

CHAPTER ONE

INTRODUCTION

Camels provide mankind with a range of products and services, e.g. wool, meat, milk and the power to resist draught. They have been domesticated about 3000 years ago (Schwartz and Dioli, 1992). Camels live in vast pastoral areas in Africa and Asia and are divided into two different species belonging to the dromedary camels *Camelus dromedarius* (one humped) that mainly live in the arid desert areas and Bactrian camel *Camelus bactrianus* (two-humped) which prefer living in the cooler areas (Farah, 1996; Yagil, 1982). The camel is ideal domestic animal in the desert with long, dry, hot periods of eight months or more and scarce, erratic annual rainfalls between 50 to 550 mm (Ramet, 2001). This unique adaptability makes camels ideal for exploitation in many pastoral systems in the arid and semi-arid areas of Africa (Yagil, 1985, Schwartz, 1992 and Wilson, 1998).

Sudan is well known as one of the largest camel populated countries in the world, the total camel population in Sudan is estimated to be more than 4.8 million head (MARFR, 2012), the majority of this number is kept by migratory pastoralists “Abbala” in arid and semi arid zones of Sudan, where camel pastoralists prevail with limited resources in subsistence production systems. Eisa and Mustafa (2011) mentioned that Sudan had many production systems including: traditional nomadic system, transhumant or semi-nomadic system, sedentary or semi-sedentary system and intensive system which is limited to racing and dairy camels. Camels in most pastoral societies are milked by men (one or two herdsman) and to prevent calves from suckling at pasture during the day it is common among the nomad, to tie up one or more teat with special strings. Camels in the Sudan and elsewhere are classified as pack (heavy) and riding (light) types according to the function they

perform and probably as a result of selection applied for these traits by the various camel-keeping tribes.

Camel milk has a good nutritive value and can be a comprehensive source of food in human diet in arid and semi-arid zones, thus many researches are still to be generated about camel milk as a source of food (Igbal and Younas, 2001). Camel milk is a complex mixture of fat, protein, lactose, minerals, and vitamins and miscellaneous constituents dispersed in water. Many factors affect camel milk components such as parity, season and physiological stage (Konuspayeva *et al.*, 2009) and number of calving, management and stage of lactation (Abu-Lehia, 1987; Alshaikh and Salah, 1994) and feed quality (Parraguez *et al.*, 2003).

Therefore camel play a vital role in social-economic and supports human being during the past ages until now and used as travel media, packing, in wars and source of food (milk and meat) also its hair and skin are used in build home, clothes and shoes.

The objectives of this study are:

- 1- To determine the effect of breed types, sex and age group on somebody measurements of some Sudanese breed types camel.
- 2- To investigate the effects of parity and breed types on some physicochemical components of some Sudanese camel milk.
- 3- To describe and evaluate camel breed types according to some morphological features.
- 4- To assess some field management practices adopted by herder men and camel owners.

CHAPTER TWO

LITERATURE REVIEW

2.1. Camel of the world:

Camels are found in Africa, Asia and the Arabian Peninsula, the family *Camellia* probably originated in north America during the Eocene period about (50 million years) before spreading towards either south America, where the family evolved as llama, alpacas, quancos and vicuas or across the bring strait into Asia, the Near east (Arabia) and Africa via north Africa (Higgins, 1984). The camel was domesticated around 2500 – 3000 B.C. (Graham, 1996). The total camels' population in the world is estimated to be about 26 million according to the Food and Agriculture Organization (FAO, 2011). All members of the camel family belong to the order Artiodactyla (even-toed ungulates); sub order Tylopoda (pad-footed) and family Camelidae (Wilson, 1984). They are pseudo-ruminants and have several unique features: they walk on pads rather than hoofs, do not have horns or antlers, and their red blood cells are oval in shape (Larson and Ho, 2003). The family *Camellia* has three genera, *Camillus*, *Lama* and *Vicuna* (the “old world genus”). The genus *Camillus* has two species, *bactrian* (two humped) and *dromedarius*; the one humped (the “new world genus”). The genus *Lama*, has three species while the *Vicugna* has only one species (Wilson, 1984).

The habitat of the dromedary is the dry hot zones of North Africa, Ethiopia, the Near East and West Central Asia. Bactrian camel occupies the cold deserts of southern areas of the former Soviet Union, Mongolia, East-Central Asia and China. The limeades exist in the cold heights of Latin America (Wilson, 1984). Morphological characters, such as morphometric measurements of body parts, are

used to distinguish camel breeds. Many studies revealed that there is a significant effect of camel breed types, sex and age on some body measurements such as barrel girth, heart girth, height at shoulder and body weight (Wardeh 1989; Dioli *et al.*, 1992; Al Khouri and Majid, 2000; Wardeh, 2004; Mehari *et al.* 2007; Ishag *et al.*, 2010; Ishag *et al.*, 2011)

2.2. Sudanese camel Breeds:

Sudanese camels are owned and raised by nomadic tribes, who migrate north and south according to the season searching for water and pasture and escape from insects. The one humped camel (*Camelus dromedaries*) is the type that exists in Sudan. It is mainly found in a belt extending between 12° N – 16° N latitude according to the recent report of HCENR (2009). Camels in Sudan are concentrated in two main regions; the Eastern States where camels are found in the Butana plain and the Red Sea hills, and Western regions of Darfour and Kordofan (Agab, 1993). In Sudan camel breed types often take the name of tribes, location or some physical characteristics (Bakheit *et al.*, 2008), Therefore, the conformational characteristics and tribal ownership is the base of distinction between camel herds in natural range lands (Ishag and Ahmed 2011). According to their function, Sudanese camels are classified into two main categories, pack (heavy) and riding (light) camels (HCENR, 2009, Gillesple, 1960 and Lesse, 1927). Wathig (2007) mentioned that hybrids between the two categories also exist. Lesse (1927) reported that the ride camels were subdivided into ride and race camels, while the pack camels were subdivided into plain and hill camels. Mason, (1979) mentioned that the Sudanese heavy type constitutes the majority of the camels kept by nomads in Sudan. In this group two types can be identified on the basis of conformation and tribal ownership: the Arabi and Rashaidi camels. On the other hand, the riding camels are restricted to the north-east of the country between the Nile and Red Sea. Two main types are

recognized, namely Anafi and Red Sea Hills (Bishari) camels (El-Fadel, 1986). The main camel keeping tribes in Butana region are the *Lahawiyin*, *Kawahla*, *Shukriya*, *Rashaida*, *Bija* and *Bawadra* (Darosa and Agab, 2005). The new classification system aims at establishing the foundation for selection of camels on the basis of their performance as meat, dairy, dDual purpose and race animals (Wardeh, 2004).

2.3. Phenotypic characteristics of Sudanese Camels:

Ishag *et al.*, (2010) reported that Anafi and Bishari breeds have the same morphological appearance in many body features such as white body colour, wool distribution on the whole body, small erect hump, thin base and long tail and rudimentary udder and teat, and relatively light weight, and classified both as riding camels. On the other hand they classified Kenani, Lahwee, Rashaidi and Kabbashi as pack camels for their higher body weights. Ishag *et al.*, (2011) conclude that Kenani camel is the largest camel breed in central and eastern Sudan.

Also Ishag *et al.*, (2010) mentioned that Rashaidi breed has large size udders and well developed milk vein which may qualify it to be classified as a dairy camel. Regarding the udder and teats feature, Kenani, Kabashi and Lahwee camels have well developed udders (medium to large size). This probably explains their capacity in milk production and considered to classify as dual purpose (beef and dairy) camels.

2.4. Sudanese camel breed types:

2.4.1. Kenani camels:

The Kenani camel breed, also known as the Rufaa camel, is found in Sinnar and Blue Nile states and is owned by *Rufaa*, *Agilieen*, *Dighame* and *Kenana* tribes. The predominant colours of these camels are dark brown, grey and yellowish. It is characterized by long hair covering the whole body especially on the hump and

neck (Al-Khoury and Majid 2000). In this camel, the hump is well developed, located in the middle of the back. The udder and teat size range between large to medium and with a well developed milk vein (Plate 1, appendices). In dry seasons (winter and summer) the camels are usually found in Kenana and Butana regions and North Blue Nile state. However, in the wet season the owners migrate with their camels to the White Nile state near Diweim town (Ishag *et al.*, 2011) .

2.4.2. Rashaidi camel:

The Rashaidi breed type is found in Eastern Sudan (Gadaref and Kassala states), bred by *Rashaida* nomadic tribe known also as *Zebaidia*. There is a common believe that this type entered Sudan from Saudia Arabia. The dominant colours of these camels are dark grey and pinkish red (Plate 2, appendices). These camel breeds are characterized by being shorter in height at shoulders; lighter in weight and have an outstanding ability to survive in drought conditions (harsh environment). In dry seasons these camels are found in Al-showak and Gabat Al-feel (Gadaref state) and move to the north from New Halfa town (Kassala state) in the wet season. Rashaidi camels produce sufficient amounts of milk ranging from 2000 to 300 kg/ head / lactation (Wardeh, 1989; Kohler- Rollefson *et al.*; 1990, Al-Khoury and Majid, 2000). This breed is always found in small numbers and raised with other types of camels. It is owned by Rashaida (Ishag *et al.*, 2011).

2.4.3. Lahwee camels:

The Lahawee camel breed type is found in Gedarif state and is bred by *Lahween* tribe. The distinguishing colours are brown, red and yellowish. The hair is medium length, the hump is centrally placed with an erect or bent to the side orientation and the size of udder and teat is medium (Plate 3, appendices). These camels are usually found in Al-showak and Gabat Al-feel (Gadaref state) in dry

seasons and move to Al-soubag area in the wet season. This breed is always found in small numbers and raised with other types of camels. It is owned by *Rshaida* and *Lahween* tribes (Ishag *et al.*, 2011) .

2.4.4 Bishari camels:

Bishari camel breed type is owned by *Bija*, and *Hadandawa*, is slightly stronger and sturdier than the Anafi (Gillepsi,1962). The breed is mainly found in eastern Sudan (Kassala and Gadaref states). It is bred by *Bishareen*, *Amarar*, *Beni Amir* and *Hadendowa* tribes. It is also bred with other tribes (*Shukria* and *Lahween*) in small numbers with other types. This breed is distinguished by its white or yellowish coat colour, short hair and concave face profile. The hump size is small to medium, located in the middle of the back, and with erect orientation. They are very famous for their racing ability (Wardeh, 1989). These animals are stronger and slightly larger than the Anafi breed type Plate 4, appendices). Al- Khouri and Majid (2000) described the Bishari camel as having short and strong legs, fine and thin skin and white to yellow colour. Bishari camels are characterized as being of small size; the udder and teats of Bishari camel are of small size (Mohamed, 2009).

2.4.5 Anafi camel:

The Anafi breed type of camel is generally found in Gadaref state (Eastern Sudan), Gezira and Sinnar states. This breed is always found in small numbers and raised with other types of camels. It is bred by and owned by *Rshaida*, *Lahween* tribes (Gadaref state) and *Shukria*. The white colour is predominant in this breed, but animals with yellowish colour are also found. The hair is short and soft and the hump is small, erect and located in the middle to the back (Plate5, appendices). The animals have small size udders and teats (Ishag *et al.*, 2011).

2.4.6. Dual purpose camels:

This group is characterized by medium body size, average milk production of 1000–1500 kg/lactation, and relatively high rate of weight gain when feed and

water are available . This group is also characterized by medium hump (Wardeh and Ould El Mustafa, 1990). Most of the pack and riding camels fit to this category, and most of Sudanese camel breed types are categorized under this group (Wardeh, 2004). Hussein (1987) mentioned that Sifdar and Eyddimo breeds in Somalia are members of this group, both of them produce 1000 kg during 6–10 months lactation.

2.5. Camel milk:

Camels can produce more milk and for a longer period of time than any other dairy animal reared under the same harsh condition (Farah *et al.*, 2007). Milk yield varies with the breed, stage of lactation and management conditions, as is true for other dairy animals (Farah and Fischer, 2004; Faye, 2005). There are many factors that might influence milk production such as camel breed, nutritional factors and stage of lactation. Milking practice such as calf suckling, milk frequencies, milking performance methods and drinking water availability can also influence milk production (Ramet, 2001). Camel milk is usually opaque-white in colour and has an acceptable taste (Yagil *et al.*, 1980; Alwan and Igwegbe, 2013). The milk normally has a sweet and sharp taste, but sometimes can also have a salty taste due to the type of plants eaten in the desert by the camels (Rao *et al.*, 1970; Khaskheli *et al.*, 2005; Alwan and Igwegbe, 2013). According to Geberhiwet (1998), lactating camels are milked three times a day, producing about 9 liters per day in the wet season and 6 liters in the dry season. The duration of lactation is 12 months, but if the camel does not conceive it will give milk for a second year. Farah *et al.*, (2004) noted that camels are usually milked twice a day –morning and evening-, however, if the need arises they can be milked every 2–3 hours.

2.5.1: Camel Milk Proteins:

Total protein content of dromedary camel milk ranges from 2.15 to 4.90% (Konuspayeva *et al.*, 2009). Camel breed types and seasonal conditions affected camel milk protein content. Protein content was found to be similar for camel milk of the same breed types (Elamin and Wilcox, 1992; Sawaya *et al.*, 1984), while varied for other breeds. Haddadin *et al.* (2008) reported that protein content differ according to season for the same breed type [lowest (2.48%) in summer and highest (2.9%) in winter]. Camel milk protein can be classified into two main components:

2.5.1.1. Caseins:

Casein is a major part of protein in camel milk. It ranges between 1.63 to 2.76 % in dromedary camel milk and comprises 52 to 87% of total milk protein (Khaskheli *et al.*, 2005). In whole casein portion, β -CN is 65 % and α s1-CN is 21 % (Kappeler *et al.*, 2003). Camel milk has more digestibility and less allergic reactions in infants as α s-CN slowly hydrolyze than β -CN (El-Agamy *et al.*, 2009). Camel milk contains 3.47 % k-casein (Kappeler *et al.*, 2003) compared to 13 % in bovine milk (Davies and Law, 1980).

2.5.1.2. Whey proteins:

Whey proteins constitute 20 to 25 % of the milk proteins that make it the second biggest fraction of protein and range from 0.63 and 0.80 % in dromedary camel milk (Khaskheli *et al.*, 2005; Mehaia *et al.*, 1995). Camel milk β -lactoglobulin is found in traces, while α -lactalbumin comprises the major camel milk protein. In the milk of bovines, α -lactalbumin constitute only 25 %, while β -lactoglobulin make 50 % of the total whey protein that make it the major whey protein of bovine milk (Kappeler *et al.*, 2003; Laleye *et al.*, 2008). Whey protein of camel milk consists of some other main components such as peptidoglycan

recognition protein, immunoglobulins, lactoferrin and serum albumin (Kappeler *et al.*, 2004; Merin *et al.*, 2001).

2.5.2. Camel Milk Fat:

The fat content of dromedary camel milk is between 1.2 and 6.4% (Konuspayeva *et al.*, 2009). Haddadin *et al.* (2008) found a strong positive correlation between fat and protein contents. Fat content of camel milk was reported to decrease from 4.3 to 1.1 percent in milk produced by thirsty camels (Yagil and Etzion, 1980). According to Abu-Lehia (1989), dromedary camel milk fat contains smaller amounts of short chain fatty acids compared with bovine milk, and a lower content of carotene (Stahl *et al.*, 2006). This lower carotene content could explain the whiter colour of camel milk fat (Abu-Lehia, 1989). Higher contents of long chain fatty acids were also reported for dromedary camel milk fat compared with bovine milk fat (Konuspayeva *et al.*, 2008). Similarly, the mean values of unsaturated fatty acid content (43%) were higher in dromedary camel milk, especially the essential fatty acids (Abu-Lehia, 1989; Haddadin *et al.*, 2008; Sawaya *et al.*, 1984).

2.5.3. Camel Milk Lactose:

Konuspayeva *et al.* (2009) mentioned that the lactose content of dromedary camel milk ranged from 2.40 to 5.80%. Khaskheli *et al.* (2005) assumed that the wide variation of lactose content is due to the type of plants eaten in the deserts. Camels usually prefer halophilic plants such as *Atriplex*, *Salosa* and *Acacia* to meet their physiological requirements of salts (Yagil, 1982). Thus, camel milk is sometimes described as sweet, salty and at other times as bitter. Haddadin *et al.* (2008) mentioned that lactose content is the only component that remains almost with no change over the season, and under hydrated or dehydrated conditions (Yagil and Etzion, 1980). But dromedary breed types can influence lactose of

camel milk with slight changes in different part of the world (Elamin and Wilcox, 1992; Haddadin *et al.*, 2008; Mehaia *et al.*, 1995; Sawaya *et al.*, 1984).

2.5.4. Camel Milk pH:

Naturally the pH of fresh camel milk ranges from 6.5 to 6.7 (Khaskheli *et al.*, 2005; and Mehaia *et al.*, 1995), but a slightly lower pH of 6.4 can be recorded (A bu-Taraboush *et al.*, 1998; Yagil *et al.*, 1984) and 6.0 have also been recorded (El-Hadi *et al.*, 2006). The pH of camel milk is similar to that of sheep milk (Yagil *et al.*, 1984), but slightly lower than bovine milk (Sawaya *et al.*, 1984). The buffering capacity of skim camel milk was reported to be lower than that of bovine milk (Al-Saleh and Hammad, 1992). The highest buffering capacity reported for skim camel milk was at pH 4.95, whereas, bovine skim milk exhibited higher buffering capacity at pH 5.65.

2.6. Camel Milk Production:

Camels are commonly used as transport media across harsh environments for both man and goods (Mukasa-Mugerwa, 1981). They also play a main role as milk supplier for a longer period of time than any other species in the same environment (Farah *et al.*, 2007). However, it is difficult to estimate the daily milk yield of camel under pastoralist conditions owing to the inconsistency of milking frequency (Mukasa-Mugerwa, 1981). Most studies did not specify if milk yield included the part consumed by the calf or not Faye (2004) reported that the part consumed by the calf could reach an average of 40 % of the total milk production. Camel milk doesn't reach the urban markets; even those near to urban areas do not consider commercialization of camel milk . It is consumed locally by families and their animals, and does not reach the urban markets because most of the camel herds are located in the arid and desert areas which are far from the commercial markets.

Many factors affect camel milk yield such as genetic origin, environmental conditions and feeding management conditions (Abdelgadir *et al.*, 2013), number of lactation and stage of lactation (Al haj and Al Kanhal, 2010). Abdelgadir *et al.* (2013) observed that the highest milk yield was at the sixth and eighth parities and the lowest at the first and ninth parities. He also observed that the total milk yield ranged from 390 to 5310 liter with lactation length 6 to 19 months.

According to Dorsa (2005) the daily milk under open grazeing system and sedentary grazing system is 4.24 and 7.5kg respectively. The lactation period for Sudanese camel was reported to extend between 10 to 20 months. Average milk production during the lactation period varied from 1200kg, excluding the consumption of young offspring,(Wardeh,1989). Table (I) shows the milk production of camels, cows, goats and sheep in Sudan (FAOSTAT, 1999-2008).

Table (2.I): Milk production in Sudan during the period of 1999-2008 (ton)

Year	Milk production (ton)								Total	%
	Camel	%	Cow	%	Goat	%	Sheep	%		
1999	78	1.5	3500	66.8	1197	22.9	461	8.8	5236	100
2000	81	1.4	4000	69.1	1245	21.5	462	8.0	5788	100
2001	82	1.3	4500	71.5	1250	19.8	463	7.4	6295	100
2002	87	1.3	5000	73.0	1295	18.9	464	6.8	6846	100
2003	91	1.2	5494	73.9	1384	18.6	464	6.2	7433	100
2004	95	1.3	5384	72.2	1500	20.1	475	6.4	7454	100
2005	100	1.3	5480	72.2	1519	20.0	487	6.4	7586	100
2006	105	1.4	5274	72.2	1437	19.7	492	6.7	7308	100
2007	110	1.5	5292	71.9	1456	19.8	498	6.8	7356	100
2008	115	1.6	5309	71.7	1475	19.9	504	6.8	7403	100

Source: FAOSTAT, (1999-2008).

2.7. Camel meat:

Camel meat is cited as a good source of protein, with low fat content and cholesterol level. The camel meat has greater total protein than beef (Babiker and Tibin, 1986). Meat breed types include Arabi in Sudan which is referred to most pack camels in Sudan regardless of the source (Wilson, 1984). However, Al-Arabi is subdivided into three breed types, the light pack which is found west of the Nile and in the area of the Red Sea, where the *Hendiweneda*, *Beni Amer* and *AL-Omara* tribes keep it, and the big Arabi in the area of Butana where the three tribes of *Shokreya*, *Battahin*, and *Lahaween* exist. The third is the heavy Arabi camel which is characterized by its heavy by the development of the hindquarters, large hump, rigid body, relatively short neck and large head, and heavy bones and muscles (Wilson, 1984; Wardeh *et al.* 1990). Mohamed (2009) reported that most of the camels in North and East Africa are rolled under this group, among them Kabashi and Shanbali in Sudan. According to Idriss (2003), the production of camel red meat in Sudan increased from 1275000 tons in 1996 to 1624000 in 2002.

2.8. Management system:

Sudanese camel herders, locally known as *abbala* adopt one of three production systems (Eisa and Mustafa, 2011) including: the traditional nomadic system, transhumant or semi-nomadic system and sedentary management system. These systems are similar to those reported in Pakistan by Iqbal (2010) and Aujla *et al* (1998). In Sudan, semi-intensive system had been practiced recently in Khartoum state for commercial camel milk production (El Zubeir and Nour, 2006).

2.8.1. The traditional nomadic management system:

The traditional nomadic system is characterized by continuous mobility for both family and camel herds through the year. In this system nomads move from one

place to another following certain migratory routes in response to availability of grazing and water. This system is adopted by *Kababish* tribes in Sinnar and North Kordofan states (Mukasa-Mugerwa, 1981; Ishag and Ahmed, 2011).

2.8.2. The semi-nomadic management system:

The semi-nomadic system, also called transhumant system, is practiced by semi-nomadic tribes (Ishag and Ahmed, 2011). This system is found in the eastern and southern parts of the camel belt in Sudan (Al Khouri and Majid, 2000; Bakheit , 1999; Abbas *et al.*, 1992). It is mainly adopted in Gadarif and Butana areas by semi-nomadic tribes such as Lahween, Kawahla and Rashaida tribes (Mohamed, 2009). This system is characterized by two phases, the first is the mobile phase in which young men travel during the dry season with their animals fetching for water and feed, while families are settled in villages, and the second phase when camel herds come home and stay around the villages especially in the rainy season (Al Khouri and Majid, 2000).

2.8.3. The sedentary management system:

The sedentary system is practiced in the eastern region of Sudan (east of River Nile and west of the Red Sea hills), it is also found in the agricultural areas in the central and southern parts of the camel belt (Al Khouri and Majid, 2000). Ishag and Ahmed (2011) mentioned that the sedentary system is adopted by the majority of camel owners in Sudan.

2.8.4. The semi-intensive management system:

The semi-intensive system had recently been established in Sudan as a commercial investment in the pre-urban areas in Khartoum state (Eisa and Mustafa, 2011). In this system camels are kept in open fences with continuous

water supply through pipelines and good feed quality including concentrate supplements are provided. Camel herders from natural pastures of Kordofan and Darfur states select a group of lactating she-camels and keep them in west Omdurman for producing milk in commercial quantities (Mohamed, 2009).

2.9. Camel Feeding:

The camel is a multi-purpose domestic livestock species, well adapted to arid zones, capable to feed in areas where other species thrive or do not survive. Camel's size helps it to eat at higher levels above the ground than cattle, sheep and goats. Mouna (2006) and Zaroug(2005) reported that range vegetation provided by clay soil such as Butana area trees and shrubs serve livestock feed in the form of leaves, twigs and pods during the long dry season when forages and grasses both are rarely found or in poor quality. Rutagwenda *et al.*, (1989) observed that unlike cattle, camels are able to seek out herbs, fruits and succulent leaves of a great variety of plants. Wilson, (1984) stated that when camels are bred extensively they are economic utilizes of rangelands. They usually browse on multi plants by taking a few bites then move to another. **Dereje and Uden (2005)** also noted that camels do not eat for a long time from one plant regarding to its density, but they move continuously, taking small bites of each plant. During the dry season especially, camels spread out during browsing, resulting in low pressure on each plant. The camel spends 8 to 10 hours grazing daily, irrespective of whether the pasture is good or poor. During summer, camels feed mainly at night especially during moonlight nights, and then rest from morning until afternoon wherever they have to bed down. The highest food consumption of 30 – 40 kg fresh forage (8–12 kg dry matter) is found on salty pastures, and the lowest food intakes (5 kg/day) are noted from dried grass pastures (Grenot, 1992) .A camel requires 8-10 hours of

grazing daily to be satisfied; this depends on breed, body size and feed availability. Comparison of feeding of camels with cattle, goats and sheep is given in table (I).

Table (2.2): Feeding of camel compared to other livestock

Livestock type	Preferred forage plant	Number of forage plants consumed*, %	Height of browse above ground level, m	Watering interval (days)
Camel	Trees and shrubs	170	3.5	10-14
Goats	Trees and shrubs	184	1.6	3-4
Sheep	Herbs and grasses	142	1.2	3-4
Cattle	Grasses	100	1.5	2

Source: Schwartz (1989)* Number of plants used by cattle is 100%

2.10. Camel Water Requirements:

Camels have remarkable ability to go without water for long periods in extremely harsh conditions and can flourish where no other domestic animal can survive, as in the desert. Camels can go without water during all winter season grasping green plants having high water content. This exceptional ability is the result of several anatomical and physiological characteristics. During the six or seven cool months in Sahara regions camels do not drink even if water is offered to them. Where green forage is available in mid climates, the camel may go several months without drinking (Ramet, 2001). Camels under very hot conditions may drink only once every eight to ten days and lose up to 30 percent of body weight through dehydration (Yagil and Etzoin, 1980; Yagil, 1982; Wilson, 1984; Yagil, 1985). Depending on the time of the year, an average size camel can drink 30-40 liters of water per day (Camels Australia Export2001). Water requirement is very much dependent on the type of grazing available and on the environmental temperature. Camels move constantly to where better feed exits, The animals are kept where the distance to water is not usually more than two days camel walk, and pastoralists prefer to water camels between 9:00 am and 3:00 pm. However, the

ability of the camel to survive a long time without drinking water should not obscure the fact that during prolonged dry seasons, camel owners face problems of water crises when there are long hours of walking between watering points and grazing areas. Sometimes herders spend one or two nights between watering sites and their dwelling sites (Ahmed *et al.*, 2006). Upton (1986) reported that unsuitable distribution of water points for live stock could limit rangeland use leading to partial overgrazing and partial under-utilization of rangeland Grenot (1992) reported that dehydrated camels were found to produce milk of higher water content and lower fat content when compared with the milk of fully watered camels. The ability of water retention in the camel body is truly, remarkable and based on many factors. Camels don't over heat, can hold up water loss and reserve fat in the hump for use in deprivation time of food and water. The camel can withstand more than 22 to 30 % water loss from its body mass, conversely, a thirsty camel on a hot summer's day has been observed to drink 27 gallons in minutes and re-hydrate very quickly (Schmidt-Nielsen, 1964; Schmidt-Nielsen, *et al.*, 1967). In Sudan Köhler *et al.*, (1991) found that Rashaidi camels need watering approximately once every six days. Watering interval vary in different seasons and climatic regions due to air temperature, type of nutrition and availability of water. According to Gauthier-Pilters *et al.* (1981) stock water is a limitation during the dry season, particularly in areas underlain by basement complex rocks (non-water bearing rocks) as in the case of Butana, Hamar district, Beja district and eastern Darfur. All these areas are important grazing land where pastoralis perform their major economic activities. Most pastoralists utilize these areas as wet season grazing land and move out before the surface water in natural ponds and dugouts is exhausted. The expansion of irrigated agriculture in Butana (New Hallfa and Rahad Scheme) provides additional sources of water through the network of canals that supply crop land with irrigation water. In a few cases water is transported by

tankers to meet commercial herd requirements during the dry seasons so that live stock will be able to utilize the large quantities of dry grass available in water deficient areas.

2.11. Breeding Management:

The breeding system is based on successful management of mate breeding camels Drosa (2005). Elmi (1989) reported that selected female camels are bred twice a year if no drought occurs, and selection of future breeding males starts at birth based on the ancestor's history. The selection process starts with choice of two to three male calves; special care is given to them. A camel female can be bred for about 22 years, 10 calves can be produced within these years period. Pregnancy lasts from 12 to 13 months in the dromedary camels the male reaches sexual maturity at seven years and is capable of serving 10 females, 10 services per day (including the night) (Ahmed *et al.* 2006) . A single male can successfully serve 60 to 67 females in breeding. Rutting bull camel will be able to identify female in heat by smelling female's genital area and by observing symptoms such as restlessness and urination (Wardah, 2004; Ahmed *et al.*, 2006).

Jasara (1998) and Farah *et al.*, (2004) noted that normally camels are sexually mature at the age of 4-5 years based on the type of breed and forage situation, however Somali camel herders rarely let them mate before they reach physical maturity at five to six years. In the other hand, Wardah (1989) mentioned that in Sudan the female camel reaches sexual maturity at the age of 3 years, but usually ready for fertility at the age of 4 to 5 years, accordingly a female camel has her first calf at 6-7 years under normal conditions. Thus, a female camel that gives birth every each year will have eight to ten calves in her breeding life of around 25 to 30 years. According to Skidmore (2005) there are many factors affecting age at puberty including nutrition, season of birth and breed of camel.

Pastoralist can detect pregnancy within 15 days of mating by observing the following signs: coiling of the tail towards the hump, frequent urination ,the head is raised with ears pointed straight and the long neck is curved back to shoulder when male camel or man approaches (Gebrehiwet,1998) .Zafuar (2000) noted that two to three weeks after copulation, successfully mated females will stand with their tails curved when approached by males.

Weaning of calves is at the age of 8-18 months, depending on the browse situation, the milk production of the dam, and the growth of the calf and future use of the calf (sale or slaughter) (Farah *et al.*, 2004). There are several different systems of weaning practiced by Somali herders, of which the most prominent is tying the dam's teats with a softened bark; this practice is common in Sudan where it is called (*sorar*). Each female camel only gives birth every each year. The gestation length is 12 to 13 months followed by 12 months nursing period (Lapidge *et al.*, 2006). Jasara and Bani (2000) reported that the majority of pastoralists reported that the weaning period is one year.

Observation of Schwartz (1992) and Farah (1995) indicated that calf management is considered important by herders and is given considerable attention. This is revealed by the fact that 96% of the calving is attended so as to intervene in case of problems such as dystocia. The respondents (68%) on the studies by Farah (1995) also indicated first suckling as taking place between one and three hours post calving. In addition, herders consider sufficient milk supply, provision of water during the dry season, provision of good pasture and tick control as important calf care measures. However, in agreement with the observations of Schwartz (1992) and Farah (1995), the majority of the respondents (75%) did not allow their calves to access initial colostrum, but instead milked it

out. This arises from a belief that colostrum will result in ill-health to newborn calves.

CHAPTER THREE

MATERIALS AND METHODS

3.1: Study area:

The study was conducted in different locations in Butana area (Gadarif, Showak (Sharif Hassab Allah, Um-gargoor and Alsobagh). The Butana plain is a semiarid clay region that covers most of the present Kassala and Gedaref States in Eastern Sudan. It lies between latitude 13° 40' and 17 ° 50' North and longitude 32 ° 40' and 36 ° 00' East. It is bound by the main River Nile on its northwestern border, the Blue Nile on its southwestern edge, the Atbara River in the northeast and by the railway connecting Kassala and Sennar on the south. The area is composed of mountainous ranges intersecting the plain to the western and southern borders. It is crossed by many seasonal rivers namely, Atbara, Seitite, Ba-Salam, Gash and Rahad Rivers. Small temporary seasonal valleys run through these plains during the rainy season. The rocky basement complex forms the geological underlining of Butana plains with sandy and stony soils in the north, light non-cracking clay in the central, eastern and western regions and dark cracking clay in the south. As a result of this and with the exception of small water catchments in the mountains mentioned before, very limited water resources are available. Seasonal shallow surface water wells are present as well as few very deep bore wells. However, the amount of water and the persistence of reserves during the summer dry season depend on the quantity of rainfall during the wet season. In the Butana, a tropical continental climate prevails ranging from a sub-equatorial condition with rain in the south to desert climate in the north. Most of the rains are in the form of showers or thunderstorms. The rainfall in Butana region is highly variable from one year to the other. It ranges between 600 mm/year in the southeast to less than

100 mm/year in the northwest. As always in the semiarid regions, rainfall is the most important climatic factor in Butana because people and their livestock depend on this factor which supports the growth of the vegetation for their animals. The annual mean temperature ranges from 32 °C during the day to 16 °C at night in January (winter) and from 46 °C during the day to 27 °C at night in May-June (summer). Two vegetation zones are existing in the area, namely semi-desert Acacia shrub and short grasslands of the North Central Sudan and secondly, the low woodland savannah of Central Sudan. The vegetation of Butana is constantly changing as a result of annual rainfall, accidental fire outbreaks and expansion of agriculture and grazing (Saint-Martin *et al.*, 1992). The Butana area is inhabited by transhumant camel owning tribes in its northern part while its southern part is populated by agro-pastoralists who practice mainly mechanized rain-fed agricultural activities for production of sorghum and sesame grains besides considerable livestock raising activities. However, irrigated agricultural schemes also exist in the northern and south-western borders of the study area comprising the New-Halfa and Rahad Agricultural Schemes. These schemes were mainly established as government efforts aimed towards encouraging settlement of the transhumant livestock nomads inhabiting Butana region as well as diversifying the activities of these pastoralist people towards agropastoralism (Abbas *et al.*, 1992; Saint-Martin *et al.*, 1992). Camel grazes in Butana on different types of browsed plants includes trees (Sunut, Samar, Kitir, Sayyal, Salam, Lao'at and Sidir), legumes (Tabar, Hantout, Diraisa, Shara and Siha), grasses (Dobalab, Tumam and Ghabash), bushes and shrubs (Tondub and Kormut) known to grow in Butana area (Darosa and Agab, 2005).

3.2. Questionnaire:

A set of detailed structured questionnaire was used to collect information from a total of 60 camel owners in different locations in Butana area.. The questionnaire was designed to obtain information on general household information, relation with camels and life mode of camel owners, purposes of keeping and rearing camels, breeding practices, milk production and milking practices, feeding and watering, constraints of camel production and veterinary services. An interview was conducted over single visits (Appendix.1)

3.3. Sex and Age Groups:

For the purpose of study of the effect of breed types, sex and age group on some of the body measurements of the five Sudanese camel breed types, two hundred and eighty (280) heads of Sudanese camels were randomly selected from Gadarif state and divided into five breed types [Bishari (n=40), Arabi (n=50), Daili (n=70), Anafi (n= 60) and Kenani (n=60)], according to sex (males=108 and females=72) and according to six categories of age groups [≤ 3 years (n=40), 3-5years (n=40), 6-7 years (n=62), 8-9 (n=61), 10-12 years (n=47) and ≥ 12 (n=30)].

3.4. Milk Sampling and Collection:

In June 2012, camel milk samples were randomly taken from she-camels in different parity numbers (one to fifth) and different breed types (Anafi n=10, Kenana n=20, Daili n=12 and Arabi n=18). She-camels were milked individually in milk pots and (40 ml) of milk samples from the 60 camels were transferred separately to sterile clean plastic containers milk samples were kept in ice in a thermo flask until analysis. Milk yield data was taken from herders.

3.5. Milk Analysis:

The determination of density, conductivity, freezing point, pH, fat, solids non fat, lactose, protein and ash were done using automatic milk analyzer device Lactoscan™ ,model name: LA, Bulgaria.



Figure (3.1): Automatic Milk Analyzer Device (Lactoscan™)

3.6. Body Measurements:

Body measurements of different camel breed subtypes were determined. The following measurements were taken by a metric tape.

Height at wither: Tip from the ground level to the highest point of the wither.

Heart girth: taken immediately behind the breast pad.

Barrel girth: taken over the highest part of the hump.

Neck length: taken from the point of the shoulder to the base of the neck.

Face length: measured from tip of the poll to the muzzle.

Tail length: from the 1st coccegal vertebra to the end of the tail.

Body weight: bodyweight of animals was estimated according to the Boue (1949) formula as follows:

$$P = 53 \text{ TAH}$$

Where: P = body weight (kg)

T = heart girth or chest (m).

A = barrel or abdominal girth (m).

H = shoulder height (m).

3.7. Statistical Analysis:

SPSS programs was used in this study, general leaner model was used in a factorial design (5x2x4), to show the effect of parity and breed types on milk yield and chemical component. The questionnaire results were analyzed mainly in the form of descriptive tabular summaries.

CHAPTER FOUR

RESULTS

4.1: Effect of parity on physicochemical components of Sudanese camel's milk:

The mean values of camel milk yield and components that were affected by parity number showed significant differences in milk yield, fat, SNF and protein ($P < 0.05$) content in different parities table (4.1). While, density, lactose, ash, temperature, freezing point conductivity and pH showed no significant differences were found ($P > 0.05$). Fourth and third parities show higher milk yield (12.53 and 11.38 pounds respectively) while first lactation showed the lowest (8.94 pounds).

The study found that the Fat, SNF and protein content gradual decrease by subsequent parity except in second lactation. Starting from the third lactation, fat, SNF and protein content showed gradual decrease. The milk in the first parity showed the highest fat content (4.06) while no significant different was observed in fat content from second to fifth lactation, however, there was a slight decrease in fat content from 3.61 to 3.49 %. The first and second lactation showed highest SNF (7.86 and 8.1 % content) respectively while the other lactation showed no significant differences ($P > 0.05$).

The results indicated that no significance ($P > 0.05$), variations observed in density, lactose, ash, freezing point and PH of the camel milk samples. Table (4.1).

Table (4.1): Effect of parity number on milk yield and components

Different superscript letters in the same column means significant at $P < 0.05$

Parity	Milk yield	Fat	SNF	Density	Lactose	Ash	Protein	Sample Temp.	Freezing point	Cond.	pH
1 st (N=16)	8.94± 2.77 ^b	4.06± 2.75 ^a	7.86± 0.36 ^{ab}	27.5± 1.21	4.32± 0.27	0.58± 0.08	2.87± 0.13 ^{ab}	14.16± 4.09	0.51± 0.02	7.78± 1.25	6.66± 0.15
2 nd (N=8)	9.88± 2.75 ^{ab}	3.61± 0.44 ^{ab}	8.1± 0.39 ^a	28.6± 1.44	4.61± 0.24	0.6± 0.1	2.96± 0.14 ^a	14.22± 3.29	0.51± 0.03	6.74± 0.93	6.65± 0.05
3 rd (N=16)	11.38± 3.1 ^a	3.37± 0.92 ^b	7.62± 0.61 ^{abc}	27.13± 1.99	4.34± 0.5	0.58± 0.06	2.78± 0.22 ^{abc}	12.67± 4.84	0.47± 0.05	8.23± 1.75	6.62± 0.13
4 th (N=15)	12.53± 4.29 ^a	3.25± 0.98 ^b	7.54± 0.68 ^b	26.92± 2.29	4.45± 0.54	0.6± 0.05	2.75± 0.25 ^b	13.26± 5.3	0.48± 0.04	7.8± 1.39	6.59± 0.08
5 th (N=5)	10.6± 1.95 ^{ab}	2.67± 0.86 ^b	7.18± 0.97 ^c	25.94± 3.38	4.4± 1.09	0.56± 0.06	2.62± 0.35 ^c	12.34± 6.48	0.47± 0.07	8.41± 2.59	6.66± 0.13
Over all	10.75± 3.44	3.49± 0.91	6.69± 0.62	27.26± 2.02	4.4± 0.5	0.59± 0.07	2.81± 0.22	13.39± 4.64	0.49± 0.04	7.82± 1.56	6.63± 0.12
Significant	*	*	*	NS	NS	NS	*	NS	NS	NS	NS

*: significant at $P < 0.05$, NS: not significant

4.2: Effect of breed types on some physicochemical components of Sudanese camel's milk:

Results in table (4.2), present effect of breed types on physicochemical milk components. The breed types were significantly ($P < 0.05$) affected the conductivity, freezing point, milk yield, fat, lactose, ash, SNF and Protein contain of camel milk. Kenana type showed the highest milk yield (13.05 pound) but it is not different from Anafi type (11.5 pound) whereas Arabi (8.67 pound) was lower than Daili (9.58 pound). Fat, SNF, lactose, ash, protein and freezing point in Anafi type showed the lowest level compare to other types. Also the results showed that Anafi was the highest (9.25) in conductivity while Daili was the lowest (6.95) with no significant difference ($P > 0.05$) between Kenana (7.98) and Arabi (7.45).

Table (4.2): Effect of breed type on milk yield and components of Sudanese camel breed typed

Type	Milk yield	Fat	SNF	Density	Lactose	Ash	Protein	Temperature	Freezing point	Conductivity	pH
Anafi (N=10)	11.50± 2.51 ^{ab}	2.53± 0.76 ^b	7± 0.59 ^b	25.38± 1.84	3.91± 0.43 ^b	0.57± 0.08 ^b	2.57± 0.21 ^b	10.24± 2.27	0.43± 0.04 ^b	9.25± 1.3 ^a	6.62± 0.1
Kenana (N=21)	13.05± 3.41 ^a	4.04± 0.64 ^a	8.1± 1.31 ^a	28.44± 4.88	4.45± 0.72 ^a	0.66± 0.11 ^a	2.96± 0.48 ^a	13.60± 4.93	0.5± 0.04 ^a	7.98± 1.36 ^b	6.62± 0.12
Daili (N=12)	9.58± 2.97 ^b ^c	3.49± 0.69 ^a	7.97± 0.55 ^a	28.21± 1.69	4.57± 0.39 ^a	0.56± 0.05 ^b	2.91± 0.2 ^a	12.58± 3.53	0.5± 0.03 ^a	6.95± 1.2 ^c	6.63± 0.1
Arabi (N=18)	8.67± 2.63 ^c	3.53± 1.05 ^a	7.73± 0.49 ^a	27.45± 1.5	4.69± 0.54 ^a	0.55± 0.06 ^b	2.83± 0.18 ^a	15.14± 5.23	0.5± 0.03 ^a	7.45± 1.6 ^{bc}	6.65± 0.13
Over all	10.82± 3.45	3.53± 0.94	7.79± 0.94	27.6± 3.28	4.46± 0.62	0.59± 0.09	2.85± 0.34	13.3± 4.65	0.49± 0.04	7.83± 1.55	6.63± 0.12
Significant	**	**	*	NS	**	**	*	NS	**	**	NS

Different superscript letters in the same column means significant at P<0.05

** : significant at P<0.01

* : significant at P<0.05

NS: no significant

4.3: Correlation between studied parameters of camel milk:

All parameters freezing point, density, fat, SNF, lactose, ash and protein were positively correlated (P< 0.01) table (4.3). But between fat and lactose, fat and ash were positively correlated (P< 0.05). The correlation of each parameter with the added water and conductivity was negatively highly significant (P<0.01).

Table (4.3): Milk components correlation matrix of some Sudanese camel breed types (n=60)

	Age	Milk yield	Fat	SNF	Density	Lactose	Ash	Protein	Added water	Temperature	Freezing point	Cond.	pH
Age	1	0.358**	-0.251	0.106	0.177	0.231	0.306*	0.114	.0311*	-0.243	-0.282*	0.126	-0.234
Milk yield	-	1	-0.038	0.096	0.116	-0.127	0.386**	0.099	0.029	-0.135	-0.111	0.180	0.148
Fat	-	-	1	0.578**	0.419**	0.306*	0.317*	0.567**	-.659**	-0.180	0.455**	-0.316*	-0.004
SNF	-	-	-	1	0.980**	0.684**	0.667**	1**	-0.726**	-0.236	0.541**	-0.376**	0.067
Density	-	-	-	-	1	0.698**	0.676**	0.982**	-0.652**	-0.219	0.504**	-0.343**	0.083
Lactose	-	-	-	-	-	1	0.546**	0.684**	-0.39**	0.131	0.593**	-0.195	0.043
Ash	-	-	-	-	-	-	1	0.67**	-0.298*	0	0.219	0.099	-0.092
Protein	-	-	-	-	-	-	-	1	-0.722**	-0.237	0.537**	-0.375**	0.063
Added water	-	-	-	-	-	-	-	-	1	0.18	-0.758**	0.589**	-0.108
Temperature	-	-	-	-	-	-	-	-	-	1	0.025	0.304*	0.131
Freezing point	-	-	-	-	-	-	-	-	-	-	1	-0.479**	0.236
Conductivity	-	-	-	-	-	-	-	-	-	-	-	1	-0.152
pH	-	-	-	-	-	-	-	-	-	-	-	-	1

** : correlation is significant at $P < 0.01$

* : correlation is significant at $P < 0.05$

4.4: Effect of camel breed types, sex and age on some body measurements:

The data in table (4.4), present the means and standard errors of the body measurements of some Sudanese camel breed types. The results of this study revealed that averages of height at wither, heart girth, barrel girth, neck length, face length, tail length and body weight were 1.85 ± 0.02 m, 2.02 ± 0.02 m, 2.52 ± 0.02 m, 1.13 ± 0.01 m, 58.84 ± 0.28 cm, 68.60 ± 0.42 cm and 512.30 ± 7.84 kg respectively. With except of heart girth and face length ($P < 0.05$) the effect of camel breed types had high significant ($P < 0.01$) on the other studied body measurements parameters. Rashaidi camel showed the lowest records in height at wither and tail length while Bishari, Arabi and Anafi camel breed types showed no significant differences ($P > 0.05$) in height at wither and tail length. Kenani camel had highly significant ($P < 0.01$) in height at wither, barrel girth, neck length, tail length and body weight. Also Kenani showed the highest value in heart girth (2.14 m). Moreover Rashaidi and Bishari ranked second and third record, while Anafi and Arabi breed types showed the lowest value in heart girth 1.97 and 1.94 m. In barrel girth Bishari and Anafi recorded the lowest value whereas Rashaidi and Arabi showed higher rank than them.

Also, the sex of camel had a significant influence on heart girth ($P < 0.01$), face length and body weight ($P < 0.05$), while height at wither, barrel girth, neck length and tail length was insignificantly ($P > 0.05$) affected by sex. The data also showed male camels had higher body measurements than females.

In addition the results showed that the age of camel had high significant ($P < 0.01$) effect on each measured parameters. The studied traits tend to increase from the 1st age group (≤ 3 years) to the 4th age group (8 – 9 years) and then decreased.

Table (4.4): Effect of breed, sex and age on some Sudanese camel breed types

Height at wither (HW), Heart girth (HG), Barrel girth (BG), Neck length, (NL), Face length								
Main effect	No.	HW (m)	HG (m)	BG (m)	NL (m)	FL(cm)	TL (cm)	BW (kg)
Breed		**	*	**	**	*	**	**
Bishari	40	1.83±0.04 ^b	1.99±0.04 ^b	2.37±0.06 ^c	1.08±0.03 ^{bc}	58.58±0.67 ^{ab}	67.58±1.02 ^b	459.13±18.97 ^{bc}
Arabi	50	1.82±0.03 ^b	1.94±0.04 ^b	2.52±0.06 ^b	1.07±0.03 ^c	57.74±0.64 ^c	67.79±0.97 ^b	492.04±18.04 ^b
Rashaidi	70	1.72±0.03 ^c	2.10±0.03 ^a	2.61±0.05 ^{ab}	1.10±0.03 ^{bc}	60.58±0.54 ^a	66.26±0.82 ^b	504.85±15.16 ^b
Anafi	60	1.81±0.03 ^b	1.97±0.03 ^b	2.41±0.05 ^c	1.19±0.03 ^b	58.17±0.57 ^b	69.56±0.87 ^b	464.83±16.11 ^c
Kenani	60	2.08±0.04 ^a	2.14±0.04 ^a	2.73±0.06 ^a	1.24±0.03 ^a	59.44±0.66 ^a	71.91±1.01 ^a	658.09±18.70 ^a
Sex		NS	**	NS	NS	*	NS	*
Male	108	1.90±0.03	2.08±0.03	2.54±0.04	1.16±0.02	59.73±0.47	69.54±0.71	541.95±13.28
Female	172	1.81±0.02	1.97±0.02	2.50±0.03	1.11±0.02	58.05±0.32	67.75±0.48	485.68±8.91
Age group		**	**	**	**	**	**	**
≤ 3years	40	1.59±0.02 ^d	1.67±0.03 ^d	2.11±0.04 ^d	1.01±0.04 ^b	52.18±0.86 ^c	60.23±0.96 ^d	301.78±12.74 ^d
3-5yrs	40	1.76±0.03 ^c	1.85±0.05 ^c	2.44±0.06 ^c	1.11±0.02 ^a	58.85±0.44 ^b	67.33±0.72 ^c	423.96±17.39 ^c
6-7yrs	62	1.83±0.03 ^{bc}	2.02±0.02 ^b	2.53±0.05 ^{bc}	1.14±0.02 ^a	60.08±0.38 ^{ab}	68.84±0.70 ^b	497.40±13.59 ^b
8-9yrs	61	1.90±0.03 ^{ab}	2.10±0.02 ^{ab}	2.70±0.03 ^a	1.15±0.02 ^a	60.21±0.33 ^a	71.34±0.64 ^a	554.00±16.02 ^a
10 – 12 yrs	47	1.85±0.03 ^{bc}	2.09±0.02 ^{ab}	2.69±0.04 ^{ab}	1.14±0.02 ^a	60.09±0.45 ^{ab}	70.49±0.73 ^{ab}	552.98±15.14 ^a
≥12 yrs	30	1.84±0.05 ^{bc}	2.05±0.05 ^a	2.64±0.04 ^{ab}	1.13±0.04 ^a	60.03±0.32 ^b	69.67±0.94 ^{bc}	550.24±26.58 ^a
Breed X sex		**	NS	NS	NS	NS	NS	**
Breed X Age		**	NS	NS	NS	**	**	**
Sex X Age		NS	NS	NS	NS	NS	NS	NS
Over all		1.85±0.02	2.02±0.02	2.52±0.02	1.13±0.01	58.84±0.28	68.60±0.42	512.30±7.84

(FL), Tail length (TL) and Body weight (BW)

Different superscript letters means within the same column are significantly different at (P<0.05)

** : Significance different P<0.01

* : Significance different P<0.05

NS: No significant

4.5. Effect of interaction between breed and sex on some body measurements:

The height at wither and body weight were significantly (P<0.01) affected by interaction between breed, sex.

4.6. Effect of interaction between breed and age on some body measurements:

Also height at wither, face length, tail length and body weight were significantly ($P < 0.01$) affected by interaction between breed, age,

4.7. Effect of interaction between sex and age on some body measurements:

The interaction between sex, age had insignificant effect ($P > 0.05$) on studied body measurements.

4.8. General household information:

The results shown in tables (4.5, 4.6, 4.7, 4.8 and 4.9) revealed that most of camel owners were above 40 years old followed by those of 31 – 40 years old, while those of 21-30 years old were less than 2% (table 4.5). About 65 % of camel owners were illiterate followed by those who completed primary school and khalwa while the lowest percentage recorded by high secondary school (5%) (table 4.6). The main activities of respondents said that 60 % of them practice rearing camels and farming, while only 38.3 % said rearing camels. (table 4.7). Moreover the majority of camel owners had experience more than 20 years 71.7 % followed by about (22 %) those have experience between 10 to 20 years while 6.7 % have less than 10 years of experience (table 4.8). The majority of camel owners bred camel, sheep (48.3 %) and 10 % of them reared all animals types (camel, cattle, sheep and goat) followed by those who owned camel, goat (3.3%) and less than 2 % who owned camel, cattle (table 4.9).

Table (4.5): Age classes of camel owners.

Age	No	%
21-30 years	1	1.7
31-40 years	20	33.3
more than 40 years	39	65.0
Over all	60	100.0

Education level	No	%
Illiterate	39	65.0
Khalwa	7	11.7
Primary	11	18.3
High secondary	3	5.0
Over all	60	100.0

Table (4.6): Education level of camel owners:

Table (4.7): Main activities of camel owners:

Type of activity	No	%
Rearing Animals	23	38.3
Farming	1	1.7
Both	36	60.0
Over all	60	100.0

Experience (year)	No	%
less than 10 years	4	6.7
10-20 years	13	21.7
more than 20 years	43	71.7
Over all	60	100.0

Table (4.8): Years of experience of camel owners

Table (4.9): Livestock species in the studied area.

Livestock species	No	%
Camel	22	36.7
Camel, cattle	1	1.7
Camel, goat	2	3.3
Camel, sheep	29	48.3
All animal types	6	10.0
Over all	60	100.0

4.9. Relation with camel and life mode of camel owners:

The results showed that about 66 % of the respondents are profession in camels rearing, followed by amateur and investor which have the 2nd and 3rd rank in

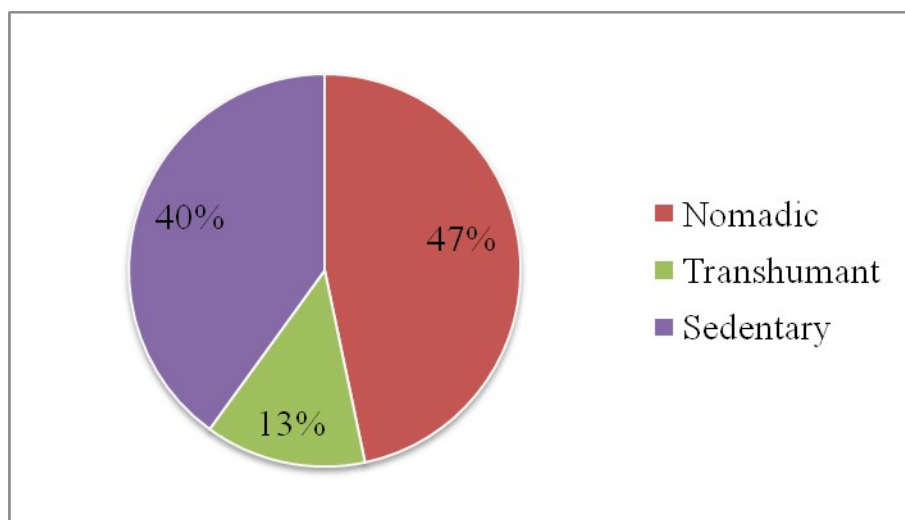
camel relation, whereas herd man (camel man) recorded 5 % (table 4.10). On the other hand about 46 % of camel owners adopted the nomadic system, followed by those adopted the sedentary system (40%), while transhumant system adopted by 13 % of camel owners (figure 4.1).

4.10. Purposes of keeping and rearing camels:

The results revealed that 65 % of camel owners rearing camels as life manner while 18.3 % rearing it for economic facilities followed by 15 % who keep camels for saving money, while less than 2 % as a social mode (figure 4.2). Moreover about 7 % of camel owners bred camel for racing but the majority 63 % bred camel for milk and meat, while 30 % bred camels for all mentioned purposes (table 4.11).

Table (4.10): Relationship between owners and camels.

Type of Relationship	No	%
Profession	40	66.7
Amateur	10	16.7
Investor	7	11.7
Herd man	3	5.0
Over all	60	100.0



Purpose	No	%
Racing	4	6.7
Milk, meat	38	63.3
All mentioned	18	30.0
Over all	60	100.0

Figure (4.1): life mode of camel owners

Table (4.11): purpose of rearing camels

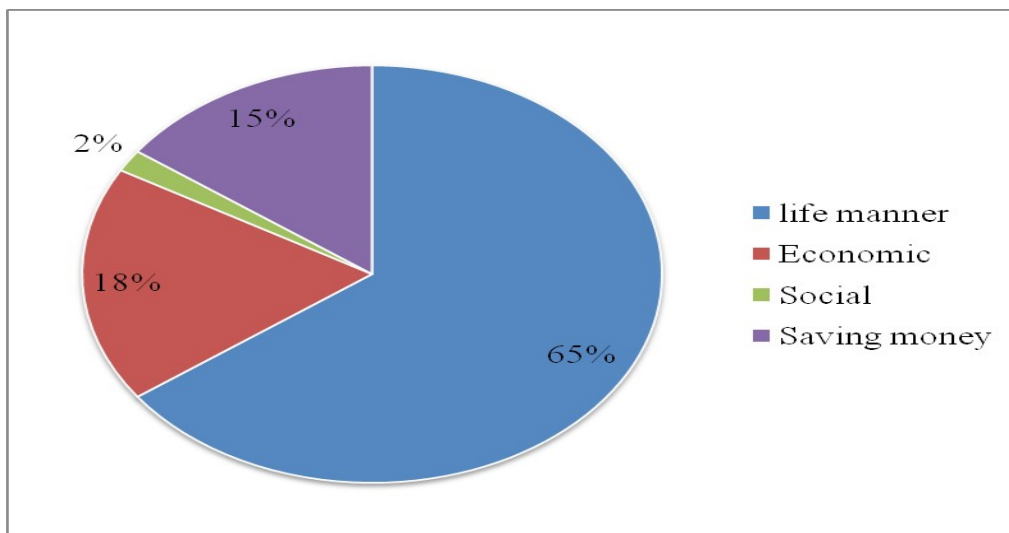


Figure (4.2): Goal of rearing camels.

4.11. Breeding practices:

The results showed in figure (4.3) that the improvement methods of herd are based on three ways, one of them is selection according to breeding history which practiced by 66.7 % followed by productivity 25 % and morphological features 8.3 %.The majority of camel owners kept breeding male camels from the same herd (90%) while the rest used male from different herd (table 4.12). On the other hand (table 4.13) showed that the majority of camel owners bred Arabi breed type (51.7%) followed by Rashaidi breed type (33.3%) and Anafi breed type (15%).The

results also revealed that about 53% of owners selecting males at 6 years, followed by 7 years (41.7%) and 8 years (5%). Moreover the end age of selection was 15 years practiced by about 51%, followed by 20 years which is practiced by 41.7 while 10 years was adopted by 6.7% of camel owners (figure 4.4 and figure 4.5). Moreover the improvement purposes showed in table (4.14) focused on both milk, meat with 78.3 % then milk purpose 10 %, milk, racing 8.3 % and racing with about 3 %.

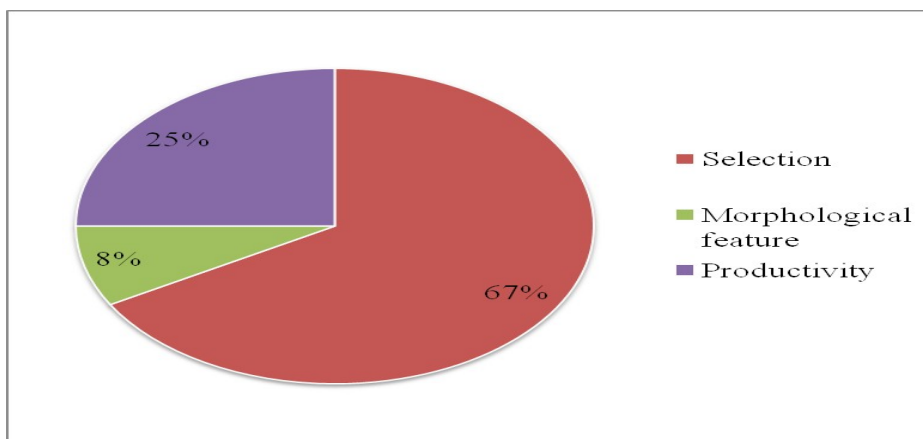


Figure (4.3): Methods of improvement

Table (4.12): Source of breeding males

Source	No	%
Same herd	54	90
Different herd	6	10
Overall	60	100.00

Table (4.13): Breed types in the study area

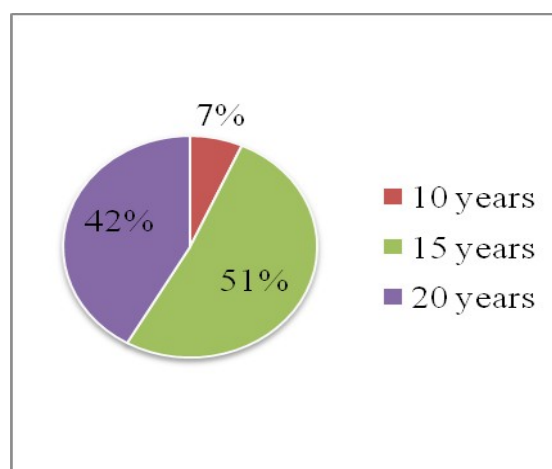
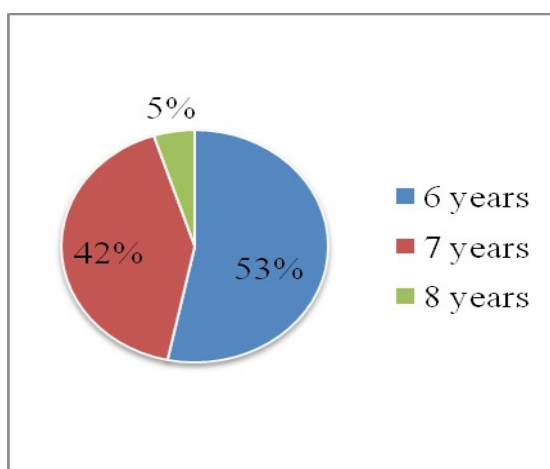


Figure (4.4): Age of male selection

Figure (4.5): Age at end of male life

Breed type	n	%
Arabi	31	51.7
Rashaidi	20	33.3
Anafi	9	15.0
Over all	60	100.0

Table (4.14): Improvement purpose

4.12. Milk production and milking practices:

Purpose	N0	%
Milk	6	10
Racing	2	3.3
Meat, Milk	47	78.3
Milk, Racing	5	8.3
Overall	60	100

The result present in figure 4.6. showed that most of she-camel (60 %) produced from 2 to 3 kg milk/day followed by 38.3 % produced 3 – 5 kg milk/day and about 2 % produced more than 5 kg milk/day, in lactation period of 10 months that practiced by about 53 % of camel owners subsequent by 14 months practiced by 42 % and 5 % of camel owners for 8 months lactation period (table 4.15). Also the results revealed that about 97 % of camel owners used calve in milk let down

while the rest milked their animals without calve (table 4.16) and the majority of owners (61.7 %) milked she-camels twice a day, while about 37 % milked their animals three times a day and only 1.7 % milked their animals once a day (table 4.17). The majority of camel owners families (95 %) consumed the produced milk, while 3.3 % sold the produced milk and 1.7 % took the milk for calve (table 4.18).

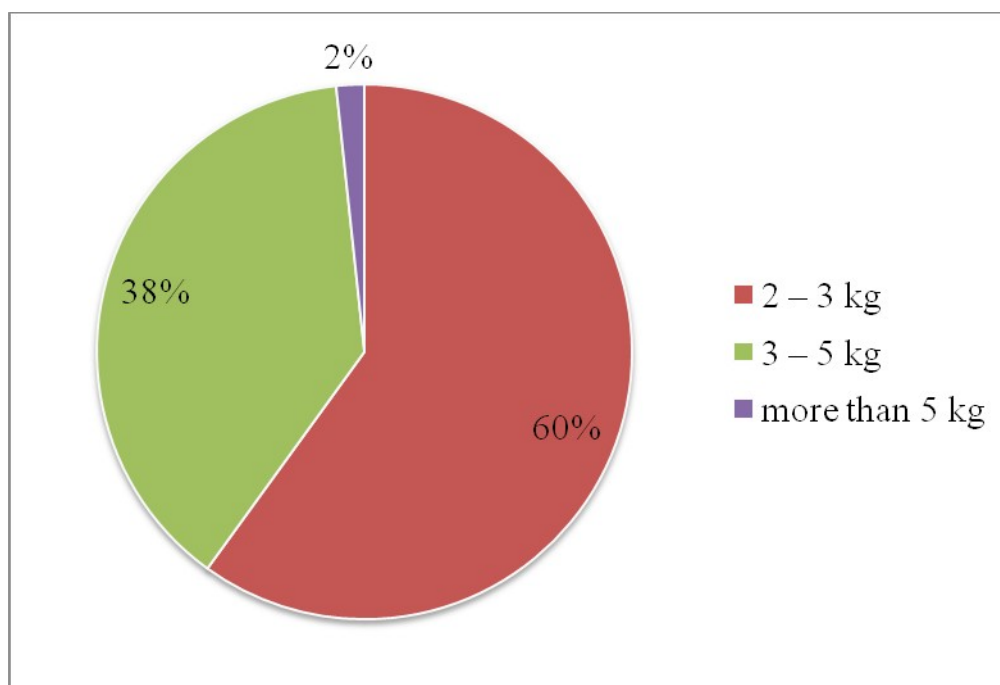


Figure 4.6: Average daily production of Milk

Table (4.15): lactation period length

Lactation period	n	%
8 months	3	5.0
10 months	32	55.3

14 months	25	41.7
Overall	60	100

Table (4.16): Methods of milk let down

Methods	n	%
With calf	58	96.7
Without calf	2	3.3
Overall	60	100

Table (4.17). Milking frequency (day)

Milking frequency	n	%
Once time	1	1.7
Twice	37	61.7
Three times	22	36.6
Overall	60	100

Table (4.18): Uses of camel milk

Uses	n	%
For calf	1	1.7

For family	57	95
For sale	2	3.3
Overall	60	100

4.13. Feeding and watering:

The results (table 4.19), indicated that the main source of feeding is rangelands (85%) while rangelands and green fodders represent only 15%. The majority of plant coverage in the area of the study is trees (60%), while grasses showed only (18.3%), (table 4.20). The data in (table 4.21) showed that the main source of water for camels is rivers (41.7%), in addition to wells and natural water net. Table (4.22), showed that the majority of camel owners watering their camels in summer every three days 71.7 % then 20 % watering their camels every two days and about 8 % watering their camels daily, while in winter more than 50 % of camel owners watering their camels every six days followed by 40 % watering their camels every four days and 5 % of camel owners watering their camels every three days.

Table (4.19): Source of feed

Source	n	%
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Rangelands	51	85
Rangelands and green fodder	9	15
Overall		

Table (4.20): Plant coverage in studied area

Plant	n	%
Trees	36	60
Bushes	13	21.7
Grasses	11	18.3
Overall	60	100

Table (4.21): Water sources in studied area

Table (4.22): Watering interval

Water source	n	%
River	25	41.7
Well	18	30.0
Natural water net	17	28.3
Over all	60	100.0

4.14. Constrains of camel production and veterinary services:

Watering frequency					
in summer			in winter		
Days	n	%	Days	n	%
One	5	8.3	Three	3	5.0
Two	12	20.0	Four	24	40.0
Three	43	71.7	Six	33	55.0
Over all	60	100.0	Over all	60	100.0

Results in figure (4.7) showed that the diseases are the main constrain faced 63.3 % of camel owners, then the second rank was the lack of feed (21.7%) followed by lack of water, financial and lack of security as 6.7 %, 5 % and (3.3%) respectively. Most of camel owners (70%) said that there is no veterinary service and the majority of them 80 % mentioned that the veterinary service was provided by the private sector and 20 % provided by the government (table 4.23).

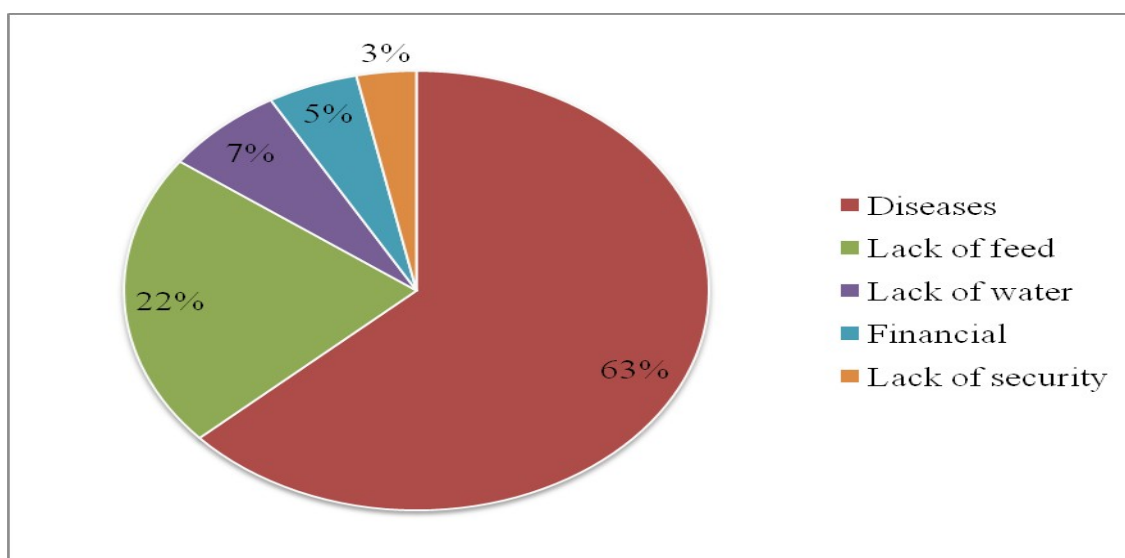


Figure 4.7: Serious constrains to camel production

Table (4.23): Reports of veterinary service and type of veterinary source

Veterinary services			Source o veterinary services		
	n	%		n	%
Yes	18	30	Government	12	20
No	42	70	Private	48	80
Overall	60	100	Total	60	100

CHAPTER FIVE

GENERAL DISCUSSION

Many authors documented that camel milk yield and components were affected by parity number, breed and other factors. (Al haj and Al Kanhal, 2010) who stated that production of camel milk affected by many factors such as breed, feeding and management conditions, lactation number and stage of lactation. The results showed that Fat, SNF and protein content showed gradual decreased by subsequent parity except in second lactation. Starting from the third lactation fat, SNF and protein content showed gradually decreased this finding is disagreed with those of Zeleke (2007) who mentioned that the effect of parity on fat content of camel milk was significant, this may be due to increase in milk production by subsequent parity number (until forth parity) and it's negative in correlated with fat content. The first and second lactation showed highest in SNF (7.86 and 8.1 % content respectively) while the other lactation showed no significant differences ($P>0.05$) theses results were similar to those found by (Riyadh *et al.*, 2012).

The results revealed that physicochemical milk components affected significantly by breed theses results were agreed with results other of researchers (Alshaikh and Salah, 1994, Mehaia *et al.*, 1995, Gaili *et al.*, 2000, Khaskheli *et al.*, 2005, Konuspayeva *et al.*, 2009, and Riyadh *et al.*, 2012). The pH content was ranged from 6.59 to 6.66 this fluctuation was found in published researches reference regarding the ash content of camel milk (Sawaya *et al.*, 1984, Dukwal *et al.*, 2007, Haddadin 2008 *et al.*, Ayadi *et al.*, 2009). These variations could be due to breed differences, milking interval, feeding, analytical procedures and water intake (Haddadin 2008 *et al.*, and Mehaia *et al.*, 1995).

The studied parameters (freezing point, density, fat, SNF, lactose, ash and protein) showed positive correlation ($P< 0.01$) this finding was agreed with (Abdelgadir *et al.*, 2013) also strong positive correlation between fat and protein

contents was found by (Haddadin *et al.*, 2008). Fat and lactose, fat and ash were positively correlated ($P < 0.05$) this finding was not agreed with (Abdelgadir *et al.*, 2013) who found it that no significant difference, this could be due to feeding, analytical procedures and water intake. The correlation of each parameter with the added water and conductivity was negatively highly significant ($P < 0.01$) these results were in line with those of (Abdelgadir *et al.*, 2013) who found a negative correlation in conductivity with fat, lactose, ash, protein and density.

The studied body measurements were height at wither, heart girth, barrel girth, neck length, face length, tail length and body weight. With except of heart girth and face length ($P < 0.05$) the camel breed types had high significant effect ($P < 0.01$). Kenani camel had highly significant ($P < 0.01$) in height at wither, barrel girth, neck length, tail length and body weight this findings agreed with those of (Ishag *et al.*, 2011). Also Kenani showed the highest value in heart girth (2.14 m) these findings were in line with those of Ishag *et al.* (2010). Moreover Rashaidi and Bishari ranked second and third record, while Anafi and Arabi breed types showed the lowest value in heart girth 1.97 and 1.94 m respectively and these results were according with those of Elbashir *et al.*, (2011). In barrel girth Bishari and Anafi recorded the lowest measure; it may be due to uses of these breeds for racing purposedtable.

The sex of camel had a significant influence on heart girth ($P < 0.01$), face length and body weight ($P < 0.05$). The data also showed male camels had higher body measurements than females, these results were similar to those mentioned by Dioli *et al.*, (1992) and Mehari *et al.*, (2007) they stated that the male camels is usually taller and heavier weight than the females. The higher values of the measured parameters of male camels might be due to physiological, morphological and activities in the different sexes(table 4.4).

The results also showed that the age of camel had high significant ($P < 0.01$) effect on each measured parameters, this findings was in line to those of Ishag *et al.*, (2010) and Elbashir *et al.*, (2011). The studied traits tend to increase from the 1st age group (≤ 3 years) to the 4th age group (8 – 9 years) and then decreased. This means that the camels reach maturity age within 8 to 9 years, then many different measurement declined this result is in line with those of Ishag *et al.*, (2013) (table4.4).

Camels are a major component of the agro-pastoral systems in arid and semi arid zones, in addition to other species (sheep, goat and cattle). In the northern part of the camel belt in Sudan the annual rainfall is relatively low (semi desert) and limited cultivation is practiced to meet all or part of the family requirements, while in the southern part of the camel's belt the annual rainfall is relatively moderate (poor savannah). This study revealed that the illiterate camel owners was 65 % which is agreed with the results found by Darosa and Agab, 2005 The study showed that the majority of camel owners considered both rearing animals and farming to be their main activity, followed by those rearing animals and then those considered that the farming was their main activity this finding is disagreed with (Ishag and Ahmed, 2011) it could be due to the nature of the study area (Butana). This study revealed that the interviewers bred mixed species of animals in studied area. Few of them bred camel with cattle, while the majority bred camel with sheep this finding is somewhat similar to (Ishag and Ahmed, 2011). Three camel production systems were found in the studied areas: Nomadic, transhumant and sedentary system. These three management systems were also reported in Pakistan (Aujla et al 1998), about 47 % of the interviewees adopted nomadic system followed by sedentary system 40 % this finding is similar to that reported by Al-Khoury and Majid (2000). Also the majority of interviewees 65 % showed that they

bred as a life manner followed by it's economic value 18.3 % this finding is similar to those of (Ishag and Ahmed, 2011). The results showed that rearing camel for their milk and meat is the first priority of the camel owners these results were not difference from the findings of (Ishag and Ahmed, 2011). On the other hand the majority of interviewers improved their camels for both meat and milk production. These findings are similar to those of Algayli *et al* (1998) also the results revealed that the main method of improvement based on breeding history (66.7 %)followed by productivity and morphological feature this finding is not far than those of (Ishag and Ahmed, 2011) who found about half of the interviewers select their camels according to the best breeding camel. The results showed that most of camel owners (90 %) kept the male from the same herd while the rest tend to use males from other herd, these results were in line with those of (Ishag and Ahmed, 2011) who found more than 88 % camel owners kept their male in the same herd. The majority of camels respondents bred Arabi and Rashaidi camels breed type 51.7%, 33.3 % respectively, this finding in accordance with those Wardeh (2004) who found Arabi camel has a wide geographic distribution in the Sudan due to its good performance for meat and milk.

The results showed that more than 93 % of interviewers select their camels in 6 to 7 years and the end age of male selection was between 15 to 20 years this findings were somewhat inline with those of (Ishag *et al.*, 2010) who mintoned that camels reach maturity (growth peak) within 7 to 9 years of age.

The lactation length in this study is in close agreement with the previous findings of Mehari *et al.*, (2007), Farah (1996) and (Ishag and Ahmed, 2011). While, the estimate of lactation period in this study is shorter than that reported by Schwartz and Walsh (1992), but shorter lactation length than the estimate found in the present study was reported by Alemayehu (2001). The milking frequency in

the present study ranged between 2 to 3 times in a day. This finding is in reasonable agreement with the finding of Mehari *et al* (2007). The milk down let in the presence of the calf is the main behavior adopted by camel owners 96.7 % this finding is agreed with those of Eisa *et al.*, (2012) who found that the importance of the calf presence to initiate milk ejection reflex.

The results showed that most of camel owners (85 %) reared their camel in the pastures and animals preferred trees and shrubs (81. 7 %). This finding is agreed with Schwartz (1989) and Darosa and Agab, 2005 who reported that camels reared on trees but the most preferred plants is (Siha) *Blepharis edulus* and *Chorchorus olitorius* kind of legumes but it was restricted only to remote inaccessible areas, natural depressions and courses of seasonal valleys and water run-ways. The results also showed 55 % of camel owners watered their camels every six days in winter and about 72 % watered their camels every three days in summer this findings is in reasonable agreement with the finding Köhler *et al.*, (1991).

The results revealed that the first serious constrain was the diseases, followed by lack of feed, lack of water, financial and lack of security this finding is in close agreement with those of Ishag and Ahmed, (2011) except in disease constrains and this could be due to differences in study area and the season of the data collection.

Chapter six

CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion:

The study concluded that the mean values of camel milk yield and component that were affected by parity number showed significant differences in milk yield, fat, SNF and protein ($P < 0.05$) content in different parities. There are some constrain can face the camel production such the veterinary services and diseases. The majority of the camel owners selected the breed from the herd. The sex of camel had a significant influence on heart girth ($P < 0.01$), face length and body weight ($P < 0.05$), while height at wither, barrel girth, neck length and tail length was insignificantly ($P > 0.05$) affected by sex.

6.2. Recommendations:

1. Increase the studies on camels to improve the production and breed.
2. To establish more sources of water near the pastures and near its gathering places.
3. Establishment of well equipped camel research center.
4. To look after owners of camels for their simple people and provide them with more education health information.
5. Furthers studies in camel milk production
6. Advise the owners to let their herds to rare in natural areas especially in forest.
7. Provisions of veterinary services for the camel owners.

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APPENDICES

Appendix (1): Plates.



Plate (1): Kenani (Rufaa) camel breed type



Plate (2): Rashaidi (Diali) camel breed ty



Plate (3):Lahwee (Arabi) camel breed type



Plate (4): Bishari camel breed type



Plate (5): Anafi camel breed type

Appendix (2):

Questionnaire

Date:

Location:

State :

Locality:

Type of herding:

Camel only ().

Camel and cattle ()

Camel and goat ()

Camel and sheep ()

All type of animals ()

Purpose of investment:

Milk only ().

Milk & meat ()

Milk & agriculture ()

All of the above ()

The owner:

1. Name

2. Age

10-20 years ()

21-30 ()

31-40 () above 40 years

Educational level:

Illiterate ().

Khalwa () Primary ()

Intermediate ()

Secondary ()

University ()

Post graduate ()

The Years of experiences:

1. Less than 10 Years ().

2. 10-20 Years ()

3. above 20 Years ()

Relation Ship with camel:

Professional ().

amateur ()

investor ()

Herd man ()

Type of camel:
 Pack (). riding () both ()
 raising ()

Breeds:
 1. Bushari (). 2. Arabic () 3. ashidi ()
 4. Anaf () 5. Shukri () 6. Kabashi ()
 7. Kinani () 8. Rofai (). 9. Lahawi ()

Herd Sizes:
 1. 1-20 (). 2. 12-40 () 3. 41-60 ()
 4. 61-80 () 5. 81-100 () 6. more than 100 ()

Number of herders:
 1. 1-5 (). 2. 6-10 () 3. more than 10 ()

Education level of herd man:
 1. Illetrate (). 2. Educated ()

Employment:
 1. Only herd man (). 2. herd man and milker ()

Herd man agreement with owner:
 1. money (). 2. animals () Both of the above ()

1. Milking:
 1. Milking let down stimulation
 1. Presences of off spring ()
 2. Without pressentce of ohspring ()
 3. Bothot above ()

2. Milking frequency:
 1. once (). 2. Twice () 3. three time ()
 4. four times () 5. more () 6. Kabashi ()

3. Methods of milking of each she camels:
 1. One milker (). 2. Two milker

4. Udder milking:

1. All the udder ().

2. Half of the udder ()

3. Three quarters ()

5. Average milk yield/ milking

1. 2 kg ().

2. 2.3 kg () 3. 5 kg ()

4. More than 5 kg ()

6. Average milk yield/ dry/ form:

1. 7 kg ().

2. less than 7 kg () 3. 10 kg ()

4. more than 10 kg ()

Lactation Period:

1. 6 months ().

2. 8 months () 3. 10 months ()

4. 12 months () 5. 14 months

Amount of camel milk:

1. offered to offspring ().

2. Used by family ()

3. amount sold ()

Camel milk products:

1. cheese ().

2. ghee () 3. skyr milk ()

4. other ()

5. fresh milk ()

1. Type of Feeding:

1. pasture only ().

2. pasture and concentrate ()

3. green fodder ()

4. green fodder and pasture () 5.

Other ()

Type of grasses in pasture:

1.

2. 3.

3. Source of crop:

1. crop growing ().

2. crop sold ()

(Watering) :

1. source of drinking water

1. The Nile () 2. Wells ()
3. national water net ()

2. Frequency of watering

1. in summer 2. in winter

Distance to drink
far() Near ().

If the
Yes () No()

4. Type of

1. Trees () 2. grass () 3. Sharps ()

1.

1.Live Stock () 2. Farming () 3. Both ()

2.

1.Nomadic () 2. Transhumant () 3. Sedentry()

3. Kept breeding male camels

1.Yes () 2. No ()

4. Source of breeding camels

1.Own herd () 2. Other herd () 3. Purchased ()

5. Age of breeding camle

1.age of selection years 2. age of end of herd life..... years

6. Goals of camel Improvement:

1. Milk () 2. meat () 3. Racing ()

4. Milk meat () 5. Milk Racing() 6. Meat Racing ()

7. Plans of camel Improvement:

1. Have You plan
1. Yes() 2. No ()

2. Method of Improvement
1. Selection () 2. Feeding () 3. Both ()

8. Reproduction performance of camel breed

1. Age of first calving() 2. Calving Interval () 3. Age
kes ()

9. Purpose of keeping camel:

1. Drought () 2. Low cost () 3. Way of life ()
4. Save money () 5. Social ()

10. Animal Health:

1. Veterinary help or Services ()
1. Yes () 2. No ()

he Sources:

1. Government () 2. Private ()

11. Serious Constraint to camel production:

1. Disease () 2. Lack of feeding () 3. Shortage of water ()
4. Labours () 5. Capital () 6. Taxes ()
7. Meat Racing () 8. Lack of Security () 9. Other ()

Morphological feature:

1 Age:-----

2 ASex:-----a/ male b/ female

3 Type: a/bushari b/ arabi c/ rashaidi d/ anafi e/ kinani

4 Type of camel: Pack () Racing () Both ()

5 Colour: -----

6 Diameter of hump -----

7 Length of Neck -----

8 Height at wither -----

9 Heart girth -----

10 Barrel girth -----

11 Face length -----

12 Tail length -----

13 Body weight -----