Introduction

Donkeys play a vital role in rural economies through the provision of draught power and transport. Compared to other equidae species, donkeys contribute the major proportion of readily available transport needs of poor women and men living in hostile environments, enabling them to integrate into social and economic processes (Swai and Bwanga, 2008). Often, donkeys are not conventional sources of meat and their uses for packing and traction do not fit within the stereotyped perspective of livestock agencies; donkeys are considered as animals of the poor men and women and therefore, highly stigmatized, marginalized and were not a focus of research (Kefena *et al.*, 2011).

An estimated 39 million donkeys live in the developing world and 36% of this population is found in Africa (Swai and Bwanga, 2008). The domestic donkey in the tropics is a small hardy animal, which rarely exceeds and usually considerably less than 110cm at the withers and its weight is usually well less than 150 kg. The dominant colour is the mousy grey, although the whole ranges from black to white are generally rare (Aganga *et al.*, 2003).

In Sudan the most common role of donkeys is transport whether riding, pack, or pulling carts. They may also be used for farm tillage, threshing, raising water and milling (Khattab *et al.*, 2008; Angara *et al.*, 2013). In Sudan, donkeys are divided into two breeds, *Makadi* which are draught donkeys and *Reefawi* which are riding donkeys (Hamid, 2004).

Donkeys are often inexpensive and have little, or no, disposal value. Although they have sometimes been considered as animals of ridicule or low status, they have excellent reputations as easily trainable and very dependable work animals as children can easily manage donkeys (Oudman, 2004).

Conformation refers to the physical appearance and outline of a horse as dictated primarily by bone and muscle structures. It is impractical to set a single standard of perfection or to specifically define *ideal* or *normal* conformation because the guidelines depend on the classification, type, breed, and intended use of the horse (Baxter, 2011).

Therefore, evaluation of conformation should relate to function, but objective studies relating conformational traits to performance or lameness problems can be difficult to perform. When conformational discrepancies are identified, it is important to differentiate between "blemishes" and "un-soundnesses." Blemishes are scars and irregularities that do not affect the serviceability of the horse. Un-soundnesses cause a horse to be lame, limit performance, or be otherwise unserviceable (Baxter, 2011).

Lameness is an indication of a structural or functional disorder in one or more limbs or the back that is evident while the horse is standing or at movement (Baxter, 2011).

Due to the scarcity of information pertaining to normal and/or abnormal body conformation of the draught donkeys in Sudan this study is designed to:

1. Determine the morphological characteristics and body measurements of draught donkeys in Tamboul area.
2. Determine abnormalities of conformation in the fore and/or hind limbs including the feet.
3. Examine problems of the back including misalignment and application of ventro-flextion test.

CHAPTER ONE

Literature Review

1. The donkey

Equidae are classified in four groups. These are: true horses (*Equus caballus*); pseudo – asses of the *E. hemionus* group; true asses (*E. asinus*); and quaggas (*E. quagga, E. greyvi,* etc...) (Scherf, 1995).The original geographical distribution was: Europe and northern Asia for horses, central and southern Asia for pseudo-asses, north and northeast Africa for donkeys and Africa south of the Sahara for zebras and quaggas (Wilson, 1990).

A close look at a group of donkeys' one notices how they differ in size, shape, colour, markings, and even in the texture of their coats (Camac, 1997). Grey in various shades is the predominant colour. Brown donkeys are fairly plentiful. Other colours are black, roan (which is a mixture of white hair and another colour, usually brown) or broken coloured, that is a combination of brown- and- white or black – and - white markings. Finally there are the rarer colours of pure white and chestnut (Camac, 1997).

Because size is important, it will be useful to have some idea of the height of the donkey. This is measured in 'hands', which is the average breadth of a person's hand, (four inches). The measurement is taken at the withers (the highest point of the donkey's shoulder), where the neck joins the back, and most of the donkeys will be between 9½ and 11 hands (38 and 44 inches or to be right up – to – date 96.5 and 111.8 centimetres) (Wilson, 1990).

The ancestors of the donkey were wild asses from Africa and Asia. In Africa there were two separate species: the Nubian, standing 12 hands, found in the north between the Mediterranean coast and the Sahara Desert; and the Somali; standing 14 hands, found from further east to the south of the Red Sea. The Nubian wild ass

had a shoulder cross which was not very marked, being either rather short or very thin, but it had no stripes on its legs; in contrast Somali wild ass had no shoulder cross, but very prominent leg stripes, reminiscent of the zebra (Wilson, 1990).

The present world donkey population is about 40 million (Wilson, 1990). It is now found in every continent of the world except the Polar Regions, following its introduction by Europeans into the Americas and Australia. Although widely distributed in terms of countries it is most commonly found in the drier areas and in mountainous regions. In Africa it is restricted in its distribution mainly by the presence of the tsetse fly, such that its numbers are very small or it is totally absent from the forested areas of west and central Africa (Wilson, 1990).

There are 18 million donkeys in Asia (about 45% of these being in China), 12 million in Africa, just over 1 million in Europe, 400 000 in the USSR and, by official figures at least, 5000 in Oceania. Almost 10% of the world's donkeys are found in Ethiopia (Wilson, 1990).

In Sudan, donkeys are becoming increasingly important animals with the increased use of donkeys instead of horses in labour as drought animal and in carrying water in addition to horses, and in transportation. This new situation can be noticed in many urban and suburban areas (Hamid *et al.*, 2001).

1.1 The donkey classification

The following classification was recorded according to Davies (2009)

Kingdom : Animalia
Phylum : Chordata
Class : Mammalia
Order : Perissoductyla
Family : Equide
Genus : *Equus*

Species : *Equus asinus*

A male donkey is called a jack and the female is a jenny (Burnham, 2002).

1.2 Donkey Breeds in Sudan

Few breeds of the donkey are available in the Sudan. The following breeds are included in the list of donkeys that are to be found in the Sudan. Pack donkeys are found in Northern Sudan. It has grey skin and is similar to Abyssinian ass. The latter is slate-grey in colour and occasionally chestnut brown colour is found (Bennett, 1948).

Pack donkey in Sudan is represented by *Makadi* (or *Derawi*). This is the widely spread donkey and represent the majority of donkeys in Sudan. They are strong donkeys 90-100cm high, have short legs and ears with long back. The neck is short and thick. They have slow movement and are often crossed with the riding donkey in known as *Al-Reefawi* to produce strong and fast cross bred donkeys (Bennett, 1948).

Riding donkey is mainly found in Northern Sudan. The individual is dark-brown to reddish-grey sometimes pale grey or white and is larger than the pack donkey. This is similar to the riding donkey in Kassala (North West Eritrea) and a variant of it is the Etbai. Riding donkey breeds in Sudan are represented by *Al-Reefawi* donkey. It is 100-120cm, high with better conformation and faster movement than pack donkey. The predominant coat colours are white and black. This type of donkeys probably originated from Egypt and is found along the banks of the Nile in Northern Sudan (Bennett, 1948).

1.3. Body measurements

1.3.1 Donkeys

Nengomasha *et al.*, (1997) estimated live weight, age and body dimensions of 302 working donkeys in the Matobo and Nkayi districts of south-western

Zimbabwe. The average age of the animals was eight to nine years (range: <1to>14years) and average weight was 144 kg (range: 78–222 kg) with a height at the withers of 105 cm. There were no significant differences between body dimensions in male and female donkeys. Heart girth was the best single predictor of live weight: Live weight (kg) = 239.16 ± 2.29 heart girth (cm).

The Bulgarian local donkeys are of the Mediterranean type. They could reach up to 100-120 cm in height (Barzev, 2004). Cyprus donkey breeds could reach up to 140 cm in height and the Martina Franca donkeys could reach up to 150 cm in height (Yılmaz and Ertuğrul, 2012c).

Average (Mean±SD) body measures and morphologic indexes of the adult Romagnolo donkeys (age ≥ 3 years; 47 donkeys, 11 males and 36 females) were reported by (Beretti *et al.*, 2005). The Height at withers, cannon circumference and dactylo-thoracic index were significantly different ($P<0.05$) between males and females. Compared to Amiata donkey (Orlandi *et al.*, 1997a,b). Romagnolo donkey is slightly higher, both in males (cm 137 vs 135.5), and in females (cm 131.6 vs 130); dactylo-thoracic index is lower, both in males (11.9 vs 12) and in females (11 vs 11.6), so denoting, beside a higher size, a lighter skeletal structure in Romagnolo than in Amiata donkey (Orlandi *et al.*, 1997a,b). There is an agreement in the literature about the origin of the two breeds. In fact, according to some Authors (A.A.V.V., 1952; Arzilli, 2002), Amiata donkey derives from Romagnolo donkey after crosses with local donkeys, characterized by a smaller size, due to environmental conditions.

Sargentini *et al.*, (2009), evaluated the morphological characteristics and biometric parameters of the Amiata donkey. The Amiata donkey is a local endangered breed and derives from the homonym mountain in Tuscany. The averages and the standard deviations of the biometric parameters and the frequency

of the morphological characters of foals, adult females and stallions were calculated. The average sizes were: height at withers 129.8±4.7 and 125.8±5.6cm, thorax circumference of 145.6±7.8 and 145.0±7.8cm, front shank circumference of 18.3±0.8 and16.9±1.5cm, for stallions and adult females respectively.

The zoometric indices of the adult females did not differ between the classes and showed that the somatic adult proportions were reached in 3-4 years old donkeys. This breed showed the features of the ancestors: the shoulder stripe of the *Equus asinus africanus* and the legs stripes of the *Equus asinus somaliensis* (Sargentini *et al.,* 2009).

Kefena, *et al.*, (2011) carried out a nationwide survey to morphologically characterize and identify the geographic distribution of Ethiopian donkeys. They re-evaluated some of the donkey populations previously identified and explored new ones from which they confirmed the existence of six distinct donkey populations and rejected one donkey population that was misidentified previously. They used twelve selected morphometric variables recorded from total of 569 adult donkeys (289 jacks and 280 jennets) spanning over wide arrays of ecologies in Ethiopia. Mean pairwise multiple comparisons (MPMC) between traits and multivariate analysis were carried out separately for jacks, jennets and aggregated gender. The MPMC showed significant differences between donkey populations for most of the traits studied.

Principal component analysis showed that three body heights (height at wither, back and rump) and body length alone account for about 87.5% of the total variations (eigen value=10.49) of the 12 measured morphometric variables. Mahalanobis as well as Euclidean distances were also found to be highly significant (Pb0.01) for pairwise comparisons of all populations (Kefena, *et al.,* 2011).

Yilmaz and Ertugrul (2011) conducted research to document the morphology of the donkeys raised in the Province of Iğdır, Turkey. They examined a total of 94donkeys (56 male and 38 female) donkeys. Results obtained yielded the following means: withers height 99.1 cm, height at rump 101.0 cm, body length 103.0 cm, heart girth circumference 111.5 cm, chest depth 45.4 cm, chest width 29.1 cm, haunch width 34.8 cm, tail length 48.3 cm, limb length 53.7 cm, cannon circumference 13.4 cm, head length 48.4 cm and ear length 21.8 cm. Yilmaz and Ertugrul, (2011) finalized their observations stating that, donkeys reached their mature body size at two years of age. Age affected morphologic traits and there were significant at ($p<0.05$)for heart girth circumference, head length and withers height, height at rump, body length, cannon circumference, ear length. All parameters examined were higher in male donkeys compared to females except for tail length (TL) which was higher in females (49.4±1.19) than male animals (47.6±1.00) (Yilmaz and Ertugrul, 2011).

Yılmaz and Ertuğrul (2012c), conducted a study to determine the morphological traits, distribution of body coat colour and body measurements of donkeys raised in the East and Southeast Turkey. They examined a total of 124 male and 70 female donkeys. Results yielded the following data: withers height 102.3 cm, height at rump 104.3 cm, body length 105.2 cm, heart girth circumference 113.5 cm, chest depth 45.7 cm, chest width 29.5 cm, cannon circumference 13.6 cm, head length 48.7 cm and ear length 21.9 cm respectively. All the measurements were higher in male animals compared to females.

1.3.2 Horses

Yilmaz and Ertugrul, (2011a), conducted a study, by analyzing sex, coat colour, and morphological dimensions and comparing coloured horses with other horse breeds in Turkey, to determine whether this group of coloured horses is a

crossbreed or a separate breed. In their study, 42 male and 35 female horses were separated into four age groups (1-3, 4-5, 6-8 and 9-18years).They obtained the following data for morphological characteristic: withers height 134.5 cm, height at rump 135.3 cm, body length 138.2 cm, heart girth circumference 153.2 cm, chest depth 61.0 cm, chest width 39.4 cm, cannon circumference 17.6 cm, head length 54.6 cm and ear length 13.4 cm

Yilmaz *et al.*, (2012a) conducted a study to define the morphological traits Malakan horses raised in Turkey. In their study a total of 106 horses, 57 male and 49 female, were examined. Descriptive statistics showed the following means: withers height 142.9±0.48 cm, height at rump 142.0±0.46 cm, body length 146.1±0.79 cm, heart girth circumference 163.2±1.09 cm, chest depth 56.4±0.38 cm, chest width 43.9±0.41 cm, cannon circumference 19.1±0.16 cm, head length 56.4±0.38 cm and ear length 12.8±0.16 cm. They reported that in Turkey the only native draught horse breed is the Malakan horse that can be crossed to other heavy horse breeds to create a new type or breed.

1.3.3 Mules

Yilmaz *et al.*, (2012b) examined mules raised in the province of Sirnak morphologically to define body dimensions by analyzing sex and age and comparing them with mules in the province of Ordu, region of East Anatolian, as well as data of Turkish, and UK mules. In their study a total of 38 mules, 18 males and 20 females, were separated into three age groups (3-5, 6-8 and 9-18 years). Descriptive statistics of morphologic traits were as follows: withers height 132.7±0.67, height at rump 133.7±0.73, body length 135.1±0.84, heart girth circumference 147.7±0.76, chest depth 60.6±0.34, cannon circumference 16.9±0.16, and head length 56.8±0.26 cm. They reported that growth of mules in

the province of Sirnak is nearly complete at 3 years of age there after their was a small difference in body size.

Yilmaz *et al.,* (2013) defined some morphological characteristics of mules raised in Van province. A total of 62 mules, 35 males and 27 females, were examined. Descriptive statistics of morphologic traits were as follow: Withers height 129.9±0.87 cm; height at rump 128.3±1.64 cm; body length 134.2±0.83 cm; heart girth circumference 148.5±0.84 cm; chest depth 59.8±0.54 cm; cannon circumference 16.2±0.16 cm; and head length 54.9±0.53 cm. They concluded that mules body development continues until 3 years of age and thereafter only slight increases can be seen in this trait. _____ _ __ _ ___ □ _ _____

1.4 Coat colour

1.4.1 Donkeys

In Italy, Beretti *et al.,* (2005) described that coat colour of the adult Romagnolo donkeys. They reported that about 75% of population showed the typical grey-dun colour, 4% was bay; but the colour of the remaining21%of the population was not reported. The entire population of Amiata donkey reared in Tuscany, Italy, presented dark grey coat with the shoulder stripe (Sargentini *et al.*, 2009).

Yılmaz and Ertuğrul, (2011) reported four different types of coat colour among donkeys in Turkey with the mouse grey was the most predominant colour among them. The detailed frequencies of body coat colour of the sampled donkeys were as follows: 54.3% mouse grey, 20.2% white, 7.4 black and 18.1% brown. In another study, the body coat colour frequencies among the donkeys in Turkey were as follows: mouse grey 31.4%, white 24.7%, black 23.7%, and brown 20.2% (Yılmaz and Ertuğrul, 2012c).

1.4.2 Horses

The frequencies of body coat colour of the sampled horses in Turkey were predominantly bay on white 55.2%, predominantly grey on white 17.2%, predominantly white on bay 8.6%, predominantly white on buckskin 8.6%, predominantly black on white 6.9%, and predominantly white on black 3.5% (Yilmaz and Ertugrul, 2011a). In another study, the frequencies of body coat colour of the sampled horses were bay 45.3%, gray 37.7%, chestnut 6.6%, black 4.7%, isabelline 2.8%, and buckskin 2.8% (Yilmaz *et al.*, 2012a).

1.4.3 Mules

Distribution of coat colour in mules raised in province of Sirnak, Turkey, were: bay 47.7%, black 7.9%, mouse gray 5.3%, white 31.6% and chestnut 10.5% (Yilmaz *et al.*, 2012b).

Yilmaz *et al.*, (2013) reported distribution of coat colour among mules was as follows: 54.8% bay colour, 24.3% white, 4.8% black, 4.8% brown, 8.1% mouse gray, and 3.2% chestnut.

1.5 The donkey conformation

Conformation is what an equid looks like, how it is "put together" and it consists of three aspect a skeleton, muscles and fat, ideally an equid should be skeletally correct with correctly developed muscles, adequate subcutaneous fat, covered by healthy skin and a glossy coat (Parker, 2012).

1.5.1 The head

The head should be in proportion to the rest of the body. The eyes should be kind, bold, large and set well apart, good eye placement means that the horse has wide vision and the ears should be level and equally mobile. The mouth should also be assessed for abnormality and also suitability to take the bit. There must be

ample room at the poll and jaw for the degree of flexion needed in dressage (Parker, 2012).

A pronounced convex profile (heavy Roman nose) is undesirable because of its plainness. Ears set too low make the donkey appear plain and unintelligent; ears set too far back make the donkey look sour and sulky, especially when accompanied by a pronounced roman nose, ears make a head look common. Eyes too small (pig eyes) bulging or prominent eyes (indicating short-sightedness) are faults. Mouth undershot (Monkey mouth) or overshot (Parrot mouth) are faults and obvious problems from a nutritional point of view. Lower lip which is longer than the upper one is a fault (Gross, 2011).

1.5.2 Neck Structure

The head should be well set on the neck that the animal looks elegant at poll. The neck should be long, elegant and well set onto a sloping shoulder. It should also flow smoothly into the chest with the muscle under the neck not over-developed. The seven cervical vertebrae of the neck should give two equal curves (Parker, 2012).

Ewe neck

The cervical vertebrae form a steep curve at the shoulder end giving an “ewe neck” conformation (Parker, 2012), where the upper part of the neck shows a distinct concavity. A heavy roll of fat along the upper surface is to be faulted. A pronounced dip in front of the withers is unsightly and is caused by lack of muscle development (Gross, 2011).

Figure 1.1: Ewe neck

Adopted from www.localriding.com (retrieved 28.4.2014)

Bull Neck

A short, thick, and beefy neck with short upper curve is called a bull neck. The attachment to its body is beneath the half-way point down the length of shoulder. Bull neck is fairly common, especially in draught breeds, Quarter Horses, and Morgans. Bull neck makes it more difficult to maintain balance if the rider is large and heavy or out of balance, which causes the horse to fall onto its forehead. Without a rider, the horse usually balances well. A bull neck is desirable for draught or carriage horses, so as to provide comfort for the neck collar. The muscles of the neck also generate pulling power. A horse with bull neck is best for non-speed sports. Bull neck is not considered a deformity (Hedge and Wagoner, 2004).

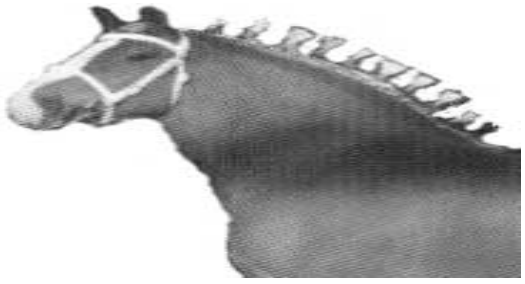


Figure 1.2: Bull neck

Adopted from www.localriding.com (retrieved 28.4.2014)

Swan neck

Swan neck is set at a high upward angle, with the upper curve arched, yet a dip remains in front of the withers and the muscles bulge on the underside. This is common, especially in saddle breeds, gaited horses, and thoroughbreds. Swan neck makes it easy for a horse to lean on the bit and curl behind without lifting its back; it is often caused by incorrect work or false collection (Hedge and Wagoner, 2004).

Figure 1.3: Swan neck

Adopted from www.localriding.com (retrieved 28.4.2014)

Knife neck

A knife neck is a long, skinny neck with poor muscular development on both the top and bottom. It has the appearance of a straight crest without much substance below. A knife neck is relatively common in older horses of any breed. It is sometimes seen in young horses. It is usually associated with poor development of back, neck, abdominal and haunch muscles, allowing a horse to go in a strung-out frame with no collection and on its forehead. It is often rider-induced, and usually indicates lack of athletic ability. Knife neck can be improved through skillful riding and the careful use of side reins to develop more muscle and stability. A knife-necked horse is best used for light pleasure riding until its strength is developed (Wikipedia, 2014).

Figure 1.4: Knife neck

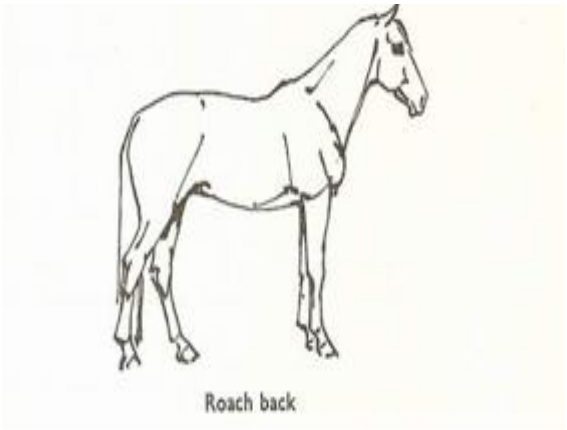
Adopted from www.localriding.com (Retrieved 28.4.2014).

1.5.3 Back structure

The back should be strong, of adequate length, and in proportion to the fore hand and hind quarters. There is considerable variation in the normal conformation of the horses back (Parker, 2012).

Roach back

This convex, raised between withers and croup and does not permit sufficient extension and flexion of legs in taking long and rapid strides (Gross, 2011).



A B

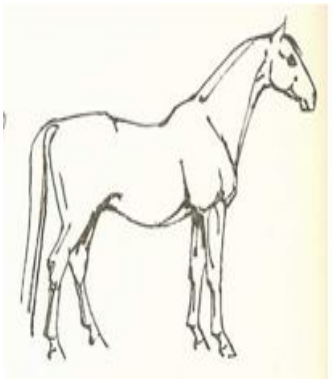
Figure 1.5: Roach back

A. Adopted from *serendipityrancher.com* (retrieved 15.3.214)

B. Adopted from *horsegroomingsupplies.com.*

Sway back

This is concave or hollow between withers and croup (Thomson, 2009). A sway back positions the rider behind the center of gravity, interfering with balance. The horse is unable to elevate for true collection, which can affect any sport but most notably dressage, jumping, and stock work. The back may get sore from lack of support and the rider's weight (Gross, 2011).



A

B

C

Figure 1.6: Sway back

A. Adopted from *serendipityrancher.com* (15.03.2014).

B. Adopted from *horsegroomingsupplies.com*

C. Adopted from allen@allenrussellphoto.com (15.03.214).

1.5.4 Pelvis structure

1.5.4.1 Pelvis normal structure

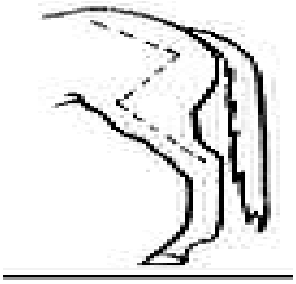
This includes the region between the hips and the buttocks. The upper surface of the croup to be gently sloping with the tail high and well attached the tail neat and straight. Buttocks should be well fleshed (Australian-Teamster donkeys tend to have a short croup, placed well back) (Thomson, 2009).

1.5.4.2 Pelvis abnormal Structure

Goose-rumped, tapering markedly from hips to head of tail, tail set too low. This lends to give a pointed appearance to rear end, rather than the correct gently rounded buttocks. It is usually accompanied by weak hind quarters .The tail should be straight without kinks, as this can be in a hereditary fault or caused by injury (Thomson, 2009).

A

B



C

Figure 1.7: Goose-rump

A. Adopted from mytevisjourney.blogspot.com (15.3.214).

B. Adopted from *horsegroomingsupplies.com*

C. Adopted from *horseinfo.com.*

1.5.5 Forelimbs

Length of stride, smoothness of gait, soundness of legs and power of propulsion depend on the structure of the forequarters. The front legs carry most of the horse weight (60-65%). As a result, most unsoundness form concussion and trauma occur in the front legs. The two most critical aspects of fore limbs conformation are the slopes and angles of the bones which absorb concussion and

the straightness and trueness of limbs, so that no one segment receives unusual wears (Lawrence, 1991).

Forequarters concussion is absorbed by the unique muscular attachment of the forelimbs to the body, the sloping shoulder blade (scapula) and, consequently, the angles formed between the shoulder blade and humerus (arm), the angles between the humerus and forearm, the small bones and tendons surrounding the carpus, the sloping springy pastern, the expansion and absorption mechanism of the hoof (Lawrence, 1991).

1.5.5.1 The Shoulder

Traditionally the ideal shoulder should have a 45º slope to the horizontal. The hoof pastern angle should be the same as the shoulder angle so that the concussive forces are absorbed equally by all the components of the limb (Pilliner *et al.*, 2009).

1.5.5.2 The Arm

The humerus or arm extends from point of shoulder to the elbow joint and should be moderately long. Humerus length is integral to the length of the stride. On the other hand, a long arm causes excessive wear of the shoulder muscles. The length of arm should be in proportion to the length of the shoulder and forearm. The length of the arm determines whether legs are set forward or back under the body. The legs should be set well forward. A long shoulder, short arm, plus long forearm and short cannon allow maximum stride extension (Lawrence, 1991).

1.5.5.3 The Forearm

Forelegs should be straight and perpendicular when viewed from all directions. The forearm is formed by the fusion of two bones the radius and the

ulna, and extends from the elbow to the knee. It should be long and well muscled. Forearm length is important in determining stride length (Lawrence, 1991).

1.5.5.4 The Cannon

The cannon should be short and flat when viewed from the side. It should have light, well defined tendons set well back to give the appearance of abundant support below the knee .When viewed from the front, and the cannon should be centered in a straight wide, clean knee, round appearing cannons and tendons. Tied in behind the knee is undesirable because it indicates small tendons and lack of support (Lawrence, 1991).

Cannon abnormal structure

The cannon it is long between the knee and fetlock, making the knees appear high relative to the overall balance of the horse (Wikipedia, 2014).

1.5.5.5 The Knee or Carpus

There are eight carpal bones arranged in two rows. Their function is to bear weight and support the body (Lawrence, 1991). Knee should be straight from both front and side views, wide, deep, and squarely placed on the leg (Lawrence, 1991).

1.5.5.6 The Fetlock

The fetlock should be set well back on pasterns of medium length that are strong and sloping. Fetlock and pastern together provide springiness to the gait and also disperse concussion. Roughened hair nicks, and scars on fetlock are evidence that a horse hits itself when in motion. The joint should be strong, clean and free from stiffness (Lawrence, 1991).

1.5.5.7 The Pastern

Both slope and length of pastern help determine smoothness, spring and stride length. A pastern which is too long and sloping (cannon footed) causes weakness because it puts undue strain on the tendons, sesamoid bones and

suspensory ligament, on the other hand, a short upright pastern increases concussion and trauma to foot and fetlock (Lawrence, 1991).

The Short upright pastern

A short upright pastern is believed to increase concussion and injuries to the fetlock and phalangeal joints, the navicular bone region, and soft tissue structures within the metacarpus. If the angle of the hoof is more upright than that of the pastern, it is referred to as a broken forward hoof-pastern axis. This type of conformation is often associated with a base-narrow, toe-in conformation and is often seen in horses with short limbs and a powerful body and limb musculature. Additionally, a straight shoulder (more vertical) usually accompanies a short upright pastern (Myers, 2008).

Figure 1.8: Short upright pastern

Adopted from (Wikipedia, 2014)

The Long sloping pastern

A long sloping pastern is characterized by a normal or subnormal angulation of the forefoot (less than 50° to 54°) with a pastern that is too long for the length of the limb. If the angle of the hoof is more acute (lower) than that of the pastern, it is referred to as a broken backward hoof-pastern axis. It is often seen in horses with long toes and/or low heels and may predispose a horse to injury of the navicular

region, flexor tendons, sesamoid bones, and suspensory ligament; long pasterns were also found to increase the odds of Thoroughbred racehorses fracturing a front limb (Myers, 2008).

1.5.5.8 The Toe

The toes should point forward and the width of the feet on the ground should be the same as the width at the origin of the limbs in the chest (Lawrence, 1991).

Toe-in or pigeon-toed

Toe-in is the position of the feet in which the toes point toward one another when viewed from the front. It's point of origin can be as high as the chest or as low as the fetlock down. It is often accompanied by a base-narrow conformation but rarely is present when the horse is base-wide. In the young foal, the condition may be seen as the result of an angular limb deformity. Proper trimming and corrective shoeing of the feet may prevent worsening of the condition, especially in growing horses. Toed-in horses tend to paddle with their feet and have an outward deviation of the foot during flight. The foot breaks over the outside toe and lands on the outside wall. Base-narrow, toe-in conformation can cause interference, especially at the fetlock region (Anderson *et al.*, 2004).

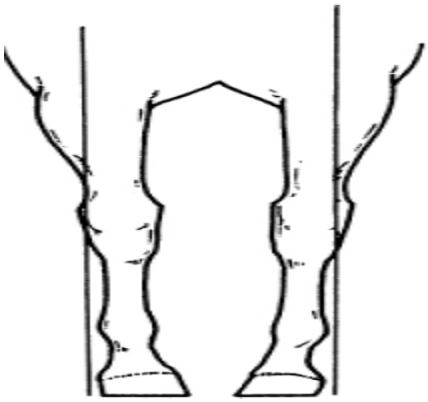


Figure 1.9: Toe-in or pigeon-toed

Adopted from Baxter, (2011).

Toe-out or splay-footed

In a toe-out or splay-footed conformation, the toes point away from one another when viewed from the front. The point of origin is usually at the chest but the condition can be associated with outward rotation of the fetlock. It may be accompanied by either base-wide or base-narrow conformation. As with a toe-in conformation, it may be controlled or partially corrected by corrective trimming or shoeing. The flight of the foot goes through an inner arc when advancing, contributing to interference with the opposite forelimb. A toe-out, base-narrow conformation is thought to increase the likelihood of limb interference and plaiting (Anderson *et al.*, 2004).

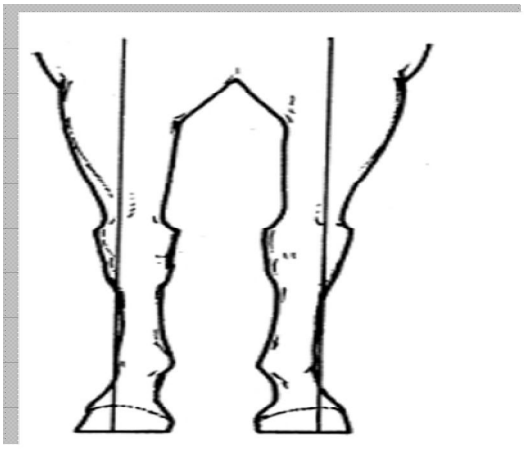


Figure 1.10: Toe-out or splay-footed

Adopted from Baxter, (2011)

1.5.5.9 The Hoof

The hoof should be in proportion to size of the horse deep, wide and open at the heel and free from cracks and rings. The hoof angle should be the same as for the pastern. The hoof and pastern angle should not be broken (Lawrence, 1991). The hoof length was 12.01±0.7 cm and the hoof width was 8.78±0.5 cm (Sargentini *et al.*, (2012).

1.5.5.10 Review of the forelimb

The forearm ties right in to centre of knee. The knee should be flat and facing straight ahead. The short cannon bone comes from centre of knee and extends to centre of fetlock. The pastern should come from centre of fetlock and drive into centre of hoof. Any deviation may lead to lameness problems. A line dropped from shoulder should bisect foreleg (forearm), knee, cannon bone, fetlock, and drop 2 inches behind heel (Lawrence, 1991).

Cranial view forelimbs

Both forelimbs should be of equal length and size and should appear to bear equal weight when the horse is standing squarely. A line dropped from the point of the shoulder (middle of the scapula-humeral joint) to the ground should bisect the limb (Anderson *et al.*, 2004).

Lateral view forelimbs

When viewed from the side, limbs should exhibit a composite of moderate angles so that shock absorption is efficient. The shoulder angle is measured along the spine of the scapula, from the point of the shoulder to the point of the withers. The angle of the scapula and shoulder tend to increase (become more upright) as horses mature from foals to adults, the shorter and straighter the shoulder, the shorter and quicker the stride, and the more stress and concussion that is transmitted to the limb. Studies in dressage horses and show jumpers have found that a more horizontal scapula was related to a higher level of performance (Anderson *et al*., 2004).

1.5.5.11 Faults in Conformation of the Forelimbs

Base-narrow

In base-narrow conformation, the distance between the centres of the feet on the ground is less than the distance between the centres of the limbs at their origin

in the chest when viewed from the front. This is often seen in horses with large chests and well-developed pectoral muscles, such as the Quarter horse. This conformation may be accompanied by a toe-in (pigeon-toed) or toe-out (splay-footed) conformation. Base-narrow conformation inherently causes the horse to bear more weight on the outside of the foot than on the inside (Baxter, 2011).

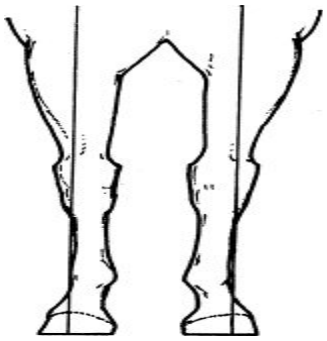


Figure 1.11: Faulty conformation of the forelimb Base-narrow

Adopted from (Baxter, 2011).

Base-wide

In base-wide conformation, the distance between the centres of the feet on the ground is greater than the distance between the centres of the limbs at their origin in the chest when viewed from the front. This condition is found most commonly in narrow-chested horses and may be accompanied by toe-out (splay-footed) position of the feet. Base-wide, toe-out conformation usually causes winging of the limb to the inside. Base-wide conformation forces the horse to land on the inside of the foot, increasing weight-bearing forces on the inside of the foot and entire limb (Baxter, 2011).

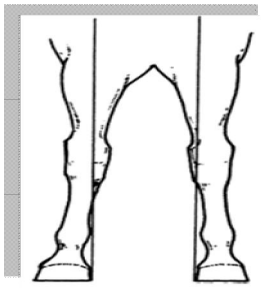


Figure 1.12: Faulty conformation of the forelimb Base-wide

Adopted from (Baxter, 2011).

Calf-Kneed/Back at the Knee

This is a bad fault; it causes excessive wear to the back tendons (Thomson, 2009).

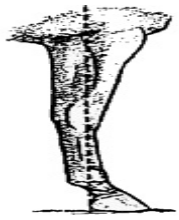


Figure 1.13: Faulty conformation of the forelimb Calf-Kneed/Back at the Knee

Adopted from *horsegroomingsupplies.com* (2011)

Lateral deviation of the carpus

Carpal varus is an outward deviation of the carpus (or inward deviation of the distal limb) when viewed from the front of the horse. It may be accompanied by a base-narrow, toe-in conformation. This condition increases tension on the lateral surface of the carpus and compression on the medial surface of the carpus and carpal bones. This deviation may be correctable in young horses but growth of the knee reached a plateau at approximately 140 days of age in Thoroughbreds, suggesting that carpal deviations (lateral or medial) should be corrected before this age (Baxter, 2011).

Bench knees (offset knees)

Bench knee is a conformation in which the cannon bone is offset to the lateral side and does not follow a straight line down from the radius when viewed from the front. Increased weight bearing on the medial splint bone is thought to occur in benched kneed horses. This is thought to contribute to increased stress on

the interosseous ligament predisposing to “splints”. This study was documented by study done on the conformational abnormalities in warm blood horses (Baxter, 2011).

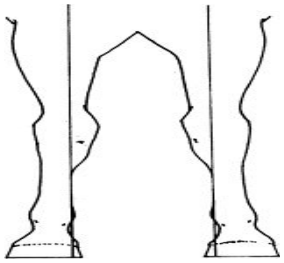


Figure 1.14: Faulty conformation of the forelimb Bench knees (offset knees)
Adopted from Baxter, (2011)

Standing under in front

With this deviation the entire forelimb from the elbow down is placed too far under the body when the horse is viewed from the side. This stance may occur in certain diseases and may not be a conformational fault. With this conformation, the base of support is shortened, the forelimbs become overloaded, the cranial phase of the stride is shortened, and the arc of foot flight may be low. This may predispose the horse to stumbling but is not problematic in many horses (Baxter, 2011).

Camped in front

This is a condition opposite to that described above (Standing under in front). The entire forelimb, from the body to the ground, is too far forward when viewed from the side. This limb position may be present with certain lameness conditions, such as bilateral navicular syndrome and laminitis (Baxter, 2011).

Figure 1.15: Faulty conformation of forelimb Camped in front

Adopted from *horsegroomingsupplies.com* (2011)

1.5.6 Hind limbs

The conformation of the hind limbs will have a dramatic effect on athletic ability because of their importance in propelling the horse forward. (Lawrence, 1991).The hind limbs constitute the "engine" of the horse regardless of its intended use. Endurance horses are characterized by longer, flatter muscles, stock horses are characterized by shorter, thicker muscles, and all-around horses have moderate muscling. Lack of hind limb musculature or a disparity between the amount of fore limb and hind limb muscle development may suggest chronic hind limb lameness problems (Baxter, 2011).

1.5.6.1 Femur

The femur should be short with the stifle pointed slightly outward so there will be a full range of movement for the hind legs (Lawrence, 1991).

1.5.6.2 Tibia

The ideal horse has along tibia (gaskin) and short cannon with low- set hocks. This allows the horse to work off of the hock and provides the maximum stride extension (Lawrence, 1991).

1.5.6.3 Hock normal structures

When viewed from the side, the hind limbs should exhibit a composite of moderate angles so that shock absorption will be efficient. A line from the point of buttock to the ground should touch the hock and end slightly behind the bulbs of the heels. If the hock is raised and the tibia shortened, cushion is reduced and performance can be limited. The hock should be clean, having no soft tissue swelling or bony projections .It should be well- defined and powerful. The angle of this joint should allow the hind leg to extend and flex during motion and offer the least amount of stress to this column of bones (Lawrence, 1991).

1.5.6.4 Deviations of hind leg conformation

Bandy –legged**:** This is wide at hock, Bowlegged and Rotates hocks in a grinding motion, Cow- hock: This is close at hocks, toes point out excessively and stress on outside of hocks, Sickle- hocked: This is wears joint out from fatigue, reduced stride and places stress on planter ligaments in rear of hock. Pastern, the pastern of the hind legs may be slightly longer than front pastern and will slope at a greater angle. Hoof, the hoof of the hind legs is sloped, slightly more than fore foot. The angle of the hoof and pastern should be equal (Lawrence, 1991).

1.5.6.5 Review of the Hind leg

A plum line dropped from point of buttocks should touch rear border of the hock, run parallel to cannon and strike the ground 3-4 inches behind the heel. From the rear, the line should bisect hock, cannon, pastern and heel (Lawrence, 1991).

Lateral view

When viewed from the side, the hind limbs should exhibit a composite of moderate angles so that shock absorption will be efficient. A line from the point of buttock to the ground should touch the hock and end slightly behind the bulbs of the heels. The hindquarter should be symmetric and well connected to the barrel

and the lower limb. The gluteal muscles should tie well forward into the back and the hamstrings should extend down low into the Achilles tendon of the hock. The relationship of the length of the bones, the angles of the joints, and the overall height of the hind limb often dictate the type of action and amount of power produced. The length and slope to the pelvis (croup) are measured from the point of the hip to the point of the buttock (Baxter, 2011).

Caudal view

From the rear, both hind limbs should be symmetrical, the same length, and bear equal weight. A left-to-right symmetry should be evident between the peaks of the croup (tuber sacrale), the points of the hip, the points of the buttock, and the midline position of the tail. A study in standard bred trotters found that hindquarter asymmetry (tuber sacrale at unequal heights) and associated factors had a negative effect on performance. In addition, poor development of the epaxial muscles in the thoraco-lumbar region and asymmetry of the hindquarter musculature but not asymmetry of the tuber sacrale was common findings in sport horses with documented sacroiliac disease. The widest point of the hindquarters should be the width between the stifles. A line dropped from the point of the buttock to the ground should essentially bisect the limb; however, the hind limbs are not designed to point absolutely straight forward. About 80% of all warm blood riding horses and standard bred trotters have outwardly rotated hind limbs. It is also normal for the stifles to point slightly outward, which in turn causes the points of the hocks to face slightly inward and the toes to point slightly outward. The rounder the belly and/or the shorter the loin and coupling, the more the stifles must point outward and the points of the hocks appear to point inward. When the cannon bone faces outward, the horse is considered to be cow-hocked; when the cannon bones face inward, the horse is bowlegged (Baxter, 2011).

1.5.6.6 Faults in Conformation of the Hind limbs

Standing under behind

Viewed from the side, the entire limb is placed too far forward or sickle hocks are present. A perpendicular line drawn from the point of the buttock (tuber ischii) would strike the ground well behind the limb (Baxter, 2011).

Excessively straight limbs "Straight behind"

When viewed from the side, there is very little angle between the tibia and femur, and the hock is excessively straight (large hock joint angle of more than 165° to 170°). This is believed to predispose the horse to bog spavin, thoroughpin, upward fixation of the patella, and high suspensory disease. Horses with large tarsal angles showed less tarsal flexion and less energy absorption at the tarsus during the impact phase, potentially contributing to the development of osteoarthritis. Generally, the pastern conformation is also too straight when the tarsus is too straight (Baxter, 2011).

Camped behind

"Camped behind" means that the entire limb is placed too far caudally when viewed from the side. A perpendicular line dropped from the point of the buttock would hit the toe, or halfway between the toe and heel. Upright pasterns often accompany this condition (Baxter, 2011).

Figure 1.16: Faulty hind limb Camped behind

Adopted from Baxter, (2011)

Base-wide

Base-wide means that when viewed from behind, the distance between the centres of the feet on the ground is greater than the distance between the centres of the limbs in the thigh region. Base-wide conformation is not as frequent in the hind limbs as in the forelimbs and is often associated with cow hocks (Baxter, 2011).

Base- narrow

Base-narrow conformation of the hind limbs means that the distance between the centers of the feet is less than the distance between the centers of the limbs in the thigh region, when viewed from behind. This is observed most commonly in heavily muscled horses. It causes excessive strain on the lateral aspect of the limb and most of the horse's weight is placed on the outside of the hooves. Base-narrow conformation is often accompanied by "bowlegs" or a condition in which the hocks are too far apart. The limbs may appear fairly straight to the hock and then deviate inward, and the hocks may bow outward during movement. When a horse has good conformation in front and is base-narrow behind, many types of interference can occur between the forelimbs and hind limbs (Baxter, 2011).

Medial deviation of the hock (cow hocks or tarsal valgus)

"Cow-hocked" means that the limbs are base-narrow down to the hock and then base-wide from the hock to the feet. The hocks are too close together and point toward one another, and the feet are widely separated. Cow-hocked conformation is a common defect and some believe that it is a serious hind limb conformation flaw. However, others feel that a slight valgus deformity of the hind limbs, provided that the metatarsal bones remain vertical, is not a cause for concern. Sickle hocks and cow hocks can occur concurrently and may have a compounding effect on hind limb lameness problems (Baxter, 2011).

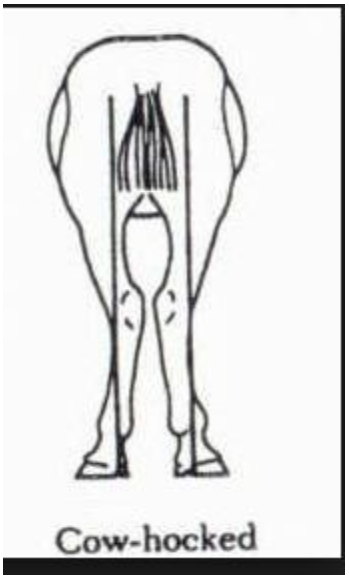


Figure 1.17: Medial deviation of the hock

Adopted from (Baxter, 2011).

Excessive angulations of the hock (sickle hock, small hock angles)

Mean hock angles in normal horses are thought to be approximately 155° to 165°. Hock angles less than 150° to 153° are considered sickle. When viewed from the side, the angle of the hock is decreased so that the horse is standing under from the hock down. This places the hock under greater stress and may predispose to synovial distention in the stifle and hock joints, and bone spavin. A small tarsal angle was significantly associated with radiographic signs of osteoarthritis in the distal tarsus in a large number of Icelandic horses (Baxter, 2011). Small hock angles may also impair a horse's ability to attain the level of collection required for good performance in advanced classes. One study on elite Swedish Warm blood sport horses found that none of the show jumpers and only one of the dressage horses were "sickle hocked. In general, sickle-hocked horses or horses with small hock angles should be avoided, although others state that many of these horses can be effectively managed (Baxter, 2011).

CHAPTER TWO

Material and Methods

2.1. Study area

This study was conducted in Tamboul area, in the east of Gezira State about 150 km south of Khartoum State.

2.2 Study population

A total number of two hundred working donkeys from both sexes (122 male and 78 female) were examined to determine the morphological characteristics, body measurements, normal and abnormal body conformation.

2.3 Morphological characteristics

2.3.1 Donkeys breed

Donkeys were classified to *Makadi, Reefawi,* and cross breed following the description of Khattab *et al.,* (2008) as follows:

2.3.1.1 *Makadi* donkey

This type is short in height (90-100cm), with heavy body, long back, heavy neck and short ears. The colour is brown -black and can tolerate fasting but reluctant to move (Figure 2.1).

2.3.1.2. *Reefawi* donkey

This donkey is long in height (100-120cm) and heavy, the body is symmetric and the main colours are white and black (Figure 2.2).

2.3.1.3 Cross breed

The donkeys that did not fall within one of the two above described breeds (Figure 2.3)

Figure 2.1: *Makadi* donkey breed

Figure 2.2: *Reefawi* donkey breed

Figure 2.3: Cross donkey breed

2.3.2 Body condition score

The body condition score was based on a scoring system of 1 to 9, 1 being emaciated and 9 obese according to Pearson and Ouassat (2000). The body condition scoring method used is shown in Table (2.1) as well as Figure (2.4).

2.3.3 Coat colour

The frequency of the body coat colour was examined visually and reported for each individual donkey following the description of Wilson (1990).

2.4 The body measurements

The measurements were taken in standing position on the two sides by three different persons, the weight tape started with the proximal point landmark to distal end of the bone. The measurement was made in centimetres and this step was repeated and a mean of the three readings was calculated (Figure 2.5).

2.4.1 The Head measurements

Head length (HL): This was measured as the distance between top corners of the two nostrils, measured straight to the front of the poll (Kefena *et al.*, 2011).

Head width: This was measured as the distance between the median canthus of the eyes. The tape was kept taut (tight or firm) and straight (Kefena *et al.*, 2011).

2.4.2 The Neck measurement

Length (NL): This was measured as the distance between the poll to the withers, with the donkey head level with the withers (Kefena *et al.*, 2011).

2.4.3 The Back measurement

Length (BAL): This was measured as the distance between withers to the croup. (Tape did not touch the back except at the ends) (Kefena *et al.*, 2011).

2.4.4 The Pelvis measurements:

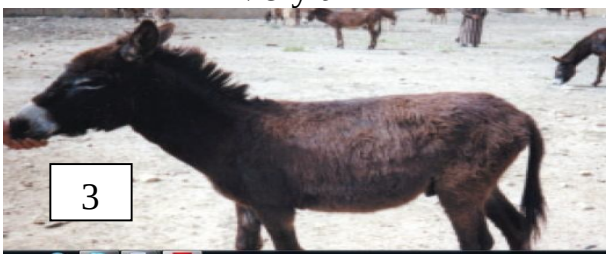
Length (PL): This was measured as the distance between points of the croup to the base of the tail (Brooks *et al.*, 2010).

Table 2.1: Donkey body condition score scale

No.	Score	Description
1	Very thin (emaciated)	Animal markedly emaciated; condemned ; bone structure easily seen over body; little muscle present ; animal weak ; lethargic
2	Thin	Animal emaciated ; individual spinous processes, ribs, tubers coxae and ischii and scapular spine all prominent; sharply defined; some muscles development; neck thin; prominent withers shoulders sharply angular
3	Less thin	Vertebral column prominent and individual spinous processes can be felt (palpated); little fat, but super spinous musculature apparent over spinous, ribs tubers coxae and ischii prominent; lion area and rump concave; little muscle or fat covering over withers and shoulders.
4	Less than moderate	Vertebral column visible; tuber ischii palpable but not visible; tuber coxae rounded but visible; rump flat rather than concave; ribs palpable but not obvious; withers; shoulders; neck with some muscles and fat cover; scapula less clearly defined.
5	Moderate	Super spinous muscles developed and readily apparent ; can palpate vertebral column ; tuber coxae rounded ; rump rounded convex tuber ischii not visible ; some fat palpable in pectoral region and at base of neck ; can palpate ribs , but not visible.
6	More than moderate	Cannot palpate spinous processes easily; back becoming flat well covered; rump convex and well muscled; some fat palpable on neck.
7	Less fat	Back flat , cannot palpate spinous processes tuber coxae just visible ; fat on neck and pectoral region begging to expand over ribs ; flank filling , neck thinking
8	Fat	Animal appears well covered with body rounded with fat and bones not discernible; flanks filled; broad back.
9	Very fat (obese)	Bones buried in fat; back broad or flat. In some cases crease down back; large accumulations of fat on neck over pectoral area and ribs; flank filled with fat.

Very thin

Thin



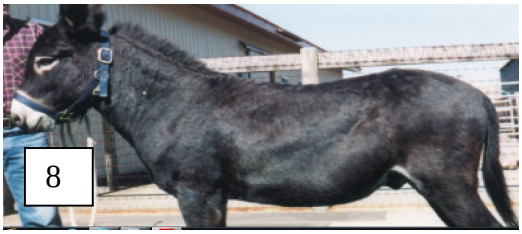
Less thin

Less than moderate

Moderate

More than moderate

Less fat



Fat

Very fat

Figure 2.5: Donkey body Condition Score 1 - 9

Adopted from Pearson and Ouassat (2000)

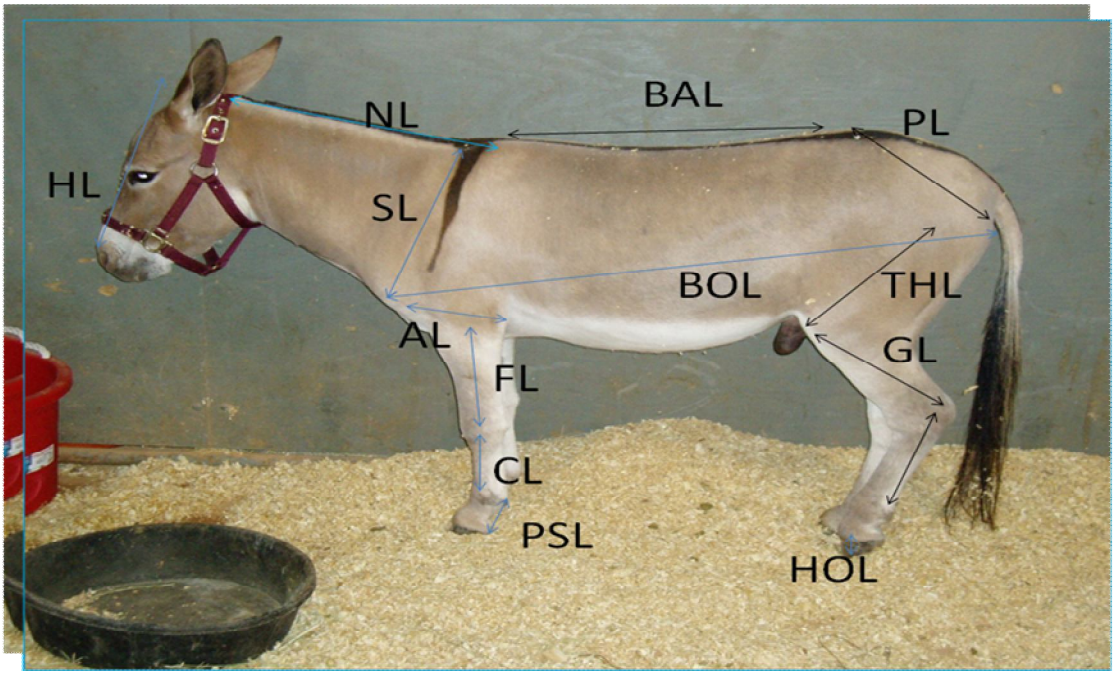


Figure 2.4: Schematic diagram showing major morphological variables measured on the donkeys

Width: This was measured as the distance between the left to the right point of the hip (Kefena *et al.*, 2011).

2.4.5 The Forelimb measurements

Shoulder length (SL): This was measured as the distance between humerus to the withers (Kefena *et al.*, 2011).

Arm length (AL): distance between the greater tubercle of humerus and the olecranon tuberosity *(tuber olecrani)(* Sobczuk and Komosa, 2012).

Forearm length (FL): This was measured as the distance between points of the elbow to the back of the knee cap (Brooks *et al.*, 2010).

Cannon length (CL): This was measured as the distance between the back of the knee cap to the ergot (Kefena *et al.*, 2011).

Pastern length (PL): This was measured as the distance between the bottoms of the fetlock joint to the top of the coronet to the bottom of the hoof (Brooks *et al.*, 2010).

2.4.6 The Hind Limb measurements

Gaskin length (GL): This was measured as the distance between the stifle to the point of the hock. The tape was kept taut and straight (Brooks *et al.*, 2010).

Hind cannon length: This was measured from the point of the hock to ergot (bottom of the fetlock) (Brooks *et al.*, 2010).

The following hoof measurements were recorded according to Stachurska *et al.*, (2008).

Hoof width: This was measured at the solar side at the widest part of the hoof (Stachurska *et al.*, 2008).

Hoof length (HOL): This was measured from the coronary rim to the heel on the ground surface at the outer heel buttress (Stachurska *et al.*, 2008).

2.4.7 The body longitudinal axis

Height: This was measured as the distance between the ground to the highest point of the withers. The tape was kept taut (tight or firm) and straight (Kefena *et al.*, 2011).

Body length (BOL): This was measured from the olecranon process of the elbow to tuber ischii (Nengomasha *et al.*, 1999).

Heart girth: This measured the circumference from the caudal edge of the withers behind the elbow (Kefena *et al.*, 2011)

2.5 Normal and abnormal body conformation

The normal and abnormal conformation of the donkeys was investigated by visual examination in anterior view or cranial view to detect (toe out unilateral or bilateral, toe in unilateral or bilateral, base narrow, base wide and bench knee), lateral view (standing under in front, camped in front, cut out under the knee, tide in knee, open knee) and caudal view or rear view (base narrow, base wide).

2.6 Statistical analysis

Collected data were analysed using SPSS software version 11.5 (SPSS, 2010). Descriptive statistics including frequencies as follow (mean, standard deviation, percentage), One-way ANOVA, independent Samples Test and correlation coefficients.

CHAPTER THREE

RESULTS

3.1. Morphological characteristics

3.1.1 Breeds of donkeys in Tamboul

As shown in Table 3.1, The *Makadi* breed was found to be dominant among the *Reefawi* and the cross breed in the sample studied where it represented 63% of the total population.

3.1.2 Coat colour frequencies

As shown in Table 3.2, the predominant coat colour in the *Makadi* breed is light brown and black, while grey and black in *Reefawi* and grey and white in Cross breed.

3.1.3 Body condition score

Body condition score being thin to obese, all this scale was found in this study except very thin (Table 3.3).

3.2 Body measurements

3.2.1 Axis measurements

Descriptive statistics (Mean ± SD) are show in Tables (3.4), Concerning the effect of breed on axis measurements analyzed one-way ANOVA results show that there are significant differences between *Makadi*, *Reefawi* and *cross* breed except the head width ($P<0.01$) and as shown in Table (3.5), concerning the effect of sex on axis measurements analyzed independent Samples Test results show that there are significant differences between male and female in HW, BAL, PL, BL and HG. But no significant differences between male and female in WH, HL, NL and PW.

Axis measurement correlation coefficients (r) among morphologic traits are given in Table (3.6) the highest values were found between WH and HG ($r=0.780$) ($P<0.01$). Other high values were found between HL and WH ($R=0.667$) ($P<0.01$).

The correlation values of HL-HG,WH-BL,HG-BL, PW-HG, BAL-HG, PW-BL, PW-WH ,BAL-WH, BAL-BL, also had high values those of higher than r = (0.450)($P<0.01$). The lowest values was found between PL and HW(r= -0.043) ($P<0.05$).

3.2.2 Forelimb measurements

Descriptive statistics (Mean ± SD) are show in Tables (3.7), Concerning the effect of breed on fore limb measurements analyzed one-way ANOVA results show that there are significant differences between *Makadi, Reefawi* and *cross* breed except the hoof width ($P<0.01$) and concerning the effect of sex on fore limb measurements analyzed independent Samples Test results show that there are no significant differences between male and female except FL ($P<0.01$) Table (3.8).

3.2.3 Hind limb measurements

Descriptive statistics (Mean ± SD) are show in Tables (3.9), Concerning the effect of breed on hind limb measurements analyzed one-way ANOVA results show that there are significant differences between *Makadi, Reefawi* and *cross* breed ($P<0.01$) and concerning the effect of sex on hind limb measurements analyzed independent Samples Test results show that there are no significant differences between male and female except THL ($P<0.01$) Table (3.10).

Table 3.1: Classification of donkeys according to breed and sex among studied sample in Tamboul, Sudan

Breed	No. of Male	No. of Females	Total (%)
Reefawi	38	22	60 (30%)
Makadi	77	49	126 (63%)
Cross	7	7	14 (7%)
Total	122	78	200

Table 3.2: Frequency of body coat colour among donkeys examined in Tamboul, Sudan

Colour Breed	*Makadi*	*Reefawi*	Cross	Total (%)
Grey	16	35	6	57 (28.5)
Light brown	21	16	2	39 (19.5)
White	2	28	3	33 (16.5)
Black	18	37	2	57 (28.5)
Brown	3	10	1	14 (7)
Total	60	126	14	200

Table 3.3: Distribution (%) of donkeys according to body condition score among studied sample in Tamboul, Sudan

Body condition score	*Makadi*	*Reefawi*	Cross	No. of donkey (%)
Moderate	23	45	3	71(35.5)
More than moderate	10	28	5	43(21.5)
Less than moderate	9	22	2	33(16.5)
Less fat	11	16	2	29(14.5)
Fat	5	12	2	19(9.5)
Less thin	0	2	0	2(1)
Very fat (obese)	1	1	0	2(1)
Thin	1	0	0	1(0.5)
Total	60	126	14	200

Table 3.4: Axis measurements (cm) according to donkey breed among examined sample in Tamboul, Sudan

Measurement	*Makadi*	*Reefawi*	Cross	Total
Withers Height	102.88±5.2*	107.52±4.2*	113.64±2.2*	106.56± 5.32*
Head length	42.00±1.9*	43.31±1.8*	44.79±2.0*	43.02± 2.04*
Head width	28.43±3.8	28.79±2.1	29.29±14	28.71± 2.72
Neck length	58.80±4.8*	59.87±5.3*	63.43±5.2*	59.80± 5.28*
Back length	56.80±4.9*	59.43±5.0*	64.57±4.0*	59.00± 5.30*
Pelvis length	27.48±2.5*	28.67±2.9*	29.79±4.5*	28.39± 3.05*
Pelvis width	29.40±2.4*	29.98±2.7*	32.00±2.9*	29.94± 2.73*
Body length	103.62±5.8*	105.92±5.9*	113.43±3.7*	105.75±6.2*
Heart girth	104.22±5.8*	108.72±5.2*	114.79±4.3*	107.80±5.98*

* Means with asterisk in the same row are significantly different: P<0.05

Table 3.5: Axis measurements (cm) according to donkeys sex among examined sample in Tamboul, Sudan

Measurement	Male	Female
Withers Height	105.98±5.1	107.45±5.6
Head length	42.86±2.1	43.27±1.9
Head width	29.17±2.6*	28.00±2.8*
Neck length	59.50±5.4	60.26±5.1
Back length	57.89±5.3*	60.73±4.8*
Pelvis length	28.09±2.8*	28.86±3.3*
Pelvis width	29.12±2.3	31.23±2.8
Body length	104.91±5.87*	107.08±6.56*
Heart girth	106.55±5.85*	109.74±5.71*

* Means with asterisk in the same row are significantly different: $P<0.05$

Table 3.6: Measurements correlation coefficients (r) according to donkey breed among examined sample in Tamboul, Sudan

	HG	BL	WH	HL	HW	NL	BAL	PL
HG								
BL	0.610**							
WH	0.780**	0.635**						
HL	0.656**	0.497**	0.667**					
HW	-0.054	-0.082	-0.070	0.000				
NL	0.362**	0.338**	0.419**	0.272**	0.111			
BAL	0.491**	0.454**	0.455**	0.378**	-0.159*	0.293**		
PL	0.372**	0.237**	0.261**	0.267**	-0.043	-0.060	0.200**	
PW	0.529**	0.478**	0.467**	0.414**	-0.082	0.248**	0.437**	0.038

*P<0.05, **P<0.01

Table 3.7: Forelimb measurements (in centimetres) according to donkeys breed among examined sample in Tamboul, Sudan

Measurement (cm)	*Makadi*	*Reefawi*	Cross	Total
Hoof length	6.16±0.97*	6.50±1.0*	8.14±2.2*	6.51±1.14*
Hoof width	5.49±0.49	5.61±.54	5.82±2.0	5.59±0.53
Pastern length	8.97±1.2*	9.40±1.2*	9.71±1.4*	9.30±1.18*
Cannon length	20.72±2.2*	22.13±2.3*	22.57±5.2*	21.74±2.34*
Fore arm length	31.22±2.4*	31.70±2.6*	33.79±4.0*	31.70±2.58*
Arm length	27.55±1.7*	28.73±1.8*	29.57±4.6*	28.43±1.85*
Shoulder length	39.08±2.7*	39.90±2.9*	41.50±3.0*	39.77±3.00*

* Means with asterisk in the same row are significantly different: $P<0.05$

Table 3.8: Forelimb measurements (centimetres), according to donkeys sex among examined sample in Tamboul, Sudan

Measurement	Male	Female
Hoof length	6.45±1.1	6.61±1.2
Hoof width	5.54±0.5	5.67±0.5
Pastern length	9.32±1.2	9.26±1.2
Cannon length	21.72±2.7*	21.76±1.1*
Fore arm length	31.23±2.8	32.44±1.9
Arm length	28.52±1.9	28.29±1.8
Shoulder length	39.75±2.9	39.79±3.1

* Means with asterisk in the same row are significantly different: $P<0.05$

Table 3.9: Hind limb measurements (centimetres) according to donkeys breed among examined sample in Tamboul, Sudan

Measurement	*Makadi*	*Reefawi*	Cross	Total
Pastern length	8.80±1.1*	9.21±1.1*	9.36±1.1*	9.10±1.11*
Cannon length	30.30±2.2*	31.44±2.0*	32.29±1.4*	31.16±2.12*
Gaskin length	36.70±2.9*	38.48±2.4*	39.14±3.1*	37.99±2.73*
Thigh length	27.58±2.8*	28.71±2.5*	31.29±3.4*	28.55±2.81*

* Means with asterisk in the same row are significantly different: $P<0.05$

Table 3.10: Hind limb measurements (centimetres) according to donkeys sex among examined sample in Tamboul, Sudan

Measurements	Male	Female
Pastern length	9.10±1.1	9.10±1.2
Cannon length	31.07±2.1	31.28±2.1
Gaskin length	37.97±2.6	38.03±2.9
Thigh length	28.16±2.4*	29.17±3.3*

* Means with asterisk in the same row are significantly different: P<0.05

3.3 Abnormal body conformation

Forelimb abnormal conformation was detected in 70 (35%) of the examined donkeys. Toe out bilateral **(**16.7%) and toe in bilateral (14.5%) was the most prominent abnormality among examined donkeys. Toe in either unilateral (14.3%) or bilateral (21.4%) was most encountered abnormality in the cross breed (Table 3.11, Figure 3.1).

Donkeys with normal 3rd - metacarpal bone conformation were found to represent 87.5% of the total population of donkeys examined, while 12.5% of the animals showed bench-knee (Table 3.12, Figure 3.2).

Abnormal carpal joint conformation was detected in 39 (19.5%) donkeys. The anterior deviation was found to be dominant among the abnormal conformation in carpal joint in the sample studied where it represented 13% of the total population, while 4% of the animals examined during the study were found to have knock knee (Table 3.13, Figure 3.3).

As shown in Figure (3.4) donkeys with normal forelimb (anterior view) were found to be 81% of the total study population, while 14.5% of the examined animals were found to be of base-wide and 4.5% base-narrow (Figure 3.5).

Distribution of donkeys (%) according to forelimb (lateral view) conformation among studied sample in Tamboul, Sudan is shown in Table (3.14) and Figure (3.6).

As shown in Table (3.15) normal hind limb (rear view) was observed in 57% of the donkeys examined, while 41% of the donkeys showed toe out bilateral hind limb conformation.

As shown in Figures (3.7 and 3.8) 54% of the donkeys examined showed normal conformation of the hind limb in rear view, while 39.5% of the animals were found to exhibit base wide and 6.5% to exhibit base narrow conformation.

As shown in Figures (3.9, 3.10) donkeys with normal conformation of the hock joint were found to represent 61% of the total study population, while 36.5% of the animals examined in the study were found to be with either cow-hock or 2.5% sickle-hock.

Donkeys with normal hind limb (lateral view) were found to represent 99.5% of the total study population, that is means no or few problems were encountered in the hind limb from this view (Table 3.16, Figure 3.11).

As shown in Table (3.17) donkeys with normal conformation of the neck were found to represent 90% of the total study population, while 6.5% of the animals used in the study were found to be of bull-neck, 2.5% ewe-neck and 0.5% swan-neck and knife-neck (Figure 3.12).

As shown in Table (3.18) 80.5% of the examined donkeys showed normal back spine conformation, while 10.5% of the animals examined in the study were found to be of convex, 8.5% of concave and 0.5% of stepped-neck (Figure 3.13).

As shown in Table (3.19) donkeys with normal conformation of the pelvis were found to be 96% of the total study population, while 4% of the animals examined in the study were found to be of goose-rump (Figure 3.14).

As shown in Table (3.20), 69.5% of the examined donkeys exhibited positive response to lumboscaral palpation, while remaining 30.5% showed negative response.

Table 3.11: Distribution (%) of donkeys according to forelimb (anterior view) conformation with respect to breed among studied sample in Tamboul, Sudan

Feet conformation	*Makadi*	*Reefawi*	Cross	% (No.)
Toe out unilateral	0	2.4	7.1	1.5 (3)
Toe out bilateral	16.7	16.7	0	16.2 (32)
Toe in unilateral	3.3	1.6	14.3	3.0 (6)
Toe in bi lateral	18.3	11.9	21.4	14.5(29)
Normal	61.7	67.5	57.1	65.0(130)
Total	100.0	100.0	100.0	100.0 (200)

A. Toe-out bilateral

B. Toe-out unilateral

C. Toe-in bilateral

Figure 3.1: Toe abnormal conformation

Table 3.12: conformation of the 3rd metacarpal bone (%) among studied sample in Tamboul, Sudan

Feet conformation	*Makadi*	*Reefawi*	Cross	Total
Bench knee	13.3	11.9	14.3	12.5
Normal	86.7	88.1	85.7	87.5
Total	100.0	100.0	100.0	100.0

Figure 3.2: Bench-knee

Table 3.13: Distribution (%) of donkeys according to forelimb carpal joint conformation among studied sample in Tamboul, Sudan

Carpal joint conformation	No. of donkeys	%
Knock knee	8	4.0
Bow legged	5	2.5
Anterior deviation	26	13.0
Posterior deviation	0	0.0
Normal	161	80.5
Total	200	100

Figure 3.3: Knee abnormal conformation (Knock-knee)

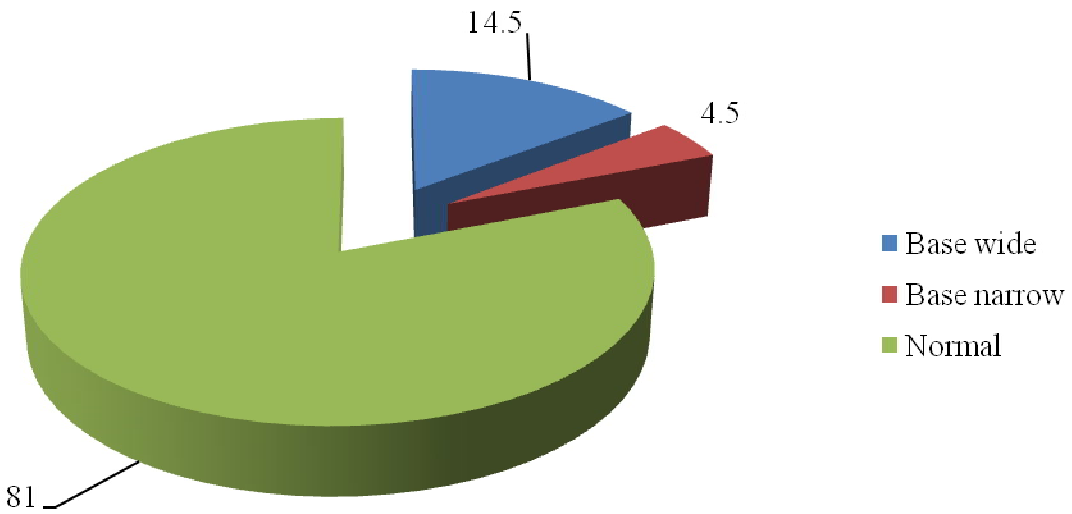
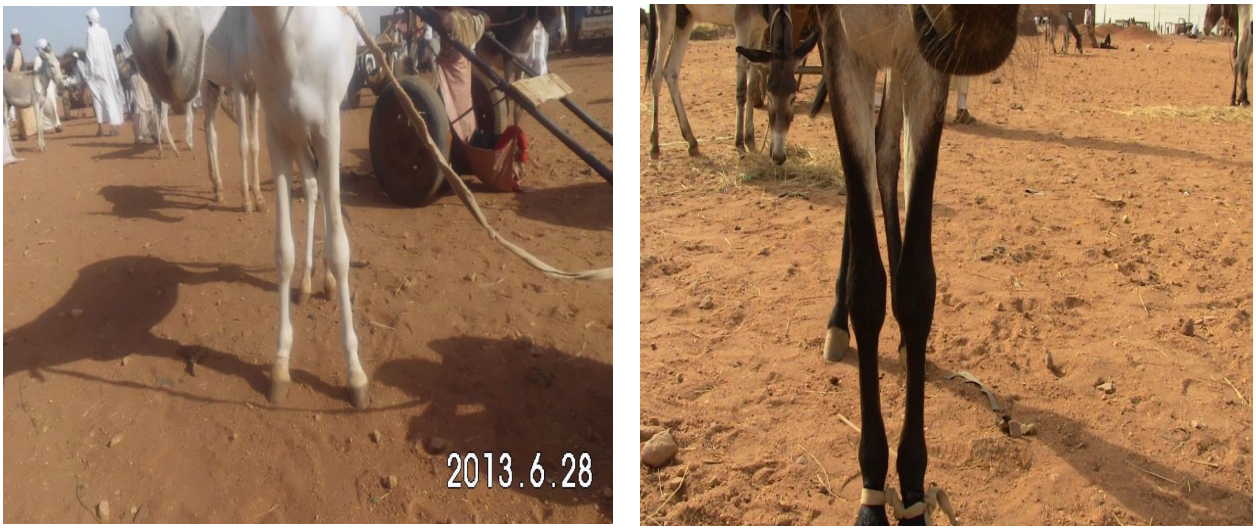


Figure 3.4: Distribution of donkeys according to normal and/or abnormal forelimb (anterior view) conformation among studied sample in Tamboul, Sudan



A. Base-wide in forelimbs **B. Base-narrow in forelimbs**

Figure 3.5: Forelimb abnormal conformation anterior view

Table 3.14: Distribution of donkeys (%) according to forelimb (lateral view) conformation among studied sample in Tamboul, Sudan

Lateral view	No. of donkeys	%
Standing under in front	3	1.5
Camped in front	1	0.5
Cut out under the knee	1	0.5
Tide in knee	1	0.5
Open knee	8	4
Normal	186	93
Total	200	100

A. Standing under in front B. Open-knee

Figure 3.6: Forelimb abnormal conformation lateral view

Table 3.15: Distribution (%) of donkeys according to Hind limb (Anterior view) conformation among study population in Tamboul, Sudan

Anterior view hind limb	No. of donkeys	%
Toe out unilateral	1	0.5
Toe out bilateral	82	41.0
Toe in bilateral	3	1.5
Normal	114	57.0
Total	200	100

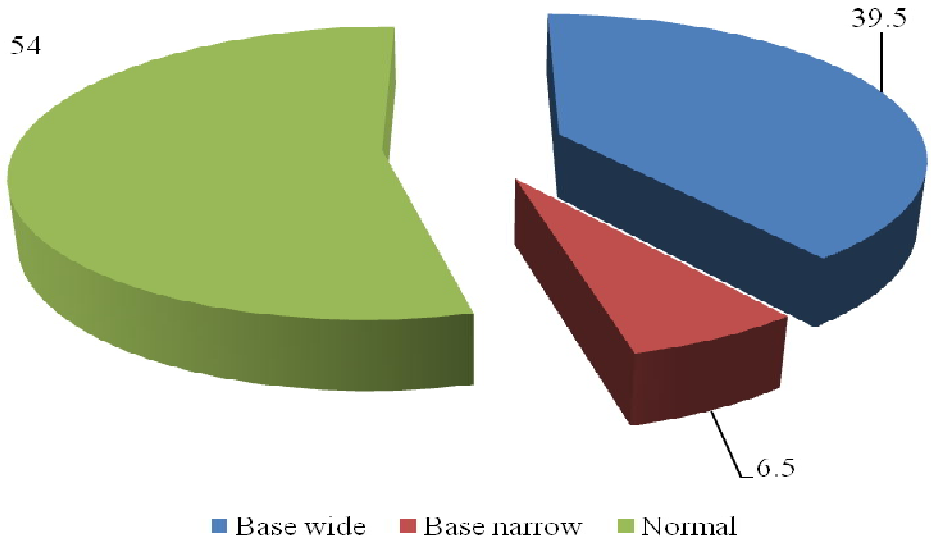


Figure 3.7: Distribution of donkeys (%) according to hind limb (rear view) among study population in Tamboul, Sudan

A. Base-narrow B. Base-wide

Figure 3.8: Hind limb abnormal conformation (rear view)

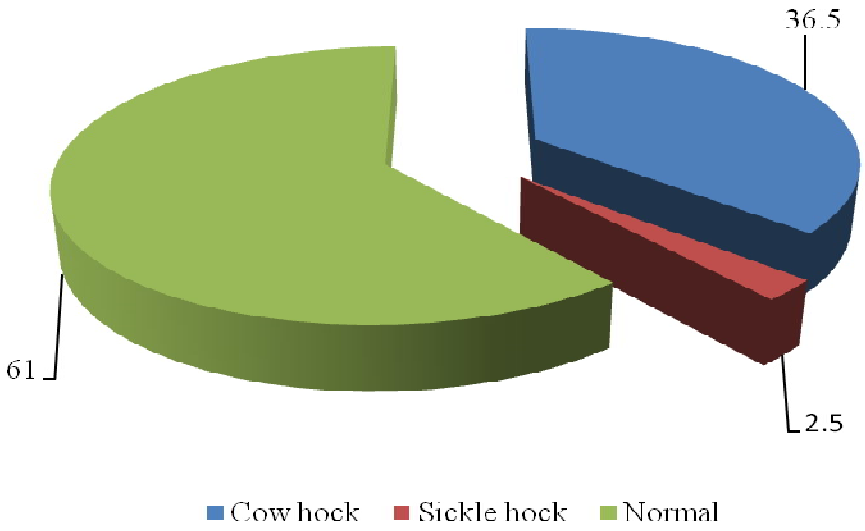
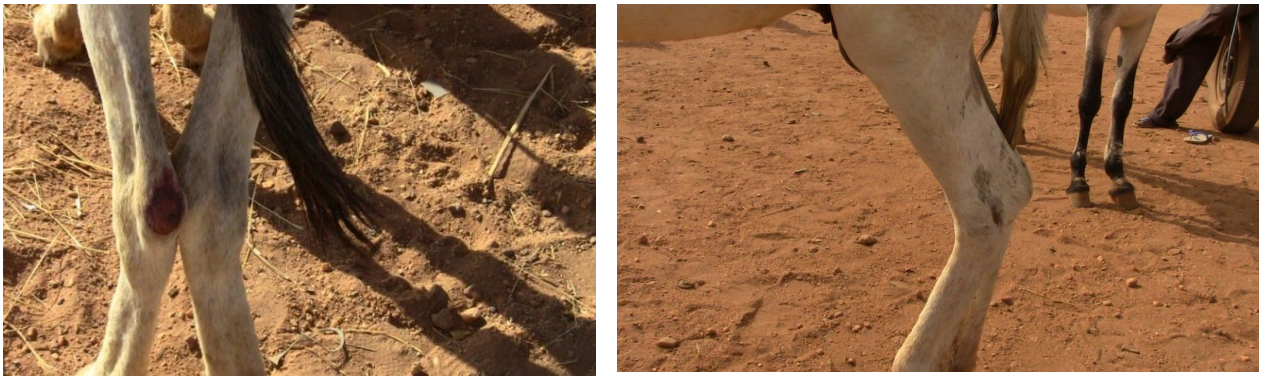


Figure 3.9: Distribution of donkeys (%) according to hock joint conformation among study population in Tamboul, Sudan



A. Cow-hock B. Sickle-hock

Figure 3.10: Donkeys with abnormal hock joint conformation

Table 3.16: Distribution (%) of donkeys according to hind limb (Lateral view) among study population in Tamboul, Sudan

Lateral view of the hind limb	No. of donkeys	%
Straight leg	0	0.0
Standing under behind	1	0.5
Camped behind	0	0.0
Normal	199	99.5
Total	200	100

Figure 3.11: Donkey showing straight leg (Hind limb, lateral view)

Table 3.17: Distribution (%) of donkeys according to neck conformation among study population in Tamboul, Sudan

Neck conformation	No. of donkeys	%
Ewe neck	5	2.5
Bull neck	13	6.5
Swan neck	1	0.5
Knife necked	1	0.5
Normal	180	90.0
Total	200	100

A. Ewe-neck

B. Bull-neck

Figure 3.12: Donkeys with different neck conformation lateral view

Table 3.18: Distribution (%) of donkeys according to back spine conformation among studied sample in Tamboul, Sudan

Back spine conformation	No. of donkeys	%
Convex	21	10.5
Concave	17	8.5
Stepped	1	0.5
Normal	161	80.5
Total	200	100

A. Convex back spine

B. Concave back spine

Figure 3.13: donkeys with different back conformation lateral view

Table 3.19: Distribution (%) of donkeys according to pelvis conformation among studied sample in Tamboul, Sudan

Pelvis conformation	No. of donkeys	%
Goose-rump	8	4.0
Normal	192	96.0
Total	200	100

Figure 3.14: Donkey with a Goose-rump conformation

Table 3.20: Distribution (%) of donkeys according to lumbo-sacral palpation test among studied sample in Tamboul, Sudan

Lumbo-sacral palpation test	No. of donkeys	%
Positive	139	69.5
Negative	61	30.5
Total	200	100

CHAPTER FOUR

Discussion

With close observation, donkey populations in Sudan exhibit considerable conformational differences, have different coat colour patterns and body sizes. However, the patterns of morphological diversities and geographical distribution of Sudanese donkeys have not been fully investigated and remained unknown.

It is estimated that there are 6350000 donkeys in Sudan (Statistical Bulletin for Animal Resources, 2000). There is a general lack of information on the breed type of the 'Sudanese' donkeys and its typical traits have not been established. Morphological characteristics (frame size, as determined by the dimensions of heart girth, body length and wither height) could usefully indicate draught and therefore performance capacity of Sudanese donkeys, since Tembo (1989) suggested that draft capability is directly proportional to size. This information could then be used to assess the donkey draught power resource available to the smallholder farmer, the main user of the donkey.

4.1 Morphological characteristics

The dominant breed of donkeys in Tamboul was the *Makadi* breed (63%) and this could be attributed to economical factors as the breed is usually used for draught purpose, for traction and work as well as the suitable price of the animal when compared with the *Reefawi* and the cross breed

In this study the prominent coat colours encountered among examined donkeys were the grey and the black representing 57% of all donkeys examined. This result agrees with that obtained by (Beretti *et al.*, 2005) in Italy, where 75% of the adult Romagnolo donkeys showed the typical grey-dun colour. Yılmaz and Ertuğrul, (2011) reported four different types of coat colour among donkeys in Turkey with the mouse grey (54.3%) was the most predominant among them. The

light brown colour in this study was reported in 19.5% of examined donkeys a similar result was obtained by Yılmaz and Ertuğrul, (2011) who reported 18.1% brown. In another study, the body coat colour frequencies among the donkeys in Turkey were as follows: mouse gray 31.4%, white 24.7%, black 23.7%, and brown 20.2% (Yılmaz and Ertuğrul, 2012a).

According to body condition score, the donkeys examined in Tamboul were found mainly between Less than moderate to Less fat (4-7 scale).

4.2 Body measurements:

The withers height of overall donkeys in Tamboul was 106.56±5.32cm, while that of the *Makadi* breed was 102.88±5.2cm which is less when compared with Reefawi (107.52±4.2cm) and the cross breed (113.64±2.2cm). These results were in close agreement with results obtained by Yılmaz and Ertuğrul (2012c) in Turkish donkeys 102.3 cm, and that of Kefena *et al.*, (2011) in Ethiopian donkeys 109.78cm, and higher than donkeys raised in Igdir, Turkey (99.1) reported by Yılmaz and Ertuğrul, (2011). But is far away from that obtained by Di Rosa *et al.*, (2007) in "Pantesco" donkey (123.35±2.28).

Withers height of male donkeys (105.98±5.1cm) was found to be shorter when compared with that of females (107.45±5.6cm). A contradictory result with that obtained by Yilmaz and Ertuğrul, (2011) in donkeys raised Igdir in Turky. Donkeys raised in East and South east Turkey showed higher measurements in male donkeys when compared with female ones Yilmaz and Ertuğrul, (2012c).

The mean of the body length of donkeys in Tamboul (105.75±6.2cm) was in close agreement with that reported by Yılmaz and Ertuğrul, (2012c) in East and Southeast of Turkey (105.2cm), and donkeys raised in Igdir, Turkey (103cm) reported by Yilmaz and Ertuğrul, (2011), and that reported by Kefena *et al.*, (2011) in Ethiopian donkeys.

The *Makadi* is shorter than the *Reefawi* (103.62±5.85cm vs 105.92±5.94cm) respectively. The cross breed showed longer body length (113.43±3.65cm) which is as the same as that reported by Kefena *et al.*, (2011) in Ethiopian donkeys (114.70cm).

The mean ±SD heart girth circumference in overall donkeys in this study was 107.80±5.99cm, *Makadi* (104.22±5.79cm) showed lower circumference when compared with the *Reefawi* (108.72±5.19cm), and the cross breed (114.79±4.26cm) (p=0.05). This finding was in agreement with the results reported by Yılmaz and Ertuğrul (2011) of donkeys raised in Igdir (111.5cm) and Yılmaz and Ertuğrul (2012c) of donkeys (113.5cm) raised in East and Southeast of Turkey, but different finding in mules and horses reported by Yılmaz, *et al.*,(2012b). The mean girth in mules were (148.2±0.84 in mules raised in Sirnak province of Turkey, and 148.6±0.73 in mules raised in East region of Turkey, and 152.3±0.76cm in mules raised in Ordu province of Turkey, and (163.2±1.09cm) of Malakan horses raised in Turkey.

The head length of overall donkeys (mean ±SD) of donkeys in Tamboul was found to be 43±5.3cm. This finding was not far from that reported by Yılmaz and Ertuğrul, (2012c) of Turkish donkeys (48.7cm) and (48.4cm) by Yılmaz and Ertuğrul (2011) in donkeys raised in Igdir, Turkey. While mules and horses showed higher measurements than donkeys (54.9±0.53, 54.7±0.45and 55.8±0.26 for mules and 56.4±0.38cm for horse (Yılmaz *et al.*, 2012a).

To our knowledge no of the above authors reported about the mean head width, which was found to measure 28.71± 2.72 cm in the current study.

The mean of the neck length investigated in this study (60 ± 5.3 cm) was higher than that reported by Kefena *et al.*, (2011) of Sinnar donkey in Ethiopia

(53.97cm). The mean back length (59± 5.3 cm), was in close agreement with that reported by Kefena *et al.*, (2011) of Sinnar donkey in Ethiopia (60.26cm).

The mean pelvis length (28±3.1 cm) was not reported in the other studies. While the mean pelvis width investigated in this study (30±2.7 cm) agreed with that reported by Kefena *et al.,* (2011) of Sinnar donkey in Ethiopia with a mean of 32.87 cm.

In the overall donkeys or (total) the mean ±SD pastern length was found 9±1.2cm; and the length of cannon 22±2.3cm; while the length of forearm 32±2.6 cm; the length of arm 28±1.9cm and the length of shoulder 40±3.0 cm (Table 3.7). Such details pertaining to the fore limb measurements were not available in the other studies. In Ethiopian donkeys forelimb cannon bone length was (19.24-24.44 cm) and the length of the foreleg was (46.78-57.57 cm) reported by Kefena *et al.*, (2011).

The measurements of the hind limb in overall donkeys reported in the current study were as follows: mean of pastern length 9±1.1 cm; cannon length 31±2.1 cm; gaskin length 38±2.7 cm; and thigh length 29±2.8 cm (Table 3.9).

The mean hoof length in overall donkeys reported in this study was 6.5±1.14 cm. This finding was different from that reported by Sargentini *et al.*, (2012) of the Amiata donkey with a mean of 12.01±0.7cm. The mean hoof width investigated in this study was 5.6±5 cm. This finding was different from that reported by Sargentini *et al.*, (2012) of Amiata donkey with a mean of 8.78±0.5 cm (Table 3.8).

4.3 Abnormal body conformation

To our knowledge no of the above authors reported about the abnormal conformation, this study demonstrated that toe-out bilateral, toe-in bilateral, base

wide and anterior deviation were the most problems in the forelimbs conformation and toe-out bilateral, base wide and cow hock in hind limbs.

The study revealed that there were no or few problems in the neck as 90% of the donkeys showed normal neck conformation, while only 2.5% reported with ewe-necked, 6.5% with bull-necked, 0.5% with swan-necked and 0.5% with knife-neck.

The study revealed that there were no serious problems encountered with the conformation of the back spine, as 80% of the examined donkeys showed normal conformation, 10.5% with convex, 8.5% with concave, and 0.5% with stepped back conformation.

The present study revealed that 96% of the examined donkeys were normal with respect to pelvis conformation, and only 4% of the donkeys showed goose-rump conformation.

Abnormal conformation reported in the hind limb as bilaterally toe-out 41%, unilaterally toe-out 0.5%, bilaterally toe-in 1.5% in feet area, base wide 39.5%, base narrow 6.5% in rear view, cow-hock 36.5%, sickle hock 2.5% in hock joint area, standing under behind 0.5 in lateral view.

According to Baxter (2011) some abnormal conformation occur in certain diseases not as fault in conformation like (Standing under in front) and some of them associated with other cases (cow hock associated with base wide in hind limb), goose-rump is usually accompanied by weak hind quarters (Thomson, 2009).

Chapter five

Conclusion and Recommendations

Information gathered in the current exploratory investigation would allow meaningful comparisons to be made between the Sudanese donkeys and those used elsewhere in Africa for work. The abnormal body conformation in working donkeys reported here may highlight the complications to be encountered during examining lameness in donkeys.

5.1 Conclusion

The study concluded that there may be a third breed (labelled here as cross breed) and showed higher body measurements when compared to the *Makadi* and the *Reefawi* breeds.

The most conformation problems was found under the carpal joint in forelimb and under the hock joint in hind limbs, all their problems were probably due to overweight, under weight, over exertion, stannous work malnutrition and bad medical care.

5.2 Recommendations

The following future studies are recommended:

a. Measurement of the angles in axis and limbs, height at rump and back, chest width, circumference.
b. Using the X-ray to determine the cause abnormal conformation.
c. Comparative studies between three breeds all over the Sudan conduct a nationwide survey to compare the morphologic characteristics of the three breeds.
d. Molecular studies genetic determination and different ion between the three breeds.

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