CHARACTERIZATION OF DONKEYS (*AQUUS ASINUS*) IN NORTHWESTERN NIGERIA USING MORPHOLOGICAL AND MORPHOMETRIC MEASURES

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,
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DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE
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ZARIA

NOVEMBER, 2016

DECLARATION

I declare that the research work titled "**SOME CHARACTERIZATION OF DONKEYS**(*AQUUS ASINUS*) **IN NORTHWESTERN NIGERIA USING MORPHOLOGICAL AND MORPHOMETRIC MEASURES**" was carried out by me at Kaduna, Kano, Katsina, Kebbi, Sokoto, Jigawa and Zamfara State of Nigeria under the supervision of Prof. G. N. Akpa and Dr. A.O. Iyiola- Tunji. The information obtained from literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation has been previously presented for another degree or diploma at any University.

PAUL JOHN APAGU

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Name Signature Date

CERTIFICATION

This dissertation titled "**SOME CHARACTERIZATION OF DONKEYS** (*AQUUS ASINUS*)**IN NORTHWESTERN NIGERIA USING MORPHOLOGICAL AND MORPHOMETRIC MEASURES**" by PAUL JOHN APAGU meets the regulations governing the award of the degree of Master of Science in Animal Science of the Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge.

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Prof. G. N. Akpa Chairman, Supervisory Committee	Signature	Date

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Dr. A. O. Iyiola-Tunji Member, Supervisory Committee	Signature	Date

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Prof. K. Bala Dean, School of Postgraduate Studies, Ahmadu Bello University, Zaria.	Signature	Date

DEDICATION

I dedicate this research to God Almighty, my creator, for keeping me alive and healthy to see to the completion of this phase of my life.

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ABSTRACT

Morphological and morphometric traits were used to determine the relationship among Red (Auraki), Black (Duni), White (Fari), Brown (Idabari) and Brown-white (Idabari-fari) donkeys at different ages. A total of 700 donkeys were used for the study. The morphological data were collected on hair type, Coat colour, Skin type, Coat colour pattern, Tail shape, Eye colour and Head profile.Morphometric measures taken were body weight, head length, head width, ear length, neck length, neck circumference, shoulder width, height at withers, heart girth, Body length and Tail length. Data obtained were subjected to different statistical analysis to determine the distribution of phenotypic traits across classes based on morphological traits. ANOVA was used to determine the effect of various classes and morphological factors on morphometric indices; correlated relationship among morphometric traits for different classes, sex and strains were carried out; principal component analysis of morphometric traits, prediction equation for body weight based on morphometric measurements, discriminant analysis for the identification of donkeys with high discriminant powers and cluster analysis to classify donkeys into different genetic groups were carried out. Significant variations was observed between morphological and morphometric ($P<0.01$) traits. The results of the study showed that the short-smooth hair type (75%), brown coat colour (86%), thick skin type (75%), solid coat colour pattern (97%), pendent tail shape (58%), black eye colour (95%) and straight head profile (86%) were preponderant in the studied populations. The correlated relationships among morphometric measurements varied significantly ($p<0.05$, 0.01) with age in pooled data and within strains. Coefficients were very high across sexes within strains. Body weight was positively and negatively correlated with other measurements due to the effect of age. Principal component indices had higher loadings for head length (0.82), ear length (0.65), neck length (0.68), neck circumference (0.72), shoulderwidth (0.83), height at withers (0.80), heart girth

(0.79) and body length (0.84) in PC1 across the strains. Sexual loadings indicated male having better prediction result when body volume and length components are considered while females are better evaluated using length and shape related measures. The BL (R^2=97%), HW (R^2=99%) and HG (R^2=100%) predominated as the major single most important predictors of body weight in a stepwise regression across the sex and age categories. Brown-fari (Idabari-fari) donkey strain was highly discriminated against with high discriminating power and this could be classified as a distinct strain of donkey. Cluster analysis of qualitative traits of donkeys using UPMGA revealed high level of dilution of the genetic pool. It is therefore concluded that donkeys in Northwestern Nigeria can be characterized using their morphological and morphometric traits. However, for their distinct classification, into the four (4) existing strains, body weight, neck circumference and tail length cannot be used; rather a more appropriate yardstick is the use of skin type (36%) and tail shape (24%) which had high genetic distance estimate.

CHAPTERONE

1.0 INTRODUCTION

Donkey is one of the ancient domesticated livestock in the history of mankind. In 1992, the world donkey population was estimated to be about 44 million (FAO, 1992).The highest number of the world donkey exists in Asian countries, followed by African and Latin America (Fernando and Starkey, 2004). Recent surveys revealed that China has the highest donkey population of about 11 million followed by Ethiopia with about 5 million donkeys (Starkey and Starkey, 1997; FAO, 2003). Nigeria is endowed with a donkey population of about 900,000 (RIM, 1992)

Nigeria is one of the countries where donkeys contribute to the daily socio-economic activities of the citizens. The current population of Nigeria is estimated to be over 173.60 million people (NBS, 2013). More than 70 million Nigerians are smallholder farmers residing in rural areas with very poor infrastructural facilities. Therefore, donkeys help to transport people and goods to the rural markets, convey sick people to the hospital, fetch water from the river or convey animal manure to the farms during the dry season. Even in urban areas, donkeys are used by people for small-scale transport services such as transportation of building materials and food items (grains) in Northern part of the country.

Most of the literature from Nigeria about donkey is focused on the use of donkeys as draught animals (Musa, 1978; Katsina, 1990; Hassan and Bode, 1990; Mohammed, 2000). The use of donkeys as draught animals in rural areas has increased considerably, which has improved the involvement of small-scale farmers in the market economy (Fernando and Starkey, 2004; Starkey and Starkey, 2004). In Nigeria about 16,000 donkeys are transported yearly from the Northern states to the Southern part of the country for meat (Blench, 2004b). They also provide greater mobility which are used for carrying firewood, loads, including water, house-hold structures, goods and children

(Marshall and Weissbrod, 2011). Presently, donkeys are used in the production of milk for children, who are allergic to bovine milk (Carrocio*et al*., 2000; Muraro *et al*., 2002; Caldin*et al*., 2005)

Donkeys have been playing significant socio-economic roles to humans since ancient times. For example, pictures of donkeys were seen in some parts of ancient Egypt (Rossel*et al*., 2008). Donkeys and their related species (for example, Mules) help to convey weapons and soldiers during wars (Fernando and Starkey, 2004)

There are four major strains of donkeys in North West Nigeria which are clearly identified by coat colours, that is, Auraki (Rust or red), Duni (Dark brown to black), Fari (Pale cream to white), and Idabari (Grey to light medium brown)(Blench *et al*.,1990; Starkey and Fielding, 2004). The coat colour is sometimes used as a determining factor for the price of a donkey in most parts of North West Nigeria (Blench *et al*., 1990). Idabari strain is the most popular donkey variety among the smallholder farmers and was reported to cost higher than the other types (Blench *et al*., 1990).Generally, donkeys with grey to light medium brown coat colour fetch higher prices compared to other types (Blench *et al*., 1990). On the other hand, donkeys with pale cream to white coat colour cost less because their population is very small which make them less popular compared to Idabari strain. The Fulani, Kanuri, Hausa and other tribes in Northern Nigeria have culture of keeping donkeys for different activities (Blench, 1997).

The characterization of domestic animal on the basis of their diversity and relationship is essential to meet future needs in Africa and Nigeria in particular. Genetic reserves capable of readily responding to directional forces imposed by broad spectrum of environment must be maintained. Maintaining genetic diversity is an insurance package against future adverse conditions. The first step in the characterization of local genetic resources is based on the knowledge of variation in the morphological traits (Delgado *et al.,* 2001). Given that the majority of the genes influencing body conformation of an animal are of common action and not local, the formation of one part is found narrowly correlated with the formation of the other (Lerner and Donald, 1996). Morphological variability has also been used to assess diversity and relationship in some breeds of livestock (Akpa *et al.*, 1998, Crepaldi*et al.*, 2001, Salako and Ngere, 2002, Zaitoun*et al.*, 2005).

1.1 Justification of the Study

Status of donkey resources is poorly understood, as well as the ongoing transformation of the livelihood systems that support them. No clear classification for donkeys exists but generally, they were being classified according to their coat colour (Blench *et al.*, 1990). Some are rust or red, dark brown to black, pale cream to white, and grey to light medium brown. In addition to distinct differences based on coat colour among donkey species, they are also clear phenotypic variations among strains or within strains. Very little is known about the morphological and morphometric relationships of Donkey strains in Nigeria. There is relatively limited information available on phenotypic diversity in Donkeys. Recent classification of donkeys is based on colour alone; there is need for more intense methods of classification. Such methods should include means of evaluating the quantitative and qualitative differences that are observable in this species. Such methods can include morphological and morphometric classifications.

The aim of this study therefore, is to determine the phenotypic diversity between and within donkey strains in Nigeria using morphometric and morphological characteristics.

1.2 Specific Objectives

The specific objectives of this study are to:

1. Morphologically characterize the donkeys for some economic importanttraits
2. Morphometrically characterize the donkeys in the study area
3. Determine the possible factors that can affect these traits.
4. Determine the relationships that exist amongst these traits; and by extension, define the predictability of body weight of these donkeys.
5. Define the possible route(s) for the classification of the existing donkey strains.

1.3 Research Hypotheses

Null Hypothesis ($_{Ho}$): There is no relationship among strains of donkey in Nigeria using morphological and morphometric characteristics.

Alternative Hypothesis ($_{Ha}$): There is relationship among strains of donkey in Nigeria using morphological and morphometric characteristics.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Domestication of Donkeys in the World

Donkey belongs to the mammalian family Equidae and species *Equus asinus*. The domestic donkey, *Equus asinus*, belongs to the horse family, *Equidae* and descended from the wild African ass (*Equus africanus*) in North-Eastern Africa. The population of donkeys is on the increase in Africa, and the animals are increasingly becoming important in transportation of farm produce (Blench, 2004a).Evidence from mitochondrial DNA studies has confirmed that the present day domestic donkey originated in Africa rather than in Asia (Beja-Pereira *et al*., 2004). It is therefore believed that donkey is the only domestic animal of African origin. The domestication events of donkey were based on two mitochondrial lineages. The first lineage wasclosely linked to the Nubian wild ass (*Equus asinus africanus)*. The second lineage showed some similarities to the Somali wild ass (*Equus casinos somaliensis*) (Beja-Pereira *et al*., 2004).

According to Brian, (1994), donkeys were probably domesticated in the North- East Africa from 4,000 BC in Egypt and the Middle East by 100 BC. Clutton-Brock, (1999) reported that archaeological evidence from Egypt further supports the idea that donkeys have been domesticated in Africa since around 6,000 to 6,500 years ago, but there is no evidence so far as to where exactly this happened in Egypt. Other places with high concentrations of domestic donkeys include South and Central Asia and Southern European countries (Brian, 1994). Moreover, Rudman, (1998) suggested that within the family Equidae, it was found that plain zebra (*Equus burchelli*), mountain zebra (*Equus zebra*), Grevy zebra (*Equus grevyi*) and the

African wild ass (*Equus asinus*) which are genetically related to the domestic donkey are still living in the wild as feral donkeys.

2.2 Estimates and Distribution of Donkeys in the World

To estimate the world donkey populations is a very heavy task. This is because of some problems such as lack of qualified personnel to do the work particularly in the developing countries, lack of funds, lack of modern equipment, lack of good roads, etc. Also, commitment of government officials and the attitude of farmers towards researchers are other possible constraints (Starkey and Starkey, 1997). According to the report of FAO (2000) on global animal diversity, it was suggested that donkeys are mainly used as means of transport to the poor in areas with less developed transport systems. As such, they were reported to be predominantly found in countries of the developing regions of the world. The highest number of donkey was reported in Asia, Africa, Latin America and the Caribbean (Table 2.1, 2.2, and 2.3). Donkeys have also been reported to be widely distributed in the countries of the near and Middle East. China has the highest donkey population used by rural women to improve agricultural productivity and in carrying out some domestic tasks (Starkey and Starkey, 1997; FAO, 2000).

2.2.1 Donkey population in America and Caribbean countries

The population of donkeys in America and Caribbean countries shows a different pattern from that of the African countries (Table 2.2). Smallholder farmers in the Caribbean countries have been reported to use donkeys for local transportation and other farm activities (Starkey, 2001). Countries such as Mexico and Brazil have higher number of donkeys compared to other countries in the Caribbean (Table 2.2). In the United States, donkeys are used as pet animals and for animal traction. The population of donkeys used for animal traction has been shown to be far less than those used as pet animals (Hutchins, 1983; Starkey and Starkey, 1997). There is an increasing interest in the protection and breeding of donkeys in America. This makes the donkey population to increase especially the large breeds used in pulling wagons and the small breeds used for riding children in holiday resorts (TDS, 1973). Figure 2.2: shows the Donkey populations in Latin America in 1996.

Table 2.1a**:** Donkey population estimates for African nations 1966-1996.

Estimated Number of donkeys (Thousands)				
	1966	**1976**	**1986**	**1996**
North Africa				
Algeria	275	463	340	230
Egypt	1162	1568	1879	1690
Libya	129	57	61	55
Morocco	950	1200	785	880
Tunisia	163	195	217	230
West and Central Africa				
Cameroon	87	40	34	36
Cape Verde	9	6	6	14
Benin	1	1	1	14
Burkina Faso	180	200	380	455
The Gambia	6	18	40	30
Ghana	15	25	13	13
Guinea	2	3	2	1
Guinea Bissau	3	2	4	5
Mali	498	380	383	611
Mauritania	170	170	149	155
Niger	315	384	367	450
Nigeria	**985**	**700**	**800**	**1000**
Senegal	161	200	255	368
Tchad	300	271	227	252
Togo	1	1	3	3

Source: FAO, 1997. Countries with estimates below 1000 donkeys have been excluded from the list. Some estimates are considered to be inaccurate (see text). [1]Guestimate for Eritrea based on old figures (see text) and Ethiopian population reduced proportionately. [2]Guestimate for Kenya based on old figures (see text)

Table 2.1b: Donkey population estimates for African nations 1966-1996.

Estimated Number of donkeys (Thousands)				
	1966	**1976**	**1986**	**1996**
Southern and Eastern Africa				
Angola	3	5	5	5
Botswana	24	105	143	235
Comoros	3	3	4	5
Djiibouti	4	5	8	8
Eritrea	-	-	-	150[1]
Ethiopia	3775	3860	4600	5000[1]
Kenya	250	270	280	300[2]
Lesotho	42	89	136	152
Malawi	0	1	2	2
Mozambiqua	15	20	20	20
Namibia	53	63	68	71
Somalia	26	22	25	24
South Africa	310	210	210	210
Sudan	590	670	650	678
Swaziland	15	14	13	12
Tanzania	160	160	170	178
Uganda	17	16	17	17
Zambia	1	1	1	2
Zimbabwe	81	92	99	104
Total	**10 781**	**11 490**	**12 397**	**13 652**

Source: FAO, 1997. Countries with estimates below 1000 donkeys have been excluded from the list. Some estimates are considered to be inaccurate (see text). [1]Guestimate for Eritrea based on old figures (see text) and Ethiopian population reduced proportionately. [2]Guestimate for Kenya based on old figures (see text).

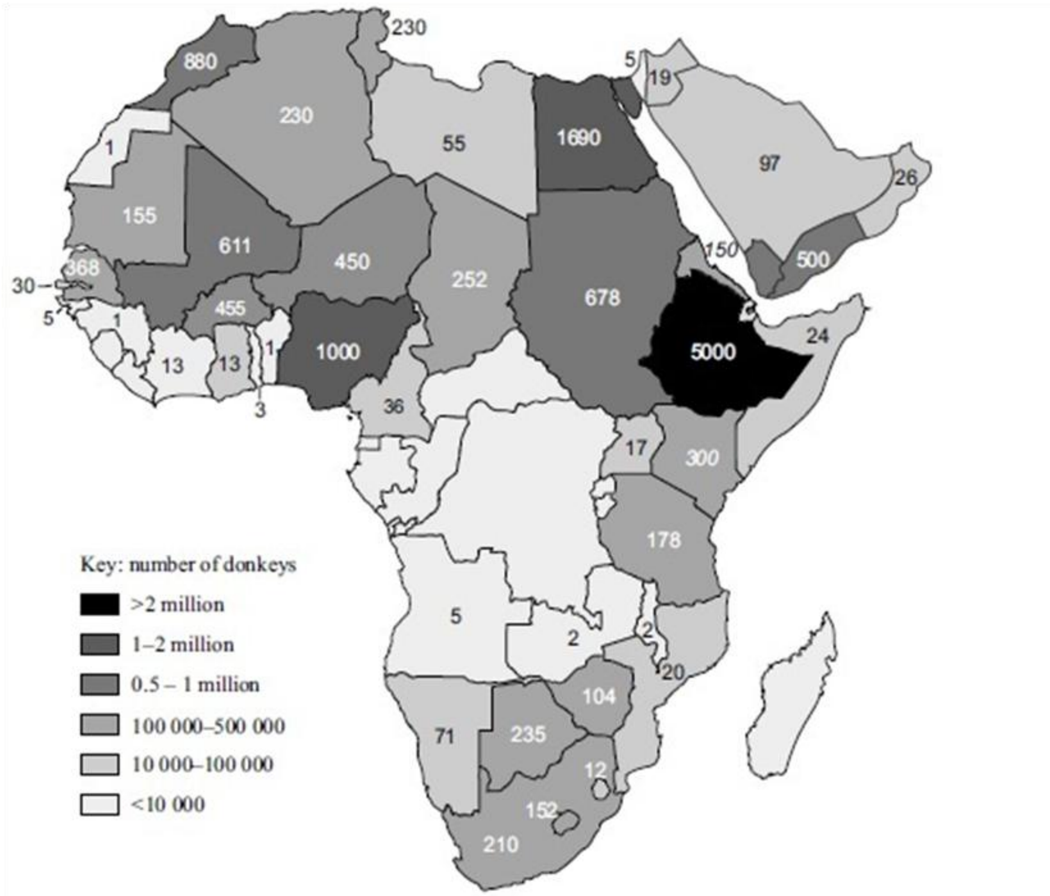


Figure 2.1: Estimates of donkey populations in Africa and Arabian Penisula in 1996. The figure shows the estimated donkey population of each country in thousands. The intensity of shading gives an appropriate visual indication of the numbers of donkeys in different countries.(Source: FAO, 1997).

Table 2.2: Donkey population estimates for Latin American and Caribbean countries.

Estimated number of donkeys (thousands)				
	1966	**1966**	**1986**	**1996**
Argentina	98	90	90	90
Bolivia	560	720	600	631
Brazil	1368	1464	1286	1370
Chile	38	33	28	28
Colombia	368	560	672	710
Costa Rica	4	6	7	8
Cuba	3	4	4	5
Dominican Republic	138	119	140	145
Ecuador	170	189	162	265
Guatemala	6	8	9	9
Haiti	155	200	215	210
Honduras	26	22	22	23
Jamaica	39	28	23	23
Mexico	3403	3318	3183	3250
Nicaragua	7	7	8	8
Paraguay	22	28	30	31
Peru	399	479	490	520
Venezuela	471	480	440	440
Total	**7275**	**7755**	**7409**	**7766**

Source: FAO, 1997. In: Starkey and Starkey (1997). Countries for which there is no FAO estimate and countries with fewer than 5000 donkeys have been excluded from this list.

Figure 2.2: Donkey populations in Latin America in 1996. The figure show the estimated population of each country in thousands. The intensity of shading gives an indication of the number of donkeys in each country. (Source: FAO, 1997).

Table 2.3: Donkey population estimates for some Asian countries 1966-1996.

Estimated number of donkeys in (thousands)				
Central Asia	**1966**	**1976**	**1986**	**1996**
Afghanistan	1200	1250	1325	1160
Bhutan	14	17	18	18
China	7438	8127	10415	10923
India	1054	1000	1200	1600
Pakistan	1300	2157	2857	3901
Middle East'				
Iran	2028	2160	2050	1400
Iraq	530	459	400	145
Israel	8	5	5	5
Jordan	96	32	19	19
Lebanon	37	15	13	24
Saudi	52	105	108	97
Syria	199	234	199	205
Oman	24	25	24	26
Turkey	1971	1476	1192	800
West Bank/Palestine	-	18	15	13
Yemen	602	790	547	500
Total	**16553**	**17870**	**20387**	**20836**

Source: FAO, 1997. In: Starkey and Starkey (1997) Countries for which there are no long-term FAO estimates (including countries of the former Soviet Union) and countries with fewer than 5000 donkeys have been excluded.

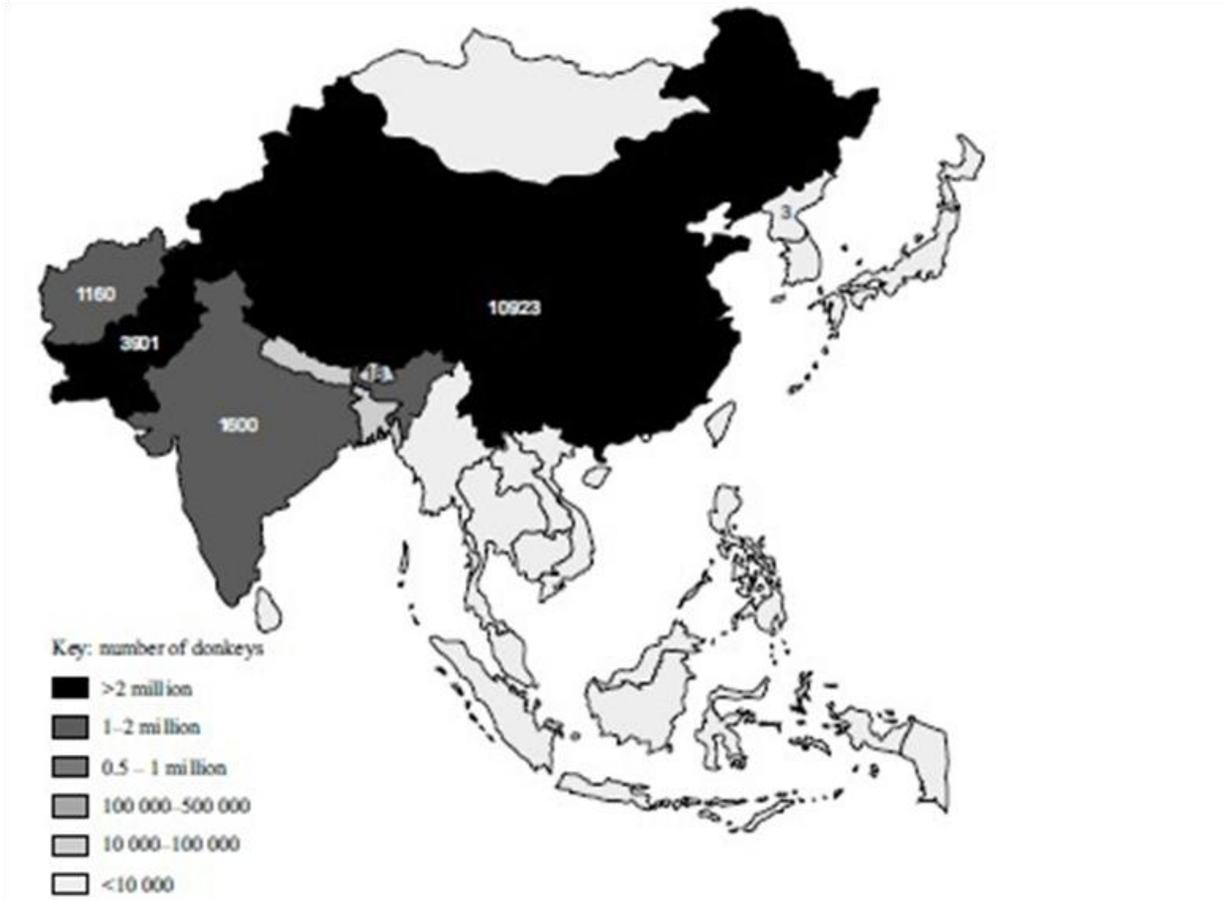


Figure 2.3: The donkey populations of southern and eastern Asia. The figures show the estimated donkey population of each country in thousands. The intensity of shading gives an approximate visual indication of the number of donkeys in the different countries (Source: FAO, 1997).

2.2.2 Donkey populations in the Middle East and Asian countries

The history of utilizing donkeys for different socio-economic activities in the Middle Eastern countries is as old as history of man. The population of donkeys in these countries depends on the role played in the farming system.

Different breeds of donkeys have been reported from the Middle East based on their sizes and population (Wilson, 2003). Donkeys are used for transport in hilly terrains and for riding purposes. The population of donkeys in the Middle East is believed to be increasing due to the increasing demands for animal traction (Wilson, 2003). Different problems as a result of certain management practices (e.g. castration of male donkeys and slaughtering of donkeys for the lions in the zoos) have made the donkey population to vary from one country to the other in the Middle East (Starkey and Starkey, 1997). The donkey populations in these countries have been reported to increase with increase in human population because of the rising demands of food and fuel which necessitates the use of donkeys for agricultural purposes and transportation (Starkey and Starkey, 1997). In countries where the level of poverty is high, the population of donkeys is reported to be high (Starkey and Starkey, 1997). Donkey population is affected by some internal and external factors that affect the social stability of a country (e.g. political crisis). The more stable the country is politically, the more likely the donkey population. For example, a large number of donkeys have been reported in China compared to other Asian countries (Starkey and Starkey, 1997).

2.2.3 Donkey population in Europe

In Europe, donkey populations vary between countries mostly due to the differences in need by the citizens based on agricultural and social purposes (Table 2.4). In some European countries such as Italy, the donkey population has been reported to increase due to the role they played in work and meat production (Polidori *et al*., 2008). Also, because of increase interest in cross-breeding programmes between donkeys and mules, the population of donkeys in some European countries shows an increasing trend (Starkey and Starkey, 1997). Donkeys are not used for agricultural purposes in majority of European countries but their role as pet animals and tourism has led to the stability of their population in countries such as England and Germany (Starkey and Starkey, 1997). However, in countries such as Bulgaria, donkeys serve an agricultural function and therefore their population is believed to be higher compared to other countries in Europe (Starkey and Starkey, 1997).

Table 2.4: Estimated donkey population in some European countries 1966-1996

Estimated number of donkeys (thousands)				
Western Europe	**1966**	**1976**	**1986**	**1996**
France	43	25	24	25
Greece	441	290	177	110
Ireland	70	34	17	14
Italy	373	168	94	27
Portugal	173	180	175	150
Spain	442	274	140	90
United Kingdom	10	10	10	10
Total	**1552**	**981**	**637**	**426**
Eastern Europe				
Albania	60	78	95	113
Bulgaria	287	326	345	291
Romania	29	38	35	32
Yugoslavia	39	32	13	-
Total	**415**	**474**	**488**	**436**

Source: FAO, 1997. In: Starkey and Starkey (1997) Countries for which there are no long-term FAO estimates and countries with fewer than 5000 donkeys have been excluded.

2.2.4Donkey populations in African countries

In Africa, donkeys are found in everywhere because of their intimate relationship with the farming systems. The number of donkeys in each country depends on the history, climatic factors and the functions of donkeys in the farming systems. Donkeys are normally found in drier parts of Africa. The population of donkeys is therefore not uniform in all the countries due to variations in their climatic conditions, culture of the people and type of management system employed (Starkey and Starkey, 1997). The culture of keeping donkeys amoung the various tribes existing in Africa has also been shown to influence their population (Blench *et al*., 1990). Donkeys are kept by many smallholder farmers in different countries and for different reasons. For example, Ethiopia has been reported to have the highest donkey population in Africa (Pearson *et al*., 2000) with implication of high foaling ability and population increase compared to countries with low donkey populations. In countries where donkeys play a major role in the farming systems such as Nigeria, several factors ranging from management, diseases, environmental conditions and nutritional factors have been reported to play a role in determining the population of donkeys (Blench *et al*., 1990; Bale *et al*., 2003). Also, Sowe *et al*., (1990) reported that the foaling ability of donkeys and other equines is related to the environmental conditions and management factors.

2.3 History and Spread of Donkeys in Africa

Several attempts have been made by different scholars (scientists) to compile the history and spread of donkeys in Africa but to date, there are no such records. New evidences about the ancestors of donkeys are still being discovered (Rossel *et al*., 2008). It is therefore thought that the lack of precise and comprehensive history about the donkey may be related to its limited uses compared to other livestock species (Blench, 2004a). The present day donkey is believed to be one of the descendants of the Africa wild ass (Equus africanus) (Rossel *et al*., 2008). However, there are some existing debates about the original ancestors of the present day donkeys. Further, due to some phenotypic variations between the donkey strains, it is sometimes argued that the present donkey strains are not pure strains compared to their original ancestors (Blench, 2004a). The main reason why donkeys were domesticated is hard to determined but it is also believed that they were the major means of transport across the Sahara especially for trading and merchandize activities due to their ability to convey heavy loads (Rossel *et al*., 2008). Egypt is thought to be the center of origin of donkeys but other possible centers of origin were also been reported (Blench, 2004a; Rossel *et al*., 2008). Historical, archaeological and linguistic evidence have shown that donkeys are of African origin with particular reference to the North Africa countries (Blench, 2004a; Rossel *et al.*, 2008). The spread of donkeys to other continents of the world is believed to be facilitated by trading, research and tourism. However, this is debatable because there are different historic versions about this (Blench, 2004a).

2.3.1 History, distribution and strains of donkey in Nigeria

The history of donkeys in Nigeria is strongly related to the trans- Saharan caravan trade, pastoral nomads and cultural influence (Blench, 1997). Arabian traders from the North Africa countries were thought to reach Northern Nigeria (Northwest and Northeast) on donkeys, horses and camels for trading activities. This is reported to be one of the possible ways to which donkeys enter into Nigeria (Blench, 1997). Archaeological evidence from excavated equid’s teeth in central Nigeria has shown that there could be other possible history of donkeys in Nigeria (Blench, 1995). The movement of pastoral nomads from the neighboring Niger Republic into different parts of northern Nigeria during dry season grazing has been reported to be one of the ways donkeys spread into Nigeria (Blench, 2004b). The Hausa, Fulani, Kanuri and other tribes in Northern Nigeria have the culture of keeping donkeys for different activities (Blench, 1997). Donkeys in Nigeria are mainly restricted to the dryer Northern states as shown in (Figure 2.4) due to the problems of trypanosomiasis caused by tsetse flies in the forest areas of Southern Nigeria. However, with the intensification of farming activities through clearing of the forests in the humid forested areas, the incidence of tsetse flies in Nigeria is decreasing and a significant number of donkeys have been reported to survive in these areas (Blench *et al*., 1990).

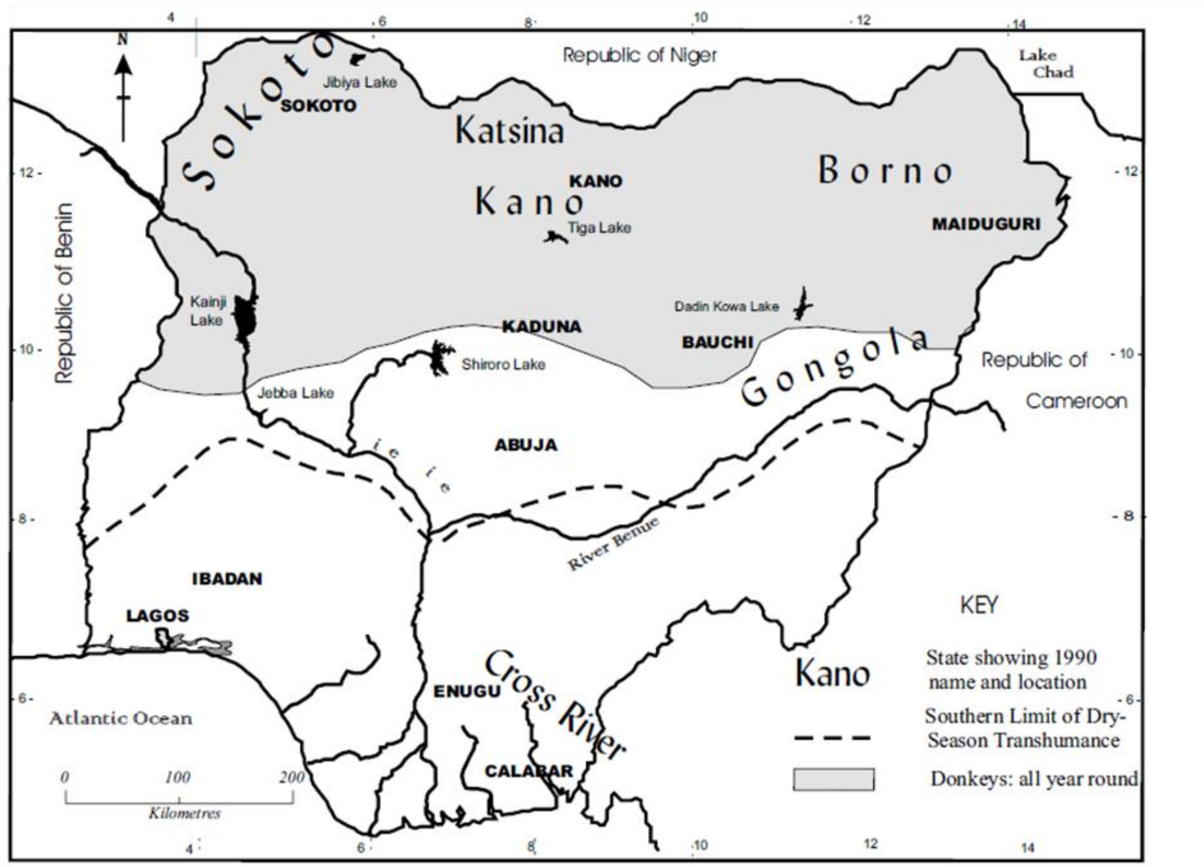


Figure 2.4: Distribution of donkeys in Nigeria.

Source: Blench 1990.

2.3.2 Production and reproduction characteristics of donkeys under traditional management.

Fielding (1988) has reviewed the reproductive characteristics of female donkeys world- wide. Studies on the productivity of donkeys under traditional management in sub- Saharan Africa are scarse, consisting principally of data from two different systems in Mali (Wilson, 1980), the Twareg pastoral herds of Niger (Wilson, Wagenaar and Louis, 1984) and Northern Nigeria (RIM, 1992). Donkeys in Nigeria are allowed to mate freely when herded, but restrictions on access to males when Jennies are used for work can mean that oestrus is overlooked. Estimates from the literature suggest that the length of the oestrus cycle is about 24 days and the length of oestrus itself 6-7 days (Fielding 1988). Donkeys are usually seasonal breeders in temperate regions but in the tropics they come into oestrus throughout the year. Variations in the annual pattern of foaling are most likely to reflect nutritional differences.

2.3.3 Classification of donkeys

2.3.3.1Definition of Breed

The concept of breed was first used in the animal breeding in the sixteenth century, but its meaning has undergone many changes with time and is still different in the minds of different people. Thus, there are various definitions as shown below:

1. Most Encyclopedias, defined breed as a population or a group of population which can be distinguished from other populations of the same species on the basis of different allele frequencies, chromosome changes or genetically determined phenotypic characteristics (Ryder, 1984).
2. Turfon (1974) used two alternative definitions:

(a) A homologous sub specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species.

(b) A homologous group for which geographical separation from phenotypically similar groups has led to general acceptance of its separate identity.

3. Carter and Cox (1982) defined a breed as a group of species possessing certain recognizable characteristics and maintained as a closed breeding population, historically in a single geographical area, after which it is frequently named.

   The food and Agriculture Organization of the United Nations (FAO, 1982) has adopted Turfon definition. Programme on Animal Genetic Resources, especially in developing countries, which do not have breeding organizations (Loftus and Scherf, 1993). It has also realized that breeds have been developed according to geographical and cultural differences to meet human food and agricultural requirements. Ryder (1964) observed that breed differences have resulted partly from man's attempt to select, transport, and cross breed to obtaining animals with desired characteristics and partly from natural processes of selection and genetic drift.

With the development of animal genetics and breeding, the time has lost some of its value. For the purposes of conservation and use of breeds, it would be important to measure their mutual relationships.

2.3.4 Strains of donkeys in Nigeria

There are four major strains of donkeys in northwest Nigeria which are clearly identified by their coat colours (Table 3.2). Brown (Idabari) strain is the most popular donkey strain among the smallholder farmers and was reported by (Blench, 1990) to costs higher than the other strains. The word “brown” is used by some breed registries to describe dark bays. There is a distinct allel that darkens a bay coat to seal brown, but it is not the cause of all forms of dark bay. Red (Auraki) strain; a reddish body colour with no black mane and tail are the same shade or lighter than body coat. White (fari) strain; one of the rarest colours, a white donkey has white hair and fully or largely unpigmented skin. These donkeys are born white, with blue and brown eyes, and remain white for life. The vast majority of so-called “white” donkeys are actually grays with fully white hair coat. Atruly white donkey that lives to adulthood occurs one of two ways: either by inheriting one copy of a dominant white (“W”) gene, of which several has been identified or is a particular type of sabino that is homozygous for the “SB-1” gene (Metallinos *et al*., 1998). Black (Duni) strain is relatively uncommon, though it is not “rare”. Most black foals are usually born a mouse grey or dun colour. As their foal coat begins to shed out, their black colour will show through, though in some breeds, black foals are born jet black (Marklund *et al*., 1996). For a donkey to be considered black, it must be completely black except for white markings. A sun-bleached black donkey is still black even though it may appear to be a dark bay or brown. The main donkey owners in Nigeria include the Fulani, village farmers and commercial transporters found in major towns and cities of Northwest Nigeria (Blench etal., 1990).

Table 2.5:Names and Colours of Donkey Strains in Nigeria

Local Name	Coat colours
Auraki	Red or Rust
Duni	Dark Brown to Black
Fari	Pale Cream to White
Idabari	Grey to light medium brown

Source: Blench*et al* (1990).

2.3.5 Classification of Nigeria Donkeys

Donkeys are kept everywhere in Northern Nigeria, with a broad distinction between their importance and ubiquity in the Northwest and Northeastern parts of the country. There are four major strains of donkeys in Northwest Nigeria which are clearly identified by their coat colours namely Auraki (Plate 2.1), Fari (Plate 2.2), Plate 2.3) and Idabari (Plate 2.4) (Blench*et al*., 1990). The coat colour is some times used as a determining factor for the price of a donkey in most parts of Northwest Nigeria (Blench *et al*., 1990). Idabari strain is the most popular donkey strain among the smallholder farmers and was reported to cost higher than the other strains (Blench *et al*., 1990). Generally, donkeys with grey to light medium brown coat colour (Idabari) fetch higher prices compared with other strains. On the other hand, donkeys with pale cream to white coat colour (Fari) cost less because their population is very small which make them less popular compared to Idabari strain. The main donkey owners in Nigeria include the Fulani, village farmers and commercial transporters found in the major towns and cities of Northwest Nigeria.

Plate 2.1: Auraki (Red) Donkey

Plate 2.2. Fari (White) Donkey

Plate 2.3: Duni (Black) Donkey

Plate 2.4: Idabari (Brown) Donkey

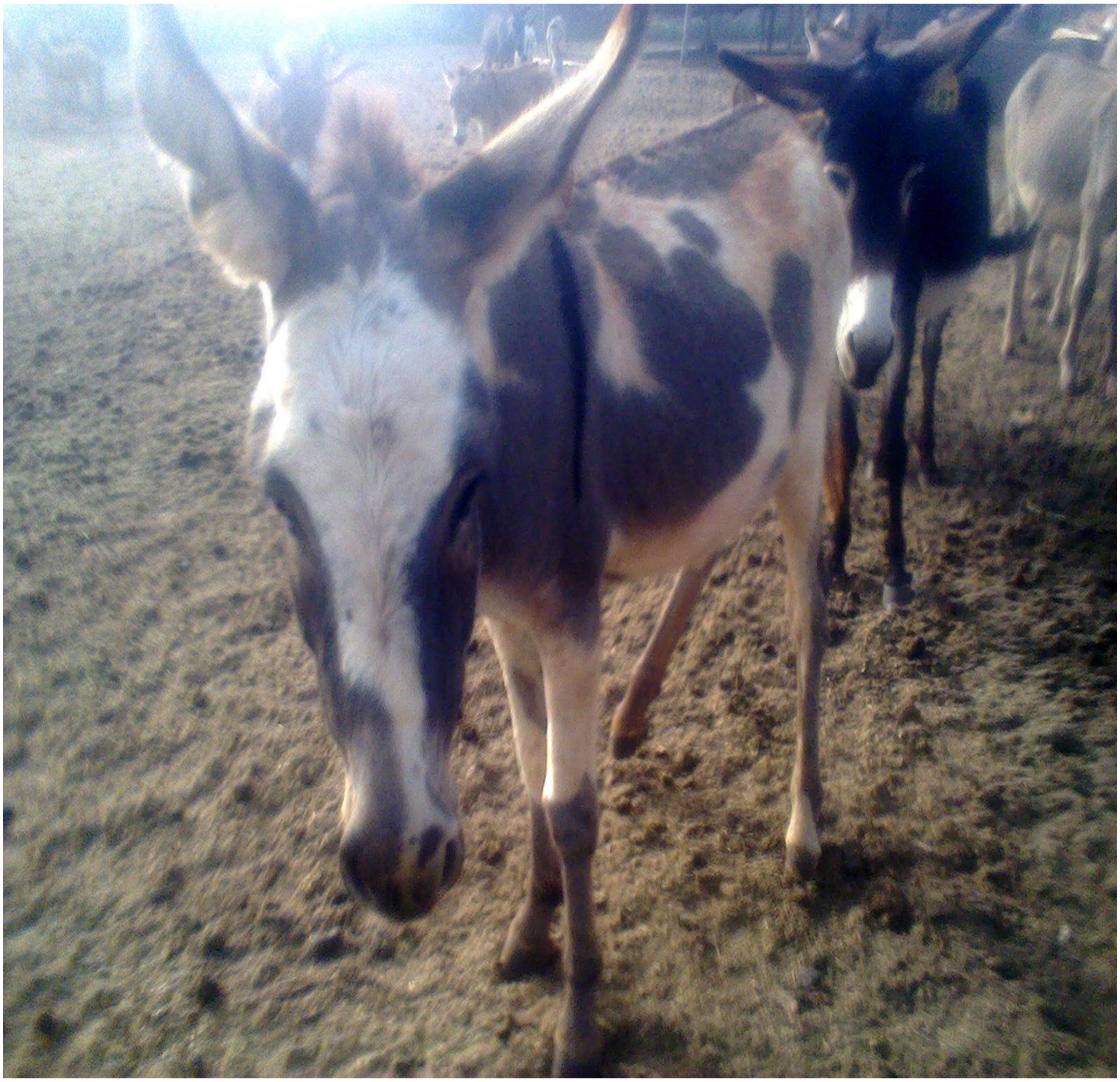


Plate 2.5: Idabari-fari(Brown-white) Donkey

2.3.6 Method of Assessing Strain Variation

Visual conformation appraisal of livestock is probably the oldest way of information collection and it played a central role in many breeding associations (Janssens and Vandepitte, 2004). Body measurements have been widely used for estimating animal's live weight especially when there is no access to weighing equipment. The method is more commonly used in cattle (El Khidir,1980), and to a lesser extends in sheep, goats, pigs, and poultry (Lawrence and Fowler, 1997). Body dimensions have been used to indicate breed origin and relationship through the medium of head measurements (Itty *et al*., 1997); or to indicate size. The use of wither height as prime indicator of type is common with beef cattle because it indicate long time bone growth (Wilson, 1989).

Body measurement and indices estimated from combinations of conventional and non-conventional body parameters provide superior guide to weights and are indicators of type and function in domestic animals (Mason, 1996; Salako, 2006b). Salako (2006a) reported that body measurements and weight measurements, describes more completely an individual or population than do the conventional methods of weighing and grading. Body measurements have been used at various times for the estimation of weights when live weights are measured alongside these parameters.

2.3.7 Live weight, Body measurements, Body conformation traits and factors affecting them

2.3.7.1 Body weight

Weight has been the pivot on which animal production thrives. The knowledge on weight assessment is very necessary because as far as all animal production management is concerned, weight assessment remains the back bone on which it is hinged. The live weight of an animal is important in determining the potential to carry out prescribed draft tasks (Bartholomew et al., 1993). Proper management of donkeys requires the ability to match the animal's live weight to draft tasks required. However, most smallholder farmers have no access to a livestock scale. Therefore there is need to establish simple and practical methods of estimating live weight of donkeys from simple body dimension. A reliable and practical method of estimating live weight is also useful when dosing animals with medicine, in the assessment of the impact of nutritional and veterinary interventions on donkeys and in determining recommendations for load carrying (Pearson and Quassat, 1996).

Body measurement is important for the prediction of live weight, carcass weight and determination of certain body conformation traits that can be take into consideration in selecting animals for genetic improvement (Akpa, 2000). Otaikhian *et al*. (2006) showed that there is a positive correlation between body parameters measured with weight gain. This means that animals at different age groups have differences in measurement of body parts like the distance between the eyes, ear length, ear width, body weight and tail length (Osinowo *et al.*,1989; Otaikhian *et al*., 2006). Animal live weight is an important feature but is seldom measured in rural areas due to lack of dependable accurate scale (Mayaka *et al.,* 1995). Scales are not readily available in most rural African farming communities (Nesamvuni *et al*., 2000)

However quantitative measures for animal conformation are desirable as it will enable reliable genetic parameters for these traits to be estimated and permit their inclusion in breeding programme (Ibe, 1989). Lawrence and fowler (1997) reported that live weight is probably the most widely used technique both in practices and in experimental work, in determining the growth rate in animals and in predicting their body composition and therefore the rate at which various tissues grow.

2.3.8 Phenotypic Characterization

2.3.8.1Morphometric characteristics

This involves baseline surveys to establish identities and characteristics of individual populations; range of existing breeds and strains, productivity and management systems (ILRI, 2011). Primary characterization refers to activities that can be carried out in a single field visit e.g. visual obsevation of morphological features, interviews with livestock keepers and measures of geographical distribution. Advanced characterization however requires repeated visits; to assess activities such as reproductive performance, growth rate, milk production and adaptive capacities of breeds etc. in specified production environments (CGRFA, 2011). Phenotypic characterizations (an aspect of primary characterization) involves skeletal and tissue measurements. Skeletal aspect includes height and length measurements; while tissue assessment involves heart girth, chest depth, punch girth, width of hips etc. (Udeh *et al.,* 2011; Essien and Adesope, 2013).

The understanding of developmental patterns of breeds can be achieved through phenotypic characterization (Orheruata and Olutogun, 1994). Phenotypic characterization is also useful for documenting diversity within and between breeds (CGRFA, 2011). It further allows conclusions to be drawn on proportionality of traits and maturity (Bene *et al.*, 2007). It has been suggested that before attempting any genetic improvement, animals must first be characterized (Mbap, 1985). A comparison of values before and after could be used to assess breeding goals (Zechner *et al.,* 2001). Furthermore, until there is proper information on phenotypic and genetic characterization of indigenous breeds, no rational decision can be made regarding their utilization and conservation (ILRI, 2009a)

Characterization of livestock genetic resources is the first step to sustainable use (Lanari *et al*., 2003). According to the FAO (2009), the global strategy involves identifying and understanding the unique genetic resources in a particular region and developing the proper use of the diversity (Franklin, 1997). Diversity is fully elucidated through characterization. At phenotypic level, using conventional and non-conventional body parameters (Salako, 2006), linear body measurements can be taken and statistically translated into breeding value (Alphonsus *et al.*, 2011). These breeding values are applied to production traits and use in breeding profitable herd through selection. Martins *etal*. (2009) also stated that morphometric measurements are applied to evaluate the characteristics of various breeds of animals and thus provide information on their suitability for selection. Tolenkhomba *et al*. (2012) further asserted that body measurements could objectively improve selection for growth by enabling breeders to recognize early and late maturing animals of different sizes.

Characterization of donkeys would therefore provide information that would be useful in decision making on development and breeding programmes for these breeds and, their effective utilization. It would also enable the design of suitable production equipment for the breeds. Furthermore, characterization would provide inventory for research institutes, academics, breeders and traditional donkey owners.

2.3.8.2Morphological characteristics

Morphological characters provide useful information used to detect genetic relationships of strains in different domesticated animal species (Jordana *et al*., 1993; Herrera *et al*.,1996). Genetic diversity and similarity among and within strains have been determined using morphometric differences (Rey *et al*., 1995; Herrera *et al*., 1996). For instance, Mukeherjee *et al* (1997) used body length and chest circumference, to show significant differences between brown and grey Bengal goat breeds. Similarly, Herrera *et al*., (1996) successfully used, shin circumference, heart girth, chest depth, rump length, and width and shoulder height to determine differences between five goat breeds in Spain. Since variation in mature body weight is considerable even among breeds with similar withers height, it was used to estimate phylogenetics relationships between some Spanish goat breeds. (Jordana *et al*., 1993; Herrera *et al*., 1996; Zaitoun et al., 2005).

Multifactorial discriminant analysis of morphological characters measured from adequately large sample sizes was successfully used to estimate overall genetic variation within and between goat populations, (Jordana et al., 1993; Herrera et al., 1996; Zaitoun et al., 2005).

In the South and Southeast Turkey, morphological study showed that 31.4 per cent of 194 donkeys were grey, 24.7 per cent were white, 23.7 per cent black and 20.1 per cent brown(Yilmaz and Ertugrus, 2011). In the Igdir area of Eastern Turkey 54.3 per cent of 94 donkeys were grey, 7.4 per cent white, 18.1 per cent black and 20.2 per cent brown (Yilmaz and Ertugrul, 2011). The Catalonian donkey breed is characterized by large-size and elongated animals with a concave profile. The coat colour is a black colour with characteristics fadings in the muzzle, orbial zone of the eyes, belly and internal face of the extremities (Folch and Jordana, 1997).

1.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

The study was carried out in the Northwest of Nigeria. The states are Sokoto, Jigawa, Kano, Katsina, Kaduna, Zamfara and Kebbi State. These States in North West Nigeria were selected for this study because of existence of high population of donkeys. All the three senatorial zones in each of the seven States were covered in this study.

Sokoto State. (Figure 3.1. Map showing Sokoto State and the selected LGAs) is located in Sudan savanna zone in the extreme North-Western Nigeria, between longitude 4º8′ E and 6º 54′ E and latitude 12º N and 13º 58′ E (Mamman *et al.*, 2000). It shares common boundaries with Niger Republic in the North; Kebbi State to the South-West and Zamfara State to the East. The humidity in January is less than 20% and between 20-40% in the Southern areas. The mean annual rainfall is 750mm and potential evapotranspiration rates have been reported to be 162cm (Mammam *et al.*, 2000). The annual mean temperature is 34.9 with highest temperature recorded in April (41.0) and the minimum temperature (13.2) occurring in January (Mamman *et al.*, 2000)

Kaduna State. (Figure 3.2. Map showing Kaduna State and the selected LGAs) is located on the Southern end of the high plains of Northern Nigeria, bounded by parallels of $9^o3′$ N and $11^o32′$ N, and extends from the upper River Mariga on $6^o5′$ E to 8^o 48′ E on the foot slopes of the scarp of Jos Plateau (Udo, 1970). The bedrock geology is predominantly metamorphic rocks of the Nigerian Basement Complex consisting of biotite gneisses and older granites. In the southern corner, younger granites and bathyliths are evident. The state experiences a tropical continental climate with distinct seasonal regimes, oscillating between cool to hot dry and humid to wet. These two seasons reflect the influences of tropical continental and equatorial maritime air masses which sweep over the entire country. However, the seasonality is pronounced with the cool to dry season being longer, than the rainy season.

Kano state. (Figure 3.3.Map showing Kano State and the selected LGAs). The state lies between longitude 9º 30′ and 12º 30′ North and latitude 9º 30′ and 8º 42′ East in the Sudan zone of Nigeria. The state is bordered by neighboring state such as Bauchi to the South East, Kaduna to the South West, Jigawa to the North East and Katsina to the North West respectively. Kano has two seasons, a wet season made up early (May, June, July) and late (August, September, October) rainy seasons and a dry season made up of early (November, December, January) and late (February, March, April) dry seasons. The annual rainfall and temperature range between 787 and 960mm and 21^{oC} and 39^{oC} respectively (KNARDA., 2001). The people of Kano state are mainly traders, farmers and civil servants.

Katsina State. (Figure 3.4. Map showing Katsina State and the selected LGAs) covering an area 23,938sq km., is located between latitudes $11^{o}8'$ and $13^{o}22'$ N and longitudes $6^{o}52'$ E and $9^{o}20'$ E. The state is bounded by Niger Republic to the North, by Jigawa and Kano states to the East, by Kaduna state to the South and by Zamfara State to the West. Katsina State forms part of the extensive plains known as the high plains of Hausa land.

The State is composed of undulating plains which generally rise gently from 360m in the North East around Daura, to 600m around Funtua in the Southwest. Generally, the state has two geological regions. The South and central parts of the state are underlain by crystalline rocks of the Basement Complex (from Funtua to DutsinMa), but in the Northern parts cretaceous sediments overlap the crystalline rocks.

The Katsina Daura plains lie at a lower base level than other parts of the state. South wards of the Katsina Daura plains, is the flat to gently undulating surface which is the end result of the years of erosion action on the surface rock. In areas around Funtua and DutsinMa, there are numerous Quartzatic and granitic hills which rise 60200m above the surrounding plains. These hills are probably the result of the intrusion of older granites into the basement complex which have undergone long periods of denudation (Buchanan and Pugh, 1955).

Jigawa State. (Figure 3.5. Map showing Jigawa State and the selected LGAs) is situated in the North Western part of the country between latitudes 11.00ºN to 13.00ºN and longitudes 8.00ºE to 10.15ºE. Kano and Katsina State border Jigawa to the West, Bauchi State to the East and Yobe State to the North East. To the North, Jigawa shares an international border with Zinder region in the republic of Niger, which is a unique opportunity for cross- border trading activities. The state has a total land area of approximately 22,410 square kilometers. Its topography is characterized by undulating land, with sand dunes of various sizes spanning several kilometers in parts of the State. The Southern part of Jigawa comprises the basement complex while the Northeast is made up of sedimentary rocks. The main rivers in Jigawa are Hadejia, Kafin Hausa, and Iggi rivers with a number of tributaries feeding extensive marsh lands in Northeastern part of the state (Usman *et al*., 2013).

Zamfara State. (Figure 3.6. Map showing Zamfara State and the selected LGAs) has general elevation of land which ranges from 244m to 366m above sea level. The hottest months in Zamfara State are March and April. The onset of rains brings a cooling effect with temperature dropping to below 36ºC (90ºF). The mean annual rain fall in the state varies slightly, from the Northern to the Southern parts of the State. For example, Gumir records an average of 579mm of rainfall, Talata Marafa records 798mm, KauraNamoda 990mm and

Moriki 1,020mm. The onset of the rains, on the average, is between mid-March and May, lasting for about six months till the end of October.

Kebbi State. (Figure 3.7. Map showing Kebbi State and the selected LGAs) is a state in North Western Nigeria with its capital at Birnin Kebbi. The State was formed from part of Sokoto State in 1991. Kebbi state is bordered by Sokoto State, Dosso region in the republic of Nigeria and the nation of Benin. Kebbi State can be divided into three relief regions, namely the high plains in the South and South East, the plain landscape in the North and the riverine lowland of the Niger and lower Rima valleys. The high plains are characterized by dissected crystalline rocks with hill ranges and domical rises (inselbergslt) has a total area of 36,800km2.

The state has Sudan and Sahel-Savannah. The Southern part is generally rocky with the traversing the state from Benin to Ngaski LGA. The Northern part of the state is sandy with the Rima River passing through Argungu to Bagudo LGA where it empties into the Niger. Agriculture is the main occupation of the people especially in rural areas, Crops produced are mainly grains; animal rearing and fishing are also common. There are 225 political wards, 3000 settlements and 1036 hard to reach settlements in the 21 Local Government Areas in the State. The location of Kebbi state in Nigeria is between 11º30′ N 4º00′ E (Lage, 2009)

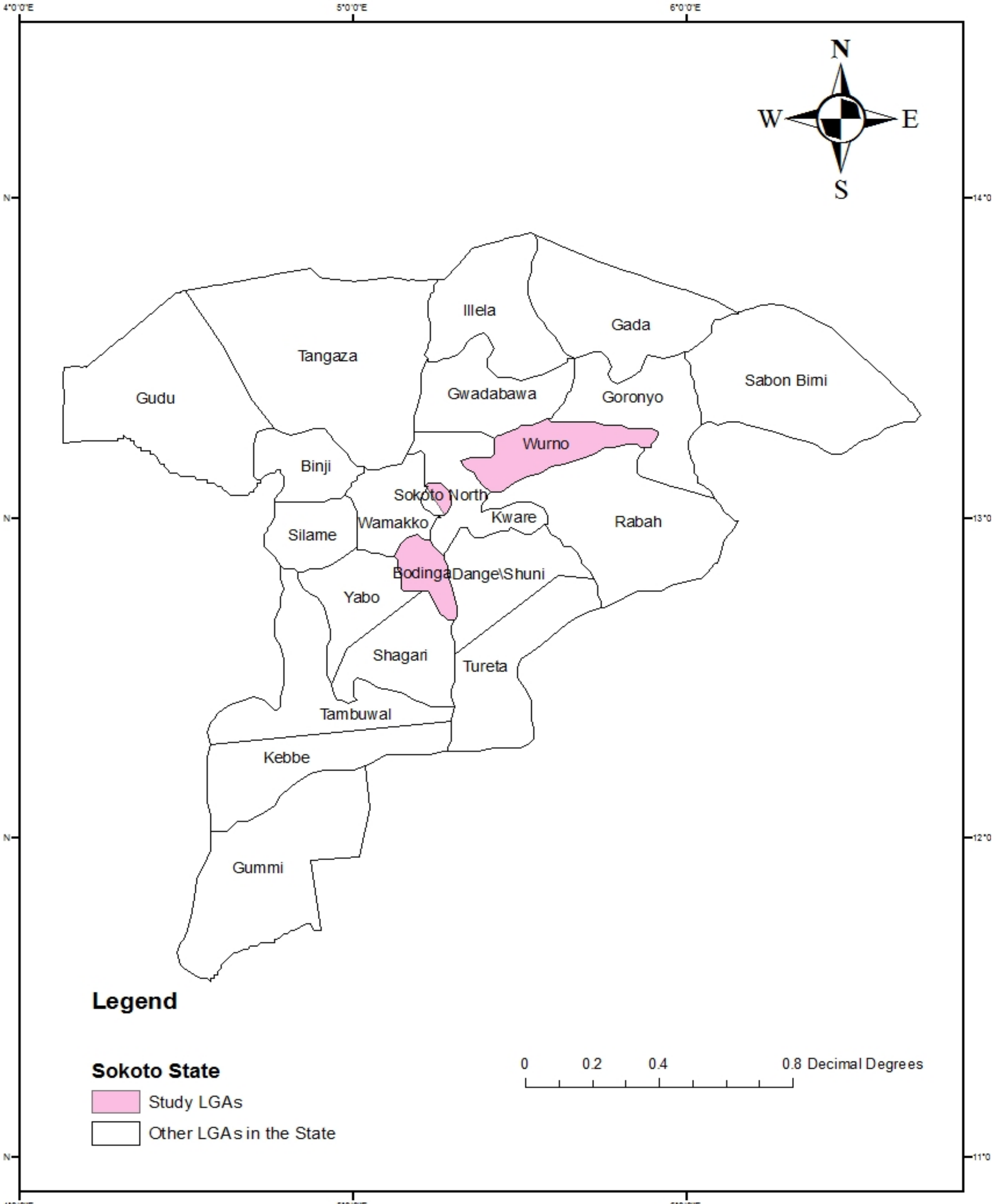


Figure 3.1 Map of Sokoto State showing sampling locations

Source: Sokoto State Urban Planning Development Authority (SOSUPDA), 2015

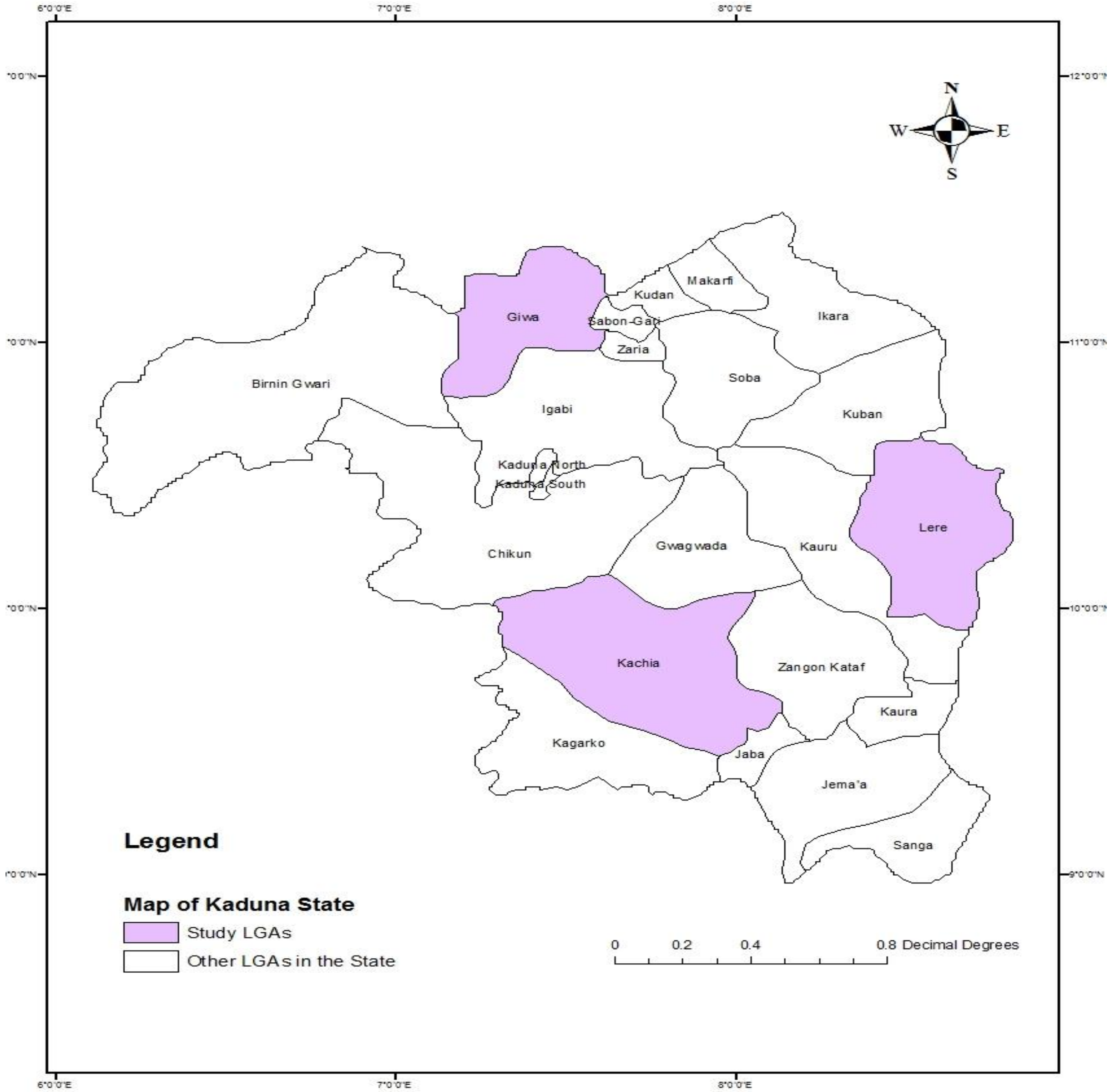


Figure 3.2 Map of Kaduna State showing sampling locations

Source: Kaduna State Urban Planning Development Authority (KASUPDA), 2015

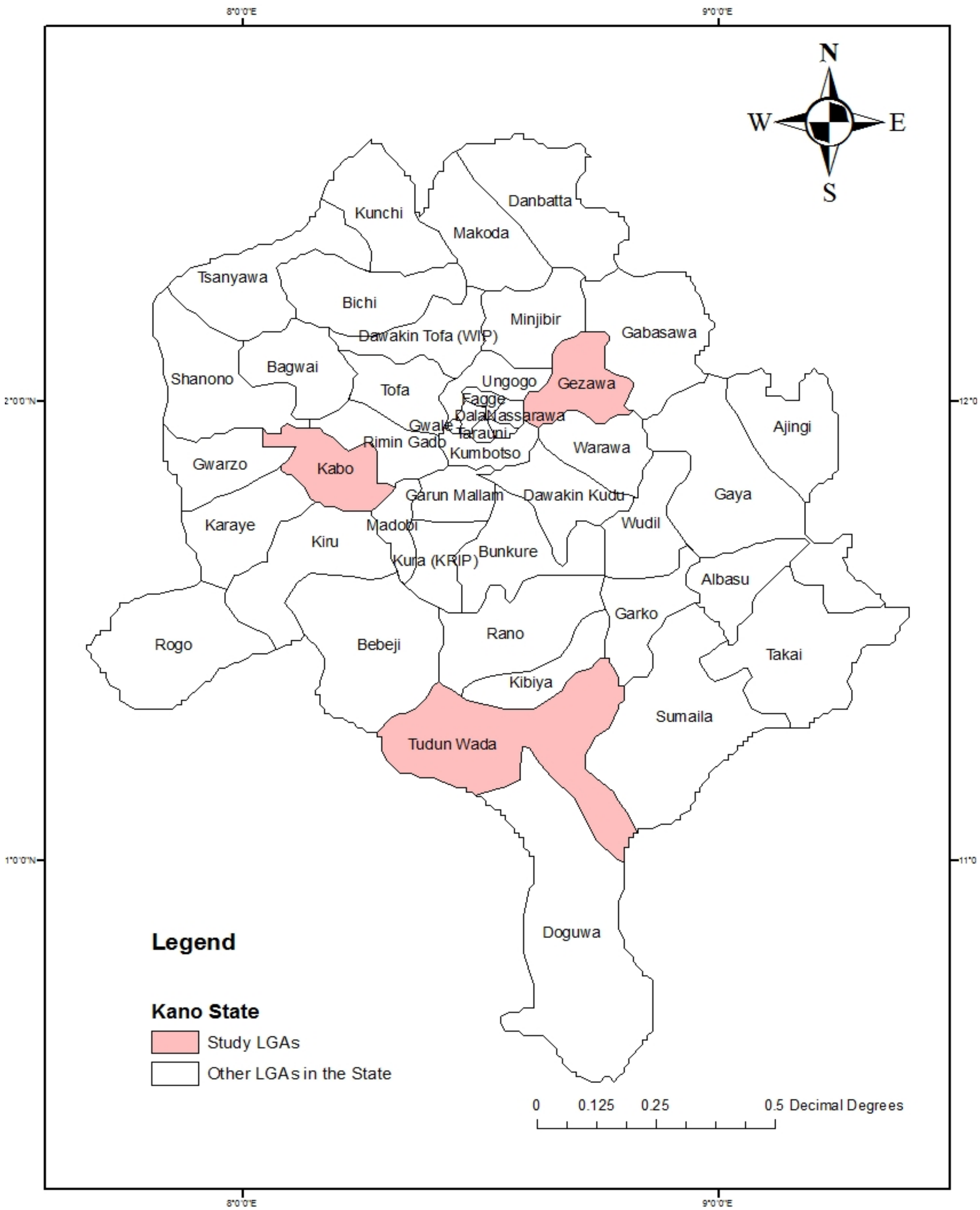


Figure 3.3 Map of Kano State showing sampling locations

Source: Kano State Urban Planning Development Authority (KANSUPDA), 2015.

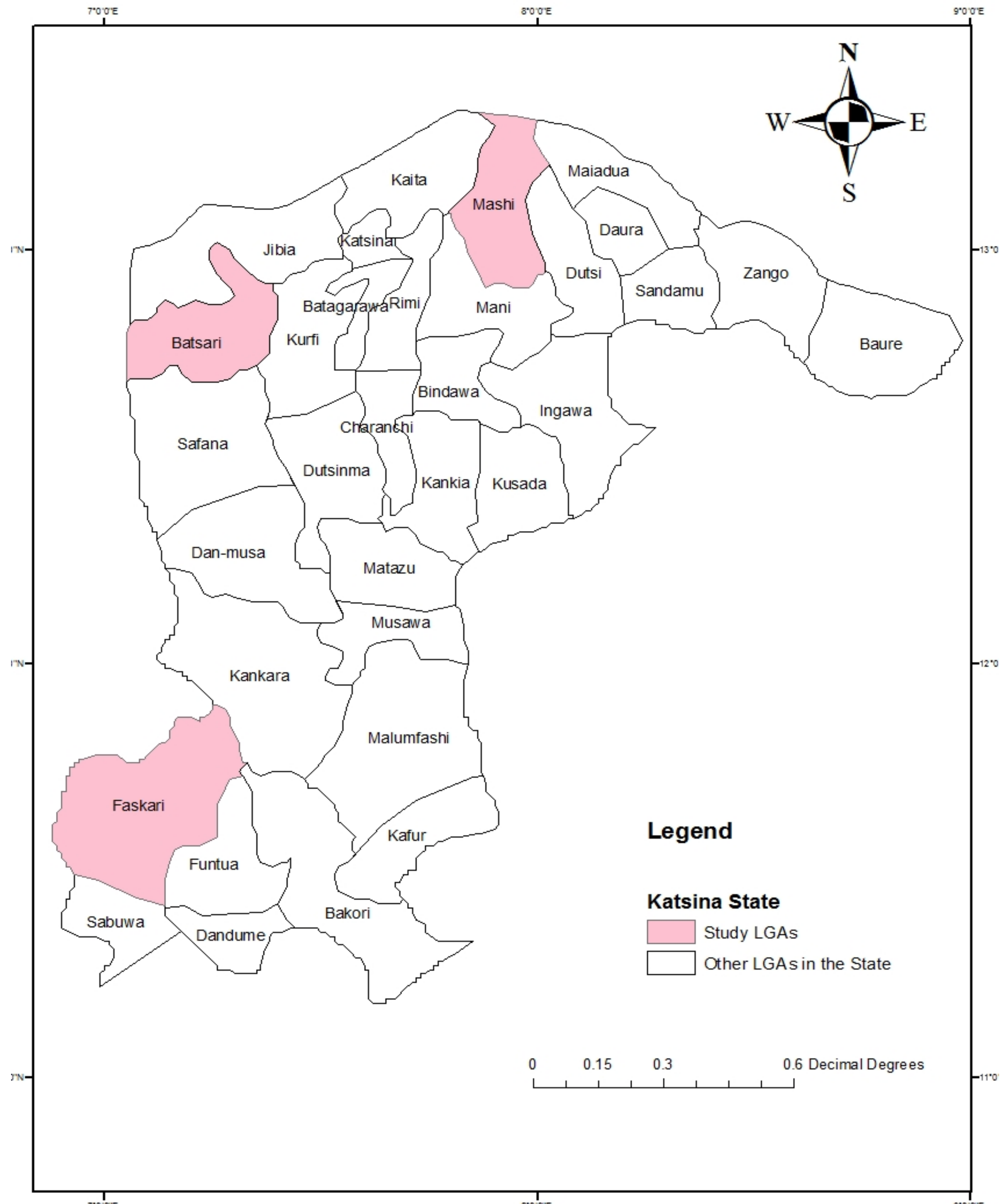


Figure 3.4 Map of Katsina State showing sampling locations

Source: Katsina State Urban Planning Development Authority (KATSUPDA), 2015

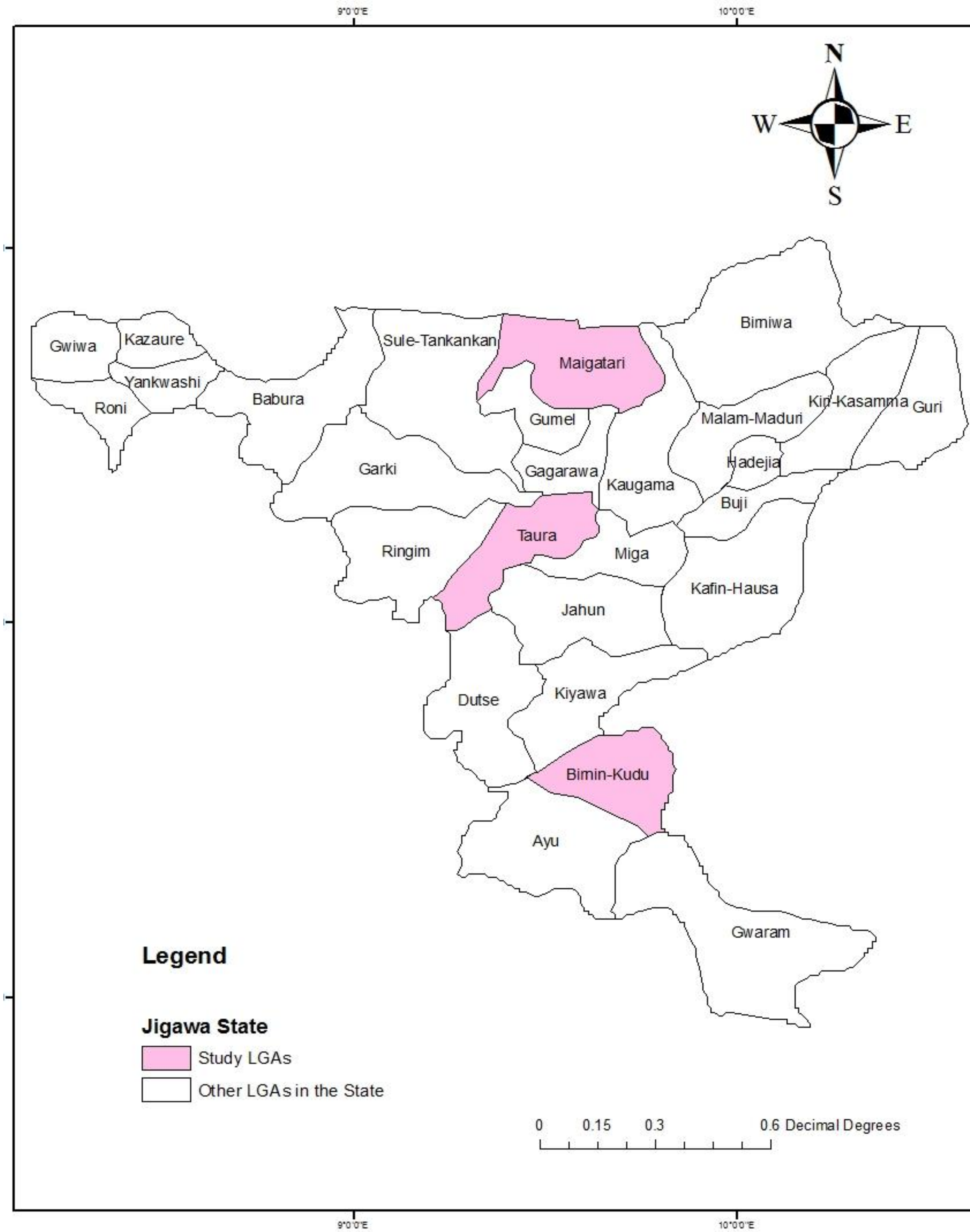


Figure 3.5 Map of Jigawa State showing sampling locations

Source: Jigawa State Urban Planning Development Authority (JISUPDA), 2015

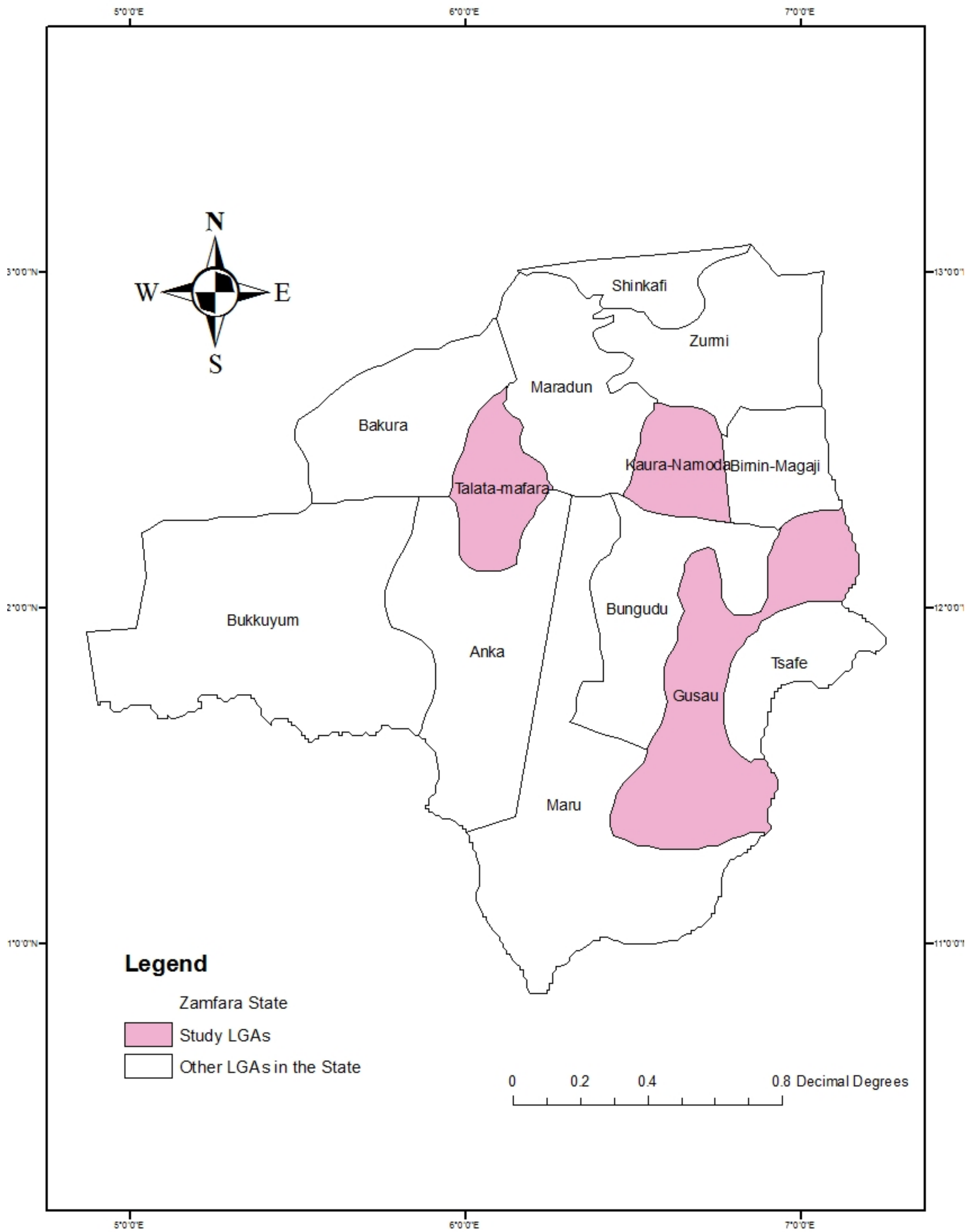


Figure 3.6 Map of Zamfara State showing sampling locations

Source: Zamfara State Urban Planning Development Authority (ZASUPDA), 2015.

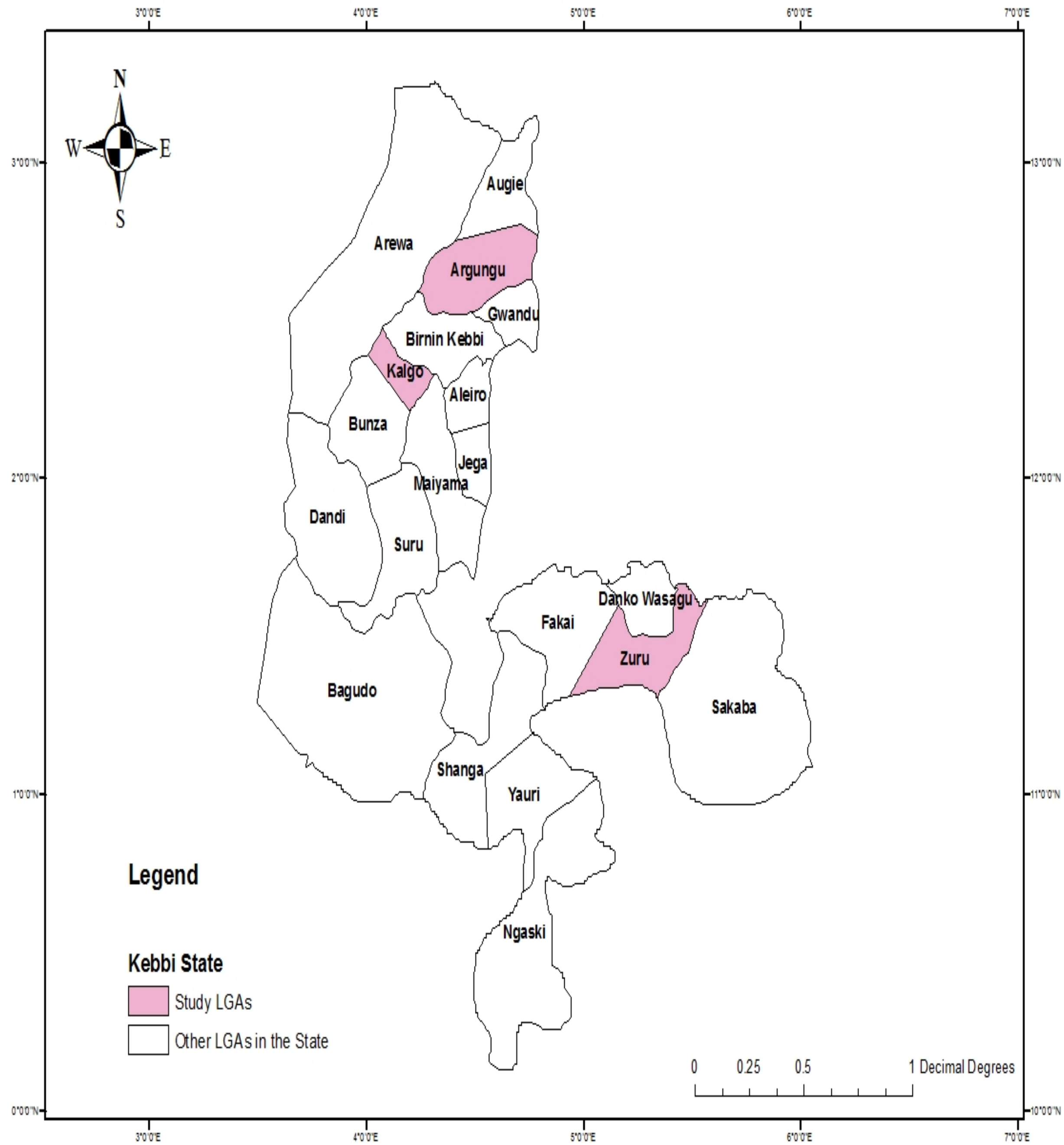


Figure 3.7 Map of Kebbi State showing sampling locations

Source: Kebbi State Urban Planning Development Authority (KESUPDA), 2015.

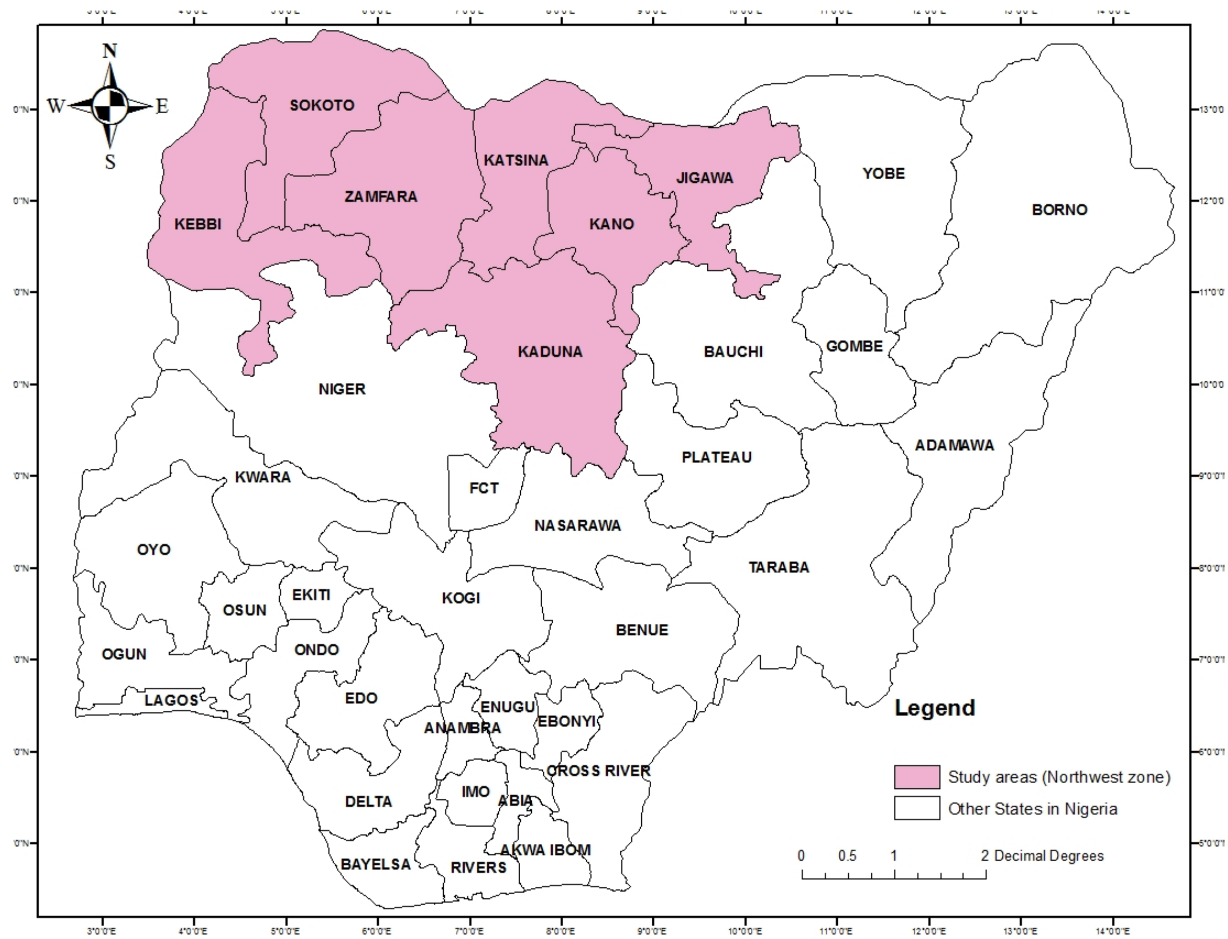


Figure 3.8: Map of Nigeria showing seven (7) States where the research was conducted

3.2 Sampling Size and Sampling Structure

A simple random sampling method was used to determine or measure donkeys, using their morphological or morphometric traits within a given senatorial zone. A total of seven hundred (700) donkeys were used for this study. Thirty three (33) donkeys were randomly selected from two different senatorial zone, thirty four (34) were also selected randomly in another zone in a particular state. A total of one hundred (100) donkeys, are weaners, young and adults were observed and measured in each of the seven (7) states.

The weaners, young and adults, males and females were observed and measured in almost equal number. Thirty three (33) weaners, young and adults, males and females were used in two (2) senatorial zones. Thirty four (34) donkeys were however, observed and measured in the third senatorial zone to make a total of 100 donkeys to be sampled per State.

3.3 Age Determination

Ages of donkeys were determined by using teeth count. The teeth on the upperand lower jaw were counted and added to give the total number of teeth of the animal. For instance, to determine the age of weaners, which ranged from 6 months – 1year, the teeth on the upper and the lower jaw were counted as shown by the formula; I 4/4+ PM 3/3=14. For the ones that is 1year, I 6/6 + PM 3/3 + M 3/3= 18. For young donkeys above 1 to 3 years, I 6/6 + PM 4/4 + M 1/1= 22, for 3 years young donkeys, I 6/6 + PM 4/4 + M 2/2 = 24. For the adult donkeys above 3years, I 6/6 + C1/1 + PM 6/6=26, I 6/6 + C2/2 + PM 6/6 = 28.Therefore, the range of teeth for weaner donkeys is 14-18, young 22-24 and aduts 26-28.Where I (incisor), C (canine), PM (premolar) and M (molar).Age of donkeys were also determined by the information provided by donkey owners. The classifications of donkeys on the basis of their age are as stated in the table below. Donkeys were allowed to graze freely under extensive system and were fed on fresh/dry grasses or hay and straws. Donkeys obtain most of their energy from structural carbohydrates. Some were fed only straw (preferably barley straw, supplemented grazing in the summer or hay in the winter) to get all the energy, protein fat and vitamins they required; grains were fed particularly to working donkeys as against feeding straw. They do best when allowed to consume smallamount of food over a long period. Donkeys can meet their nutritional needs on 6 to 7 hours of grazing per day on average dry land pasture that is not stressed by drought. If they worked long hours or do not have access to pasture, they require hay or similar dried forage, with no more than a 1:4 ratio of legumes to grass. They also required salt salt and mineral supplement, and access to clean, fresh water.

Table 3.1: Classifications of donkeys on the basis of their age

Age group	Classification	No of teeth
6 months to 1year	Weaners	14-18
Above 1year to 3 years	Young	22-24
Above 3 years	Adult	26-28

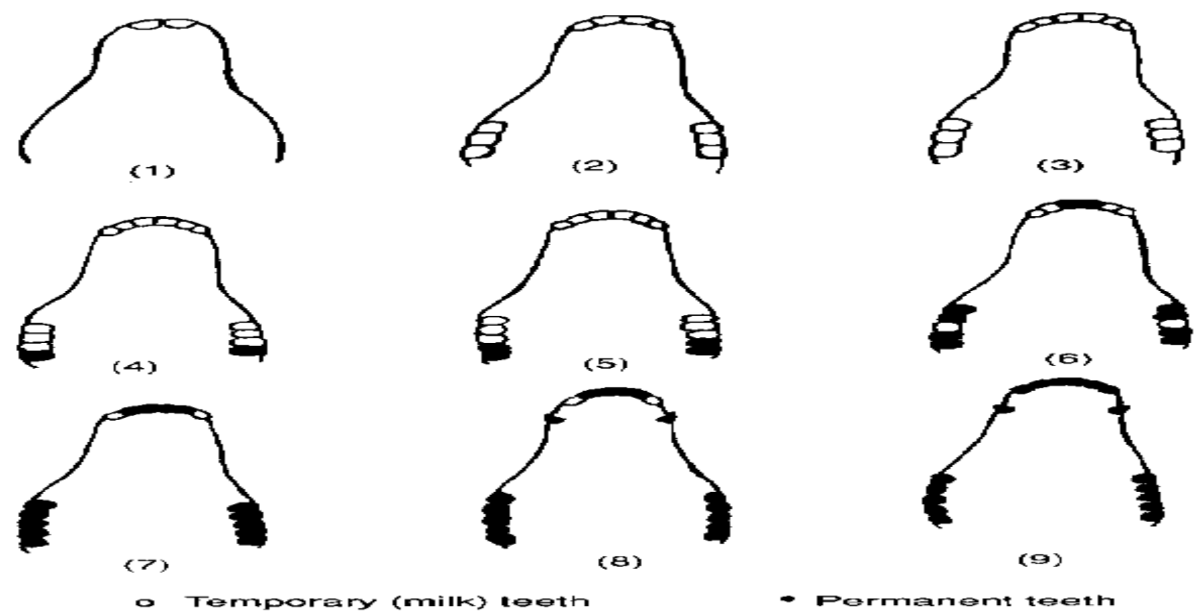


Figure 3.9. Dentition of donkeys

Source: FAO, 2003.

3.4. Data Collection

3.4.1 Phenotypic characterization

3.4.2 Morphological measurement

The morphological characters that were observed on each animal include: hairtype (HT), skin type (ST), coat colour (CC), coat colour pattern (CCP), tail shape (TS),eye colour (EC) and head profile (HP).

Hair Type: This was observed and categorized into Short-Smooth, Short-Rough and Long-Curly (woolly) hair types

Coat Colour Pattern: This was observed and categorized as solid and patched.

Skin Type: This was observed and categorized as thick and thin.

Coat colour: This was observed and categorized as rust or red, dark brown to black, pale cream to white and grey to light medium brown

Tail shape: This was observed and categorized as pendent and high-set.

Eye colour: This was observed and categorized as black, brown and white.

Head profile: This was observed and categorized as sub-concave and straight.

3.4.3 Morphometric measurements

Weights of the animals were measured using prediction equation. Flexible measuring tape was used to take the body measurement. During body measurement, animals were made to stand upright and restrained by assistants in such away that their necks, heads and ears were stretched almost in a straight line. Each measurement was taken for at least two times and recorded to the nearest centimeter or kilogram.

Reference marks for body measurement according to the method of Searle *et al*., (1989a and b), and Salako (2006a) are as shown in (plate 3.1) was adapted.

1. **Body Weight (BWT)**: This was determine using prediction equation (kg)
2. **Head Length (HL)**: Measured as the distance from between the ears to the upper lip (cm).
3. **Head Width (HDW)**: Measured as the distance between the outer ends of both eyes (cm).
4. **Ear length (EL)**: Measured as the distance from the base to the zygomatic arch of the ear (cm).
5. **Neck length (NL)**: Measured as the distance from the base of the cervical vertebra to the base of the top shoulder (cm).
6. **Neck circumference (NC)**: Taken as the circumference of the neck at the midpoint (cm).
7. **Shoulder width (SW)**: Measured as the horizontal distance between the two shoulders or distance between the lateral tuberisities of the humeri which is also described as the widest point over the intraspinus muscle (cm).
8. **Height at Wither (HW)**: Vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones to the fore hoof (cm).

9. **Heart girth (HG)**: Measured as the circumference of the body at the narrowest point just behind the shoulder perpendicular to the circumference of the body, just in front of the hind leg perpendicular to the body axis (cm).

10. **Body length (BL)**: Distance between points of shoulder to point of hip i.e the distance from the first thoracic vertebrae to base of tail. This is also described as the distance between the most cranial palpable spinosus process of thoracic vertebrae and either sciatic tubers or distance between the tops of the pelvic bone (cm).

11. **Tail length (TL)**: Measured from the base of the tail to the tip (cm).

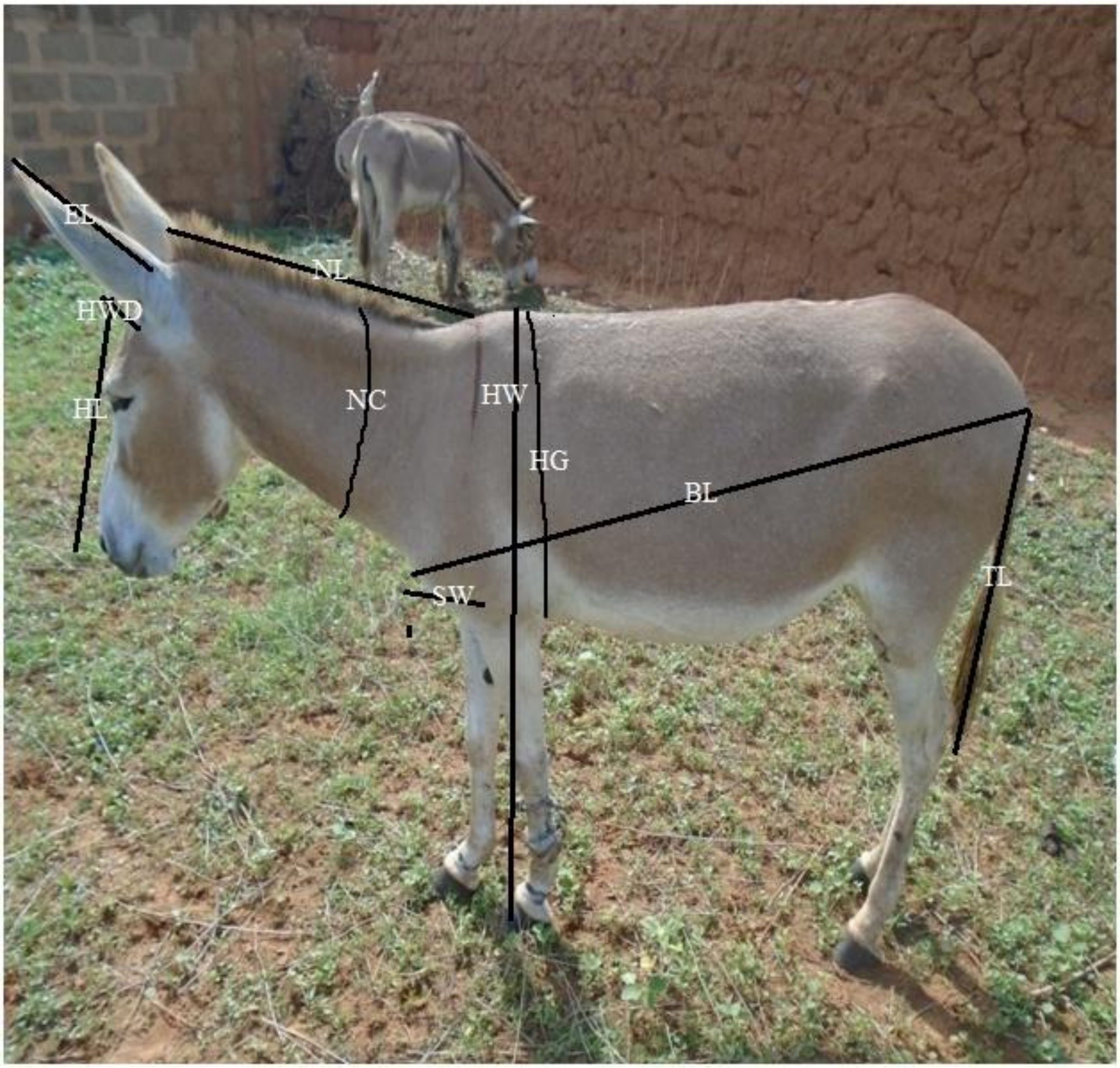


Plate 3.1 Metric measures of donkey

3.4.4 Statistical analysis

For descriptive statistics, frequency counts and Chi Square test of SAS (2004) were used. General Linear Model procedure of SAS (2004) was used to analyze the effect of sex, age, location, strain and interactions as shown in the model below:

$Y_{ijkl}=\mu+S_i+A_i+L_k+V_l+ (V\times S)_{li} + (L\times V)_{kl} +\varepsilon_{ijkl}$

Where Y_{ijkl}=observation of each trait of the ij^{th} Animal.

μ= population mean

S_i=fixed effect of the i^{th} sex (males and females)

A_j= effect of the j^{th} age (weaners, young and adults)

L_k=effect of k^{th} location (Kaduna, Kano, Kebbi, Katsina, Sokoto, Jigawa and Zamfara State)

V_l= fixed effect of l^{th} strain (Auraki, Fari, Duni and Idabari)

$V\times S_{(li)}$= The effect of interaction of l^{th} level of strain, with i^{th} level of sex

$L\times V_{(kl)}$= The effect of interaction of k^{th} location, with l^{th} level of strain.

ε_{ijkl}= residual error

3.4.5 Phenotypic frequency analysis of morphological traits

The distribution of the measured qualitative traits were assessed for significance using Chi-square analysis and computed based on pooled data within strain and sex using the Frequency procedure of R 2.13.0 (R Development Core Team, 2015) statistical package.

$$\text{Chi-square } (x^2) = \frac{(\text{Observed freq} - \text{Expected freq})^2}{\text{Expected freq}}$$

Measures of association between body weight of donkey and linear body measurements were analyzed by Proc Reg of SAS (SAS, 2004). Cluster analysis was used to evaluate morphological traits through the use of principal component analysis in R software (R Core Team, 2015).

3.4.6 Analysis of variance of morphometric traits

The effects of strain, sex, location and certain morphological traits on linear measurement were estimated using the GLM procedure of the statistics analysis system SAS (2004) statistical package. These were computed on the basis of interaction with age groups.Statistically significant means were separated using Duncan Multiple Range Test (DMRT) Duncan, (1955).

3.4.7 Correlation analysis

The degrees of association between all pairs of metric variables were computed for all the animals within each strainswithin age groups using CORR procedure of SAS (2004) statistical package. This was done to evaluate changing magnitude of association among variables.

Correlation coefficient was estimated according to this formular:

σ_{xy} =CoV_{xy}/ $\sqrt{Var_x\ Var_y}$

Where;

$CoVar_{xy}$ = Covariance of traits x and y

Var_x = Variance of trait x

Var_y = Variance of trait y

3.4.8 Principal component analysis of morphometric traits

The Principal component analysis of metric measurements and their contribution to live body weight was evaluated using the Factor Procedure of R 3.0.3 (R Development Core Team, 2015) package for overall pooled data and based on strains, age, sex, location and their interactions.

3.4.9 Principal component analysis procedures

The correlation coefficients of body weight and linear body measurements were determined. From the correlation matrix, data for the principal component factor analysis was generated. According to Everitt*et al.* (2001), principal component analysis was used to transform the variables in a multivariate data set x_1, x_2, ---, xp, into new variables, y_1, y_2,---, y_p which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$y_1 = a_{11}\ x_1 + a_{12}\ x_2 + \text{------------------} + a_{1p}x_p$$

$$y_2 = a_2\ x_1 + a_{22}\ x_2 + \text{-------------------} + a_{2p}x_p$$

$$y_p = a_{p1}\ x_1 + a_{p2}\ x_2 + \text{------------------} + a_{pp}x_p$$

With the coefficients being chosen so that y_1, y_2, ------, y_p account for decreasing proportions of the total variance of the original variables, x_1, x_2, ------, x_p.

Or in matrix form:

$$Y_1 = a'x$$

The a_{ji} are scaled such that $a_1'a_1=1$. Y_1 will accounts for the maximum variability of the p variables of any linear combinations. The variance of Y_1 is $\lambda_{1.}$ The next, principal component Y_1 was formed such that its variance, λ_2 was the maximum amount of the remaining variance and that it is orthogonal to the first principal component. That is,

$$a_i'a_2= 0$$

The components were extracted until some stopping criteria was encountered or until p components are formed. The weights that were used to create the principal components are the eigenvectors of the characteristics equation:

$$(R- \lambda_1 I)a = 0$$

Where R is the correlation matrix. The λ_1 are the eigenvalues, the variances of the components. The eigenvalues are obtained by solving $(R- \lambda_1 I)a = 0$ for $\lambda_{1.}$

In the cause of evaluation, factors were rotated with varimax rotation of Kaiser. The aim of the Varimax rotation was to maximize the sum of variances of a_{ij}^2 quadratic weight. Anti-image correlations, Kaiser – Meyer Olkin measures of sampling adequacy and Barlett's Test of Sphericity was computed to test the validity of the factor analysis of the data sets. The appropriateness of the factor analysis was further tested using communalities and ratio of cases to variables.

The stepwise variable selection multiple regression procedure was used to obtain models for predicting body weight from body measurements (a) and from established Principle component (b).

$BW = a + B_i x_i +$ ---------- Bk x K-------- (a)

$BW = a + B_iPC_i +$ --------- B_kPC_k -------- (b)

Where; BW is the body weight, a is the regression intercept, B_i is the i-th partial regression coefficient of the i^{th} linear body measurement, X_i represents independent variables (i.e body measurements) or PC_i represent the i-th principal component and K represents infinity.

3.4.10 Regression analysis

Stepwise regression procedure was used to find the best linear combination of metric variables that can best predict the live weight. This was performed for each strain of donkey. The following linear multiple regression models were applied.

$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots\ldots b_iX_i$

Where:

Y = the dependent variable (Live weight)

a = the intercept of regression curve on y – axis and is the value of the dependent variable y when all independent variables are Zero.

b_1 = the partial regression coefficient associated with respective independent variable X_1.

X_1= the independent variables (i.e. body measurement) the regression assumes that the Independent variable has no measurement error.

And that the above errors about the regression line are equal. The regression analysis was carried out using the REG procedure of R 2.13.0 (R Development Core Team, 2015) package. Comparism of regression equations were based on coefficient of determination (R^2).

3.4.11 Discriminant analysis

Involves the determination of a linear equation like regression that were predicted the group the case belonged to. The form of the equation or function that were used is:

$D= v_1 X_1+ v_2 X_2+ v_3 X_3 ....v_iX_i+ a$

Where D = discriminate function

v = the discriminant coefficient or weight for that variable

X = respondent's score for that variable

a = a constant

i = the number of predictor variables

3.4.12 Classification analysis

The classification of Auraki, Duni, Fari and Idabari donkeys (by using Euclidean as the distance measurement, Single Linkage, Average Linkage, and Complete Linkage were applied, and the obtained results were compared. The simple discriminant analysis procedure was used to classify the strains using the R 2.13.0 (R Development Core Team, 2015) package. DISCRIM procedure to calculate the probabilities of including an animal in determining the strain, taking into account the error made in classification of the strain. Stepwise discriminant procedure (STEPDISC) was applied to determine, which performance traits were used in the final clustering analysis, this procedure determined the variables that had more discriminating power than the others. The third type of analysis, canonical discriminant analysis (CANDISC procedure), was used to perform uni-and multivariate analysis to derive canonical variables (CAN), which was used to match the donkey strain groups until reached the satisfactory number of clusters (genetic groups) and to show the clustering groups among these four donkey strains. Mahalanobis distances, the canonical coefficients and a scatter diagram for visual interpretation of the different groups were also generated during the canonical discriminant analysis. These distances were used to construct a dendrogram using the unweighted pairs group method analysis implemented in R 2.13.0 (R Development Core Team, 2015).

3.4.13 Cluster analysis

Cluster analysis of qualitative traits of donkeys using UPMGA was used for clustering of the strains using dendrogram in other to determine the relatedness among donkey strains for coat colour, hair type, skin type, coat colour pattern, tail shape, eye colour and head profile.

Distances were used to construct a dendrogram using the unweighted pairs group method analysis implemented in R 2.13.0 (R Development Core Team, 2015) package TREE procedure that prints the dendogram based on the distances between the clusters introduced in PROC CLUSTER procedure.

CHAPTER FOUR

4.0 RESULTS

4.1 Morphological Traits Characterization of Donkeys

Table 4.1 shows the distribution of some observed morphological characteristics in donkeys. In coat colour pattern, two variants were observed in a donkey which was majorly solid (97%). Coat colour was mostly brown (86%) with other colours in rear occurrence (2-5%) with redcoat colour at the most subsistence level (2%). The eye colour is majorly black (95%) with white and brown at rear occurrence (1-4%). Three hair types were observed with short-smooth hair type (75%) being the most popular. The occurrence of short- rough and long-curly was in the range of 11-14%. For skin type, the occurance of thick skin type is three times (75%) that of thin skin type (25%). Majority of the donkeys observed within the Northwest zone of Nigeria had straight head profile (86%) with a minority of them exhibiting sub-concave head profile (14%). The observed tail shape variants were fairly distributed in these donkeys. The occurrence of the pendent shape was superior (58%) to the high-set shape (42%).

However, the reliability on the distribution of measured characteristics differedfrom one characteristicsto the other. There was a high level of reliability for solid (96-98%) coat colour distribution pattern of donkeys in Northwest Nigeria. Brown coat colour had high level of reliability with the occurrence of (85-87%). The eye colour of donkeys in Northwestern Nigeria would more often than not, turn out to be black (93-96%); with brown and white eye colours in rare occurrence (0.1-5%). Hair type shows that there was high confidence that donkeys in Northwestern Zone of Nigeria would exhibit Short-smooth hair type (71-78%) with short-rough hair type showing an intermediate occurrence (11-16%) and long-curly at low occurrence (8-13%). Skin type distribution indicated that thick skin type would always occur in levels high level (71-78%) and thin skin type at moderate occurrence (21-28%). Head profile of donkeys would more often than not be straight (83-88%) with moderate occurrence of sub-concave type (11-16%). The observed two tail shapes of donkeys were in intermediate occurrence in nature. However, the pendent tail shape had higher distribution (53-61%) than high set tail shape (38-46%).

Table 4.1 Distribution of some observed morphological characteristics in donkeys.

Characteristics	N	Variants	Frequency (%)	Confidence level (%)	Chi-square value	LOS
Coat colour pattern	700	-	100		688.05	**
		Solid	97	96-98		
		Patches	3	2-5		
Coat colour	700	-	100		2044.01	**
		Brown	86	85-87		
		Black	5	3-7		
		White	4	3-6		
		Red	2	0.1-1		
		Brown-white	3	2-4		
Eye colour	700	-	100		1227.47	**
		Black	95	93-96		
		Brown	4	2-5		
		White	1	0.1-0.8		
Hair type	700	-	100		555.53	**
		Short-smooth	75	71-78		
		Short-rough	14	11-16		
		Long-curly	11	8-13		
Skin type	700	-	100		179.02	**
		Thick	75	71-78		
		Thin	25	21-28		
Head profile	700	-	100		365.77	**
		Straight	86	83-88		
		Sub-concave	14	11-16		
Tail shape	700	-	100		16.05	**
		Pendent	58	53-61		
		High-set	42	38-46		

LOS; Level of significance, N; Number, (%); Percent, **P□ 0.01.

4.2 Factors Affecting Morphological Traits of Donkeys

Table 4.2: Strain distribution of qualitative traits of donkeys. Significant differences (P□ 0.01) occurred between the populations of some observed morphological traits of donkeys in Northwestern Nigeria. Two coat colour pattern were observed in donkeys with solid coat colour pattern being the most popular and predominantly in brown associated with Brown donkeys. Majority of the donkeys had black (596) eye colour which were recorded in brown donkeys while the least were also recorded in white (1) donkeys. The hair type were predominantly short-smooth which were observed in brown donkeys (473). Donkeys with thick skin type predominated, which were associated with brown colour (465) while the thin skin type was the least, which was associated in brown-white donkeys. Straight head profile were majorly observed in brown donkeys (539) with the sub-concave head profile being the least observed in brown-white (2) donkeys. Pendent tail shape was majorly observed in brown donkeys (354) with the least in brown-white (3) strain.

Table 4.3: Sex distribution of qualitative traits of donkeys. Significant differences (P□ 0.01) existed among all the qualitative traits with the exception of tail length (TL). Solid coat colour occurred more in females than males. It favoured females than males in terms of solid and patches. Coat colour favours females than males irrespective of the strain. White eye colour only occurred in female while the brown eye colour occurred more in males than females and black more in females than males. Short-smooth hair type occurred more in females than males while short-rough and long-curly occurred more in males than females. Skin type showed that whether thin or thick favored females more than males. Head profiles indicate that females are a bit more of straight profile than a male while sub-concave is more popular

in males than females. Tail shape indicates that females exhibits more of the either of the two shapes, that is, pendent and high-set than the male.

Table 4.2: Distribution of morphological traits among donkey strains

				Strais				
Traits	**N**	**Red**	**Black**	**White**	**Brown**	**Brown-white**	X^2	**LOS**
Coat colour pattern	700							
Solid	697	17	34	28	618	0	1507.61	**
Patches	3	0	0	0	0	3	0.00	NS
Eye colour	700							
Black	670	17	31	23	596	3	1994.21	**
Brown	29	0	3	4	22	0	23.66	**
White	1	0	0	1	0	0	0.00	NS
Hair type	700							
Short-smooth	527	10	25	18	473	1	1605.63	**
Short- rough	98	2	6	3	86	1	281.89	**
Long-curly	75	5	3	7	59	1	162.67	**
Skin type	700							
Thick	527	12	29	20	465	1	1537.62	**
Thin	173	5	5	8	153	2	506.97	**
Head profile	700							
Straight	603	13	30	20	539	1	1818.15	**
Sub-concave	97	4	4	8	79	2	229.86	**
Tail shape	700							
Pendent	403	8	16	22	354	3	1161.88	**
High-set	297	9	18	6	264	0	647.61	**

LOS; Level of significant, X^2; C hi-Square, N; Number, **P□ 001.

Table 4.3: Sex distribution of morphological traits of donkeys

		Sex			
Traits	**N**	**Male**	**Female**	X^2	**LOS**
Coat colour pattern	700	-	-	357.04	**
Solid	697	334	363		
Patches	3	1	2		
Coat colour	700	-	-	1046.93	**
Brown	618	298	320		
Black	34	15	19		
White	28	13	15		
Red	17	8	9		
Brown-white	3	1	2		
Eye colour	700	-	-	649.01	**
Black	670	319	351		
Brown	29	16	13		
White	1	0	1		
Hair type	700	-	-	325.09	**
Short- smooth	527	243	284		
Short- rough	98	54	44		
Long- curly	75	38	37		
Skin type	700	-	-	99.95	**
Thick	527	249	278		
Thin	173	86	87		
Head profile	700	-	-	213.26	**
Straight	603	281	322		
Sub-concave	97	54	43		
Tail shape	700	-	-	10.19	NS
Pendent	403	190	213		
High-set	297	145	152		

LOS; Level of significance, NS; Non significant difference at (P□ 0.05), X^2; Chi-Square,

N; Number, **P□ 0.01.

4.3: Morphometric Characterization of Donkeys and Factors Affecting them

Table 4.4: The morphometric characterization of donkeys in Northwestern zone is presented in table 4.4. The table defined 11 measures for 3 stages of growth in donkeys encompassing body weight, head length, head width, ear length, neck length, neck circumference, shoulder width, height at withers, heart girth, body length and tail length. Generally, there were inconsistencies in the variations within the measures at the various stages of growth. Body weight was highly variable at weaner (36.9%) and Adult (70.5%) stages and low at the young (9.4%) stage. The variations in some of the measures were generally low, decreasing as the animals matures. Head length 10.7-3.9%, head width 12.5-6.7%, neck length 10.3-5.1%, neck circumference 10.2-7.1%. The ear length had consistence low variability across the 3 stages of growth (4.9%, 4.7% and 3.6%). Shoulder width had high variability of 15% at the weaner stage with the variability decreasing to low as the animals matured to young (13%) and adult (11%). The height at withers was highly variable at the adult stage (70.1%) but had low variability at weaner (5%) and young (2.8%) stages. The heart girth and body length had low variabilities at the various stages of growth, exhibits a decreasing trend as the animal matures, heart girth (8.2%, 3.9% and 3.9%). However, the tail length of the donkeys exhibited higher variabilities at weaner (20.1%) and the young (14.8%) stages and low at the adult stage (11.7%).

The within age group morphometric characteristics of donkeys by strains are shown in Table 4.5. Body weight had low variability among the morphometric traits of weaner donkeys within Duni strains. Consistent decrease variability were observed in neck length at weaner (3.4%), young (1.8%)and adult (1.2%) stages. In Idabari strains, the variation in some of the morphometric were consistently low as the animal matures across the age categories from weaner to adult. Neck length 0.7-0.3%, neck circumference 0.7-0.4%, shoulder width 1.1-0.7% and body length 0.6-0.2%.The body measures for Auraki strains were highly variable for neck circumference at weaner stage (10.9%), but had low variabilityfor young (3.4%) and adult stages (1.8%) across the age categories.Shoulder width was highly variable (14.3%) at weaner, but decreases to low from young (6.9%) to adult (3.3%) as the animals matures.Similar trend of growth for the morphometric traits measured were also observed in Fari and Idabari-fari.

Table 4.6:The effect of strain on morphometric characteristics of weaner, young and adult donkeys are presented in Table 4.6. The effect of strain on morphometric traits of weaner donkeys were significant (P□ 0.01). The heaviest body weight (115.7±3.06kg) was recorded for brown weaner donkeys. However, the least body weight was recorded for brown-white (52.3±11.00kg). The head length of weaner donkeys were similar for black (40.3±1.43cm) and brown (40.2±0.31cm) strain and were longer than head length of red weaner donkey (33.0±3.21cm). Wide neck circumference was obtained in black (49.1±2.03), white (49.4±1.16cm) and brown (50.2±0.37cm) donkeys. The shoulder width and height at withers were similar across the strains. The largest heart girth (94.7±0.56cm) was obtained in brown donkeys while the smallest heart girth (83.5±4.5cm) was obtained in brown-white donkeys. The longest body lengths were recorded in black (93.8±1.87cm) and brown (92.3±0.55cm) donkeys. Longest tail length (50.3±2.67cm) was recorded in black strain while the shortesttail length was however, recorded in red (35.7±7.79cm) donkeys.

The effect of Strain on morphometric traits of young donkeys showed thatthe body weight and linear body measurements were not significantly affected by strain(P□ 0.05) except for neck length and tail lengths (P□ 0.01). Young donkeys withlonger neck length were observed in red (46.5±1.50cm) and black (46.4±0.84cm) donkeys. The shorter neck length was observed in white (42.8±1.22cm) donkeys. Longer tail length (63.0±2.00cm) was observed in red donkeys while shorter tail length was observed in white (49.9±2.77cm) donkeys and brown (52.7±0.58) young donkeys.

Effect of strain on morphometric traits of adult donkeys showed that strainsignificantly (P□ 0.01) affected neck length, neck circumference and tail length. The brown-white donkey strain had the longest neck length (52.0cm) compared to other trains. The neck circumference of adult donkeys was widest for red (63.9±1.17cm), white (60.5±1.84cm) and brown (62.8±0.27cm) and wider for black (59.5cm) donkeys. The most narrow neck circumference was obtained in brown-white (57.0cm) donkeys. The shoulder width was longer for the solid strains (Red, Black, Brown and White) compared to the mixed strain (brown-white).

Table 4.4.Within age group morphometric characteristics of donkeys

Characteristics	Weaner (N=210)	CV%	Young (N=210)	CV%	Adult (N=280)	CV%
BWT(kg)	114.3±2.92	36.9	115.0±0.75	9.4	142.6±6.01	70.5
HL(cm)	39.9±0.29	10.7	45.3±0.19	5.9	47.4±0.11	3.9
HWD(cm)	12.3±0.11	12.5	13.9±0.09	9.1	15.0±0.06	6.7
EL(cm)	22.9±0.08	4.9	24.2±0.08[b]	4.7	25.0±0.05	3.6
NL(cm)	38.6±0.27	10.3	44.1±0.20	6.7	46.9±0.14	5.1
NC(cm)	50.0±0.35	10.2	57.8±0.30	7.6	62.7±0.27	7.1
SW(cm)	17.5±0.19	15.5	20.8±0.19	13.0	22.8±0.15	11.0
HW(cm)	92.8±0.36	5.7	100.1±0.19	2.8	110.5±4.63	70.1
HG(cm)	94.3±0.53	8.2	105.1±0.29	3.9	111.0±0.26	3.9
BL(cm)	92.0±0.52	8.2	101.9±0.28	4.0	106.6±0.22	3.6
TL(cm)	45.9±0.64	20.1	52.8±0.54	14.8	57.8±0.41	11.7

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, CV; Coefficient of variation, %; percent, N; Number.

Table 4.5a. Within age group morphometric characteristics of donkeys by strains

Traits	**Strain**	**Weaner (N=210)**	**CV%**	**Young (N=210)**	**CV%**	**Adults (N=280)**	**CV%**
	Duni						
BWT		120.7±2.07	1.7	135.2±3.54	2.6	158.1±9.71	6.1
HL		40.3±1.43	3.5	46.3±0.47	1.0	46.9±0.49	1.0
HWD		12.0±1.06	8.8	14.1±0.18	1.3	15.0±0.27	1.8
EL		22.6±0.40	1.8	24.1±0.24	0.1	24.7±0.27	1.1
NL		39.0±1.32	3.4	46.4±0.84	1.8	46.5±0.55	1.2
NC		49.1±2.03	4.1	58.4±1.11	1.9	59.5±1.76	2.9
SW		18.7±1.19	6.4	20.7±0.72	3.5	22.2±0.84	3.9
HW		92.6±2.38	2.6	100.8±0.81	0.8	103.6±0.92	0.9
HG		93.0±2.55	2.7	105.5±0.90	0.9	109.0±1.30	1.2
BL		93.8±1.87	2.0	102.8±0.69	0.7	105.3±1.04	0.9
TL		50.3±2.67	5.3	55.2±1.61	2.9	53.3±2.28	4.3
	Idabari						
BWT		122.3±0.64	0.5	138.5±0.94	0.7	141.2±2.50	1.8
HL		40.2±0.31	0.8	45.2±0.19	0.4	47.4±0.12	0.3
HWD		12.4±0.10	0.8	13.9±0.09	0.6	15.0±0.06	0.4
EL		22.9±0.08	0.3	24.2±0.08	0.3	25.0±0.06	0.2
NL		38.9±0.28	0.7	43.9±0.21	0.5	46.9±0.15	0.3
NC		50.3±0.37	0.7	57.7±0.32	0.6	62.8±0.27	0.4
SW		17.5±0.19	1.1	20.8±0.19	0.9	22.9±0.16	0.7
HW		93.1±0.37	0.4	100.1±0.20	0.2	111.3±5.23	4.7
HG		94.7±0.56	0.6	105.1±0.31	0.3	111.2±0.27	0.2
BL		92.3±0.55	0.6	101.9±0.29	0.3	106.6±0.25	0.2
TL		45.9±0.68	1.5	52.7±0.58	1.1	57.9±0.43	0.7
	Auraki						
BWT		107.2±2.80	2.6	125.6±7.13	5.7	141.1±3.78	2.7
HL		33.0±3.21	9.7	46.0±1.00	2.2	47.4±0.36	0.8
HWD		11.7±0.33	2.7	14.5±0.50	3.4	15.3±0.26	1.7
EL		22.0±0.58	2.6	24.5±0.50	2.0	25.3±0.22	0.9
NL		32.3±2.67	8.3	46.5±1.50	3.2	46.7±0.48	1.0
NC		44.3±4.81	10.9	58.0±2.00	3.4	63.9±1.17	1.8
SW		16.3±2.33	14.3	21.5±1.50	6.9	22.8±0.75	3.3
HW		89.7±3.71	4.1	101.5±0.50	0.5	104.1±0.84	0.8
HG		93.0±6.08	6.5	105.5±0.50	0.5	110.1±1.37	1.2
BL		87.3±7.26	8.3	103.5±0.50	0.5	107.4±1.01	0.9
TL		35.7±7.79	2.2	63.0±2.00	3.2	58.9±1.38	2.3

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, CV; Coefficient of variation, %; percent, N; Number.

Table 4.5b. Within age group morphometric characteristics of donkeys by strains

Traits	**Strain**	**Weaner**	**CV%**	**Young%**	**CV%**	**Adults**	**CV%**
	Fari						
BWT		139.9±10.0	7.1	144.4±3.81	2.6	151.6±3.76	2.5
HL		38.0±1.28	3.4	44.0±1.29	2.9	47.6±0.68	1.4
HWD		11.8±0.33	2.8	13.6±0.44	3.2	14.5±0.38	2.6
EL		22.6±0.34	1.5	23.9±0.51	2.1	25.1±0.52	2.1
NL		36.3±1.26	3.4	42.8±1.22	2.9	46.5±0.87	1.9
NC		49.4±1.16	2.3	58.1±1.24	2.1	60.5±1.84	3.0
SW		16.7±1.01	6.0	19.6±1.12	5.7	20.6±0.94	4.6
HW		90.3±2.03	2.2	99.2±1.49	1.5	102.8±0.70	0.7
HG		91.4±2.19	2.4	104.3±1.74	1.7	110.1±1.37	1.2
BL		89.0±2.19	2.5	101.1±2.38	2.3	107.8±1.01	0.9
TL		45.0±2.67	5.9	49.9±2.76	5.5	57.0±3.38	5.9
	Idabari-fari						
BWT		141.3±12.6	8.9	-	-	147.4	-
HL		36.5±1.50	4.1	-	-	46.0	-
HWD		10.5±0.50	4.8	-	-	16.0	-
EL		23.0±1.00	4.3	-	-	26.0	-
NL		37.0±1.00	2.7	-	-	52.0	-
NC		45.5±3.50	7.7	-	-	57.0	-
SW		15.0±1.00	6.7	-	-	17.0	-
HW		86.5±2.50	2.9	-	-	107.0	-
HG		83.5±4.50	5.4	-	-	115.0	-
BL		80.0±4.00	5.0	-	-	108.0	-
TL		45.5±3.50	7.7	-	-	60.0	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, Coefficient of variation, %; percent, N; Number.

Table 4.6. Effect of strain (coat colour) on morphometric characteristics of weaner, young and adult donkeys

Age group/Strain	N	Red (N=3)	Black (N=10)	White (N=11)	Brown (N=184)	Brown-white (N=2)	SEM	LOS
Weaner	**210**							
BWT(kg)		89.6±35.29^{ab}	111.4±15.92^{a}	111.9±12.24^{a}	115.7±3.06^{a}	52.3±11.00^{b}	18.79	**
HL(cm)		33.0±3.21^{b}	40.3±1.43^{a}	38.0±1.28^{ab}	40.2±0.31^{a}	36.5±1.50^{ab}	1.87	**
HWD(cm)		11.7±0.33	12.0±1.06	11.8±0.33	12.4±0.10	10.5±0.50	0.64	NS
EL(cm)		22.0±0.58	22.6±0.40	22.5±0.34	22.9±0.08	23.0±1.00	0.51	NS
NL(cm)		32.3±2.67^{b}	39.0±1.32^{a}	36.3±1.26^{ab}	38.9±0.28^{a}	37.0±1.00^{ab}	1.74	**
NC(cm)		44.3±4.81^{b}	49.1±2.03^{a}	49.4±1.16^{a}	50.2±0.37^{a}	45.5±3.50^{b}	2.26	**
SW(cm)		16.3±2.33^{a}	18.7±1.19^{a}	16.7±1.01^{a}	17.5±0.19^{a}	15.0±1.00^{b}	1.20	**
HW(cm)		89.7±3.71^{a}	92.6±2.38^{a}	90.3±2.03^{a}	93.1±0.37a	86.5±2.50^{b}	2.34	**
HG(cm)		93.0±6.08^{ab}	93.0±2.55^{ab}	91.4±2.19^{ab}	94.7±0.56^{a}	83.5±4.50^{b}	3.42	**
BL(cm)		87.3±7.26^{ab}	93.8±1.87^{a}	89.0±2.19^{ab}	92.3±0.55^{a}	80.0±4.00^{b}	3.35	**
TL(cm)		35.7±7.79^{b}	50.3±2.67^{a}	45.0±2.67^{ab}	45.8±0.68^{ab}	45.5±3.50^{ab}	4.09	**
Young	**210**	**Red (N=2)**	**Black (N=13)**	**White (N=9)**	**Brown (N=186)**	**Brown-white**	**SEM**	**LOS**
BWT(kg)		118.8±0.84	115.7±1.85	112.3±5.49	115.1±0.79	-	4.88	NS
HL(cm)		46.0±1.00	46.3±0.47	44.0±1.29	45.2±0.19	-	1.19	NS
HWD(cm)		14.5±0.50	14.1±0.18	13.6±0.44	13.8±0.09	-	0.57	NS
EL(cm)		24.5±0.50	24.1±0.24	23.9±0.51	24.2±0.08	-	0.51	NS
NL(cm)		46.5±1.50^{a}	46.4±0.84^{a}	42.8±1.22^{b}	43.9±0.21^{ab}	-	1.30	**
NC(cm)		58.0±2.00	58.4±1.11	58.1±1.24	57.7±0.33	-	1.98	NS
SW(cm)		21.5±1.50	20.7±0.72	19.6±1.11	20.8±0.19	-	1.21	NS
HW(cm)		101.5±0.50	100.8±0.80	99.2±1.49	100.1±0.20	-	1.27	NS
HG(cm)		105.5±0.50	105.5±0.90	104.3±1.74	105.1±0.31	-	1.89	NS
BL(cm)		103.5±0.50	102.8±0.69	101.1±2.38	101.9±0.29	-	1.84	NS
TL(cm)		63.0±2.00^{a}	55.2±1.61^{ab}	49.9±2.77^{b}	52.7±0.58^{b}	-	3.47	**
Adults	**280**	**Red (N=12)**	**Black (N=11)**	**White (N=8)**	**Brown (N=248)**	**Brown-white (N=1)**	**SEM**	**LOS**
BWT(kg)		139.3±4.29	137.4±3.90	134.9±4.51	143.2±6.77	147.4	45.35	NS
HL(cm)		47.4±0.36	46.9±0.49	47.6±0.68	47.4±0.12	46.0	0.84	NS
HWD(cm)		15.3±0.26	15.0±0.27	14.5±0.38	15.0±0.06	16.0	0.45	NS
EL(cm)		25.3±0.22	24.7±0.27	25.1±0.52	25.0±0.06	26.0	0.41	NS
NL(cm)		46.7±0.48^{b}	46.5±0.55^{b}	46.5±0.86^{b}	46.9±0.15^{b}	52.0^{a}	1.06	**
NC(cm)		63.9±1.17^{a}	59.5±1.78^{b}	60.5±1.84^{a}	62.8±0.27^{a}	57.0^{c}	1.97	**
SW(cm)		22.8±0.75^{a}	22.2±0.84^{a}	20.6±0.94^{a}	22.9±0.16^{a}	17.0^{b}	1.11	**
HW(cm)		104.1±0.84	103.6±0.92	102.8±0.70	111.4±5.23	107.0	34.89	NS
HG(cm)		110.1±1.37	109.0±1.30	110.5±1.79	111.2±0.27	115.0	1.94	NS
BL(cm)		107.4±1.01	105.3±1.04	107.8±0.92	106.6±0.25	108.0	1.72	NS
TL(cm)		58.9±1.38	53.3±2.28	56.0±3.38	57.9±0.43	60.0	3.03	NS

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Not significant, SEM= Standard Error Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.7.Indicates the effect of sex on morphometric traits of weaner, young and adult donkeys. Sex of weaner donkeys affected (P□ 0.01) body weight (BWT), head length (HL),neck length (NL), neck circumference (NC), shoulder width (SW) and tail length (TL) in weaner donkeys. Other morphometric traits were however not affected by sex (P□ 0.05). Male weaner donkeys had higher body weight (137.76±6.32kg), head length (38.72±0.88cm), neck length (37.93±0.84cm), shoulder width (17.76±0.45cm) and tail length (46.27±1.99) than the females.

Sex affected (p□ 0.01) Body length (BWT), head length (HL), ear length (EL) neck circumference (NC), height at wither (HW), heart girth (HG) and tail length (TL) of young donkeys. Other morphometric traits were however not affected by sex (p□ 0.05). The female young donkeys were superior for BWT (120.19±2.24kg), HW (100.83±0.60cm), HG (106.26±0.89cm) while the male young donkey were superior for HL (45.99±0.55cm), EL (24.24±0.23cm), NC (58.73±0.94cm) and TL (55.34±1.49cm).

Sex significantly affected (p□ 0.01) body weight (BWT), head length (HL), head width (HWD), neck circumference (NC),heart girth (HG) and body length (BL) of adult donkeys. Female adults had higher values than males forBWT (149.68±24.25),HWD (15.46±0.19cm) HG (112.08±0.96cm) and BL (107.87±0.91cm).

The effect of location on morphometric traits of weaner, young and adult donkeys areexpressed in table 4.8. All the traits (body weight and linear body measurements) of weaner donkeys were significantly (P□ 0.01) affected by location. Kano State recorded the heaviest body weight (125.65±7.52kg) with the least body weight coming from weaner donkeys of Katsina (96.54±7.48kg) and Kaduna (93.28±7.24kg) States. The head length (HL) of weaner donkeys in Zamfara (39.98±1.09cm) and Kebbi (40.88±1.09cm) were the longer while the shortest head length was recorded by weaner donkeys in Katsina state (36.79±1.05cm). Head width (HWD) was widest in weaner donkeys from Kebbi state (13.32±0.37cm) while the least value for HWD was recorded in Kaduna state (10.77±0.35cm). Generally, the weaner donkeys from Kebbi state had the longest neck length (39.22±1.03cm), widest neck circumference (51.09±1.29cm) and shoulder width (20.06±0.51cm), highest height at withers (92.97±1.31cm) and longest tail length (49.48cm). However, the neck length (NL) of weaner donkeys from Kebbi state was similar to those from Zamfara. Also, Tail length of weaner donkeys from Kebbi state was similar to those from Sokoto (48.28±2.31cm) and Zamfara (47.18±2.47cm) states.

For young donkeys, all the biometric traits were significantly affected (P□ 0.01) by location. The heaviest body weight was recorded on young donkeys sampled from Kano (118.68±2.77kg), Kebbi (119.03±2.81kg), Sokoto (115.17±2.50kg) and Zamfara (118.40±2.81kg) States.Whereas, the least body weight was recorded for young donkeys in Kaduna (102.44±2.74kg). The head length (HL) of young donkeys in Kaduna (47.27±0.69cm) was the longest while the shortest head length was recorded in Kano (44.46±0.69) and Sokoto (44.48±0.63) states. The widest head width (HWD) in young donkeys was recorded from Kebbi (15.27±0.32cm) state while the least value for HWD was recorded in Jigawa (13.66±0.32cm), Kano (13.49±0.32cm) and Sokoto (13.67±0.29cm) states. Ear length (EL) was longest in young donkeys sampled from Kaduna (24.86±0.28cm) state whereas Jigawa (23.64±0.28cm) and Kano (23.34±0.29cm) states had the shortest EL. The longest neck length (NL) for young donkeys sampled was observed in Jigawa (45.36±0.79cm), which was not significantly different from Kaduna (45.26±0.80cn), Kebbi (45.29±0.82cm), Sokoto

(45.36±0.73cm) and Zamfara (45.28±0.82cm) States. Neck circumference (NC) was wider in young donkeys from Kaduna (59.41±1.17cm), Sokoto (58.92±1.07cm) and Zamfara (59.20±1.19) states while the least was recorded in Jigawa (55.58±1.16cm) state. Generally, the young donkeys from Kebbi state had the highest values for shoulder width (23.42±0.62cm), height at wither (101.66±0.76cm) and body length (104.61±1.12cm). However, the height at wither of young donkeys from Kebbi state was similar (P□ 0.05) to those from Kaduna. Body length of young donkeys from Kebbi state was also similar (P□ 0.05) to those from Kaduna (104.89±1.09cm). The bngest Tail lengths (TL) were recorded in Sokoto (58.65±1.70cm) and Zamfara (58.56±1.91cm) states while the shortest TL was observed in Jigawa (51.99±1.86cm) and Kano (51.20±1.89cm) states.

Effect of location on morphometric traits of adult donkeys was significant (P□ 0.01). An adult donkey with the heaviest body weight was recorded from Kebbi State (176.67±28.08kg). However, the least body weight was recorded in Jigawa (129.80±24.77kg) state. Kano (46.76±0.49cm) and Kebbi (47.90±0.49cm) states were the locations where the longest head length was sampled while the shortest head length was recorded by adult donkeys in Sokoto state (46.53±0.45cm). The widest head width (HWD) for adult donkeys was observed from Kebbi state (16.46±0.22cm) whereas the least value for HWD was recorded in Sokoto state (14.54±0.20cm). Adult donkeys with the longest ear length (EL) was observed in Zamfara state (25.42±0.25cm) while the short EL were however, observed in Jigawa (25.03±0.25cm), Kano (25.07±0.25cm), Katsina (25.07±0.25cm), and Kebbi (24.95±0.25cm) states. The neck length of adult donkeys sampled from Zamfara state (48.31±0.66cm) was the longest, whereas the shortest was recorded in all the remaining states. Generally, the adult donkeys from Kano state had the highest values for neck circumference

(62.06±1.19cm), shoulder width (21.73±0.54cm), body length (107.13±1.06cm) and tail length (57.78±1.63cm). However, the neck circumference of adult donkeys from Kano was similar (P□ 0.05) to those from Katsina. Tail length of adultdonkeys from Kano state was also similar (P□ 0.05) to those from Katsina (57.78±1.63cm), Kebbi (59.11±1.61cm), Sokoto (59.52±1.48cm) and Zamfara state (59.84±1.61cm).

Table 4.7: Effect of sex on morphometric traits of weaner, young and adult donkeys

Age group/traits	N	Male	Female	Overall	SEM	LOS
Weaners(210)						
BWT (kg)	210	137.7±6.32[a]	78.0±5.92[b]	114.33	2.92	**
HL (cm)	210	38.7±0.88[a]	37.6±0.83[b]	39.93	0.29	**
HWD (cm)	210	12.0±0.30	11.9±0.28	12.31	0.11	NS
EL (cm)	210	22.5±0.25	22.6±0.23	22.91	0.08	NS
NL (cm)	210	37.9±0.84[a]	36.6±0.78[b]	37.28	0.17	**
NC (cm)	210	48.4±1.05[a]	47.8±0.98[b]	48.16	0.26	**
SW (cm)	210	17.7±0.45[a]	17.1±0.42[b]	17.46	0.19	**
HW (cm)	210	90.4±1.06	90.5±0.99	92.82	0.36	NS
HG (cm)	210	91.1±1.45	91.5±1.36	94.33	0.53	NS
BL (cm)	210	89.4±1.48	88.9±1.39	92.00	0.52	NS
TL (cm)	210	46.2±1.99[a]	44.3±1.86[b]	45.88	0.64	**
Young (N=210)						
BWT (kg)	210	113.0±2.24[b]	120.1±2.24[a]	115.02	0.75	**
HL (cm)	210	45.9±0.55[a]	45.4±0.56[b]	45.26	0.19	**
HWD (cm)	210	14.2±0.25	14.1±0.26	13.85	0.09	NS
EL (cm)	210	24.2±0.23[a]	23.8±0.23[b]	24.15	0.08	**
NL (cm)	210	44.8±0.64[a]	45.1±0.65[a]	44.98	0.20	NS
NC (cm)	210	58.7±0.94[a]	57.0±0.95[b]	57.90	0.30	**
SW (cm)	210	21.3±0.49	21.4±0.49	20.75	0.19	NS
HW (cm)	210	100.3±0.59[b]	100.8±0.60[a]	100.14	0.19	**
HG (cm)	210	105.0±0.88[b]	106.2±0.89[a]	105.06	0.29	**
BL (cm)	210	102.7±0.88	103.1±0.89	101.92	0.28	NS
TL (cm)	210	55.3±1.49[a]	53.8±1.52[b]	52.81	0.54	**
Adult (N=280)						
BWT (kg)	280	135.2±24.17[b]	149.6±24.25[a]	142.60	6.01	**
HL (cm)	280	47.6±0.42[a]	46.8±0.42[b]	47.37	0.11	**
HWD (cm)	280	15.3±0.19[b]	15.4±0.19[a]	15.01	0.06	**
EL (cm)	280	25.1±0.22	25.2±0.22	25.00	0.05	NS
NL (cm)	280	47.5±0.58	47.8±0.57	47.69	0.14	NS
NC (cm)	280	61.3±1.04[a]	60.3±1.02[b]	60.83	0.26	**
SW (cm)	280	22.0±0.46	22.0±0.46	22.83	0.15	NS
HW (cm)	280	107.2±18.69	106.9±18.76	110.51	4.63	NS
HG (cm)	280	110.2±0.95[b]	112.0±0.96[a]	111.03	0.26	**
BL (cm)	280	106.4±0.91[b]	107.8±0.91[a]	106.62	0.23	**
TL (cm)	280	56.5±1.39	57.1±1.39	57.79	0.41	NS

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS:Not significant at P>0.05, SEM= Standard Error of Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.8a. Effect of location on morphometric traits of weaner donkeys

Traits	N	Jigawa N=100	Kaduna N=100	Kano N=100	Katsina N=100	Kebbi N=100	Sokoto N=100	Zamfara N=100	Overall mean	SEM	LOS
BWT(kg)	700	105.4±7.59^{c}	93.2±7.24^{d}	125.6±7.52^{a}	96.5±7.48^{d}	119.2±7.79^{ab}	103.7±7.35^{cd}	111.3±7.79^{b}	114.33	2.92	**
HL(cm)	700	37.4±1.06^{c}	37.9±1.01^{c}	37.1±1.05^{c}	36.7±1.05^{d}	40.8±1.09^{a}	39.1±1.03^{b}	39.9±1.09^{a}	39.93	0.29	**
HWD(cm)	700	11.6±0.36^{c}	10.7±0.35^{d}	11.9±0.36^{c}	12.1±0.36^{b}	13.3±0.37^{a}	11.2±0.35^{c}	12.7±0.37^{b}	12.31	0.11	**
EL(cm)	700	22.0±0.29^{c}	23.0±0.28^{a}	22.7±0.29^{b}	22.3±0.29^{b}	22.6±0.30^{b}	22.5±0.29^{b}	22.8±0.30^{a}	22.91	0.08	**
NL(cm)	700	37.1±1.00^{b}	36.8±0.96^{c}	36.3±0.99^{c}	36.0±0.99^{c}	39.2±1.03^{a}	36.4±0.97^{c}	38.9±1.03^{a}	37.27	0.17	**
NC(cm)	700	44.2±1.26^{e}	48.0±1.20^{c}	47.1±1.25^{d}	49.1±1.24^{b}	51.0±1.29^{a}	47.2±1.22^{d}	50.0±1.29^{b}	48.15	0.26	**
SW(cm)	700	16.8±0.54^{d}	17.7±0.52^{c}	17.5±0.54^{c}	16.1±0.53^{d}	20.0±0.56^{a}	14.2±0.52^{e}	19.5±0.56^{b}	17.46	0.19	**
HW(cm)	700	87.0±1.28^{d}	91.5±1.22^{b}	93.9±1.27^{a}	87.7±1.26^{d}	92.9±1.31^{a}	89.2±1.24^{c}	91.0±1.31^{b}	92.82	0.36	**
HG(cm)	700	88.7±1.74^{cd}	91.0±1.66^{c}	99.5±1.73^{a}	89.9±1.72^{d}	95.3±1.79^{b}	87.2±1.69^{d}	90.5±1.79^{c}	94.33	0.53	**
BL(cm)	700	88.8±1.78^{c}	86.2±1.69^{d}	96.3±1.76^{a}	86.1±1.75^{d}	92.8±1.82^{b}	84.6±1.72^{e}	89.5±1.82^{c}	92.00	0.52	**
TL(cm)	700	44.4±2.39^{b}	42.4±2.28^{c}	42.4±2.36^{c}	42.9±2.35^{bc}	49.4±2.45^{a}	48.2±2.31^{a}	47.1±2.47^{ab}	45.86	0.64	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.8b: Effect of location on morphometric traits of young donkeys

Traits	**N**	**Jigawa N=100**	**Kaduna N=100**	**Kano N=100**	**Katsina N=100**	**Kebbi N=100**	**Sokoto N=100**	**Zamfara N=100**	**Overall mean**	**SEM**	**LOS**
BWT(kg)	700	109.6±2.73^{b}	102.4±2.74^{c}	118.6±2.77^{a}	114.7±2.59^{ab}	119.0±2.81^{a}	115.1±2.50^{a}	118.4±2.81^{a}	115.02	0.75	**
HL(cm)	700	45.3±0.69^{bc}	47.2±0.69^{a}	44.4±0.69^{c}	45.2±0.65^{bc}	46.7±0.71^{b}	44.4±0.63^{c}	46.4±0.71^{b}	45.26	0.19	**
HWD(cm)	700	13.6±0.32^{d}	14.3±0.32^{c}	13.4±0.32^{d}	14.1±0.29^{c}	15.2±0.32^{a}	13.6±0.29^{d}	14.6±0.32^{b}	13.85	0.09	**
EL(cm)	700	23.6±0.28^{e}	24.8±0.28^{a}	23.3±0.29^{e}	23.7±0.27^{e}	24.2±0.29^{bc}	24.6±0.26^{b}	23.9±0.29^{d}	24.15	0.08	**
NL(cm)	700	45.3±0.79^{a}	45.2±0.80^{a}	44.4±0.81^{b}	43.9±0.76^{c}	45.2±0.82^{a}	45.3±0.73^{a}	45.2±0.82^{a}	44.98	0.20	**
NC(cm)	700	55.5±1.16^{b}	59.4±1.17^{a}	57.0±0.18^{ab}	57.4±1.10^{ab}	57.7±1.19^{ab}	58.9±1.07^{a}	59.20±1.19^{a}	57.90	0.30	**
SW(cm)	700	22.2±0.61^{c}	21.2±0.61^{c}	20.7±0.61^{d}	21.8±0.57^{c}	23.4±0.62^{a}	17.8±0.56^{e}	22.52±0.62^{b}	20.75	0.19	**
HW(cm)	700	98.4±0.74^{c}	101.9±0.74^{a}	101.0±0.75^{a}	99.7±0.69^{c}	101.6±0.76^{a}	100.6±0.68^{b}	100.5±0.76^{b}	100.14	0.19	**
HG(cm)	700	103.3±1.09^{d}	106.8±1.09^{b}	107.2±1.10^{a}	104.5±1.03^{c}	106.0±1.12^{ab}	104.5±0.99^{c}	106.8±1.12^{b}	105.06	0.29	**
BL(cm)	700	101.4±1.09^{b}	104.8±1.09^{a}	103.5±1.10^{a}	101.8±1.03^{b}	104.6±1.12^{a}	101.0±0.99^{b}	103.3±1.12^{ab}	101.92	0.28	**
TL(cm)	700	51.9±1.86^{c}	47.8±1.87^{d}	51.2±1.89^{c}	55.9±1.76^{b}	57.9±1.91^{b}	58.6±1.70^{a}	58.5±1.91^{a}	52.81	0.54	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.8c.Effect of locations on morphometric traits of adult donkeys

Traits	**N**	**Jigawa N=100**	**Kaduna N=100**	**Kano N=100**	**Katsina N=100**	**Kebbi N=100**	**Sokoto N=100**	**Zamfara N=100**	**Overall mean**	**SEM**	**LOS**
BWT(kg)	700	129.8±24.77^{c}	136.4±28.00^{b}	139.2±28.21^{b}	137.4±28.33^{b}	176.6±28.08^{a}	136.6±25.76^{b}	140.9±28.08^{b}	142.60	6.01	**
HL(cm)	700	46.7±0.48^{bc}	47.6±0.49^{b}	46.7±0.49^{a}	46.7±0.49^{bc}	47.9±0.49^{a}	46.5±0.45^{c}	47.3±0.49^{b}	47.37	0.11	**
HWD(cm)	700	15.0±0.22^{c}	15.5±0.22^{c}	15.7±0.22^{b}	15.7±0.22^{b}	16.4±0.22^{a}	14.5±0.20^{d}	15.7±0.22^{d}	15.01	0.06	**
EL(cm)	700	25.0±0.25^{b}	25.2±0.25^{ab}	25.0±0.25^{b}	25.0±0.25^{b}	24.9±0.25^{b}	25.3±0.23^{ab}	25.4±0.25^{a}	25.00	0.05	**
NL(cm)	700	47.7±0.65^{b}	47.1±0.66^{b}	47.7±0.67^{b}	47.3±0.66^{b}	47.7±0.66^{b}	47.7±0.60^{b}	48.3±0.66^{a}	47.68	0.14	**
NC(cm)	700	57.9±1.16^{c}	60.8±1.17^{b}	62.0±1.19^{a}	62.0±1.19^{a}	60.9±1.18^{b}	60.9±1.08^{b}	61.5±1.18^{ab}	60.90	0.26	**
SW(cm)	700	22.3±0.53^{b}	22.0±0.53^{b}	21.7±0.54^{a}	21.7±0.54^{a}	23.1±0.54^{a}	18.3±0.49^{c}	23.2±0.52^{a}	22.83	0.15	**
HW(cm)	700	98.6±21.48^{c}	123.3±21.66^{a}	100.6±21.80^{b}	100.8±21.92^{b}	123.6±21.73^{a}	101.4±19.93^{b}	101.1±21.72^{b}	110.51	4.63	**
HG(cm)	700	107.8±1.10^{c}	111.6±1.11^{ab}	111.7±1.12^{ab}	111.7±1.13^{ab}	110.6±1.12^{b}	111.6±1.02^{ab}	112.8±1.12^{a}	111.03	0.26	**
BL(cm)	700	106.9±1.04^{ab}	107.3±1.05^{a}	107.1±1.06^{a}	107.7±1.07^{a}	106.4±1.06^{b}	106.6±0.97^{ab}	107.8±1.06^{a}	106.62	0.23	**
TL(cm)	700	52.1±1.59^{b}	50.5±1.61^{b}	57.7±1.63^{a}	57.7±1.63^{a}	59.1±1.61^{a}	59.5±1.48^{a}	59.8±1.61^{a}	57.79	0.41	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.9:Hair type significantly (P□ 0.01) affected the morphometric traits of weaner, young and adult donkeys. All the traits (body weight and linear body measurements) of weaner donkeys were significantly (P□ 0.01) affected by hair type. Generally, donkeys with short-smooth hair type had higher values for all the biometric traits measured than short-rough and long-curly types. The BWT (117.62±4.58kg), HL (40.69±0.45cm), NL (39.19±0.42cm), NC (50.71±0.53cm) and TL (46.75±0.99cm) for short-smooth hair type were similar to that of short-rough. Weaner donkeys with short-smooth hair type had the widest HWD (12.67±0.16cm) while the smallest HWD (11.89±0.19cm) was recorded in weaner donkeys with long-curly hair type. Longest EL (23.18±0.12cm) was observed in weaner donkeys with short-curly hair type. The broadest SW (18.25) was obtained in donkeys with short-smooth whereas the smallest SW (16.22±0.34cm) was obtained in long-curly hair type donkeys. The highest HW (94.59±0.54cm) was obtained in short-smooth hair type. However, the shortest HW (89.95±0.64cm) was obtained from long-curly hair type. Largest HG (97.11±0.77cm) was recorded in short-smooth hair type donkeys while the smallest HG (89.97±0.93cm) was recorded in long-curly hair type. Longest BL (94.51±0.77cm) was recorded in short-smooth hair type. However, shortest BL (87.95±0.93cm) was recorded in weaner donkeys with long-curly hair type.

Young donkeys were significantly (P□ 001) affected by hair type. All the traits (body weight and linear body measurements) of young donkeys were also affected by hair type except HWD. The young donkeys with long-curly hair type had high value for HL (47.50±1.90cm), HWD (14.00±0.90cm), NL (46.00±2.10cm), NC (58.50±3.11cm), SW (22.00±1.92cm), BL (103.00±2.89cm), and TL (57.00±5.50cm) compared to short-smooth and long-curly hair type. The NC (58.50±3.11cm) was similar to that of short and smooth hair type. Heaviest BWT (115.23±0.79kg) was recorded in short-smooth hair type while the small BWT was recorded in short-rough (113.15±2.57kg) and long-curly (112.14±7.69kg) hair type. Longest HL (47.50±1.90cm) was observed in young donkeys with long-curly hair type. However, short HL was observed in short-rough (45.28±0.63cm) and short-smooth hair type. Young donkeys with the longest EL (24.18±0.08cm) was observed in short-smooth hair type. Shortest EL (22.50±0.79cm) was observed in young donkeys with long-curly hair type. Longest NL (47.00±2.10cm) was obtained in long-curly hair type while the shortest NL (43.50±0.70cm) was obtained in short-rough hair type. Broader SW (22.00±1.92cm) was recorded in long-curly hair type whereas the most narrowSW (20.22±0.64cm) was recorded in short-rough hair type. The highest HW (100.23±0.21cm) was observed in young donkeys with short-smooth hair type while least HW (97.00±2.00cm) was observed in long-curly hair type. Largest HG (105.18±0.29cm) was obtained in young donkeys with short-smooth hair type whereas the smallest HG (102.00±2.92cm)was obtained in donkeys with long-curly hair type. Longest BL (103.00±2.89cm) was obtained in long-curly hair type. Shortest BL (100.17±0.96cm) was obtained in short-rough hair type. The longest TL (57.00±5.50cm) was recorded in young donkeys with long-curly hair type. However, the shortest TL (49.67±1.83cm) was recorded in short-rough hair type donkeys.

Adult donkeys with long-curly hair type recorded high values for HL (47.57±0.49), NC (63.79±1.19), SW (24.00±0.67), HG (112.71±1.15), BL (107.29±1.03), TL (59.29±1.82) compared to short-rough and short-smooth hair type. The HL (47.50±1.90cm) and SW (24.00±0.67), were similar to those of short-rough hair type. Widest HWD (15.29±0.27cm) was obtained in short-rough hair type whereas the smallest HWD (14.79±0.27cm) was obtained in long-curly hair type. Adult donkeys with short-rough hair type recorded the longest EL (25.21±0.24cm) while shortest EL (24.86±0.24cm) was recorded in long-curly hair type.

Donkeys with short-rough hair type recorded the longest NL (47.79±0.64cm). The short NL were observed in long-curly (46.71±0.64cm) and short-rough (46.83±0.15cm). Long and curly hair type donkeys recorded the widest NC (63.79±1.19cm) while the smallest NC (62.07±1.19cm) was recorded in short-rough hair type. Largest HG (112.71±1.15cm) was observed in long-curly hair type donkeys whereas the least HG (109.79±1.15) was observed in short-smooth hair type. Adult donkeys with long-curly hair type recorded the longest BL (107.29±1.03cm). Shortest BL (105.86±1.03cm) was recorded in short-rough hair type. The longest TL (59.29±1.82cm) was recorded in long-curly hair type. However, adult donkeys with short-rough hair type recorded the shortest TL (56.79±1.82cm).

Table 4.9 Effect of hair type on morphometric traits of weaner, young and adult donkeys

Age group/traits	Long – curly	Short - rough	Short - smooth	SEM	LOS
Weaner					
Body weight (kg)	106.6±5.49^{b}	116.9±5.19^{a}	117.6±4.58^{a}	2.91	**
Head length (cm)	38.3±0.55^{b}	40.4±0.51^{a}	40.6±0.45^{a}	0.29	**
Head width (cm)	11.8±0.19^{c}	12.2±0.19^{b}	12.6±0.16^{a}	0.11	**
Ear length (cm)	22.5±0.14^{c}	22.8±0.14^{b}	23.1±0.12^{a}	0.08	**
Neck length (cm)	37.3±0.51^{b}	39.0±0.48^{a}	39.1±0.42^{a}	0.27	**
Neck circumference (cm)	47.7±0.64^{b}	51.1±0.60^{a}	50.7±0.53^{a}	0.35	**
Shoulder width (cm)	16.2±0.34^{c}	17.5±0.32^{b}	18.2±0.28^{a}	0.19	**
Height at withers (cm)	89.9±0.64^{c}	93.1±0.61^{b}	94.5±0.54^{a}	0.36	**
Heart girth (cm)	89.9±0.93^{c}	94.6±0.88^{b}	97.1±0.77^{a}	0.53	**
Body length (cm)	87.9±0.93^{c}	92.3±0.88^{b}	94.5±0.77^{a}	0.52	**
Tail length (cm)	44.1±1.13^{b}	46.2±1.13^{a}	46.7±0.99^{a}	0.64	**
Young					
Body weight (kg)	112.1±7.69^{b}	113.1±2.57^{b}	115.2±0.79^{a}	0.75	**
Head length (cm)	47.5±1.90^{a}	45.2±0.63^{b}	45.2±0.19^{b}	0.19	**
Head width (cm)	14.0±0.90	13.8±0.30	13.8±0.09	0.09	NS
Ear length (cm)	22.5±0.79^{c}	24.0±0.27^{b}	24.1±0.08^{a}	0.08	**
Neck length (cm)	47.0±2.10^{a}	43.5±0.70^{c}	44.1±0.22^{b}	0.20	**
Neck circumference (cm)	58.5±3.11^{a}	59.0±1.04^{a}	57.6±0.32^{b}	0.30	**
Shoulder width (cm)	22.0±1.92^{a}	20.2±0.64^{c}	20.7±0.19^{b}	0.18	**
Height at withers (cm)	97.0±2.00^{c}	99.5±0.67^{b}	100.2±0.21^{a}	0.19	**
Heart girth (cm)	102.0±2.92^{c}	104.1±0.97^{b}	105.1±0.29^{a}	0.29	**
Body length (cm)	103.0±2.89^{a}	100.1±0.96^{c}	102.0±0.29^{b}	0.28	**
Tail length (cm)	57.0±5.50^{a}	49.6±1.83^{c}	53.0±0.56^{b}	0.54	**
Adult					
Body weight (kg)	142.8±26.95	134.8±26.95	143.02±6.35	6.01	NS
Head length (cm)	47.5±0.49^{a}	47.6±0.49^{a}	47.3±0.12^{b}	0.11	**
Head width (cm)	14.7±0.27^{c}	15.2±0.27^{a}	15.0±0.06^{b}	0.06	**
Ear length (cm)	24.8±0.24^{c}	25.2±0.24^{a}	25.0±0.06^{b}	0.05	**
Neck length (cm)	46.7±0.64^{b}	47.7±0.64^{a}	46.8±0.15^{b}	0.14	**
Neck circumference (cm)	63.7±1.19^{a}	62.0±1.19^{c}	62.6±0.28^{b}	0.27	**
Shoulder width (cm)	24.0±0.67^{a}	24.0±0.67^{a}	22.7±0.16^{b}	0.15	**
Height at withers (cm)	104.5±20.78	103.3±20.78	111.2±4.89	4.63	NS
Heart girth (cm)	112.7±1.15^{a}	109.7±1.15^{c}	111.0±0.27^{b}	0.26	**
Body length (cm)	107.2±1.03^{a}	105.8±1.03^{c}	106.6±0.24^{b}	0.23	**
Tail length (cm)	59.2±1.82^{a}	56.7±1.82^{c}	57.7±0.43^{b}	0.41	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Non significant difference at (P□0.05), SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

The effect of skin type on morphometric traits of weaner, young and adult donkeys are presented in Table 4.10. Skin type of weaner donkey affected (P□ 001) shoulder width (SW), height at withers (HW), heart girth (HG), body length (BL) and tail length (TL). Other morphometric traits were however not affected by skin type (P□ 0.05). Thick skin type had high value for SW (17.78±0.28cm), HW (93.57±0.54cm), HG (95.44±0.79cm) and BL (92.83±0.79cm). Widest SW (17.78±0.28cm) was observed in thick skin type while the smallest SW (17.21±0.25cm) was observed in thin skin type. Highest HW (93.57±0.54cm) was observed in weaner donkeys with thick skin type. The lowest HW (92.24±0.19cm) was obtained in thin skin type. Weaner donkeys with the thick skin type had the largest HG (95.44±0.79cm) with thin skin type being the least (93.46±0.71cm). Weaner donkeys with thick skin type recorded the longest BL (92.83±0.79cm) whereas the shortest BL (91.34±0.69cm) was recorded in thin skin type. Longest TL (46.95±0.85cm) was obtained in weaner donkeys with thin skin type. However, the shortest TL (44.51±0.94cm) was obtained in weaner donkeys with thick skin type.

Skin type of young donkeys affected (P□ 0.01) body weight (BWT), head length (HL), head width (HWD), shoulder width (SW), height at withers (HW), heart girth (HG) and tail length (TL). Other morphometric traits were however not affected (P□ 0.01). Thick skin type had high value for BWT (115.20±0.78kg), HL (45.28±0.19cm), HW (100.25±0.20cm), HG (105.12±0.29cm) and TL (52.85±0.56cm). Young donkeys with thick skin type recorded the heaviest BWT (115.20±0.78cm) while thin skin type recorded the least BWT (112.94±2.63kg). Longest HL (45.28±0.19cm) was recorded in donkeys with thick skin type whereas the least HL (45.06±0.65cm) was recorded in thin skin type. The thin skin type donkeys had the widest HWD (15.59±0.31cm) than thick skin type (13.88±0.09cm). Longest EL (24.19±0.08cm) was observed in young donkeys with thick skin type whereas thin skin type recorded the least EL

(23.65±0.27cm). The SW (22.00±0.65cm) of thin skin type was broader than the ones with thick skin (20.65±0.19cm). The HW (100.25±0.20cm), HG (105.12±0.29) and TL (52.85±0.56cm) of thick skin type were higher, bigger and longest than the HW (98.94±0.69cm), HG (104.35±1.00cm) and TL (52.35±1.90cm) of young donkeys with thin skin type.

Skin type of adult donkeys significantly affected (P□ 0.01) head length (HL), head width (HWD), shoulder width (SW), heart girth (HG) and body length (BL). Other morphometric traits were however not affected (P□ 0.01). Thin skin type had high value for HL (47.82±0.29cm), HWD (15.18±0.16cm) and SW (24.10±0.39cm) compared to the HL (47.30±0.12cm), HWD (14.98±0.06cm) and SW (22.63±0.16cm) of adult donkeys with thick skin type. The HG (111.12±0.28cm) and BL (106.75±0.25cm) of thick skin type were bigger and longer compare to the HG (110.46±0.69cm) and BL (105.85±0.61cm) of adult donkeys with thin skin type.

Table 4.10. Effect of skin type on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**				**Young**				**Adult**			
Traits	Thick	Thin	SEM	LOS	Thick	Thin	SEM	LOS	Thick	Thin	SEM	LOS
BWT(kg)	113.4±4.39	115.0±3.92	2.91	NS	115.2±0.78	112.9±2.63^{b}	0.75	**	143.6±6.48	136.2±16.12	6.01	NS
HL(cm)	40.1±0.44	39.7±0.39	0.29	NS	45.2±0.19^{a}	45.0±0.65^{b}	0.19	**	47.3±0.12^{b}	47.8±0.29^{a}	0.11	**
HWD(cm)	12.3±0.16	12.3±0.14	0.11	NS	13.8±0.09^{b}	15.5±0.31^{a}	0.09	**	14.9±0.06^{b}	15.1±0.16^{a}	0.06	**
EL(cm)	23.0±0.12	22.8±0.10	0.08	NS	24.1±0.08^{a}	23.6±0.27^{b}	0.08	**	25.0±0.06	25.0±0.15	0.05	NS
NL(cm)	38.8±0.41	38.4±0.38	0.27	NS	44.0±0.21	44.1±0.72	0.20	NS	46.9±0.15	46.6±0.38	0.14	NS
NC(cm)	50.0±0.53	49.9±0.47	0.35	NS	57.7±0.32	57.8±1.07	0.30	NS	62.5±0.29	62.9±0.72	0.27	NS
SW(cm)	17.7±0.28^{a}	17.2±0.25^{b}	0.19	**	20.6±0.19^{b}	22.0±0.65^{a}	0.18	**	22.6±0.16^{b}	24.1±0.39^{a}	0.15	**
HW(cm)	93.5±0.54^{a}	92.2±0.49^{b}	0.36	**	100.2±0.20^{a}	98.9±0.69^{b}	0.19	**	111.6±4.99	103.7±12.42	4.63	NS
HG(cm)	95.4±0.79^{a}	93.4±0.71^{b}	0.53	**	105.1±0.29^{a}	104.3±1.00^{b}	0.29	**	111.1±0.28^{a}	110.4±0.69^{b}	0.26	**
BL(cm)	92.8±0.79^{a}	91.3±0.69^{b}	0.52	**	101.9±0.29	101.4±0.99	0.28	NS	106.7±0.25^{a}	105.8±0.61^{b}	0.23	**
TL(cm)	44.5±0.94^{b}	46.9±0.85^{a}	0.64	**	52.8±0.56^{a}	52.3±1.90^{b}	0.54	**	57.8±0.44	57.3±1.09	0.41	NS

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 001, NS: Non significant difference at (P□ 0.05), SEM= Standard Error Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.11.Presents the influence of coat colour pattern on morphometric traits of weaner, young and adult donkeys. All the biometric traits of weaner donkeys were significantly affected (P□ 0.01) body weight, head length, head width, neck length, neck circumference, shoulder width, height at withers, heart girth and body length. Other morphometric traits were however not affected (P□ 0.05). Weaner donkeys with solid coat colour pattern were superior in terms of BWT (114.92±2.91kg), HL (39.98±0.29cm), HWD (12.34±0.11cm), NC (50.05±0.35cm), SW (17.49±0.19cm), HW (92.89±0.36cm), HG (94.44±0.53cm) and BL (92.12±0.52cm) compared to BWT (52.25±29.64cm), HL (36.50±3.02cm), HWD (10.50±1.08cm), EL (23.00±0.79cm), NL (37.00±2.82cm), NC (45.50±3.59cm), SW (15.00±1.91cm), HW (86.50±3.72cm), HG (83.50±5.39cm) and BL (80.00±5.31cm) of weaner donkeys with patches.

Influence of coat colour pattern on morphometric traits of adult donkeys significantly affected (P□ 0.01) on head length (HL), head width (HWD), ear length (EL), neck length (NL), neck circumference (NC), shoulder width (SW), heart girth (HG), body length (BL) and tail length (TL). Other morphometric traits were not affected (P□ 0.05). Adult donkeys with patches were higher in terms of HWD (16.00±1.01cm), EL (26.00±0.91cm), NL (52.00±2.37cm) HG (115.00±4.33cm), BL (108.00±3.85cm) and TL (60.00±6.81cm) compared to HWD (15.01±0.06cm), EL (25.00±0.05cm), NL (46.85±0.14cm), HG (111.02±0.26cm), BL (106.62±0.23cm) and TL (60.00±6.81cm). Adult donkeys with solid pattern were higher in terms of HL (47.38±0.11cm), NC (62.67±0.27cm) and SW (22.86±0.15cm) compared to HL (46.00±1.86cm), NC (57.00±4.46cm) and SW (17.00±2.49cm) of donkeys with patches.

Table 4.12.The influence of tail shape on morphometric traits of weaner, young and adult donkeys. Tail shape of weaner donkeys affected (P□ 0.01) all the linear body measurements. Weaner donkeys with high-set tail shape were superior in terms of BWT (120.39±6.03kg HL

(41.12±0.60cm), HWD (12.69±0.22cm), EL (23.22±0.16cm), NL (39.51±0.57cm), NC (51.35±0.72cm), SW (18.51±0.38cm), HW (94.69±0.74cm) HG (93.69±0.60cm), BL (94.18±1.07cm) and TL (48.61±1.30cm) compared to the pendent tail shape of weaner donkeys.

Tail shape of young donkeys significantly affected (P□ 0.01) head length (HL), head width (HWD), neck length (NL), neck circumference (NC), shoulder width (SW) and tail length (TL). Othermorphometric traits were however not affected (P□ 0.05). Young donkeys with high-set tail shape were superior in terms of HL (45.67±0.25cm), HWD (14.06±0.12cm), NL (44.32±0.28cm), NC (58.19±0.42cm), SW (21.17±0.26cm) and TL (55.12±0.71cm) compared to the young donkeys with pendent tail shape.

Body weight and linear body measurements head width (HWD), ear length (EL), neck circumference (NC), heart girth (HG), and tail length (TL)of adult donkeys were significantly (P□ 0.001) affected. Other biometric traits were however not affected (P□ 0.05). Adult donkeys with high-set tail shape were superior in terms of BWT (149.35±8.52cm), HWD (15.09±0.09cm), EL (25.11±0.08cm), NC (62.94±0.38cm), HG (111.47±0.37cm), and TL (58.74±0.57cm) than adult donkeys with pendent tail shape.

Table 4.11: Influence of coat colour pattern on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**				**Young**				**Adult**			
Traits	Solid	Patches	SEM	LOS	Solid	Patches	SEM	LOS	Solid	Patches	SEM	LOS
BWT(kg)	114.9±2.91^{a}	52.2±29.64^{b}	2.91	**	115.0±0.75	-	0.75	-	142.5±6.03^{a}	147.3±100.67	6.01	NS
HL(cm)	39.9±0.29^{a}	36.5±3.02^{b}	0.29	**	45.2±0.19	-	0.19	-	47.3±0.11^{a}	46.0±1.86^{b}	0.11	**
HWD(cm)	12.3±0.11^{a}	10.5±1.08^{b}	0.11	**	13.8±0.09	-	0.09	-	15.0±0.06^{b}	16.0±1.01^{a}	0.06	**
EL(cm)	22.9±0.08	23.0±0.79	0.08	NS	24.1±0.08	-	0.08	-	25.0±0.05^{b}	26.0±0.91^{a}	0.05	**
NL(cm)	38.6±0.28^{a}	37.0±2.82^{b}	0.27	**	44.0±0.20	-	0.20	-	46.8±0.14^{b}	52.0±2.37^{a}	0.14	**
NC(cm)	50.0±0.35^{a}	45.5±3.59^{b}	0.35	**	57.7±0.30	-	0.30	-	62.6±0.27^{a}	57.0±4.46^{b}	0.27	**
SW(cm)	17.4±0.19^{a}	15.0±1.91^{b}	0.19	**	20.7±0.19	-	0.18	-	22.8±0.15^{a}	17.0±2.49^{b}	0.15	**
HW(cm)	92.8±0.36^{a}	86.5±3.72^{b}	0.36	**	100.1±0.19	-	0.19	-	110.5±4.65	107.0±77.63	4.63	NS
HG(cm)	94.4±0.53^{a}	83.5±5.39^{b}	0.53	**	105.0±0.29	-	0.29	-	111.0±0.26^{b}	115.0±4.33^{a}	0.26	**
BL(cm)	92.1±0.52^{a}	80.0±5.31^{b}	0.52	**	101.9±0.28	-	0.28	-	106.6±0.23^{b}	108.0±3.85^{a}	0.23	**
TL(cm)	45.8±0.64	45.5±6.53	0.64	NS	52.8±0.54	-	0.54	-	57.7±0.41^{b}	60.0±6.81^{a}	0.41	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Non significant difference at (P□ 0.05), SEM= Standard Error Mean,LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.12: Influence of tail shape on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**				**Young**				**Adult**			
Traits	Pendent	High-set	SEM	LOS	Pendent	High-set	SEM	LOS	Pendent	High-set	SEM	LOS
BWT(kg)	112.4±3.33^{b}	120.3±6.03^{a}	2.91	**	114.8±1.08	115.1±1.04	0.75	NS	135.9±8.46^{b}	149.3±8.52^{a}	6.01	**
HL(cm)	39.5±0.33^{b}	41.1±0.60^{a}	0.29	**	44.7±0.26^{b}	45.6±0.25^{a}	0.19	**	47.4±0.16	47.3±0.16	0.11	NS
HWD(cm)	12.2±0.12^{b}	12.6±0.22^{a}	0.11	**	13.6±0.12^{b}	14.0±0.12^{a}	0.09	**	14.9±0.08^{b}	15.0±0.09^{a}	0.06	**
EL(cm)	22.8±0.09^{b}	23.2±0.16^{a}	0.08	**	24.0±0.11	24.2±0.11	0.08	NS	24.9±0.08^{b}	25.1±0.08^{a}	0.05	**
NL(cm)	38.3±0.31^{b}	39.5±0.57^{a}	0.27	**	43.8±0.29^{b}	44.3±0.28^{a}	0.20	**	46.7±0.20	46.9±0.20	0.14	NS
NC(cm)	49.6±0.39^{b}	51.3±0.72^{a}	0.35	**	57.2±0.44^{b}	58.1±0.42^{a}	0.30	**	62.3±0.38^{b}	62.9±0.38^{a}	0.27	**
SW(cm)	17.1±0.21^{b}	18.5±0.38^{a}	0.19	**	20.3±0.27^{b}	21.1±0.26^{a}	0.18	**	22.9±0.21	22.7±0.21	0.15	NS
HW(cm)	92.2±0.41^{b}	94.6±0.74^{a}	0.36	**	99.9±0.28	100.3±0.27	0.19	NS	110.0±6.54	110.0±6.58	4.63	NS
HG(cm)	93.6±0.60^{b}	96.4±1.09^{a}	0.53	**	105.0±0.41	105.1±0.39	0.29	NS	110.6±0.36^{b}	111.4±0.37^{a}	0.26	**
BL(cm)	91.3±0.59^{b}	94.1±1.07^{a}	0.52	**	101.8±0.41	102.0±0.39	0.28	NS	106.4±0.32	106.7±0.33	0.23	NS
TL(cm)	45.0±0.72^{b}	48.6±1.30^{a}	0.64	**	50.3±0.74^{b}	55.1±0.71^{a}	0.54	**	56.8±0.57^{b}	58.7±0.57^{a}	0.41	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 001, NS: Non significant difference at (P□ 0.05), SEM= Standard Error of Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.13 reflect the influence of eye colour on morphometric traits of weaner, young and adults donkeys significantly affected (P□ 0.01) body weight (BWT), head width (HWD), neck length (NL), shoulder width (SW) and body length (BL) of weaner donkeys. Other biometric traits were not affected (P□ 0.05). Black eyed donkeys recorded the heaviest BWT (115.01±2.96kg) than brown eyed (94.59±15.95cm) ones. Widest HWD (12.86±0.58cm) were observed in brown eyed donkeys with the least HWD (12.30±0.11cm) in black eyed ones. Longest NL (38.69±0.28cm) was obtained in black eye donkeys with the short NL (37.43±1.50cm) in brown eyed weaner donkeys. Wider SW (17.86±1.02cm) were observed in brown eyed with the least SW (17.45±0.19cm) in black eyed donkeys. Brown eyed donkeys recorded the longest BL (92.10±0.53cm) with the short BL (89.00±2.87cm) in brown eyed weaner donkeys.

Influence of eye colour on biometric traits of young donkeys affected (P□ 0.01) BWT, HWD, NL, NC and HG while the other biometric traits were however not affected (P□ 0.05). BWT (117.07±3.84cm), HWD (14.38±0.45cm), NL (45.00±1.05cm), NC (58.50±1.56cm) and HG (105.88±1.46cm) of young donkeys with brown coloured eyes were superior to black coloured eyes.

The eye colour of adult donkeys affected (P□ 0.01) all the linear body measurements except body weight (P□ 0.05). Longer head length was obtained in black eye (47.36±0.11cm) and brown eye (47.86±0.49cm) with the shortest head length (45.00±1.85cm) being recorded in white eye. Widest HWD (15.14±0.27cm) was observed in brown eyed adult donkeys with the smallest HWD (14.00±1.01cm) in white eye. White donkeys recorded the longest EL (26.00±0.19cm) while the shortest EL (24.86±0.24cm) was recorded in black eyed donkeys. Longest NL (52.00±2.37cm) was observed in white with short NL in brown (46.71±0.63cm) and black

(46.86±0.15cm) eyed donkeys. The neck circumference and shoulder width in black eyed was similar to brown eyed donkeys. Brown eyed adult donkeys had the highest HW (168.00±20.48cm) while the shortest HW (101.00±76.63cm) was recorded in white adult donkeys. Longest BL (110.00±3.85cm) was obtained in white whereas the shortest BL (106.00±1.03cm) was in brown. Black eyed adult donkeys recorded the longest TL (57.86±0.42cm). However, the shortest TL (52.00±6.81cm) was recorded in white eyed donkeys.

Table 4.13. Influence of eye colour on morphometric traits of weaner, young and adult donkeys

Age group/Ttraits	Black	Brown	White	SEM	LOS
Weaner					
BWT(kg)	115.0±2.96^{a}	94.5±15.95^{b}	-	2.91	**
HL(cm)	39.9±0.30	39.5±1.62	-	0.29	NS
HWD(cm)	12.3±0.11^{b}	12.8±0.58^{a}	-	0.11	**
EL(cm)	22.9±0.08	23.0±0.43	-	0.08	NS
NL(cm)	38.6±0.28^{a}	37.4±1.50^{b}	-	0.27	**
NC(cm)	50.0±0.36	50.0±1.92	-	0.35	NS
SW(cm)	17.4±0.19^{b}	17.8±1.02^{a}	-	0.19	**
HW(cm)	92.8±0.37	92.4±2.00	-	0.36	NS
HG(cm)	94.3±0.54	93.8±2.91	-	0.53	NS
BL(cm)	92.1±0.53^{a}	89.0±2.87^{b}	-	0.52	**
TL(cm)	45.8±0.65	47.0±3.49	-	0.64	NS
Young					
BWT(kg)	114.94±0.77^{b}	117.07±3.84^{a}	-	0.75	**
HL(cm)	45.25±0.19	45.50±0.95	-	0.19	NS
HWD(cm)	13.84±0.09^{b}	14.38±0.45^{a}	-	0.09	**
EL(cm)	24.15±0.08	24.25±0.40	-	0.08	NS
NL(cm)	44.04±0.21^{b}	45.00±1.05^{a}	-	0.20	**
NC(cm)	57.73±0.31^{b}	58.50±1.56^{a}	-	0.30	**
SW(cm)	20.75±0.19	20.88±0.96	-	0.18	NS
HW(cm)	100.15±0.20	99.88±1.01	-	0.19	NS
HG(cm)	105.03±0.29^{b}	105.88±1.46^{a}	-	0.29	**
BL(cm)	101.93±0.29	101.88±1.46	-	0.28	NS
TL(cm)	52.78±0.55	53.63±2.77	-	0.54	NS
Adult					
BWT(kg)	143.1±6.19	133.7±26.95	131.1±100.83	6.01	NS
HL(cm)	47.3±0.11^{a}	47.8±0.49^{a}	45.0±1.85^{b}	0.11	**
HWD(cm)	15.0±0.06^{b}	15.1±0.27^{a}	14.0±1.01^{c}	0.06	**
EL(cm)	25.0±0.06^{b}	24.8±0.24^{c}	26.0±0.91^{a}	0.05	**
NL(cm)	46.8±0.15^{b}	46.7±0.63^{b}	52.0±2.37^{a}	0.14	**
NC(cm)	62.6±0.27^{a}	63.0±1.19^{a}	55.0±4.45^{b}	0.27	**
SW(cm)	22.8±0.15^{a}	22.9±0.67^{a}	18.0±2.51^{b}	0.15	**
HW(cm)	107.5±4.71^{b}	168.0±20.48^{a}	101.0±76.63^{c}	4.63	**
HG(cm)	111.0±0.27^{a}	110.0±1.16^{b}	111.0±4.34^{a}	0.26	**
BL(cm)	106.6±0.24^{b}	106.0±1.03^{c}	110.0±3.85^{a}	0.23	**
TL(cm)	57.8±0.42^{a}	56.9±1.82^{b}	52.0±6.81^{c}	0.41	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 001, NS: Non significant difference at (P□0.05), SEM= Standard Error of Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

The head profile of weaner donkeys significantly affected (P□ 001) head length (HL), head width (HWD), ear length (EL), neck circumference (NC), shoulder width (SW), height at withers (HW) and body length (BL) (Table 4.14). However, other morphometric traits were not affected (P□ 0.05). Weaner donkeys with straight head profile were superior in terms of HL (40.15±0.36cm), HWD (12.44±0.13cm), EL (23.02±0.09cm), NC (50.41±0.43cm), SW (17.66±0.23cm), HW (93.54±0.44cm) and BL (92.98±0.63cm) compared to weaner donkeys with sub-concave head profile.

Head profile of young donkeys significantly affected (P□ 0.01) body weight (BWT), head length (HL), neck length (NL), neck circumference (NC), shoulder width (SW), height at withers (HW), heart girth (HG), body length (BL) and tail length (TL) with other morphometric traits not affected (P□ 0.05). BWT (121.82±4.08kg), HL (46.43±1.01cm), NL (46.57±1.11cm), NC (60.71±1.65cm), SW (21.57±1.02cm), HW (101.57±1.07cm), HG (108.57±1.55cm), BL (103.29±1.55cm) and TL (55.00±2.96cm) of young donkeys with sub-concave head profile were superior to those of young donkeys with straight head profile.

Head profile of adult donkeys significantly affected (P□ 001) shoulder width other linear body measurement were not affected (P□ 0.05). Adult donkeys with sub-concave head profile recorded the widest SW (23.40±0.56cm) while narrow SW (22.79±0.16cm) was recorded in adult donkeys with straight head profile.

Table 4.15.The effect of interaction of strain and sex on morphometric traits of weaner donkeys. The strain and sex interaction on morphometric traits of weaner donkeys affected (P□ 0.01) body weight (BWT), head length (HL), neck length (NL), neck circumference (NC), shoulder width (SW), and height at wither (HW). Other morphometric traits were however not affected by

strain, sex and location interaction (P□ 0.05). Males had higher values for BWT (143.44±0.33kg), HL (47.84±0.15cm), NC (63.48±0.39cm) and SW (17.60±0.19cm) than females. The heaviest BWT (143.44±33kg) was observed in brown male weaner donkeys while small BWT (84.94±3.02kg) was observed in female weaner. Longest HL (47.84±0.15cm) was recorded in male weaner whereas the shortest HL (47.02±0.14cm) was recorded in females. Weaner donkeys with the longest NL (47.05±0.20cm) was observed in females while shortest NL (46.69±0.23cm) was observed in males. Broader NC (63.48±0.39cm) was obtained in male weaner whereas the female weaner recorded the smallest NC (62.26±0.35cm). The male weaner recorded the wider SW (17.60±0.19cm) while smaller SW (17.23±0.20cm) was recorded in females. The longest HW (93.16±0.49cm) was observed in female weaner donkey. However, the shortest HW (92.91±0.47cm) was observed in male weaner.

Table 4.14. Influence of head profile on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**				**Young**				**Adult**			
Traits	Straight	Sub-concave	SEM	LOS	Straight	Sub-concave	SEM	LOS	Straight	Sub-concave	SEM	LOS
BWT(kg)	111.5±3.58	115.7±5.06	2.91	NS	114.7±0.76[b]	121.8±4.08[a]	0.75	**	142.9±6.24	138.1±22.51	6.01	NS
HL(cm)	40.1±0.36[a]	39.5±0.51[b]	0.29	**	45.2±0.19[b]	46.4±1.01[a]	0.19	**	47.3±0.12	47.5±0.42	0.11	NS
HWD(cm)	12.4±0.13[a]	12.0±0.18[b]	0.11	**	13.8±0.09	14.0±0.48	0.09	NS	15.0±0.06	15.0±0.23	0.06	NS
EL(cm)	23.0±0.09[a]	22.7±0.13[b]	0.08	**	24.1±0.08	24.1±0.43	0.08	NS	25.0±0.06	24.9±0.20	0.05	NS
NL(cm)	38.7±0.34[a]	38.4±0.48[a]	0.27	NS	43.9±0.21[b]	46.5±1.11[a]	0.20	**	46.8±0.15	46.5±0.53	0.14	NS
NC(cm)	50.4±0.43[a]	49.2±0.60[b]	0.35	**	57.6±0.31[b]	60.7±1.65[a]	0.30	**	62.6±0.28	62.4±0.99	0.27	NS
SW(cm)	17.6±0.23[a]	17.0±0.32[b]	0.19	**	20.7±0.19[b]	21.5±1.02[a]	0.18	**	22.7±0.16[b]	23.4±0.56[a]	0.15	**
HW(cm)	93.5±0.44[a]	91.4±0.62[b]	0.36	**	100.0±0.19[b]	101.5±1.07[a]	0.19	**	110.9±4.81	104.2±17.35	4.63	NS
HG(cm)	95.5±0.63[a]	91.8±0.89[a]	0.53	**	104.9±0.29[b]	108.5±1.55[a]	0.29	**	111.0±0.27	110.8±0.97	0.26	NS
BL(cm)	92.9±0.63[a]	90.0±0.89[b]	0.52	**	101.8±0.29[b]	103.2±1.55[a]	0.28	**	106.5±0.34	106.9±0.86	0.23	NS
TL(cm)	46.1±0.78	45.2±1.10	0.64	NS	52.7±0.55[b]	55.0±2.96[a]	0.54	**	57.7±0.42	58.5±1.52	0.41	NS

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Non significant difference at (P□0.05), SEM= Standard Error of Mean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.15.Effect of strain and sex (interaction) on biometric traits of weaner donkeys

Strain	Sex	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Idabari	Male	143.4±33^{a}	47.8±0.15^{a}	12.4±0.12	24.9±0.08	46.6±0.23^{b}	63.4±0.39^{a}	17.6±0.19^{a}	92.9±0.47^{b}	94.2±0.66	92.3±0.66	46.51±0.87
	Female	84.9±3.02^{b}	47.0±0.14^{b}	12.2±0.12	25.0±0.07	47.0±0.20^{a}	62.2±0.35^{b}	17.2±0.20^{b}	93.1±0.49^{a}	94.9±0.69	91.8±0.69	45.16±0.90
	Overall mean	114.33	39.93	12.31	22.91	37.27	48.15	17.46	92.82	94.33	92.00	45.86
	SEM	2.92	0.29	0.11	0.08	0.17	0.26	0.19	0.36	0.53	0.52	0.64
	LOS	**	**	NS	NS	**	**	**	**	NS	NS	NS

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Not significantdifference at P>0.05, SEM= Standard Error ofMean, LOS= Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.16.The effect of interaction of location and strain on morphometric traits of weaner donkeys. All the traits (body weight and linear body measurements)were significantly affected (P□ 0.01) by location and strains interaction. The biggest BWT was recorded in Duni (164.92±20.06kg) strain from Kebbi State. While the least body weight (BWT) was recorded in Fari (95.25±17.38kg).The longest head length (HL) was observed in Duni (44.50±2.74cm) strain from Zafara state. While the shortest head length (HL) was observed in Fari (34.25±2.37cm) strain from Kaduna State. Widest HWD was observed in Duni strain from Kebbi state (14.50±0.85cm) and Zamfara State (14.50±0.85cm). The smallest HWD was recorded in Duni strain from Kaduna State (8.00±0.85). Weaner donkeys with the longest ear length (EL) were obtained in Duni (24.00±0.75cm) strain from Kaduna state. While the shortest ear length (EL) was observed in Auraki (21.50±0.75) from Kano state. Longest neck length (NL) was recorded in Duni (43.50±2.60cm) strain from Zamfara state whereas the shortest neck length (NL) was recorded in Auraki (31.00±2.60) strain from Kano state. The highest value was recorded for neck circumference (NC) in Duni (55.00±3.21cm) strain from Zamfara state. While least value for NC was recorded in Auraki (43.00±3.21cm). Widest shoulder width (SWD) was observed in Duni (22.50±1.33cm) from Kebbi state whereas the smallest shoulder width (SWD) was observed in Fari (13.16±1.08cm) strain from Sokoto state. The highest height at wither (HW) measured was obtained in Duni (101.00±3.27cm) weaner donkeys from Kebbi state. The shortest HW measured were obtained in Idabari (89.83±0.93cm) from Jigawa and Fari (89.25±2.83cm) from Kaduna state. High value was recorded in Idabari (102.71±1.22cm) from Kano state for heart girth (HG). While the least value for HG was recorded in Fari (88.16±3.74cm) from sokoto state. Longer body length was observed in Idabari (98.96±1.22cm) from Kano and Duni (100.00±4.60cm) strains from Kebbi state. Weaner donkeys with long tail length were observed

in Duni (63.00±6.00cm) from Kebbi state and Fari (55.00±4.89cm) strains from Sokoto state. However, the shortest tail length (TL) was observed in Auraki (35.50±6.00cm).

Table 4.16a**:** Effect of location and strain (interaction) on biometric traits of weaner donkeys

St ate	Strain	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)
Jigawa	Fari	125.0±20.06^{d}	40.0±2.74^{e}	12.0±0.85^{f}	22.5±0.75^{fg}	35.0±2.60^{i}	49.0±3.21^{f}
	Idabari	113.0±5.71^{fg}	39.5±0.78^{ef}	12.1±0.24^{ef}	22.4±0.21^{gh}	39.0±0.74^{d}	46.5±0.91^{g}
Kaduna	Duni	115.3±20.06^{f}	40.0±2.74^{e}	8.0±0.85^{i}	24.0±0.75^{a}	36.5±2.60^{h}	51.5±3.21^{cd}
	Fari	95.2±17.38^{j}	34.2±2.37^{h}	12.5±0.73^{d}	21.7±0.65^{i}	34.2±2.26^{j}	51.2±2.78^{cd}
	Idabari	100.2±5.79^{ij}	40.2±0.79^{e}	11.2±0.24^{h}	23.5±0.21^{b}	38.6±0.75^{e}	49.6±0.92^{e}
Kano	Auraki	116.5±20.06^{f}	39.0±0.73^{fg}	11.5±0.24^{g}	21.5±0.75^{j}	31.0±2.60^{k}	43.0±3.21^{i}
	Idabari	131.4±5.36^{c}	39.0±0.73^{fg}	12.3±0.22^{de}	23.1±0.20^{c}	38.0±0.69^{f}	49.2±0.85^{ef}
Katsina	Idabari	104.8±5.56^{hi}	38.8±0.76^{g}	12.5±0.23^{d}	22.6±0.21^{ef}	37.5±0.72^{g}	51.1±0.89^{cd}
Kebbi	Duni	164.9±20.06^{a}	43.5±2.74^{b}	14.5±0.85^{a}	23.5±0.75^{b}	40.5±2.60^{bc}	51.0±3.21^{d}
	Idabari	123.4±5.36^{de}	42.7±0.73^{c}	13.6±0.22^{b}	23.0±0.20^{d}	40.7±0.69^{b}	53.1±0.85^{b}
Sokoto	Fari	138.3±16.38^{b}	38.8±2.24^{g}	11.1±0.69^{h}	22.3±0.61^{h}	36.6±2.13^{h}	46.0±2.62^{h}
	Idabari	107.4±5.71^{gh}	38.8±0.78^{g}	11.7±0.24^{g}	22.7±0.21^{e}	37.7±0.74^{fg}	49.4±0.91^{ef}
Zamfara	Duni	118.3±20.06^{ef}	44.5±2.74^{a}	14.5±0.85^{a}	23.0±0.75^{d}	43.5±2.60^{a}	55.0±3.21^{a}
	Idabari	118.4±5.36^{ef}	41.7±0.73^{d}	12.9±0.22^{c}	23.2±0.24^{c}	40.2±0.69^{c}	51.8±0.85^{c}
	Overall mean	114.33	39.93	12.31	22.91	37.27	48.15
	SEM	2.92	0.29	0.11	0.08	0.17	0.26
	LOS	**	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, ****P□ 0.01**,SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.16b: Effect of location and strain (interaction) on biometric traits of weaner donkeys

St ate	Strain	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Jigawa	Fari	20.0±1.33^{c}	94.5±3.27^{e}	95.5±4.58^{e}	95.5±4.60^{b}	40.0±6.00^{g}
	Idabari	16.9±0.37^{g}	89.8±0.93^{h}	92.6±1.30^{g}	92.0±1.31^{d}	46.0±1.70^{e}
Kaduna	Duni	19.5±1.33^{d}	95.5±3.27^{cd}	96.0±4.58^{d}	93.5±4.60^{c}	47.0±6.00^{de}
	Fari	18.7±1.15^{e}	89.2±2.83^{h}	95.7±3.96^{de}	87.5±3.98^{f}	43.2±5.19^{f}
	Idabari	17.5±0.38^{f}	94.5±0.94^{e}	94.2±1.32^{f}	89.2±1.32^{e}	42.9±1.73^{f}
Kano	Auraki	17.5±1.33^{f}	91.0±3.27^{g}	98.0±4.58^{c}	94.0±4.60^{c}	35.5±6.00^{h}
	Idabari	17.4±0.35^{fg}	96.5±0.87^{b}	102.7±1.22^{a}	98.9±1.22^{a}	42.9±1.60^{f}
Katsina	Idabari	16.3±0.36^{h}	90.6±0.90^{g}	90.6±1.27^{h}	89.6±1.27^{e}	43.5±1.66^{f}
Kebbi	Duni	22.5±1.33^{a}	101.0±3.27^{a}	101.0±4.58^{b}	100.0±4.60^{a}	63.0±6.00^{a}
	Idabari	19.8±0.35^{c}	95.1±0.87^{de}	98.3±1.22^{c}	95.5±1.22^{b}	49.3±1.60^{b}
Sokoto	Fari	13.1±1.08^{j}	90.8±2.67^{g}	88.1±3.74^{i}	87.8±3.75^{f}	55.0±4.89^{a}
	Idabari	14.3±0.37^{i}	91.2±0.93^{g}	90.2±1.30^{h}	87.1±1.31^{f}	48.2±1.70^{bc}
Zamfara	Duni	21.5±1.33^{b}	96.0±3.27^{c}	98.0±4.58^{c}	96.0±4.60^{b}	49.0±6.00^{bc}
	Idabari	19.3±0.35^{d}	93.3±0.87^{f}	93.3±1.22^{fg}	92.2±1.22^{d}	47.85±1.60^{cdss}
	Overall mean	17.46	92.82	94.33	92.00	45.86
	SEM	0.19	0.36	0.53	0.52	0.64
	LOS	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.17: revealed the effect of strain and sex interaction on morphometric traits of young donkeys. The body weight (BWT), head length (HL), ear length (EL), neck circumference (NC), height at wither (HW), heart girth (HG) and tail length (TL) were significantlyaffected (P□ 0.01) by strain and sex interaction. Other morphometric traits were however not affected (P□ 0.05). Male Idabari had the highest values for HL (45.60±0.25cm), EL (24.30±0.11cm), NC (58.63±0.43cm) and TL (53.58±0.65cm) than females.

Table 4.18.The effect of location and strain interaction on morphometric traits of young donkeys. The results showed that all the traits (body weight and body linear measurements) were significantly affected (P□ 0.01) by location and strain interaction. Fari strain of young donkey from Kaduna state recorded the biggest body weight (126.78±5.79kg) while the least body weight (98.89±6.68cm) was recorded in Fari strain of donkey from Katsina state. The longest head length (46.82±0.45cm) was observed in Idabari strain from Kaduna state. However, the shortest HL (42.00±1.68cm) was observed. Wider HWD were recorded in Fari (15.00±0.68cm) strain from Kaduna and Idabari (14.94±0.24cm) strain from Kebbi State. Smallest HWD was recorded in Fari (13.00±0.79cm) from Katsina State. Longest EL was obtained in Idabari (24.93±0.20cm) strain from Kaduna State while the shortest was obtained in Duni (23.25±0.58cm) from Jigawa State. The young donkey with the longest NL was observed in Duni (47.12±1.58cm) from Jigawa State. Shortest NL was observed in Fari (42.00±2.00cm) strain of young donkeys from Katsina State. Youngdonkeys with the widest NC was recorded in Idabari (59.52±0.79cm) from Jigawa State while the smallest was also recorded in Idabari (55.02±0.83cm) from Jigawa State. Wider SW was recorded in Duni (22.50±1.15cm) from Jigawa and Idabari (22.72±0.38cm) from Kebbi State. However, smaller SW was observed in Duni (17.25±1.15cm) and Idabari (17.08±0.44cm) strains from Sokoto State. Higher HW

wererecorded in Idabari (101.39±0.49cm) from Kaduna and Idabari (101.13±0.47cm) from Kebbi State while the shortest was recorded in Fari (94.50±1.80cm) from Katsina State. Young donkey strain with the largest HG was observed in Fari (109.25±2.32cm) from Kaduna State. However, the smallest HG was obtained in Fari (99.50±2.68cm) strain from Katsina State. Longest BL was observed in Fari (106.75±2.23cm) from Kaduna State while the shortest BL was obtained in Fari (93.00±2.58cm) from Katsina State. The young donkey strain with the longest TL was recorded in Duni (57.87±3.49cm) from Sokoto State. However, the shortest TL was recorded in Idabari (45.89±1.20cm) strain from Kaduna State.

Table 4.17:Effect of strain and sex (interaction) on biometric traits of young donkeys

Strain	Sex	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Idabari	Male	111.3±0.99[b]	45.6±0.25[a]	13.8±0.11	24.3±0.11[a]	43.7±0.29	58.6±0.43[a]	20.7±0.21	99.9±0.26[b]	104.3±0.40[b]	101.6±0.38	53.5±0.65[a]
	Female	118.2±0.97[a]	44.8±0.24[b]	13.7±0.11	24.0±0.10[b]	44.1±0.29	56.7±0.42[b]	20.7±0.21	100.2±0.26[a]	105.5±0.39[a]	101.8±0.37	52.0±0.64[b]
	Overall mean	115.02	45.26	13.85	24.15	44.98	57.90	20.75	100.14	105.06	101.92	52.81
	SEM	0.75	0.19	0.09	0.08	0.20	0.30	0.19	0.19	0.29	0.28	0.54
	LOS	**	**	NS	**	NS	**	NS	**	**	NS	**

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Not significantdifference at P>0.05, SEM= Standard Error of Mean, LOS= Level of significant, ab; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.18a:Effect of states and strain (interaction) on biometric traits of young donkey

State	Strain	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)
Jigawa	Duni	109.8±5.28^{e}	45.8±1.33^{b}	14.0±0.62^{c}	23.2±0.58^{g}	47.1±1.58^{a}	56.1±2.30^{g}
	Idabari	107.9±1.90^{f}	44.7±0.48^{c}	13.2±0.22^{e}	23.7±0.21^{e}	44.3±0.57^{c}	55.0±0.83^{h}
Kaduna	Fari	126.7±5.79^{a}	46.0±1.46^{b}	15.0±0.68^{a}	24.5±0.63^{bc}	42.5±1.73^{e}	58.2±2.52^{c}
	Idabari	118.1±1.82^{b}	46.8±0.45^{a}	13.9±0.21^{c}	24.9±0.20^{a}	44.4±0.54^{c}	59.5±0.79^{a}
Kano	Idabari	116.8±1.79^{bc}	43.9±0.45^{d}	13.2±0.21^{e}	23.5±0.19^{f}	43.2±0.53^{d}	56.7±0.78^{ef}
Katsina	Fari	98.9±6.68^{g}	42.0±1.68^{e}	13.0±0.79^{f}	23.0±0.73^{g}	42.0±2.00^{f}	56.5±2.91^{fg}
	Idabari	113.6±1.85^{d}	44.8±0.46^{c}	13.7±0.21^{d}	23.9±0.20^{de}	42.9±0.55^{d}	57.2±0.80^{de}
Kebbi	Idabari	117.2±1.75^{bc}	46.2±0.44^{b}	14.9±0.20^{a}	24.3±0.19^{c}	44.2±0.52^{c}	57.5±0.76^{d}
Sokoto	Duni	112.1±5.28^{d}	46.1±1.33^{b}	13.8±0.62^{cd}	24.5±0.58^{bc}	45.3±1.58^{b}	57.2±2.30^{de}
	Idabari	113.1±2.02^{d}	43.9±0.51^{d}	13.3±0.23^{e}	24.6±0.22^{b}	44.1±0.60^{c}	58.8±0.88^{bc}
Zamfara	Idabari	116.6±1.75^{c}	45.9±0.44^{b}	14.2±0.20^{b}	24.0±0.19^{d}	44.2±0.52^{c}	58.9±0.76^{ab}
	Overall mean	115.02	45.26	13.85	24.15	44.98	57.90
	SEM	0.75	0.19	0.09	0.08	0.20	0.30
	LOS	**	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error of Mean, LOS= Level of significant, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.18b.Effect of states and strain (interaction) on biometric traits of young donkey

State	Strain	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Jigawa	Duni	$22.5{\pm}1.15^{a}$	$97.1{\pm}1.42^{g}$	$102.5{\pm}2.12^{g}$	$102.7{\pm}2.04^{c}$	$51.5{\pm}3.49^{d}$
	Idabari	$21.5{\pm}0.41^{c}$	$98.1{\pm}0.51^{f}$	$102.8{\pm}0.76^{g}$	$100.2{\pm}0.73^{f}$	$50.3{\pm}1.25^{e}$
Kaduna	Fari	$22.0{\pm}1.26^{b}$	$100.7{\pm}1.56^{ab}$	$109.2{\pm}2.32^{a}$	$106.7{\pm}2.23^{a}$	$48.5{\pm}3.82^{g}$
	Idabari	$20.3{\pm}0.39^{d}$	$101.3{\pm}0.49^{a}$	$105.9{\pm}0.73^{cd}$	$103.4{\pm}0.70^{b}$	$45.8{\pm}1.20^{h}$
Kano	Idabari	$20.0{\pm}0.39^{d}$	$100.4{\pm}0.48^{bc}$	$106.7{\pm}0.72^{b}$	$102.3{\pm}0.69^{cd}$	$49.3{\pm}1.18^{f}$
Katsina	Fari	$18.0{\pm}1.45^{e}$	$94.5{\pm}1.80^{h}$	$99.5{\pm}2.68^{h}$	$93.0{\pm}2.58^{h}$	$49.0{\pm}4.42^{fg}$
	Idabari	$21.4{\pm}0.40^{c}$	$99.4{\pm}0.49^{e}$	$104.1{\pm}0.74^{e}$	$101.1{\pm}0.71^{e}$	$54.4{\pm}1.22^{c}$
Kebbi	Idabari	$22.7{\pm}0.38^{a}$	$101.1{\pm}0.47^{a}$	$105.4{\pm}0.70^{d}$	$103.4{\pm}0.67^{b}$	$56.3{\pm}1.16^{b}$
Sokoto	Duni	$17.2{\pm}1.15^{f}$	$100.1{\pm}1.42^{cd}$	$104.6{\pm}2.12^{e}$	$102.1{\pm}2.04^{d}$	$57.8{\pm}3.49^{a}$
	Idabari	$17.0{\pm}0.44^{f}$	$100.0{\pm}0.54^{d}$	$103.4{\pm}0.81^{f}$	$99.6{\pm}0.78^{g}$	$56.6{\pm}1.33^{b}$
Zamfara	Idabari	$21.7{\pm}0.38^{bc}$	$100.0{\pm}0.47^{cd}$	$106.1{\pm}0.70^{bc}$	$102.2{\pm}0.67^{cd}$	$56.6{\pm}1.16^{b}$
	Overall mean	20.75	100.14	105.06	101.92	52.81
	SEM	0.19	0.19	0.29	0.28	0.54
	LOS	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NS: Not significant, SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.19:shows the effect of strain and sex interaction on morphometric traits of adult donkeys. Body weight (BWT), head length (HL), head width (HWD) ear length (EL), neck circumference (NC), neck length (NL), heart girth (HG) and body length (BL) were significantly affected (P□ 0.01) by strains and sex interaction whereas other morphometric traits were not affected (P□ 0.05). Female brown adult donkeys had high values for BWT (151.00±9.03kg), HWD (15.08±0.67cm), EL (25.06±0.08cm), NL (47.05±0.21cm), HG (112.04±0.34cm) and BL (107.41±0.33cm) compared to male brown donkeys.

Table 4.20:revealed the effect of locations and strains on morphometric traits of adult donkeys. All the traits (body weight and linear body measurements) were significantly affected (P□ 0.01) by location and strain interaction. The biggest body weight (179.06±17.53kg) was recorded in Idabari from Kebbi state while the least body weight (120.78±74.29kg) was recorded in Auraki from Kebbi state. Longest head length (50.00±1.18cm) was observed in Fari from Kaduna whereas the shortest HL (45.00±1.18cm) was observed in Duni strain from Kaduna state. Auraki donkey strain from Kebbi recorded the widest head width (16.50±0.57cm) while Fari strain from Sokoto recorded the least HWD (13.50±0.49cm). Ear length (26.00±0.64cm) was longest in Fari strain from Kaduna whereas the shortest EL (24.50±0.64cm) was obtained in Duni from Kaduna state. Neck length (NL) was longer in Auraki (48.00±1.72cm) from Kebbi and Auraki (48.00±1.72) strains from Zamfara state. The wider neck circumference (NC) was obtained in Fari (67.00±2.92cm) from Kaduna and Auraki (67.25±2.53cm) strains from Kano. Shortest NC (51.50±2.92cm) were recorded in Duni donkey strain from Kaduna state. Shoulder width (SWD) was widest in Auraki (24.50±1.18cm) strain from Kano while the shortest SWD (18.50±1.36cm) was observed in Fari strain from Kaduna state. The height at wither (132.51±13.61cm) was the highest in Idabari train from Kaduna. However, the shortest height at wither (HW) were recorded

in Idabari (101.87±14.14cm) from Jigawa and Duni (101.50±57.38cm) strains from Kaduna state. Larger heart girth (HG) were obtained in Fari (115.50±2.83cm) from Kaduna and Auraki (115.25±2.45cm) strains from Kano state while the smallest HG (104.50±2.83cm) was observe in Auraki adult donkey from Kebbi state. Longest body length (108.00±2.33cm) was obtained in Auraki donkeys from Kano state whereas the adult donkey with the shortest BL (104.00±2.69cm) was observed in Duni strain from Kaduna state. Adult donkey strain that had the longest tail length (62.00±3.56cm) was recorded in Auraki strain from Kano state. However, the shortest TL (42.50±4.11cm) was recorded in Fari strain from Kaduna state.

Table 4.19:Effect of strain and sex (interaction) on biometric traits of adult donkeys

Strain	Sex	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Idabari	Male	134.2±9.94^{b}	47.8±0.16^{a}	14.8±0.08^{b}	24.9±0.09^{b}	46.6±0.23^{b}	63.4±0.39^{a}	22.8±0.18	111.9±7.68	110.0±0.38^{b}	105.6±0.36^{b}	57.6±0.55
	Female	151.0±9.03^{a}	47.0±0.14^{b}	15.0±0.67^{a}	25.0±0.08^{a}	47.0±0.21^{a}	62.2±0.34^{b}	22.9±0.17	111.1±6.97	112.0±0.34^{a}	107.4±0.33^{a}	58.2±0.49
	Overall mean	142.60	47.37	15.01	25.00	47.68	60.83	22.83	110.51	111.03	106.62	57.79
	SEM	6.01	0.11	0.06	0.05	0.14	0.26	0.15	0.63	0.26	0.23	0.41
	LOS	**	**	**	**	**	**	NS	NS	**	**	NS

Key:BWT; Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder;;widthHeight at withers; HG ;Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, NSNon- significant at P<0.05; SEM= Standard Error of Mean, LOS=Level of significance, ab; Means with different superscripts along same row shows significant differences (P□ 001).

Table 4.20a:Effect of location and strains (interactions) on biometric traits of adult donkey

State	Strain	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)
Jigawa	Idabari	130.4±18.31[de]	46.8±0.29[e]	14.6±0.14[f]	24.8±0.16[e]	46.6±0.43[de]	60.0±0.72[g]
Kaduna	Duni	135.0±74.29[cbd]	45.0±1.18[g]	15.5±0.57[c]	24.5±0.64[f]	44.5±1.72[h]	51.5±2.92[i]
	Fari	142.4±74.29bc	50.0±1.18[a]	15.5±0.57[c]	26.0±0.64[a]	45.5±1.72[g]	67.0±2.92[a]
	Idabari	135.6±17.62[cbd]	48.0±0.28[c]	15.1±0.13[e]	25.0±0.15[d]	46.4±0.41[ef]	63.1±0.69[de]
Kano	Auraki	148.1±64.33[b]	48.5±1.03[b]	15.0±0.49[e]	25.7±0.55[b]	46.2±1.49[f]	67.2±2.53[a]
	Idabari	138.5±17.53[bcd]	47.7±0.28[d]	14.2±0.13[g]	24.8±0.15[e]	46.5±0.41[ef]	63.2±0.69[cd]
Katsina	Idabari	137.3±17.43[bcd]	46.9±0.28[e]	15.3±0.13[d]	24.8±0.15[e]	47.0±0.40[c]	64.0±0.68[b]
Kebbi	Auraki	120.7±74.29[e]	47.5±1.18[d]	16.5±0.57[a]	25.0±0.64[d]	48.0±1.72[a]	59.0±2.92[h]
	Idabari	179.0±17.53[a]	48.1±0.28[c]	16.0±0.13[b]	24.7±0.51[e]	46.8±0.41[d]	63.2±0.69[cde]
Sokoto	Fari	137.9±64.33[bcd]	46.0±1.03[f]	13.5±0.49[h]	25.0±0.55[d]	46.5±1.49[ef]	59.0±2.53[h]
	Idabari	136.4±18.30[bcd]	46.7±0.29[e]	14.1±0.14[g]	25.3±0.16[c]	47.0±0.42[c]	62.7±0.72[ef]
Zamfara	Auraki	138.8±74.29[bcd]	48.0±1.18[c]	15.5±0.57[c]	25.0±0.64[d]	48.0±1.72[a]	62.5±0.92[f]
	Idabari	140.7±17.62[bcd]	47.5±0.28[d]	15.3±0.13[d]	25.2±0.15[c]	47.5±0.41[b]	63.6±0.69[c]
	Overall	142.60	47.37	15.01	25.00	47.68	60.83
	SEM	6.01	0.11	0.06	0.05	0.14	0.26
	LOS	**	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 001,SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

Table 4.20b: Effect of location and strains (interactions) on biometric traits of adult donkey

State	Strain	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
Jigawa	Idabari	23.0 ± 0.34^{c}	101.8 ± 14.14^{g}	107.7 ± 0.69^{h}	106.2 ± 0.66^{ghi}	52.7 ± 1.01^{ef}
Kaduna	Duni	21.0 ± 1.36^{e}	101.5 ± 57.38^{g}	105.5 ± 2.83^{i}	104.0 ± 2.69^{j}	47.5 ± 4.11^{g}
	Fari	18.5 ± 1.36^{g}	102.0 ± 57.38^{fg}	115.5 ± 2.83^{a}	107.5 ± 2.69^{bc}	42.5 ± 4.11^{h}
	Idabari	23.2 ± 0.32^{c}	132.5 ± 13.61^{a}	111.4 ± 0.67^{de}	106.6 ± 0.64^{efg}	52.1 ± 0.97^{f}
Kano	Auraki	24.5 ± 1.18^{a}	106.0 ± 49.69^{c}	115.2 ± 2.45^{a}	108.0 ± 2.33^{a}	62.0 ± 3.56^{a}
	Idabari	24.0 ± 0.32^{b}	104.3 ± 13.54^{de}	111.3 ± 0.67^{e}	106.5 ± 0.64^{fgh}	59.8 ± 0.97^{c}
Katsina	Idabari	22.5 ± 0.32^{d}	104.3 ± 13.46^{de}	111.6 ± 0.66^{cde}	106.9 ± 0.63^{de}	58.9 ± 0.96^{d}
Kebbi	Auraki	23.0 ± 1.36^{c}	103.5 ± 57.46^{de}	104.5 ± 2.83^{j}	103.5 ± 2.69^{k}	53.0 ± 4.11^{e}
	Idabari	24.1 ± 0.32^{b}	128.4 ± 13.54^{b}	110.7 ± 0.67^{f}	105.9 ± 0.64^{i}	60.4 ± 0.97^{bc}
Sokoto	Fari	19.2 ± 1.18^{f}	103.2 ± 49.69^{ef}	109.5 ± 2.45^{g}	107.7 ± 2.33^{ab}	60.0 ± 3.56^{c}
	Idabari	19.2 ± 0.34^{f}	104.4 ± 14.33^{d}	111.7 ± 0.69^{cde}	106.0 ± 0.66^{hi}	60.5 ± 1.01^{bc}
Zamfara	Auraki	22.5 ± 1.36^{d}	104.5 ± 57.38^{d}	112.0 ± 2.83^{c}	107.5 ± 2.69^{bc}	61.0 ± 4.11^{b}
	Idabari	24.0 ± 0.32^{b}	104.6 ± 13.61^{d}	112.8 ± 0.67^{b}	107.1 ± 0.64^{cde}	60.8 ± 0.97^{b}
	OVM	22.83	110.51	111.03	106.62	57.79
	SEM	0.15	0.63	0.26	0.23	0.41
	LOS	**	**	**	**	**

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01,SEM= Standard Error of Mean, LOS= Level of significance, abc; Means with different superscripts along same row shows significant differences (P□ 0.01).

4.4: Measures of Relationships and Associations in Donkeys

Table 4.21.indicates the correlated relationships between morphometric traits of donkeys. The traits were significantly ($p<0.05$, 0.01) and positively correlated amongst themselves (r=0.09-0.87). The magnitude of correlations between body weight and body dimensions were low (r=0.13-0.23) except that between body weight and height at withers which was high (r=0.68). However, height at withers had low correlations (r=0.09-0.14) with other body dimensions. Other body dimensions had moderate to high positive correlations amongst themselves (r=0.41-0.87) except for low relationships between ear length and head length (r=0.13).

Table 4.22.represent the age group differentiated correlations between morphometric traits of donkeys. At the weaner stage, all the growth measures were positively and significantly correlated ($p<0.05$, 0.01, r=0.19-0.80) except for the non significant correlation between ear length and body weight (r=0.09) and ear length and head width (r=0.06). Body weight had low to moderate relationship with body dimensions (r=0.21-0.56) at this stage; so was head width, ear length, neck length, neck circumference and shoulder width with other body dimension measures (r=0.19-0.51) except for the high positive relationships between head length and neck length (r=0.80) and circumference (r=0.75); height at withers and heart girth (r=0.80); height at withers and body length (r=0.72;) and heart girth and body length (r=0.79).

At young stage, except the non significant ($p>0.05$) negative relationship between ear length and shoulder width (r=-0.01), all relationships between the growth measures were positively low to moderate (r=0.13-0.59) with the following non significant ($p>0.05$) relationships between tail length and body length (r=0.10); neck length and head width (r=0.10) and tail length and ear length (r=0.08). All the same, high positive correlations were recorded for body weight with height at withers, heart girth and body length (r=0.66-0.84); height at withers and heart girth (r=0.63); and heart girth and body length (r=0.67)

The adult stage of growth exhibited non-significant (p>0.05) negative correlations between body weight and shoulder width (r=-0.04), shoulder width and height at withers (r=-0.04), and height at withers and body length (r=-0.01). Body weight was positively but non-significantly (p>0.05) correlated with head length, neck length, neck circumference, shoulder width, body length and tail length (r=0.02-0.09). However, body weight was significantly correlated with height at withers (p<0.01; r=0.72), head width (p<0.05, r=14), ear length (p<0.05, r=0.10) and heart girth (p<0.05; r=0.13). The relationships of shoulder width with ear length; height at withers with head length, head width, ear length, neck length and circumference; tail length with ear length, shoulder width and height at withers were non-significant (p>0.05; r=0.02-0.09). Other relationships between the body dimensions were significantly low to moderate (p<0.05; r=0.11-0.53).

Table 4.21: Correlated relationships between morphometric traits of donkeys

Traits	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
HL(cm)	0.19**	-									
HWD(cm)	0.20**	0.61**	-								
EL(cm)	0.16**	0.13*	0.52**	-							
NL(cm)	0.18**	0.72**	0.46**	0.57**	-						
NC(cm)	0.17**	0.78**	0.61**	0.63**	0.75**	-					
SW(cm)	0.13*	0.67**	0.67**	0.45**	0.62**	0.64**	-				
HW(cm)	0.68**	0.13*	0.14*	0.13*	0.12*	0.13*	0.09*	-			
HG(cm)	0.22**	0.72**	0.65**	0.64**	0.72**	0.78**	0.65**	0.14*	-		
BL(cm)	0.22**	0.74**	0.63**	0.60**	0.72**	0.73**	0.67**	0.13*	0.87**	-	
TL(cm)	0.23**	0.56**	0.46**	0.41**	0.58**	0.58**	0.49**	0.10*	0.53**	0.51**	-

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05, SEM= Standard Error of Mean, LOS= Level of significance.

Table 22. Age group differentiated correlations between morphometric traits of donkeys

Weaner	Traits	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.32**	-									
	HWD(cm)	0.21*	0.25*	-								
	EL(cm)	0.09^{NS}	0.40**	0.06^{NS}	-							
	NL(cm)	0.33**	0.80**	0.22*	0.31**	-						
	NC(cm)	0.28**	0.75**	0.27**	0.39**	0.64**	-					
	SW(cm)	0.28**	0.46**	0.35**	0.22*	0.39**	0.46**	-				
	HW(cm)	0.29**	0.51**	0.27**	0.46**	0.43**	0.51**	0.44**	-			
	HG(cm)	0.28**	0.44**	0.36**	0.35**	0.38**	0.49**	0.47**	0.80**	-		
	BL(cm)	0.41**	0.50**	0.31**	0.29**	0.43**	0.49**	0.48**	0.72**	0.79**	-	
	TL(cm)	0.56**	0.42**	0.19*	0.19*	0.41**	0.42**	0.25*	0.23*	0.21*	0.25*	-
Young	Traits	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.30**	-									
	HWD(cm)	0.25*	0.38**	-								
	EL(cm)	0.21*	0.39**	0.28**	-							
	NL(cm)	0.28**	0.46**	0.10^{NS}	0.13*	-						
	NC(cm)	0.47**	0.47**	0.18*	0.27**	0.39**	-					
	SW(cm)	0.19*	0.39**	0.31**	-0.01^{NS}	0.26*	0.22*	-				
	HW(cm)	0.66**	0.34**	0.19*	0.35**	0.21*	0.36**	0.18*	-			
	HG(cm)	0.84**	0.32**	0.20*	0.18*	0.28**	0.45**	0.24*	0.63**	-		
	BL(cm)	0.64**	0.47**	0.28**	0.22*	0.33**	0.39**	0.40**	0.59**	0.67**	-	
	TL(cm)	0.10^{NS}	0.28**	0.18*	0.08^{NS}	0.34**	0.31**	0.38**	0.17*	0.16*	0.17*	-
Adult	Traits	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.08^{NS}	-									
	HWD(cm)	0.14*	0.25**	-								
	EL(cm)	0.10*	0.21*	0.20*	-							
	NL(cm)	0.03^{NS}	0.20*	0.16*	0.11*	-						
	NC(cm)	0.02^{NS}	0.37**	0.24**	0.23**	0.21*	-					
	SW(cm)	-0.04^{NS}	0.41**	0.32**	0.01^{NS}	0.19*	0.27**	-				
	HW(cm)	0.72**	0.07^{NS}	0.09^{NS}	0.06^{NS}	0.01^{NS}	0.03^{NS}	-0.04^{NS}	-			
	HG(cm)	0.13*	0.27**	0.24**	0.38**	0.29**	0.53**	0.21*	0.02^{NS}	-		
	BL(cm)	0.08^{NS}	0.24**	0.20*	0.27**	0.30**	0.29**	0.27**	-0.01^{NS}	0.52**	-	
	TL(cm)	0.09^{NS}	0.13*	0.16*	0.07^{NS}	0.24**	0.27**	0.08^{NS}	0.03^{NS}	0.32**	0.21*	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05 NS: Not significance difference at (P□ 0.05).

Table 4.23.reflects the sex differentiated correlation coefficients between morphometric traits of donkeys. In the male differentiated relationships, body weight was not significantly ($p>0.05$) correlated with body dimension measures ($r=-0.002$ to 0.09), except between body weight and tail length ($p<0.01$; $r=0.43$).

In females, body weight relationships with body dimension measures were significantly positive and low to high in magnitude ($p<0.05$, 0.01; $r=0.18$-0.98) with height at withers exhibiting the single high relationship of 98%.

In both the males and females, the body dimension measures were positively and significantly correlated among themselves ($p<0.05$, 0.01; $r=0.11$-0.88). However, there was non-significant ($p>0.05$) positive correlation between tail length and height at withers ($r=0.07$) in the males; and height at withers and shoulder width ($r=0.06$) in the females.

Table 4.24. The coat colour pattern differentiated correlations between morphometric traits of donkeys. The correlations between the growth measures in both the patched and solid coat patterns were positive and significant ($p<0.05$, 0.01; $r=0.12$-1.00). The relationships were strong for the patched colour pattern ($r=0.33$-1.00) with the relationship between body weight and other growth measures being very strong ($r=0.65$-0.99). On the other hand, in the solid colour pattern, the relationships between body weight and other growth measures were not strong enough ($r=0.16$-0.29) except that between body weight and height at withers ($r=0.65$). Generally, the correlations were stronger for the patched than for the solid coat colour pattern.

Table 4.25.presents the head profile differentiated correlations between morphometric traits of donkeys. The correlated relationships between the biometric measures of growth were significant ($p<0.05$, 0.01) and positively correlated ($r=0.11$-0.94) for both sub-concave and straight head

profile; except the non-significant ($p>0.05$) correlations between height at withers and shoulder width ($r=0.07$), and tail length and height at withers ($r=0.09$) in the straight head profile. Generally, the correlations were stronger for sub-concave than for straight head profiles.

Table 23. Sex differentiated correlations between morphometric traits of donkeys

Male	Traits	BWT(kg)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.04^{NS}	-									
	HWD(cm)	0.09^{NS}	0.61**	-								
	EL(cm)	-0.03^{NS}	0.67**	0.53**	-							
	NL(cm)	-0.15^{NS}	0.76**	0.57**	0.54**	-						
	NC(cm)	0.02^{NS}	0.81**	0.61**	0.63**	0.75**	-					
	SW(cm)	0.06^{NS}	0.67**	0.63**	0.49**	0.64**	0.68**	-				
	HW(cm)	-0.002^{NS}	0.14*	0.12*	0.12*	0.13*	0.17*	0.12*	-			
	HG(cm)	0.04^{NS}	0.75**	0.67**	0.65**	0.73**	0.80**	0.70**	0.14*	-		
	BL(cm)	0.09^{NS}	0.79**	0.61**	0.64**	0.74**	0.78**	0.73**	0.13*	0.88**	-	
	TL(cm)	0.43**	0.47**	0.41**	0.36**	0.57**	0.52**	0.46**	0.07^{NS}	0.54**	0.54**	-
Female	**Traits**	**BWT(kg)**	**HL(cm)**	**HWD(cm)**	**EL(cm)**	**NL(cm)**	**NC(cm)**	**SW(cm)**	**HW(cm)**	**HG(cm)**	**BL(cm)**	**TL(cm)**
	HL(cm)	0.27**	-									
	HWD(cm)	0.28**	0.63**	-								
	EL(cm)	0.25**	0.60**	0.51**	-							
	NL(cm)	0.25**	0.86**	0.58**	0.59**	-						
	NC(cm)	0.25**	0.78**	0.61**	0.63**	0.76**	-					
	SW(cm)	0.18*	0.69**	0.60**	0.43**	0.62**	0.62**	-				
	HW(cm)	0.98**	0.14*	0.16*	0.15*	0.12*	0.11*	0.06^{NS}	-			
	HG(cm)	0.33**	0.72**	0.64**	0.64**	0.72**	0.79**	0.63**	0.16*	-		
	BL(cm)	0.30**	0.72**	0.65**	0.59**	0.72**	0.71**	0.64**	0.13*	0.88**	-	
	TL(cm)	0.23**	0.65**	0.52**	0.47**	0.59**	0.65**	0.53**	0.13*	0.53**	0.52**	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05 NS: Not significance difference at (P□ 0.05).

Table 4.24. Coat colour pattern differentiated correlations between morphometric traits of donkeys

Patched	Traits	BWT(cm)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.99**	-									
	HWD(cm)	0.99**	0.99**	-								
	EL(cm)	0.92**	0.97**	0.93**	-							
	NL(cm)	0.99**	0.99**	0.99**	0.92**	-						
	NC(cm)	0.94**	0.97**	0.95**	0.99**	0.93*	-					
	SW(cm)	0.65**	0.56*	0.64*	0.33*	0.68**	0.36*	-				
	HW(cm)	0.99**	0.99**	0.99**	0.95**	0.99**	0.96**	0.60**	-			
	HG(cm)	0.99**	0.99**	0.99**	0.96**	0.99**	0.97**	0.58*	0.99**	-		
	BL(cm)	0.99**	0.99**	0.99**	0.96**	0.99**	0.97**	0.58*	0.99**	1.00**	-	
	TL(cm)	0.96**	0.99**	0.97**	0.99**	0.96**	0.99**	0.44*	0.98**	0.99**	0.99**	-
Solid	Traits	BWT(cm)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.27**	-									
	HWD(cm)	0.23**	0.61**	-								
	EL(cm)	0.23**	0.64**	0.52**	-							
	NL(cm)	0.26**	0.81**	0.57**	0.57**	-						
	NC(cm)	0.24**	0.79**	0.61**	0.63**	0.75**	-					
	SW(cm)	0.16**	0.68**	0.62**	0.46**	0.63**	0.65**	-				
	HW(cm)	0.65**	0.14*	0.14*	0.14*	0.12*	0.14*	0.09^{NS}	-			
	HG(cm)	0.27**	0.72**	0.64**	0.64**	0.72**	0.78**	0.65**	0.53**	-		
	BL(cm)	0.29**	0.75**	0.62**	0.61**	0.72**	0.73**	0.68**	0.13*	0.15*	-	
	TL(cm)	0.26**	0.56**	0.46**	0.41**	0.59**	0.59**	0.49**	0.10*	0.66**	0.52**	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05 NS: Not significance difference at (P□ 0.05).

Table 4.25. Head profile differentiated correlations between morphometric traits of donkeys

Sub-concave	Traits	BWT(cm)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.61**	-									
	HWD(cm)	0.35*	0.65**	-								
	EL(cm)	0.45**	0.67**	0.49**	-							
	NL(cm)	0.54**	0.88**	0.61**	0.69**	-						
	NC(cm)	0.59**	0.89**	0.66**	0.74**	0.83**	-					
	SW(cm)	0.47**	0.79**	0.68**	0.54**	0.72**	0.78**	-				
	HW(cm)	0.64**	0.87**	0.62**	0.74**	0.83**	0.86**	0.75**	-			
	HG(cm)	0.62**	0.89**	0.63**	0.70**	0.86**	0.88**	0.79**	0.94**	-		
	BL(cm)	0.64**	0.85**	0.59**	0.65**	0.79**	0.79**	0.76**	0.88**	0.92**	-	
	TL(cm)	0.71**	0.62**	0.45**	0.49**	0.64**	0.61**	0.48**	0.57**	0.59**	0.61**	-
Straight	**Traits**	**BWT(cm)**	**HL(cm)**	**HWD(cm)**	**EL(cm)**	**NL(cm)**	**NC(cm)**	**SW(cm)**	**HW(cm)**	**HG(cm)**	**BL(cm)**	**TL(cm)**
	HL(cm)	0.23**	-									
	HWD(cm)	0.20**	0.58**	-								
	EL(cm)	0.19**	0.60**	0.49**	-							
	NL(cm)	0.22**	0.78**	0.53**	0.52**	-						
	NC(cm)	0.19**	0.75**	0.57**	0.58**	0.71**	-					
	SW(cm)	0.12*	0.63**	0.63**	0.39**	0.58**	0.59**	-				
	HW(cm)	0.66**	0.12*	0.13*	0.11*	0.10*	0.12*	0.07^{NS}	-			
	HG(cm)	0.22**	0.65**	0.62**	0.59**	0.66**	0.74**	0.60**	0.13*	-		
	BL(cm)	0.24**	0.69**	0.61**	0.56**	0.69**	0.69**	0.64	0.11*	0.85**	-	
	TL(cm)	0.21**	0.54**	0.44**	0.37**	0.56**	0.57**	0.47**	0.09^{NS}	0.65**	0.47**	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05 NS: Not significance difference at (P□ 0.05).

The tail shape differentiated correlations between the morphometric traits of donkeys is presented in Table 4.26. The observed relationships were significant ($p<0.05$, 0.01) and positive ($r=0.11-0.89$) in both high-set and pendent tail shapes; except for non significant cases for tail shape body weight and shoulder width ($r=0.03$); height at withers with neck length, neck circumference and shoulder width ($r=0.01-0.09$) in the high-set; and tail length and height at withers ($r=0.08$) in the pendent tail shape. Generally, the relationship is stronger in the pendent than in the heigh-set tail shapes.

Table 4.27.The stepwise regression analysis for the best linear combinations of metric variables for predicting live body weight of donkeys.The predictors significantly ($p<0.01$) predicted body weight of these donkeys with good efficiencies (R^2=67-100%).The prediction of body weight of Nigeria donkeys based on sex and age categories revealed thatthe combination of NC and TL were the best predictors of body weight (BWT) in male weaner donkeys(R^2= 100%). The best predictors of body weight in female weaners was body length (BL) with the (R^2 =100). The head width (HWD), neck length (NL), neck circumference (NC), and height at withers (HW) (R^2 = 100)were the best predictors of BWT in male young donkeys and heart girth in females(R^2=100). The best predictors in male adult donkeys were NC and BL(R^2=100). For female adults, height at withers (HW) and heart girth were the best predictors of BWT (R^2= 100%). Tail length (TL) featured more prominently in the prediction of body weight male and female weaners;height at wither (HW) and neck circumference for male young; and heart girth for female young. Body length featured more prominently for male adults and height at withers for female adults.

Table 4.28**.**revealed the discriminant analysis of the best linear combination of metric variable for predicting live body weight of donkeys. The brown-white (0.33) donkeys were closer to brown (0.32) donkeys for HG while the red (0.28) were closer to black (0.28) donkeys. The body

length (1.35), head width (1.05) and ear length in red, ear length (15.41) and body length (1.35) in black, ear length (15.67) and body weight (1.25) in brown and also ear length (16.71) and body length (1.04) in brown-white donkeys, which contributed significantly to the body weight. The principle behind the ear length and body weight is that, they are variables that are robust enough to predict body weight of donkeys.

Table 4.26. Tail shape differentiated correlations between morphometric traits of donkeys

High- set	Traits	BWT(cm)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.18*	-									
	HWD(cm)	0.16*	0.59**	-								
	EL(cm)	0.21*	0.58**	0.48**	-							
	NL(cm)	0.15*	0.74**	0.54**	0.53**	-						
	NC(cm)	0.15*	0.74**	0.55**	0.56**	0.71**	-					
	SW(cm)	0.03^{NS}	0.61**	0.54**	0.32**	0.54**	0.48**	-				
	HW(cm)	0.94**	0.12*	0.16*	0.13*	0.09^{NS}	0.07^{NS}	0.01^{NS}	-			
	HG(cm)	0.19*	0.60**	0.66**	0.57**	0.63**	0.70**	0.49**	0.13*	-		
	BL(cm)	0.18*	0.66**	0.57**	0.54**	0.63**	0.67**	0.56**	0.10*	0.83**	-	
	TL(cm)	0.19*	0.51**	0.41**	0.38**	0.52**	0.55**	0.32**	0.11*	0.43**	0.46**	-
Pendent	Traits	BWT(cm)	HL(cm)	HWD(cm)	EL(cm)	NL(cm)	NC(cm)	SW(cm)	HW(cm)	HG(cm)	BL(cm)	TL(cm)
	HL(cm)	0.46**	-									
	HWD(cm)	0.36**	0.59**	-								
	EL(cm)	0.29**	0.64**	0.50**	-							
	NL(cm)	0.48**	0.83**	0.56**	0.56**	-						
	NC(cm)	0.42**	0.80**	0.61**	0.64**	0.75**	-					
	SW(cm)	0.37**	0.69**	0.62**	0.48**	0.64**	0.71**	-				
	HW(cm)	0.11*	0.15*	0.13*	0.14*	0.15*	0.19*	0.14*	-			
	HG(cm)	0.46**	0.75**	0.62**	0.65**	0.74**	0.80**	0.71**	0.16*	-		
	BL(cm)	0.53**	0.76**	0.63**	0.61**	0.74**	0.75**	0.71**	0.15*	0.89**	-	
	TL(cm)	0.40**	0.54**	0.44**	0.38**	0.58**	0.57**	0.54**	0.08^{NS}	0.54**	0.51**	-

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, *P□ 0.05 NS: Non significance difference at (P□ 0.05).

Table 4.27. Stepwise regression analysis for the best linear combination of metric variables for predicting live body weight of donkeys

Sex/Categories	**Predictor**	**Prediction equation**	**R^2**
Male weaner	TL	□ 28.204 + 3.69TL	0.99**
	NC TL	□ 5.0991 + (□ 0.73NC) + 3.81TL	1.00**
Female weaner	BL	□ 167.75 + 2.75BL	1.00**
Male young	HW	□ 112.05 + 2.24HW	0.67**
	NC HW	□ 113.75 + 1.11NC+ 1.60HW	0.89**
	HWD NC HW	□ 117.92 + 2.65HWD + 1.09NC+ 1.28HW	0.97**
	HD NLNC HW	□ 130.92 + 2.58HWD +0.56NL+ 0.99NC + 1.24HW	1.00**
Female young	HG	□ 204.73 + 3.06HG	1.00**
Male adult	BL	□ 249.59 + 3.64BL	0.97**
	NC BL	□ 242.92 + (□ 0.58NC) + 3.92BL	1.00**
Female adult	HW	□ 46.997 + 1.78HW	0.99**
	HW HG	□ 256.33 + 1.77HW + 1.88HG	1.00**

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01.

Table 4.28. Discriminant analysis of the best linear combination of metric variable for predicting live body weight of donkeys

Traits/strain	Red	Black	White	Brown	Brown-white
HL(cm)	-0.39	-0.14	-	-0.19	-0.48
HWD(cm)	1.05	0.78	-	0.78	0.73
EL(cm)	15.94	15.41	-	15.67	16.71
NL(cm)	0.39	0.58	-	0.44	0.95
NC(cm)	-1.16	-1.32	-	-1.21	-1.41
SW(cm)	-0.85	-0.85	-	-0.87	-1.19
HW(cm)	-0.001	0.00	-	0.001	-0.001
HG(cm)	0.28	0.26	-	0.32	0.33
BL(cm)	1.35	1.33	-	1.25	1.04
TL(cm)	-0.05	-0.06	-	-0.07	0.001

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, CV; Coefficient of variation, %; percent, N; Number.

Table 4.29. The Principal component analysis of metric measures and their contributions to live body weight of donkeys by strains. Thispresents the share of total variance, factor loading and Eigen value of principal components of morphometric traits of Nigerian donkeys by strain.The result from the PC showed that three components were extracted from the original ten morphometric traits of the Auraki donkeys. The first PC accounted for 71.1% of within sample variation with loadings for (HL, EL, NL, NC, SW, HW, HG and BL) with the second accounting for 9.5% variance and the loading of HWD. In the Duni donkeys, PC1, PC2 and PC3 had % variance of 62.1, 16.1 and 6.3%respectively. Trait loadings were HL, HWD, EL, NL, NC, SW, HG and BL for PC 1. HW and TL were the loadings in PC 2 and 3 with the % variance of 1.61 and 0.63. In the Fari, PC1, PC2 and PC3 had % variance of 100.0, 8.5 and 68.7% of total variance respectively across components. Loadings indicated were HL, HWD, EL, NL, NC, HW,HG, BL and TL (PC1); HWD, NL, SW, and HW (PC2). Trait loadings in PC3 were not significant. Idabari had PC1, PC2 and PC3 with % variance of 88.0, 9.8 and 4.9% respectively. Loadings indicated were HL, HWD, EL, NL, NC, HW, HG, BL and TL (PC1); HL, NC, SW, HW, HG, BL and TL (PC2) and HL, HWD, NL, and SW (PC3) respectively. Similarly for Idabari-fari, the % variances were 69.9, 14.4, and 7.7%respectively. Trait loadings wereHL, HWD, EL, NL, NC, SW, HW, HG, and BL (PC1) and NL, HW, HG, BL and TL (PC2).Trait loadings were not significant in PC3 for all the morphometric traits recorded.

Table 4.30. The Principal component analysis of metric measures and their contributions to live body weight of donkeys by Age. This presents the share of total variance, factor loading and Eigen value of principal components of morphometric traits of Nigerian donkeys by age. The result from PC showed that three components were extracted from the original ten morphometric traits of weaner, young and adults. For weaner donkeys, PC1 accounted for 30.6% of within

sample variation with loadings for (HL, HWD, EL,NL, NC, SW,HG, BL and TL) with the second PC accounting for 11.5% variance and loadings of (HL and SW) respectively. In young donkeys, PC1 and PC2 had % variance of 48.8 and 12.7% respectively. Trait loadings were HL, HWD, EL, NL, NC, SW, HW, HG, BL, and TL across the components. Loadings indicated were (HL, HWD, EL, NL, NC, SW, HW, HG, BL, and TL) for PC1 while PC2 were (SW and TL). In adult donkeys, PC1 and PC2 had % variance of 38.4 and 12.9% of total variance respectively across the components. Loadings indicated were (HL, HWD, EL, NL, NC, SW, HW, HG, BL, and TL) in PC1, NL and TL in PC2. Most of the metric traits in all PC2 for weaner, young and adults were not significant.

Table 4.29. Principal component analysis of metric measures and their contributions to live body weight of donkeys by strain.

Strains	Auraki				Duni				Fari				Idabari				Idabari-fari			
Traits	PC1	PC2	PC3	com	PC1	PC2	PC3	com	PC1	PC2	PC3	com	PC1	PC2	PC3	com	PC1	PC2	PC3	com
HL	**0.82**	0.39	0.25	0.89	**0.81**	0.07	0.35	0.78	**0.93**	0.36	0.00	1.00	**0.66**	0.51	0.51	0.96	**0.77**	0.35	0.39	0.87
HWD	0.22	**0.88**	0.11	0.84	**0.69**	0.11	0.31	0.59	**0.89**	0.46	0.00	1.00	**0.64**	0.21	0.70	0.95	**0.89**	-0.02	0.25	0.85
EL	**0.65**	0.22	0.43	0.67	**0.83**	0.09	-0.08	0.71	**0.99**	0.12	0.00	1.00	**0.89**	0.24	0.26	0.92	**0.81**	0.01	-0.01	0.66
NL	**0.68**	0.49	0.17	0.74	**0.75**	0.06	0.42	0.75	**0.87**	0.50	0.00	1.00	**0.79**	0.27	0.47	0.93	**0.65**	0.57	0.18	0.77
NC	**0.72**	0.37	0.24	0.72	**0.81**	0.06	0.37	0.79	**0.99**	0.15	0.00	1.00	**0.81**	0.47	0.20	0.92	**0.79**	0.24	0.74	0.74
SW	**0.83**	0.16	-0.19	0.76	**0.68**	0.00	0.45	0.66	0.22	**0.98**	0.00	1.00	0.24	**0.60**	0.72	0.93	**0.59**	0.33	0.12	0.48
HW	**0.80**	0.29	0.42	0.90	0.09	**0.92**	-0.04	0.85	**0.91**	0.42	0.00	1.00	**0.72**	0.59	0.31	0.95	**0.74**	0.59	0.06	0.89
HG	**0.79**	0.32	0.39	0.89	**0.87**	0.09	0.23	0.82	**0.92**	0.39	0.00	1.00	0.49	**0.80**	0.24	0.95	**0.84**	0.41	0.07	0.88
BL	**0.84**	0.37	0.17	0.87	**0.86**	0.09	0.24	0.79	**0.92**	0.39	0.00	1.00	0.41	**0.81**	0.34	0.93	**0.81**	0.47	0.14	0.90
TL	0.14	0.13	0.9	0.85	0.36	0.10	**0.85**	0.86	**0.97**	0.24	0.00	1.00	**0.80**	0.43	0.19	0.86	0.08	**0.92**	0.23	0.89
Eigen va	7.11	0.95	0.74		6.21	1.61	0.63		10.0	0.85	6.87		8.80	0.98	0.49		6.99	1.14	0.77	
Eigen %	71.1	9.5	7.4		62.1	16.1	63.0		100.0	8.5	68.7		88.0	9.8	4.9		69.9	14.4	7.7	

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01

Table 4.30. Principal component analysis of metric measures and their contributions to live body weight of donkeys by Age

	Weaner			Young			Adult		
Traits	PC1	PC2	Com	PC1	PC2	com	PC1	PC2	com
HL(cm)	**0.59**	**0.42**	91.6	**0.74**	0.17	96.7	**0.82**	-0.49	93.9
HWD(cm)	**0.51**	0.32	78.6	**0.47**	0.14	90.7	**0.44**	-0.22	84.9
EL(cm)	**0.46**	-0.41	85.5	**0.44**	-0.31	94.1	**0.52**	-0.04	90.2
NL(cm)	**0.50**	-0.09	100.0	**0.57**	0.34	100.0	**0.74**	0.45	100.0
NC(cm)	**0.69**	-0.03	96.3	**0.68**	0.02	98.5	**0.80**	0.29	97.3
SW(cm)	**0.52**	**0.68**	70.7	**0.54**	**0.50**	85.1	**0.66**	-0.09	79.2
HW(cm)	0.07	-0.06	52.8	**0.69**	-0.49	71.6	**0.80**	-0.38	62.3
HG(cm)	**0.77**	-0.33	91.6	**0.72**	-0.39	48.8	**0.79**	-0.49	38.4
BL(cm)	**0.66**	-0.19	42.1	**0.78**	-0.24	61.4	**0.79**	-0.39	51.4
TL(cm)	**0.45**	-0.28	62.5	**0.46**	**0.58**	78.4	**0.49**	**0.49**	72.1
Eigen value	3.06	1.15		4.88	1.27		3.84	1.29	
Eigen percent	30.6	11.5		48.8	12.7		38.4	12.9	

Keys: BWT: Body weight; HL: Head length; HD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, PC: Principal component analysis.

Table 4.31.revealed the Principal component analysis of metric measures and their contributions to live body weight of donkeys by Sex. This shows the share of total variance, factor loading and Eigen value of principal components of morphometric traits of Nigerian donkeys by sex. PC1 and PC2 for male donkeys accounted for 61.1% of between sample variation with loadings for HL, HWD, EL, NL, NC, SW, HG, BL and TL with the second PC accounting for 9.8% variance and the loading of HW. Majority of the biometric traits in PC2 for male were not significant. In female donkeys, PC1 and PC2 had % variance of 61.9 and 9.9%. The trait loadings were HL, HWD, EL, NL, NC, SW, HW, HG, BL, and TL respectively across the components. All the trait loadings in PC2 were not significant except HW.

Table 4.32. Principal components cluster analysis of morphological traits of donkeys. This shows the share of total variance, factor loading and Eigen value of principal components of morphological traits of Nigerian donkeys. The result from PC showed that three components were extracted from the original seven morphological traits of donkeys. PC1 accounted for 30.1% of within sample variation with loadings for tail shape, head profile and hair type. The trait loadings in PC 2 were coat colour and coat colour pattern. In PC 3, the traits loadings was eye colour.

Table 31. Principal component analysis of metric measures and their contributions to live body weight of donkeys by sex

	Male			Female		
Traits	PC1	PC2	com	PC1	PC2	Com
HL(cm)	**0.89**	-0.01	97.14	**0.90**	-0.0002	75.07
HWD(cm)	**0.76**	-0.01	91.98	**0.77**	-0.04	91.87
EL(cm)	**0.74**	0.02	94.89	**0.73**	0.06	95.24
NL(cm)	**0.85**	-0.04	100.00	**0.87**	-0.06	100.00
NC(cm)	**0.89**	0.02	99.00	**0.88**	-0.06	98.98
SW(cm)	**0.81**	-0.03	88.63	**0.77**	-0.14	88.19
HW(cm)	0.18	**0.98**	78.64	0.19	**0.98**	77.89
HG(cm)	**0.91**	-0.03	61.91	**0.89**	-0.02	61.91
BL(cm)	**0.91**	-0.03	71.67	**0.87**	-0.03	71.77
TL(cm)	**0.64**	-0.02	84.05	**0.73**	0.03	83.65
Eigen value	6.19	0.98		6.19	0.99	
Eigen percent	61.9	9.8		61.9	9.9	

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, **P□ 0.01, %: Variance, PC: Principal component.

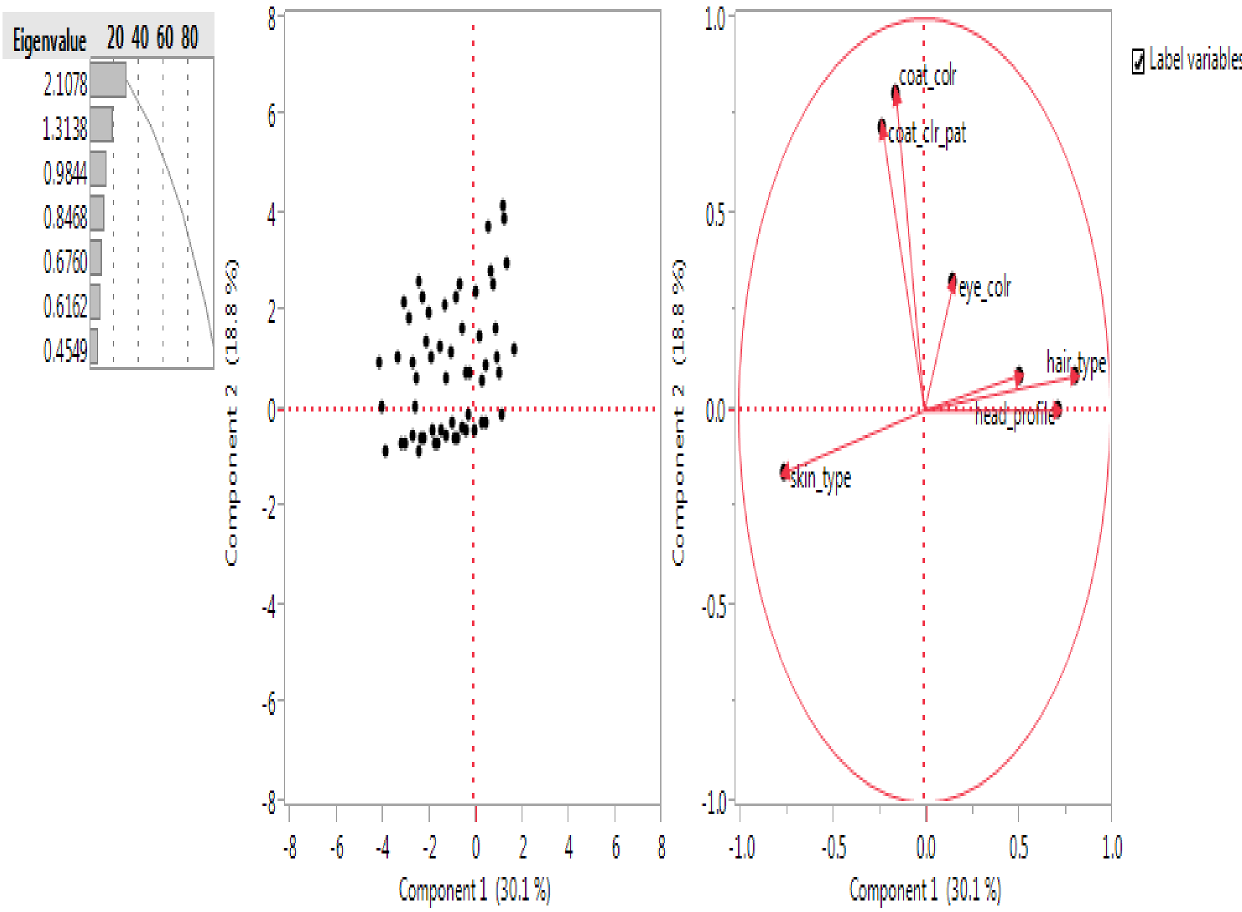
Table 4.32. Principal components cluster analysis of morphological traits of donkeys

	Principal components			
Traits	**PC1**	**PC2**	**PC3**	**Communality**
Coat colour	-0.15	**0.81**	-0.02	30.11
Skin type	-0.75	-0.16	0.12	48.88
Coat colour pattern	-0.23	**0.72**	-0.36	62.94
Tail shape	**0.51**	0.09	0.08	75.04
Eye colour	0.16	0.33	**0.89**	84.69
Head profile	**0.72**	-0.02	-0.13	93.50
Hair type	**0.81**	0.09	-0.10	100.00
Eigen value	2.11	1.31	0.98	
Eigen percent	30.1	18.8	14.1	

PC; Principal component, **P□ 0.01.

Figure 4.1a and 4.1b: shows the clusters analysis and biplot of morphological traits of donkeys. In component 1 about 30.1% form component 1 while 18.8% form component 2. Component 1 had the high contribution in terms of hair type, eye colour, coat colour pattern, tail length and coat colour. The second component had the least contribution in terms of skin type and head profile.

Figure 4.2: shows the scatter diagram for cluster analysis. The scatter diagram shows the distribution or spread of data among the morphological traits of donkeys. Far and distant relationships were observed between skin type and head profile, coat colour pattern and eye colour while closed genetic relationships were observed between hair type and coat colour. The closer the distribution of morphological traits among themselves, the closer the relationships and the further or distant the traits, the more distant is the relationships among the morphological traits of donkeys. The single and double dots signs show the degree of clustering between each of the class.



4.1a: Cluster analysis of morphological traits.

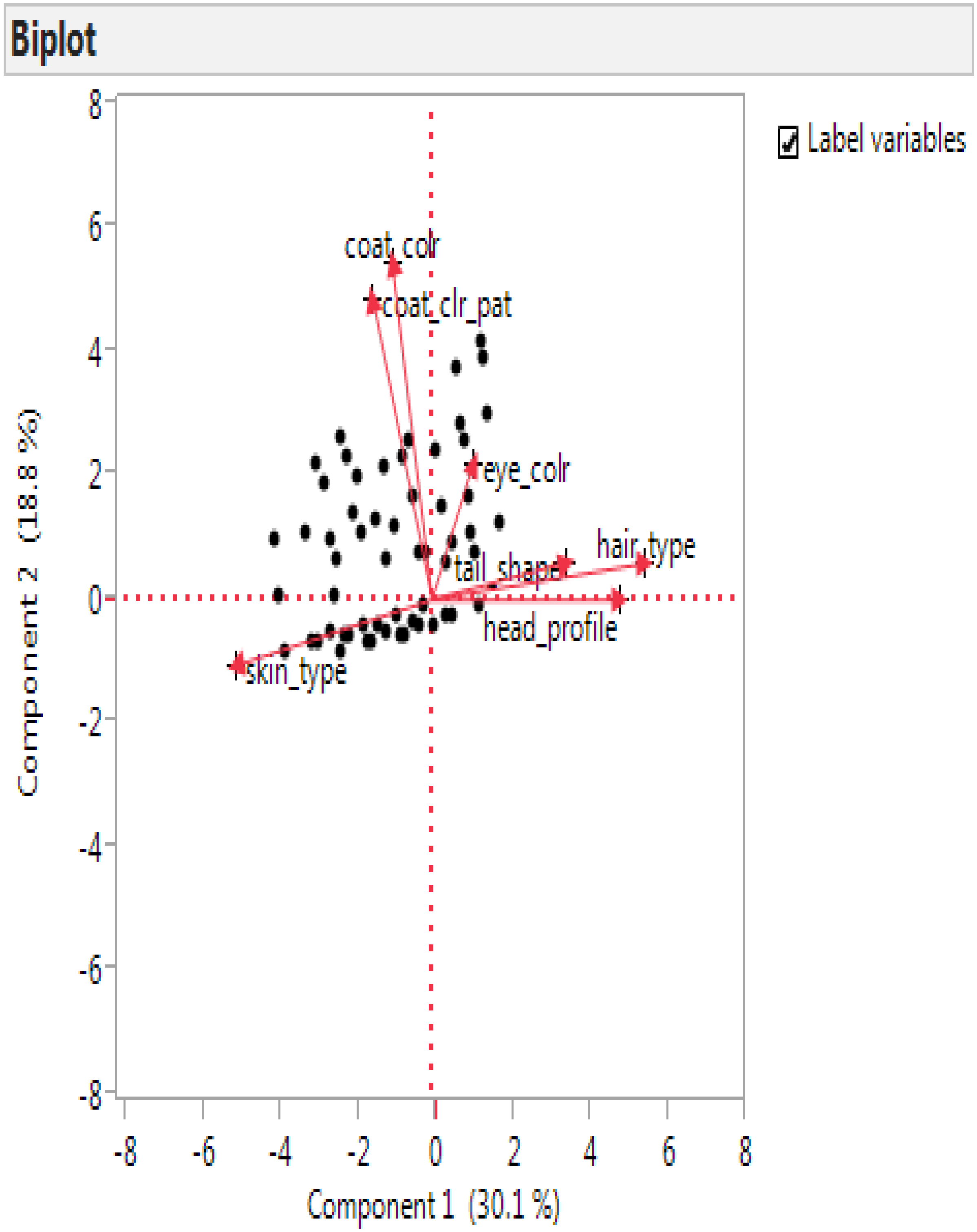


Figure 4.1b: Biplot of morphological traits of donkeys.

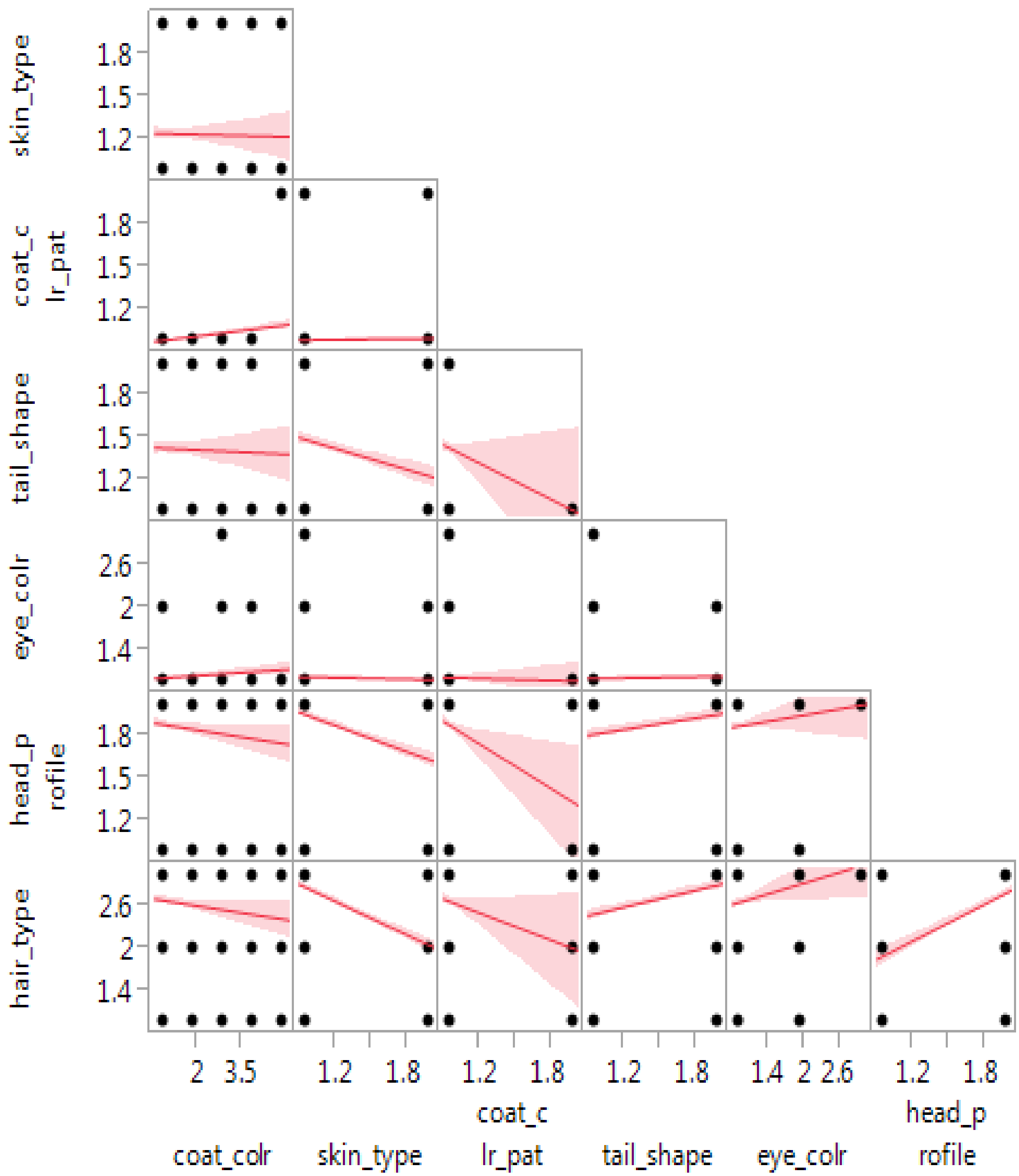


Figure 4.2: Scatter diagram for the cluster analysis

4.5: Classification of Donkeys of Northwestern Nigeria

Table 4.33.Classified donkeys by the application of Euclidean to measure distance. In male black donkey, closer genetic relationships was observed for head width (16, 16), between cluster 1 and 2 and shoulder width (21, 21) in male red donkey. For female donkeys, the genetic distance between cluster 1 and 2 for ear length for female red (26, 21),femaleblack (21, 26) and female brown (26, 21) were similar for ear length across the strains. Other morphometric trait showed distant genetic relationship among the strains. In female donkey, close relationship was also observed between cluster 1and 2 for HWD (15, 11), and EL (26, 21). In female black donkey strains, relationships existed between HWD (11,14), EL (21, 26) and SW (15, 19). In white donkeys, HWD (11, 14) and EL (23, 26), and in brown donkeys, HWD (17, 11), EL (26, 21). In brown-white female donkey strains, close relationships was also observed in HL (38, 35), HWD (11, 10), EL (24, 22), NL (38, 36) NC (49,42), SW (14, 16), HW (89, 84) and TL (49, 42).

Table 4.34.The classification by the application of single, average and complete linkage. The heaviest body weight was recorded in male red (141.90kg) donkey strain with a distance of 6.75cm among all the strains of donkeys. Male donkey with the smallest body weight was recorded in white (123.55kg) with a distance of 12.01cm.

Female donkey with the heaviest body weight was recorded in brown donkey (123.07kg) donkey strain with a distance of 16.78cm while the female donkey with the smallest body weight was recorded in brown-white (52.25kg).

Table 4.35.displays the simple discriminant analysis for strain classification. Simplediscriminant analysis for strain classification of donkeys in Northwest Nigeria showed that no difference existed in body weight, neck circumference and tail length across strains and therefore cannot be used to

distinguish them. Ear length (EL) and body length (BL) were the only biometric measures with high discriminant powers to differentiate the donkey strains. The discriminant for ear length was (14.06) Red, (13.59) Black, (13.74) White, (13.80) brown and (14.85) Brown-white and for body length, (1.20) Red, (1.19) Black, (1.18) White, and (1.13) Brown.

The simple discriminant analysis for sex classification showed that the ear length EL (13.75) in male and (13.77) in female and body length (BL) in male (1.23) and female (1.25) had high value and were more superior for body weight and other body linear measurements.

Table 4.33. Classification by the application of Euclidean to measure distance

Male	**Traits/strain**	**Red**		**Black**		**White**		**Brown**		**Brown-white**	
		Cluster		**Cluster**		**Cluster**		**Cluster**		**Cluster**	
	Traits	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
	HL(cm)	48	39	48	46	47	36	28	48	-	-
	HWD(cm)	16	12	16	16	13	11	11	15	-	-
	EL(cm)	26	22	22	25	26	22	22	25	-	-
	NL(cm)	49	35	47	43	45	35	32	47	-	-
	NC(cm)	65	51	62	50	60	50	39	47	-	-
	SW(cm)	21	21	24	22	20	17	13	23	-	-
	HW(cm)	107	97	110	105	105	80	77	99	-	-
	HG(cm)	114	104	108	101	111	82	69	108	-	-
	BL(cm)	109	99	109	100	109	87	73	101	-	-
	TL(cm)	60	49	46	68	64	35	33	53	-	-
Female	HL(cm)	49	28	32	48	36	48	49	34	38	35
	HWD(cm)	15	11	11	14	11	14	17	11	11	10
	EL(cm)	26	21	21	26	23	26	26	21	24	22
	NL(cm)	47	27	33	46	38	46	47	33	38	36
	NC(cm)	71	35	40	65	47	61	60	38	49	42
	SW(cm)	24	14	15	19	15	25	20	12	14	16
	HW(cm)	108	85	80	106	86	105	104	79	89	84
	HG(cm)	118	92	82	115	84	112	114	73	88	79
	BL(cm)	109	89	87	107	84	112	106	70	84	76
	TL(cm)	63	22	45	61	38	68	65	39	49	42

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Table 4.34.Classification by the application of single, average and complete linkage.

Sex	Strain	Body weight (kg)	Distance
Male	Brown	130.29	16.64
	Red	141.90	6.75
	Black	137.87	9.32
	White	123.55	12.01
Female	Brown	123.07	16.78
	Red	115.90	10.91
	Black	109.60	11.40
	White	113.45	12.09
	Brown-white	52.25	0.00

Table 4.35. Simple discriminant analysis for Strain classification

Traits/traits	Red	Black	White	Brown	Brown-white
BWT(kg)	-0.04	-0.04	-0.03	-0.03	-0.04
HL(cm)	-0.09	0.20	0.12	0.14	-0.18
HWD(cm)	0.03	-0.23	-0.33	-0.24	-0.23
EL(cm)	14.06	13.59	13.74	13.80	14.85
NL(cm)	0.13	0.29	0.07	0.17	0.69
NC(cm)	-1.19	-1.37	-1.21	-1.27	-1.46
SW(cm)	-0.99	-1.04	-1.18	-1.02	-1.34
HW(cm)	0.03	0.03	0.02	0.03	0.04
HG(cm)	0.04	0.05	0.08	0.11	0.11
BL(cm)	1.20	1.19	1.18	1.13	0.92
TL(cm)	-0.03	-0.04	-0.06	-0.05	0.03

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Figure 4.3.The discriminant function of the donkey strains. Two functions were generated by discriminant analysis. The first function is represented by green colour. Idabari, Auraki and Duni were clustered together while the remaining Idabari and Fari were clustered together to form another function. Generally, there are two centroids which were grouped together based on the characteristics. The implication of the centroid in selection implies that differences were manifested between the two strains which means that Auraki, Idabari and Duni can be selected together based on their characteristics while Idabari-fari and Fari can also be selected based on their similar characteristics.

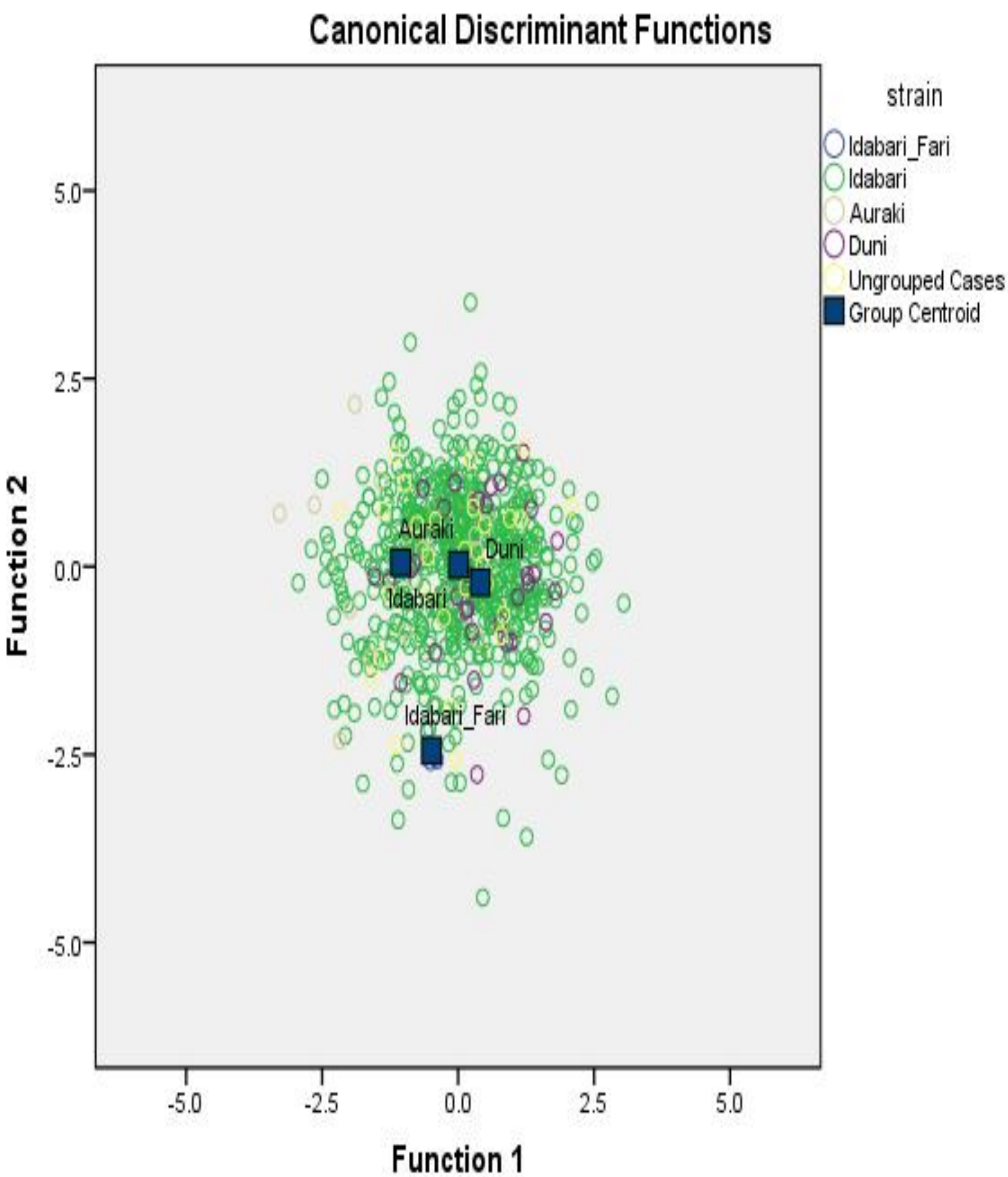


Figure 4.3: Discriminant function of the donkey strains

Table 4.36.The stepwise discriminant analysis to determine the variables with more discriminating power than others in the final cluster analysis. Low and negative discriminating power were observed among weaner, young and adults for BWT, HWD, NC, SW and TL. Low and positive discriminating power were observed among majority of the biometric traits. EL had high discriminant power among all the biometric traits across the age groups for weaner (14.35), young (14.17) and adults (13.89).

Table 4.37.indicates the canonical discriminant analysis value to match the donkey strains into genetic groups (clusters). The result from the canonical discriminant analysis showed that four components were extracted from the original ten morphometric traits of red donkeys. The trait loadings were HWD NC SW HG and BL were obtained in CAN 1, HL, NL, SW, HG and BL in CAN 2, HWD and EL in CAN 3. Black donkeys had high trait loadings in CAN 1 for BWT, HL, HWD, EL, NC, SW, HG and BL, CAN 2 for HL, NL, SW, BL and TL, 3 for HWD, EL and TL. White donkey strains had high trait loadings for HWD, NC, SW, HG and BL in CAN 1. CAN 2 had HL, NL and SW. CAN 3 recorded HWD and EL. Brown donkey strains recorded high values in terms of NC in CAN 1. CAN 2 were HL, NL and SW. EL was obtained in CAN 3. For brown-white donkeys, NC was observed in CAN 1. HL, NL and SW in CAN 2. The trait loadings in CAN 3 were EL and NL, respectively.

Table 4.38.revealed the UPMGA (Unpaired Mean Grade Average) Cluster between populations for studied morphological traits of donkeys. Skin type and tail shape had the highest genetic distance estimates with average values of 24% and 36% respectively. The overall result showed that the genetic relationships between the strains of donkeys are homogeneous.

Table 4.36a.Stepwise discriminant analysis to determine the variables with more discriminated power than others in the final cluster analysis.

Traits/age group	Weaner	Young	Adult
BWT(kg)	-0.067	-0.0625	-0.068
HL(cm)	0.389	0.332	0.299
HWD(cm)	-0.675	-0.7275	-0.346
EL(cm)	14.35	14.17	13.89
NL(cm)	0.208	0.367	0.122
NC(cm)	-1.243	-1.316	-1.264
SW(cm)	-1.559	-1.579	-1.284
HW(cm)	0.058	0.052	0.059
HG(cm)	0.115	0.081	0.123
BL(cm)	1.203	1.225	1.208
TL(cm)	-0.078	-0.038	-0.037

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Table 4.36b. Stepwise discriminant analysis to determine the variables with more discriminated power than others in the final cluster analysis.

Traits	Male	Female
BWT(kg)	-0.07	-0.08
HL(cm)	0.20	0.08
HWD(cm)	-0.29	-0.28
EL(cm)	13.75	13.77
NL(cm)	0.21	0.27
NC(cm)	-1.34	-1.42
SW(cm)	-1.25	-1.27
HW(cm)	0.06	0.67
HG(cm)	0.15	0.24
BL(cm)	1.23	1.25
TL(cm)	-0.01	-0.04

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Table 4.37a. Canonical discriminant analysis to match the donkey strains into genetic groups (clusters)

	Class means on canonical variables											
Strains	**Red**				**Black**				**White**			
Traits	**Can 1**	**Can 2**	**Can 3**	**Can 4**	**Can 1**	**Can 2**	**Can 3**	**Can 4**	**Can 1**	**Can 2**	**Can 3**	**Can4**
BWT(kg)	0.25	0.12	0.007	-0.13	**0.90**	0.36	0.02	-0.24	0.25	0.11	0.01	-0.13
HL(cm)	0.40	0.58	0.15	-0.19	**0.61**	**0.77**	0.16	-0.15	0.39	0.58	0.15	-0.19
HWD(cm)	0.51	0.38	0.52	0.13	**0.71**	0.45	0.53	0.09	0.51	0.37	0.52	0.13
EL(cm)	0.29	0.04	**0.61**	-0.16	0.55	0.07	**0.82**	-0.15	0.29	0.04	**0.61**	-0.16
NL(cm)	0.14	**0.61**	0.42	-0.05	0.22	**0.85**	0.48	-0.04	0.14	**0.61**	0.42	-0.05
NC(cm)	**0.62**	0.18	0.33	-0.09	**0.91**	0.22	0.35	-0.07	**0.62**	0.18	0.33	-0.09
SW(cm)	**0.62**	**0.64**	0.37	-0.09	**0.71**	**0.63**	0.31	-0.05	**0.62**	**0.64**	0.37	-0.09
HW(cm)	0.09	0.08	0.08	-0.20	0.59	0.41	0.33	-0.61	0.09	0.08	0.08	-0.20
HG(cm)	0.58	0.31	0.32	-0.17	**0.84**	0.39	0.34	-0.13	0.57	0.31	0.32	-0.17
BL(cm)	0.59	0.43	0.18	0.21	**0.82**	0.53	0.18	0.15	0.58	0.43	0.18	0.21
TL(cm)	0.19	0.31	0.43	0.15	0.41	0.59	**0.67**	**0.67**	0.19	0.31	0.43	0.15

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Table 4.37b. Canonical discriminant analysis to match the donkey strains into genetic groups (clusters)

Class means on canonical variables								
Strains	**Brown**				**Brown/white**			
Traits	**Can 1**	**Can 2**	**Can 3**	**Can 4**	**Can 1**	**Can 2**	**Can 3**	**Can 4**
BWT(kg)	0.29	-0.01	-0.19	-0.12	0.29	-0.01	-0.19	-0.12
HL(cm)	-0.04	**0.70**	-1.11	-0.81	-0.04	**0.70**	-1.11	-0.80
HWD(cm)	0.16	0.06	0.48	0.45	0.15	0.06	0.48	0.45
EL(cm)	-0.17	-0.43	**0.80**	-0.13	-0.17	-0.43	**0.80**	-0.13
NL(cm)	-0.04	**0.70**	-1.11	-0.81	-0.01	**0.66**	**0.67**	0.10
NC(cm)	**0.89**	-0.98	-0.02	0.16	**0.89**	-0.98	-0.02	0.16
SW(cm)	0.46	0.55	0.33	-0.29	0.46	0.54	0.33	-0.29
HW(cm)	-0.17	0.05	0.12	-0.11	-0.17	0.05	0.12	-0.11
HG(cm)	0.09	-0.15	0.04	-1.61	0.09	-0.15	0.04	-1.61
BL(cm)	0.40	0.14	-0.64	1.87	0.39	0.14	-0.63	1.86
TL(cm)	0.16	0.06	0.48	0.45	-0.25	0.002	0.29	0.36

Keys: BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length.

Figure 4.4: shows the canonical discriminant analysis to match the donkey strains into genetic groups (clusters). The three strains that is, red, black, brown were clustered or separated into a separate groups while brown-white and brown were also separated into a distinct group. The five groups of strains were joined together by conceptual cluster that is, the points in a cluster shared some general property that derives from the entire sets of points in the intersection of the circles belonging to each donkey strains. The implication is that, the greater the similarity (or homogeneity) within a strain, the greater the differences between groups, the better or more distinct the clustering, and also the better the chances for selection.

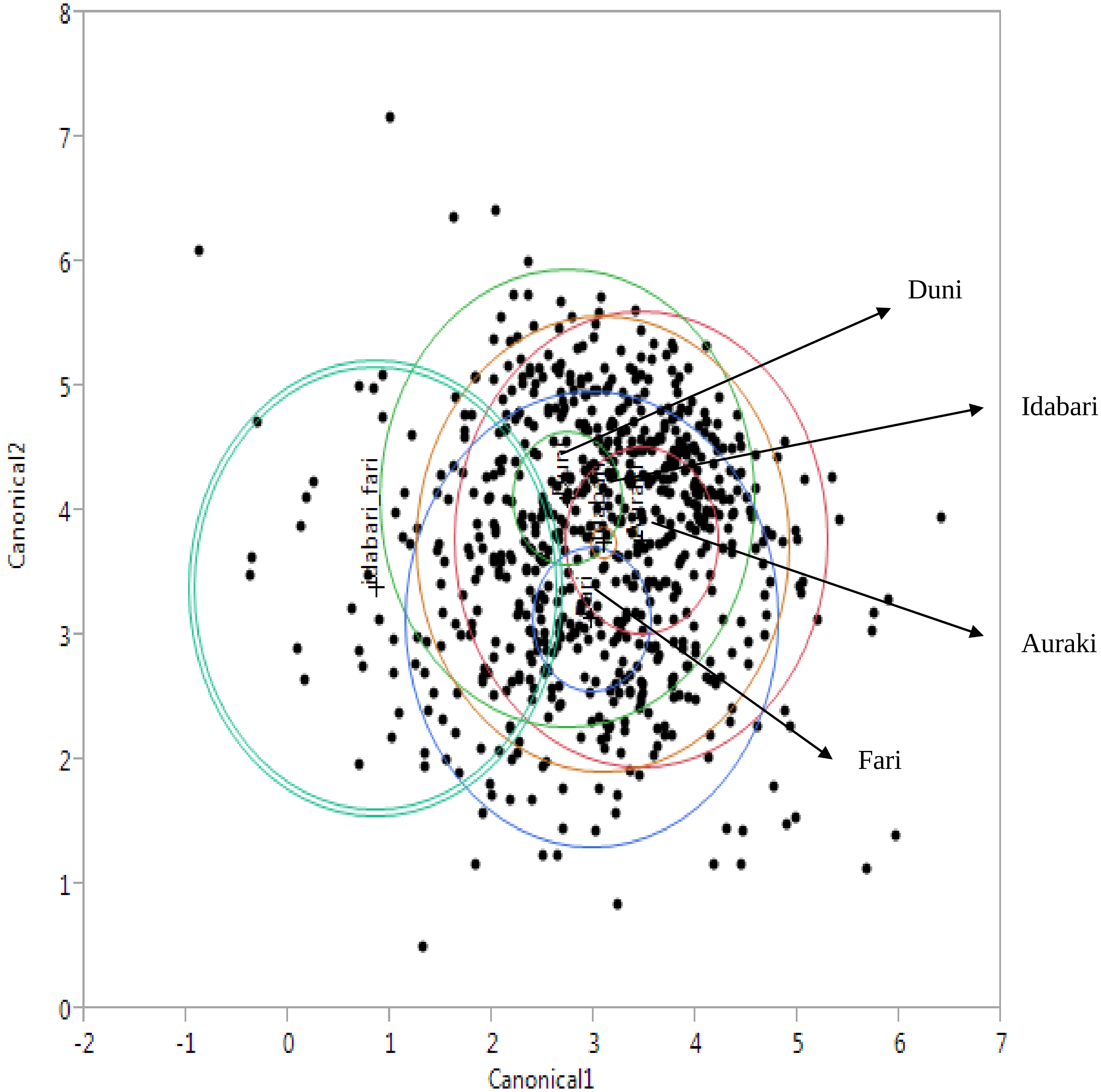


Figure 4.4: Canonical discriminant analysis to match the donkey strains into genetic groups (clusters).

Table 4.38:UPMGA Cluster Showing relationship between populations for Coat colour, Hair type, Skin type, Coat colour pattern, Tail shape, Eye colour and Head profile.

	Coat colour		**Hair type**		**Skin type**		**Coat colour pattern**		**Tail shape**		**Eye colour**		**Head profile**	
Node	Dist.	Population	Dist.	Population	Dist.	Population	Dist.	Population	Dist.	Population	Dist.	Population	Dist.	Population
1	0.0000	4,5	0.0000	1,2	0.0001	3,4	0.000	3,4	0.0000	2,4	0.0000	4,5	0.0000	4,5
2	0.0000	3,4,5	0.0002	4,5	0.0025	1,3,4	0.0000	2,3,4	0.0208	1,2,4	0.0000	3,4,5	0.0000	3,4,5
3	0.0000	2,3,4,5	0.0007	3,4,5	0.0194	1,2,3,4	0.0000	1,2,3,4	0.0359	3,5	0.0000	2,3,4,5	0.0000	2,3,4,5
4	0.0000	1,2,3,4,5	0.0067	1,2,3,4,5	0.3608	1,2,3,4,5	1.0000	1,2,3,4,5	0.2442	1,2,3,4,5	0.0000	1,2,3,4,5	0.0000	1,2,3,4,5

Figure 4.5-4.11 showed the Dendogram of this cluster series. In figure 4.5, the node containing group 1 (Auraki), 2 (Duni), 3 (Fari), 5 (Idabari-fari) and 4 (Idabari) for skin colour were closer to one another. However, in figure 4.6 for hair type, the node containing group 1 (Auraki) and 2 (Duni) were farther from node containing 4 (Idabari), 5 (Idabari-fari) and 3 (Fari) for hair type and indicating that Auraki and Duni are closer and similar for hair type but are distant from Idabari, Idabari-fari and Fari. In figure 4.7 for skin type, 1 (Auraki) 4 (Idabari) and 3 (Fari), were farther from the node containing 2 (Duni) and distant from 5 (Idabari-fari). For coat colour pattern, 1 (Auraki), 2 (Duni), 4 (Idabari) and 3 (Fari) are closer to one another but distant from the node containing 5 (Idabari-fari) in figure 4.8. In figure 4.9 for tail shape, the node containing 2 (Duni) and 4 (Idabari) are similar and closer to each other compared to 1 (Auraki), but distant from the node containing 3 (Fari) and 5 (Idabari) which are similar and closer to each other. In figure 4.10 for eye colour, the node containing 1. 2, 3, 5 and 4 are similar and closer to one another. For head profile, 1 (Auraki), 2 (Duni) 3 (Fari) 5 (Idabari-fari) and 4 (Idabari) are also similar and closer to one another in figure 4.11. Tail shape and skin type showed more relationships among all the morphological traits of donkeys. Tail shape had 24.4% within the population of 1, 2, 3, 4 and 5 while skin type had 36% within the population of 1, 2, 3, 4 and 5.

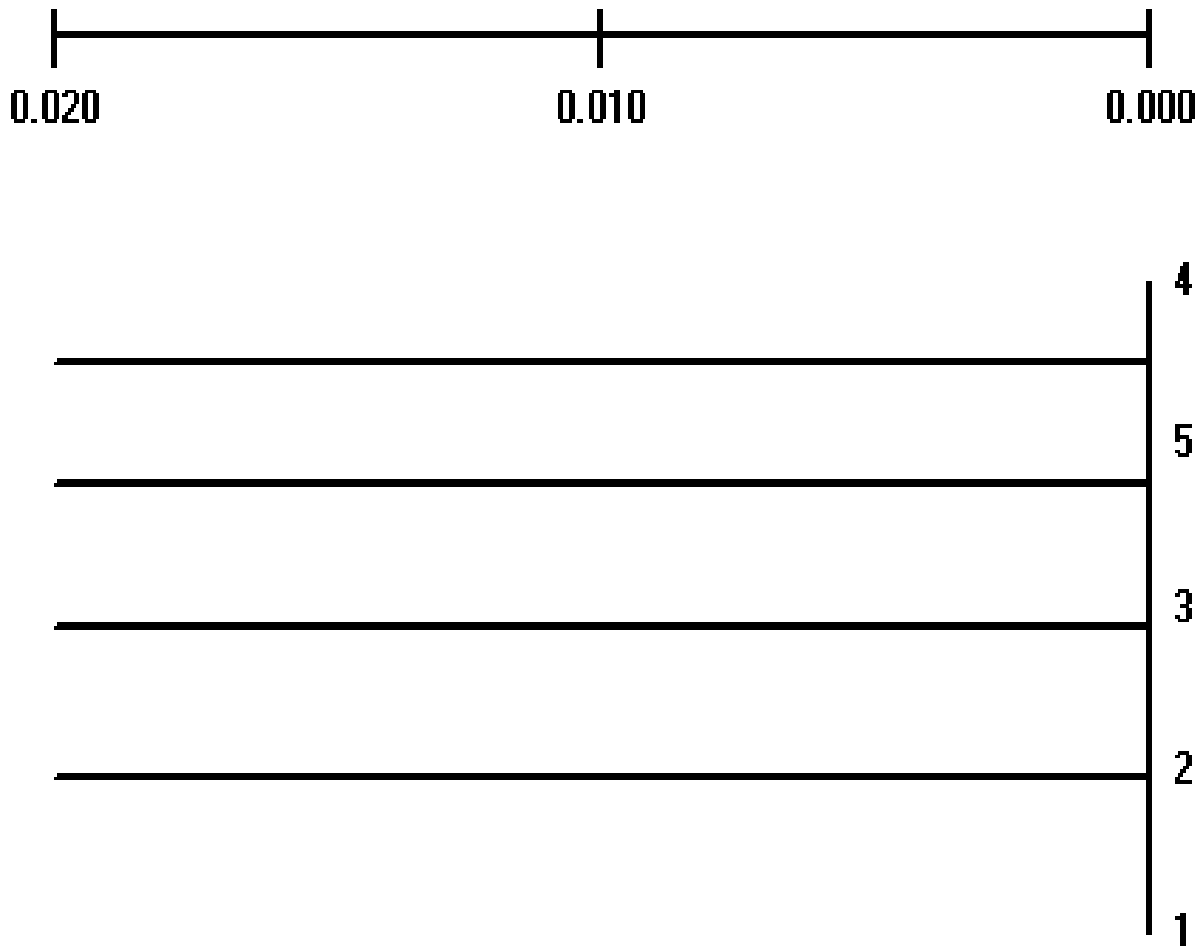


Figure 4.5:Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Coat colour.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

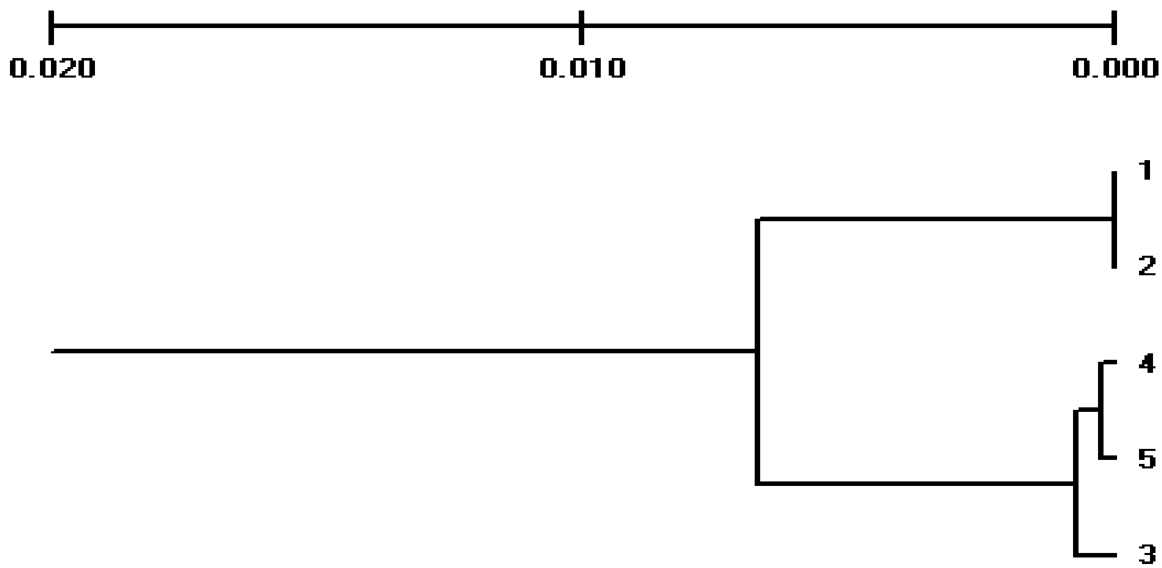


Figure 4.6.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Hair type.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

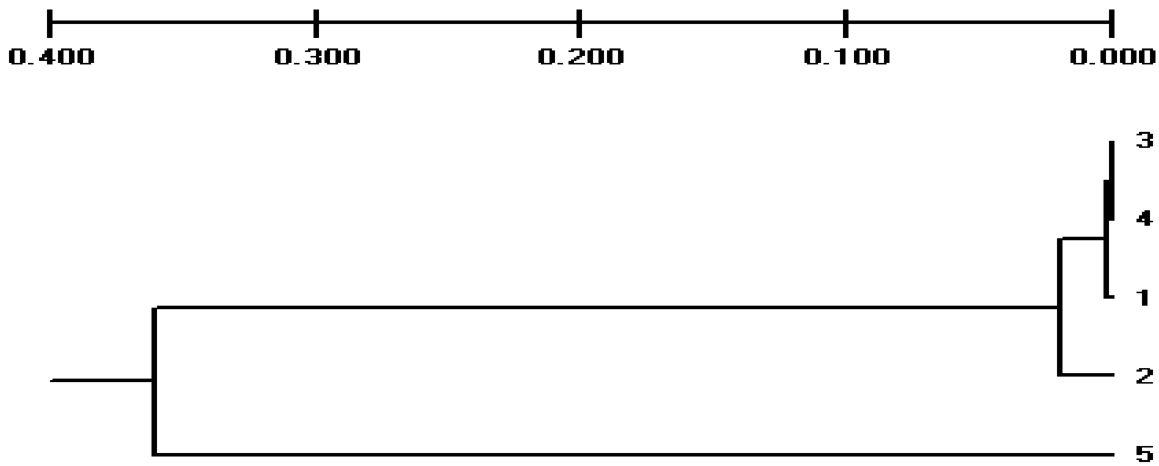


Figure 4.7.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Skin type

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

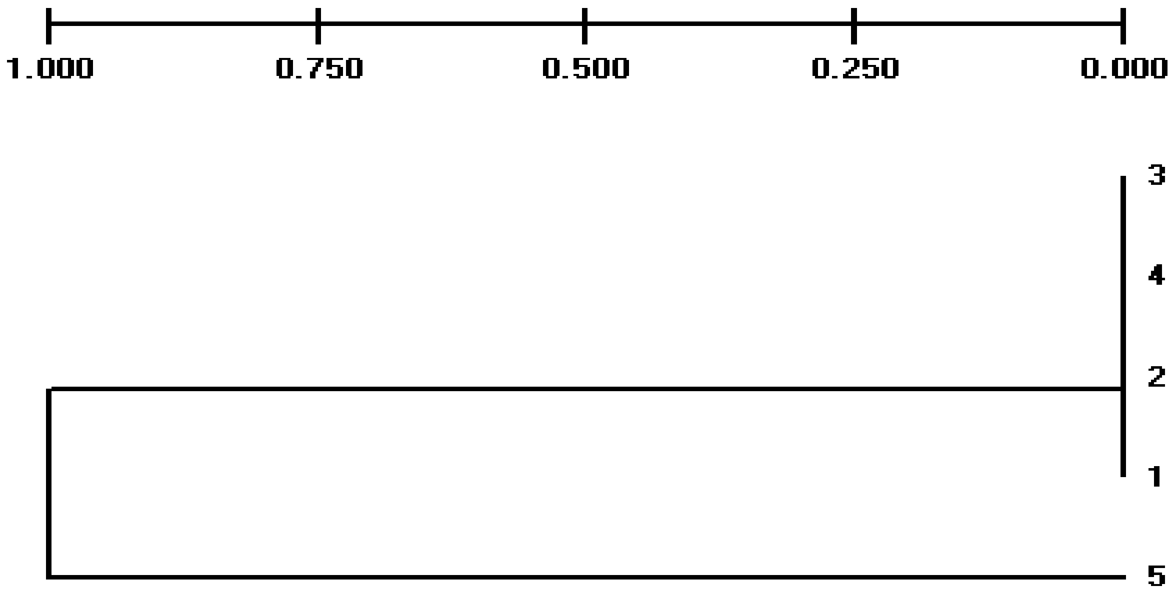


Figure 4.8.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Coat colour pattern

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

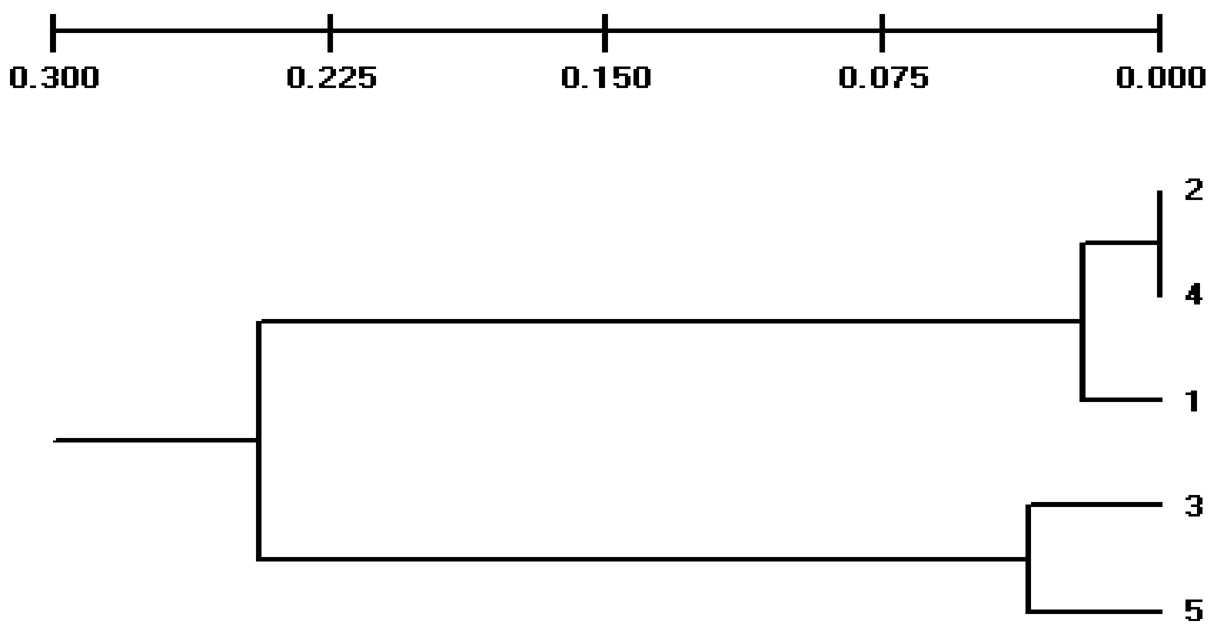


Figure 4.9.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Tail shape.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

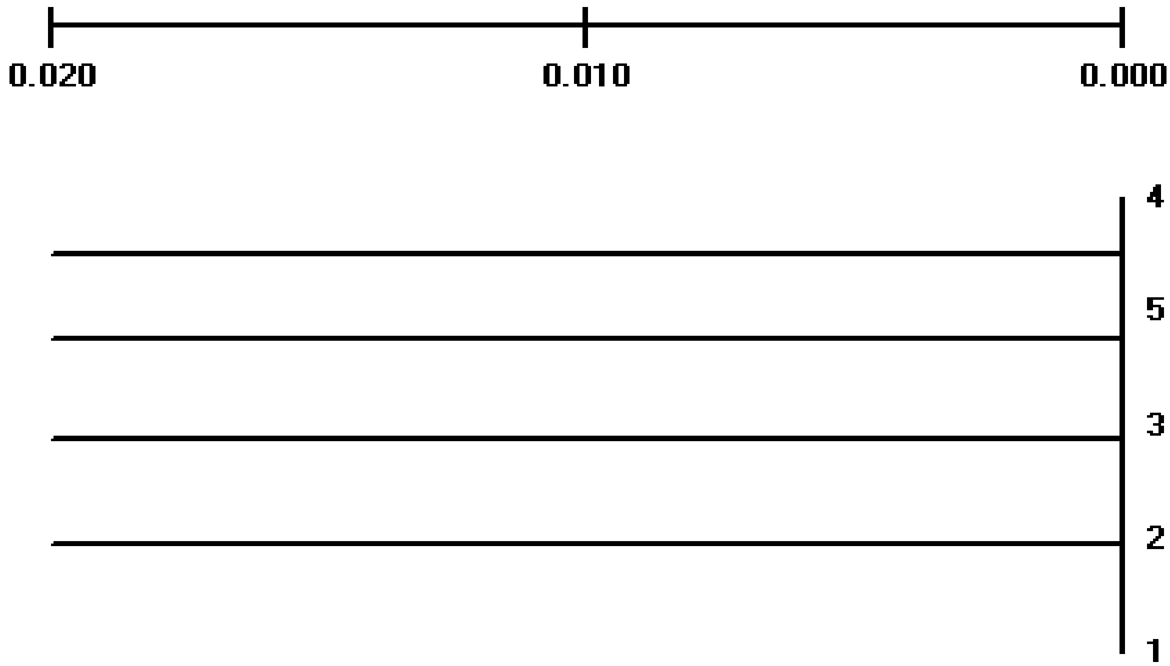


Figure 4.10.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Eye colour.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

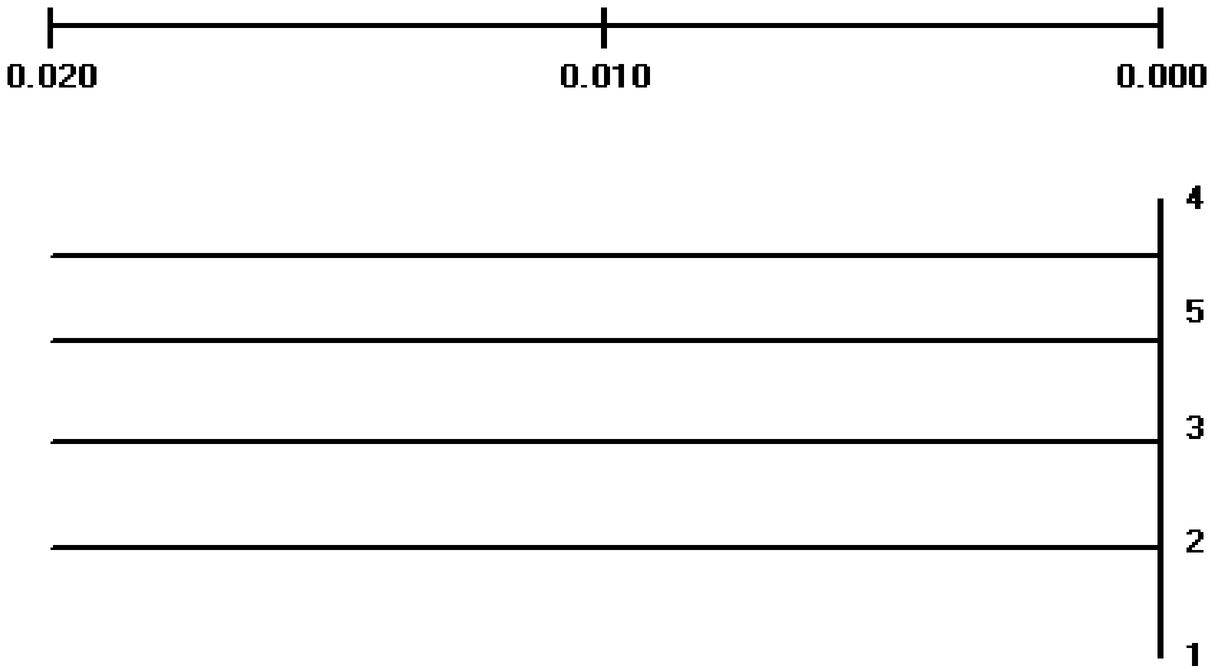


Figure 4.11.Dendogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Head profile.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

CHAPTER FIVE

5.0 DISCUSSION

5.1 Morphological Characteristics of Donkey Population Studied

The distribution of coat colour type variants obtained in the present study agreed with the findings ofBlench *etal*., (1990) that Idabari strain (brown donkey) is the most popular donkey strain among small holder farmers and was reported to costs higher than other strains. The pattern observed in this study for coat colour, eye colour, skin type, head profile and tail shape were similar to the observations made by Blench *etal*., (1990) in donkey. Donkeys with black eye colour were more predominant and showed high level of reproducibility (93-96%). However, the preponderance of short-smooth hair type over short- rough and long- curly in the study of Blench *etal*., (1990) was at variance with the trend observed in this study. Differences in sampling method, location and source of surveyed animals may be responsible for these variations. This implies that the propensity towards smooth hair structure could be an advantage as it provides a medium for conventional heat loss from the animal body surface from the tropical environment. This is supported by the assertion that hair structures have an important role to play in the adaptability of animals to different ecological zones (Banerji, 1984). Donkeys in the Northwest Nigeria were mostly of solid colour pattern (98-99%), brown colour (86-90%), black eye colour (93-96%), short- smooth hair (71-78%), thick skin (71-78%), pendent tail shape (53-61%) and straight head profile (83-88%).

Yilmaz and Ertugrul (2011) reported that the frequency of body coat colour of the sampled donkeys were 38.0% mouse grey, 21.2% white, 20.9% black and 19.9% brown. This is not in agreement with this finding which showed that the brown coat colour had a frequency of 88.0%, black 5.0%, white 4.0%, red 2.0% and brown-white 1.0%. The percentages in coat colour variations in strains may be because of the differences caused by an environment or as a result of the sampling technique being employed in the research.

This diversity or phenotypic differentiation amongst strains of donkey might not be unrelated with territorial distribution and the historical and cultural context. Flock movements and traditional livestock exchange might have affected occurrence of some traits which are linkedto major gene (Odubote, 1994).The heterogeneous traits observed in the P-value for all the morphological traits indicated that the population was at HWE for these loci. Differences in the effect of strain among the qualitative traits of donkeys may be attributed to genetic variations among the donkeys. The morphological traits of the donkeys are heterogeneous and in Hardy-weighberg equilibrium.

5.2 Morphometric Characterization of Donkeys and Factors Affecting them

5.2.1 Distribution of morphological traits of donkeys by sex

The distribution of morphological traits of donkeys by sex varied from literature reports Blench *etal*., (1990), and Yakubu *et al*., (2010). However, the pattern of higher frequency in the female than the male or almost equal distribution between the sexes in this study were consistent with the findings of Yakubu *et al*., (2010) and may be due to the preponderance of the female than the male in the population structure as more females are kept by farmers than males and males are subjected to higher selection intensity and culling compared to the females. Significant differences observed between the sexes might be due to sexual dimorphism which might be hormonal.

5.2.2. Within age group morphometric characteristics of donkeys

Inconsistencies exist in variations within the measures of growth of donkeys at weaner, young and adult stages, implying lack of uniformity in morphometric traits of these donkeys. For example, body weight was highly variable at weaner (36.9%) and adult (70.5%) stages but low at the young (9.4%). This is not in agreement with the result obtained by Predrag *et al*., (2015) reported that body measures for group of animals disclosed high homogeneity. The high level of homogeneity points out to the uniformity of morphometric characteristics of Balkan donkey breed. Significant morphometric differences in body length, head length, chest circumference and body weight were found between age groups.

5.3 Effect of Strain, Age, Sex and Location on Morphometric Traits of Donkeys

5.3.1Effect of strain on morphometric traits of donkeys

Body measures for Northwest Nigerian donkeys were highly homogenous for young and adult but heterogenous for weaner donkeys across strains. This high level of homogeneity points out to the uniformity of morphometric characteristics of the strain of donkey. A significant difference recorded by weaner donkey was in line with the pattern obtained by Stanisic and Dimitrijevic(2015). This could be viewed from genetics and physiology perspective that the body system is still in its developmental process which had not been fully established and at that time the genetic influence are highly unstable.

5.3.2. Effect of Age on morphometric traits of donkeys

Body weight of 52.30 to 115.70kg in brown through to white strain of donkeys in this study were higher than those published by Hintz *et al*., (1979) in the thoroughbred description. Values of 111-132 Kg reported by Stanisic and Dimitrijevic (2015) were higher to the values obtained in this study in young donkeys. Where differences in age is not so large, morphometric traits were quite similar especially for length wise traits in this study for young and adults. Morphometric measurements have been reported to vary positively with age of the animals (Ojedapo *et al*., 2007). The prediction of body weight from linear body measurements seemed to be better in kids than adult goats. Animals of different age groups will have differences in measurements of body parts (Osinowo *et al*., 1989; Otoikhian *et al*., 2006). In adult animals body length assumes more important role as an indicator of body weight (Baffour-Awuah *et al*., 2000). Patterns of growth of body parts based on age have been highlighted by Mavule *et al*., (2013); they stated that body parts developed at a different rate at different age groups. Some morphometric parameters were early maturing and stopped growing before others.

5.3.3. Effect of sex on morphometric traits of donkeys

Sexual dimorphism exist in the morphometric traits of donkeys in Northwest Nigeria with females having heavier body, larger head width, wider heart girth and body length values while the males had longer head, taller height and wider neck in the adult donkeys. The sex differences obtained in the morphometric traits of donkeys could be attributed to sexual dimorphisms (Yakubu and Akinyemi, 2010; Carneiro *et al*., 2010). Festa-Bianchet *et al*., (1996) reported that most dimorphism developed during post weaning because of faster mass favouredby males during the age of 1-2 years. They also suggested that males might have a longer season of mass gain each year throughout their lives, while females divert annual resources into reproduction, rather than body mass.

The effect of sex on morphometric traits of donkey showed that there were significant differences between male and female weaner donkeys. High values were observed in males forHL (47.64±0.42cm) compared with female (46.82±0.42cm). This is in agreement with the findings of Yilmaz and Ertugrul (2011) that the HL (48.8±0.48) for male is higher than females (48.0±0.49). Males had a wider skull and headthan females, in a similar way to that found by other authors in saddle-house breed (Hevia *et al*., 1993; Jordana and Folch 1996). This confirmed earlier findings of Folch and Jordana (1997), who had suggested sexual dimorphism in Catalonian donkeys. There were significant differences in the body sizes between males and females. This finding showed that males (107.26±18.69cm) tended to be taller than their female (106.93±18.76cm) counterpart. The heavier BWT (149.68±24.25kg), larger HG (112.08±0.91cm) and BL (107.87±0.91cm) of female could be attributed to pregnancy as some of the females could be pregnant during the course of the study.

5.3.4. Effect of Location on morphometric traits of donkeys

The significant effect of location on morphometric traits of these donkeys may be attributed to differences in the climatic conditions of these locations as well as management practises in the various herds at the seven locations. Stanisic and Dimitrijevic (2015) indicated that large variations among donkey populations are due to differences in geographical distribution and management.

Wilson (1981) reported that there was little physical variation in donkeys found throughout Africa and that donkeys rarely exceed a height at withers of 105cm. This is not in agreement with the result of this study. The result of this finding revealed that matured adult donkey attained a maximum height at withers of about 132.51±13.16cm in Idabari strain from Kaduna state which can be attributed to differences in location.

The results from the present study showed that significant (P□ 0.01) differences were observed in all the morphometric traits measured for weaners and young donkeys with the exception of HW, BL, SWD and NL. There was a relatively high variation in these traits as well. This agreed with the work of Beja-Pereira *et al*., (2004) that the wither heights, for example, is the most probably influenced by the origin of the given individual, as it can be an adaptation to specific conditions of that place. The cause of these differences can be found in different domestication families of the populations. According to this study, maximum wither height for adult donkeys were obtained from Kaduna (132.51±13.16cm) and Kebbi (123.68±21.73cm). This is not in agreement with the findings of Aganga (1994) who reported maximum of 110cm withers heights for Botswana donkeys, which means those donkeys were somewhat smaller than Nigerian donkeys. Barzev (2004) reported withers height of 100-120cm from Bulgaria, 140cm from Cyprus and Pearson and Ouassat (1996) reported 129cm from Morocco which is in the range of values obtained in this study. The specific conditions of the African continent enabled donkeys to develop a typical habit, which play a key role in order to survive in dry locations.

Ellis *et al.*(1994) reported that other body dimensions of the Zimbabwean donkeys as well as live weight indicated no major difference between male and female donkeys of similar maturity, frame size and live weight. This agreed with this present study which showed that there were no significant differences between HWD, EL, HW, HG and BL in weaner donkeys, HWD, NL, SW and BL in young donkeys and EL, NL, SW, HW and TL in adult donkeys.

5.4 Measures of Relationships and Associations in Donkeys

5.4.1 Correlated Relationship among Morphometric Traits of Donkeys

The correlated relationships within the morphometric traits of donkeys were low, moderate and high. Yilmaz and Ertugrul (2011) reported high value for correlation between WH and BL (r=0.77) and low correlation between BL and HL (r=0.21). This is in agreement with the finding of this study which showed that there were low and high positive correlations between body weight and shoulder width (0.13), height at withers and body length (0.99) and other body linear measurement of donkeys.

The recurring negative associations between BWT and SW (-0.04), SW and HW (-0.04), HW and BL (-0.01) in adult donkeys were at variance with literature reports among this traits (Cam et al., 2010; Semakula *et al.*, 2010; and Okpeku et al., 2011). It appeared that negative and increasing coefficient of association increased with age. Das *et al.* (2002) working with buffaloes noted that from 6 to 24 months of age, the correlation coefficient of body weight of calves was positive and highly significant; but decreasing gradually with increasing age of calves. Earlier reports by Sethi *et al*. (1996) also supported these findings in buffaloes.

5.4.2 Prediction of body weight using morphometric measurements

Body weight of donkeys across age groups and sex can be predicted majorly using NC, TL, HW, HWD, BL, and HG using a stepwise regression approach. The highest correlation observed in this study was in the category of male weaner BWT= -5.0991 + (-0.73NC), female weaner BWT= -167.75 + 2.75BL, male young BWT= -130.92 + 2.58HWD + 0.56NL + 0.99NC + 1.24HW, female young BWT= -204.73 + 3.06HG, male adult BWT= -242.92 + (-0.58NC) + 3.92BL, female adult BWT= -256.33 + 1.77HW + 1.88HG with R^2value of unity (R^2=1.00) for all the categories of donkeys. This agreed with observations of Eley and French 1993) which indicated that a predictive equation containing two variables produces a better correlation with liveweight than an equation with only one, but that little additional benefit was gained by the inclusion of three or more variables.The live weight of an animal is important in determining the potential to carry out prescribed draft tasks (Batholomew *et al*., 1993). There were strong relationship between body weight and some body dimensions, particularly HG. This is in agreement with the results published elsewhere (Eley and French, 1993; Pearson and Ouassat, 1996). This agreed with this finding that addition of two or three variables gave a reasonable degree of reliability in predicting the body weight of donkeys.

5.4.3 Principal component analysis of morphometric traits

Three components were majorly extracted in this study. The first component which can be termed a generalized component has its highest loadings on HL, EL, NL, NC, HG and BL and can be grouped as size measurement. This observation agreed with the reports of several researchers who had worked on principal component analysis for growth measures. Yakubu *et al*., 2010 extracted three components in quantitative classification of goats breeds in western Nigeria. The present result revealed zoometric phenotypic differentiation between donkey strains such as body shapes and sizes.

5.4.4. Principal component analysis of metricmeasres and their contribution to live body weight of donkeys by age

By measurement of some body parameters, the age of an animal can be assessed and the timing for different management practices can be pegged accurately to bring animals to good and desired weight at maturity (Mavule *et al*., 2013). The obtained loadings for weaner and young of extremities and height related traits in PC1 may be indicative of rapid growth. In young donkeys, head length, heart girth and body length were the best predictors of body weight. This is termed body volume and length measures. In adult donkeys, head length, neck circumference and height at withers were the best predictors. This is also called body volume and length measures.

5.4.5. Principal component analysis of metric measures and their contribution to live body weight of donkeys by sex

Principal component analysis of metric measures in donkeys revealed that predicting body weight in males should employ volume related measures (neck circumference, shoulder width and heart girth) while length wise traits should be used for females (ear length, body length and height at withers) for high efficiency of prediction. The differences in linear body measurements between sexes in different studies were attributed to sexual dimorphism (Gatford *et al.*, 1998; Egena *et al*., 2010). Baffour-Awuah *et al*., (2000) observed that females had longer bodies than males and this was also reflected in other measurements such as head length, rump length and tail length. This is not in agreement with the results of this findings which showed that males had longer bodies than females and this was also reflected in other biometric traits such as ear length, neck circumference, shoulder width, heart girth and body length. This might account for why HG and BL had higher PC1 (0.91 and 0.91) loadings in males than the females (0.89 and 0.87). This clearly shows sexual dimorphism in component loadings in Nigerian donkeys. However, in both sexes, head length, head width, ear length, neck circumference, which were almost the same with the same height at wither and may be a pointer to the supposition that in predicting live weight, length wise traits should be focused on females while volume related measures should be employed in males in addition to neck circumference, shoulder width and heart girth. Hassan and Ciroma (1992) recommended that sex influence on morphometric traits should not be ignored to predict body weight in sheep and goats. Contrary to this assertion, Mahieu *et al.*, (2011), reported that there was no sex effect on heart girth to live weight relationship hence there was no need for gender corrections.

5.4.6 Principal component cluster analysis of morphological traits of donkeys

Comparison of the selected morphological traits revealed significant differences (P□ 0.001) among component clusters of morphological traits of donkeys with the highest loadings. Tail length (0.51), head profile (0.72) and hair type (0.81) were the traits that contributed significantly to the component clusters in PC1, coat colour (0.81) and coat colour pattern (0.72) in PC2 and eye colour (0.89) in PC3. The result of this study is similar to that of Predrag *et al*. (2015) who reported that morphological similarities as indicated by clustering between Balkan donkeys and

Albanian donkeys could be attributed to closed geographic proximity and the overlap of their habitat. This imposes the need for molecular characterization of the donkey strains to get insight in their molecular genetic diversity. Manly (1994) demonstrated that morphological variables that have the highest correlation among themselves are good raw materials for multivariate analysis. This implies that selecting donkeys for one morphological trait, improve other variable that has high correlation with it. Coat colour pattern had the highest cluster while hair type and head profile also formed another cluster. This implies that donkeys could be differentiated using these two cluster groups.

5.5 Classification of Donkeys of Northwestern Nigeria

5.5.1 Disciminant analysis for strain classification

Brown-white (Idabari-fari) was highly discriminated which had high discriminating power and they could be classified or differentiated as distinct strains of donkeys. The differences between donkey strains in this study might be as a result of environment or genetic constitution of the animals, which is similar to the findings of (Yakubu and Ibrahim, 2011) who reported that the differences between breeds may have genetic underpinning.

5.5.2. Stepwise discriminant analysis to determine the variables with more discriminated power than others

The two length measurents, ear length and body length could be an indication for phenotypic differentiation in strains of donkeys. The result of this study showed that ear length was found to be the most discriminating character followed by the body length. This result was not in harmony with Salako and Ngere (2002) were tail length was obtained to be the best discriminating variable between Yankasa and WAD sheep but partly in agreement with the findings of Agievezor *et al*., (2012) reported tail length, rump height, chest girth, ear length and chest depth as the best discriminating variable to separate WAD, Uda, Yakasa and Balami sheep. The superiority of the ear length and body length as the best discriminators might be because of the length related traits of donkeys.

5.5.3. Canonical discriminant analysis to match the donkey strains into genetic groups (clusters)

Black donkeys had more canonical weight on the generalized canonical component followed by red and white donkeys. This implies that the red and white had a close genetic relationship as compared to others that extracted their loadings on a single component. This buttressed by the reports of Carneiro *et al.,* (2010) in sheep, Yakubu *et al.,* (2011a) in goats and Kefena *et al.,* (2011) in donkeys. This is in conformity with thisfinding which showed that red, black, and white were clustered together into the same genetic group for ear length in CAN 3 across the strains, neck circumference and shoulder width across the strains in CAN 1. These might be attributed to a closed genetic origin among donkey strains and the traits can be selected for genetic improvement, classification of donkey strains into genetic groups and for prediction of body weight.

5.5.4. UPMGA (Unpaired Mean Grade Average) cluster between morphologica traits of donkey populations studied

Skin type and tail shape had the highest genetic distance estimates with average values of 24% and 36%. The genetic relationships between the strains of donkeys are homogeneous. Morphological similarities as indicated by hierarchical clustering between breeds of donkeys were similar in this study, which indicated that there were similarities between morphological traits of donkey strains in Nigeria. This could be attributed to close geographic proximity and overlap of their habitat. However, comparison of selected morphological traits of donkeys elsewhere revealed significant differences among the Albanian donkey population (Papa and Kume, 2012) and Catalonian donkey breed (Folch and Jordana, 1997).

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

Some morphometric and morphological traits of 700 donkeys were obtained from (7) seven states using random sampling technique according to the age of the animals from Kaduna, Kano, Katsina, Kebbi, Sokoto, Jigawa and Zamfara weresampled for various morphometric traits. Morphometric measures were body weight, head length, head width, ear length, neck length; neck circumference, shoulder width, height at withers, heart girth, body length, tail length respectively. Data were collected on hair type (long-curly (LC); short-rough (SR) and short-smooth (SS), Coat colour (Black (BK); Brown (BN); Brown/white (BN/WT); Red (RD) and White (WT), Skin type (Thick (TK) and Thin (TN), Coat colour pattern (patches (PS) and Solid (SD), Tail shape (Highset (HS) and Pendent (PD), Eye colour (Black (BK); Brown (BN) and White (WT), Head profile (Straight (ST) and Sub-concave (SCVE).

Data analysis was done using General Linear Model procedure of SAS, 2004. Correlation, regression, Principal component, discriminant and cluster analysis of morphometric and morphological traits were carried out.

Notable observations in this study showed that Short-smooth hair variant, Brown coat colour, Thick skin type, Solid coat colour pattern, Pendent tail shape, Black eye colour and Straight head profile were prevalent in the populations.

Generally, genetic distance analysis based on the morphological loci indicated closer relationship between the strains. Observed effect of strain, location, sex and their interaction on morphometric measurements were varied. Correlation relationships among morphometric measurements also varied with sex and within strains, but coefficients were generally low to moderate with the exception of the relationship between HL,HWD, HW, NL, BL and TL which were generally high in the strain Idabari-fari (Brown-white).

Principal component analysis indicated higher loadings for HL, HWD, EL, NL, NC, SW HW, HG and BL in PC1 with the exception of TL. The high loadings for strains are indicated in PC1 for Brown-white (Idabari-fari) strain. The implication of these high loadings was that, they contributed most to the body weight and they should be the traits to be considered for predicting body weight and genetic improvement of donkeys. TL, HWD, NL, NC, HW and BL were noted in the males and BL, HG and HW were the major factors in females. HW, HG and BL predominated as major predictors in the stepwise regression across all the strains. The only morphological traits with high discriminating powers to classify the donkey strains based on their high genetic distance estimations are skin type (24%) and tail shape (36%). The brown-white donkeys were highly differentiated into a separate genetic group.Simple discriminant analysis for strain classification of donkeys of Northwestern Nigeria revealed no differences in body weight, neck circumference and tail length across the strains and therefore cannot be used to classify the donkeys into strains.Unpaired mean Grade Average (UPMGA) cluster among donkey strains revealed homogeneous genetic relationship among donkey strains in Northwestern Nigeria.

6.2 CONCLUSIONS

1. Donkeys in the Northwest Nigeria were mostly of solid coat colour pattern (98-99%), brown coloured (86-90%), black eyed (93-96%), short-smooth haired (71-78%), thick skinned (71-78%), pendent tail shape (53-61%) and straight head profiled (83-85%).

2. The adult body size measures of donkeys in Northwestern Nigeria were body weight (142.6kg), Body length (106.6cm), Heart girth (111.0cm), Height at withers (110.5cm), Shoulder width (22.8cm), Neck circumference (62.7cm), Neck length (46.9cm), Head length (47.4), Head width (15.0cm), Ear length (25.0cm) and Tail length (57.8cm).

3. There were variations in the morphometric traits of the donkeys due to strain, sex and location effects with brown donkeys having the heaviest body weight for strains while males from Kebbi state exhibited the heaviest body weight (176.67kg) for Adult donkeys.

4. The morphometric traits of the weaner donkeys were heterogeneous and in Hardy-Weinghberg equilibrium.

5. Lack of uniformity exist in the measures of growth of donkeys of northwestern Nigeria at weaner (36.9%CV) and Adult (70.5%CV) stages but fairly uniform at the young (9.4%CV) stage.

6. Sexual dimorphism exist in the body size measures of donkeys with females having heavier body weight, larger head width, wider heart girth and longer body while the males have longer head, taller height and wider neck in the adult donkeys.

7. Zoometric phenotypic differentiations exist among the observed strains of donkeys in the Northwestern Nigeria.

8. There is sexual dimorphism in the sex differentiated correlations between body weight and body dimension measures in adult donkeys with males exhibiting low (r=-0.002 to 0.09) and non-significant ($p>0.05$) correlations while the females exhibited significant ($p<0.05$-0.01) and low to moderate positive correlations (r=0.18-0.33).

9. Unpaired mean Grade Average (UPMGA) cluster among donkey strains revealed homogeneous genetic relationship between them.

10. Body weight of donkeys across age groups and sexes can be predicted using Neck circumference, Tail length, Height at withers, Head width, Body length and Heart girth using stepwise regression or principal component analysis approach.

11. Principal component analysis of metric measures in donkeys revealed that predicting body weight in males, should employ volume related measures (neck circumference, shoulder width and heart girth) while length-wise traits (ear length, body length and height at withers) should be used for females to achieve high efficiency of prediction.

12. Simple discriminant analysis for strain classification of donkeys of Northwestern Nigeria revealed no differences in body weight, neck circumference and tail length across the strains and therefore cannot be used to classify the donkeys into strains.

13. Ear length and body length were the only biometric measures with high discriminant powers to differentiate the donkey strains. The discriminating power for ear length was Red (14.06), Black (13.59), White (13.74), Brown (13.80) and Brown-white (14.85); and for body length, Red (1.20), Black (1.19), White (1.18) and Brown (1.13).

14. The only morphological traits with high discriminating powers to classify the donkey strains based on their high genetic distance estimations are skin type (24%) and tail shape (36%). The brown-white donkeys were highly differentiated into a separate genetic group.

15. Donkeys in Northwestern Nigeria cut across the three basic adult size classifications of small (Red donkeys from Kebbi state; 120.78kg), medium (White donkeys; 142.46kg) from Kaduna state and large (Brown donkeys from Kebbi state; 179.09kg).

6.3 RECOMMENDATIONS

The following are recommended:

1. The zoometric phenotypic differentiations that exist among strains of donkeys in Northwest Nigeria should be exploited for genetic improvement of the species.
2. Any breed improvement programme(s) to be instituted for donkeys should take advantage of the observed heterogeneous nature of the morphological and biometric traits of these animals in Northwestern Nigeria.
3. Prediction of body weight in donkeys should be sex dependent; utilizing volume related measures (neck circumference, shoulder width and heart girth) for males and length related measures (ear length, body length and height at withers) for females across age groupings.
4. There is need to screen and conserve the four basic donkey strains (Ash-brown, Red, Black and White) to arrest further genetic erosion and dilution in these strains.
5. Ear length, body length, skin type and tail shape should be used in classifying donkeys into strains because of their high genetic estimate.
6. Further studies should be carried out on molecular studies for determination of diversity that exists among donkey strains.

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APPENDICES

Appendix i

Plate i: Measuring tape

Appendix ii

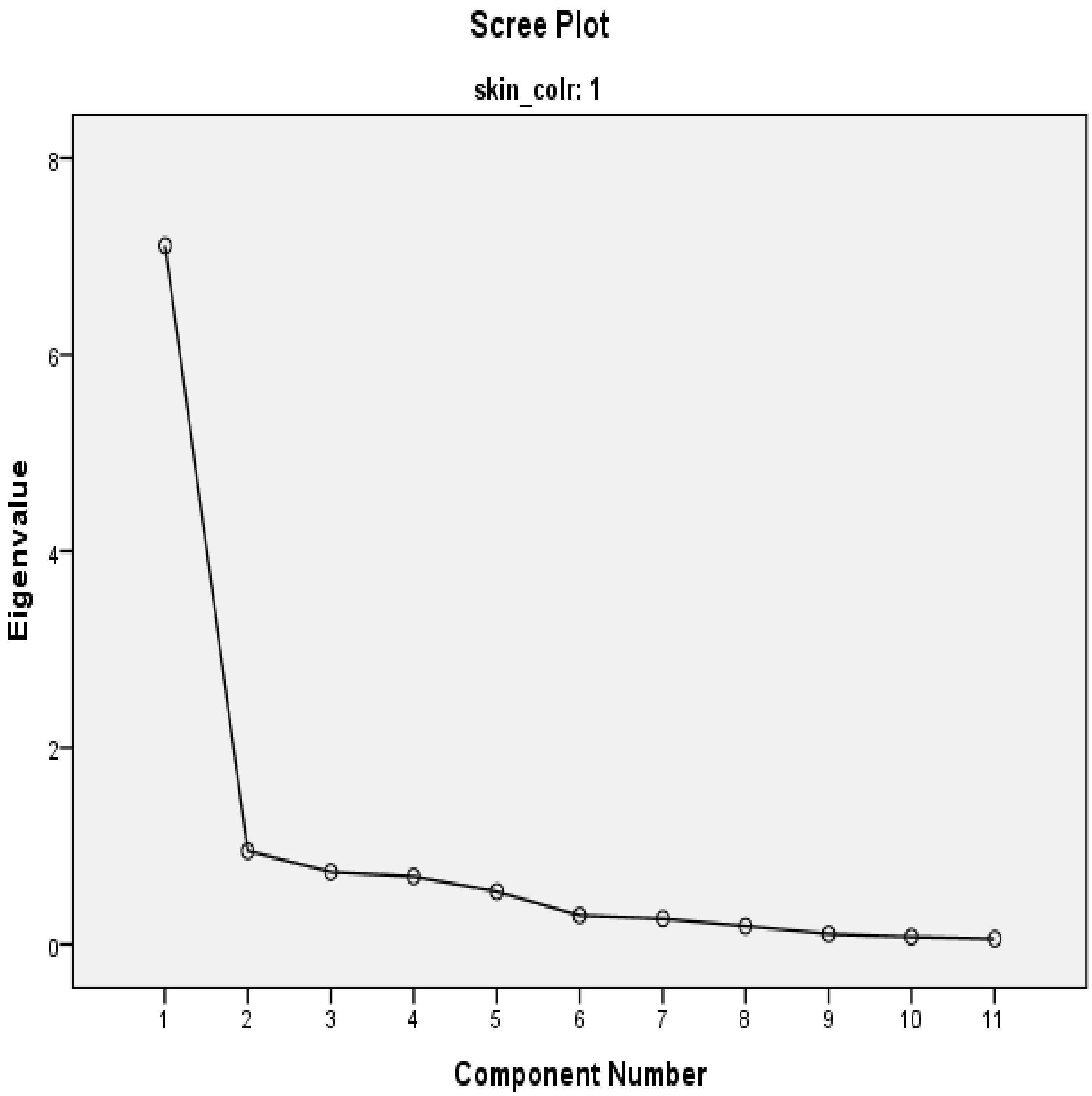

Figure i: Screen plot based on skin colour

Appendix iii

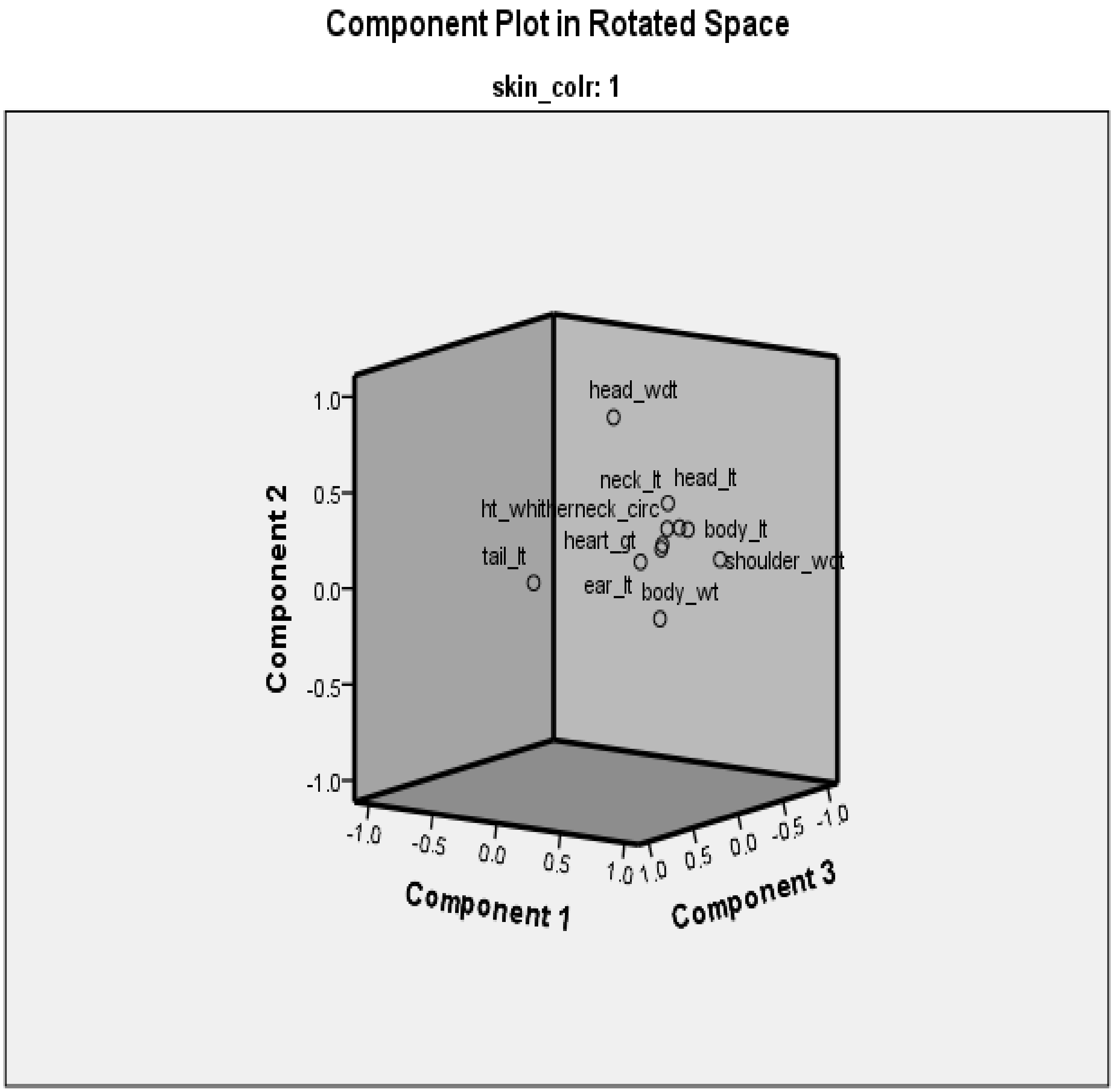

Figure ii: Component plot in rotated space based on skin colour