not included in selection indexes because genetic improvement of dairy cattle was based almost exclusively on increased production per cow (Boettcher, 2010). This was because, milk sales were the primary source of income for most dairy producers; the infrastructure for recording of milk production was available and programs for data collection and storage were active, and; genetic improvement is maximized when only a single trait is considered, so selection for functional traits would have decreased the responses obtained for yield traits (Boettcher, 2010).

2.1.1 Importance of functional traits

Reduced labour: Functional traits generally have been reported to have their impacts on the costs of production, rather than on income (Boettcher, 2010). This can be proven when minimal labour is applied to increase production per cow with a corresponding increase in production per farm. For example, when a reduced number of personnel produced milk that can sufficiently satisfy a good number of people; when computer applications are used by fewer personnel to manage data of financial information, costs of veterinary intervention and reproduction as well as feeding of large scale dairy cattle production to retain superior animal; in addition, as cattle have become more like machines, docility in cows are important for training of the animal because aggressiveness can directly disrupt the routine procedures of daily management of the rest of the herd (Boettcher, 2010). More so, as aggressiveness in cattle has been found to cause kicking, roaming, jumping of fences or violent struggle during handling as well posing safety threat, there is an increase in the costs of production associated with treatment, labor and drugs, (Boettcher, 2010; Grandin, 2018). Cattle that however remain calm during handling are known to have higher average daily gains in terms of milk than cattle that become agitated during restrain (Grandin, 2018).

Increased performance: Many health and reproductive traits have negative genetic correlations with production (Pryce *et al.*, 1997). Experiments with lines of cattle selected for increased production have proven that genetically superior cattle for production require more health care and higher treatment costs (Dunklee *et al.*, 1994; Jones *et al.*, 1994). The great accomplishment in genetic improvement for milk yield has been attained at the cost of lessened fertility, disease resistance and general functionality (Pryce and Veerkamp, 2001). The use of artificial insemination and embryo transfer technologies to increase family sizes had led to genetic gains in milk yield through identification of few superior animals (Weigel, 2001). This on the contrary has also led to a great reduction in the effective population size of most dairy breeds (Weigel, 2001) through the increased chances of inbreeding depression (Kearney *et al.*, 2004) with its consequential effect on production, growth, health and fertility (Weigel, 2001).

2.1.2 Obstacles to selection for functional traits

The difficulties associated with breeding for improvement of functional traits may be the reason why functional traits have low deserved attention over the years. Some of these reasons were associated heritability, data recording and statistical analysis and issues of discontinuous data.

Low heritability: Lower heritability of functional traits when compared to the production traits (Table 2.1) and because the precision of selection is dependent on heritability which poses a difficulty as the genetic gains of numerous functional traits of cows might be difficult to determine (Boettcher, 2010; Buch, 2011). A relatively high precision of selection for a functional trait that has a low heritability could be obtained if the records on progeny are obtainable (Buch, 2011). Furthermore, low heritability is an indication that influences other than genetics play the major role in the phenotypic variability in a trait (Moore and Shenk, 2016), so intervention through changes in the environment with management was considered the most logical approach to obtain improvement (Boettcher, 2010).

Insufficient data and difficulty in data recording and statistical analysis: Over the years, selection for improved milk production was possible because recording programs were already proven to collect the required data (Boettcher, 2010). In most countries few data is routinely collected on health and other functional traits. Data collection and collation for genetic evaluation of functional traits specifically, is expensive and often difficult to justify economically and to analyze statistically which might have been the reason why only few data on functional traits such as health is often collected (Boettcher, 2010). Slow or poor improvement in the functional traits could be due to large economic values on the milk production traits and negative genetic correlations between the milk productions traits and the functional traits even if the economic values are determined correctly (Buch *et al.,* 2009). For example, mastitis is the most economically important disease in dairy production, and genetic evaluation based on its incidence could be of great value in a selection program, especially when the negative genetic relationship with production (Boettcher, 2010) is considered.

Problems Associated with Discontinuous Data: An advantage of production traits over many functional traits is that the data for yield are continuous and tend to be normally distributed (Boettcher, 2010). The negative genetic trend in the functional traits may occur if the sires of the selected cows are bulls without estimated breeding values (EBV) for the functional traits, for example, foreign bulls (Buch *et al.*, 2009).

Duration of milk production per cow can take just about any values between 5000 and 25,000 kg, with most of the data centered on a population average (Boettcher, 2010). Data such as these are easy to analyze statistically with a standard linear model (Boettcher, 2010). Most of the statistical procedures commonly used for genetic evaluation assume that the dependent variables (or at least the residual effect) are normally distributed (Boettcher, 2010). Furthermore, the genetic model generally believed to be correct is an infinitesimal model, which assumes that the genetic effect contributing to an animal's phenotype is the sum of the effects of many genes. This leads to a continuous and normally distributed genetic effect (Boettcher, 2010).

2.2 Cattle Handling

Cattle handling involves any activities where workers control cattle such as working with cattle in paddocks, laneways, yards, transportation, feedlots, abattoirs, sale-yards and activities relating to on-farm cattle sales (Safe Work Australia, 2016). A correct handling, minimises injuries to both the cattle and the handler (Grandin, 1999), reduces product quality loss and lessen stress on animals by enhancing quality food production and good animal welfare (Raussi, 2003).

Table 2.1: Heritability estimates of production, functional, and indicator traits

Trait type	Trait	Heritability
Production	Milk yield	0.17 - 0.45
	Fat yield	0.25 - 0.47
	Protein yield	0.20 - 0.34
	Fat %	0.31 - 0.41
Functional	Calving interval	0.02 - 0.16
	Number of services	0.02
	Mastitis incidence	0.03 - 0.15
	Cystic ovaries	0.02
	Retained placenta	0.01 - 0.02
	Ketosis	0.08
	Milk fever	0.04 - 0.09
	Longevity	0.04- 0.10
Indicator	Body condition	0.10 - 0.58
	Change in body condition	0.07- 0.10
	Somatic cell count	0.14 - 0.20
	Udder depth	0.18 - 0.33
	Teat length	0.21 - 0.33
	Foot angle	0.09- 0.15
	Lactation persistency	0.18

Source: Boettcher (2010).

The basic components of cattle handling are interdependent; these include the handler, the cattle and the facilities. An understanding of these dependencies is essential for subsequent improvement in cattle handling. Research and practical observations have identified factors pertinent to each element (Handling cattle-NSW, n. d).

2.2.1 Handler

Desirable attributes for handlers are a positive attitude to stock; understanding of animal behaviour; the ability to recognize and interpret animal actions; and the allowing of sufficient time for operations (Handling cattle-NSW, n. d). Handler's knowledge of cattle behaviour, in regard to ability to predict an animal's response can reduce stress with lower possibility of injury to animals or people (Grandin, 1999).

To avoid injuries to either the handler or the cattle, resulting from crowding, crushing, kicking, or head booting and running over the handler in response to stimuli would require an understanding of the flight zone of the cattle (Devoe and Dvorak, 2010). The flight zone is the animal's safety zone, and its size varies depending on the animal's degree of wildness or tameness (Grandin, 1999). The cattle flight zone (Grandin 1998) varies from a few feet to 100 yards and are determined by three interacting factors: genetic traits (excitable versus calm); amount of contact with people (on daily or yearly basis); and the quality of the contact with people (negative versus positive).

2.2.2 Livestock

Cattle, because of their size, strength, speed and potential for aggression, need to be handled thoughtfully and with confidence. Livestock differ in their ease of handling due to factors which include previous experiences, breed characteristics, sex and physiological state (Handling cattle-

NSW, n. d). Social behaviour is influenced by age, breed, and sex; for example *Bos indicus* and *Bos indicus*-cross animals are more sensitive or reactive than British or European breeds (Handling cattle- NSW, n. d). Young bulls, when moved in groups, show a degree of playfulness (pushing and shoving), but bulls become more aggressive and territorial with age due to their requirement for more space of about 6 meters on gateways or in yards (Handling cattle-NSW, n. d; Laffan, 2015). Cows with young calves can be very protective, so handling them in the presence of their mothers can be dangerous (Handling cattle- NSW, n. d). Cattle, especially *Bos indicus* breeds, do not like being singled out either in the paddock or in yards and so, they become extremely agitated and aroused. Bulls are uncontrollable when fighting; they become highly aroused and will break away suddenly so handlers have to be extremely careful to avoid injury (Laffan, 2015).

To forestall injuries, an optimum herd size for an area and for a population has to be estimated after many variables are considered (Akpa *et al.,* 2012). A theoretical concept of optimum herd size takes account of the prevailing environmental conditions, biological capacity (performance) of the species, herd management practice, and resource use and distribution (Iro, 2009). For the pastoralist of Northern Nigeria, none of these factors are static; therefore, optimum herd size is dynamic, varying by a wide margin, depending on the circumstance of the individual handler. Iro (1994) reported Fulani cattle herd size to be 80 - 100. In a related study, Adisa and Badmos (2009) reported an average cattle herd size of 41, while majority of herdsmen (46.4%) herded 41 - 60 cattle. A survey of pastoralist households by Akpa *et al*. (2012) in Zaria and environs revealed that, the pastoralist herd size ranged from 16 to 69 cattle per herd. Okoli *et al.* (2012) also reported that, majority of Fulani pastoralist (63.60%) maintained herd size of 41 to 70 heads in the humid rain forest of Imo State, Nigeria.

2.2.3 Facilities and handling aids

The basic element of design is to allow for good flow of stock as poorly designed or maintained facilities can lead to confusion and stress on cattle. For instance a higher incidence of stress and injury to both stock and handlers is associated with poorly constructed facility (Handling cattle-NSW, n. d). The Ohio Beef quality assurance project (n. d) had advised that though correctly design facilities are suitable in cattle handling yet, suitable handling equipment is secondary in importance to the handler's experience in terms of safety handling. In 2007, Health and Safety Executive (HSE) found that the equipment routinely used to restrain cattle include the crush, race, gates, hurdles, halters, sticks and ropes.

Canes, sticks and electric prodder: The use of drafting canes and sticks can extend the distance of control over cattle as it effectively increases the length of the stock handler's arm. Holding a cane in front of a beast's head will cause it to either stop or turn (Laffan, 2015). Hitting or pushing an animal moving in the right direction though, is unnecessary and ineffective and dangerous as this can cause cattle to kick. Electric prodders, however, are a useful aid if used correctly; for instance, a prodder should not be used on an animal which has nowhere to go or is already moving in the right direction, such as animals at the back of a mob (Handling cattle-NSW, n. d). Moreso, willful acts of abuse include, but are not limited to: dragging a conscious, non-ambulatory animal; intentionally applying prods to sensitive parts of the animal such as the eyes, ears, nose, anus, or testicles,; deliberate slamming of gates on livestock, ; malicious driving of ambulatory livestock on top of one another either manually or with direct contact with motorized equipment (This excludes loading a non-ambulatory animal for transport),; hitting or beating an animal, or; live animals frozen to the floor or sides of the trailer (Grandin, 2014).

Crush race and bails: When cattle is separated from the group, the flight zone is limited that the animal can hardly escape especially when an individual is in the race or crush, thus, makes the animal stressed and upset, as its flight zone is attacked (Handling cattle-NSW, n. d). Under these situations, there is a greater chance of injury to both the cattle and the handler, because, the animal is likely to make sudden movements, for example, when placing an anti-backing bar behind the beast or handling the animal through the rails an injury to the handler is possibile; when working around a cattle restrained in a head bail, the animals can still move backwards and forwards very quickly (Handling cattle-NSW, n. d). It is therefore important that bail, hooks and locks are effective, to minimise injury to the handlers and prevent premature escape of the cattle.

Cattle yards: Safe cattle handling guide (2017) recommended cattle yards to be designed with the intention of gradual scaling down the size of individual yards toward the working area/crush due to certain behaviours that characterised the cattle in a confinement. These include; running to a point of escape (often an entrance gate); circling the handler in yards and running most consistently on the curve; following each other; showing strong resistance to cross strong shadow stripes as well as to walk from a bright, sunlit area of the yard into a dark area such as a shed. This kind of recommended design can reduce injuries to both the handler and the cattle.

2.3 Milking Dairy Cows

Milking process involves close interaction between man, animal and technology and is one of the most important tasks in the daily dairy farming routine (Schick, 2009). The increase in the use of automation has made milking easier and faster, however, hand-milking with its tedious forms of physical workload is recommended as the most comfortable and best method of milking since it does not cause damage to the teats and the cow will remain comfortable if milking is done correctly (Meagher *et al.*, 2019).

2.3.1 Hand milking

Hand milking is the traditional technique employed to coax cows to surrender a part of their milk produced for human consumption through the use of calf to stimulate milk let-down (Harris, 2017). Hand milking techniques perfected over centuries still work today. Although the techniques might not be suitable for cows in large dairy farms, it still allows one to check for mastitis before the milking process begins (Harris, 2017).

2.3.2 Automated or robotic milking

Automated or robotic milking is the system adopted by commercial dairy producers where the use of fancy milking machines are employed (Harris, 2017). The increased desire for social life and more freedom has led many farms to take advantage of the new technology (Mathijs, 2004). The popularity of this technology had given rise to adoption of more than 8000 farms in 25 different countries from inception in 1992 by the year 2008 (Ellen, 2013).

The most common reason for the adoption of automatic milking system (AMS) was associated to lower labour requirements as farmer do not have to rely so much on employees to have a high turnover rate of milk yield (Ellen, 2013). De Koning (2011) reported that a single stall robot system can milk 55-65 cows per day, resulting in 5-10% increase in milk yield through increased in milking frequency. Although there are benefits in the adoption of automatic milking system (AMS), De Koning, (2011) reported that milk quality can be reduced in some cases, welfare and health can be compromised due to more sporadic observation of cows and implement into a pasture-based system is difficult and can cause issues with cow traffic in the barn.

2.4 Workability Traits

Workability could be best described as the suitability of an animal to carry out a purpose on the farm (Ellen, 2013). The functional traits that facilitate working with cows on the farm are categorized as workability traits (GIFT, 1999); the most important ones are milkability (milking speed) and temperament (or disposition) because they have economic effects on the production system (Schutz and Pajor, 2001; Groen, 2004).

Workability traits have gained much attention on dairy production due to introduction of new technologies that increased the production per cow with minimal cost of production (Boettcher, 2010). For example, in the dairy industry workability traits such as milk yield per minute of box time, milking interval and habituation of heifers (Vosman *et al.,* 2014) are becoming more relevant due to automatic or robotic milking systems (Chesnais *et al.*, 2016).

2.4.1 Milkability

Milkability has been defined as the aptitude of a cow to let-down milk from the udder and to be fully milked (Lee and Choudhary, 2006). Milkability is a functional trait (Gray *et al.*, 2012) that could affects involuntary culling as superior cattle with major milk protein genes that serves as markers for both milk yield and composition are retained in the breeding flock (Sammy *et al.*, 2018). From economic angle, milkability has been a trait of great interest in the dairy cattle breeding programmes because of problems due to economic loss (Schick, 2009; Gray *et al.*, 2012) such as increased labor (Lee and Choudhary, 2006); and increased risk of mastitis (Querengasser *et al*., 2002) resulting from milk flow disorder.

Milkability has been reported to be influenced by several factors (Querengasser *et al*., 2002; Tancin *et al*., 2006; M'hamdi *et al*., 2012; Carlstrom, 2014) irrespective of breed and country.

The factors were further classified as environmental factors with quantifiable effects (milking conditions, lactation stage, herd test day, year and age at calving, season and year of calving) and environmental factors with inestimable effects such as infectious diseases and parasitic infestations (Tshilate, 2017). However, the most prominent factors identified were herd-year season and calving, parity and milk yield (Tshilate, 2017).

Herd- year and season of calving (HYS): this has been proven as a non-genetic factor that have a significant effect on variation of milkability among parity and milk yield from several studies (Guler, *et al.,* 2009; El-Awady and Oudah, 2011; Povinelli *et al.,* 2003). It has been reported to account for about 48.34% and 78.33% the variation in average milking flow and milking time respectively (Tshilate, 2017). Some researchers fitted HYS as a fixed effect in their models for genetic analysis of the milkability traits (Gade *et al.,* 2006; Tshilate, 2017). The herd management practices that have been proven to affect milkability include feeding schedule, pre-stimulation time, and milking machine function (Zucali *et al.,* 2009; Jones, 2009; Salamon *et al.*, 2011). For example, milk flow rates has been estimated to be higher in cows that calved in autumn and winter than in those that calved in summer and spring (M'hamdi *et al*., 2012). This probably may be due to season effects on milk yield (Tshilate, 2017). Also, cows that calve in summer may have low milk flow due to high environmental temperatures in the first three to four months of lactation (Guler *et al*., 2009; Cho *et al*., 2004).

Milk yield**:** Carlstrom *et al*. (2009) reported a significantly high correlation between milk yield and milk flow as high milk yield was observed from cows with the corresponding high milk flow rate using automated milking systems (AMS) data. This could have been due to high contribution of milk yield to variation in maximum milk flow and milking time among HYS and parity (Tshilate, 2017).

Parity**:** The findings of Tshilate (2017) showed that parity had the lowest contribution to variation in milkability traits among other contemporaries (HYS and milk yield). Researchers (Naumann and Fahr, 2000; Aydin *et al.*, 2008; Strapark *et al*., 2011) had observed a negative correlation between parity and average milk flow. However, Strapak *et al.* (2011) and M'hamdi *et al*. (2012) reported highest milk flow rates in lactating dairy cows to be associated with adaptability to the milking machines.

Milking conditions**:** Milking routines that is consistent from one milking to the next and from one milker to the next (Jones, 2009) is important to maximize milk flow-rate especially when calm cows are milked (Jones, 2009). An ample time can be saved when a proper handling of the cow and a careful udder preparation is been maintain (Tshilate, 2017). Higher milk yield per milking, peak milk flow rate, followed by a reduction of total time of milking and of incline phase, and lesser bimodality can be obtain under a better udder preparation (Salamon *et al.* 2011). Pre-stimulation of cows before the start of milking can ensure fast and complete milk removal and maintenance of proper udder health (Tshilate, 2017). Heifers calving for the first time are usually stressed up when in close contact with humans especially during milking (Zucali *et al.*, 2009).

Factors with inestimable effects**:** Animals can usually live with some parasites such as (lice, ticks, mange mites, flies, roundworms, hookworms, lungworms, eyeworms, tapeworms, flukes, coccidia) without any clear signs of disease (Husbandry Unit 10.6, 2019). However, the presence of these parasites decreases production (weight gain, milk yield, calvings) which means economic losses for the farmers (Husbandry Unit 10.6, 2019).

***Genetic factors affecting milkability*:** Carlstrom (2014) observed the trend from several studies irrespective of breed or country that milkability is genetically associated with milk yield, udder capacity, resistance from the teat canal and hormonal let-down reflex. Carlstrom (2014) also observed that there was high heritability and highly significant relative genetic variation among milkability (flow rate and milking time) in dairy cattle. This means that milkability between cows within herds differs significantly, and a larger proportion of these differences are genetically determined. Genetic relationship between milking speed with milk yield and udder measurements has been estimated in some breeds of dairy cattle such as Brown Swiss (Wiggans *et al.,* 2007); Canadian Holstein (Sewalem *et al*., 2011); Italian Brown swiss (Santus and Bagato, 1998; Juozaitiene *et al.,* 2006); and Croatian Holstein (Spehar *et al.,* 2017).

Milkability has been estimated to be positively correlated with udder depth (Sewalem *et al.,* 2011); rear udder width and rear udder height (Wiggans *et al.,* 2007) and udder depth and positively correlated with milk yield (Juozaitiene *et al.,* 2006). Similarly, significant correlations were estimated between milkability and udder measurements (udder depth, rear udder width, and rear udder height) in Croatian Holstein (Spehar *et al*., 2017). Lee and Choudhary (2006) reported significant correlation between milkability with milk production traits in Italian Brown Swiss and its genetic correlation of 0.30 was reported by Samoré *et al.,* (2010).

2.4.2 Cattle Temperament

The word temperament has been used to define the fear-related behavioral responses of cattle when exposed to human handling (Fordyce *et al.,* 1988). It is a trait that is closely related to the productivity of animals (Neja *et al.,* 2015). For instance, in the beef cattle industry the selection of cattle for temperament by producers was primarily for safety reasons however, implications associated with productivity and profitability have been proven (Cooke *et al.,* 2011).

An understanding of bovine behaviour is needed to create optimum living conditions for dairy cattle (Neja, *et al*., 2015). This is because one of the factors affecting milk production is the behaviour of dairy cows, otherwise known as the temperament. Temperament has been described as the response of an individual over time which differs to a stressor or an environmental challenge such as a perceived threat, presence of a conspecific, human, novel sound, smell, and unfamiliar objects (Grignard *et al.,* 2001). The response of this animal must be consistent over circumstance to define the factor influencing the trait (Turner *et al.,* 2011) both behaviourally and physiologically (Sutherland *et al.,* 2012; Louise and Hanne, 2015). This behavioural and physiological response of animals is of interest to animal scientists, veterinarians, livestock producers, as well as the general public (Réale, *et al*., 2007). The importance of which in the human population, varies depending on the animal species, as it influences research in this area (Jones, 2013).

The physiological response of cattle to stressors is one of the body's principal control mechanisms for environmental disturbance, which is comprised of the sympathetic-adrenal-medullary (SAM) and hypothalamic pituitary-adrenal (HPA) axis (Hemsworth *et al*. 2011). The HPA is prompted in these situations to releases corticosteroid hormones, cortisol and corticosterone, as a result of a series of physiological events to which the animal is subjected to (Hemsworth *et al*. 2011). Behaviorally, the cattle response to stressors or handling manifests itself in a variety of ways like struggling, agitated movements, attempt to escape, vocalize, show increased respiration rates, defecate, show changes in their ear, head and tail positions and facial expressions and are more or less motivated to move away from the handling area or handler (Haskell, *et al.,* 2014). Accordingly, during milking, the cow may also step, kicks or flinches with its hind legs in response to the stressors (Haskell, *et al.,* 2014). Cattle response to handling like shyness to boldness, exploration, avoidance, activity, sociability, aggressiveness and emotionality such as fearfulness constitute an important aspect of behavioural genetics (Boissy and Bouissou, 1995; Réale *et al*., 2007 and Friedrich *et al*., 2015).

Cattle temperament has been found to be influenced by several factors such as production system, breed type, sex, age, and horn status, season, body weight and body condition (Fordyce *et al*., 1988; Abubakar *et al.,* 1991; Voisinet *et al.,* 1997). Cooke *et al.* (2011) found that the most prominent characteristics that affect cattle temperament are production system and breed type among its contemporaries (sex, age, and horn status) as blood cortisol concentrations was greater in temperamental cattle compared to calm cattle. The findings of Abubakar *et al.* (1991) on the influence of breed, sex, season, age, body weight and body condition on temperament in progeny from purebred (Zebu) and crossbred (Friesian-Zebu crossbred) dairy cows showed that all the variables with the exception of age, had significant effects on temperament.

Low blood cortisol concentrations are more associated with calm cattle; however, *Bos indicus* genes have more excitable temperament than *B. taurus* cattle (Fordyce *et al*., 1988; Voisinet *et al.,* 1997; Abuabakar *et al.,* 1991). Also, cattle that are frequently exposed to human contact have low behavioral reactivity (Fordyce *et al.,* 1985). For example, cattle nurtured on extensive production systems, particularly if they have *Bos indicus* genes, are potentially difficult to control and handle, which can pose significant management, economic, and productivity problems (Cooke *et al.,* 2011). On the bases of sex, male animals that have higher temperament were animals with better body condition (Abubakar *et al.,* 1991). Similarly, seasonal variation also had effect on temperament as this trait was observed to be lowest in the hot, dry season (Abubakar *et al.,* 1991).

Abubakar *et al.,* (1991) reported a positive and significant phenotypic correlations between breed, sex, season variation, age, body weight, body condition and temperament while strength of movement having the highest correlation with the overall temperament score. Live weight was negatively correlated with temperament, while there was a positive correlation between temperament and body condition (Abubakar *et al.,* 1991).

2.4.3 Techniques for assessing workability (milkability and temperament) traits

Numerous subjective and objective techniques of assessing cattle workability (temperament and milkability) traits have been developed. Yet the extent to which workability traits is quantified by these techniques is not certain in many breeds of dairy cattle (Jones, 2013). The techniques employed to determine each component of workability traits are described as follows:

1. *Techniques for assessing milkability traits*

The data for milkability traits could be obtained using both subjective and objective techniques (Meyer and Burrnside, 1987; Gray *et al.,* 2011). Traditionally, evaluations for milkability have been based on subjective observations, where the farmers or herdsmen have scored the animals once on a scale from slow to fast milking (Jakobsen, 2006). In the early 1990s the linear classification system was introduced and since then milkability records reflect the herdsmen's assessment of the milking speed on a scale from 1 - 9. Most other countries with recording of milkability have traditionally also used some kind of subjective scoring on different scales, from 1-3 to 1-9 (Jakobsen, 2006).

The subjective techniques mostly employed by researchers (Gray, *et al.,* 2011; Sewalem *et al.,* 2011) were scored on a 5 point scale of 1 - 5 from very slow to very fast as follows:

1: If the cow is very fast milk yielding;

2: If the cow is fast milk yielding;

3: If the milking flow of the cow is moderate;

4: If the cow is slow milk yielding;

5: If the cow is very slow milk yielding.

Objectively, it is measured quantitatively as average flow rate, peak flow rate or milking time (Gray *et al.*, 2011). In the Nordic cattle genetic evaluation (NAV) Sweden and Finland still use subjective scores whereas Denmark use objective measures since 2011 (Carlstrom, 2014). For the correct use and interpretation of milkability traits data, the understanding of factors affecting milkability traits is an important criterion.

2. Techniques for assessing temperament traits

Temperament unlike milkability is difficult to quantify objectively and therefore many different techniques of assessment are used (Jones, 2013). Even though the trait is difficult to evaluate and standardize, and its measurements are mostly subjective, it has been proven to correlate favourably with productive traits such as milk yield and body weight (Kunowska-Slósarz and Slósarz, 2008).

The techniques were established based on different observations of cattle behaviour, and thus it is not clear to what extent they are measuring the same dimensions of temperament (Jones, 2013). However, in choosing a technique for temperament assessment, it is important to consider the equipment, time and experiment necessary to perform the task, the situation and the purpose of assessment, and the circumstance as some methods may be more applicable than others (Jones, 2013; Friedrich *et al.*, 2015). The commonly used temperament assessment techniques are described as follows:

Chute temperament score: Chute temperament assessment (Grandin, 1993) or the "weigh crate" methodology (Ludovic *et al.*, 2016) is a subjective restrained-method used to evaluate behavioural reactivity and fear response to handling in domestic ruminants. The individual behaviour of the restrained animals in a squeeze chute (Friedrich *et al.*, 2015) or manually operated chute (Woiwode *et al.*, 2016) are recorded on a 5-point score for a period about 30 seconds. The scoring criteria are as follows:

1: calm, no movement;

2: calm with occasional movements;

3: moderately movements;

4: abrupt episodic movements; and

5: permanent episodic movements

Source: (Grandin, 1993).

The five point scale of chute temperament score adapted and widely used in the present day by (Grandin, 1993) hypothesis was a modification of the methodology hypothesized and adopted by Fordyce *et al.* (1985) on a 7 point scale. Grandin (1993) investigated the behavioural agitation during handling over time utilized the same definitions for scores 1 - 4 as Fordyce *et al* (1985), and condensed scores 5 - 7 into a single score of 5. Based on temperament scores given, cows could also be classified as either "calm" (scores 1 - 2), "moderate" (score 3), or "nervous" (scores 4 - 5). A modification of this method was further done to suit responses made by animals on a hydraulic squeeze chute on a 4- point score rating as follows:

1: calm no movement;

2: restless, shifting weights;

3: head throwing, squirming and occasionally shaking of the squeeze chute and;

4: violently and continually shaking of the squeeze chute.

Source: (Grandin *et al.*, 1995).

The advantages of temperament assessment using chute temperament scoring method (Jones, 2013) is that it requires only one equipment, the handling chute, and no additional equipment is required; This assessment is fast, and can be used across a large majority of beef farms, as most operations have a squeeze chute for handling. The major disadvantages according to (Jones, 2013) are that the methodology is subjective and could vary between individuals due to assessors differences in observing the animal and interpretation of the scoring criteria, the observer's previous experience can also influence the assessment, and thus consistency and bias among observers is a potential concern; the ultimate concern using a visual scoring system is that it lacks sensitivity, which results in little variation among resulting scores, thus, a large proportion of individuals end up being assigned the same score, although they may be opposite extremes of the same score. To minimises errors the methodology is usually carried out by 2 observers at the distance of 3-3.5 meters laterally to the weighing crate, to detect movements made by cows during a 30-seconds restrain period and a video recording device for reevaluation, in case of a divergent scoring (Friedrich *et al.*, 2015).

Chute exit speed: Flight speed or chute exit speed as a method of assessing temperament (Burrow *et al.* 1988) was developed based on the observation that calm animals exit the weigh scale at a slower speed than the more aggressive ones. Two methods of assessing temperament using the exit speed trait have been employed namely: the subjective and the objective methods (Jones, 2013). Researchers (Lanier and Grandin, 2002; Jones, 2013) described exit speed as a subjective method that classifies the gait movement of the animal on a 4- point scale in relation to temperament. This method as adopted was used in situation where calculated chute exit speed is not easily determined as the animal exit the chute:

1: The animal walked;

2: The animal trot (the animal walked but in a hurry);

3: The animal run; and

4: The animal jumped out of the chute.

The benefit of this method is that it can be used across all farms, even in the absence of equipment, during routine handling. Assigning a chute exit score requires the observer to be trained and paying close attention to animal movement. The assessment is subject to individual interpretation of gait movements and amid result in identification of variations between individuals due to the difficulty to detect true differences (Jones, 2013).

The objective method incorporates a timing system where an animal exit the confined area, triggering the first set of sensors, starting the timer until it has traveled the measured distance usually 1.7m to 2.0m. The speed is calculated by dividing the measured distance in meters by the reported time in seconds. The animal that takes the longest time to cover the assigned distance is considered to be docile in temperament (Burrow *et al.*, 1988). This method was developed as an alternative to flight distance test by (Fordyce *et al.*, 1982) which was believed to be too time-consuming and difficult to perform as a component of routine management procedures. The benefits of using this method are: it is an objective measure, which involves a quantitative value for assessment and linear comparison; it is not subject to individual interpretation or bias; it could also be easily incorporated into routine handling procedures. However, using an electronic timing system to determine chute exit speed requires purchase, set-up and maintenance of the equipment. The technique of assessing the speed at which an animal leaves the handling chute can also be done without the investment in equipment (Jones, 2013).

Movement measuring device: the Movement measuring device (MMD) developed by Stookey *et al.,* 1994) is an electronic device used to calculate the amount of movement made by an animal for a period of 60 seconds when connected to a load cells attached to an electronic weigh scale and displayed on liquid crystal display (LCD). The temperament of the animals in relation to this device is defined based on the number of peaks or movements the animal makes; higher peaks are indication of an agitated response and presumably a more reactive temperament. Similarly, lower peaks are indication of calmer or docile temperament animals. The number of peaks output by the MMD was found to be highly, positively correlated with the amount of movement determined from video analysis of the same animal sample (Stookey *et al*. 1994). Although the equipment has not been commercialized for routine on-farm use and its installation to a weigh scale and maintenance is difficult and capital intensive; the method is an objective quantifiable measure for assessing behavioural response to handling that is not subject to individual interpretation (Jones, 2013).

Pen temperament assessment (PT): The pen temperament methodology (Hammond *et al.*, 1996) is a subjective and a non-restrain method of assessing temperament on a 5-point scoring scale based on the response the cow exhibits. The method was employed in such a way that a small group of cows (4-5) in a pen could be assessed while an assessor tries to approach them (Hammond *et al.*, 1996) The scoring criteria are as follows:

1: Non- aggressive: walk slowly, can approach closely, not excited by humans or novel objects;

2: Slightly aggressive: runs along fences, will stand in corner if humans stay away, may pace fence;

3: Moderately aggressive: runs along fences, head up and will run if humans move closer, stop before hitting gates or humans;

4: Aggressive: runs, stays in back of group (in case in group), head high and very aware of humans, may run into fences and gates even with some distance, will likely run into fences if alone in pens;

5: Very aggressive: excited, runs into fences, runs over humans and anything else in path.

Source: (Hammond, *et al*., 1996).

Like the subjective chute exit temperament assessment methodology, PT technique is fast and does not require any equipment (Jones, 2013). However, the separation of larger herds into smaller groups for assessment is time consuming; potential risk is involved as handlers approach the cattle to carry out the evaluation; PT is subject to individual assessor's interpretation of animal behaviour and the description of each criterion for the scoring system, which impacts inter-observer reliability. The lack of sensitivity of a scoring system test is also of disadvantage because it results in reduced variation between individuals (Jones, 2013).

Facial hair whorls position: The Whorl placement methodology (Grandin *et al*.,1995) as modified by Brouacek *et al*. (2007); and was to investigate the hypothesis that the speed of solving maze tests and locomotors behavior of cattle in open-field tests are affected by the height location of facial whorl. The hair whorl position has been categorized on the basis of location and presence of the hair patterns as, high, middle, low, and none (Schmidek *et al*., 2010). That is, "High" if above the eyes; "middle" if at the eye level; "low" if below the eye level and "none" if absent. Schmidek, *et al.* (2010) evaluated the association between facial hair whorl and temperament in non-castrated male cattle (Bos indicus *Bos taurus* and *Bos indicus* – Angus and

Nelore) in a weighing crate and found out that there was no significant association between facial hair whorl and temperament as the location of facial hair whorls did not prove to be an applicable tool in the identification of temperament in cattle evaluated.

Exposed Eye White Percentage: Research has shown that the sympathetic nervous system (SNS) is involved in the response to stress-related stimuli, whereby the muscle that lifts the upper eyelid is stimulated, resulting in increased visible eye white (Sandem *et al*., 2002). The exposed eye white (EY) or sclera indicates cattle emotions in response to inducing stimuli such as frustration, satisfaction, fear or aggression-related which are modules of temperament (Sandem, *et al*., 2002; 2004; 2006). This could thus be useful in assessing animal welfare and interpreting an animals' response to specific situations such as handling (Sandem *et al*., 2002; 2004). The procedure involves analyzing still images from video shots taken of the animals' heads during handling (Sandem *et al*., 2002). The diameter measurements of the displayed picture on the monitor were recorded using a ruler for the total visible eye (area not covered by eyelids) and the dark iris / pupil (Sandem *et al*., 2002). The total exposed eye white percentage was calculated from these area approximations using the formula for an ellipse by the equation (Sandem *et al*., 2002; Core *et al*., 2009):

$$EY\% = \frac{100(\mathrm{ATE}-AI)}{\mathrm{ATE}}$$

Where: ATE: area of total eye, E Y: Exposed Eye White.

Area of iris: (AI)

To avoid measuring errors associated with the use of ruler placement, a computer software program (Sigma Pro 5.0) which calculates the area of a traced portion of an image in terms of pixels from still computer images is used. This is done by tracing the outer perimeter of the total eye and perimeter of the iris, for possible calculation of the area of the visible eye components (Core *et al*., 2009). The advantages of the EY percentage method of temperament assessment are that it is objective in nature and allows for linear comparison between individual animals' responses to being handled (Jones, 2013). The use of this technique however does require an investment in equipment, experience using the computer software program and a substantial time investment for image selection and analysis (Jones, 2013).

Milking temperament scores: The major problem associated with assessing cows for milking temperament trait is the agnostic behavior of the cow such as kicking (Gergovska *et al*. 2012**;** Ellen, 2013). Kicking from the cow while milking can present problems such as: safety threat to the life of the handler and a higher chance that the cow may not be milked; damage to both the teat cleaning devices and the teat cups; incomplete milking and consequently less milk yield, as well as longer attachment time (Rousing *et al*., 2004). Cows kick off the teat cups for a multitude of reasons, notably being inexperience resulting from first lactation coupled with hormonal imbalance; separation from the calf; heat period; exposure to a new surroundings associated with fear of novel objects; hunger; and the teats could be sore from mastitis and/or of being milked too frequently (The Prairie Homestead, 2014), otherwise, the cow could have a desirable temperament. Like chute exit speed, milking temperament is a restrained method that is assessed subjectively on a five point scale (Gibbons *et al.* 2011; Ellen, 2013; Grandin 2018a**)** as follows:

1: The animal is very calm, never shows restlessness, fully calm and obedient during preparation and milking itself, this is the ideal dairy cow;

2: The animal is calm, stand calm on the bedding (the milking place), does not show any restlessness during preparation and milking, but may move frequently, shift their point of gravity from one side onto the other; sometimes slash with the tail; show slight restlessness;

3: A moderate animal that is calm as a whole, but moves a lot, can sometimes lift a leg during preparation and milking, but without kicking; and often slash with the tail or sometimes look restless;

4: The animal is nervous- looks very restless during preparation and milking; sometimes attempt to kick the milk man, move from one foot to another all the time; startle upon reaching an arm to them;

5: The animal is very nervous – looks very restless during preparation and milking itself lift the leg while attempting to kick the milkman, move from one foot to another, slash with the tail, upon reaching towards them they pull back or react.

Studies by (Ellen, 2013; Grandin 2015) have this method of assessment for dairy cows, for instance, those in Sweden are evaluated for their general temperament on a scale of one (1) through nine (9), one being very nervous or unfavourable and nine being very calm or favourable (Ellen, 2013**)**.

Measurements of cortisol and heart rate: Cortisol and heart rate are often used to measure the activity of the hypothalamic– pituitary–adrenal axis and sympatho-adrenal medullary system as supplementary indicators for the stress response in cattle (Grignard *et al.*, 2001; King *et al.*, 2006; Curley *et al*., 2008; Burdick *et al*., 2010; Café *et al*., 2011a). Higher heart rates and cortisol levels are an indication of more excitable or temperamental cattle. Furthermore, Burdick *et al*., (2010) found a positive correlation between temperament and rectal temperature.

2.2.4 Relationships among cattle workability assessment techniques

Relationship among Temperament traits: Statistically significant, high positive relationships between temperament assessed by different methods would have proven that they are quantifying similar components of temperament; however several researches (Müller and von Keyserlingk 2006; Curley *et al*., 2006; Core *et al.*, 2009; Cafe *et al*., 2011b; Gibbons *et al*., 2011; Sebastian *et al*., 2011; Schwartzkopf-Genswein *et al*., 2012); have opposed the notion. Jones (2013) reported that the combination of different techniques to assess temperament may provide a more complete evaluation for which selection can be accurately based (Jones, 2013). For example, the combination of behaviour records and physiological and endocrinological parameters were used in behavioural studies to determine the accuracy of phenotype of a temperament type (Friedrich *et al.*, 2015).

Chute temperament score was low to moderate positively correlated with chute exit speed and highly positively correlated with exposed eye white area in a study (Core *et al.*, 2009) to explore their relationship on heifers, steers and bulls while in a handling chute. This suggests that a low positive correlation between the assessment techniques measures less closely related aspects of temperament than high to moderate correlation. A low correlation provides evidence that these techniques are not ranking cattle based on temperament in a similar manner (Jones, 2013).

Schwartzkopf-Genswein *et al.*, (2012) assessed the temperament of steers using five techniques repeated twice on consecutive days to investigate the relationship between them while restrained in the chute, and upon release from the chute. Chute flight time and flight distance test were also performed. The results indicated a significant negative correlation between chute flight time and chute exit score, suggesting that cattle which left the handling chute at a faster speed also required less time to cover the measured distance. Also, chute flight time was significantly correlated with chute temperament score assigned while the animal was moved into the chute and during restraint, indicating that higher scores meant a faster chute exit (Schwartzkopf-Genswein *et al.*, 2012). However, in a study conducted on 55 dairy Holstein-Friesian heifers, Gibbons *et al.*

(2011) reported no significant correlation between the median chute temperament score and mean chute exit speed. In addition, the repeatability of the chute temperament score was low and non-significant indicating the temperament results were not consistent over the three (3) assessments conducted over four (4) week period.

Cafe *et al.* (2011b) investigated the relationship between chute temperament score and chute exit speed, measured on 14 separate occasions over the span of eight months for a group of Brahman cattle (82 steers, 82 heifers), and for a group of Angus cattle (25 steers, 25 heifers). Results indicated that a significant, positive relationship between these two measures of temperament assessment for Brahman and Angus cattle. It was also observed that the correlations between the repeated measures of chute exit speed were greater than for repeated assessments of chute temperament score and the strength of correlations for both declined over time (Cafe *et al.* 2011b). They also recommended that due to the decline in the response of cattle to handling over time is an indication that the response to handling stabilised after some familiarisation with the handlers and facility. Similar to previous work (Grandin, 1993; Burrow and Dillon, 1997) suggested that a more accurate assessment of temperament can be obtained from averaging repeated measures using the same technique (Café *et al.,* 2011b).

Sebastian *et al.* (2011) investigated the correlation and repeatability between two objective (chute exit time and movement measuring device) and one subjective (chute temperament score) techniques of temperament assessment on a group of common beef breed steers at a feedlot. Each assessment was performed three times over a period of four months. The result which showed a statistically significant moderate negative and consistent relationship among the objective measures (Chute exit time and MMD) was an indication that these assessment techniques were repeatable and measures similar attributes of temperament over the four months period as cattle that took a longer time leaving the chute were less reactive. Similarly, a negative correlation was observed between chute temperament score and exit time (Sebastian *et al.,* 2011).

Curley *et al.* (2006) examined the relationship and repeatability between two subjective (chute and pen temperament scores) and one objective (chute exit speed) method of temperament assessment conducted on Brahman bulls. The assessment was performed three times on each animal at an interval of sixty days. Results indicated a low to moderate positive correlation between all temperament measures at the first day of data collection first pen temperament score assessments had a low, positive association with subsequent pen temperament scores however; first chute temperament score was not significantly associated with subsequent assessments using this technique. The conclusions of Curley *et al.,* (2006) suggest that chute exit speed is the most appreciated tool for temperament assessment as it is a potential sign of an animals' disposition throughout its lifetime, and may be more useful than subjective techniques as it has a higher level of repeatability (Curley *et al.,* 2006).

2.4.5 Significance of workability traits in dairy cattle production

The importance of studying workability traits as evaluated in different breeds of dairy cattle are many and diverse but tied down to the advent and adoption of new technologies and economic implications (Boettcher, 2010) as earlier cited. It is imperative to note that the subjective scoring of workability traits (temperament and milkability) is due to the perception of the observer and usually based on experimental protocols, but have been proven to be favourably correlated with quantitative records (Schwartzkopf-Genswein *et al.,* 2012) as discussed below:

Milk yield and milking speed: The relationship between fear of humans was reported to be positively correlated with milk flow rates (Sutherland and Dowling, 2014); negatively correlated with milk yield (Breuer *et al*., 2000; Hemsworth *et al*., 2000; Uetake *et al*., 2004) and explained by Breuer *et al*., (2000) to have accounted for 19 percent of the variation in milk yield between farms. The genetic correlation estimates of 0.41 to 0.53 between temperament and milkability (Wethal and Heringstad, 2019) is an indication that a calmer temperament cow is associated with a faster milking speed. More so, lower milk production have been found to be associated with cows that step more during milking in response to novel object, or that respond stronger to social separation have (Louise and Hanne, 2015). Docile cows on exposure to human handling when compared to highly temperamental cows had longer milking duration, higher milk yield, reduced residual milk, increased heart rates, lower incidence of movement and kicking behavior (Rushen *et al*., 1999). On the contrary, Purcell *et al*., (1988); Rousing *et al.,* (2004) reported the relationship between fear of humans and milk yield to be insignificant.

Stress response: It is thought that animals that are not excessively fearful of novel objects or isolation from other animals will cope better with modern intensive or semi-intensive farming systems than more reactive animals (Kilgour *et al*.,2006; Gibbons *et al*., 2009b). Similarly, it has been hypothesised that an animal with high social motivation will integrate and cope better with group housing than poorly sociability animals as they show low aggression, suffer less stress and have less negative impact on other animals (Gibbons *et al.,* 2009a, 2010).

Physiological hormones: The dynamics of the hormone, oxytocin, have been widely analyzed as a possible explanation for the correlation between temperament and milk performance (Friedrich *et al.,* (2015). The variation in the activation of the sympathetic nervous system (SNS) is the causal physiological mechanisms for disturbances in milk letdown by peripheral inhibition of the effects of oxytocin (Van Reenen *et al*., 2002). More so, the fact that the release of oxytocin may be repressed by the central nervous system (CNS) due to increased levels of endorphin and cortisol when cows are milked in a novel environment has been established by Bruckmaier and Blum (1998). A negative effect of the novelty on milk production that confirms lower plasma oxytocin concentrations in unfamiliar milking parlours (Rushen *et al*., 2001) was a contradiction to the findings of Sutherland *et al*., (2012) who reported a higher oxytocin concentrations and a drop in milk yield after milking in novel environments.

Animal handler safety: Cattles, because of their size and strength in relation to humans, handling the animal is associated with a significant degree of danger (Kilgour *et al*., 2006). The choice for more docile animals is thus necessary to improve the safety of animal handlers by reducing injuries (Voisinet *et al*., 1997) as fearful or aggressive animals are more difficult to work with, by wasting the time required for routine tasks (milking), and posing safety threat to both the animal and the handler (Voisinet *et al.*, 1997; Rushen *et al.*, 1999) either by kicking or pining (Jones, 2013).

2.5 The Bunaji Cattle Breed

The common names of the Bunaji breed of cattle are; Akou, White Fulani, Fellata, White Bororo, White Kano and Yakanaji (AGTR, n. d). The breed is characterised by a high degree of diversity (Norezzine *et al.* 2019); the most numerous of the Nigerian cattle breeds; its socio-economic importance with wide distribution in several West African countries (Tawah and Rege, 1996). The breed is currently threatened by persistent interbreeding with other cattle breeds such as the Muturu and Sokoto Gudali. Minimal efforts have been made to ensure that they are characterised and documented despite their invaluable qualities (Hanotte *et al*., 2010). The Bunaji cattle are mainly owned by the nomadic Fulani people who occupy the belt between the Sahara and the Rainforest from the west of the River Senegal to the east of Lake Chad, including parts of western Senegal, southern Mauritania, in and around the flood plains of Niger, Chad, Cameroon and northern Nigeria especially Kaduna State (Ducrotoy, *et al*. 2016; Kubkomawa, 2017).

2.5.1 Physical characteristics

The coat colour of Bunaji cattle is commonly white on a black skin with black ears, eyes, muzzle, hooves, horn tips and tip of tail (AGTR, n. d). Their humps and dewlaps are well developed. The head is long, wide across the forehead and with a straight or concave appearance; average adult wither height is 130 cm; the neck is strong providing an upward carriage for the head; horns are slender, medium to long (81 to 107 cm), lyre shaped: curved outwards and upwards, with an outward turn at the tip (AGTR, n. d). The Bunaji cattle are generally taller and narrower bodied cattle; the rump is of good length but has a marked slope from hook to pin bones. The udder is well-developed, of a good shape and strong attachment. Teats are well positioned and are of medium to reasonably large size (Tawah and Rege 1996).

2.5.2 Peculiarity

The general shallowness of the body and lack of width give the breed a “leggy appearance”. This characteristic of the breed has been described as an adaptation to long distance trekking in the pastoral management (Tawah and Rege 1996). The breed is of interest in that it is more tolerant to heat when compared to the N’Dama and Gudali, more resistant to dermatophilosis than the Muturu and N’Dama breeds, resistant to intestinal helminth parasites, and has low mortality rate. Although it is less resistant to trypanosomosis than the N’Dama, it is more tolerant than the Gudali and other zebu types (Tawah and Rege 1996).

2.5.3 Breed status

The population estimate of the Bunaji cattle in Nigeria, Cameroon and the Central African Republic is about 9,645,000. The Bunaji cattle are the most numerous and widespread of all the Nigerian cattle breeds, representing about 37.2% of the national cattle population; they also represent 33% of the national cattle population in Cameroon (AGTR, n.d)

2.5.4 Utility

The Bunaji cattle are commonly used for milk, meat and draught although the traditional owners keep them mainly for milk (Kugonza *et al*., 2011). Their dairy potential is better than most zebus, and is comparable to the Kenana of the Sudan. Average lactation length is about 220 days. The total lactation milk yield ranges from 627 to 1034 kg (AGTR, n. d.) and 2300kg (Kubkomawa, 2017) hence the yield expressed per unit body weight would give them good milking rank. The mean butter-fat percentages of the cattle range from 4.10 to 7.50 (Tawah and Rege, 1996). Their conformation and body size make them suitable for draught. They are good beef animals which fatten quite well in feedlots and on natural pastures. The average birth weights computed in the different regimes range from 18.2 to 24.2 kg while mature weight of bulls and cows in the improved system of management is 350-665 and 250-380 kg respectively (Tawah and Rege 1996; AGTR, n. d). Feedlot studies indicate that these cattle can achieve growth performance of one kilogram per day (AGTR, n.d). Slaughter and carcass weights of 325 and 166 kg were reported in well-finished steers while the dressing percentage has been reported to be 50-60 (AGTR n. d). The average age at first calving is 40-49 months and average calving interval 403 days (Tawah and Rege 1996; AGTR, n. d).

2.5.5 Growth and live weights

Estimates of live weights from birth to weaning and post weaning suggest substantial variation in the growth of the Bunaji cattle as the report of Olawumi and Salako (2010) estimates the average birth weight for the calves to be 23.82kg with male calves having superior values than females. The mean values were 24.54±0.51 and 23.19+ 0.48kg for males and females, respectively. Kanai *et al.* (2013) reported the mean values of the quantitative traits of the bulls and cows under semi intensive management as follows hearth girth (141 and 151) cm, height at wither (60 and 58) cm, tail length (111 and 107) cm, body weight (201 and 249) kg, and for-head length (17) cm respectively.

2.5.6 Carcass characteristics

A dressing percentage ranging between 53.05±1.44 and 51.03±0.23 for the Bunaji bulls and cows, with the bulls having significantly higher live weight, carcass weight, quantity of beef and hump muscles than cows (Lamidi *et al*., 2004) was reported. On the average, Bunaji bulls gave 119.03±3.22kg of beef when compared to 110.77±7.22kg of boneless beef produced by the cows constituting a total of 65.55±0.51 and 63.8± 1.14% of the carcass weight of the bulls and cows (Lamidi, *et al.*, 2004) respectively. The external offal of the bulls has significantly higher weight (54.15 ± 1.12kg) than the cows (43.38±2.44kg) representing about 17.28 ± 0.23 and 15.28m ± 0.71% of the live weight of the bulls and cows respectively. No significant difference in the total internal offal (liver, kidney, heart, spleen, lungs, trachea, stomach and intestines) of the bulls and cows was found. The internal offal represent about 5.25 ± 0.15 and 6.75 ± 0.34% of the carcass weight of the bulls and cows (Lamidi *et al.*, 2004) respectively.

2.5.7 Milk production characteristics

Estimates of lactation milk yield of the Bunaji cows maintained under various management systems in Nigeria have been reported. Under supplemented feeding, Alphonsus, *et al*. (2011) reported 1322.30kg total milk yield of Bunaji cattle over 325.92 days of lactation in Zaria. Similarly, Aliyu, *et al*. (2018) reported 1288.60 ± 142.11 kg over the lactation length of 208.78 ± 14.99 days in Vom, Jos. Yakubu (2011) reported average milk yield of 1.92 kg on weekly basis over six consecutive month period. Olutogun *et al*. (2006) reported an average of 1600kg in Vom, Jos. Tona *et al*. (2015) reported the range of 2.29kg - 3.28kg average milk yield in Ogbomosho under supplemented feeding. Bala *et al*. (2017) reported the least squares mean of total milk yield, daily milk yield, lactation length, calving interval, gestation length and age at first calving were 676.39±0.45 kg, 3.54±0.02 kg, 191.07±0.27 days, 382.36±0.59 days, 270.85±0.16 days, and 46.20 ± 2.49 months respectively.

An average milk yield of (2.68 ± 0.36) is significantly higher under supplemented feeding when compared to (1.39 ± 0.06) the non-supplemented feeding in Senegal (Sawadogo *et al*., 1999). Milk yield decreases from 2.3kg/day in early dry season (December) to 1.2kg / day in late dry season (May/ June), and decreases in average production of 2.80 kg at calving to 1.8kg at 10 months after calving in Senegal (Sawadogo *et al*., 1999).

Findings on the constituents of Bunaji cattle milk under different management systems have been reported (Adesina, 2012; Tona *et al.*, 2015) as shown on Table 2.2.

Table 2.2: Milk Yield and Composition of Bunaji Cattle Reared Under Different Management System

Milk composition	Semi intensive system of management	Traditional system of management
Average total yield (Kg)	2.29 – 3.28	
Water (%)		87.17 ± 0.30
Fat (%)	3.75- 4.70	3.60 ± 0.11
Protein (%)	3.38 – 3.65	3.68 ± 0.11
Total solids (%)	12.44 – 13.77	
Solids- not -fat (SNF) (%)	8.55 – 9.07	
Lactose (%)	4.42 – 4.62	4.89 ± 0.10
Ash (%)	0.80 – 0.84	0.65 ± 0.06
Calcium (mg/kg)	1000 – 1120	1313 ± 77
Phosphorus (mg/kg)	850.03- 970.02	859 ± 78
Magnesium (mg/kg)	120.04 – 135.67	140 ± 30
Potassium (mg/kg)	1800.52 – 2200.30	1353 ± 131
Sodium (mg/kg)	470.03 – 560.67	441 ± 25
Iron (mg/kg)		0.67 ± 0.09
Zinc (mg/kg)		5.27 ± 1.22
Copper (mg/kg)		0.13 ± 0.04

Semi intensive system of management (Tona *et al.*, 2015); Traditional system of management (Adesina, 2012

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The survey was carried out in three Local Government Areas of Kaduna State namely; The State which comprises of 23 local government areas (Figure 1) occupied an area of 48,473.2Km^2 has an estimated population of 8,252,400 as at March 21, 2016 (Census, 2006). The State shares common borders with Zamfara, Katsina, Niger, Kano, Bauchi, Plateau and Abuja States. The area belongs to the northern Guinea savannah zone based on vegetation classification. The state extends from Tropical grass land (Guinea Savannah) to the Sudan Savannah. The grass land is a vast region covering the southern part of the State about Latitude 11^0 00' North of the equator. Kaduna State is marked by two seasons; the dry windy season and the wet or rainy season. The wet season is usually from April through October with great variations as one move northwards. The prevailing vegetation of tall grasses and big trees are of economic importance during both the rainy and dry seasons. The vast grass land coupled with reduced number of Tse-tse flies' infestation makes the area conducive for cattle production. The position of the State lies between longitude 30^0 East of the Greenwich Meridian and Latitude 9^0 11^0, 30^1 North of the equator. The location of the study areas are: Kajuru (Longitude 9^0 59^{1}N and Latitude 7^0 13^{1}E), Giwa (longitude 11^0 18^{1}N and Latitude 7^0 27^1 0'' E) and Sabon-Gari (longitude 7^0 41^1 49.2''E and latitude 11^0 9^1 50.4" N) respectively.

3.2 Sources of Data Collection

Both primary and secondary data were used in this study. Primary data were obtained through survey method by administering structured questionnaires to handlers with formal education while personal interview method was used to administer questionnaire to handlers without formal education. The secondary data used in the study were cited from relevant literatures.

3.3 Instrument, Techniques and Content Validity of Data Collection

The questionnaires were developed by providing questions that led to answering the research questions in the form of data which when analysed enables the researcher to proffer solution based on the specific objective. Specialist in animal science and agricultural extension professionals assisted to validate or critique the content of the questionnaire and ensure that the questions provided help to solve the research objective one (1). Information were included where necessary.

3.3.1 Procedure for data collection

Enumerators were trained before collecting data on the field to ensure that they were able to collect accurate data for the study. Questionnaires were administered in Giwa, Sabon-gari and Kajuru local government areas of Kaduna State.

3.4 Population, Sampling Procedure and Sample Size

A multi stage sampling technique was employed for this study. In the first stage, Kaduna State (a northern State) was purposively selected for its vital position in cattle production as the larger number of cattle are found in the northern part of Nigeria (AGTR, n. d.; Ducrotoy, *et al*. 2016; Kubkomawa, 2017). In the second stage, Kajuru, Giwa and Sabon-Gari local government areas (L.G.A) were randomly selected (with replacement) from the 23 local government areas that made up the State. In the third stage, four villages were purposively selected from each local government area based on their high involvement in Bunaji cattle handling. In Kajuru, Kamshi-

Iburu, Kasuwan-Magani Kufana and Doka were the villages selected. In Giwa, Shika, Guga, Biye and Tsibiri (Janbaba) were the villages selected; while the villages selected in Sabon-Gari, were Zango, Samaru, Bomo and Mil-goma Tsakiya. The estimated population of 40, 989.006 (3.1%) families were into livestock farming in the State; of which 13.8% (5,656.48) families were into cattle production (Kaduna State Agricultural Structure Survey, 2017). The three L.G.A of the State constituted a total of 12.30% (696) farming families who were into cattle production: Kajuru- 4.00% (227), Giwa- 4.60% (260) and Sabon-Gari- 3.70% (209) respectively.

The total of 101 questionnaires constituting 14.50% of its total cattle handlers were randomly administered to respondents in the 12 villages of the three LGAs of the State as follows: Kajuru (33); minimum of 8, maximum of 9 per village, Giwa (38); minimum of 9, maximum of 10 per village, and Sabon-gari (30); minimum of 7, maximum of 8 per village respectively. The questionnaires were administered to respondents whose primary purpose of handling was for beef and/or milk production, health, research, trading and draught in individual households, village major markets, veterinary clinics, abattoirs and farms. Ninety-six (96) cattle handlers responded.

3.5 Analytical Tools and Techniques

All primary data were obtained from ninety-six (96) retrieved structured questionnaires. The data obtained were coded and analysed using IBM SPSS (2017) statistics (Version 25) predictive analysis software at 5% level of significance. The socio-economic characteristics and test of knowledge of the respondents, and the perception to the animal's temperament were analysed using simple descriptive statistics such as frequency, means and percentage to achieve objective one.

3.6 Experimental site

The empirical study was carried out at Alhaji Adamu Haruna Farms, along Kaduna–Kachia express way, Kamshi- Iburu, Kajuru Local Government Area of Kaduna State (Figure 3.1). The farm is located on Latitude 10.303217 and Longitude 7.831113 *(*Handheld GPS Receiver-GERMIN 78 CSX).

3.7 Experimental Animals and Management practice

Fifty-one (51) multiparous, non-pregnant, lactating Bunaji cows sorted from four different herds of the same farm and geographical location were used in this study. These cows were tagged in their third stage of lactation and certified clinically. The experiment was carried out within a month (May to the beginning of June, 2018), just after the peak of dry season and the onset of rainy season. The experimental cows had access to salt-lick prior to grazing and they had unrestricted access to drinking water. Feeding was via unrestricted grazing under the supervision of the herdsmen for about 8 - 9 hours period daily.

3.8 Data Collection and Traits Definition

3.8.1 Facial hair whorls position

The whorl placement (FW) methodology (Grandin *et al.*, 1995) was to investigate the hypothesis that the speed of solving maze tests and locomotor behavior of cattle in open-field is affected by the height location of facial whorl. The hair whorl position was determined on the basis of three patterns: high, middle and low.

1. High hair whorl position if the center was above the top of eye level;
2. Middle if the center was located in between the top and the bottom of the eyes;

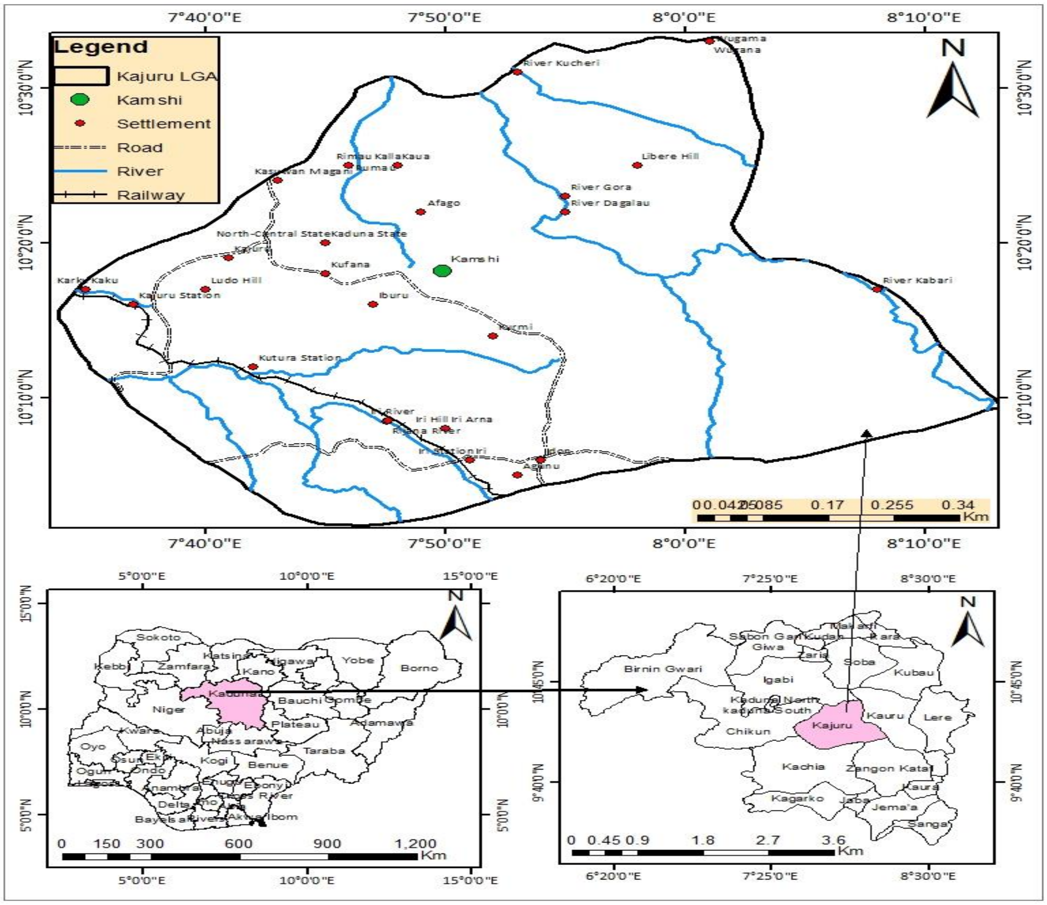

Figure 1: Map of the study locations

3. Low if the center was located below the bottom of the eye level.

3.8.2 Pen temperament

The pen temperament (PT) assessment (Hammond *et al*., 1996) was done in such a way that a small group of cows (4-5) were placed in a pen or to a corner of the pen and assessed while an observer tries to approach them. The scoring scale of 1 to 5 as adopted by Gibbons *et al.*, (2009b); Piovezan *et al.,* (2013) was used to defined the response of the cow as follows:

1: The cow is non- aggressive, if it walk slowly, can be approach closely, is not excited by humans or novel objects;

2: The cow is slightly aggressive, if it runs along fences when being approached or standing in corner if humans stay away, may pace fence;

3: The cow is moderately aggressive, if it runs along fences, head up and will run if humans move closer, stop before hitting gates to avoid humans;

4: The cow is aggressive, runs, stays in back of group (in case in group), head high and very aware of humans, may run into fences and gates even with some distance, will likely run into fences if alone in pens;

5: The cow is very aggressive, if it is excited, runs into fences, runs over humans and anything else in path (Gibbons *et al.*, 2009b).

3.8.3 Chute temperament

The chute (CT) test assessed the strength of response to confinement, whilst the animal was inside the chute (Grandin, 1993). This involves the observer scoring an animal's behavioral response on a five (5) point scale, while the animal is restrained by a head gate in a manually operated chute (Woiwode *et al*. 2016). The scoring criteria are:

1: The cow is calm, no movement;

2: The cow is slightly restless;

3: The cow will be squirming, occasional shaking of chute and / or vocalization;

4: Continuous vigorous movement of chute and vocalization;

5: The cow would be rearing, twisting or violently struggling.

3.8.4 Chute Exit Score (CES) / Chute Exit Speed (FS)

The chute exit speed developed by Burrow *et al*. (1988) was carried out using two methodologies, the subjective and the objective as adopted by (Lanier and Grandin, 2002; Jones, 2013; Adedibu and Musa, 2017). The subjective methodology involved the classification of the gait of the animal as it leaves the chute based on a four point scale:

1: The cow walked;

2: Trot (the cow walked but in a hurry);

3: The cow run;

4: The cow jumped out of the chute.

The objective method which is the flight speed incorporated a digital stop watch to record the time where cow exit the chute until it has traveled the measured distance of 2.0m (Adedibu and Musa, 2017). The speed was calculated by dividing the measured distance in meters by the reported time in seconds (Adedibu and Musa, 2017).

3.8.5 Milkability

The data for milkability traits (Ellen, 2013) measured were milk flow rate, weekly milk yield, and milking duration. The cows were hand-milked in the morning by restraining the calf to the fore-leg of the dam, as well as restraining the hind legs. This was necessary to avoid disruption by the calf, as well as preventing kicks from the dam and in the same vein giving it the impression that the calf is sucking.

Milk yield collected was measured in litres using a plastic calibrated cylinder of 1.00 Litre capacity. The duration of the milking was recorded in seconds with the aid of a digital stop watch. The operation was repeated three more times on weekly basis following the same procedure. Milkability was determined as milking flow-rate (FR) or milking speed (Test day milk yield divided by milking duration) in litres per minute.

$$\mathrm{FR} = \frac{\text{Milk yield (Y)in litres}}{\text{milking duration (D)in minutes}}$$

The subjective method of estimating milkability was also done on a 1 - 5 point scale from very fast milkers to very slow milkers as follows:

1. The animal’s milk flow is very fast or easy;
2. The animal’s milk flow is fast;
3. The animal’s milk flow is moderate;
4. The animal’s milk flow is slow;
5. The animal’s milk flow is very slow.

3.8.6 Milking temperament

The milking temperament scores were assessed on a five point scale (Gibbons *et al.* 2011; Ellen, 2013; Gergovska *et al*. 2012**)** as follows:

1: The cow is very calm if it never shows restlessness, fully calm and obedient during preparation and milking itself, the ideal dairy cow;

2: The cow is calm if it stands calmly on the bedding (the milking place), does not show any restlessness during preparation and milking, but may move frequently, shift their point of gravity from one side onto the other; sometimes slash with the tail; show slight restlessness;

3: The cow is moderately- calm but move a lot, and can sometimes lift a leg during preparation and milking, but without kicking; they often slash with the tail or sometimes look restless;

4: The cow is nervous- they look very restless during preparation and milking; sometimes attempt to kick the milk man, move from one foot to another all the time; startle upon reaching an arm to them;

5: The cow is very nervous if it is very restless during preparation and milking, lifts the leg in attempting to kick the milkman, move from one foot to another and slash with the tail, upon reaching towards them they pull back or react.

3.8.7 Udder conformation traits

The udder traits that were measured in the experiment include: rear udder height (RUH), rear udder width (RUW), Udder hock distance (UD), Central ligament (CL), fore teat placement (FTP), and teat length (TL) measured in centimeters (cm) using flexible tape (IHFA, 2006: in Alphonsus, *et al.*, 2011), as follows:

a. Rear Udder Height (RUH): This is the distance between the bottom of the vulva and the milk secreting tissues, in relation to the height of the animals;
b. Rear Udder Width (RUW): This was determined by measuring the width of the udder from the maximum dimension;

c. Udder Depth or udder- hock distance(UD): This is the distance from the lowest part of the udder floor to the hock or distance between rear attachment;
d. Central ligament: This is a supporting ligament at the base of the dividing halves of the rear udder. It is measured as the depth of cleft at the base of the rear udder;
e. Fore Teat Placement (FTP): This is the position of the front teat from central of quarters
f. Teat length (TL): This is the length of the front teat.

3.8.8 Body linear measurements

All the body linear measurements were recorded in centimeters (cm) except for body weight which was recorded in Kilogram (kg) using a universal weigh band (WEBO animal measure, ref. 240591, manufactured by Kruuse Den, and approved by the Danish Agricultural Association, Denmark). Details of the body linear measurements (Tebug *et al*., 2018) are described as follows:

a. Ear length (EL): Measured from the ear base to the zygomatic arc of the ear;
b. Chest girth (CG): Measured as standing the animal with the head in any normal position and placing a flexible tape around the animal at the point of lowest circumference just behind the fore-legs and the hump
c. Tail length (TL): Measured from the base of the tail to the tip (caudal vertebrae)
d. Body length (BL): Measured as the highest point on the shoulder to the pin bone
e. Height at wither (HW): Measured as the distance from the ground to the highest point of the withers when the animal is standing in an upright position
f. Thigh length (TL): Measured as the length between the hip joint up to the stifled joint
g. Body weight (BW): Measured as the weight equivalent of the chest girth reading on the weighing band.

Plate I: Assessment of Milking Temperament

Plate II: Set up for the determination of milk yield in litres

3.9 Statistical Analysis

The data on temperament, milkability, udder and body linear measurements in the experiment were analyzed using SAS (2000) version (9.0) at 5.0% level of significance. Computation using means procedure was done to determine the means and standard error for each of body linear traits, udder traits, temperament and milkability traits; and coefficients of variation (CV) to determine the variability in the population sample. Significant differences in means were compared using the Duncan Multiple Range Test (Duncan, 1995) to achieve objectives 2 and 3. Computation of Pearson correlation coefficients to determine the degrees of phenotypic relationship among all variables was done to achieve objectives 4 and 5. The estimates of the phenotypic correlation coefficients (r) were done to evaluate the changing magnitude of association among variables according to the formular:

$$\gamma_{A_1A_2} = \frac{\sigma A_1 A_2}{\sqrt{\sigma^2 A_{1.} \sigma^2 A_2}}$$

Where $\sigma A_1 A_2$ is the covariate between traits A_1 and A_2 and $\sigma^2 A_1$ and $\sigma^2 A_2$ are variance for traits A_1 and A_2, respectively.

Further explorations to determine the relationships of the traits were performed using principal components analysis (PCA) was analysed using IBM SPSS (2017) statistics (Version 25) predictive analysis software. Only PCA components (PCs) with Eigen values >1 were considered (Kaiser Meyer Olkin’s rule) and used as new uncorrelated variables. Bartlett's sphericity test was used to determine the degree of interrelations between variables and adequacy for use in the analysis.

3.10 Statistical Model

The workability traits follow the general linear model:

$Y_{ijk} = \mu + T_i + M_j + e_{ijk}$

Where;

Y_{ijk} the individual's phenotypic value for the trait (body weight, milk yield, udder or body linear measurement);

M the overall mean;

T_i the i^{th} effect of the T temperament trait;

M_j the j^{th} effect of the M milkability trait;

$\mathbf{e_{ijk}}$ the residual random error, nid $(0, \sigma^2)$

nid $(0, \sigma^2)$: Normally and independently distributed with zero means and constant variance.

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-Economic Background, Test of Knowledge and Perception of Cattle Handlers to Temperament Trait of Bunaji Cattle

4.1.1 Socio-economic background of Bunaji cattle handlers

Table 4.1 shows the socio-economic characteristics of the respondents in the study areas. The result of the analysis showed that, about 47% (majority) of the respondents were pastoralists, 23% were Animal Scientist and Veterinary doctors, 15% were cattle traders, and 13.5% were village cattle rearers. Fewer (11.50%) females were involved in handling especially in situation were capable men were not available. About 56%, mostly animal scientist, veterinary doctors, cattle traders and village cattle rearers were learned whereas those who have not had the opportunity of obtaining a formal education were mostly herders (39.58%).

Contact experience

Thirty three percent (33%) of the respondents mainly veterinary doctors and herders who worked on research farms and some herders have had contact with Bunaji cattle on a large herd size of above fifty (50), about 30% mostly herders have had contact on a herd size between eleven to fifty (11-50). While 12.5% of the respondents without herd, were mainly animal scientist, veterinary doctors and cattle traders who worked in the abattoirs. About twenty percent (19. 79 %) that have a herd size of less than six were majorly village cattle rearers who purposely rear Bunaji bulls for draught and beef. About 57% of handlers mostly herders have had contact with Bunaji cattle for the period of over ten (10) years for the obvious reason that they grow with the hobby from childhood (as expressed by the respondents).

Twenty eight percent (28%) of the respondents mostly animal scientist, Veterinary doctors and cattle traders have had contact with Bunaji cattle on both permanent handling facilities like chute, weighing crate, crush, forcing pen, dispersal pens, race, and automated milking machine, and on temporary facilities like ropes and cords respectively, about 60% mostly pastoralists and village cattle rearers have had contact only on temporary facilities like ropes and curds. the few traders (4.17%) only make use of such facilities like the chute in abattoirs for ease of handling.

4.1.2 Test of knowledge to temperament trait of Bunaji cattle by handlers

Table 4.2 shows the distribution of respondents based on their knowledge to temperament traits of Bunaji cattle. The perceived temperament of Bunaji cattle varied among their handlers. Majority of the respondents (56.25%) have at one time culled out highly temperamental cattle. Over 51% of the respondents' perceived offspring of the cows seems to exhibits the same character with their parents. It was also observed that most aggressions on the farm are caused by bulls and cows (65%). A high (46.88%) incidence of aggression occurs when the Buanji cattle are to be restrained for routine management operations other than for aggression associated with resource based.

4.1.3 Perception of handlers to temperament traits in Bunaji cattle based on their socio-economic background

The perceived temperament of Bunaji cattle by its handlers is described on Table 4.3. The perceived temperament of *Bunaji* cattle varied among their handlers. The minimum, maximum and overall mean scores of 1, 5 and 3.32 shows that Bunaji cattle were generally perceived to be moderately-reactive by its handlers. The perceptions by majority of handlers below the mean

Table 4.1: Socio- Economic Background of Bunaji Cattle Handlers in the Study Areas

Parameter	Anim. Scientist	Vet. Doctors	Cattle Traders	Pasto-ralist	Village rearers	Total	(%)
Local Government							
Kajuru	0.00	0.00	0.00	29 (30.20)	4 (4.17)	33	34.38
Giwa	6 (6.25)	6 (6.25)	7 (7.29)	9 (9.37)	9 (9.37)	37	38.54
Sabon Gari	7 (7.29)	3 (3.12)	8 (8.33)	8 (8.33)	0.00	26	27.08
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	100.00
Sex							
Male	11(11.45)	8 (8.33)	14 (14.58)	41 (42.70)	11 (11.45)	85	88.58
Female	2 (2.08)	1 (1.04)	1 (1.04)	5 (5.21)	2 (2.08)	11	11.46
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Age (years):							
1 - 10.	0.00	0.00	0.00	3 (3.13)	0.00	3	3.13
11-20.	0.00	0.00	0.00	4 (4.17)	0.00	4	4.17
21-30.	8 (8.33)	9 (9.37)	6 (6.25)	16 (16.67)	5 (5.21)	44	45.83
> 30	5 (5.21)	0.00	9 (9.38)	23 (23.96)	8 (8.33)	45	46.88
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Academic qualification							
Non formal	0.00	0.00	3 (3.13)	38 (39.58)	1 (1.04)	42	43.75
Primary	0.00	0.00	3 (3.13)	4 (4.17)	3 (3.13)	10	10.42
Secondary	0.00	0.00	3 (3.125)	3 (3.125)	6 (6.25)	12	12.50
Tertiary	13(13.54)	9 (9.37)	6 (6.25)	1 (1.04)	3 (3.12)	32	33.33
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96 (100.00)	
Experience (years)							
< 1	1 (1.04)	0.00	1 (1.04)	1 (1.04)	3 (3.13)	6	6.25
1—5.	4 (4.17)	8 (8.33)	2 (2.08)	2 (2.08)	4 (4.17)	20	20.83
6 –10.	5 (5.21)	1(1.04)	4 (4.17)	3 (3.13)	2 (2.08)	15	15.63
➢ 10	3 (3.12)	0.00	8 (8.33)	40 (41.67)	4 (4.17)	55	57.29
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96 (100.00)	
Herd size							
Nil	3 (3.12)	4 (4.17)	4 (4.17)	1 (1.04)	0.00	12	12.50
1—5	1 (1.04)	0.00	5 (5.21)	0.00	13 (13.54)	19	19.79
6—10	1 (1.04)	0.00	1(1.04)	2 (2.08)	0.00	4	4.17
11—50	4 (4.17)	0.00	4 (4.17)	21 (21.88)	0.00	29	30.21
51-100.	0.00	1 (1.04)	1 (1.04)	13 (13.49)	0.00	15	15.63
➢ 100	4 (4.17)	4 (4.17)	0.00	9 (9.38)	0.00	17	17.71
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96 (100.00)	
Handling facilities							
Permanent	1 (1.04)	4 (4.17)	4 (4.17)	0.00	2 (2.08)	11 (11.46)	
Temporary	3 (3.13)	0.00	0.00	42 (43.75)	13 (13.54)	58 (60.42)	
Both	9 (9.38)	5 (5.21)	11 (11.46)	2 (2.08)	0.00	27 (28.13)	
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96 (100.00)	

Values in parenthesis ( ) stands for values in percentages.

Table 4.2: Test of Knowledge to Temperament Traits in Bunaji Cattle

Parameter	Anim. Scientist	Vet. Doctors	Cattle Traders	Pasto-ralist	Crop farmers	Total	(%)
Temperament perception							
Very calm	0.00	0.00	0.00	1 (1.04)	0.00	1	1.04
Calm	1 (1.04)	0.00	2 (2.08)	18 (18.75)	5 (5.21)	26	27.08
Moderate	7 (7.29)	5 (5.20)	6 (6.25)	9 (9.37)	4 (4.17)	31	32.29
Nervous	5 (5.21)	4 (4.17)	2 (2.08)	11 (11.46)	2 (2.08)	24	25.00
Very nervous	0.00	0.00	4 (4.17)	7 (7.29)	2 (2.08)	13	13.54
no response	0.00	0.00	1 (1.04)	0.00	0.00	1	1.04
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13(13.54)	96	(100.00)
Is temperament Heritable?							
Yes	12 (12.50)	9 (9.37)	9 (9.37))	16 (16.67)	3 (3.12)	49	51.04
No	0.00	0.00	2 (2.08)	10 (10.41)	2 (2.08)	14	14.58
don’t know	1 (1.04)	0.00	4 (4.17)	20 (20.84)	8 (8.33)	33	34.38
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Do you cull Bunaji based on temperament?							
Yes	9 (9.38)	4 (4.17)	7 (7.29)	26 (27.08)	8 (8.33)	54	56.25
No	3 (3.13)	5 (5.21)	6 (6.25)	18 (18.75)	2 (2.08)	34	35.42
No response	1 (1.04)	0.00	2 (2.08)	2 (2.08)	3 (3.33)	8	8.33
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Most reactive temperamental class of cattle							
Bulls > Cows > Calves	5 (5.21)	7 (7.29)	9 (9.38)	18 (18.74)	8 (8.33)	47	48.96
Cows > Bulls > Calves	5 (5.21)	1 (1.04)	4 (4.17)	15 (15.62)	0.00	25	26.04
Cows > Calves > Bulls	1 (1.04)	0.00	0.00	3 (3.33)	0.00	4	4.17
Calves > Bulls > Cows	1 (1.04)	1 (1.04)	0.00	8 (8.33)	3 (3.33)	13	13.54
Don't know	1 (1.04)	0.00	2 (2.08)	2 (2.08)	2 (2.08)	7	7.29
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Activity that cause cattle arousal							
Loading/weighing/ear-ta./dr	1 (1.04)	0.00	8 (8.33)	0.00	2 (2.08)	11	11.46
Dehorning/castration./foot tr.	1 (1.04)	2 (2.08)	3 (3.33)	1 (1.04)	4 (4.17)	11	11.46
Pregnancy examination	1 (1.04)	0.00	0.00	0.00	0.00	1	1.04
Parasites control	1 (1.04)	0.00	0.00	34 (35.42)	1 (1.04)	36	37.50
Vaccination/medication/dos	3 (3.33)	2 (2.08)	4 (4.17)	8 (8.33)	6 (6.25)	23	23.96
Udder cleaning/ milking	2 (2.08)	0.00	0.00	3 (3.33)	0.00	5	5.21
All of the above	4 (4.17)	5 (5.21)	0.00	0.00	0.00	9	9.38
Total	13 (13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)
Places of cattle aggression							
On handling facilities	4 (4.17)	5 (5.21)	9 (9.38)	24 (25.00)	3 (3.33)	45	46.88
On the field at grazing	6 (6.25)	3 (3.33)	3 (3.33)	15 (15.63)	2 (2.08)	29	30.21
In pens or yards	3 (3.33)	1 (1.04)	3 (3.33)	7 (7.29)	8 (8.33)	22	22.92
Total	13(13.54)	9 (9.38)	15 (15.63)	46 (47.92)	13 (13.54)	96	(100.00)

Values in parenthesis ( ) stands for values in percentages, tr: trimming, dos: dosing, >: greater than.

were male pastoralists from Kajuru of ages below thirty (30) years who had non- formal education but had more number of years of handling experience on temporary facilities and on large herd size above 50 cattle number; Village cattle rearers from Giwa local Government area who were above 20 years of age and who handle Bunaji cattle for draughts. The perception above the mean were mostly animal scientist, veterinary doctors and cattle traders from Giwa and Sabon- Gari Local government areas who were above 20 years of age, have had privilege of obtaining formal education and whose purpose of handling are health related.

4.2 Descriptive Statistics, of the Traits in the Study Population and the Effect of Milkability on Milk Yield, Udder and Body Linear Traits.

4.2.1 Descriptive statistics of body weight, udder, and body linear measurements of the Bunaji cows

The mean values for the descriptive statistics for body weight, body linear measurements, udder traits and facial hair whorls of the Bunaji cows are presented on Table 4.4.

The mean, minimum and maximum values of the body weight and body linear traits were within normal distribution in the sample population. Among udder traits, majority of the cows had their fore-teat placement and teat lengths above the means; central ligaments below the means; udder depth, rear udder heights and rear udder widths were within normally distribution in the sampled population. The coefficients of variation (CV) ranged from 4.40% (height at wither) to 16.40% (Body weight) for body measurements; 6.89 % (udder depth) to 43.21% (central ligament) for udder traits; and 0% for the facial hair whorls as all the cows had the center of the whorls above the eye level.

Table 4.3: Perception of Handlers to Temperament Traits in Bunaji Cattle (N= 96)

S/No.	Parameter	Perceived temperament score 1	2	3	4	5	Mean	Min.	Max.
1.	**Local Government Area**								
	Kajuru	1	17	9	7	0	2.65	1	4
	Giwa	0	7	12	7	7	3.42	2	5
	Sabon- Gari	0	1	7	12	9	4.00	2	5
	Total	1	25	28	26	16	3.32	1	5
2.	**Category of handlers**								
	Animal Scientists	0	0	7	6	0	3.46	3	4
	Veterinary Doctors	0	0	5	4	0	3.44	3	4
	Cattle Traders	0	2	6	2	5	3.67	2	5
	Pastoralist (herders)	1	18	9	9	9	3.15	1	5
	Village cattle rearers	0	5	1	5	2	3.31	2	5
	Total	1	25	28	26	16	3.32	1	5
3.	**Sex of respondents**								
	Male	1	25	23	23	13	3.26	1	5
	Female	0	0	5	3	3	3.82	3	5
	Total	1	25	28	26	16	3.32	1	5
4.	**Age of respondents (years)**								
	1 - 10.	0	0	3	0	0	3.00	3	3
	11-20.	1	1	2	0	0	2.25	1	3
	21-30.	0	18	13	10	4	3.00	2	5
	30 years and above	0	6	10	16	12	3.77	1	5
	Total	1	25	28	26	16	3.32	1	5
5.	**Educational level**								
	Non-formal	1	17	0	1	6	2.76	1	5
	Primary	0	3	10	9	5	3.59	2	5
	Secondary	0	3	3	5	1	3.33	2	5
	Tertiary	0	2	15	11	4	3.53	2	5
	Total	1	25	28	26	16	3.32	1	5
6.	**Purpose of handling**								
	Beef production	0	2	8	3	4	3.53	2	5
	Milk production	1	18	11	12	6	3.08	1	5
	Farming (draught)	0	5	0	7	3	3.53	2	5
	Meat and milk trading	0	0	0	1	3	4.75	4	5
	Health	0	0	8	3	0	3.27	3	4
	Prestige	0	0	1	0	0	3.00	3	3
	Total	1	25	28	26	16	3.32	1	5

N: number of observation, 1: Very calm (non- reactive), 2: Calm (slight- reactive), 3: Moderately- calm, 4: Reactive (nervous/ aggressive), 5: Very reactive (nervous or aggressive), Min. minimum, Max.: maximum.

Table 4.3: Continued

Parameter	Perceived temperament score					Mean	Min.	Max.
	1	2	3	4	5			
Handling experience (years)								
Less than 1	0	0	2	2	3	4.14	3	5
1—5.	0	2	8	9	0	3.37	2	4
6 –10.	1	2	9	3	0	2.93	1	4
Above 10	0	21	9	12	13	3.31	2	5
Total	1	25	28	26	16	3.32	1	5
Herd size								
None	0	2	2	0	0	2.50	2	3
1—10	0	0	0	1	0	4.00	4	4
11—50	1	6	20	19	15	3.67	1	5
51-100	0	8	1	5	1	2.93	2	5
Over 100	0	9	5	1	0	2.47	2	4
Total	1	25	28	26	16	3.32	1	5
Type of handling facility								
Permanent	0	7	9	2	3	3.05	2	5
Temporary	1	17	11	13	3	3.00	1	5
Both	0	1	8	11	10	4.00	2	5
Total	1	25	28	26	16	3.32	1	5

N: number of observation, 1: Very calm (non- reactive), 2: Calm (slight- reactive), 3: Moderately- calm, 4: Reactive (nervous/ aggressive), 5: Very reactive (nervous or aggressive), Min. minimum, Max.: maximum.

Table 4.4: Descriptive Statistics for the Mean Body Weight, Body Linear measurements, Udder traits and facial hair whorls of the Bunaji Cows (N =51)

Variable	Mean ± SE	Min.	Max.	CV (%)
Body Weight (Kg)	212.05 ± 4.87	145.30	305.00	16.40
Body Linear traits (cm)				
Ear Length	20.87 ± 0.27	16.00	25.00	9.35
Chest Girth	134.12 ± 1.12	117.50	154.25	5.96
Tail Length	107.15 ± 1.27	92.00	127.00	8.43
Body Length	118.59 ± 0.97	104.00	135.00	5.86
Height at Wither	127.50 ± 0.79	114.00	141.00	4.40
Thigh Length	66.61 ± 0.42	59.00	73.00	4.47
Facial hair whorl	1.00	1.00	1.00	0.00
Udder traits (cm)				
Rear Udder Height	18.82 ± 0.33	12.00	24.00	15.82
Rear Udder Width	12.78 ± 0.27	8.00	18.00	15.15
Udder depth	30.66 ± 0.30	26.25	34.40	6.89
Central Ligament	2.36 ± 0.17	1.00	4.00	43.21
Fore Teat Placement	7.741 ± 0.40	2.00	15.00	36.77
Teat Length	4.18 ± 0.15	2.50	8.00	25.86

cm: centimeter, Kg: kilogram, SE: standard error, Max.: maximum, Min.: minimum, and CV: coefficient of variation, %: percentage.

4.2.2 Objective assessment of milkability and temperament of the Bunaji cows

Table 4.5 shows the descriptive statistics for the objective measure of milkability and temperament of the Bunaji cows in the study. Majority of the cows yielded their weekly milk below the mean. The milking duration of most cows was higher than the mean while the milk flow-rates were below the means. The average milk yield was 0.92 ± 0.05 litres per milking and the peak flow-rate was 1.60litres/minute. Similarly the speed with which majority of the cows exit the chute to cover a distance of 2.0 meters was below the mean (1.75 ± 0.17 meters per seconds). The coefficients of variation (CV) ranged from 40.11% to 45.65% for milk yields, 30.60% - 38.35% for milking duration and from 40.19% - 60.70% for milk flow-rates respectively and 69.71% for chute exit speed.

4.2.3 Distribution and means of the subjective techniques of temperament and milkability of the Bunaji cows

Table 4.6 describes the percentage distribution of Bunaji cows based on the subjective assessment of temperament and milkability. The mean, minimum and maximum values of the workability traits shows that the temperament values exhibited by majority of the cows were below the mean for milking temperament (MT), chute temperament (CT) and chute exit score temperament (CES) techniques; normally distributed for pen temperament (PT) technique; and above the mean for milkability trait (AMS) respectively. The coefficients of variation (CV) for these traits ranged from 25.48 % (AMS) to 53.10 % (PT).

4.2.4 Effect of milkability on milk yield, udder and body measurements on the Bunaji cows

Table 4.7 shows the effect of milkability on milk yield, udder and body measurements on the Bunaji cows defined on a linear scale of one (very fast milk yielding cows) to five (very slow

Table 4.5: Descriptive Statistics for the Objective Assessment of Milkability and Temperament of the Bunaji Cows (N =51)

Variable	Mean ± SE	Min.	Max.	CV %
Milk yield (Y) in litres				
First milk yield (Y1)	0.81 ± 0.05	0.28	1.70	40.65
Second milk yield (Y2)	0.88 ± 0.06	0.15	2.10	45.65
Third milking yield (Y3)	0.98 ± 0.06	0.40	2.05	41.30
Fourth milk yield (Y4)	1.02 ± 0.06	0.25	2.10	43.77
Average milk yield (AMY)	0.92 ± 0.05	0.30	1.89	40.11
Milking duration (D) in minutes				
First milking duration (D1)	2.01 ± 0.10	1.01	3.76	34.52
Second milking duration (D2)	2.02 ± 0.10	0.72	3.81	36.23
Third milking duration (D3)	2.32 ± 0.13	1.10	4.77	38.35
Fourth milking duration (D4)	2.31 ± 0.11	1.13	4.65	35.03
Average milking Duration (AMD)	2.16 ± 0.09	1.17	3.80	30.60
Milking Flow rates FR in litres/ minutes				
First flow-rate (FR1)	0.43 ± 0.02	0.13	0.87	40.19
Second flow-rate (FR2)	0.49 ± 0.04	0.15	1.60	60.70
Third flow-rate (FR3)	0.47 ± 0.03	0.19	1.59	52.77
Fourth flow-rate (FR4)	0.46 ± 0.03	0.21	1.46	47.41
Average flow-rate (AFR)	0.45 ± 0.03	0.17	1.30	46.82
Exit speed Temperament (FS)/ $m.sec^{-1}$	1.75 ± 0.17	0.33	5.00	69.71

SE: standard error, Max.: maximum, Min.: minimum, CV: coefficient of variation. % percentage, $m.sec^{-1}$: meters per seconds.

Table 4.6: Summary Statistics for the Distribution of Bunaji Cows based on the Subjective Assessment of Temperament and Milkability (N = 51)

	Scores					**Mean**				**P- vale**
Traits	**1**	**2**	**3**	**4**	**5**	**± SE**	**Min**	**Max**	**CV (%)**	
MT	12 (23.53)	23 (45.10)	10 (19.61)	3 (5.88)	3 (5.88)	2.25 ± 0.15	1	5	47.63	<0.0001
PT	15 (29.41)	9 (17.65)	5 (9.86)	13 (25.49)	9 (17.65)	2.84 ± 0.21	1	5	53.74	<0.0001
CT	12 (25.53)	14 (27.45)	11 (25.17)	5 (9.80)	9 (17.65)	2.71 ± 0.20	1	5	51.89	<0.0001
CES	21 (41.18)	6 (11.76)	14 (27.45)	10 (19.61)	NA	2.25 ± 0.17	1	4	53.10	<0.0001
AMS	2 (3.92)	3 (5.88)	4 (7.84)	21 (23.53)	21 (23.53)	4.10 ± 0.15	1	5	25.48	<0.0001

N: number of observations, SE: standard error, min.: minimum, max.: maximum, CV: coefficient of variation, MT: milking temperament, PT: pen temperament, CT, Chute temperament, CES: chute exit score, AMS: average milkability score, Number in parenthesis: percentage distribution. Temperament score 1: the animal is very calm, and score 4 (for CES) or 5 (for MT, PT, CT): the animal is very reactive. AMS score 1 (the cow milk very fast) and score 5 (the cow milk very slowly), NA: not applicable, <: Less than.

milk yielding cows). The result showed that all the milk yield and udder traits were significantly ($P < 0.05$) affected by milkability; there was an increased in the weekly milk yield among the different milkability groups (MS1, MS2…MS5). Though the different milkability groups had some similarities ($P>0.05$) in their milk yield and udder traits; the very high milkability group (MS1) were distinguished from the very low milkability groups (MS5) by a significantly ($P < 0.05$) higher milk yield, lower udder height, wider width of the rear udder, less pronounced central ligament and longer teat lengths, respectively.

4.3 The Effect of Temperament Traits on Exit speed, Milk Yield, Milkability, Udder and Body Linear Measurements

4.3.1 The effect of milking temperament on milk yield, milkability, udder and body linear traits of the Bunaji cows

Table 4.8 showed the effect of milking temperament score (MT) on an observable scale of one to five (very calm to very nervous). The result showed that: milk yield, milking duration, all udder and body linear traits were significantly ($P < 0.05$) affected by MT except for body lengths. The milk yield of the very calm cows was significantly higher than the calm and moderately calm groups but similar to the yield of nervous and very nervous cows ($P>0.05$). The different milking temperament groups (MT1, MT2 … MT5) had similar characteristic in their milkability and rear udder width. There were similarities in the milking duration, udder and body linear traits between the different temperament groups; but the very nervous groups (MT5) were significantly ($P < 0.05$) different from the very calm groups by their longer duration of milking, more pronounced central ligament and longer ear and tail lengths.

Table 4.7: Effect of Milkability Traits on Milk Yield, Udder and Body Linear Measurements of Bunaji Cows (N=51)

Traits	Milkability Scores (MS)					
	MS1 (n = 2)	**MS2 (n = 3)**	**MS3 (n = 4)**	**MS4 (n = 21)**	**MS5 (n= 21)**	**SEM**
Flow-rates (FR)/ litres per minutes						
Fr1	0.77^{a}	0.73^{a}	0.60^{b}	0.48^{c}	0.28^{d}	0.02
Fr2	1.54^{a}	0.78^{b}	0.73^{b}	0.52^{c}	0.26^{d}	0.04
Fr3	1.32^{a}	0.77^{b}	0.66^{b}	0.47^{c}	0.30^{d}	0.03
Fr4	1.19^{a}	0.72^{b}	0.65^{b}	0.48^{c}	0.31^{d}	0.03
Average total FR (AFR)	1.17^{a}	0.74^{b}	0.65^{c}	0.48^{d}	0.28^{e}	0.03
Milk Yield (Y) in litres						
Y1	1.28^{a}	0.80^{bc}	0.93^{b}	1.00^{b}	0.60^{c}	0.06
Y2	1.80^{a}	0.93^{b}	1.00^{b}	1.03^{b}	0.61^{c}	0.05
Y3	1.95^{a}	1.02^{b}	1.06^{b}	1.14^{b}	0.71^{c}	0.06
Y4	2.03^{a}	1.21^{b}	1.09^{b}	1.22^{b}	0.69^{c}	0.06
Average milk yield (AMY)	$1.7l^{a}$	0.99^{b}	1.10^{b}	1.10^{b}	0.64^{c}	0.05
Udder Characteristics (cm)						
Rear udder height (RUH)	19.50^{b}	21.67^{a}	18.75^{c}	19.04^{bc}	18.15^{c}	0.33
Rear udder width (RUW)	15.50^{a}	14.67^{ab}	12.50^{ab}	12.81^{ab}	12.33^{c}	0.27
Udder depth (UD)	28.63^{ab}	28.25^{b}	31.38^{a}	30.28^{ab}	31.44^{a}	0.30
Central ligament (CL)	0.75^{c}	2.33^{a}	2.00^{b}	1.79^{b}	2.56^{a}	0.14
Fore teat placement (FTP)	7.25^{b}	10.16^{a}	9.25^{ab}	8.05^{b}	6.84^{b}	0.40
Teat length (TL)	5.25^{a}	4.50^{b}	4.13^{bc}	4.45^{b}	3.77^{c}	0.15
Body Linear traits (cm)						
Ear Length (EL)	21.00^{b}	21.67^{a}	20.88^{b}	20.57^{b}	21.05^{b}	0.27
Chest Girth (CG)	142.25^{a}	133.67^{c}	138.13^{b}	132.76^{c}	134.00^{c}	1.12
Tail Length (TL2)	120.50^{a}	108.33^{ab}	99.00^{b}	105.33^{ab}	107.43^{ab}	1.49
Body Length (BL)	124.50^{a}	117.33^{c}	119.00^{bc}	116.87^{c}	119.86^{b}	0.97
Height at Wither (HW)	133.50^{a}	132.33^{a}	122.50^{b}	126.55^{ab}	128.14^{ab}	0.79
Thigh Length (TL3)	65.00^{c}	68.00^{a}	64.00^{d}	66.93^{a}	66.74^{b}	0.42
Body weight (kg)	246.65^{a}	208.10^{c}	228.50^{b}	208.06^{c}	210.57^{c}	4.89

[abcde]: means with different superscript differ significantly (P < 0.05) within the rows and between the column, N; total number of observation, Milkability scores (MS1 - - MS5): very fast milking to very slow milking animals, (1—4): first to fourth weekly milking, cm: centimeter, kg: kilogram, n: number of observations.

Table 4.8: Effect of Milking Temperament on Milk Yield, Milkability, Milking Duration, Udder and Body Measurements of the Bunaji Cows

Variable	Milking Temperament (MT) scores					
	1 (n=12)	**2** (n=23)	**3** (n=10)	**4** (n=3)	**5** (n=3)	SEM
Average Total Milk yield (AMY)	1.01^{a}	0.90^{a}	0.87^{ab}	0.93^{a}	0.93^{a}	0.05
Average total flow-rate (AFR)	0.52^{a}	0.44^{ab}	0.38^{c}	0.49^{ab}	0.44^{b}	0.03
Average total duration (AMD)	2.03^{b}	2.15^{ab}	2.36^{a}	2.04^{b}	2.24^{a}	0.09
Udder Traits (cm)						
Rear Udder Height (RUH)	17.79^{d}	19.21^{b}	18.88^{bc}	18.50^{c}	20.17^{a}	0.33
Rear Udder Width (RUW)	13.17^{a}	12.72^{a}	12.40^{ab}	12.67^{a}	13.00^{a}	0.27
Udder Depth (UD)	30.33^{b}	30.66^{b}	30.50^{b}	31.50^{a}	31.67^{a}	0.30
Central ligament (CL)	1.79^{b}	2.28^{a}	2.21^{a}	1.50^{b}	2.43^{a}	0.14
Fore teat placement (FTP)	7.58^{c}	7.06^{c}	9.05^{b}	10.00^{a}	7.00^{c}	0.40
Teat Length (TL)	4.42^{a}	4.18^{ab}	4.20^{ab}	3.33^{c}	4.00^{ab}	0.15
Body linear Measurements (cm)						
Ear Length (EL)	21.04^{b}	20.74^{bc}	20.70^{bc}	20.33^{c}	22.33^{a}	0.27
Chest Girth (CG)	138.83^{a}	130.92^{b}	132.30^{b}	140.58^{a}	139.33^{a}	1.12
Tail Length (TL2)	108.4^{b}	103.30^{c}	108.90^{b}	106.33^{b}	116.67^{a}	1.49
Body Length (BL)	119.08	118.34	118.20	119.67	118.67	0.97
Height at Wither (HW)	127.25^{b}	125.91^{b}	130.40^{a}	131.17^{a}	127.33^{b}	0.79
Thigh Length (TL3)	66.00^{c}	66.32^{c}	66.70^{c}	69.66^{a}	67.83^{b}	0.42
Body Weight (BW)/Kg	230.74^{a}	199.57^{b}	203.33^{b}	238.33^{a}	235.67^{a}	4.89

[abcd]: Means with different superscripts within the rows are not significantly different ($p < 0.05$), n: number of observations, cm: centimeter, kg: kilogram, temperament scores (1, 2, 3, 4 and 5): very calm, calm, moderately-calm, nervous and very nervous cows, n: number of observations, SEM: standard error of the mean.

4.3.2 Effect of chute exit temperament on flight speed, udder and body linear measurements of the Bunaji cows

Table 4.9 showed the effect of chute exit temperament (CES) on a four point scale; one (the cow walked) and four (the cow jumped) and its corresponding effect on flight speed, body weight, body linear measurements and udder characteristics. The results showed that exit speed had significant ($P < 0.05$) effect on body weight, tail length, body length, rear udder height and rear udder width. Calm cows that walked (CES1) and trot (CES2) exit the chute at a significant ($P < 0.05$) slower speed than cows that ran (CES3) and jump (CES4). The chest girth (or body weight equivalent), tail lengths and body lengths of CES1 and CES2 groups were similar and not significantly ($P>0.05$) different from CES3 and CES4 groups. However, the cows that trot were significantly ($P < 0.05$) different from cows that jumped while exiting the chute by their higher weight, longer tail and wider widths of the rear udder.

4.3.3 Effect of pen temperament on body weight, body measurements and udder traits of the Bunaji cows

The effect of pen temperament (PT) scores (Table 4.10) were described on a five point linear scale of one (calm) to five (very aggressive) animal. The result showed that PT had significant effect on udder traits, body linear measurements and exit speed. The exit speed, rear udder heights and udder depths of the cows were not significantly different ($p > 0.05$) between the temperament groups (PT1, PT2… PT5). Although PT5 were very aggressive, they also had significantly ($p < 0.05$) lower body weight, shorter tail length, body lengths and longer teat lengths than their counterparts. There were similarities between PT1 and PT2, PT3 and PT4 in their tail lengths and height at wither; the former differ significantly ($p < 0.05$) from the latter by shorter tails and higher wither height.

Table 4.9: The Effect of Chute Exit Temperament on Exit Speed, Body Weight, Udder and Body Linear Measurements of the Bunaji Cows

Variables	Chute exit Score (CES)				SEM
	CES1 (n=18)	CES2 (n=12)	CES3 (n=8)	CES4 (n=13)	
Exit speed (FS) m/s	0.77^{c}	1.33^{c}	2.09^{b}	3.28^{a}	0.17
Body weight (BW)kg	219.14^{ab}	215.44^{ab}	226.41^{a}	190.25^{b}	4.89
Body linear traits (cm)					
Ear length (EL)	21.42	20.58	20.88	20.38	0.27
Chest girth (CG)	135.25^{ab}	135.23^{ab}	137.50^{a}	129.44^{b}	1.12
Tail length (TL2)	106.22^{ab}	107.92^{ab}	113.13^{a}	104.08^{b}	1.49
Body length (BL)	118.86^{ab}	118.63^{ab}	123.38^{a}	115.23^{b}	0.97
Height at wither(HW)	125.81	130.33	128.63	126.54	0.79
Thigh length (TL3)	66.11	67.58	67.25	66.00	0.42
Udder traits (cm)					
Rear udder height (RUH)	19.71^{a}	17.46^{b}	18.75^{ab}	18.93^{ab}	0.33
Rear udder width (RUW)	13.31^{ab}	12.17^{b}	14.12^{a}	11.77^{b}	0.27
Udder Depth (UD)	30.72	31.20	30.81	30.98	0.30
Central Ligament (CL)	1.94	2.33	2.16	2.12	0.14
Fore teat placement (FTP)	7.34	8.01	8.00	7.89	0.40
Teat length (TL)	4.30	3.88	4.31	4.22	0.15

^{abc} Means within the rows with the same superscript are not significantly different (P>0.05), n: number of observations (cows), m/s: meters per seconds, kg: kilogram, cm: centimeter, score 1: the cow walked, 2: the cow trotted, 3: the cow ran, 4: the cow jumped, SEM: standard error of the mean.

Table 4.10: The Effect of Pen Temperament Scores on Body Measurements and Udder Characteristics of the Bunaji Cows (N=51)

Traits	Pen Temperament (PT) Score					
	1	**2**	**3**	**4**	**5**	**SEM**
	(n =16)	**(n = 8)**	**(n = 5)**	**(n= 13)**	**(n = 9)**	
Exit speed (FS) m/sec.	1.32^{ab}	1.98^{a}	1.72^{a}	1.92^{a}	2.06^{a}	0.17
Body weight (BW)kg	217.54^{a}	204.29^{ab}	207.66^{ab}	226.33^{a}	191.43^{c}	4.89
Body linear traits (cm)						
Ear length (EL)	21.03^{a}	21.25^{a}	20.80^{a}	20.92^{a}	20.22^{b}	0.27
Chest girth (CG)	135.89^{a}	132.56^{ab}	133.65^{ab}	136.27^{a}	129.50^{c}	1.12
Tail length (TL2)	105.50^{b}	105.50^{b}	109.20^{a}	111.23^{a}	104.56^{c}	1.49
Body length (BL)	118.59^{b}	120.81^{a}	118.40^{b}	120.69^{a}	113.67^{c}	0.97
Height at wither(HW)	126.91^{b}	127.38^{b}	127.80^{ab}	129.08^{a}	126.22^{b}	0.79
Thigh length (TL3)	67.34^{ab}	66.50^{ab}	64.60^{b}	67.85^{a}	64.72^{b}	0.42
Udder traits (cm)						
Rear udder height (RUH)	18.78^{ab}	18.81^{ab}	19.50^{a}	18.62^{ab}	18.83^{a}	0.33
Rear udder width (RUW)	13.41^{a}	12.38^{b}	11.60^{c}	12.96^{a}	12.39^{b}	0.27
Udder depth (UD)	30.92^{a}	30.88^{a}	30.28^{ab}	30.60^{a}	30.30^{ab}	0.30
Central Ligament (CL)	1.84^{b}	2.74^{a}	2.70^{a}	2.07^{b}	1.78^{b}	0.14
Fore teat placement (FTP)	8.22^{a}	6.25^{c}	7.94^{b}	8.81^{a}	6.57^{c}	0.40
Teat length (TL)	3.99^{b}	4.13^{b}	3.80^{bc}	4.22^{b}	4.72^{a}	0.15

abc: Row means with the same superscript do not differ significantly ($P>0.05$), scores 1: non-aggressive, 2: slightly aggressive, 3: moderately aggressive, 4: aggressive and 5: very aggressive, SEM: standard error of the mean, cm: centimeter, m/sec.: meters per seconds,

4.4 Phenotypic Correlations of Milkability with Milk Yield, Milking Duration and Udder Traits of the Bunaji Cows

4.4.1 Phenotypic correlation of udder measurements with milkability traits

Table 4.11 showed the phenotypic correlation of udder measurements with milkability traits. Significant (P < 0.05) positive correlations among udder traits were observed between udder depth (UD) and central ligament (CL), rear udder width (RUW) and rear udder height (RUH), fore-teat placement (FTP). Similarly, milkability traits (FR) were significantly (P < 0.05) and positively correlated with RUW, teat lengths (TL) and FTP, and negatively correlated with UD and CL. Correlations among FR traits was high (P< 0.01), positive and increases in the weekly milking.

4.4.2 Phenotypic correlation of milkability traits with milk yields and milking duration of the Bunaji cows

Table 4.12 showed the phenotypic correlation of milk yields (Y1-Y4) and durations (D1-D4) with milkability traits in the weekly milking of the Bunaji cows: high significant (P<0.01) positive relationships among milk yield (Y), milk duration (D), and between milk yield and milkability (FR) traits; and a significant (P < 0.05) negative relationship between milkability and milking duration traits. The high correlation among milk yield, milkability and milking duration traits increased in the weekly milking.

4.5 Phenotypic Correlation of Temperament with Milkability, Milk Yield, Udder and Body Linear Traits of the Bunaji Cows

4.5.1 Correlations between temperaments and milkability traits of the Bunaji cows

Table 4.13 shows the phenotypic correlation coefficients of temperaments traits; milking temperament (MT), pen temperament (PT), chute temperament (CT), chute exit score (CES) and

Table 4.11: Phenotypic Correlation of Udder Measurements with Milkability Traits of the Bunaji Cows

	RUH	RUW	UD	CL	FTP	TL	FR1	FR2	FR3	FR4
RUH										
RUW	0.30*									
UD	-0.37*	-0.33*								
CL	0.09	-0.14	0.34*							
FTP	0.20	0.29*	-0.37	-0.08						
TL	0.13	0.05	-0.22	-0.22	0.15					
FR1	0.24	0.32*	-0.33*	-0.33*	0.26*	0.24				
FR2	0.18	0.34*	-0.34*	-0.39*	0.20	0.35*	0.74**			
FR3	0.25*	0.39*	-0.39*	-0.34*	0.23	0.32*	0.75**	0.84**		
FR4	0.21	0.33*	-0.28*	-0.32*	0.22	0.30*	0.81**	0.86**	0.91**	
AFR	0.24	0.36*	-0.36*	-0.37*	0.25*	0.33*	0.87**	0.92**	0.95**	0.96**

*: Significant (P< 0.05), **: High significant (P<0.01), 1-4: first to fourth weekly number of milking, AFR: average total flow-rate, RUH: rear udder height, RUW: rear udder width, CL: central ligament, UD: udder depth, FTP: fore teat placement, TL: teat length, UD: udder depth.

Table 4.12: Phenotypic Correlation of Milkability Traits with Milk Yields and Milking Duration of the Bunaji Cows

Yield (Y)	Y1	Y2	Y3	Y4	AMY	D1	D2	D3	D4	AMD	FR1	FR2	FR3	FR4
Y1														
Y2	0.78**													
Y3	0.75**	0.83**												
Y4	0.76**	0.90**	0.91**											
AMY	0.87**	0.95**	0.94**	0.97**										
Milking duration (D)														
DI	0.45*	0.29*	0.19	0.16	0.28*									
D2	0.14	0.18	-0.05	0.07	0.09	0.67**								
D3	0.27*	0.30*	0.39*	0.32*	0.35*	0.58**	0.51*							
D4	0.35*	0.37*	0.44*	0.50*	0.45*	0.61**	0.58**	0.79**						
AMD	0.36*	0.34*	0.30*	0.32*	0.35*	0.83**	0.80**	0.87**	0.89**					
Milkability (flow-rates)														
FR1	0.57**	0.53*	0.55**	0.62**	0.61**	-0.42*	-0.43*	- 0.31*	-0.20	-0.39*				
FR2	0.54*	0.71**	0.72**	0.70**	0.72**	- 0.19	-0.48*	- 0.14	-0.11	-0.26*	0.74**			
FR3	0.37*	0.55**	0.58**	0.56**	0.56**	-0.33*	-0.45*	-0.45*	-0.29*	-0.44*	0.75**	0.84**		
FR4	0.46*	0.65**	0.59**	0.62**	0.63**	-0.33*	-0.36*	-0.32*	-0.30*	-0.38*	0.81**	0.86**	0.91**	
AFR	0.50*	0.65**	0.66**	0.67**	0.67**	-0.34*	-0.47*	-0.33*	-0.24	-0.40*	0.87**	0.92**	0.95**	0.96**

*: Significant ($P < 0.05$), **: Highly significant ($P<0.01$), Y: milk yield in litres, 1—4: first to fourth weekly milking. AMY: average milk yield in litres, AFR: average total flow-rate in litres per minutes, AMD: average milking duration in minutes.

chute exit speed (FS) with milkability traits; average milkability score (AMS) and average flow-rates (AFR) of the Bunaji cows. The negative correlations between milkability traits (AFR and AMS) was very high ($P<0.01$) and nearly perfect. The correlation between CS, CES, FS was very high ($P<0.01$) and positive. Moderate positive correlation ($P < 0.05$) was observed between PT with CT and CES. The correlations of all temperament traits were not significant ($P>0.05$) with the milkability traits.

4.5.2 Correlation of temperaments with udder and body linear measurements of the Bunaji cows

Table 4.14 showed the phenotypic correlations of temperaments with udder and body linear measurements of the Bunaji cows. The result shows significant ($P < 0.05$) negative correlations between: chute score (CT) with ear length (EL), chest girth (CG) and body weight (BW); chute exit score (CES) with BW; milking temperament (MT) with central ligament (CL); chute exit speed (FS) with rear udder width (RUW); and positive correlations between MT with udder depth.

4.5.3 Correlation of temperament traits with milk yield, and milking duration of the Bunaji cows

Table 4.15 shows the phenotypic correlation of temperament traits with milk yield, and milking duration of the Bunaji cows. Significantly ($P < 0.05$) positive correlated traits were observed between pen temperament (PT) with third milk yield (Y3), average milk yield (AMY), first milking duration (D1) and third milking duration (D3); and chute temperament (CT) with first milking duration (D1).

Table 4.13: Phenotypic Correlation between Temperament and Milkability Traits of the Bunaji Cows (N = 51)

	M.T	P.T	C.T	CE. S	FS	FR1	FR2	FR3	FR4	AFR
Milking temperament(MT)										
Pen temperament (PT)	0.16									
Chute temperament (CT)	0.06	0 .34*								
Chute Exit Score (CES)	0.14	0.26*	0.72**							
Chute exit speed (FS) m/s	0.17	0.21	0.65**	0.82**						
First Flow-rate (FR1)	-0.08	-0.03	-0.09	-0.09	-0.09					
Second flow-rate (FR2)	-0.12	0.20	-0.03	-0.12	-0.21	0.74**				
Third flow-rate (FR3)	-0.18	0.06	-0.07	-0.11	-0.19	0.75**	0.84**			
Fourth flow-rate (FR4)	-0.08	0.10	-0.15	-0.19	-0.22	0.81**	0.86**	0.91**		
Average milking flow-rate (AFR)	-0.12	0.10	-0.10	-0.14	-0.19	0.87**	0.93**	0.95**	0.96**	
Average Milkability score (AMS)	0.12	-0.09	0.02	0.04	0.11	-0.85**	-0.89**	-0.88**	-0.87**	-0.94**

N: number of observations, *: Significant (P< 0.05), * *: Highly significant (P<0.01), AFR: Average flow-rate, m/s: meters per seconds.

Table 4.14: Phenotypic Correlation between Temperament with Udder and Body Linear Traits of the Bunaji Cows

	MT	PT	CT	CES	FS
RUH	0.18	-0.01	-0.09	-0.01	-0.06
RUW	-0.07	-0.14	-0.24	-0.21	-0.31*
UD	0.15	-0.11	-0.08	-0.14	0.22
CL	0.07	-0.04	-0.06	0.06	0.11
FTP	0.14	-0.05	-0.05	0.08	0.06
TL	0.20	0.20	0.20	0.01	-0.01
EL	0.06	-0.13	-0.26*	-0.19	-0.12
CG	0.03	-0.16	-0.33*	-0.24	-0.13
TL2	0.17	0.10	-0.02	-0.03	-0.01
BL	-0.01	-0.15	-0.14	-0.13	-0.18
HW	0.17	0.04	-0.10	0.04	0.04
TL3	0.24	-0.18	-0.09	-0.01	0.05
BW	0.03	-0.11	-0.37*	-0.27*	-0.17

*:Significant (P< 0.05), * *: Highly significant (P<0.01), RUH: rear udder height, RUW: rear udder width, FTP: fore teat placement, TL: teat length, UCR: udder clearance, CL: central ligament, EL: ear length, CG: chest girth, TL2: tail length, BL: body length, TL3: thigh length, BW: body weight, MT: milking temperament, PT: pen temperament, CT, Chute temperament, CES: chute exit score

Table 4.15: Phenotypic Correlation of Temperament with Milk Yield and Milking Duration of the Bunaji Cows

	M T	P T	C T	CE S	F S
Y1	-0.13	0.24	0.08	0.07	0.01
Y2	-0.03	0.20	0.01	0.01	-0.03
Y3	-0.08	0.31*	0.02	-0.06	-0.10
Y4	-0.06	0.21	0.03	0.02	-0.01
AMY	-0.08	0.25*	0.03	0.01	-0.04
D1	-0.06	0.25*	0.25*	0.22	0.16
D2	0.11	-0.01	0.06	0.16	0.23
D3	0.19	0.25*	0.02	0.01	0.08
D4	0.07	0.11	0.11	0.14	0.20
AMD	0.10	0.18	0.13	0.15	0.19

*: Moderate significance ($P< 0.05$), * *: Highly significance ($P<0.01$), Y: yield in litres, 1—4: first to fourth weekly milking. AMY: average yield in litres, AMD: average milking duration in minutes, Y: milk yield in litres, D: milking duration in minutes, MT: milking temperament, PT: pen temperament, CT: chute temperament, CES: chute exit score, FS: chute exit speed.

4.6 Further Exploration of the Relationships of Workability with Milk Yield, Milking Duration, Udder and Body Linear traits

In other to both reduce the dimension and avoid collinearity problems common in the analysis of closely related traits, principal components analysis (PCA) was used to further explore the relationships with other traits after a varimax rotation as follows:

4.6.1 Relationship between temperament and milkability traits of the Bunaji cows

The eigenvectors and the eigenvalues of principal components and percentage of the total variance explained by each principal component (PC) of the correlation coefficients for workability traits are shown on Table 4.16. The Kaiser-Meyer-Olkin (KMO) measure of Sampling adequacy was high (0.626) and the Bartlett's Test of Sphericity (χ^2) = 205.63 of the correlation coefficients were significant (P< 0.001) for the workability traits.

Three PCs had eigenvalues greater than one (>1) and explained about 80.77% of the total variance (Table 4.16). Eigenvectors > 0.4 were considered to provide a high correlation between PCs and workability traits. Three variables- chute temperament (CT), chute exit score temperament (CES) and chute exit speed temperament (FS) on Component- 1 (PC1); Average milkability score (AMS) and average milk flow-rate (AFR) on Component -2 had significant higher loadings only on one component. While milking temperament score (MT) and pen temperament score (PT) had significant high loadings on Component three. Communality for the workability traits measured ranged from 0.50 for pen temperament to 0.96 for objective milkability traits.

Table 4.16: Principal Component Analysis of the Correlation Coefficient of Temperament and Milkability Traits of the Bunaji Cows

	PC1	PC2	PC3	PC4	Communality
MT	0.27	-0.10	**0.85**	-0.44	0.80
PT	0.39	0.35	**0.48**	0.70	0.50
CT	**0.82**	0.25	-0.16	0.08	0.77
CES	**0.89**	0.21	-0.17	-0.15	0.86
FS	**0.88**	0.13	-0.15	-0.20	0.81
AFR	-0.38	**0.90**	0.03	-0.11	0.96
AMS	0.30	**-0.93**	0.02	0.16	0.95
Eigenvalue	2.70	1.93	1.02	0.79	
Eigen Percentage (%)	38.59	27.61	14.57	11.22	
Cumulative	38.59	66.20	80.77	91.99	
KMO = 0.626					
Bartlett's Test of Sphericity (χ^2) = 509.50					

PC: principal components, MT, PT, CT and CES: subjective temperament traits, for milking, Pen chute and chute exit scores, AMS and AFR: subjective scores and objective measure of milkability, FS: objective temperament traits for chute exit speed, KMO: Kasier-Meyer-Okin; P<0.001.

4.6.2 Relationship between milkability and udder traits of the Bunaji cows

Table 4.17 shows the eigenvectors and the eigenvalues of principal components and percentage of the total variance explained by each principal component (PC) of the correlation coefficients of the objective measure of milkability and udder traits. Three PCs had eigenvalues greater than one (>1) and explained about 70.73% of the total variance. Eigenvectors > 0.4 were considered to provide a high correlation between PCs and workability traits. The Kaiser-Meyer-Olkin (KMO) measure of Sampling adequacy was high (0.613) and the Bartlett's Test of Sphericity (χ^2) = 509.50 of the correlation coefficients were significant ($P< 0.001$) for the correlated traits.

Higher loading was observed for the variables of milkability (FR2, FR3, FR4 and AFR) and rear udder width (RUW) in Component 1 (PC1); rear udder height (RUH), udder depth (UD) and fore-teat placement (FTP) in PC2; Central ligament (CL) and teat length (TL) in PC3. Rear udder width, UD, CL and TL were significantly loaded in more than one component (values > 0.40). Communality for the traits measured ranged from 0.38 for TL to 0.99 for average milk flow-rate (AFR).

4.6.3 Relationship of milkability traits with milk yield and milk duration of the Bunaji cows

Table 4.18 shows the eigenvectors and the eigenvalues of principal components and percentage of the total variance explained by each principal component (PC) of the correlation coefficient of the objective traits for milkability, milk yield and milk duration of the Bunaji cows. The first two principal components (PC1 and PC2) had eigenvalues >1 and explained about 85% of the total variance extracted. The first principal component (PC1) accounts for 50.34% milk flow-rate and milk yield traits. The loadings for milking duration traits were high under Component 2.

Table 4.17: Principal Component Analysis of the Correlation Coefficient of Milkability and Udder Traits of the Bunaji Cows

	PC1	PC 2	PC 3	Communality
FR1	0.86	-0.12	0.13	0.77
FR2	0.90	-0.22		0.86
FR3	0.93	-0.13	0.13	0.89
FR4	0.92	-0.23	0.18	0.93
AFR	0.97	-0.19	0.13	0.99
RUH	0.34	0.64	0.31	0.61
RUW	0.48	0.45	0.16	0.46
UD	-0.52	-0.53	0.38	0.70
CL	-0.45	0.20	0.68	0.70
FTP	0.36	0.57	-0.17	0.48
TL	0.41		-0.46	0.38
Eigenvalue	5.30	1.42	1.05	
Eigen Percentage (%)	48.22	12.94	9.58	
Cumulative	48.22	61.16	70.73	

KMO = 0.613

Bartlett's Test of Sphericity (χ^2) = 205.64

PC: principal components, FR1-FR4: milk flow-rates of the first to fourth weekly milking, AFR: average milk flow-rate of the four weekly milking, RUH: rear udder height, RUW: rear udder width, UD: udder depth, UC: udder cleft, CL: central ligament, FTP: fore teat placement, TL: teat length. KMO: Kasier-Meyer-Okin; P<0.001.

Table 4.18: Principal Component Analysis of the Correlation Coefficient of Milkability traits with Milk Yield and Milking Duration of the Bunaji Cows

	PC1	**PC2**	**PC3**	**Communality**
FR1	0.83	-0.34	-	0.80
FR2	0.91	-0.21	-	0.88
FR3	0.85	-0.42	0.14	0.87
FR4	0.88	-0.35	0.15	0.89
AFR	0.92	-0.36	-	0.98
Y1	0.74	0.44	0.24	0.74
Y2	0.86	0.40	0.12	0.90
Y3	0.87	0.37	-0.22	0.88
Y4	0.88	0.38	-0.12	0.93
AMY	0.90	0.42	-	0.99
D1	-	0.83	0.38	0.70
D2	-0.25	0.76	0.43	0.65
D3	-	0.87	-0.38	0.75
D4	-	0.89	-0.27	0.81
AMD	-	0.99	-	0.99
Eigenvalue	7.55	5.20	0.74	
Percentage	50.34	34.66	4.90	
Cumulative	50.34	85.00	89.90	

PC: principal component, FR1-FR4, Y1-Y4 and D1-D4: flow-rates, milk yield and milking durations of the first to fourth weekly milking, AFR, AMY and AMD: averages of milk flow-rate, milk yield and milking duration of the four weekly milking.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Socio-Economic Background and Perception of Cattle Handlers to Temperament Trait of Bunaji Cattle

5.1.1 Socio-economic background of the respondents

The high involvement of male gender means that male predominates in cattle handling within the study areas. The predominance could be attached to cattle size, strength, speed and potential for aggression which requires a thoughtful and confident handling (Handling cattle-NSW, n. d). The obvious reason for high number of experienced pastoralist agrees with AGTR (n. d) that most cattle breeds were named after their respective tribe and ancestry. However, their low level of involvement in formal learning places them at the extreme end of which better understanding of temperament and other issues of life among them could be difficult. The differences among handlers resulting from the kind of facility used and the herd size involved was attributed to the purpose to which Bunaji cattle was handled as expressed by the respondents.

5.1.2 Test of knowledge to temperament trait of Bunaji cattle by handlers

The perception of the majority of the handlers by culling out very reactive cows agrees with the report of Grandin (2018a) that cattle keepers have been indirectly selecting cattle by breeding only cattle which are calm when in contact with humans. Highly temperamental animals (Maffei *et al*., 2018) have safety implications (Grandin, 1993; Breuer, *et al*. 2000; Haskell, *et al.* 2014). Their perception that high incidence of aggression occurs when the Buanji cattle are to be restrained for routine management operations agrees with Turner *et al.* (2013); Adedibu and

Musa (2017). Most aggressions on the farm are caused by bulls and cows especially when carrying out health related activities (Handling cattle- NSW (n. d).

5.1.3 Perception of cattle handlers to temperament traits of Bunaji cattle

The overall average perception score in the study revealed that the animal were moderately reactive. Handling cattle- NSW (n. d) had that *Bos indicus* and *Bos indicus*-cross animals are more sensitive or reactive than British or European breeds. The perception suggests how the animal sensitivity is viewed when it is to be approached, driven, weighed and treated for injury, transported and other routine activities like milking (Haskell *et al.,* 2014). Respondent opinions in regard to ability to predict the animal's response could have differed by their knowledge of: cattle handling, the cattle and the facilities used in handling (Handling cattle-NSW, n. d).

5.2 Description of Traits in the Study Population

5.2.1 Body weight, body linear measurements, udder traits and Facial hair whorls of the Bunaji cows

The body linear traits, udder depth, rear udder heights and rear udder widths were evenly distributed (symmetrical) while fore-teat placements, teat lengths and central ligaments were asymmetrical in the population. By implication, majority of the cows had their udder teats longer and widely placed and a less pronounced or weak central ligament (that is, less than 3.00cm) - ICAR (2018).

The coefficient of variation (CV) suggests that the differences in individual traits for body weight, udder and body linear measurements in relation to the mean were within the range of acceptability for fore teat placement (FTP) to very good for height at wither (Ebrahimi, 2018).

While the 0.00% CV for facial hair whorls position implies that the trait is homogenous in this population as all the animals had the center of their facial hair whorls located in between the top and the bottom of the eyes.

5.2.2 Descriptive statistics of workability (temperament and milkability) traits of the Bunaji cows

The subjective workability traits of the Bunaji cows shows that pen temperament (PT) trait was symmetrical; while milking temperament (MT), chute temperament (CT), chute exit score (CES) and average milkability score (AMS) were asymmetrical in the study population. Lower temperament scores (scores 1 and 2) for less reactive cows as opposed to higher scores (scores 4 and 5) for more reactive cows denotes that the animal is suitable to be approach, driven, weighed and treated for injury; and exhibits minimal danger to the handlers and other cows in the heard (Haskell *et al.*, 2014). The average milkability score (AMS) denotes that majority of the cows yielded their milk slowly.

Similarly, the objective workability traits of the Bunaji cows shows that milk yields, milk duration, milkability and chute exit speed temperament traits were asymmetrical in the population. The peak, average and minimum flow-rate indicates that the fastest milked cows in the herd saved 1.02 - 2.40 minutes more time than the average and the lowest milked cows. This is highly profitable to the farmer (Schick, 2009).

The coefficient of variability (CV) denotes that the differences in milking duration’ traits relative to the mean was within the acceptable range. All the CVs of temperament, milk yield and milk flow-rates traits were too wide and therefore not suitable for precise valuation (Ebrahimi, 2018).

The mean MT value reported in this study agrees with the mean values of 2.30 reported for Holstein cows in Japan (Abe *et al.,* 2002). The mean PT score observed in this study was higher than the values of 2.1 to 2.6 for Bunaji and Bunaji x Simmental cross bred bulls reported by Adedibu and Musa (2017). The mean chute exit speed (FS) temperament in this study was in the range category of < 1.9 m/s values that defined the cows to be lowly temperamental against 2.4m/s for the highly temperamental (Burrow, 1991). Objectively, the average, minimum and maximum milk flow recorded in this study was by far lower than the values of 2.30, 1.41 and 4.50 litters/minutes in the Holstein Frisian cows (Lee and Choudhary, 2006).

The combination of the subjective and objective techniques as applied to assess workability trait may provide a more complete evaluation for which selection can be accurately based (Jones, 2013). The applications of workability (temperament and milkability) traits in this dairy production are paramount from economic and welfare stand point, because the profit for the farmer is increased through reduction in cost associated with injuries and labour as less time with fewer personnel would be required to handle and milk more animals.

5.2.3 The effect of milkability on milk yield, udder and body linear traits of the Bunaji cows

The milk yields associated with very fast, fast, moderate and slow yielding cows (milkability groups) were indication that wider udders have higher capacity to contain more milk (Carlstrom, 2014). Lower heights of the rear udder (ICAR, 2018) and udder depth and widely placed teats (Bretschneider *et al.,* 2015) associated with fast milkability group suggest a weak median suspensory and central supportive ligaments (White and Denton, 2015; ICAR, 2018), by implication a sagging udder. A sagging udder could attract involuntary culling because they are prone to injuries or lesions and contamination by mastitis causing organisms (Bhutto *et al.*, 2010;

Singh *et al.*, 2014). Longer teats associated with fast milkability group are moderate when compared to the Jersey cows ranging between 3.9cm – 8.9cm (Bharti *et al.*, 2015). Due to problems usually encountered with teat cups in robotic milking system, symmetrically and more centrally placed teats on the quarter associated with very slow milk yielding cows are more desirable (Carlstrom, 2014; White and Denton, 2015). Thus the very slow milkability as oppose to the fast milkability group would require longer time and more personnel to milk a substantial amount of milk.

5.3 The Effect of Temperament on Milk Yield, Milkability, Udder and Body Linear Traits of the Bunaji Cows

5.3.1 The effect of milking temperament on milk yield, milkability, udder and body linear traits of the Bunaji cows

The result suggest that high milk flow (milkability) or reduction in total milking time in this herd was attributed to high milk yield, large udder capacity and moderate teat size (Carlstrom, 2014). Significant effect of temperament on milk yield and flow-rate in cows has been reported (Sewalem *et al.* 2011; Gergovska *et al*. 2012; Neja *et al.*, 2015; Szentleleki *et al*. 2015). Low udder heights associated with very nervous cows suggest weak median suspensory ligaments (MSL) which is characterised by sagginess of udders (Bretschneider, *et al.*, 2015; Bharti *et al.*, 2015). Too wide and unevenly placed fore-teats associated with the nervous and moderate cows are problematic in automatic or robotic milking system due to teat cups placement (Carlstrom, 2014). Similarly longer tails in dairy industry are prone to injury; contamination by disease agents; and can cause discomfort during milking (AVMA, 2014). This probably explains the reason behind high nervousness during milking. The shallow central ligament (ICAR, 2018) of very calm and nervous cows indicated that the udder were loose and saggy (White and Denton, 2015), a situation common with high milk yielding animals (Bretschneider, *et al*., 2015). In relation to the body linear measurements, the calm and moderately calm were smaller than their counterparts. It can thus be concluded that though absence of a physiological factors such as injuries and disease causing organisms might not be totally out of place; the very nervous cows had a lot of desirable qualities, but their high temperament are undesirable for frequent milking.

5.3.2 The effect of exit score temperament in relation to exit speed, udder and body linear traits of the Bunaji cows

The result suggested that the animals that exit the handling chute at a slower speed were calm because they took a longer time to traverse the distance. Though the fastest and slow cows were similar in terms of udder characteristics, the most reactive cows that exit the chute at a higher speed were distinguished by a small body weight (chest girth), tail length and body length. Faster exit speed in cattle have been associated with lower body weight (Burrow, 1997); greater basal concentrations of glucocorticoids and catecholamines that have a consequential poor growth performance, carcass characteristics, and immune responses; and greater carcass bruising compared to the calmer cattle (Burdick *et al.*, 2011). It is thus recommended that cows that exit the chute at a speed above 3.0 m/sec. are extremely dangerous and should be treated with caution.

5.3.3 The effect of pen temperament (PT) scores on udder and body linear measurements

The result suggested that: the cows that were very reactive to a novel object (human approach) in handling pen had a significant advantage in their short tail over their counterpart. However their body weight, body lengths and longer udder teats shows their deficiencies. Short or docked tails are encouraged in the dairy industry because the problems associated with discomfort to the milking personnel and closer proximity to the ground such as injuries or breakage and contamination with disease causing organisms are prevented (AMVA, 2014). Like tail lengths, longer udder teats have close proximity to the ground and especially where the median suspensory or central ligament is weak (White and Denton, 2015). The lower body weights and body lengths of the very aggressive cows agrees with Burrow (1997) and Burdick *et al*. (2011) that very reactive animals have poor growth performance. Thus the implication of high temperament and low growth performance has handling safety' and production consequences.

5.4 Phenotypic Relationship of Milkability with Udder, Milk Yield and Duration Traits

5.4.1 Relationship of milkability with udder traits of the Bunaji cows

The result suggests that the increase in consistency of the weekly milking was almost perfected. A significant ($P < 0.05$) increase in RUH will lead to an increase in udder capacity (RUW) and width between fore teats; and a decrease in udder depth (UD) and central ligament (CL). This implies that deep udders (shallow-udder hock distance) resulting from weakened central ligaments could lead to; uneven placement of fore-teats (Bretschneider *et al.*, 2015); close proximity of udders to the ground especially in high milk yielding herd (Bharti *et al.*, 2015). Therefore large udder capacity (RUW), moderate to widely placed long teats; and weak central supporting ligaments are influenced by the increase in milk flow-rate.

5.4.2 Relationship of milkability with milk yield and duration traits of the Bunaji cows

The results suggest that the increase in consistency of the method of milk collection was very high and nearly perfect. The rate at which an increase in milk yields will influence the increase of milk flow is very high, and a significant increase in milk flow will significantly reduce the time of milking. This implies that if the time of milking is significantly reduced, more number of cows could be milked and be frequently milked, thus reducing cost associated with time for the dairy farmer. Similar relationship was reported on Jersey cows (Erdem *et al.*, 2011).

5.5 Phenotypic Relationship between Temperament with Milkability, Milk Yield, Udder and Body Linear Traits of the Bunaji Cows

5.5.1 Phenotypic relationship between workability traits of the Bunaji cows

The highly negative correlation between the subjective (AMS) and the objective (AFR) milkability assessment techniques indicated that the decrease in milkability score influenced by the increase in milk flow traits was very high and nearly perfect. Although the subjective scores (AMS) would be more suitable for assessment on a larger scale, the objective trait (AFR) is capable of eliminating observer bias and may offer better tools for selection (Jones, 2013). The highly significant positive relationships of chute exit score (CES) chute (CT) and Chute exit speed (FS) temperaments suggest that these techniques measured more similar attributes of temperament (Sebastian *et al.*, 2011; Jones, 2013) than moderately correlated values of PT with CS and FS. Therefore individual Bunaji cows classified as reactive in terms of CT are expected to be reactive for CES and FS respectively. Some researchers (Core *et al.* 2009; Cafe *et al.* 2011) have reported moderate relationship between CT score and FS on a group of Brahman cattle (Core *et al.* 2009) and Angus cattle (Cafe *et al.* 2011). The relationship of CES and FS indicate that Bunaji cows which exit the handling chute at a faster speed also required less time to cover the measured distance as higher scores meant a faster chute exit (Schwartzkopf-Genswein *et al.*, 2012). The negative and non-significant relationships between workability (temperament and milkability) traits suggest that breeders should pursue an independent program for each of temperament and milkability traits in this study population.

5.5.2 Relationship of temperament with udder and body linear traits of the Bunaji cows

The results means that high temperament scores for nervous cows during milking were influenced by the increase in udder depth. Short ears, lighter body weight and flightiness were influenced by the higher scores for reactive cows in the handling chute. Deep udders in dairy cows have been associated with injuries and infection (Bhutto *et al.*, 2010; Singh *et al.*, 2014). High reactivity of cattle has been reported to be associated with faster exit speed, lower body weight (Burrow, 1997); poor growth performance, carcass characteristics, and immune responses (Burdick *et al*., 2010). Large udders probably due to the high capacity to contain milk as opposed to small udders would limit the speed at which the cows exit the chute. From safety stand point, a better understanding of the cows' temperament traits would improve the handler's safety and the animal's welfare.

5.5.3 Relationships between temperament with milk yield and milking duration of the Bunaji cows

Reactive cows that were either nervous during milking or aggressive during handling in chutes would require longer duration of milking. This relationship is not economical to the farmer as the cost associated with milking would be increased (Schick, 2009; Gray, *et al*., 2012). This agrees with (Louise and Hanne, 2015) that cows that respond strong to social separation were associated with longer milking duration and low milk yield.

5.6 Further Exploration of the Relationship between Workability Traits (Temperament and Milkability) with other Traits in the Study

5.6.1 Relationship between temperament and milkability traits

The first three Principal components (Table 16) summarized the percentage of total variance that best explained the data which is in agreement with Kaiser Meyer Olkin's (MKO) rule. The MKO measure of sampling adequacy (MSA) obtained indicated the existence of significant correlations between linear type traits and the existence of true factors, buttressing the suitability of the data for PCA analysis. KMO-MSA greater than 0.5 is a must for satisfactory PCA analysis to proceed

Hair *et al*. (2009). The high association of subjective scores (chute score, chute exit score) and objective (chute exit speed) temperament measures in PC1 signifies that they make the greatest contribution towards total variation of handling temperament of the Bunaji cows. PC1 could therefore be used as an index for measuring animal strength to confinement. Similarly, the association of milking temperament (MT) and pen temperament (PT) in PC3 could be used as an index for measuring the fear response of the cows to milking and handling. While PC2 could be used as an index for measuring milk yield per unit time due to its high loadings for the subjective and objective traits of milkability.

The result in this study showed that each principal component is an association of related workability traits which define the suitability of the animal to either handling or milking. It also suggests that there is reduction in the number of type traits used in selection for subjective and objective milkability and temperament measures of Bunaji cows which confirms the findings of Sebastian *et al.* (2011) and Louise and Hanne (2015) that the consistencies of the objective measures of beef cattle temperament over time are as reliable as the subjective scores. Findings of this study are in agreement with Curley *et al.* (2006) who obtained positive correlations between exit velocity and chute score (subjective) in Brahman cattle. The use of principal component one (PC1), two (PC2), and three (PC3) in this study provided a means of reduction in the number of objective and subjective type traits of workability which could be used in explaining the temperament and milkability trait,

5.6.2 Relationship between milkability and udder traits

The higher loading of RUH, RUW, FTP UD, CL and TL in the PCs in this study is consistent with Sinha *et al*. (2021), where six extracted components accounted for 69.43% of the total variance of linear udder traits to explain udder and teat confirmation traits in a group of Indian Sahiwal cows. The association of milk flow-rate traits (FR2, FR3, FR4 and FR5), rear udder width, udder depth, central ligament, teat length and their association in PC1 signifies that they make the greatest contribution towards total variation in the total milk yield per unit time of the Bunaji cows. The associations of PC2 with rear udder height, fore-teat placements, rear udder width and depth are grouped as the second largest contributors towards udder variance and are good descriptors of the mammary system; while CL and TL associated with PC3 are a good description of posterior udder system. Carlstrom (2014) reported that milkability is significantly determined by the capacity of the udder to contain milk and the resistance from the teat canal. The highest communality associated with AFR confirms its equilibrium position between udder and teat conformation traits.

5.6.3 Relationship of milkability and traits of milk yield and milk duration of the Bunaji cows

The percentage of total variance that best explained the data was summarized in the first two principal components (PCs). About 85% of the total variations are explained using these first 2 principal components for the traits. This result is consistent with the findings of Burak and Haja (2008) who estimated first 4 principal components for milk yield and milking Speed weight measure in Swiss dairy cattle. In this study, the type trait as a predictor of milkability, milk yield and milking duration were less accurate with only two principal components. Thus Principal components could be used for all workability traits and would be useful in both dimension reduction and avoiding collinearity problems, common in the analysis of closely related functional traits (GIFT, 1999) such as temperaments or milkability.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The evaluation of workability traits associated with handling and milking of Bunaji cows was carried out to explore the phenotypic relationships and dependencies among temperament and milkability traits that significantly affect the function of Bunaji cows. Fifty-one (51) multiparous, non-pregnant, lactating cows were used for this study. The cows were tagged in their third stage of lactation and certified clinically fit for the study. The techniques implored to assess the animals' workability traits were average milk flow-rate and subjective milkability score for milkability trait; and milking, pen, chute, chute exit score and chute exit speed for temperament traits. Data of milkability, temperament, udder and body linear measurements in the experiment were analysed using SAS (9.0) version. Computations using means procedure were done to: determine the means and standard error for each trait; and coefficients of variation (CV) to determine the variability in the population sample. Significant differences in means were compared using the new Duncan Multiple Range Test (DMRT). Pearson correlation coefficients were computed to determine the degrees of relationship among and between variables for all animals within each temperament and milkability groups. Further exploration using principal components analysis was used to determine the relationships of the traits. The result of these findings showed that: majority of the cattle handles perceived the temperament of Bunaji cattle to be moderately reactive. Milk yield (MY), rear udder height (RUH), rear udder width (RUW); udder depth (UD); central ligament (CL), fore teat-placement (FTP), tail lengths (TL2), were significantly ($p < 0.05$) affected by milkability (AFR). Temperament traits had significant ($p<0.05$) effect on exit speed, milk yield, milkability and body measurements. Milkability was significantly correlated with RUH, TL, FTP, UD, CL and milking duration (D). Chute temperament score (CT), chute exit score (CES) and chute exit speed (FS) were highly ($P<0.01$) correlated temperament traits as they had high significant loadings on only one principal components; similarly the milk flow-rate traits and milkability score (AMS). The correlation between temperament and milkability traits were not significant ($p>0.05$).

6.2 Conclusions

The conclusions from this study were:

i. Bunaji cattle handles usually cull out highly temperamental cattle from the herd;
ii. Cows with very fast milkability scores (MS1) had the highest flow-rate and milk yield;
iii. Bunaji cows with milking temperament score 1 (very calm) produced more milk than those of the milking temperament score 3 (moderately calm). Bunaji cows that jump while exiting the chute at a higher speed (score 5) were more reactive and dangerous;
iv. An improvement on milkability traits would significantly reduce the total time of milking;
v. Different handling temperament traits would give a better insight to temperament and its influence on the animal.

6.3 Recommendations

The recommendations from this study were:

i. Farmers and dairy producers should be encouraged to rear cows that have high milk flow trait;
ii. Handlers need to be conscious of temperaments of cattle to ensure safety.
iii. Breeders could pursue an independent program for each of temperaments and milkability traits;
iv. This study could be replicated for other breeds of cattle.

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APPENDIX 1

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE,
AHMADU BELLO UNIVERSITY, ZARIA

Questionnaire for Cattle Handlers' Perception on Bunaji Cattle Temperament

Dear respondent,

Your response to the questions will be used strictly for the purpose of the study by the researcher.

Thank you.

Sunday Hgyab Lot (P16AGAN8035)

SECTION A:
Socio-Economic Background of the Respondent

a) What is the name of this village /Town?..………………………………………………………
b) What is the name of this L.G.A? ………………………………………………….......................
c) What is your sex? (a) Male ( ) (b) Female ( )
d) What is your age range (years)? (a) l0 years & below ( ) (b) 11-20 ( ) (c) 21- 30 ( ) (d) Above 30 ( )
e) What is your level of formal education? (a) Non-formal ( ) (b) Primary ( ) (c) Secondary ((d) Tertiary ( )
f) What is your primary occupation? (a) Animal scientist ( ) (b) Veterinary surgeon ( ) (c) cattle trader ( ) (d) Pastoralist / nomad/ herder ( ) (e) village cattle rearers ( ) (e) others, please specify ….

g) Do you owned, keep or handle Bunaji cattle? Yes/ No ……………..

h) Which of the following described your primary purpose for keeping, owning or handling Bunaji cattle? (a) Meat ( ) (b) milk ( ) (c) draught( ) (d) health ( ) (e) prestige ( )

SECTION B: CONTACT EXPERIENCE

i) For how long have you been in contact with Bunaji cattle? (a) less than one year ( ) (b) 1-5 years ( ) (c) 6-10 years ( ) (d) above ten years ( )

j) What is the size of your Bunaji cattle herd? (a) None ( ) (b) 1- 50 ( ) (c) 51- 100 ( ) (c) 101 to 200 ( ) (d) More than 200 ( )

k) Indicate the type of permanent handling facility often used by you in handling Bunaji cattle? Chute ( ), weighing crate ( ), crush ( ), forcing pen ( ), dispersal pens ( ), race ( ), automated milking machine ( ), ropes ( ), cords ( ) others (please specify)…….

***SECTION C*:**

Test of Knowledge and Perception to Temperament Trait of Bunaji Cattle

Use the score below to answer questions one and two below

1: Non-reactive (the animal is very calm),

2: slight reactive (the animal is calm),

3: moderately reactive,

4: reactive (the animal is nervous or aggressive),

5: Very reactive (the animal is very nervous or very aggressive).

1. Which of the score best described your perception on the behavioral reactivity of Bunaji cattle to an environmental challenge (tick as appropriate)? (a) 1 (b) 2 (c) 3 d) 4 (e) 5
2. Which of the scores described your perception of temperament on
   i. Bulls ( ), (ii) Cows (iii) Calves
3. Do you think the behavioral response of the offspring cattle is similar to its parents? (a) Yes (b) No (c) I can't say
4. Do you normally cull out very reactive cattle from the herd? (a) Yes (b) No (c) I don't know
5. Can cattle aggressiveness cause injury in the herd? (a) Yes (b) No (c) I don't know
6. Which areas of the farm Bunaji cattle often express their aggression? (a) Fields ( ) (b) yards ( ) (c) covered pens ( ) (d) permanent handling facilities ( ) (e) others …… (please specify)
7. Which of the under-listed handling activities is (are) the most frequently performed task expose Bunaji cattle reactivity? (tick as applicable)
   (a) Dehorning/ Foot trimming ( ) (b) Dosing/ medication/ vaccination/Artificial insemination ( ) (c) loading/weighing /Ear tagging ( ) (d) pregnancy examination/ assisted calving ( ) (e) Government inspection/ Diseases / Pregnancy/ diagnosis ( )

Thank you for your time and for your kind input!