

**PROFILING PHYSIOLOGICAL, HAEMATOLOGICAL AND SERUM
BIOCHEMICAL PARAMETERS OF DONKEYS (*Equus asinus*) IN
NORTHWESTERN NIGERIA**

BY

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BY

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**A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,
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**DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE
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ZARIA, NIGERIA**

MARCH, 2017

DECLARATION

I declare that this research work titled “**PROFILING PHYSIOLOGICAL, HAEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS OF DONKEYS (*Equus asinus*) IN NORTHWESTERN NIGERIA**” was carried out by me in Katsina, Zamfara and Jigawa States of Nigeria under the supervision of Prof. P. P. Barje and Dr. B. M. Shehu. The information obtained from literatures 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.

IBRAHIM BATURE

Signature

Date

CERTIFICATION

This dissertation titled “**PROFILING PHYSIOLOGICAL, HAEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS OF DONKEYS (*Equus asinus*) IN NORTHWESTERN NIGERIA**” carried out by IBRAHIM BATURE 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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DEDICATION

I dedicate this research work to my mentor Late Professor Abubakar Usman Kibon and our UNIMAID father Late Professor Aliyu Usman Mani (a victim of UNIMAID bomb blast). May their gentle souls rest in perfect peace. Amen.

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ABBREVIATIONS, DEFINITIONS, GLOSSARY AND SYMBOLS

% - Percentage

µl – microlitre

ALP – Alkaline phosphatase

ALT – Alanine transaminase

AST – Aspartate transaminase

BCG – Bromocresol green (BCG)

cm – centimeter

FAO – Food and Agricultural Organisation

fL – Femtolitre

g – gram

g/dl – Grams per decilitre

g/L – Grams per litre

IU/L – International unit per litre

kg – kilogram

MCH – Mean corpuscular haemoglobin.

MCHC – Mean corpuscular haemoglobin concentration.

MCV – Mean corpuscular volume.

mmol/L – millimole/litre

°C – Degree Celsius

PCV – Packed Cell Volume.

pg – Picogram

pH – Potential of hydrogen

RBC – Red blood cells.

WBC – White blood cells.

ABSTRACT

The aim of the study was to determine the normal range of some physiological, haematological and serum biochemical parameters and how these vary with sex, age and location under tropical savannah conditions in Northwestern Nigerian donkeys. The study was conducted by taking vital signs and blood samples from 125 donkeys across three states in Northwestern Nigeria. The donkeys were grouped according to their locations, sex and age. The physiological, haematological and serum biochemical profiles obtained from donkeys reared in Northwestern Nigerian were consistent with previous reports and within the recommended reference range established in some tropical countries across the world. There was a significant difference ($P < 0.05$) in respiratory rate between male and female donkeys, with female donkeys having the higher value (26.70 breaths/minute) than male (25.77 breaths/minute). Significant difference ($P < 0.05$) also existed in rectal temperature, respiratory rate and pulse rate among different age groups. Younger donkeys had the highest values of 37.85°C, 27.39 breaths/minute and 56.95 beats/minute for rectal temperature, respiratory rate and pulse rate respectively, compared to 37.61 °C, 25.84 breaths/minute and 48.36 beats/minute in adult donkey and 37.51 °C, 25.50 breaths/minute and 48.86 beat/minute in old donkeys. Location also had effect on rectal temperature and pulse rate of donkeys. Zamfara donkeys had significantly higher rectal temperature value (37.73 °C) than Jigawa (37.68 °C) and Katsina (37.55 °C) donkeys, while Katsina donkeys had higher respiratory rate (53.66 breaths/minute) than Jigawa (50.51 breaths/minute) and Zamfara (49.29 breaths/minute) donkeys. There were significant differences ($P < 0.05$) between male and female donkeys in the counts of neutrophils, lymphocytes and eosinophils. Packed cell volume, hemoglobin, white blood cells (WBC), neutrophils,

lymphocytes, eosinophils, and basophils were significantly affected by age. Only WBC counts differed significantly ($P < 0.05$) among donkeys in different locations. Biochemical parameters of glucose, total serum protein, potassium, creatinine and uric acid differed significantly ($P < 0.05$) between male and female donkeys. There were significant difference ($P < 0.05$) between young, adult and old donkeys for glucose, activities of aspartate amino transaminase, alanine amino transaminase and alkaline phosphatase, concentrations of albumin, sodium, potassium, bicarbonate, urea, creatinine and uric acid. Location also had effect on activities of ALT and ALP, total serum protein, albumin, globulin, sodium, bicarbonate, urea, creatinine, calcium and uric acid concentrations. It can be concluded that physiological, haematological and serum biochemical parameters varied according to age, sex and location. Further investigations should be conducted across geopolitical zones of Nigeria in order to determine the effect of season, management system and develop a larger data to establish the normal reference range of physiological, haematological and serum biochemical profile of Nigerian donkeys.

CHAPTER ONE

1.0 INTRODUCTION

In Nigeria, like anywhere else, donkey (*Equus asinus*) has been used as a work animal mainly for transportation; conveying farm produce to the market or pulling of carts and other farm tillage equipment (Starkey and Starkey, 2004; Blench *et al.*, 2004; Hassan *et al.*, 2013) and of recently for production of milk for children, who are allergic to bovine milk (Carrocio *et al.*, 2000; Caldin *et al.*, 2005; Mansueto *et al.*, 2013), and in animal assisted therapy and activity in humans (Borioni *et al.*, 2012). However, donkey production is constrained by many production factors such as poor nutrition, disease, poor genetic potential, management and harsh environmental factors (Ademosum, 1994; Yilma *et al.*, 1997; Simenew *et al.*, 2011). Of all the factors, poor nutrition and disease conditions are rampant with significant impact on the performance of animals (Ademosum, 1994; Crane, 1997). Donkeys are known to survive with little management. Their body conditions may fluctuate during the year as feed supply fluctuates resulting in poor body condition, weight loss and delay in resumption of ovarian cycles after parturition (Pearson *et al.*, 1999).

The low productivity of livestock on pasture-based extensive grazing systems needs to be improved, and this entails an evaluation of their nutritional status. The assessment of nutritional and health status of animals can be made by determining the concentrations of certain blood metabolite such as non-esterified fatty acids (NEFA), β -hydroxybutyrate (BHB), glucose and cholesterol (Ndlovu *et al.*, 2007). Their concentrations indicate the extent of the metabolism of energy, proteins and other nutrients in the animals (Pambu-Gollah *et al.*, 2000; Agenas *et al.*, 2006). Changes in the concentration of circulating nutrient-sensitive metabolites are important signals of the metabolic status of the animal and the organs function (Lindsay *et al.*, 1993; Wettemann *et al.*, 2003). Other blood metabolites, such as total protein,

albumin, globulin, creatinine and urea, are indicators of the protein status. Factors including the physiological status of an animal, health status, breed, nutrition, season and age may affect the concentration of these metabolites in the blood (Ndlovu *et al.*, 2007).

It has been established that rectal temperature, respiratory rate and heart rate are relevant body parameters for immediate evaluation of stress and health status and adaptability of animals (Ayo *et al.*, 1996; Minka and Ayo 2007; Dey *et al.*, 2010). Disease diagnosis in animals is largely dependent on physiological examination and laboratory results expected to reflect biological variations. This in turn requires understanding of the basal physiological, haematological and serum biochemical profiles of an apparently healthy animal whose measurement provides invaluable information concerning the health status of an animal (Mori *et al.*, 2003; Mori *et al.*, 2004).

Haematological evaluations were carried out for a variety of reasons such as screening procedure to determine the general health and nutritional status of the animal, as an adjunct to an infection and to ascertain the progress of disease conditions (Friday *et al.*, 2014) and distinguish between normal and stress conditions (Olabanji *et al.*, 2007). Haematological values provide baseline information for comparison in conditions of nutrient deficiency, physiology and health status of farm animals (NseAbasi *et al.*, 2014) and help in providing information on the relationship between blood characteristics and the environment (Ovuru and Ekweozor, 2004; Isaac *et al.* 2013).

However, unlike other livestock species, there is very scanty information on the baseline physiological, haematological and serum biochemical parameters of the donkey in Nigeria, some of the works published includes; Yakubu and Chafe (2005); Garba *et al.* (2015); Zakari *et al.* (2015) and Zakari *et al.* (2016). Therefore, a study on the donkey to

determine the parameters is necessary, and it will be the basis for providing interventions that may improve the productivity of the donkey.

1.1 JUSTIFICATION

The assessment of nutritional status, stress and disease diagnosis are mainly dependent upon deviation from the normal range of physiological, haematological and serum biochemical values. However, in the absence of established reference value of any physiological and blood parameters, one can be exposed to misinterpretation of nutritional deficiencies, and in diagnosing and treating different disease conditions (Simenew *et al*, 2011). Despite the extended use of haematology in equine nutrition and medicine, interpretation may be a challenge in some cases, because it can be significantly influenced by a great number of factors such as sex, age and location (Jain, 2003; Rose and Hodgson, 2004; Messer, 2005; Kramer, 2015). In Nigeria, there were scanty reported works that determined the normal physiological, haematological and biochemical profile of working donkeys under traditional management system. Therefore, this study was designed to evaluate and establish these parameters in donkeys found in Northwestern Nigeria.

1.2 OBJECTIVE OF THE STUDY

The broad objective of this study was to determine physiological, haematological and serum biochemical profiles and their variations with age, sex and location in donkeys reared in Northwestern Nigerian

1.2.1 Specific Objectives of the Study

1. To determine physiological, haematological and serum biochemical profile of donkeys in Northwestern Nigeria.

2. To assess the variation in physiological, haematological and serum biochemical parameters among different ages and sexes of donkeys in Northwestern Nigeria.
3. To assess the variation in physiological, haematological and serum biochemical parameters among donkeys in three states of Northwestern Nigeria.

1.1 Experimental Hypothesis

1. Null Hypothesis (H_0) = Location has no effect on physiological, haematological and serum biochemical parameters of donkeys in Northwestern Nigeria.
Alternate Hypothesis (H_a) = Location has effect on physiological, haematological and serum biochemical parameters of donkeys in Northwestern Nigeria.
2. Null Hypothesis (H_0) = Sex has no effect on physiological, haematological and serum biochemical parameters among male and female of donkeys in Northwestern Nigeria.
Alternate Hypothesis (H_a) = Sex has effect on physiological, haematological and serum biochemical parameters among male and female of donkeys in Northwestern Nigeria.
3. Null Hypothesis (H_0) = Age has no effect on the physiological, haematological and serum biochemical of Northwestern Nigerian donkeys.
Alternate Hypothesis (H_a) = Age has effect on the physiological, haematological and serum biochemical of Northwestern Nigerian donkeys

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Donkey

Donkeys *Equus asinus*, belong to a sub-genus of the genus *Equus* (Order; *Perissodactyla*, Family; *Equidae*). Morphologically, *Equus asinus* are associated with having tufted tails, counter shaded colouring, chestnuts on the forelimbs only, square occipital crests and wide external auditory ear (Groves and Ryder 2000). Three species of the sub-genus *Equus asinus*, each with a number of subspecies that make up the large population of donkeys around the world are currently recognized (Fig. 2.1). They can be found in tropical savannas and arid hill country in Nigeria, Sudan, Eritrea, Somalia, Australia, and other arid and desert habitats elsewhere in its range (Eisenmann, 1995).

Sequencing of mitochondrial DNA from domestic donkeys from African and Asiatic have indicated that the African wild donkey, and in particular the Somali wild donkey, is the most likely progenitor of the domestic donkey. This suggests that North Africa is the most likely location of evolution of the domestic donkey (Beja-Pereira *et al.*, 2004).

2.2 Origin and Domestication of Donkeys

There is no documented history of donkey in Africa despite the huge number of years it was domesticated. However, archaeological findings of wall-paintings and other iconography are evidence from Egypt that suggests that donkeys were first domesticated about 5000 years ago, although the location of this domestication is unknown (Beja-Pereira *et al.*, 2004; Blench, 2013). Extraction of DNA from osteological material and its comparison with synchronic collections have overturned the usual narrative of early domestication, without entirely shifting to a new paradigm (Beja-Pereira *et al.*, 2004). Elsewhere in the

continent, although there are representations of wild donkey in rock-art, evidence for the domestic donkey is notable chiefly by its absence (Blench, 2013).

The precise wild progenitor of the domestic donkey is disputed. Eisenmann (1995) has reviewed the competing arguments by reporting that there were comparably early skeletons in the Near East but whether these are domestic donkeys remains uncertain. Groves (1966, 1986) set out the possible ancestors of the donkey and indicated that present-day wild populations are no longer sufficiently homogeneous to resolve the question unambiguously. Bokonyi (1991) argued that domestication took place in Egypt and Clutton-Brock (1992) notes that the skeletons of three domestic donkeys found in an Egyptian tomb dated back to 4500-4000 BC. The wild donkey, *Equus africanus*, is indigenous to the African continent, and is usually divided into a chain of races with subspecies spreading from the Atlas Mountains eastwards to Namibia, down the Red Sea and probably as far as the border of present-day northern Kenya (Groves 1966; Haltenorth and Diller 1980; Kingdon, 1997). The extent to which the wild donkey penetrated the interior of Africa is controversial, but it is generally considered unlikely that it ever occurred in sub-Saharan regions. The Nubian wild donkey is cited in many textbooks as the progenitor of the donkey, although other races may also have contributed to the gene-pool (Epstein, 1984).

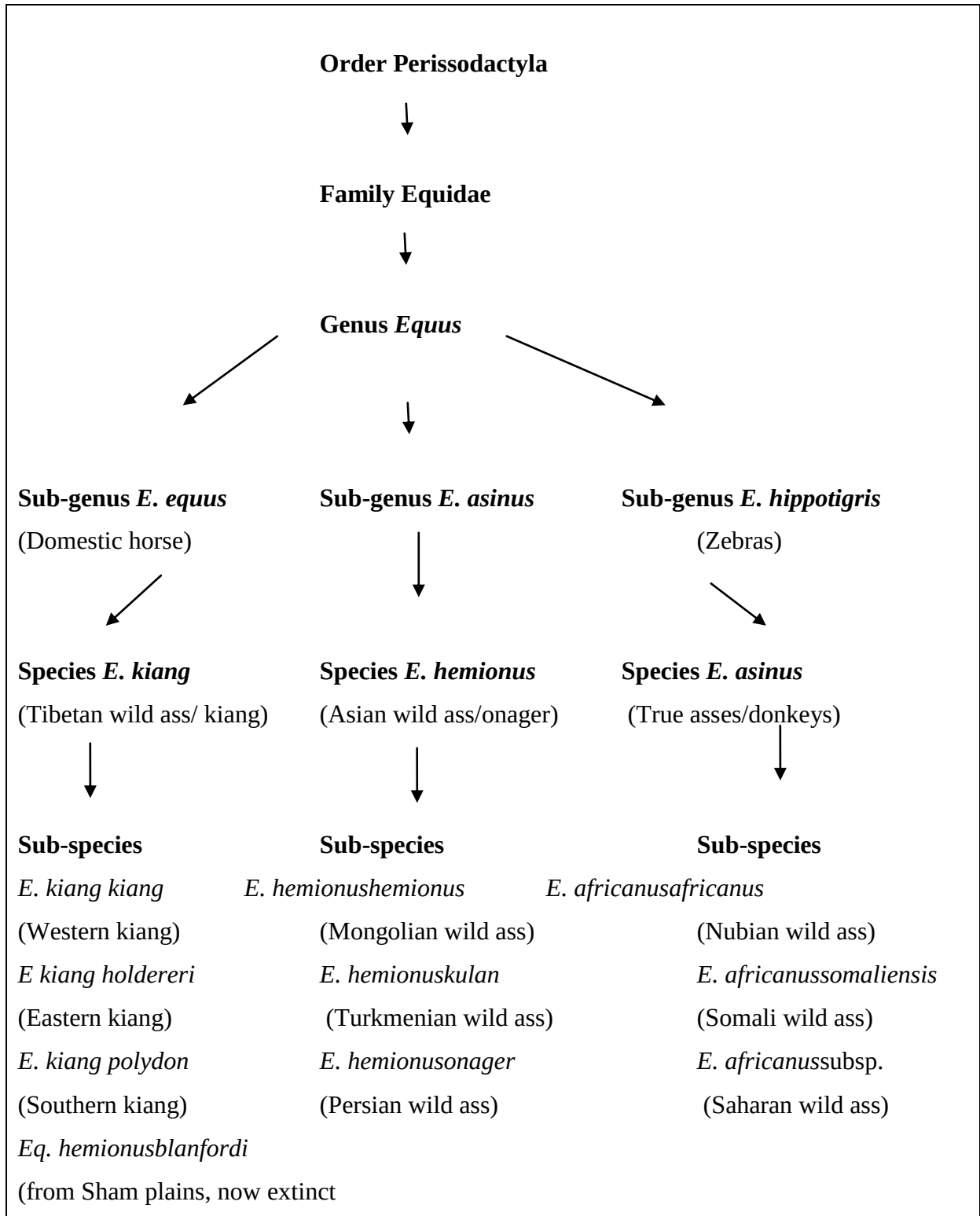


Figure 2.1: Phylogenetic tree of the Donkeys

Source: Groves and Ryder, 2000

Four notional races, *Atlanticus*, *Africanus*, *Taeniopus* and *Somaliensis* are shown in earlier studies (Haltenorth and Diller, 1980). However, two of these, *Atlaaanticus* and *Taeniopus*, have been rejected more recently and indeed the proposed *Atlanticus* race turns out to have been based on misidentified zebra bones (Kingdon, 1997). The main features differentiating races of wild donkey are the number and type of stripes and the shoulder crosses. However, their characterization may be somewhat blurred, since populations that survived into historical times have almost certainly crossed with feral donkeys, leading to a merger of characteristics. Haltenorth and Diller (1980) describe the characteristics of the African races of wild donkey and it seems that there is some correspondence between local forms of the donkey and the phenotypes of the wild donkey. For example, *Equus asinus somaliensis* is noted for rings on both fore and hind legs. Thus, Somali donkey is described as having zebra markings on the legs (Mason and Maule, 1960). In contrast, West African donkeys usually have distinct shoulder crosses (shown in representations of the Atlas Wild Donkey), but rarely any leg markings. Of these races, the wild donkey of the Atlas Mountains became extinct by 300 AD, and is known only through representations and possible skeletal material.

2.3 World Domestication and Distribution of Donkeys

Donkeys were particularly used along the trade route from the Pacific Ocean to the Mediterranean. It is through these journeys, which took several years, that mixing of different donkey breeds occurred (Camac, 1997). The donkey was later found to be useful in the Mediterranean for agriculture as well as transportation and with the growth of the Roman Empire, donkeys spread to Northern Europe and eventually to Britain with the Roman invasion (Beja- Pereira *et al.*, 2004). Donkeys only became important in Britain in the sixteenth century, when the advent of war resulted in a scarcity of horses (Camac, 1997). At

the end of the 1800's, with the invention of the combustion engine, donkey population in Britain drastically declined along with the massive decrease in horse numbers. Although, presently there is a sizable number of donkeys in Britain because they are used as pets and companion animals (Blench, 2013). The situation is currently very different in the developing world like Nigeria where donkeys are essential to the agricultural and industrial economies of many of these countries (Hassan *et al.*, 2013). Many impoverished families are dependent on their donkey(s) for their livelihood and health (Starkey and Starkey, 1997).

In many countries, particularly in developing countries, donkey population statistics are estimates and extrapolations. Substantial donkey populations occur in remote rural areas of developing countries where it is difficult or impractical to survey them accurately (Starkey and Starkey, 1997). Most of the data on the donkey population collected by the Food and Agriculture Organization (FAO) were based on estimates submitted by National Agricultural Ministries (FAO, 2004). Today, the world equine population is estimated at over 113 million (Table 1), with over one billion people directly dependent upon them (Prentis, 1994). More than eighty five percent (85%) of all equids, 97% of all donkeys, 98% of all mules and 74% of all horses in the world are found in developing countries (Fielding, 1988). Furthermore, 37.3% (about 42 million) of the world equine population is made up of donkeys (Starkey and Starkey, 1997). When the global trend in the use of equine species is examined over the last four decades, the population of horses has been static, that of the mules has risen while the donkey has declined. However, in most developing countries, particularly in Africa, the picture is different with the earliest FAO estimate of the world donkey population being from 1961 and estimated 37 million. Since then, the world donkey population has increased steadily and it was estimated to be about 43million, an increase of approximately 19% (FAO,

2004). Almost half of the world donkey population is found in Asia, over one quarter in Africa and the rest in Latin America (Starkey and Starkey, 1997).

2.4 Estimates of Donkey population in Africa and Nigeria

In Africa, donkeys are found everywhere because of their intimate relationship with the farming system (Hassan *et al.*, 2013). The total African donkey population has increased by 30% in the last 30 years; from 10.7 million in 1966 to 13.6million in 1996 (Table 2.2 a,b). Most of the increase has been in the semi-arid areas of the continent, notably in Sahelian West Africa, Ethiopia and Egypt (Starkey and Starkey, 1997). In Nigeria, the population of donkey is large, but estimates have fluctuated (Hassan *et al.*, 2013). The 2011 National Agricultural Sample Survey indicated that Nigeria was endowed with population of 974,499 donkeys (FMA, 2016).

2.5 Nigerian Donkeys

In Nigeria, donkeys have not attracted the attention of the researchers despite their prominent contribution to the socio-economic activities of the low-income groups in rural and urban areas (Hassan *et al.*, 2013). Donkeys have received less attention than horses as far as development policies are concerned although they cost less to manage and have remarkable tolerance to diseases and poor nutrition (Blench *et al.*, 1990). Unfortunately, there is paucity of information at both national and international levels concerning donkeys and their production, and this may partly be ascribed to the small population of donkeys worldwide. (Sadiq *et al.*, 2013). Some authorities consider the donkey as endangered species that is likely to be extinct unless efforts are made to increase their numbers (Ismael *et al.*, 2010).

Table 2.1: Regional distribution of Donkeys in the World

Region	No. of breeds	Percentage of world population
Africa	26	26.9
Asia and Pacific	32	37.6
Europe and the Caucasus	51	3.7
Latin America and the Caribbean	24	19.9
Near and Middle East	47	11.8
North America	5	0.1
World	185	43 Million heads

Source: Starkey and Starkey, (1997)

Table 2.2a: Donkey population in North, West and Central Africa (1966–1996)

Estimated number of donkeys (thousands)				
North Africa	1966	1976	1986	1996
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	1
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
Total	5,418	5,884	5,946	6,479

Source: FAO, (1997).

Countries with estimates below 1000 donkeys have been excluded from the list. Some estimates are considered to be inaccurate.

¹ Guesstimate for Eritrea based on old figures and Ethiopian population reduced proportionately.

² Guesstimate for Kenya based on old figures.

Table 2.2b: Donkey population in South and East Africa (1966–1996)**Estimated number of donkeys (thousands)****Southern and Eastern Africa**

Angola	3	5	5	5
Botswana	24	105	143	235
Comoros	3	3	4	5
Djibouti	4	5	8	8
Eritrea	-	-	-	150 ¹
Ethiopia	3775	3860	4600	5000 ¹
Kenya	250 ²	270 ²	280 ²	300 ²
Lesotho	42	89	136	152
Malawi	0	1	2	2
Mozambique	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	5,593	5,606	6,451	7,173

Source: FAO, (1997).

Countries with estimates below 1000 donkeys have been excluded from the list. Some estimates are considered to be inaccurate.

¹ Guesstimate for Eritrea based on old figures and Ethiopian population reduced proportionately.

² Guesstimate for Kenya based on old figures.

However, in 1970s donkey population in Nigeria was drastically reduced due to oil exploration and trade (Blench *et al.*, 1990). At that time, it was relatively cheaper to use other means of transport such as trucks and motorcycles due to excellent road networks. In the late 1980s, there was economic hardship due to changes in government policy, which led to rising costs in transport fares as a result of unstable fuel prices and degraded road networks (Blench, 2004). In the early 2000s, donkeys started gaining popularity again among the smallholder farmers for employment opportunities and as reliable option for poverty reduction in Nigeria (Fielding 1988).

2.5.1 History and Spread of Donkeys in Nigeria

The history of the donkey in Nigeria is strongly related to the trans-Saharan caravan trade, pastoral nomads and cultural influence (Blench, 1997). Arabian traders from the North African countries were thought to reach Northeast and Northwestern Nigeria on donkeys, horses and camels for trading activities which could be the major reason why donkey entered Nigeria (Blench, 1997; Hassan *et al.*, 2013). Archeological evidence from excavated equid's teeth in Nigeria has shown that there could be other possible history of the donkey in Nigeria (Blench, 1995). The movement of pastoral nomads from neighbouring Niger Republic into different parts of Northern Nigeria, especially during dry season in search of grazing land, has been reported to be one of the possible ways of donkey spread in Nigeria (Blench *et al.*, 2004). 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 due to problems of trypanosomosis, which is prevalent in Southern Nigeria (Blench *et al.*, 1990).

2.5.2 Strains of donkeys in Nigeria

There is no any established donkey breeds in Nigeria. The coat colour offer is sometimes used as determining factor for distinguishing and pricing of donkeys, although there is little evidence that these colours are linked to the productivity or hardiness of donkeys (Blench *et al.*, 1990). Four breeds or types of donkey are recognized in Nigeria (Table 2.3). The highest prices are paid for the *Idabari*, as it is said to have a stronger body and can carry heavier loads than the other breeds (Blench *et al.*, 1990). 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 (Blench *et al.*, 1990). The vast majority of so-called “white” donkeys are actually grays with fully white hair coat. A truly 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.

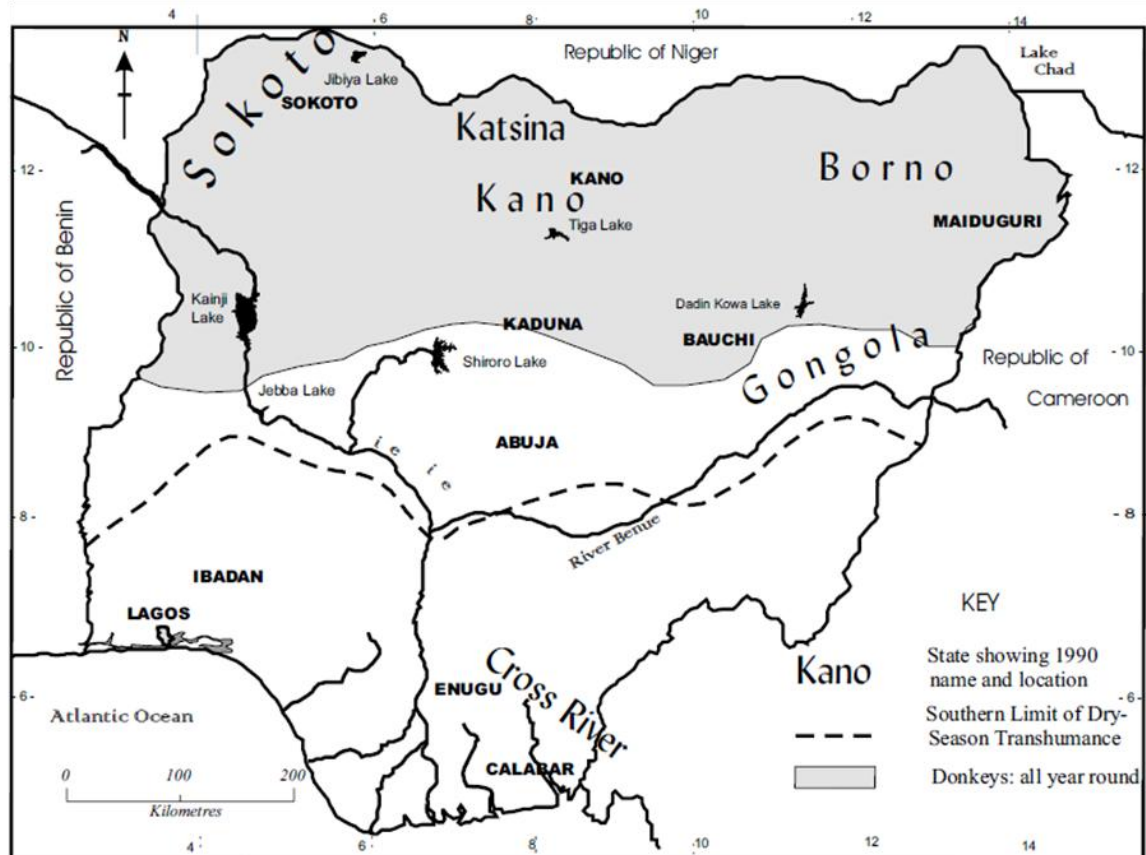


Figure 2.3: Distribution of donkeys in Nigeria.

Source: Blench *et al.*, (1990).

Table 2.3 Names and associated skin colours of strains of donkeys in Nigeria

Local Name (Hausa)	Colour
<i>Auraki</i>	Rust or red
<i>Duni</i>	Dark brown to black
<i>Fari</i>	Pale cream to white
<i>Idabari</i>	Grey to light-medium brown

Source: Blench *et al.*, (1990).

The main donkey owners in Nigeria include the Fulani, village farmers and commercial transporters found in major towns and cities of Northwest Nigeria (Blench *et al.*, 1990).

2.6 Socio-Economic Role of Donkeys in Nigeria

Donkeys play significant socio-economic roles in terms of income generation, employment opportunities and improvement of livelihoods of many smallholder farmers and their families in Nigeria (Hassan *et al.*, 2013). Donkeys are not conventional sources of meat; the primary function of donkeys in Nigeria has traditionally been used as pack animals (Blench *et al.*, 2004). They are also used as meat animal in South- Eastern part of the country (Hassan *et al.*, 2013). Donkeys are also used for traction and transport in many Northern parts of Nigeria (Sadiq *et al.*, 2013). Donkeys are preferred as draught and transport animals because they are friendly, hardy, quiet and more economical, compared to horses and oxen (Ayo *et al.*, 2013). They can be maintained on local farm produce, and are easy to train, intelligent and patient while working (Inns, 1979).

2.6.1 Ownership and Use of Donkey in Nigeria

The two groups of people who own donkeys in Northern Nigeria are FulBe pastoralists and village farmers. The Teda people, who are professional Donkey breeders, are confined to Niger Republic (Blench, 2013). FulBe use donkeys mainly as pack animals when migrating from one grazing area to another. During transhumance, donkeys are loaded with tents and camp utensils, and they carry children, women and old people to new locations. They also carry poultry, in cages, and lambs and kids too young to trek (Blench, 2013). During migration women normally control the donkeys, while the men drive the main herds of other livestock. Donkeys are usually hobbled and tethered at night, and are untethered, but still hobbled, during the day and allowed to scavenge for grazing in the vicinity of the camp (Blench, 2013).

In the villages of most parts of semi-arid Nigeria farmers aspire to own donkeys, although donkeys are much more common in the northwest and northeast regions than in the north-central (Blench, 2013). Donkeys are kept primarily to carry loads and as personal transport. They are used also for: drawing and carrying water, carrying mud to repair compound walls, moving manure from compounds to fields, transporting crop residues from fields, bringing harvested crops back to compounds and carrying goods to market (Blench, 2013).

2.7 Donkey Nutrition

Feeding is an important aspect in the management of any farm animal. It requires knowledge of the feeding behavior and nutrient requirements of animals for specific production functions. The objective of feeding donkeys should be to make judicious use of available feed during times of deficit. This may be achieved by using the body condition scores of the donkeys as feeding guides or, where available, appropriate nutrient requirement data may be used (Aganga *et al.*, 2000).

In arid and semi-arid areas, donkeys eat a wide variety of feeds, they graze on forbs, shrubs and the bark of trees and are normally allowed to graze for six to seven hours a day on free range (Hangmann and Prasad, 1995). Donkeys are monogastric herbivore. Thus, they utilize roughages, cellulose and hemicellulose efficiently (Aganga and Tsopito, 1998). The dry matter intake of the donkey is higher compared to other large herbivores, being about 3.1 per cent of live weight (Maloiy, 1973). Donkeys are grazers as well as browsers, their teeth and lips permit them to graze close to the ground; thus they can graze short vegetation efficiently. They are also non-selective grazers and can feed on a wide variety of foodstuffs, including kitchen left overs (Aganga and Tsopito, 1998). Donkeys are extremely efficient at digesting fibrous, poor quality plant material and have evolved as browsers (eating woody

shrubs and trees) as well as grazers (Hangmann and Prasad, 1995). A general rule of thumb is that a donkey should be provided a daily allowance of straw or hay equal to 5% of its bodyweight, even though it may only eat about half of this (Jones, 1997). This author also recommended that for a 200-300 kg donkey carrying 25-70 kg load at 4 km/hour, 6 hours/day, the diet should consist of 500 g grain (coarsely ground maize or sorghum) and 2.5 kg chaff (by-product of dry cereal milling) or cowpea pods or peanut shells and also chaff could be replaced with hay or straw (dry grass) (Jones, 1997).

2.7.1 Nutrient requirements of donkeys

2.7.1.1 Water requirements of donkeys

Donkeys have lower water requirement per unit of body weight than other domesticated animals, except the camel (Aganga *et al.*, 2000). Water intake of a donkey is influenced by the amount of work being done, the temperature and humidity of the environment, the dryness of the feed being consumed and the physiological status of the animal (Muellar *et al.*, 1998). Water requirement of a fully-grown adult donkey is in the range of 18 to 35 litres per day depending on physiological status and environmental condition (Fielding and Krause, 1998). Ram *et al.* (2004) reported that donkey can consumed 0.6 L/day (Resting donkey) to 13.25L/day (Working donkey) in 28-32°C ambient temperature and 64-70 relative humidity. Donkeys appear to feel less thirsty than other animals when exposed to water deprivation and may continue to eat when most animals, other than the camel, have stopped eating as a result of water shortage and can withstand up to 20 - 25 percent weight loss due to dehydration and recover this loss when water becomes available (Maloiy, 1973). Dehydration in the thermo-neutral zone and at high ambient temperatures of 40°C depresses food intake, but apparently increases digestibility of ingested dry matter (Fielding and Krause 1998). Maloiy (1973) stated that intermittent changes in temperature, such as diurnal variation

in air Temperature of deserts, do not depress appetite provided water is not limited. Donkeys should be offered water at least once or preferably twice per day to ensure good functioning of their digestive system and provide opportunity for body water to evaporate, so maintaining body temperature (Dill *et al.*, 1980). Donkeys should not be offered very cold water during or immediately after working and the water must be clean since donkeys may refuse to drink dirty water, even when they need water (Jones 1997).

2.7.1.2 Energy requirement of the donkeys

Donkeys require less energy per unit of body weight than cattle for walking due to skeletal differences, which makes movement in equids more energy efficient (Fielding and Krause 1998). Digestible energy (D.E) requirement of donkeys per unit of body weight is about 75 percent which is similar than 75% of horses and 65% of ponies (Pearson *et al.*, 2005). D.E requirement can be estimated at $465 W^{0.75}$ KJ/day where $W^{0.75}$ is metabolic weight. Therefore a donkey of 150 kg requires for maintenance $465 \times 150^{0.75}$ kJ of digestible energy = 19931 kJ or in practical terms 20 MJ (McCarthy, 1986; Mueller *et al.*, 1998; Fielding and Krause 1998; NRC, 2007). Energy requirement for work above maintenance is influenced by the size of the load, the slope of the land, the nature of the ground and the positioning and balancing of the load on the donkey (Mueller *et al.*, 1998). Energy requirements can be estimated from the energy costs of the different activities associated with work and knowledge of the amount of work done and distance travelled (Tables 2.4 and 2.5) (Source Pearson *et al.*, 1994, 1995). The donkey energy needs increases with the increase in workload (Mueller *et al.*, 1994).

2.7.1.3 Protein requirement of donkeys

The protein requirement of donkey is influenced by the physiological status of the animal and the workload. Young growing donkeys and pregnant or lactating animals require

more protein than mature, non-pregnant animals (Aganga *et al.*, 2000). Quality of protein fed to donkeys influences total daily protein requirement. Donkeys have ability to recycle urea, therefore when calculating essential protein requirement, this ability should be taken into consideration (NRC, 2007). Essential amino acids (EAA) are the amino acids which must be provided in the diets to the animal since it cannot synthesised the EAA by itself, or which cannot be synthesised by the bacteria in the digestive system or store it in sufficient quantities to meet its requirements, for example methionine and lysine (Wilson, 1990). The challenge to the nutritionists is to develop recommendations on crude protein requirements for donkeys that can allow farmers to make economic decisions on feeding practices of the donkeys. Good feeding of donkeys with adequate protein supply can enable the animals to better resist disease challenges and improve their growth rate (Aganga *et al.*, 2000). Clair (2016) reported that, donkey need 3.8 – 7.4% Crude Protein compared to 8 -12 % CP need of matured horse, because of their key adaptive feature to internally recycled nitrogen.

2.7.1. 4 Minerals and vitamins requirement of donkey

The skeleton is the load bearing structure for efficient working life, thus in the donkey this must be optimally developed and strong. Working donkeys need mineral supplements to replace the minerals lost in sweat (Aganga *et al.*, 2000). Donkeys should be provided with a mineral lick of a mixture of dicalcium phosphate and salt, which will replenish the sodium lost in sweat (Youssef *et al.*, 1972). About three teaspoons of salt per day should be added to donkey diet, mineral lick blocks should also be provided in the pen (Fielding and Krause, 1998).

Table 2.4: The energy costs of various activities associated with work in donkeys

Observation	Location	Site	Energy cost (kJ)	Source
Walking, J/m/kg live weight	Tunisia	Sandy/gravel tracks	1.37	Dijkman, pers. comm.
	Niger	Laterite tracks	1.43	Pearson, 1994
	USA	Gravel roads	0.98	Youssef <i>et al.</i> , 1972
	UK	Treadmill	0.97	Dijkman, 1992
Carrying, J/m/kg carried	Tunisia	Sandy/gravel tracks	1.8-2.3	Dijkman, pers. Comm.
	UK	Treadmill	1.1	Dijkman, 1992
Pulling, J/m/kg pulled	UK	Treadmill	31.2	Pearson, 1994
	UK	Treadmill	26.5	Dijkman, 1992

Adapted from Pearson *et al.* (1995).

Table 2.5: The energy requirements for work for a donkey

Parameters	Activities		
	Load Carriage	Ploughing 2.6Hours	Carting of load
Live weight of donkey (kg)	20	120	120
Distance travelled (km)	15	5.5	15
Load carried (kg)	40	0.25	40
Energy cost of walking (1.40 J/m/kg) ¹	2520	1380	2520
Energy cost of carrying/Pulling (2.3 J/m/kg carried) ¹	1380	4016	6000
Total net energy of work (kJ)	3900	5336	8520
Proportion of total energy cost of work used in walking	65%	25%	30%
Total Net Energy Requirement	0.31	0.42	0.67

Adapted from Pearson *et al.* (1995).

2.8 The Performance and Capabilities of Donkeys

The size of a donkey is a limitation to the amount of work they can do (Pearson *et al.*, 1995). Most adult African donkeys fall in the weight range of 90–210 kg, which is less than the live weight of most cattle used for draft work (Pearson and Ouassat, 1996). However, if donkeys are well managed they can do many of the tasks undertaken by oxen, provided that they are teamed in sufficient numbers to provide the necessary draught force required to complete the task (Pearson *et al.*, 1995).

Studies in Zimbabwe have shown that well-fed, well-trained donkeys teamed in fours are capable of sustaining a combined draft force of over 1 kN for a 4-hour working period (**Hagmann and Prasad, 1994**). This power output is sufficient to plow relatively deep soil with a mould board plow, as well as complete most other agricultural tasks associated with crop production, in an acceptable time (**Hagmann and Prasad, 1995**). However, animals are not always in such good condition, nor is it always possible to use a team of four animals. These problems can be alleviated by improving the management of the animals to improve the power supply or by reducing the demand for power by modifying the implements or tillage practices (**Hagmann and Prasad 1994**).

2.9 Physiological, Haematological and Biochemical Parameters in donkeys.

The idea of the metabolic profile test is not new. It has been carried out in human medicine to assess the nutritional health status of populations and as a routine screening test for patients admitted to hospital (Williams *et al.*, 1970). However, Payne *et al.* (1970) and many other researchers in the late 60s gave considerable interest in monitoring the metabolic status in the site of animal herds, in order to assess the adequacy of dietary intake for production and to help diagnose the nature of existing metabolic problems. Thereafter, the use

of this test was developed to describe various aspects that are associated with this measurement (Rowland and Pecock, 1971; Payne *et al.*, 1973).

Biochemical investigations have played a pivotal role in the diagnosis and prognosis of diseases both in human and veterinary medicine (Ismael *et al.*, 2010). Laboratory aids are used extensively in the diagnosis of disease, in preventive medicine, and as management tools. Reference values of clinically healthy animals serve as a guide to the clinician evaluating parameters (Mori *et al.*, 2003). Whereas there have been considerable studies of the blood constituents of the horse example (Lawal *et al.*, 2013), very little work seems to have been published on the donkey. There have been few studies of donkeys' blood values in Nigeria (Yakubu and Chafe, 2005; Garba *et al.*, 2015; Zakari *et al.*, 2016). but these were derived from small numbers of young animals kept under experiment situation and did not cover all the values of interest to us. Biochemical values obtained abroad may not be fully applicable to our conditions because they are influenced by breed and environmental and management differences.

The metabolic profile test can be used routinely to predict the metabolic diseases before their appearance. It can act as a monitor for detecting any abnormality that may affect animal health, production or performance. Then quick preventive strategies could be taken to minimize harmful situations (Ismael *et al.*, 2010). The use of physiological, biochemical and haematological indices as a screening method for diagnostic purposes has become a standard procedure in animal science and veterinary medical practice (Ismael *et al.*, 2010). Studies reported on equine blood constituents have been concerned with horses (Jain, 1986;Harvey, 1990; Bauer, 1990, Kaneko *et al.*, 1997).The concentrations of blood components were often measured during the course of disease, either as an aid to diagnosis or to elucidate consequence of the disease metabolic process (McMurray *et al.*, 1978).

Very little work seems to have been published in the donkey, whereas there has been a considerable report of the haematology of the horse (Kaneko *et al.*, 1997) for instance, in Iran, Nayeri (1978) was the first to report the normal values in some haematological and biochemical parameters of the donkey. Nayeri (1978) conducted his experiment with 100 adult Iranian (Fares province of Iran) donkeys, 50 of each sex. Nayeri results showed that female animals showed higher mean values for total erythrocytes, eosinophil, neutrophil, and basophil, serum calcium, glucose, Na and K. Male animals show higher mean values for haemoglobin concentration, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and serum cholesterol and inorganic phosphate.

Haematological and serum biochemical values were also determined in donkeys (*Equus asinus*) in United States of America by Zinkl *et al.* (1990). Gupta *et al.* (1994) reported different haematological and biochemical values for the donkeys in India. French and Patrick (1995) reported the reference values for haematological, physiological and biochemical parameters in domestic donkey (*Equus asinus*) in United Kingdom. In Spain Folch *et al.* (1997), described the reference range and influence of age and sex on haematological values of the endangered Catalanian donkey. Also Jordana *et al.* (1998) set the clinical biochemical parameters of the endangered Catalanian donkey. In Brazil, Mori *et al.* (2003, 2004), reported the reference values on serum biochemical and haematological parameters of Brazilian donkey breed. In Sabia, Stanisic *et al.* (2015), reported Morphological, Biochemical and Haematological characterization of Endangered Balkan Donkey breed. In Ethiopia, Etana *et al.* (2011), reported Determination of reference physiological values for working donkeys of Ethiopia. In Botswana, Mushi *et al.* (1999), reported Haematological studies on apparently healthy donkeys in Oodi, Kgatleng district

Botswana. In Mexico, De Aluja *et al.* (2006) described Haematological and Biochemical Reference Values in the Donkey (*Equus asinus*) in Mexico. In Sudan, Babeker and Abdalbagi (2014) also described Haematological profile of Donkey (*Equus asinus*) breed in White Nile State, Sudan. Another work in Sudan was done by Ismael *et al.* (2010), described seasonal variation in some blood serum biochemical metabolites of Donkey in Sudan and also, Seri *et al.*, (2006) reported Reference Values on Serum Biochemical Parameters of Sudanese Donkey (*Equus asinus*) breed.

In Italy, Laus *et al.* (2015) reported Reference Values for Haematological and Biochemical Parameters of Mixed Breed Donkeys (*Equus asinus*). In Ethiopia also, Simenew *et al.* (2011) described Reference Values of Clinically Important Physiological, Haematological and Serum Biochemical Parameters of Apparently Healthy Working Equids of Ethiopia. In Ethiopia also, Lemma and Moges (2009) reported Clinical, Haematological and Serum Biochemical Reference Value of Working Donkeys (*Equus asinus*) owned by transport operators in Addis Ababa, Ethiopia. In Saudi Arabia, Al-Busadah and Homeida (2005) described Some Physical Variables, Biochemical and Haematological Parameters in Hassawi Ass.

All the values reported for physiological, haematological and serum biochemical parameters in working donkeys were not exactly the same. There are differences from previously known referenced values of other part of the world. This indicates tha the determination of these values for indigenous donkeys in Nigeria is important. The values to be obtained in the present studies may represent all the working donkeys in Northwestern Nigeria and constitute potential reference values that may be used for the assessment of the health status of the donkeys in the studied area.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Area of the study

The field research was conducted in three selected northwestern states of Nigeria; Katsina, Zamfara and Jigawa. Within each state three (3) Local Government Areas with sizable donkey population were selected. The Local Government Areas covered in Katsina were Kurfi, Daura and Dandume, in Zamfara were Tsafe, Kauran Namoda and Bakura, and in Jigawa were Roni, Kiyawa and Maigatari.

3.2 Geographical Description of Study Areas

Katsina State is located between Latitudes 11°08'N and 13°22'N and Longitudes 6°52'E and 9°20'E and covering an area 23,938 sq. km (Rumah and Sheikh, 2010). 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 (Geographic Information System, 2016). The state is composed of undulating plains which generally rise gently from 360 m in the Northeast around Daura, to 600 m around Funtua in the Southwest (Ladan, 2014). Katsina has the total annual rainfall ranges from 600-1000 mm/annum with temperature of about 37°C and relative humidity 60% whole year (Geographic Information System, 2016).

Zamfara State is located on Latitude 11°10'N and Longitude 6°15'E, covering an area of 39,762 square km with estimated population of 3,582,912 and Gusau as capital city (UNEP/OCHA, 2010). The state is bounded by Niger Republic to the North, by Katsina to the East, Kaduna State to the South, and Sokoto and Niger State to the West (Geographic Information System, 2016). The general elevation of the land ranges from 244 m to 366 m above sea level, and the mean annual rainfall in the State varies slightly from the northern to

the southern parts of the State, Gumi records an average of 579 mm of rainfall, Talata Mafara records 798 mm, Kauran Namoda 990 mm and Moriki 1,020 mm between mid May to October temperature of about 41.4°C and relative humidity 56% whole year (Geographic Information System, 2016).

Jigawa State is located between Latitude 11°00'N to 13°00'N and Longitude 8°00'E and 10°15'E and covering an area of 23,154 square km (Geographic Information System, 2016). The state is bounded by Niger Republic to the North, by Katsina and Kano to the West, by Yobe State to the Northeast and by Bauchi State to the East (Geographic Information System, 2016). The total annual rainfall ranges from 600 mm/annum in the north to 1000 mm/annum in the Southern parts of the state and the relief is generally undulating, but rock outcrops are common in areas of basement complex rocks, in the southern part of the state, the relief is about 500-600 metres above sea level. The mean annual temperature is about 37°C and in the coolest month the temperature reduces to 21°C and raised up to 38°C in the hottest month (Geographic Information System, 2016). Evapo-transpiration is very high and relative humidity is highest in August (up to 80 per cent) and low in January through March (twenty three to thirty percent) when it is moderated by the harmattan (Geographic Information System, 2016).

3.3 Experimental Animals and Design

A total of 125 donkeys owned by subsistence farmers were sampled using simple stratified random sampling method from all the states. They consisted of forty (40) from the three Local Government Areas in Katsina State (Kurfi, Daura and Dandume), forty three (45) from the three Local Government Areas in Zamfara State (Tsafe, Kauran Namoda and Bakura) and thirty nine (39) from three Local Government Areas in Jigawa State (Roni, Kiyawa and Maigatari). The donkeys were grouped according to their locations, sex and age.

There were a total of 66 males and 59 females sampled across the three states. The donkeys were divided into three age groups namely; Young (≤ 3 years, $N = 33$), Adult (3 - 10 years, $N = 53$) and Old (> 10 years, $N = 39$) (Table 1). The ages of the animals were determined using dentition (Crane, 1997). The design of the experiment was $3 \times 3 \times 2$, that is 3 locations, two sexes and 3 age group.

3.4 Data Collection

3.4.1 Physiological measurements of Donkey

All measurements and sampling were performed during the morning time from 6 am to 9 am. Parameters of rectal temperature ($^{\circ}\text{C}$), respiratory rate (breaths/minute) and pulse rate (beats/minute) were measured in accordance with routine clinical procedures. Rectal temperature was measured from the rectum of donkeys using digital thermometer, pulse rate was taken from heart location which is under the left side at the cardiac region behind the elbow using stethoscope and respiratory rate was assessed by closely observing number of nostril movements per minute as reported by Wosu (2002).

3.4.2 Collection of blood

Blood samples (8 ml) were drawn from the jugular vein of each donkey using a 10 ml heparinised vacutainer tube (BD Vacutainer Systems, Plymouth, UK). Blood samples were divided into two and placed into two separate vacuum tubes; one without anti-clotting agent for biochemical analysis (red capped tubes) and the other containing 10% anti coagulant EDTA (green cap tubes) and was used for haematological analysis. Immediately after collection, all blood samples with anti coagulant EDTA were innervated gently about ten times (10x) and placed over ice in an ice packed “polio vaccine” box (Weiser, 2002a; Charles, 2007).

Table 3.1: Distribution of experimental animals over the study area

State	Local Government	Male			Female			Total
		Young Adult	Old		Young Adult	Old		
Katsina	Kurfi	2	3	2	3	4	1	15
	Daura	1	2	3	2	3	2	13
	Dandume	1	1	2	3	3	2	12
Zamfara	Tsafe	2	3	3	1	2	2	13
	Kauran Namoda	2	8	3	1	2	2	18
	Bakura	2	4	2	2	2	2	14
Jigawa	Roni	2	3	1	2	3	2	13
	Kiyawa	3	3	2	1	3	3	15
	Maigatari	2	2	2	1	2	3	12
Total		17	29	20	16	24	19	125

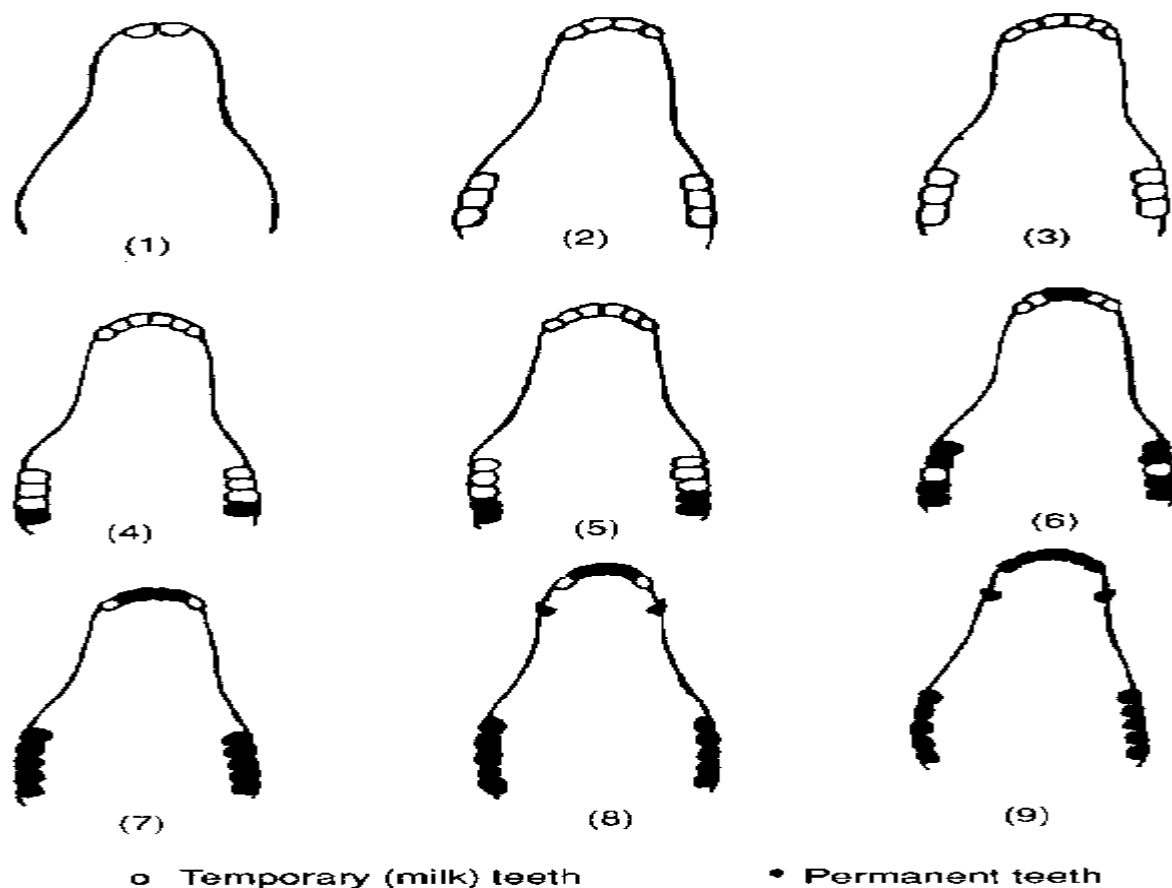


Figure 3.1: Age determination by dentition of donkey 0-4years

Key

Teeth on the upper and lower jaws are similar.

- (1) Birth: 2 RTorary front teeth
- (2) One month old: 4 front RTorary teeth, 3 RTorary cheek teeth on each side
- (3) Six to nine months: 6 front RTorary teeth
- (4) One year old: 4 cheek teeth present
- (5) One and a half years: 5 cheek teeth
- (6) Two and a half years: 2 permanent front teeth replace 2 RTorary teeth
- (7) Three and a half years: 4 permanent front teeth showing
- (8) Four years old: 4 canines show and 6 cheek teeth
- (9) Four and a half years: 6 permanent front teeth

Source: FAO (2003).

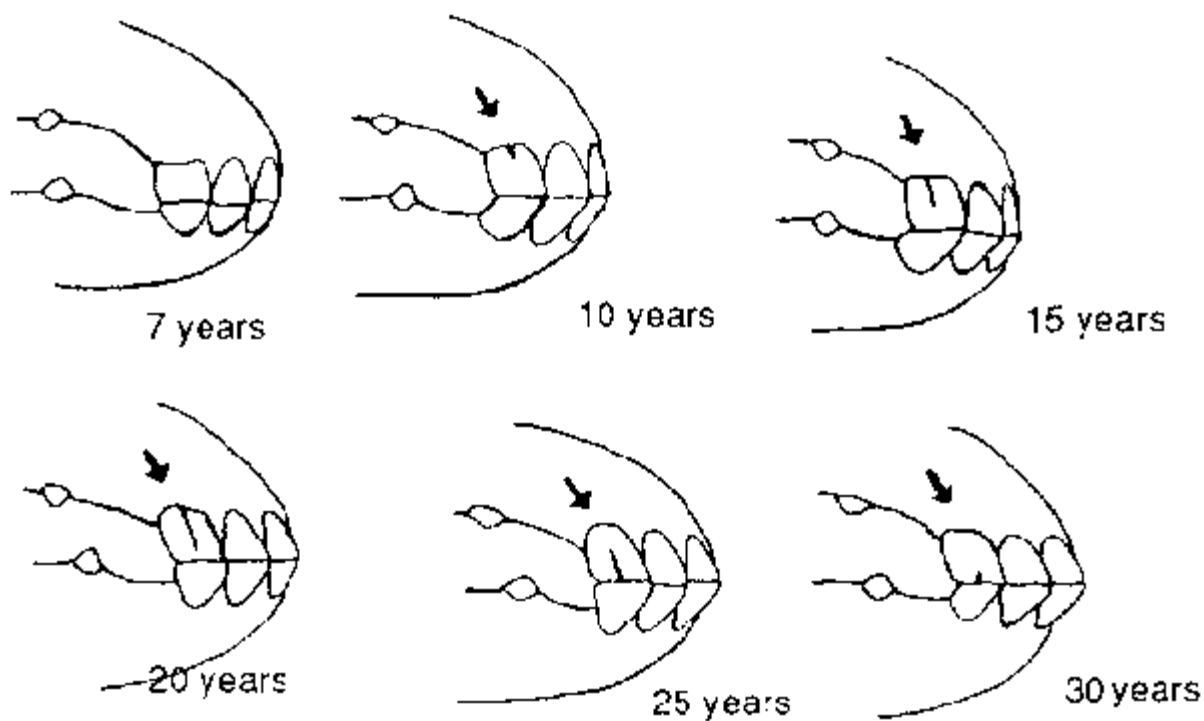


Figure 3.2: Age determination by dentition using Galvayne groove 7-30years

Key

- 1) Full teeth, 7-years
- 2) The groove appears at 10 years of age as a little canal on the top of the corner front teeth.
- 3) 15 years of age, the groove will reach the middle of the tooth
- 4) At 20 years, it has reached the bottom. It then starts to fill up.
- 5) By 30 years of age, the groove has disappeared.

Source: FAO (2003).

3.4.3 Haematological methods

Haematological analysis was performed using automatic cell counter (Sysmex- KX-21). Red blood cells (RBC), haemoglobin (Hgb) and total serum protein concentrations (TSP), Packed cell volume (PCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV), white blood cells (WBC), lymphocytes, neutrophils, eosinophils, monocytes and basophils counts were determined.

3.4.3.1 Overview of the Instrument (Sysmex-KX-21)

Sysmex-KX-21 performs speedy and accurate analysis of 18 parameters in blood and detects the abnormal samples. To assure easy sorting of abnormal samples in the laboratory, the instrument displays abnormal analysis data with abnormal marks, attached on the LCD screen. Thus, displayed analysis data allow the detecting those samples which are outside the tolerance and need further analysis and reconsideration. The KX-21 employs three detector blocks and two kinds of reagents for blood analysis. The WBC count is measured by the WBC detector block using the DC detection method. The RBC count and platelets are taken by the RBC detector block, also using the DC detection method. The HGB detector block measures the hemoglobin concentration using the nonacyanide haemoglobin method.

3.4.4 Serum Biochemical Methods

Blood plasma was separated by centrifugation at 1800 $\times g$ for 15 min at 4°C. The plasma was stored at -20°C and transported to Ahmadu Bello University Teaching Hospital (ABUTH) Zaria, Nigeria for the assay of the nutrient sensitive metabolites. The concentrations of the nutrient-sensitive metabolites were measured using the Vitros 950 Chemistry Systems auto-analyser (Ortho Clinical Diagnostics, UK). Blood glucose was

measured based on the method of Trinder (1969), while cholesterol was determined based on the enzymatic method of Allain *et al.* (1974). The total blood protein concentration was determined based on the Biuret reaction (Doumas *et al.*, 1981) and albumin determination based on the method of Doumas and Biggs (1972), while globulin concentration in plasma was computed as the difference between the total protein and albumin concentrations (Mapekula *et al.*, 2011). Urea determination was based on the method by Sampson *et al.* (1980), while creatinine determination was done according to the method by Ambrose *et al.* (1983). The concentration of total bilirubin, triglyceride and activities of alkaline phosphate, alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) were determined using automated system photometer 5010 (Robert Rieck GmbH and coKG, Berlin, Germany). Serum electrolytes: sodium, potassium, chloride and calcium were analyzed using Roche AVL 9180 Snap pack Electrolyte analyzer (Roche Diagnostic Corporation 9115 Hague road, USA, 2002). The results were automatically analyzed and printed out with the sample identification number.

The accuracy and reliability of the procedures, instruments and the reagents were ensured through quality control and careful handling of the sample. The above procedures were described in detailed below:

3.4.4.1 Serum total protein

Serum total protein was analyzed using two different methods due to the availability of the kits according to the following methods.

Biuret method

Total serum protein was analyzed by Biuret method (King and Wootton, 1956) using kits (Randox laboratories Ltd., UK). Copper ion in alkaline solution reacts with the peptide

linkage of amino acids of the serum protein producing a violet colour. The optical density of the developing colour was measured at 540 nm using Jenway spectrophotometer (Jenway 6105 U. V. /vis. Spectrophotometer, U. K.). The total serum protein values were measured in g/100 ml of serum and then converted to g/l.

3.4.4.2 Serum albumin

Serum albumin also was analyzed using two different types of kits according to the following methods:-

Bromocresol green

Albumin is the most abundant serum protein representing 55-65% of the total protein. It is synthesized in the liver and has a half life of 2 to 3 weeks. The main biological functions of albumin are to maintain the water balance in serum and plasma and to transport and store a wide variety of ligands for example, fatty acids, calcium, bilirubin and hormones such as thyroxine. Albumin also provides an endogenous source of amino acids. Hypoalbuminaemia is associated with the following conditions: an albuminaemia; impaired albumin synthesis in the liver; liver disease; malnutrition or mal-absorption; generalized shock; burns or dermatitis; kidney disease and intestinal disease. Hyperalbuminaemia has little diagnostic relevance except, perhaps in dehydration.

The serum albumin concentration was determined by Bromocresol green method (BCG) according to Bartholomew and Delany (1966) using kits (Randox laboratories Ltd., United Kingdom). The BCG solution (buffer indicator consists of 17.3 ml of 1 M sodium citrate plus 32.7 ml of 1 M citric acid plus 6 ml of 0.01 M bromocresol green plus 800 ml of distilled water) reacted with the serum albumin, producing a blue colour.

The absorbance was read at 630 nm using spectrophotometer (Jenway 6105 U. V. vis. Spectrophotometer, U. K.). Albumin values were measured in g/100 ml of serum and then converted to g/l.

3.4.4.3 Serum globulin

The serum globulins (g/l) were determined by deduction of the values of serum albumin from total serum protein values.

3.4.4.4 Serum urea

Serum urea concentration was measured by an enzymatic colorimetric method using a commercial kit (Randox laboratories Ltd., United Kingdom) according to Fawcett and Scott (1960). The intensity of the developing colour was measured at 600 nm using Jenway spectrophotometer (Jenway 6105 U. V. /vis. Spectrophotometer, U. K.).

Principle

Urea in the presence of water and urease is hydrolyzed to produce ammonia and carbon dioxide. In a modified Berthelot reaction, ammonia ions react with hydrochloride and salicylate to give a green dye, the increase of absorbance at 600 nm is proportional to urea concentration in sample.

3.4.4.5 Serum creatinine

Creatinine is derived from creatine and creatine phosphate in muscle tissue and may be defined as a nitrogenous waste product. Creatinine is not reutilized but is excreted from the body in the urine via the kidney. It is produced and excreted at a constant rate which is proportional to the body muscle mass. As a consequence of the way in which creatinine is excreted by the kidney, creatinine measurement is used almost exclusively in the assessment of kidney function. Creatinine is measured primarily to assess kidney function and regarded as the most useful endogenous marker in the diagnosis and treatment of kidney disease. It has

certain advantages over the measurement of urea. The plasma level of creatinine is relatively independent of protein ingestion, water intake, rate of urine production and exercise. Since its rate of production is constant, elevation of plasma creatinine is indicative of under- excretion, suggesting kidney impairment. Depressed levels of plasma creatinine are rare and not clinically significant.

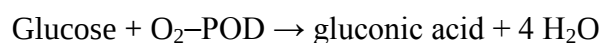
Colorimetric method

Principle

The serum creatinine concentration was determined by spectrophotometric method using kits (Randox laboratories Ltd., UK). Creatinine in alkaline solution reacts with picric acid to form a coloured complex. The amount of the complex formed is directly proportional to the creatinine concentration. The intensity of the developing colour was measured at 492 nm using Jenway spectrophotometer (Jenway 6105 U. V. /vis. Spectrophotometer, UK) according to Bartels *et al.* (1972).

3.4.4.6 Serum glucose

Glucose was determined using kits (Randox laboratories Ltd., UK) after enzymatic oxidation in the presence of glucose oxidase. The hydrogen peroxide formed reacts, under catalysis of peroxidase, with phenol and 4 aminophenazone to form red – violet quinoneimine dye as indicator. The formed colour was measured at 500 nm using Pharmacia LKB, Ultrospec III UV/Visible Spectrophotometer (Pharmacia LKB Biochrom Ltd., Science Park, Cambridge, UK) according to Barham and Trinder (1972).



3.4.4.7 Aspartate aminotransferase

Aspartate aminotransferase (AST) catalyze the transamination of L-aspartate and 2-oxoglutarate to oxaloacetate and glutamate. The enzyme occurs in almost all cells, but it is used primarily as a diagnostic enzyme for liver and muscle disease because of its high activity in these tissues, serum AST has high sensitivity for liver disease (Duncan *et al.*, 1994).

Glutamicoxaloacetic transaminase (GOT) was measured by monitoring the concentration of oxaloacetate hydrazone formed with 2, 4– dinitrophenylhydrazine according to Reitman and Frankel (1957). The formed colour was measured at 530 nm using Jenway spectrophotometer (Jenway 6105 U. V. /vis. Spectrophotometer, UK).

3.4.4.8 Alanine aminotransferase

Alanine aminotransferase (ALT) is a soluble cytosolic enzyme that catalyzes the reversible transamination of L-alanine and 2-oxoglutarate to pyruvate and glutamate. Hepatic ALT activity in donkey, horses, cattle, sheep, goats, and pigs is very low, which precludes its use for detecting liver disease in these species (Duncan *et al.*, 1994).

Glutamic – pyruvic transaminase (GPT) was measured using kits (Randox laboratories Ltd., UK) by monitoring the concentration of pyruvate hydrazone formed with 2, 4– dinitrophenylhydrazine according to Reitman and Frankel (1957). The formed colour was measured at 530 nm using Jenway spectrophotometer (Jenway 6105 U. V. /vis. Spectrophotometer, UK).

3.4.4.9 Serum inorganic phosphorus

Phosphorus outside the skeleton plays an even fascinating role. It is involved in vital cellular structures and serves in the degradation and synthesis of numerous carbon compounds. High-energy phosphate bonds play a fundamental role in storage, liberation and transfer of energy (Kaneko *et al.*, 1997).

The serum inorganic phosphorus was determined according to Taussky and Shorr (1953) and Goldenburg and Fernandez (1966) using kits (Randox Laboratories Ltd., UK). Serum inorganic phosphorus reacts with molybdate in strong acid medium to form phosphomolybdate complex. The phosphomolybdate reacts with metol solution to form a blue colour, which is read at 690 nm using Jenway spectrophotometer (Jenway Spectrophotometer, UK). Serum phosphorus values were measured in mmol/l of serum.

3.4.4.10 Serum calcium

Calcium in the extracellular fluid is critical for normal neuromuscular excitability, capillary and membrane permeability, normal muscle contraction, normal transmission of nerve impulses, and normal blood coagulation (Kaneko *et al.*, 1997).

The serum calcium concentration was determined by photometric colorimetric test cresolphthalein method kit (Randox Laboratories Ltd., UK). Calcium ions form a violet complex with o-cresolphthalein complex one in alkaline medium. The intensity of the developing colour was measured at 570 nm using Jenway Spectrophotometer (Jenway Spectrophotometer, UK).

The calcium values were calculated in mmol/l of serum according to Sarkar and Chauhan (1967) and Barnett *et al.* (1973).

3.4.4.11 Serum Sodium and Potassium

Sodium and potassium concentrations in the serum were determined by flame photometry technique as described by Wootton (1974). A volume of 0.1 ml of serum was diluted with 9.9 ml of deionized water in a test tube. The knob of the light filter was adjusted to sodium and potassium then the power was connected and the galvanometer light switched on. The gas switch was turned and the flame was ignited. The high standards were adjusted to full scale and the diluted serum samples and low standards were measured. Sodium and

potassium values were measured in mEq/L and then converted to mmol/L according to Kaneko *et al.* (1997).

3.5 Data Analyses

The Data obtained were analyzed using the General Linear Model (GLM) procedure of SAS (2008) and the significant differences in the treatments were separated using Duncan's Multiple Range Test.

3.5.1 Statistical Model

3 x 2 x 3 Factorial arrangement

3 states, 2 Sexes and 3 age groups

$$Y_{ijkl} = \mu + L_i + A_j + S_k + (L_i \times A_i) + (L_i \times S_k) + (A_i \times S_k) + (L_i \times A_j \times S_k) + e_{ijkl}$$

where:

Y_{ijkl} : Observation of k^{th} Donkey of the i^{th} location j^{th} sex and l^{th} age

μ : is the population mean.

L_i : effect of i^{th} location.

S_j : effect of j^{th} sex.

A_l : effect of l^{th} age.

e_{ijkl} : is the random error.

CHAPTER FOUR

RESULTS

4.1 Baseline Values of the parameters

Table 4.1 shows the results of baseline physiological parameters of donkeys found in Northwestern Nigeria. The rectal temperature values ranges from 35.5°C to 38.4°C with mean value of 37.65 ± 0.03 °C, whereas, respiratory rate values ranged from 18 breaths/minute to 34.0 breaths/minute with mean respiratory rate of 26.20 ± 0.21 breaths/minute and the pulse rate values of donkeys in Northwestern Nigeria ranges from 42.00 beats/minute to 64.00 beats/minute with mean pulse rate of 51.13 ± 0.54 beats/minute.

The results of the analysis of haematological parameters of donkeys found in Northwestern Nigeria are shown in Table 4.2, the PCV values ranged from 26.00% to 50.00% with mean value of $33.71 \pm 0.61\%$, while hemoglobin values ranged from 7.80 g/dl to 15.60 g/dl with mean value of 10.99 ± 0.21 g/dl. The RBC values ranged from $4.00 \times 10^6/\mu\text{l}$ to $8.00 \times 10^6/\mu\text{l}$ with mean value of $5.79 \pm 0.11 \times 10^6/\mu\text{l}$. The MCV activities ranged from 36.25 fL to 90.90 fL with mean value of 58.54 ± 1.02 fL, whereas MCH activities ranged from 9.75 pg to 31.20 pg with mean value of 19.27 ± 0.34 pg and MCHC values ranged from 22.00 g/dl to 41.94 g/dl with mean value of 32.75 ± 0.37 g/dl. The WBC activities ranged from $3.60 \times 10^9/\mu\text{l}$ to $14.80 \times 10^9/\mu\text{l}$ with mean value of $7.21 \pm 0.34 \times 10^9/\mu\text{l}$. The neutrophils counts of donkeys found in Northwestern Nigeria ranged from 30.00% to 58.00% with mean value of $41.59 \pm 0.82\%$. The lymphocytes counts of donkeys found in Northwestern Nigeria ranged from 2.00% to 70.00% with mean value of $56.06 \pm 1.09\%$. The monocytes counts of donkeys found in Northwestern Nigeria ranged from 0% to 6.00% with mean value of $0.75 \pm 0.13\%$. The eosinophils counts of donkeys found in Northwestern Nigeria ranged from 0.00% to

7.00% with mean value of $0.59\% \pm 0.13$. The basophils counts of donkeys found in Northwestern Nigeria ranged from 0.00% to 2.00% with mean value of $0.11 \pm 0.04\%$.

The results of the biochemical analysis as presented on Table 4.3 shows that glucose levels in donkeys of Northwestern Nigeria ranged from 1.40 mmol/L to 4.60 mmol/L with mean glucose of 3.03 ± 0.05 mmol/L. The AST, ALT and ALP activities ranged from 4.00 IU/L to 48.00 IU/L, 4.00 IU/L to 51.00 IU/L and 54.00 IU/L to 191.00 IU/L with means activity of 19.80 ± 0.81 IU/L, 16.30 ± 0.72 IU/L and 115.10 ± 2.39 IU/L respectively. The concentrations of total serum protein, albumin, globulin of donkey ranged from 58.00 g/L to 89.00 g/L, 25.00 g/L to 53.00 g/L and 23.00 g/L to 56.00 g/L with mean concentrations of 72.9 ± 0.85 g/L, 36.8 ± 0.70 g/L and 36.10 ± 0.73 g/L respectively. The concentrations of sodium, potassium, chloride, bicarbonate, urea, creatinine, calcium and uric acids of donkeys found in Northwestern Nigeria ranged from 112.4 mmol/L to 156.00 mmol/L, 3.70 mmol/L to 10.00 mmol/L, 83.00 mmol/L to 110.00 mmol/L, 5.40 mmol/L to 58.00 mmol/L, 2.30 mmol/L to 18.60 mmol/L, 47.00 mmol/L to 172.00 mmol/L, 1.48 mmol/L to 5.86 mmol/L and 80.00 mmol/L to 180.00 mmol/L with mean concentrations of 131.10 ± 0.87 mmol/L, 5.21 ± 0.10 mmol/L, 101.40 ± 0.39 mmol/L, 27.30 ± 0.87 , 7.87 ± 0.32 , 127.20 ± 2.68 mmol/L, 3.03 ± 0.08 mmol/L and 133.67 ± 3.08 respectively. The serum pH of donkeys found in Northwestern Nigeria ranged from 7.00 to 9.00 with mean pH of 7.76 ± 0.04 .

4.2 Variation in physiological parameters of donkey

There were no significant difference between male and female donkey in rectal temperature and pulse rate (Table.44). However, respiratory rates, were significant ($P < 0.05$) higher in female donkeys than in the male donkeys.

Similarly, there were significant ($P<0.05$) variations between young, adult and old donkeys in all the physiological parameters (Table 4.5). Rectal temperature, respiratory rate and pulse rates were significantly higher ($P<0.05$) in the young than in adult and old donkeys, whose values were statistically similar.

On the other hand, there were significant ($P<0.05$) variations in physiological parameters in donkeys across study locations (Table 4.6). Rectal temperatures were significantly higher ($P<0.05$) in donkeys found in Jigawa State and Zamfara State than Katsina State. Respiratory rates were faster ($P<0.05$) in donkeys found in Katsina State and Zamfara State than Jigawa State. Pulse rate were higher ($P<0.05$) in donkeys found in Katsina State than Jigawa State and Zamfara State.

Table 4.1: Baseline Physiological values of donkey in Northwestern Nigeria

Parameters	No.	Mean $\pm$ S.E	Min.	Max.	C.V	Reference values	
RT ($^{\circ}$ C)	125	37.65 $\pm$ 0.03	35.5	38.4	0.98	37.70	French and Patrick (1995)
						37.60	AL-Busadah & Homeida (2005)
						37.67	Lemma and Moges (2009)
						37.70	Etana <i>et al.</i> (2011).
						37.47	Simenew <i>et al.</i> (2011).
RR(Breaths/min)	125	26.2 $\pm$ 0.21	18.0	34.0	8.84	14.00	AL-Busadah a&Homeida (2005)
						26.90	Etana <i>et al.</i> (2011)
						40.89	Simenew <i>et al.</i> (2011)
PR (Beats/min)	125	51.13 $\pm$ 0.54	42.0	64.0	11.7	51.00	Canocoo <i>et al.</i> (1991)
						47.89	Etana <i>et al.</i> (2011).
						51.65	Simenew <i>et al.</i> (2011)

RT: Rectal Temperature, RR: Respiratory Rate, PR: Pulse rate, No. Number, Min. Minimum, Max. Maximum, S.E: Standard error, C.V: Coefficient of variation.

Table 4.2: Baseline Haematological values of donkey in Northwestern Nigeria

Parameters	Mean $\pm$ SE	No.	Min	Max	C.V	Reference Values
PCV (%)	33.71 $\pm$ 0.61	125	26.00	50.00	15.95	32 to 53*
Hgb (g/dl)	10.99 $\pm$ 0.21	125	7.80	15.60	16.55	7.0 to 19.0*
RBC ($\times 10^6/\mu\text{l}$)	5.79 $\pm$ 0.11	125	4.00	8.00	17.07	5.7 to 6.9*
MCV (fL)	58.54 $\pm$ 1.02	125	36.25	90.90	15.46	37 – 58.5*
MCH (pg)	19.27 $\pm$ 0.34	125	9.75	31.20	15.79	12.3 – 19.7*
MCHC (g/dl)	32.75 $\pm$ 0.37	125	22.00	41.94	10.09	31 – 38.6*
WBC($\times 10^9/\mu\text{l}$)	7.21 $\pm$ 0.34	125	3.60	14.80	42.06	5.4 – 14.3*
NEUT (%)	41.59 $\pm$ 0.82	125	30.00	58.00	17.48	30 – 75*
LYMP (%)	56.06 $\pm$ 1.09	125	2.00	70.00	17.31	25 – 60*
MONO (%)	0.75 $\pm$ 0.13	125	0	6.00	153.15	1 – 8*
EOS (%)	0.59 $\pm$ 0.13	125	0	7.00	194.42	1 – 10*
BASO (%)	0.11 $\pm$ 0.04	125	0	2.00	313.89	0 – 3*

S.E: Standard error, C.V: Coefficient of variation, No.: Number, Min: Minimum; Max: Maximum, PCV: Packed Cell Volume, Hgb: Haemoglobin concentration, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, NEUT: Neutrophils, LYMP: Lymphocytes, MONO: Monocytes, EOS: Eosinophils, BASO: Basophils.

*Reference values Adapted from Diney and Khubenov (1986).

Table 4.3: Baseline Biochemical values of donkey in Northwestern Nigeria

Parameters	No.	Mean $\pm$ S.E	Min	Max	C.V	Reference Values
Glucose (mmol/L)	125	3.03 $\pm$ 0.05	1.40	4.60	18.10	*2.00 to 6.62
AST (IU/L)	125	19.8 $\pm$ 0.81	4.00	48.0	40.62	*197 to 612
ALT (IU/L)	125	16.3 $\pm$ 0.72	4.00	51.0	44.04	** to 29
ALP (IU/L)	125	115.1 $\pm$ 2.39	54.0	191.0	20.73	**36 to 970
TSP (g/L)	125	72.9 $\pm$ 0.85	58.0	89.0	11.62	*54.87 to 95
Albumin (g/L)	125	36.8 $\pm$ 0.70	25.0	53.0	19.06	*26.06 to 28.82
Globulin (g/L)	125	36.1 $\pm$ 0.73	23.0	56.0	20.14	*31.5 to 59.3
Na ⁺ (mmol/L)	125	131.1 $\pm$ 0.87	112.4	156	6.67	*123 to 168
K ⁺ (mmol/L)	125	5.21 $\pm$ 0.10	3.70	10.0	19.30	*4.19 to 4.54
Cl ⁻ (mmol/L)	125	101.4 $\pm$ 0.39	83.0	110.0	3.80	*92 to 133
HCO ₃ ⁻ (mmol/L)	125	27.3 $\pm$ 1.19	5.0	58.0	43.79	*19.8 to 21.3
Urea (mmol/L)	125	7.87 $\pm$ 0.32	2.30	18.6	40.92	*2.98 to 8.15
Creatinine (umol/L)	125	127.2 $\pm$ 2.68	47.0	172.0	21.06	*83.17 to 91.92
Ca ²⁺ (mmol/L)	125	3.03 $\pm$ 0.08	1.48	5.86	26.71	*2.95 to 3.09
pH	125	7.76 $\pm$ 0.04	7.00	9.00	5.11	-
UA (umol/L)	125	133.67 $\pm$ 3.08	80.0	180.0	23.08	-

S.E: Standard error, C.V: Coefficient of variation, No.: Number, AST: Aspartate transaminase, ALT: Alanine transaminase, ALP: Alkaline phosphatase, TSP: Total serum protein, Na⁺: Sodium, K⁺: Potassium, Cl⁻: Chloride, HCO₃⁻: Bicarbonate, Ca²⁺: Calcium, pH: serum pH, UA: Uric acid.

* Reference values Adapted from De Aluja *et al.*, (2006).

** Reference values Adapted from Simenew *et al.*, (2011).

Table 4.4: Effect of Sex on physiological parameters of donkey

Parameters	No.	Male	Female	S.E.M	LOS
RT (°C)	125	37.65	37.66	0.04	NS
RR (Breaths/min)	125	25.77 ^b	26.70 ^a	0.02	*
PR (Beats/min)	125	51.38	50.88	0.50	NS

S.E.M: Standard error of mean. No.: Number, LOS: Level of Significance. RT: Rectal Temperature. RR: Respiratory Rate. PR: Pulse rate.

Means within rows with different alphabetical superscript are significantly different (*= P<0.05)

NS = No significant

Table 4.5: Effect of age on physiological parameters of donkey

Parameters	Young	Adult	Old	S.E.M	LOS
RT (°C)	37.85 ^a	37.61 ^b	37.51 ^b	0.06	*
RR (Breaths/min)	27.39 ^a	25.84 ^b	25.50 ^b	0.33	*
PR (Beats/min)	56.95 ^a	48.36 ^b	48.86 ^b	0.80	**

S.E.M: Standard error of mean. LOS: Level of Significance. RT: Rectal Temperature. RR: Respiratory Rate, PR: Pulse rate.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

**= P<0.01

Table 4.6: Effect of location on physiological parameters of donkey

Parameters	Jigawa	Katsina	Zamfara	S.E.M	LOS
RT (°C)	37.68 ^a	37.55 ^b	37.73 ^a	0.06	*
RR (Breaths/min)	25.63	26.39	26.61	0.33	*
PR (Beats/min)	50.51 ^b	53.66 ^a	49.29 ^b	0.80	*

S.E.M: Standard error of mean. LOS: Level of Significance. RT: Rectal Temperature. RR: Respiratory Rate. PR: Pulse rate.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

4.3 Variation in haematological parameters of donkey

Table 4.7 shows the variation of haematological parameters with sex in donkeys of Northwestern Nigeria. Neutrophils counts were significantly ($P<0.05$) higher in male donkeys than female, while lymphocytes counts were significantly ($P<0.05$) higher in females than male donkeys and eosinophil counts were significantly higher in male than female donkeys.

Variation of haematological parameters due ages of the donkeys were presented on Table 4.8. Packed cell volume and haemoglobin were significantly ($P<0.05$) higher in adult and old donkeys than in young donkeys. The WBC counts were significantly ($P<0.05$) higher in young than adult and old donkeys while neutrophils counts were significantly ($P<0.05$) highest in old than adult and young donkeys. Lymphocytes counts were significantly ($P<0.05$) higher in adult donkeys followed by young and old donkeys, whereas monocytes counts were significant ($P<0.05$) higher in young than old and adult donkeys. Eosinophils and basophils counts were significant ($P<0.05$) higher in young than adult and old whose values are statistically similar.

Similarly, the variation in haematological parameters of donkeys across three states of Northwestern Nigeria where presented on Table 4.9. Neutrophils and lymphocytes counts were significantly ($P<0.05$) higher in donkeys found in Jigawa State and Zamfara State than donkeys found in Katsina State. Monocytes counts in blood of donkeys in Jigawa State were significantly ($P<0.05$) higher than that of Katsina State and Zamfara State. Eosinophils counts of donkeys found in Katsina State were significant ($P<0.05$) higher than donkeys found in Zamfara State and Jigawa State Basophils counts were significant ($P<0.05$) higher in donkeys found in Katsina State than donkeys found in Jigawa State and Zamfara State, whose values were statistically similar.

Table 4.7: Effect of sex on haematological parameters of donkey

Parameters	No.	Male	Female	S.E.M	LOS
PCV (%)	125	33.64	33.77	0.87	NS
Hgb (g/dl)	125	10.86	11.11	0.25	NS
RBC ($\times 10^6/\mu\text{l}$)	125	5.69	5.87	0.32	NS
MCV (fL)	125	59.27	57.93	1.63	NS
MCH (pg)	125	19.26	19.28	0.50	NS
MCHC (g/dl)	125	32.51	32.96	0.53	NS
WBC ($\times 10^9/\mu\text{l}$)	125	7.01	7.38	2.14	NS
NEUT (%)	125	44.21 ^a	39.40 ^b	1.00	*
LYMP (%)	125	53.63 ^b	58.09 ^a	1.06	*
MONO (%)	125	0.81	0.69	0.20	NS
EOS (%)	125	0.90 ^a	0.33 ^b	0.30	*
BASO (%)	125	0.17	0.07	0.05	NS

S.E.M: Standard error of mean, No.: Number, LOS: Level of Significance, PCV: Packed Cell Volume, Hgb: Hemoglobin concentration, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, NEUT: Neutrophils, LYMP: Lymphocytes, MONO: Monocytes, EOS: Eosinophils, BASO: Basophils.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

NS = No significant

Table 4.8: Effect of age on haematological parameters of donkey

Parameters	Young	Adult	Old	S.E.M	LOS
PCV (%)	31.88 ^b	34.27 ^a	34.80 ^a	0.56	*
Hgb (g/dl)	10.36 ^b	11.34 ^a	11.19 ^a	0.20	*
RBC (x10 ⁶ /μl)	5.51	5.88	5.94	0.76	NS
MCV (fL)	59.35	57.85	58.61	1.25	NS
MCH (pg)	19.24	19.57	18.94	0.80	NS
MCHC (g/dl)	32.55	33.19	32.42	1.22	NS
WBC (x10 ⁹ /μl)	8.73 ^a	6.96 ^b	5.70 ^c	0.38	*
NEUT (%)	41.45 ^b	38.40 ^c	45.56 ^a	0.56	*
LYMP (%)	55.69 ^b	60.60 ^a	50.96 ^c	1.27	**
MONO (%)	1.30 ^a	0.33 ^c	0.72 ^b	0.28	**
EOS (%)	0.68 ^a	0.57 ^b	0.52 ^b	0.03	*
BASO (%)	0.33 ^a	0.03 ^b	0.00 ^b	0.10	*

S.E.M: Standard error of mean, LOS: Level of Significance, PCV: Packed Cell Volume, Hgb: Hemoglobin concentration, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, NEUT: Neutrophils, LYMP: Lymphocytes, MONO: Monocytes, EOS: Eosinophils, BASO: Basophils.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

**= P<0.01

NS = No significant

Table 4.9: Effect of location on haematological parameters of donkey

Parameters	Katsina	Jigawa	Zamfara	SEM	LOS
PCV (%)	31.59	31.75	31.19	1.21	NS
Hgb (g/dl)	11.56	10.20	10.57	1.39	NS
RBC ($\times 10^6/\mu\text{l}$)	5.98	5.41	5.47	0.88	NS
MCV (fL)	59.52	58.98	57.24	1.27	NS
MCH (pg)	19.50	19.03	19.46	0.44	NS
MCHC (g/dl)	32.84	32.25	34.10	0.63	NS
WBC ($\times 10^9/\mu\text{l}$)	7.25	6.71	5.95	1.20	NS
NEUT (%)	40.81 ^b	47.30 ^a	48.37 ^a	1.34	*
LYMP (%)	56.81 ^a	50.85 ^b	51.00 ^b	2.00	*
MONO (%)	0.66 ^b	0.90 ^a	0.48 ^c	0.50	*
EOS (%)	1.20 ^a	0.60 ^c	1.07 ^b	0.25	*
BASO (%)	0.29 ^a	0.05 ^b	0.07 ^b	0.29	*

S.E.M: Standard error of mean, LOS: Level of Significance, PCV: Packed Cell Volume, Hgb: Hemoglobin concentration, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, NEUT: Neutrophils, LYMP: Lymphocytes, MONO: Monocytes, EOS: Eosinophils, BASO: Basophils,
Means within rows with different alphabetical superscript are significantly different.

*= $P < 0.05$

NS = No significant

4.4 Variation in serum biochemical parameters of donkey

The variations in serum biochemical parameters with sex in donkeys of Northwestern Nigeria were showed on Table 4.10. Glucose, total serum protein, potassium, creatinine and uric acid levels were significant ($P<0.05$) higher in female than male donkeys.

Similarly, the variations in serum biochemical parameters with ages of donkeys in the Northwestern Nigeria were presented on Table 4.11. Glucose levels were significantly ($P<0.05$) higher in young donkeys than in Adult and old donkeys, whereas, aspartate transaminase (AST) enzymes were significantly ($P<0.05$) higher in Young and adult than old donkeys. Alanine transaminase (ALT) enzymes were significantly ($P<0.05$) higher in old than adult and young donkeys, while Alkaline phosphatase (ALP) levels were significantly ($P<0.05$) higher in young than in adult and old donkeys. Albumins, potassium and uric acid content of donkeys' serum were significantly higher ($P<0.05$) in young and adult than old donkeys. Sodium concentrations were significantly higher ($P<0.05$) in Young and Old than in Adult donkeys of Northwestern Nigeria. Bicarbonate concentrations were significantly higher ($P<0.05$) in adult and old than in young donkeys. Urea concentrations were significantly higher ($P<0.05$) in adult donkeys than in young and old donkeys found in Northwestern Nigeria. Creatinine levels were significantly higher ($P<0.05$) in young donkeys than adults and old donkeys.

On the other hands, the variations in serum biochemical parameters due to locations of donkeys were presented on Table 4.12. Alanine transaminase (ALT) enzymes were significantly ($P<0.05$) higher in donkeys found in Jigawa State and Zamfara State than that of Katsina State. Alkaline phosphatase (ALP) were significantly ($P<0.05$) higher in donkeys found in Katsina State than Zamfara State and Jigawa State. Total serum protein and Albumin

levels were significantly ($P<0.05$) higher in donkeys of Katsina State than Jigawa State and Zamfara State. Concentrations of globulins were significantly ($P<0.05$) higher in donkeys found in Zamfara State than Jigawa State and Katsina State. Sodium concentrations were significantly ($P<0.05$) higher in donkeys of Jigawa State than Katsina State and Zamfara State. Bicarbonate concentration were significantly ($P<0.05$) higher in donkeys found in Zamfara State followed by Jigawa State and Katsina State. Urea levels were significantly higher ($P<0.05$) in donkeys of Zamfara State followed by Jigawa State and Katsina State. Creatinine concentrations were significantly higher ($P<0.05$) in donkeys found in Katsina State than Jigawa State and Zamfara State. Calcium concentrations were significantly higher ($P<0.05$) in donkeys of Jigawa State followed by Katsina State and Zamfara State. Uric acid concentration were significantly higher ($P<0.05$) in donkeys found in Katsina State followed by Jigawa State and Zamfara State.

4.5 Interactions between variations in sex, age and location of physiological, haematological and serum biochemical parameters of donkeys

Table 4.13 shows effect of interaction between sex, age and location on physiological parameters of donkeys of Northwestern Nigeria. There were no significant interaction effect ($P>0.05$) between location, age and sex on Respiratory rate. However, there was significant ($P<0.05$) interaction effect between sex, age and location on rectal Temperature and Respiratory rate. Rectal temperature was significantly ($P<0.05$) higher in young male donkeys of Zamfara State, but significantly ($P<0.05$) lower in old male donkeys of Katsina State. The pulse rate values were significantly ($P<0.05$) higher in young male and female donkeys of Jigawa State, young male and female donkeys of Katsina State and young male donkeys of Zamfara State. The least statistically significant ($P<0.05$) values of pulse rate were recorded

in adult male donkeys of Jigawa State, Old male donkeys of Jigawa State, old male and female donkeys of Zamfara State.

The interaction effects between sex, age and location on haematological parameters of donkeys found in Northwestern Nigeria were presented on Table 4.14. There were no significant interaction ($P>0.05$) effect between location, age and sex on PCV, Haemoglobin, RBC, activities of MVC, MCH and MCHC, and neutrophils, lymphocytes, monocytes and eosinophils counts. However, there were significant ($P<0.05$) interactions effect between sex, age and location on WBC and basophils counts. WBC were significantly ($P<0.05$) higher in old female donkeys of Katsina State. The least WBC were recorded in adult old female donkeys of Jigawa State, young male donkeys of Katsina State, young female donkeys of Zamfara State and adult male of Zamfara State. Basophils counts were significantly ($P<0.05$) higher in young male donkeys of Katsina State.

Table 4.14 presented an interaction effect between sex, age and location on serum biochemical parameters of donkeys found in Northwestern Nigeria. There were no significant interaction effect ($P>0.05$) between location, age and sex on AST, ALT, ALP, Total Serum Protein, Globulins, Potassium and Uric acid concentrations. However, there were significant ($P<0.05$) interactions effect between sex, age and location on glucose, albumin, sodium, chloride, bicarbonate, urea, creatinine, calcium and serum pH. Glucose level were significantly ($P<0.05$) higher in young female donkeys of Katsina State, young female donkeys of Zamfara State and adult female donkeys of Zamfara State. The least glucose levels were obtained in adult male donkeys of Zamfara State. Albumins were significantly ($P<0.05$) higher in adult male donkeys of Katsina State. The least albumin levels were recorded in old female donkeys of Zamfara State. Sodium concentrations were significantly ($P<0.05$) higher

in young old male of Jigawa State and old female of Jigawa State. The significantly ($P<0.05$) lower concentrations were obtained in young male donkeys of Katsina State, young male and female donkeys of Zamfara State, adult male and female donkeys of Zamfara State. The chloride concentrations were significantly ($P<0.05$) higher in young female donkeys of Jigawa State, adult male and female donkeys of Jigawa State, old female donkeys of Jigawa State, adult female donkeys of Katsina State, old male donkeys of Katsina State, young female donkeys of Zamfara State, adult male and female donkeys of Zamfara State and old male and female donkeys of Zamfara State. The significantly ($P<0.05$) lower chloride concentrations were obtained in adult male donkeys of Katsina State. Bicarbonate concentrations were significantly higher ($P<0.05$) in adult female donkeys of Katsina State, old male donkeys of Katsina State, adult male and female donkeys of Zamfara State and old male donkeys of Zamfara State. The significantly lower ($P<0.05$) bicarbonate concentrations were obtained in adult male donkeys of Katsina State. Urea concentrations were significantly higher ($P<0.05$) in adult male donkeys of Katsina State. The significantly least ($P<0.05$) urea concentrations were recorded in adult male donkeys of Jigawa State, adult male donkeys of Katsina State and adult male donkeys of Zamfara State. Creatinine concentrations were significantly higher ($P<0.05$) in adult male donkeys of Katsina State. The significantly least ($P<0.05$) concentrations of creatinine were observed in young male donkeys of Jigawa State. Calcium concentrations were significantly higher ($P<0.05$) in old female donkeys of Jigawa State. The significantly lower ($P<0.05$) concentrations of calcium were observed in old male donkeys of Zamfara State. Serum pH values were significantly higher ($P<0.05$) in adult male donkeys of Katsina State. The significantly lower ($P<0.05$) pH values were observed in young male donkeys of Zamfara State.

Table 4.10: Effect of sex on serum biochemical parameters of donkey

Parameters	No.	Male	Female	S.E.M	LOS
Glucose (mmol/L)	125	2.86±0.07 ^b	3.27±0.08 ^a	0.05	*
AST (IU/L)	125	20.36±1.13	19.02±1.11	0.98	NS
ALT (IU/L)	125	16.61±1.05	15.81±0.89	1.03	NS
ALP (IU/L)	125	113.39±3.21	117.63±3.56	3.50	NS
TSP (g/L)	125	71.64±1.07 ^b	74.81±1.34 ^a	1.09	*
Albumin (g/L)	125	36.58±0.90	37.22±1.13	1.00	NS
Globulin (g/L)	125	35.07±0.99	37.59±1.03	1.10	NS
Na ⁺ (mmol/L)	125	130.53±1.23	131.90±1.19	1.21	NS
K ⁺ (mmol/L)	125	5.03±0.09 ^b	5.47±0.20 ^a	0.08	*
Cl ⁻ (mmol/L)	125	101.61±0.54	101.05±0.53	0.50	NS
HCO ₃ ⁻ (mmol/L)	125	27.46±1.57	26.96±1.85	1.22	NS
Urea (mmol/L)	125	8.14±0.44	7.47±0.46	0.40	NS
Creatinine (umol/L)	125	125.33±3.99 ^b	129.93±3.11 ^a	0.17	*
Ca ²⁺ (mmol/L)	125	2.99±0.11	3.07±0.11	0.10	NS
pH	125	7.74±0.06	7.78±0.05	0.14	NS
UA (umol/L)	125	126.27±4.09 ^b	144.29±4.20 ^a	4.08	*

S.E.M: Standard error of mean, No.: Number, LOS: Level of Significance, AST: Aspartate amino transaminase, ALT: Alanine amino transaminase, ALP: Alkaline phosphatase, TSP: Total serum protein, Na⁺: Sodium, K⁺: Potassium, Cl⁻: Chlorine, HCO₃⁻: Bicarbonate, Ca²⁺: Calcium, pH: serum pH, UA: Uric acid.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

NS = No significant

Table 4.11: Effect of age on serum biochemical parameters of donkey

Parameters	Young	Adult	Old	SEM	LOS
Glucose (mmol/L)	3.25±0.07 ^a	2.96±0.09 ^b	2.86±0.09 ^b	0.07	*
AST (IU/L)	21.21±1.57 ^a	19.39±1.28 ^a	18.63±1.19 ^b	1.11	*
ALT (IU/L)	15.79±0.65 ^b	17.86±1.19 ^a	17.71±1.92 ^a	0.64	*
ALP (IU/L)	120.82±3.47 ^a	113.98±3.79 ^b	109.38±5.34 ^c	1.34	*
TSP (g/L)	73.69±1.64	73.93±1.26	70.13±1.44	1.68	NS
Albumin (g/L)	37.21±1.16 ^a	37.30±1.18 ^a	35.50±1.25 ^b	0.85	*
Globulin (g/L)	36.49±1.16	36.62±1.12	34.63±1.63	1.59	NS
Na ⁺ (mmol/L)	131.80±1.63 ^a	128.94±1.09 ^b	133.96±1.98 ^a	1.30	*
K ⁺ (mmol/L)	5.31±0.22 ^a	5.29±0.15 ^a	4.92±0.09 ^b	0.38	*
Cl ⁻ (mmol/L)	100.20±0.53	101.79±0.66	102.25±0.76	1.52	NS
HCO ₃ ⁻ (mmol/L)	22.14±1.55 ^b	29.63±1.83 ^a	30.04±2.77 ^a	2.00	**
Urea (mmol/L)	6.61±0.41 ^b	9.72±0.48 ^a	6.27±0.57 ^b	0.90	**
Creatinine (umol/L)	133.52±6.08 ^a	122.65±2.8 ^b	122.13±5.08 ^b	2.06	**
Ca ²⁺ (mmol/L)	2.97±0.13	2.98±0.12	3.19±0.19	1.87	NS
pH	7.81±0.06	7.69±0.07	7.78±0.07	0.17	NS
UA (umol/L)	134.24±4.83 ^a	136.89±5.37 ^a	127.08±5.39 ^b	2.09	*

S.E.M: Standard error of mean, LOS: Level of Significance, AST: Aspartate amino transaminase, ALT: Alanine amino transaminase, ALP: Alkaline phosphatase, TSP: Total serum protein, Na⁺: Sodium, K⁺: Potassium, Cl⁻: Chlorine, HCO₃⁻: Bicarbonate, Cr: Creatinine, Ca²⁺: Calcium, pH: serum pH, UA: Uric acid.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

NS = No significant

Table 4.12: Effect of location on serum biochemical parameters of donkey

Parameters	Jigawa	Katsina	Zamfara	SEM	LOS
Glucose (mmol/L)	3.07±0.07	3.20±0.09	2.91±0.10	1.88	NS
AST (IU/L)	18.38±0.85	20.83±2.37	20.83±2.34	1.54	NS
ALT (IU/L)	16.25±0.66 ^a	13.11±1.01 ^b	17.67±1.49 ^a	1.22	**
ALP (IU/L)	106.03±2.64 ^c	128.50±4.86 ^a	118.07±4.27 ^b	2.09	**
TSP (g/L)	71.35±1.32 ^b	77.56±2.01 ^a	72.48±1.24 ^b	1.62	*
Albumin (g/L)	36.68±1.00 ^b	43.17±1.79 ^a	34.29±0.88 ^b	2.18	**
Globulin (g/L)	34.68±0.92 ^b	34.39±1.12 ^b	38.19±1.36 ^a	1.30	*
Na ⁺ (mmol/L)	136.47±1.42 ^a	128.56±1.82 ^b	127.06±0.92 ^b	1.69	*
K ⁺ (mmol/L)	5.53±0.22	5.16±0.17	4.92±0.08	0.98	NS
Cl ⁻ (mmol/L)	101.49±0.46	97.89±1.22	102.76±0.47	2.80	NS
HCO ₃ ⁻ (mmol/L)	20.12±0.78 ^b	15.39±1.30 ^c	39.13±1.12 ^a	1.27	**
Urea (mmol/L)	7.07±0.52 ^b	5.00±0.24 ^c	9.85±0.38 ^a	0.06	**
Creatinine (umol/L)	121.15±4.27 ^b	154.94±2.31 ^a	121.10±3.74 ^b	3.88	**
Ca (mmol/L)	3.74±0.09 ^a	3.08±0.10 ^b	2.32±0.06 ^c	0.15	*
pH	7.86±0.05	8.11±0.06	7.51±0.06	1.20	NS
UA (umol/L)	137.40±4.41 ^b	142.78±7.91 ^a	126.19±4.84 ^c	1.18	*

S.E.M: Standard error of mean, LOS: Level of Significance, AST: Aspartate transaminase, ALT: Alanine transaminase, ALP: Alkaline phosphatase, TSP: Total serum protein, Na: Sodium, K: Potassium, Cl: Chlorine, HCO₃: Bicarbonate, Ca: Calcium, pH: serum pH, UA: Uric acid.

Means within rows with different alphabetical superscript are significantly different.

*= P<0.05

**= P<0.01

NS = No significant

Table 4.13: Interactions between effect of sex, age and location on physiological parameters of donkeys

Parameters	Jigawa								Katsina								Zamfara							
	Young		Adult		Old		Young		Adult		Old		Young		Adult		Old		SEM	LOS				
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female						
RT (°C)	37.77 ^{ab}	37.90 ^{ab}	37.55 ^{abc}	37.72 ^{abc}	37.57 ^{abc}	37.65 ^{abc}	37.75 ^{abc}	37.77 ^{ab}	37.85 ^{ab}	37.15 ^{cd}	36.95 ^d	37.65 ^{abc}	38.05 ^a	37.90 ^{ab}	37.72 ^{abc}	37.80 ^{ab}	37.72 ^{abc}	37.30 ^{bcd}	0.18	*				
RR(Breaths/min)	26.75	27.50	25.00	25.75	25.75	25.75	28.50	30.25	24.00	27.00	23.00	26.75	27.25	28.00	25.00	27.00	25.75	26.50	1.01	NS				
PR (Beats/min)	59.50 ^a	59.00 ^a	46.75 ^d	48.50 ^{bcd}	46.00 ^d	48.50 ^{bcd}	58.00 ^a	58.50 ^a	51.00 ^{bcd}	52.50 ^{bc}	57.50 ^a	47.25 ^{cd}	58.75 ^a	52.75 ^b	48.50 ^{bcd}	49.00 ^{bcd}	47.00 ^d	47.00 ^d	1.65	*				

S.E.M: Standard error of mean, LOS: Level of Significance, RT: Rectal Temperature, RR: Respiratory Rate, PR: Pulse rate.
Means within rows with different alphabetical superscript are significantly different.
*= P<0.05
NS = No significant

Table 4.14: Interactions between effect of sex, age and location on haematological parameters of donkeys

Parameters	Jigawa						Katsina						Zamfara						SEM	LOS
	Young		Adult		Old		Young		Adult		Old		Young		Adult		Old			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
PCV (%)	29.75	27.75	32.25	31.75	35.00	33.25	33.25	39.00	37.75	37.75	40.75	36.00	27.25	27.75	30.75	32.25	35.75	31.15	2.13	NS
Hgb (g/dl)	9.75	8.48	9.85	10.83	11.65	11.65	11.40	12.98	12.48	12.55	11.58	11.20	8.90	9.28	10.23	10.35	11.90	10.60	0.72	NS
RBC (x10 ⁶ /µl)	4.95	5.88	5.43	5.73	6.23	6.28	5.88	6.88	6.70	6.65	6.08	6.10	4.70	4.85	4.55	5.25	6.48	5.88	0.48	NS
MCV (fL)	60.20	50.37	59.83	55.97	56.42	53.38	56.68	56.98	56.50	60.44	64.73	59.29	57.59	57.44	60.89	61.56	55.33	53.89	3.29	NS
MCH (pg)	19.71	15.74	18.64	19.12	18.78	18.67	19.41	18.96	18.68	20.10	19.01	18.22	19.00	19.19	20.25	19.70	18.41	18.30	0.96	NS
MCHC (g/dl)	32.79	30.68	31.07	34.13	33.29	35.34	34.43	33.26	33.01	33.25	28.76	30.92	32.64	33.42	33.25	32.11	33.29	34.18	1.40	NS
WBC (x10 ⁹ /µl)	5.55 ^{de}	5.33 ^{de}	7.48 ^{bcde}	4.80 ^e	9.40 ^{abc}	5.10 ^e	4.50 ^e	10.00 ^{ab}	6.15 ^{cde}	5.83 ^{cde}	8.95 ^{abcd}	12.35 ^a	6.82 ^{bcde}	4.85 ^e	4.10 ^e	6.60 ^{bcde}	6.65 ^{bcde}	5.98 ^{cde}	1.14	*
NEUT (%)	43.50	36.00	46.75	38.75	50.00	46.50	40.96	41.50	36.75	33.75	44.00	41.75	51.50	36.50	44.25	45.50	48.50	46.25	2.93	NS
LYMP (%)	53.75	61.00	53.25	61.00	47.50	53.25	54.67	57.00	60.50	65.25	55.75	56.50	47.25	57.75	54.00	55.00	46.25	51.00	3.08	NS
MONO (%)	1.75	1.25	0.00	0.00	1.00	0.00	1.80	0.50	0.25	0.75	0.25	2.00	0.75	1.75	0.00	0.00	2.25	1.00	0.70	NS
EOS (%)	0.00	0.50	0.00	0.25	1.25	0.00	1.35	0.50	2.00	0.25	0.00	0.00	0.50	0.25	0.75	0.50	2.00	1.75	0.55	NS
BASO (%)	0.00	0.25 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	1.00 ^a	0.25 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.50 ^b	0.00 ^b	0.17	*

S.E.M: Standard error of mean, LOS: Level of Significance, PCV: Packed Cell Volume, Hgb: Hemoglobin concentration, WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, NEUT: Neutrophils, LYMP: Lymphocytes, MONO: Monocytes, EOS: Eosinophils, BASO: Basophils,
Means within rows with different alphabetical superscript are significantly different. *= P<0.05

Table 4.15: Interactions between effect of sex, age and location on serum biochemical profile of donkeys

Parameters	Jigawa						Katsina						Zamfara						SEM	LOS
	Young		Adult		Old		Young		Adult		Old		Young		Adult		Old			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Glucose (mmol/L)	3.05 ^{abc}	3.70 ^a	2.70 ^{bcd}	3.38 ^{ab}	3.33 ^{bcd}	2.95 ^{bc}	2.85 ^{bcd}	3.28 ^{ab}	3.15 ^{abc}	2.83 ^{bcd}	2.48 ^{cd}	2.95 ^{bc}	3.20 ^{abc}	3.75 ^a	2.15 ^d	3.75 ^a	2.73 ^{bcd}	2.88 ^{bc}	0.21	*
AST (IU/L)	17.50	17.50	13.25	24.25	18.75	16.00	24.50	21.25	22.00	27.50	26.50	18.25	29.00	23.75	19.50	13.75	14.00	19.75	4.21	NS
ALT (IU/L)	18.00	13.50	12.00	21.00	14.50	14.25	18.25	10.00	11.25	24.50	23.25	21.00	18.75	15.25	15.75	19.75	18.25	12.50	4.09	NS
ALP (IU/L)	106.0	113.3	97.5	98.5	95.0	107.2	113.0	134.5	124.8	113.5	142.2	110.8	121.0	126.0	122.5	109.2	89.8	106.8	10.62	NS
TSP (g/L)	71.50	79.75	70.00	77.75	66.75	75.00	78.50	72.25	82.00	74.25	69.00	70.75	70.75	76.50	74.00	76.50	70.75	69.25	4.22	NS
Albumin (g/L)	33.8 ^{bcd}	42.8 ^{ab}	34.8 ^{bcd}	41.0 ^{abc}	34.0 ^{bcd}	38.8 ^{bcd}	41.3 ^{bc}	39.0 ^{bcd}	50.0 ^a	34.0 ^{bcd}	33.3 ^{bcd}	37.0 ^{bcd}	35.3 ^{bcd}	31.3 ^{bcd}	34.0 ^{cd}	35.3 ^{bcd}	37.8 ^{bcd}	29.5 ^d	2.92	*
Globulin (g/L)	3.05	3.70	2.70	3.38	3.33	2.95	2.85	3.26	3.15	2.83	2.48	2.95	3.20	3.75	2.150	3.750	2.73	2.88	0.22	NS
Na ⁺ (mmol/L)	146.7 ^a	129.8 ^{cd}	132.2 ^{bcd}	138.0 ^{abc}	141.8 ^{ab}	143.8 ^a	122.3 ^d	132.8 ^{bcd}	130.0 ^{cd}	128.4 ^{cd}	130.3 ^{cd}	132.5 ^{bcd}	125.4 ^d	126.3 ^d	123.4 ^d	125.6 ^d	128.8 ^{cd}	127.0 ^{cd}	3.47	*
K ⁺ (mmol/L)	4.69	7.37	6.00	6.85	4.72	4.92	4.88	4.90	4.95	4.98	4.88	5.12	4.85	5.08	5.27	4.69	4.75	4.97	0.47	NS
Cl ⁻ (mmol/L)	99.4 ^{abc}	102.8 ^a	101.8 ^a	101.8 ^a	100.2 ^{abc}	101.8 ^a	100.8 ^{abc}	95.5 ^{bc}	95.0 ^c	104.0 ^a	103.7 ^a	101.3 ^{ab}	100.2 ^{abc}	102.0 ^a	101.9 ^a	102.0 ^a	105.2 ^a	103.5 ^a	1.88	*
HCO ₃ ⁻ (mmol/L)	12.47 ^{fg}	23.27 ^{de}	23.25 ^{de}	19.50 ^{efg}	17.50 ^{efg}	19.75 ^{efg}	20.75 ^{ef}	15.50 ^{efg}	11.75 ^g	43.75 ^a	46.75 ^a	19.75 ^{efg}	30.55 ^{cd}	33.20 ^{bc}	43.65 ^a	42.12 ^a	40.00 ^a	47.50 ^{ab}	2.59	*
Urea (mmol/L)	4.55 ^d	8.85 ^{abc}	12.12 ^a	8.25 ^{bc}	4.05 ^d	4.27 ^d	6.32 ^{cd}	4.05 ^d	5.00 ^a	11.12 ^{ab}	8.90 ^{abc}	4.95 ^d	9.40 ^{abc}	9.20 ^{abc}	11.82 ^a	10.35 ^{ab}	6.70 ^{cd}	9.00 ^{abc}	1.02	*
Creatinine (umol/L)	62.2 ^f	122.7 ^{bcde}	126.2 ^{abcde}	148.5 ^{abc}	142.5 ^{abcd}	140.0 ^{abcd}	154.5 ^{ab}	147.2 ^{abc}	158.8 ^a	123.5 ^{bcde}	109.3 ^{de}	117.5 ^{cde}	115.5 ^{cde}	125.7 ^{abcde}	131.0 ^{abcde}	119.5 ^{cde}	103.0 ^e	99.7 ^e	10.37	*
Ca ²⁺ (mmol/L)	3.39 ^{bc}	3.85 ^{cde}	4.65 ^c	3.3 ^{cde}	3.66 ^{bcd}	4.20 ^{ab}	2.9 ^{def}	2.77 ^{efg}	3.4 ^{cde}	2.41 ^{fg}	2.56 ^{bc}	3.88 ^{fg}	2.24 ^{fg}	2.31 ^{fg}	2.26 ^{fg}	2.32 ^{fg}	2.14 ^g	2.39 ^{fg}	0.24	*
pH	8.20 ^{ab}	7.75 ^{cd} ^{ef}	7.50 ^{efg}	7.63 ^{defg}	8.10 ^{abc}	8.13 ^{abc}	7.88 ^{bcde}	8.05 ^{abc}	8.35 ^a	8.03 ^{abcd}	7.50 ^{efg}	8.03 ^{abcd}	7.28 ^g	7.55 ^{efg}	7.38 ^{fg}	7.45 ^{efg}	7.33 ^{fg}	7.50 ^{efg}	0.13	*
UA (umol/L)	110.0	155.0	175.0	170.0	115.0	127.5	127.5	165.0	115.0	165.0	125.0	135.0	120.0	135.0	140.0	140.0	150.0	115.0	12.97	NS

S.E.M: Standard error of mean, LOS: Level of Significance. AST: Aspartate transaminase, ALT: Alanine transaminase, ALP: Alkaline phosphatase, TSP: Total serum protein, Na⁺: Sodium, K⁺: Potassium, Cl⁻: Chlorine, HCO₃⁻: Bicarbonate, Ca²⁺: Calcium, pH: serum pH, UA: Uric acid.
Means within rows with different alphabetical superscript are significantly different. *= P<0.05, NS = No significant

CHAPTER FIVE

DISCUSSION

The values of physiological, haematological and serum biochemical parameters obtained in this study were similar to those obtained in donkey Sanctuary Working Worldwide, England (French and Patrick, 1995), Sokoto (Nigeria) (Yakubu and Chafe, 2008), Ethiopia (Lemma and Moges, 2009; Simenew *et al.*, 2011; Etana *et al.*, 2011), Sudan (Seri *et al.*, 2006; Ismael *et al.*, 2010; Babeker and Abdalbagi, 2014), Botswana (Mushi *et al.*, 1999), Saudi Arabia (Al-Busadah and Homeida 2005), Mexico (De Aluja *et al.*, 2006), Italy (Laus *et al.*, 2015), Serbia (Stanisic *et al.*, 2015), Brazil (Mori *et al.*, 2003, 2004), Spain (Folch *et al.* 1997; Jordana *et al.*, 1998). The values obtained were consistent with previous reports and within the published normal ranges.

5.1 Physiological Parameters:

The mean rectal temperature of donkey (37.65°C) observed in the present study were similar to 37.70 °C obtained by French and Patrick (1995), 37.60 °C obtained by AL-Busadah and Homeida (2005), 37.67°C obtained by Lemma and Moges (2009) and 37.70°C obtained by Etana *et al.* (2011), The value was slightly higher than 37.47 °C reported by Simenew *et al.* (2011).

The higher rectal temperature values observed in young donkeys compared to adult and older donkeys agreed with those reported by French and Patrick (1995) and Etana *et al.* (2011). This high rectal temperature in young donkeys may be attributed to their high metabolic rate (Fielding and Krause, 1998). The mean rectal temperature value for Zamfara donkeys in this study was higher compared to Jigawa and Katsina donkeys. This may be due to slight differences in environmental factors.

Respiratory rate was measured using nostril movement method because Etana *et al.*, (2011) reported that there was no significant different ($P > 0.005$) between the three methods of nostril movement, tracheal sound and abdominal movement used in measuring respiratory rate. The mean value for respiratory rate (breaths per minute) obtained in the present study is (26.2 breaths/minutes) and this was similar to the 26.9 breaths/minutes reported by Etana *et al.* (2011). The value was lower than 40.89 breaths/minutes reported by Simenew *et al.* (2011) and higher than 14.0 breaths/minutes reported by AL-Busadah and Homeida (2005). The younger donkeys had faster Respiratory rate than adult and old donkeys in the present study and this is in agreement with the report of French and Patrick (1995) and Etana *et al.* (2011). Female donkeys respired faster than males (26.70 breaths/minutes v 25.77 breaths/minutes). This finding agreed with the report by Etana *et al.* (2011) who recorded 28.40 breaths/minutes for female and 27.50 breaths/minutes for male donkeys respectively. This is because the volume of female lungs are somewhat smaller than that of males lungs therefore females have a slightly faster respiratory rate (again, it is because more oxygen is needed and more CO₂ needs to be exhaled out of the body) (Etana *et al.*, 2011).

The mean pulse rate (beats per minute) in the present study was (51.13 beats/minute). This value was similar to the 51.00 beats/minutes obtained by Canocoo *et al.* (1991) and 51.65 beats/minutes obtained by Simenew *et al.* (2011). The value was slightly higher than 46.5 beats/minutes reported by Al-Busadah and Homeida (2005) and 47.89 beats/minutes reported by Etana *et al.* (2011). The slight differences in pulse rate from the present study might be due to variations in environmental and geographical locations. The pulse rate of young donkeys (56.95 beats/minutes) was higher than in adult and old donkeys. This value agreed with similar report of (55.40 beats/minutes, 47.60 beats/minutes and 47.60 beats/minutes), reported by

Etana *et al.* (2011) for young, adult and old donkeys respectively. The mean pulse rate value for adult (48.36 beats/minute) and old (48.86 beats/minute) donkeys were statistically similar and slightly higher compared to the result of 43 beats/minute reported by Canocoo *et al.* (1991), and the 47.60 beats/minute reported by Etana *et al.* (2011). These slight differences in pulse rate might be due to variations in environmental and geographical locations. The mean pulse rate value for Katsina donkeys in this study was higher compared to those of Jigawa and Zamfara donkeys. This difference may be due to environmental factors.

5.2 Haematological Parameters:

The haematological values established in the present study are consistent with previously published data for donkeys from Sokoto, Nigeria (Yakubu and Chafe, 2008), Ethiopia (Simenew *et al.*, 2011), Italy (Laus *et al.*, 2015), Serbia (Stanisic *et al.*, 2015), Brazil (Mori *et al.*, 2003) and Romania (Mot *et al.*, 2010). Differential white blood cell (WBC) counts of neutrophils, lymphocytes, eosinophils showed significant differences ($P < 0.05$) between male and female, and this result agreed with the report of Botros *et al.* (1970), Maloiy and Boarer (1971), Jain (1986), Diney and Khubenov (1986), Hill (1989); Zinkl *et al.* (1990); French and Patrick (1995), Folch *et al.* (1997), Mushi, *et al.* (2000), Etana *et al.* (2011) and Babeker and Abdalbagi (2014). The trend of haematological parameters with respect to age shows that adult and old donkeys have higher PCV, Hgb and RBC counts than young donkeys and this result agreed with the findings of Canocoo *et al.* (1991), Folch *et al.* (1997) and Etana *et al.* (2011). The higher counts of erythrocytes in the young donkeys could be associated with iron deficiency in the young donkeys (Zinkl *et al.* 1990). Total WBC value was higher in young donkeys than adult and old donkeys. This result agrees with the findings of French and Patrick (1995), Folch *et al.* (1997), and Etana *et al.* (2011). The higher WBC

counts in the young donkeys could be attributed to its increased bone marrow production in young animals (Sgorbini *et al.*, 2013). Total WBC counts showed a significant decrease with age, while lymphocyte number did not seem to be influenced by age. Similar results were reported by Zinkl *et al.* (1990), Stanisic *et al.* (2015). Age is the main factor that causes steady decline in WBC values (Zinkl *et al.*, 1990; Folch *et al.*, 1997; Etana *et al.*, 2011). The location of donkeys has effect on WBC counts only, and there was no previously reported haematological research on donkey or close species like the horse in Katsina State, Jigawa State or Zamfara State to compare. The variations in WBC counts could indicate variations due to disease tolerance among donkeys in Northwestern Nigeria.

5.3 Serum Biochemical Parameters:

The values obtained in this study for serum biochemical parameters in Northwestern Nigerian donkeys were consistent with previous reports and within the recommended reference ranges (Zinkl *et al.*, 1990; French and Patrick 1995; Jordana *et al.*, 1997; Mori *et al.*, 2003; Etana *et al.*, 2011; Stanisic *et al.*, 2015 and Garba *et al.*, 2015). Results on biochemical analysis showed significant differences ($P < 0.05$) between male and female donkeys for glucose, total serum protein, potassium, creatinine and uric acid, with female having the higher concentration than male. These findings are similar to those obtained by Zinkl *et al.* (1990) and Al-Busadah and Homeida (2005). The higher glucose level in female may be due to the less workload, compared to males. Jordana *et al.* (1998) recorded no effect of sex on these parameters in Catalanian donkey breeds.

Age had the most influence on the serum biochemical parameters studied. Eleven out of the 16 variables showed significant differences between young and adult donkeys. Glucose, aspartate transaminase (AST), alkaline phosphatase (ALP), albumin, sodium, potassium and

uric acid showed a significant decrease as age advanced. Similar results, with some exceptions, were reported by Zinkl *et al.* (1990), Sow *et al.* (2012), Girardi *et al.* (2013) and Annita *et al.* (2016). The high levels of glucose in young donkeys during the first year of age may be due to nutrition, which is mainly done by breastfeeding in the beginning, and naturally change during this period, with increasing forage intake (Annita *et al.*, 2016). The higher the forage intake, the lower the glucose level. The aspartate transaminas (AST) activity is lower in old animals. This result agreed with the report of Sow *et al.* (2012) who reported low AST activity of young donkey. The abundance of muscle and physical efforts influence significantly AST activities (Padalino *et al.*, 2007). The nutritional status could explain the muscle abundance; thus, the variation in AST activities was most probably due to muscle abundance. The result of decreasing ALT level agreed with the findings of Veronesi *et al.* (2014). The ALP activity was significantly higher in young donkeys and it decreased with age. This agreed with the findings of Zinkl *et al.* (1990), Laus *et al.* (2015) and Stanisic *et al.* (2015). Albumin concentrations of young and adult are statistically similar but higher than the concentrations recorded albumin in old donkeys, which agreed with the report of Keneko (1989) that there is slight decrease in concentrations of albumin as age advances. Bicarbonate concentration increases with age. The early decrease in serum urea concentrations was similar to that reported by Sgorbini *et al.* (2013), Veronesi *et al.* (2014) and Annita *et al.* (2016). Creatinine concentration reduced with age and this agreed with the finding of Etana *et al.* (2011). The significant differences in creatinine concentrations may reflect the differences in the feeding conditions between different groups of donkeys (Al Shafei *et al.*, 2015). Creatinine concentration depends upon the total body content of creatinine, which in turn, depends upon dietary intake and muscle mass (Kaneko, 1989; Al-Busadah and Homeida, 2005). The higher

level of urea in adult donkeys compared to young donkeys may be due to components of adult donkey especially proteins Kaneko (1989)

The results of investigation by French and Patrick (1995) using large sample of approximately 4000 donkeys also showed that biochemical parameters were not affected by sex and age of donkeys. French and Patrick (1995) said differences observed by other authors may be due to small non-normal sample data or inadequate use of parametric statistics.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Physiological measurements and blood samples of 125 donkeys were obtained from three (3) Northwestern States, Jigawa, Katsina and Zamfara using random sampling technique according to the ages and sexes of the animals. The physiological parameters measured were rectal temperature, respiratory rate and pulse rate. The blood samples collected were taken to laboratory for haematological and serum biochemical examinations. Data were analyzed using the General Linear Model (GLM) procedure of SAS (2008) and the significant differences in the treatments were separated using Duncan's Multiple Range Test.

This study established a baseline range of values for physiological, haematological and serum biochemical parameters of donkeys in Northwestern Nigeria. The study also investigated possible effect of age, sex, location and their interactions on the mentioned parameters of donkeys found in Northwestern Nigerian.

The results of the current study indicated that there are considerable variations in physiological, haematological and serum biochemical values due to sex, age and location of donkeys. Therefore, these variations should be noted during physiological assessment, haematological and serum biochemical interpretations. The strong positive correlation between rectal temperature, pulse rate and respiratory rate in this study implies that a rise in one of the physiological parameters could leads to a rise in the others. Although there are pioneer data on some of these parameters, the present finding may contribute a lot by further enhancing our understanding on physiological parameters of Nigerian donkeys. The results obtained from

this study will provide useful information for researchers, animal physiologists, veterinary practitioners, farmers, research institutions, governments and other organizations to help in improving the welfare of donkeys and to prevent them from going into extinct. The data could also be of helpful in establishing valuable reference values that would allow animal physiologists and veterinary practitioners to establish an appropriate interpretation of laboratory data and give these animals appropriate care.

6.2 Conclusions

1. The mean physiological, haematological and serum biochemical profile of donkeys in Northwestern Nigeria were established.
2. This study indicated that there were considerable variations in physiological, haematological and serum biochemical values due to sex, age and location of donkeys.
3. The study showed that there was strong positive correlation between rectal temperature, pulse rate and respiratory rate.
4. It was discovered that female donkeys Respire faster than male donkeys; while younger donkeys were having higher rectal temperature, pulse rate and respiratory rate.
5. WBC counts were higher in younger donkeys than adult and old donkeys; while location had strong influence on WBC counts.
6. The study showed that, female donkeys have higher serum glucose and protein levels; whereas age has strong influence on the serum biochemical parameters.

6.3 Recommendations

Physiological, haematological and serum biochemical parameters varied according to season, environment and management factors. Further research should be conducted across geopolitical zones of Nigeria to investigate and establish the effects of season, environment and management systems on donkeys (*Equus asinus*).

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APPENDICES

Appendix i



Plate i: Stethoscope

Appendix ii

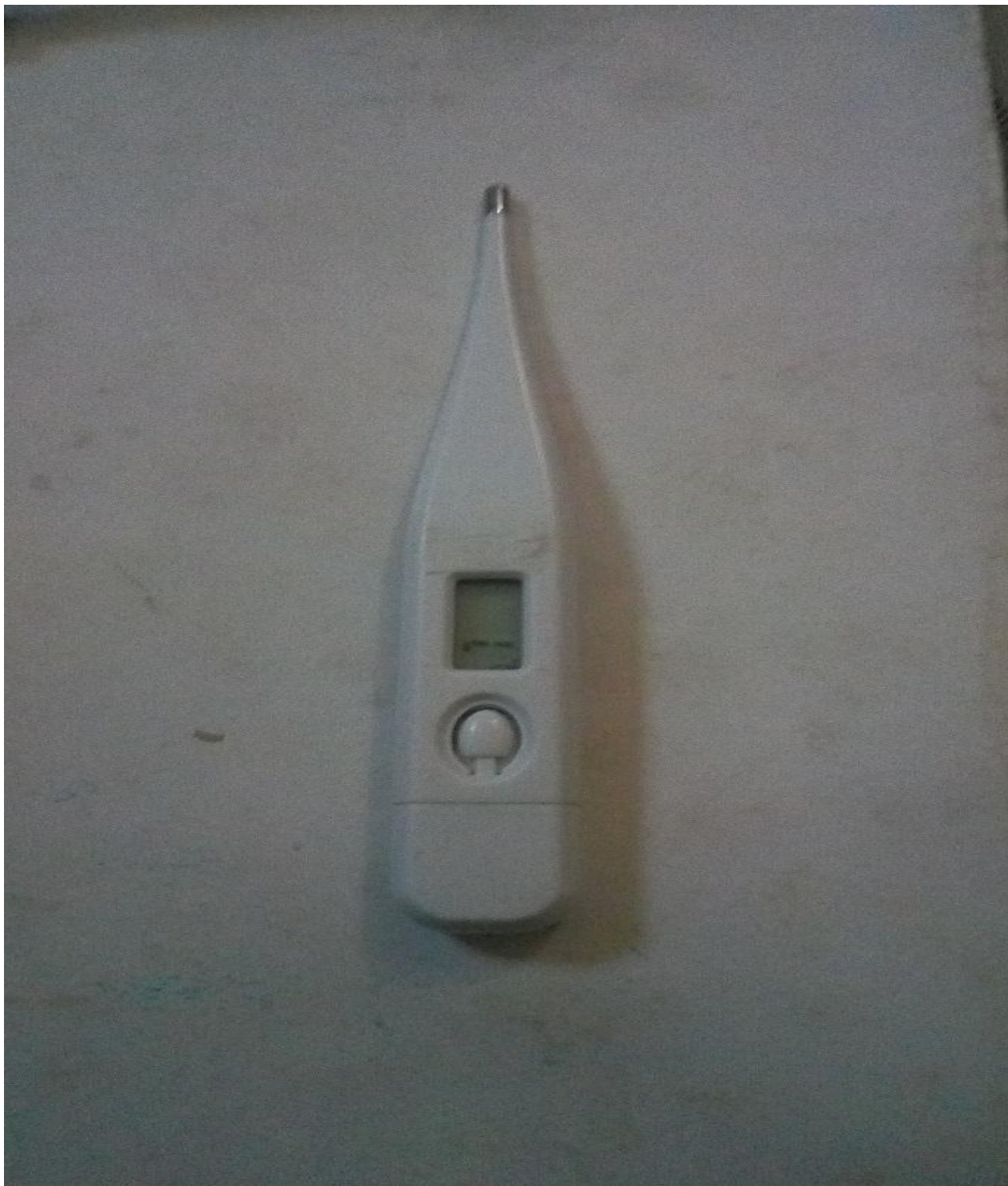


Plate ii: Digital Thermometer

Appendix iii



Plate iii: Blood samples for Haematology

Appendix iv



Plate iv: Ice Packed Box

Appendix v



Plate v: Taking Rectal Temperature of Young Donkeys

Appendix vi



Plate vi: Counting nostril movement to take respiratory rate of Donkey.

Appendix vii



Plate vii: Counting Pulse Rate of Donkey using Stethoscope and stop watch.

Appendix viii



Plate viii: Taking blood samples of Donkey from jugular vein.

Appendix ix



Plate ix: Haematology auto analyzer.

Appendix x



Plate x: Blood Samples for Haematology.

Appendix xi



Plate xi: Katsina state Map

Appendix xii



Plate xii: Zamfara state Map



Plate xiii: Jigawa state Map

Appendix ivx: Some Interaction Tables

Table 1: Effect of age on sex related physiological parameters

	Young			Adult			Old		
	Male	Female	SEM	Male	Female	SEM	Male	Female	SEM
Parameters									
Rec. temp. (°C)	37.85±0.05	37.86±0.04	0.02	37.63±0.06	37.59±0.08	0.07	37.47±0.13	37.55±0.07	0.07
Resp. R. (Beath/min)	27.00±0.50	27.83±0.76	0.61	25.19±0.40 ^b	26.61±0.35 ^a	0.21	25.23±0.39	25.74±0.42	0.40
P.R (Beat/min)	58.05±0.69 ^a	55.72±1.48 ^b	0.51	47.74±0.80 ^b	49.09±0.61 ^a	0.39	49.29±1.58	48.47±0.93	0.84

Rec. temp: Rectal temperature. Resp. R.: Respiratory rate. PR: Pulse rate.

Table 2: Effect of age on sex related hematological parameters of donkey

Parameters	Young		Adult		Old		SEM
	Male	Female	Male	Female	Male	Female	
PCV	32.68	31.08	33.42	34.83	36.42	33.31	3.96
HGB	10.40	10.33	10.77	11.73	11.48	10.92	1.83
WBC	5.18 ^b	9.28 ^a	5.46 ^b	6.72 ^a	9.15 ^a	8.29 ^a	1.46
RBC	5.28	5.73	5.86	5.89	5.92	5.97	4.31
MCV	56.03	59.67	57.41	58.14	61.38	56.05	2.84
MCH	19.56	18.93	18.59	20.22	19.63	18.29	1.24
MCHC	33.25	31.86	32.37	33.74	31.91	32.89	2.43
T.P	6.31	6.66	6.85	7.06	6.91	6.32	3.32
NEUT	43.64	39.27	41.75	36.17	47.25	44.00	3.19
LYMP	53.06 ^b	58.32 ^a	56.50 ^b	63.33 ^a	51.33 ^b	50.62 ^c	3.22
MONO	1.52	1.08	0.33	0.33	0.58	0.85	0.80
EISINO	0.78	0.58	1.17	0.17	0.75	0.31	1.02
BASO	0.42	0.25	0.08	0.01	0.00	0.00	0.25
B.C	0.58	0.50	0.01	0.17	0.00	0.00	0.55

Table 3: Effect of location on sex related traits hematological parameters of donkey

Parameters	Jigawa		Katsina		Zamfara		SEM
	Male	Female	Male	Female	Male	Female	
PCV	31.89 ^b	30.80 ^b	35.39 ^a	36.55 ^a	31.24 ^b	29.78 ^b	1.21
HGB	10.23	10.24	11.51	11.93	10.58	9.76	1.39
WBC	6.81 ^b	5.42 ^b	7.12 ^a	9.27 ^a	5.87 ^b	5.60 ^b	1.20
RBC	5.43	5.93	5.93	5.85	5.00	5.44	0.88
MCV	59.05	52.93	59.70	62.26	57.06	59.65	1.27
MCH	19.02	17.65	19.53	19.59	19.37	19.53	0.44
MCHC	32.21	33.28	32.86	32.66	34.06	32.86	0.63
T_P	5.88	6.67	7.61	6.71	6.53	6.40	1.96
NEUT	47.26 ^a	41.80 ^b	40.26 ^b	37.60 ^c	48.03 ^a	42.00 ^b	1.34
LYMP	50.79 ^c	54.40 ^b	57.48 ^a	60.95 ^a	51.12 ^c	55.22 ^b	2.00
MONO	0.95	0.40	0.62	1.00	0.78	0.52	0.50
EISINO	0.63	0.35	1.13	0.32	1.09	0.33	1.00
BASO	0.05	0.05	0.28	0.09	0.00	0.06	0.25
B_C	0.32	0.20	0.22	0.09	0.09	0.44	0.29

Table 4: Effect of location on age related hematological parameters of donkey

Parameters	Jigawa			Katsina			Zamfara			SEM
	Young	Adult	Old	Young	Adult	Old	Young	Adult	Old	
PVC	29.27 ^b	30.93 ^b	33.54 ^a	34.51 ^a	37.06 ^a	36.17 ^a	26.20 ^b	32.00 ^a	33.18 ^a	3.12
HGB	9.32 ^a	10.19 ^a	11.04 ^a	11.38 ^a	12.31 ^a	11.35 ^a	9.24 ^b	10.58 ^a	11.12 ^a	1.50
WBC	5.22 ^b	6.12 ^b	6.81 ^b	9.00 ^a	5.94 ^b	10.76 ^a	5.96 ^b	5.29 ^b	6.69 ^b	2.02
RBC	5.33	5.59	6.10	5.73	6.09	5.78	4.81	5.28	5.96	1.84
MCV	56.61 ^b	55.99 ^b	55.23 ^b	61.78 ^a	59.75 ^a	62.27 ^a	54.52 ^b	59.91 ^a	56.05 ^b	2.61
MCH	18.18	18.54	18.18	20.15	20.56	19.76	19.26	19.79	18.79	3.07
MCHC	31.89	33.15	33.03	33.11	33.23	31.76	35.81	32.92	33.62	1.93
T.P	5.89	6.63	6.22	7.07	7.24	7.02	6.20	6.60	6.60	1.80
NEUT	41.82 ^a	43.87 ^a	47.39 ^a	40.83 ^a	33.69 ^b	43.58 ^a	45.20 ^a	47.19 ^a	47.27 ^a	3.17
LYMP	55.18 ^b	55.80 ^b	46.85 ^c	56.21 ^b	64.75 ^a	55.42 ^b	51.70 ^b	53.48 ^b	49.46 ^b	2.98
MONO	1.46	0.20	0.54	1.27	0.44	0.92	1.10	0.00	1.18	1.72
EISINO	0.55	0.13	0.85	0.87	0.93	0.17	0.50	0.76	1.64	1.01
BASO	0.18	0.00	0.00	0.50	0.00	0.06	0.00	0.00	0.18	0.34
B.C	0.82	0.00	0.08	0.33	0.13	0.00	0.40	0.00	0.27	0.29

Table 5: Effect of age on sex related biochemical parameters of donkey

	Young		Adult		Old		
Parameters	Male	Female	Male	Female	Male	Female	SEM
Glucose	3.07±0.08	3.49±0.11	2.74±0.10	3.41±0.16	2.84±0.16	2.88±0.09	1.15
AST	22.53±2.13	19.43±2.31	19.41±1.57	19.36±2.26	19.09±2.48	18.23±0.80	3.74
ALT	17.84±0.54 ^a	13.00±0.91 ^b	14.48±1.49 ^b	18.71±1.77 ^a	20.09±3.75 ^a	15.69±1.54 ^a	2.56
ALP	116.68±4.59 ^b	126.43±5.10 ^a	115.10±4.95 ^b	111.64±5.72 ^b	103.18±7.75 ^c	114.61±7.33 ^b	2.56
T.P	72.16±1.99	75.79±2.76	72.93±1.49 ^b	76.00±2.31 ^a	67.36±2.16	72.46±1.74	4.93
Albumin	36.79±1.28	37.79±2.18	36.97±1.49	38.00±1.96	35.18±1.87	3+5.77±1.76	2.91
Globulin	35.37±1.43	38.00±1.93	35.97±1.46	38.00±1.65	32.18±2.71	36.97±1.46	3.50
Na	132.76±2.76	130.50±0.99	127.45±1.26	131.99±1.96	134.73±2.59	133.31±3.01	5.29
K	4.96±0.11 ^b	5.79±0.48 ^a	5.15±0.16 ^a	5.59±0.33 ^a	4.82±0.18 ^b	5.00±0.09 ^a	1.30
Cl	100.92±0.50	99.22±1.01	101.63±0.94	102.13±0.59	102.72±1.24	101.85±0.96	1.52
HCO ₃	22.88±2.29 ^b	21.14±1.99 ^b	29.49±2.31 ^a	29.89±3.08 ^a	30.00±4.01 ^a	30.08±3.97 ^a	2.54
Urea	6.67±0.51 ^b	6.53±0.69 ^b	9.81±0.63 ^a	9.54±0.70 ^a	6.27±0.95 ^b	6.27±0.72 ^b	0.68
Cr	112.27±9.59 ^c	136.43±3.99 ^a	133.69±3.72 ^a	133.69.3.72 ^a	119.00±6.83 ^b	125.82±7.79 ^b	3.25
Ca	3.03±0.21	2.89±0.13	3.01±0.17	2.94±0.17	2.93±0.25	3.41±0.25	1.13
pH	7.76±0.09	7.89±0.13	7.75±0.09	7.94±0.17	7.85±0.06	7.41±0.17	1.22
U.A	120.53±5.64 ^b	152.86±5.39 ^a	129.66±6.56 ^b	151.86±8.28 ^a	127.27±9.83 ^b	126.92±5.93 ^b	7.56

AST: Aspartate transaminase. ALT: Alanine transaminase. ALP: Alkaline phosphatase. Na: Sodium.

K: Potassium. Cl: Chlorine. HCO₃: Hydrocarbonate. Cr: Creatinine. Ca: Calcium. U.A: Uric acid.

Table 6: Effect of location on age related biochemical parameters of donkey

Parameters	Young			Adult			Old			SEM
	Jigawa	Katsina	Zamfara	Jigawa	Katsina	Zamfara	Jigawa	Katsina	Zamfara	
GLU	3.25	3.16	3.35	2.99	3.28	2.83	3.02	2.94	2.66	1.77
AST	18.00 ^b	20.75 ^b	25.30 ^a	19.31 ^b	21.00 ^b	19.00 ^b	17.54 ^b	19.85 ^b	19.91 ^b	2.52
ALT	16.55 ^a	13.75 ^b	17.40 ^a	15.94 ^a	11.83 ^b	16.95 ^a	16.39 ^a	12.86 ^b	19.27 ^a	2.11
ALP	108.36 ^d	130.58 ^a	122.80 ^b	105.43 ^d	124.33 ^b	117.52 ^c	104.77 ^d	108.29 ^d	114.82 ^c	2.85
TP	72.73	75.75	72.30	71.13	81.17	74.00	70.46	67.00	69.73	3.89
ALBU	37.36 ^b	39.83 ^b	33.90 ^b	36.00 ^b	49.83 ^a	34.71 ^b	36.92 ^b	37.71 ^b	33.82 ^c	3.56
GLOB	35.36	35.92	38.40	35.13	31.33	39.29	33.54	33.86	35.91	1.64
NA	139.73 ^a	129.67 ^b	125.65 ^c	132.48 ^b	126.33 ^b	126.99 ^b	138.62 ^a	126.09 ^b	128.46 ^b	3.40
K	5.73	5.23	4.96	5.85	5.00	4.94	4.97	4.43	4.86	1.55
CL	100.98	98.58	101.28	102.38	96.50	102.87	100.85	99.10	103.91	2.28
HCO	18.72 ^c	17.00 ^c	32.07 ^b	22.31 ^c	12.17 ^d	40.19 ^a	18.62 ^c	14.79 ^d	43.55 ^a	3.00
UREA	6.16	5.00	9.05	9.88	5.00	10.95	4.39	4.70	8.49	3.47
CR	91.00 ^d	152.92 ^a	120.72 ^b	131.44 ^b	159.00 ^a	128.09 ^b	134.00 ^b	156.43 ^a	108.09 ^c	5.01
CA	3.69	2.93	2.22	3.66	3.39	2.35	3.89	3.23	2.36	1.12
PH	8.01	7.99	7.38	7.57	8.33	7.61	8.08	8.01	7.44	2.85
U_A	125.46 ^b	150.83 ^a	124.00 ^b	155.38 ^a	126.67 ^b	125.71 ^b	125.39 ^b	124.28 ^b	124.00 ^b	6.26

Table 7: Effect of location on sex related traits biochemical parameters of donkey

	Jigawa		Katsina		Zamfara		
Parameters	Male	Female	Male	Female	Male	Female	SEM
GLU	2.91	3.24	3.18	3.23	3.33	2.70	1.05
AST	19.1	17.7	19.7	21.5	18.6	21.8	3.81
ALT	15.5	17.1	11.4	14.2	18.4	16.2	2.90
ALP	108.2 ^d	103.9 ^d	133.7 ^a	125.2 ^b	115.5 ^c	123.1 ^b	4.05
TP	68.0 ^c	74.7 ^b	72.3 ^b	80.9 ^a	76.2 ^b	70.6 ^c	2.21
ALBU	34.2 ^b	39.2 ^b	37.7 ^b	46.6 ^a	34.2 ^b	34.3 ^b	2.50
GLOB	35.6 ^b	33.8 ^b	34.6 ^b	34.3 ^b	36.3 ^b	42.0 ^a	2.11
NA	135.8 ^a	137.2 ^a	132.4 ^a	126.1 ^b	126.1 ^b	127.5 ^b	3.64
K	5.98	5.08	5.23	5.11	4.86	4.96	2.11
CL	102.0	101.0	96.3	99.0	102.1	103.1	2.65
HCO	20.7 ^b	19.5 ^b	15.3 ^b	15.5 ^b	41.7 ^a	37.8 ^a	3.26
UREA	7.09	7.01	4.17	5.53	9.67	9.94	2.04
CR	132.3 ^c	110.0 ^e	149.3 ^b	158.5 ^a	116.9 ^d	123.2 ^d	3.22
CA	3.66	3.83	2.79	3.26	2.37	2.30	1.49
PH	7.84	7.88	8.06	8.14	7.55	7.49	0.90
U_A	143.8 ^b	131.0 ^c	160.0 ^a	131.8 ^c	137.1 ^b	120.7 ^d	8.30