Udder Conformation and Milkability of She-Camel
(Camelus dromedarius) in EL- Showak, Eastern Sudan

By
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A thesis Submitted for the Fulfillment of the Requirements for the
Degree of Doctor of Philosophy in Animal Production
(Dairy Production)

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August 2006
In the name of Allah, the beneficent, the Merciful

{Will they not regard the camels, how they are created?}
Al-Ghashiyah (18).
DEDICATION

This work is dedicated to:
The soul of my parents,
brothers, sisters,
Wife and son
With everlasting love and respect.

Mohamed Osman Eisa
ACKNOWLEDGEMENT

First of all, my thanks and praise to Allah who gave me patience and will to accomplish this work.

I am most grateful to my supervisor Prof. Abu Nekhaila for his deep interest, keen supervision and valuable help during all stages of this work.

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Thank You Very Much.

M.O. EISA.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>i</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF PHOTOS</td>
<td>xi</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>xii</td>
</tr>
<tr>
<td>ABSTRACT (ARABIC VERSION)</td>
<td>xiv</td>
</tr>
<tr>
<td>CHAPTER ONE: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTER TWO: LITERATURE REVIEW</td>
<td>6</td>
</tr>
<tr>
<td>2.1 Historical background</td>
<td>7</td>
</tr>
<tr>
<td>2.2 Camel habitat in the Sudan</td>
<td>8</td>
</tr>
<tr>
<td>2.3 Camel population</td>
<td>12</td>
</tr>
<tr>
<td>2.4 Classification of Sudanese camel</td>
<td>12</td>
</tr>
<tr>
<td>2.5 Camel as milk producers</td>
<td>17</td>
</tr>
<tr>
<td>2.5.1 Camel udder</td>
<td>17</td>
</tr>
<tr>
<td>2.5.1.1 Anatomy and physiology</td>
<td>17</td>
</tr>
<tr>
<td>2.5.1.2 Udder measurement</td>
<td>19</td>
</tr>
<tr>
<td>2.5.2 Camel milk</td>
<td>28</td>
</tr>
<tr>
<td>2.5.3 Milk letdown</td>
<td>30</td>
</tr>
<tr>
<td>2.5.4 Milking procedure</td>
<td>31</td>
</tr>
<tr>
<td>2.5.5.1 Milk yield</td>
<td>32</td>
</tr>
<tr>
<td>2.5.5.2 Milk yield per udder quarter</td>
<td>35</td>
</tr>
<tr>
<td>2.5.6.1 Milk composition</td>
<td>38</td>
</tr>
<tr>
<td>2.5.6.2 Milk composition per udder quarter</td>
<td>43</td>
</tr>
<tr>
<td>2.5.7 Milking time, and flow rate</td>
<td>44</td>
</tr>
</tbody>
</table>
3.1 Introduction 

3.2 Materials and methods

3.2.1 Study area

3.2.2 Experimental animals

3.2.2.1 Identification

3.2.2.2 Herd managements

3.2.2.3 Milking practice

3.2.3 Data collection

3.2.3.1 Daily milk yield

3.2.3.2 Age, parity order and date of calving

3.2.3.3 Udder measurements

3.2.3.4 Teats measurements

3.2.3.5 Milk vein measurements

3.2.3.6 Body weight estimation

3.2.4 Statistical analysis

3.3 Results

3.3.1 Daily milk yield

3.3.2 Udder measurements

3.3.3 Correlation between udder measurements and daily milk yield

3.3.4 Teats measurements

3.3.5 Correlation between teats measurements and daily milk yield

3.3.6 Milk vein measurements

3.3.7 Correlation between milk vein measurements and daily milk yield
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4 Discussion</td>
<td>69</td>
</tr>
<tr>
<td>CHAPTER FOUR: Experiment Two</td>
<td></td>
</tr>
<tr>
<td>Variations in Milk Yield and Composition Between Fore and Rear Udder Halve</td>
<td>72</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>73</td>
</tr>
<tr>
<td>4.2 Materials and methods</td>
<td>74</td>
</tr>
<tr>
<td>4.2.1 Study area</td>
<td>74</td>
</tr>
<tr>
<td>4.2.2 Experimental animals</td>
<td>74</td>
</tr>
<tr>
<td>4.2.2.1 Identification</td>
<td>75</td>
</tr>
<tr>
<td>4.2.2.2 Herd managements</td>
<td>75</td>
</tr>
<tr>
<td>4.2.2.3 Milking practice</td>
<td>75</td>
</tr>
<tr>
<td>4.2.3 Data collection</td>
<td>78</td>
</tr>
<tr>
<td>4.2.3.1 Age, parity order and date of calving</td>
<td>78</td>
</tr>
<tr>
<td>4.2.3.2 Body weight estimation</td>
<td>78</td>
</tr>
<tr>
<td>4.2.3.3 Udder measurements</td>
<td>78</td>
</tr>
<tr>
<td>4.2.3.4 Milk yield determination</td>
<td>79</td>
</tr>
<tr>
<td>4.2.3.5 Milk composition determination</td>
<td>79</td>
</tr>
<tr>
<td>4.2.3.5.1 Determination of protein</td>
<td>79</td>
</tr>
<tr>
<td>4.2.3.5.2 Determination of fat</td>
<td>81</td>
</tr>
<tr>
<td>4.2.3.5.3 Determination of lactose</td>
<td>82</td>
</tr>
<tr>
<td>4.2.3.5.4 Determination of moisture and total solids</td>
<td>82</td>
</tr>
<tr>
<td>4.2.3.5.5 Determination of ash</td>
<td>84</td>
</tr>
<tr>
<td>4.2.3.5.6 Determination of pH</td>
<td>84</td>
</tr>
<tr>
<td>4.2.3.5.7 Determination of sodium Na</td>
<td>84</td>
</tr>
<tr>
<td>4.2.3.5.8 Determination of potassium K</td>
<td>85</td>
</tr>
<tr>
<td>4.2.3.5.9 Determination of phosphorus P</td>
<td>85</td>
</tr>
<tr>
<td>4.2.3.5.10 Determination of calcium Ca</td>
<td>86</td>
</tr>
<tr>
<td>4.2.4 Statistical analysis</td>
<td>87</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: Experiment Three

Study on Milk Stimulation Interval Using the Nomadic Traditional Methods

5.1 Introduction 98
5.2 Materials and methods 100
5.2.1 Study area 100
5.2.2 Experimental animals 100
5.2.2.1 Identification 100
5.2.2.2 Herd managements 102
5.2.2.3 Milking practice 102
5.2.3 Data collection 102
5.2.3.1 Age, parity order and date of calving 102
5.2.3.2 Udder measurements 103
5.2.3.3 Body weight estimation 103
5.2.3.4 Monitoring of milk stimulation interval (MSI) 104
5.2.3.5 Determination of milk yield (MY), milking duration (MD) and milk flow rate (MFR) 105
5.2.4 Statistical analysis 105
5.3 Results 105

5.3.1 Parity order 105
5.3.2 Body weight groups 108
5.3.3 Udder measurements before and after milking 108
5.3.4 Milking time 111
5.3.5 Correlations with milk yield and milk traits 111
5.3.6 Correlations with body w.t, and udder measurements 111
5.4 Discussion

CHAPTER SIX: GENERAL DISCUSSION

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.2 Recommendations

REFERENCES
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Estimate of camel’s population by states</td>
<td>13</td>
</tr>
<tr>
<td>3.1</td>
<td>Details of she-camels used for the study</td>
<td>50</td>
</tr>
<tr>
<td>3.2</td>
<td>Means and standard deviation of daily milk yield (liter)</td>
<td>59</td>
</tr>
<tr>
<td>3.3</td>
<td>Minimum and maximum daily milk yield (liter)</td>
<td>59</td>
</tr>
<tr>
<td>3.4</td>
<td>Udder measurements (cm)</td>
<td>62</td>
</tr>
<tr>
<td>3.5</td>
<td>Pearsons correlation between udder measurements and daily milk yield</td>
<td>63</td>
</tr>
<tr>
<td>3.6</td>
<td>Teats measurements (cm)</td>
<td>65</td>
</tr>
<tr>
<td>3.7</td>
<td>Pearsons correlation between teats measurements and daily milk yield</td>
<td>66</td>
</tr>
<tr>
<td>3.8</td>
<td>Milk vein measurements (cm)</td>
<td>68</td>
</tr>
<tr>
<td>3.9</td>
<td>Pearsons correlation between milk vein measurements and daily milk yield</td>
<td>68</td>
</tr>
<tr>
<td>4.1</td>
<td>Details of she-camels used for the study</td>
<td>76</td>
</tr>
<tr>
<td>4.2</td>
<td>The composition of sorghum residuals</td>
<td>77</td>
</tr>
<tr>
<td>4.3</td>
<td>Minerals contents of sorghum residuals</td>
<td>77</td>
</tr>
<tr>
<td>4.4</td>
<td>Paired T. test for fore and rear udder halve measurements</td>
<td>88</td>
</tr>
<tr>
<td>4.5</td>
<td>Paired T. test for milk yield, protein, fat and lactose</td>
<td>91</td>
</tr>
<tr>
<td>4.6</td>
<td>Paired T. test for moisture, total solids, ash and pH</td>
<td>92</td>
</tr>
</tbody>
</table>
LIST OF FIGURES
<table>
<thead>
<tr>
<th>Fig</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Estimate of camels (%) by states</td>
<td>14</td>
</tr>
<tr>
<td>3.1</td>
<td>Minimum and maximum daily milk yield (liter).</td>
<td>60</td>
</tr>
<tr>
<td>4.1</td>
<td>Milk yield percentage per udder halve</td>
<td>89</td>
</tr>
<tr>
<td>5.1</td>
<td>Minimum and maximum milk stimulation interval/sec. according to parity order</td>
<td>107</td>
</tr>
<tr>
<td>5.2</td>
<td>Minimum and maximum milk stimulation interval/sec. according to body weight groups</td>
<td>110</td>
</tr>
<tr>
<td>5.3</td>
<td>Minimum and maximum milk stimulation interval/sec. according to milking time</td>
<td>113</td>
</tr>
</tbody>
</table>

**LIST OF PHOTOS**
<table>
<thead>
<tr>
<th>Photo</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>A bronze figure of camel found at Merwi</td>
<td>9</td>
</tr>
<tr>
<td>2.2</td>
<td>Camel in stone drawing, Alhamadab</td>
<td>10</td>
</tr>
<tr>
<td>2.3</td>
<td>Udder of she-camel</td>
<td>18</td>
</tr>
<tr>
<td>2.4</td>
<td>Well developed milk vein</td>
<td>21</td>
</tr>
<tr>
<td>3.1</td>
<td>Measurement of udder height</td>
<td>53</td>
</tr>
<tr>
<td>3.2</td>
<td>Measurement of teat length</td>
<td>54</td>
</tr>
<tr>
<td>3.3</td>
<td>Measurement of milk vein diameter</td>
<td>57</td>
</tr>
<tr>
<td>4.1</td>
<td>Milking practice: Two milkers with two plastic pails</td>
<td>80</td>
</tr>
<tr>
<td>4.2</td>
<td>Milk samples preparation</td>
<td>83</td>
</tr>
</tbody>
</table>

**ABSTRACT**
16 she-camels were chosen from a large herd of camel belonging to the Lahween tribe in Eastern Sudan. The breed is known locally as (Arabi-Lahwee) The animals were sub-divided in to three groups: A, B and C according to the parity order, of 3rd, 4th and 5th parity, respectively, to investigate the correlation between various udder, teats and milk vein measurements with daily milk yield. Despite the increment of daily milk yield with advancing parity order, the results however revealed non-significant effect on daily milk yield. The daily milk yield of the three groups was 2.2±0.94, 2.9±0.45 and 3.5±2.16 liters, respectively. The daily milk yield in group (A) was sig. (P < 0.05) correlated with udder depth (15.3±1.3 cm), distance between fore teats (12.9±2.9 cm.), and distance between rear teats (9.9±1.9 cm.). In group (B) measurements including udder height of fore quarters (108.0±3.0 cm.) and of rear quarters (107.0±3.0 cm.) and the distance between the right teats (3.3±0.2 cm.) were sig. (P<0.05) correlated with daily milk yield. In group (C) the fore teats diameter (3.1±0.4 cm.) and the distance between the right teats (3.7±2.9 cm.) were found to be sig. (P < 0.05) correlated with daily milk yield. Others measurements were found insignificantly correlated with daily milk yield in the three groups. Concerning the fore and rear udder half measurements. The depth of fore quarters was 20.9±0.75 cm. and which was sig. (P < 0.01) deeper than the rear quarters (13.1±0.75 cm.), the results also indicated sig. differences (P < 0.05) between the height of fore and rear udder halves, (110.9±0.36 versus 110.2±0.36 cm, respectively). The distance between teats in the fore quarters (13.2±0.36 cm.) which was sig. (P < 0.01) longer than rear quarters (9.9±0.36 cm.), the teats diameter of the rear quarters (2.5±0.1 cm.) that was sig. (P < 0.01) greater than the diameter of the fore quarters (2.1±0.1 cm). Teat length on the other hand showed non-significant difference between the udder halves. The data pertaining to milk yield and composition of the fore and rear udder quarters documented that rear udder half produced 57.5% of the total milk yield, whereas the fore quarters yielded only
42.5% (P < 0.01). The rear quarters produced milk, which was highly sig. (P < 0.01) richer in protein% (3.38±0.19) and P% (1.077±0.022), and sig. (P<0.05) richer in moisture% (90.42±0.34), K% (1.25±0.032) and pH (6.38±0.043), also scored high but non-sig. values in fat% (3.31±0.18) and Ca% (7.169±0.034). While milk from the fore udder quarters scored highly sig. (P<0.01) value in lactose% (3.25±0.3), sig. (P < 0.05) value in total solids% (10.44±0.312) and high but non-sig. values in Na% (0.64±0.012) and ash% (0.59±0.027). Concerning the amount of nutrients contained milk from rear quarters provided higher amount of nutrients compared to milk of fore quarters. In this study neither parity order, body weight groups nor milking time (morning and evening) not showed any sig. impact on milk stimulation interval (MSI). For the 3rd, 4th and 5th parity orders MSI was 116.4±21.5, 127.0±42.8 and 109.8±7.7 seconds, respectively (means 116.3±12.7 seconds). Body weight groups scored 113.8±18.2 and 118.9±18.9 seconds for <500 and >500 kg, respectively, and at morning and night time reported 68.1±5.4 and 70.9±73 seconds, respectively as MSI. Milk yield (MY) (912±119.6 ml), milking duration (MD) (78.2±4.2 sec.), udder measurements including size, depth, circumference, teat length and diameter showed negative and non-sig. correlation with MSI. While body weight (517.9±19.3 kg) was positively and sig. (P < 0.05) correlated and milk flow rate (11.7±1.3 ml/sec) reported positive and non-sig. correlation with MSI. Sig. (P<0.01) variations in the measurements of the udder depth, circumference, size, teat length and teat diameter before and after milking were observed.
لا يمكنني قراءة النص العربي المكتوب بخط اليد.
The document contains text in Arabic, which appears to be discussing a scientific or technical topic, possibly related to the field of food science or chemistry. The text includes various mathematical expressions and scientific notations, indicating a detailed analysis or experimental results. However, due to the style and structure of the text, a direct translation is not straightforward without additional context or a more complete view of the document.
CHAPTER ONE

INTRODUCTION
CHAPTER ONE

INTRODUCTION

Sudan is a very large country, occupies 2,505,813 square kilometer of territory. The grazing lands constitute 40.4% from total Sudan area. The pastoralists of Sudan own 90% of the national herd of livestock, (Ministry of Animal Resources, 2005).

Sudan ranks first among the Arab countries and second in Africa with respect to animal population. The Sudan is considered as the second country in the world in camel’s population. According to resent estimates of livestock, there are about 40 million heads of cattle, 50 million heads of sheep, 43 million heads of goat, and 4 million heads of camels (Ministry of Animal Resources, 2005).

Sudanese camels belong to the family camelidae and the suborder tylopoda. The tylopoda themselves belong to the order artiodactyla or cloven-footed animals. The family of camelidae contains the genera Camelus (old world camel) and lama (new world camel). The camelidae originated in North America where the earliest fossil remains of camelidae have been found (Simpson, 1945). The genus Camelus migrated from North America in the late Tertiary across the existing land bridge to Asia and Africa. Included in the genus camelus are the one-humped dromedary (Camelus dromedarius), and the two-humped bactrian (Camelus bactrianus). The term dromedary in derived from the Greek “dromados” (run) and in the strict sense is used for riding camels. The dromedary is slim, long-legged, short haired and has its habitat in warm arid and semi – arid areas (Simpson, 1945).

The dromedary was probably domesticated on the South coast of the Arabian Peninsula in the region of present day Yemen and Oman.
around 3,000 B.C., and then introduced with the spice trade into North Africa and the horn of Africa.

The history of the dromedary camel in the Sudan is even more obscure. It is believed to have entered the Sudan from Egypt. A specimen of camel hair rope of the old kingdom was found at Fayum in upper Egypt dating about 2980-2474 B.C., indicating that the animal had moved south by that period. In Sudan, the oldest evidence is a bronze figure of camel with a saddle found at Merwi and estimated to date between 25-15 B.C. (Addision, 1934; Robinson, 1936).

The distribution area of the dromedary in the Sudan extends over the arid and semi-arid areas. So the camel can feed in areas where other species do not thrive and perhaps don’t survive. This animal is enabled by special anatomical and physiological features to defy an extremely dry and hot climate to a great extent (Burgemeister, 1979).

The country is home to some of the most well-known camel nomads, the Kababish, Shukrua, Hadandowa, Lahaween, Rashaida and others. And the dromedary camel plays a significant role in the livelihood of pastoral people, providing them with food and transport.

Like others mammalian the she-camel of dromedary has an udder, which is composed of four quarters, each separately constituted and supported by strong ligaments. Each quarter is composed of secretory tissues in which the milk is made. The milk drains by the milk ducts to the milk cistern located above each teat.

Camel milk is the stable diet of many nomadic desert people for considerable periods, and they rely completely on camel milk for more than a month without having drinking water especially in the grazing area or during the migratory routes (Al-Amin, 1979). Recent estimation of milk production of Sudanese camel about 48,000 tons, (Ministry of Animal Resources, 2005).
Most of the milk is drunk fresh, and sometimes sour (Garis) or with tea, and the amount of milk taken depend on the milk yielding capacity of the she-camel, the amount allowed for the calf, length of lactation, and of course the forage availability and water (Brain, 1979).

When lactating she-camels are kept at good nutritional plan and managed under hygienic conditions the camel milk is comparable to milk from other conventional sources in content, appearance and nutritive value. The dromedary milk has high vitamin C content and comparatively longer shelf life. The pH is within 6.5 to 6.8 %, mean specific gravity 1.03, freezing point 0.75 C, SNF ranges from 8.9 to 14.3%, fat from 2.9 to 5.5%, protein 2.5 to 4.5%, lactose 2.9 to 5.8%, ash 0.80 to 0.95% and water 86 to 88%. The camel milk fat globules are small and contain comparatively more unsaturated fatty acids. The camel milk has high concentration of lactoferrins and also has bacteristatic and therapeutic properties, (Khanna, 1999).

From the nutritional standpoint camel’s milk contains approximately 700 cal. or 2931 kJ energy per kg. About 4 kg milk are sufficient to meet full caloric requirement of an adult Human being and 1.8 kg milk would provide his entire daily protein requirements, (Khanna, 1999).

Unlike other conventional dairy species, the camel has not passed through process of selection for improvement of milk production, yet the camel has great genetic potential to produce milk economically, (Kanna, 1999). The majority of the studies conducted on camels concentrate on anatomical features, traditional management and physiological adaptation to desert condition (Cauvet, 1925; Schmidt-Nielsen, 1964; Bulliet, 1975; Gauthires and Dagg, 1981).

The vital socio-economic roles of the camel in the support of livelihood of millions of people inhabit the dry and arid zones cannot be
overemphasized. Information about camel milk is mostly limited and repeated to some data on yield and gross composition. Studies on udder conformation and milkability of she-camel have not received any attention.

The present study was initialed to highlight a new channel in dairy research, since camels are an overlooked resource in the country.
2.1 Historical background

Camels belong to the family camelidae and thereby to the sub-order tylopoda. The tylopoda themselves belong to the order artiodactyla or cloven-footed animals. The family of Camelidae contains the genera *Camelus* (old world camel) and *Lama* (new world camel). The camelidae originated in North America where the earliest fossil remains of camelidae have been found. The genus camelus migrated from North America in the late Tertiary across the existing land bridge to Asia and Africa. Included in the genus camelus are the one-humped dromedary
(Camelus dromedarius), and the two-humped bactrian (Camelus bactrianus), Simpson (1945) and Zeuner (1963).

The domestication of the camel occurred relatively recently compared with other animals, such as sheep, (10,000 B.C), goats (8000 B.C), pigs (6500 B.C) and cattle (5000 B.C), (Planhol and Rognon, 1970). Opinions on when camels were first domesticated differ widely, while, Free (1944); Zenner (1963); Ripinsky (1975) and Bulliet (1975) believe that camels were domesticated before 2000 B.C., on the other hand Epsteon (1971), taking into account the earliest Egyptian and Mesopotamian archaeological evidence, dated domestication as early as the fourth millennium B.C., Walz (1956), however believed that camels were domesticated perhaps during the 13th or 12th century B.C., but not before 2000 B.C., however Farah (1996) reported that first camel domestication has not yet been established. The oldest written reference to camels in the Bible, where it is stated that Abraham sent his servant with ten camels from Palestine to Mesopotamia to seek a bride for his son Isaac. Today it is assumed that this happened around 1800 B.C., it is however, generally thought that domestication of camels had begun in 2000-4000 B.C, with dromedaries being kept principally in central and Southern Arabia.

The history of the dromedary camel in Sudan is even more obscure. It is believed to have entered the Sudan from Egypt. A specimen of camel hair rope of the old kingdom was found at Fayum in Upper Egypt, dating about 2980-2474 B.C., indicating that the animal had moved south by that period. In Sudan, the oldest evidence is a bronze figure of camel with saddle found at Merwi, (Photo 2.1) and estimated to date between 25-15 B.C., (Addison, 1934; Robinson, 1936). Track of historical trends in the Sudan is difficult because of lack of reliable data,
(Roment, 2001). Probably the camels entered the Sudan through the following routes:

1- North West Africa route during the 4th to 6th century.
2- Egyptian route.
3- Red Sea route (most recent), (Salman, 2002).

### 2.2 Camel habitat in the Sudan

Camels in the Sudan are spread in a belt configuration; it extends between latitudes 12-16 N (Wardeh, 1989). This belt is characterized by erratic rainfall, less than 350 mm. Disease such as trypanosomiasis and the unsuitability of the clay soil prevented migration of camels into the Southern part of the Sudan (Al-Amin, 1979). Agab (1993) reported that

![Photo 2.1 A bronze figure of camel found at Merwi (25-15 B.C).](image)

**Source:** Sudan National Museum, Khartoum.

(by M.O. Eisa, 2006)
Photo 2.2 Camel in stone drawing, Alhamadab.
Source: Sudan National Museum, Khartoum.
(by M.O. Eisa, 2006)
Camels in Sudan are concentrated in two main regions: the Eastern state, where camels are found in the Butana plains and the Red Sea hills, and the Western Regions (Darfour and Kordofan). In Butana area of Sudan camels is commonly raised under nomadic conditions in a geographical zone, which lies approximately between latitude 14-16 N and longitude 33-36 E. Atbara River to the East, River Nile to the West and Blue Nile bind the area to the South and Southwest.

The rainfall in this zone is low to moderate. Vegetation consists of semi-desert grassland on clay in the north and on an area of rich savannah with acacia thorn-land on dark cracking clay, alternating with grass areas in the South, (Abu-sin, 1997).

The Butana is inhabited by different camel owning tribes such as Shukria, Lahween, Kawahla and Rashida. All of these tribes are ancient camel breeders and have maintained pastoral life for centuries. Due to fluctuation in rainfall and the scarcity of pasture especially in the rather long dry season (Nov.-July), these tribes practice transhumant mode of range utilization (Abbas et al., 1992).

Like other nomads, camel owning tribes are continuously on the move seeking grazing and water. The camel migration patterns in Eastern Sudan are different from these of Western Sudan; the distances traveled are shorter and the area is not so arid in Western Sudan, (Al-Amin, 1979).

2.3 Camel population

It has always been difficult to make reasonable estimates of camel numbers in the world, mainly because camels exist in desert areas with
difficult accessibility. Romet (2001) reported that from 1950-1980, there was a decrease in the number of camels, for several reasons such as mechanization of transport, sedentarization of nomads and exceptional drought.

Camel’s population in the world is estimated as 18.5 million heads. Dromedary camels comprise 95%, while the remaining 5% are Bactrian. The near East, North Africa and the Sahel region have about 70% (12.6 million) of the world dromedary population. Somalia and Sudan together own about half of this numbers, (Kesseba et al., 1991).

Sudan is rated the second in numbers of camel population in the world. Camels constitute 22% of the animal biomass in Sudan and 26.3% of the number of camels in the Arab world (Sokr and Majid, 1998). The last estimation of camel’s population in the Sudan was about 3908 thousands head (Table 2.1), Ministry of Animal Resources (2005). Alwasyla (1995) reported that about one million of camel’s population in the Sudan is found in the Butana area, Lahween and Rashaida tribes own 12.1% and 11.4%, respectively.

2.4 Classification of Sudanese camels

Unlike other conventional animals farm species, the camel has not passed through process of selection to perform certain physiological functions such as milk or meat production.

Table 2.1 Estimate of camel’s population by states

<table>
<thead>
<tr>
<th>States</th>
<th>Camels</th>
<th>States</th>
<th>Camels</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Kordofan</td>
<td>738221</td>
<td>Northern</td>
<td>40252</td>
</tr>
<tr>
<td>Region</td>
<td>Number</td>
<td>Nile Region</td>
<td>Code</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------</td>
<td>------------------</td>
<td>------</td>
</tr>
<tr>
<td>South Kordofan</td>
<td>198526</td>
<td>River Nile</td>
<td>93792</td>
</tr>
<tr>
<td>West Kordofan</td>
<td>501787</td>
<td>Khartoum</td>
<td>5471</td>
</tr>
<tr>
<td>North Darfour</td>
<td>484592</td>
<td>North Upper Nile</td>
<td>0</td>
</tr>
<tr>
<td>South Darfour</td>
<td>91447</td>
<td>Unity</td>
<td>0</td>
</tr>
<tr>
<td>West Darfour</td>
<td>350157</td>
<td>Gongoli</td>
<td>0</td>
</tr>
<tr>
<td>Elgedarif</td>
<td>202434</td>
<td>N. Bahr Elgazal</td>
<td>0</td>
</tr>
<tr>
<td>Kassala</td>
<td>526408</td>
<td>W. Bahr Elgazal</td>
<td>0</td>
</tr>
<tr>
<td>Red Sea</td>
<td>273951</td>
<td>Albohairat</td>
<td>0</td>
</tr>
<tr>
<td>Blue Nile</td>
<td>175078</td>
<td>Warab</td>
<td>0</td>
</tr>
<tr>
<td>Sennar</td>
<td>95746</td>
<td>Bahr Elgabal</td>
<td>0</td>
</tr>
<tr>
<td>Elgezira</td>
<td>101217</td>
<td>E. Equatoria</td>
<td>0</td>
</tr>
<tr>
<td>White Nile</td>
<td>28919</td>
<td>W. Equatoria</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>3908000</td>
</tr>
</tbody>
</table>

Camels in Sudan are classified as pack (heavy) and riding (light) types according to the function which they perform (Gillesple, 1960). The riding camel has received more attention and has undergone intensive selection. The following classification is based on conformation and tribal ownership.

2.4.1 Pack camel
This type comprises 90% of the total number of camels in Sudan. It is characterized by large, heavily built body, with the capacity for developing, relatively large hump and includes the following types:

**a- Arabi camels:** Is a sandy, gray, large, heavily built animal with a well developed hump. It has the widest distribution in the Sudan mainly due to its good performance as work animal; AL-Arabic is subdivided in to three breed types:

  i- **Light pack:** Which is fund East of the Nile and in the area of the Red sea and bred by Hadandwa, Beni Amer and AL Amarar tribes.

  ii- **Big Arabi:** Spread in Buttana region and bred by Shukria, Bataheen and Lahaween tribes in Eastern Sudan.

  iii- **Heavy Arabi:** Camel which is characterized by its heavy weight, big hump, long neck, big head, roman nose, heavy bones, its sandy gray or fawn color, usually with long hair on the hump and the shoulder (Khour, 2000). Also is known as the largest camel in size in Sudan. It is spread in the desert and semi-desert areas West of the Nile River. This types includes Kababish camels which is found in Northern Kordofan.

  iv- **Garbawy and Fiesani Camels:** Are found mainly in northern Darfour Provinces (Zayeed et al., 1991).

**b- The Rashaidi camels:** This type is pinkish-red in colour, slightly shorter, not quite as heavy as Arabi camel type and less numerous. Rashaidi camels are herded mainly by the Rashaida nomads of Eastern Sudan who recently migrated from Saudia Arabia. Some Rashaidi camels are owned by the people who share the same ecological zone like the Shukrya, Lahween and Bataheen (Al-amin, 1979). In milk production Rashidi camel produce sufficient amount of milk (2000-
2.4.2 Riding camels

This is the type whose conformation with riding and is selected for speed. It is lighter in body weight, and characterized by small heads and ears, long and fine shoulders, very deep chest and well muscled quarter. It is mainly bred in the North-East of the country between the River Nile and Red Sea. And include the following types:

a- The Anafi camel: The Anafi camel is the faster. It has long legs, white body colour, small hump and long narrow head. They are bred by Juhayneya, Al Rufaa, Kanana, Shukreya and Kawahla tribes.

b- The Bishari camel: These camels are reared by Bisharian, Al Omarar and Hedandwa and Beni Amir in Kassala and the Red Sea regions. They are very famous for their racing ability (Wardah, 1989a). These animals are stronger and slightly large then Anafi type. Khouri (2000) described the Bishari camel as short and strong legs, fine and thin skin and white to yellow colour.

Various camel-owing nomadic groups have developed riding camels from crosses of Bishari or Anafi camel with their local strains.

2.5 Camel as milk producers

2.5.1 Camel udder

2.5.1.1 Anatomy and physiology

The camel like the cow has a four quartered udder, it is firmly suspended from the abdomen with out deep cuts (Sharm, 1963).

In the prepuberal and nulliparour females, only the small teats are visible, as the mammary tissue does not develop until the end of the first pregnancy. At the peak of lactation, the udder is well developed in size and show well developed milk vein. The udder of the she camel consists of four glandular quarters, each with it is own teat (Nosir, 1974). The left and right halves of the udder are separated from each other by
fibro elastic tissue extending from the linea alba and prepubic tendon and a groove is generally visible between the lift and right halves. The lateral aspect of the quarters is covered by tissue from the abdominal tunic and the caudal abdominal wall. The anterior and posterior quarters are independent but there is no visible separation between them, (Smuts, 1987). And the teats that are directed carino ventrally possess two openings. Conformation of the udder can change according to breed, age and stage of lactation, (Tibary and Anussi, 2000).

In South American camelidae, contrast radiography has shown that each quarter is composed of two distinct glands each leading to separate...
streak canal within the respective teat. The udder is therefore composed of eight (8) separate glands (Fowler, 1998). Each mammary gland consists of parenchyma, connective stroma, ducts and alveolar systems. The gland is made of several individual lobules separated by septa of connective tissue (interlobular connective tissue). The glandular unites of the lobule, the alveoli are separated from each other by intralobular connective tissue, which projects from the interlobular connective tissue (Nosier, 1974). There are no anostomoses between glands (Fowler, 1998). The duct system begins with small intralobular ducts that enlarge progressively and each duct is lined by an epithelium resting on distinct basement membrane. The duct epithelium is low, simple and secretory in the smallest intralobular duct but becomes columnn in the larger duct (Nosier, 1974).

The secretory units, acini or alveoli, are small vesicles of unequal size that from the lobule-alveolar system. The epithelial lining of the alveoli (flattened to columnar epithelium) shows great variation according to stage of lactation and secretory activity of the gland. In the non-lactating she-camel, the number and size of alveoli per lobule decreases, the parenchymatous tissue regresses and the interalveolar filled with interstitial connective tissue (Nosier, 1974).

2.5.1.2 Udder measurements

A well developed mammary system forms one of the major components of the dairy animal score card. An estimate of size of the udder before and after milking may form an index for its capacity and
collapsibility, (Mishra et al., 1978). As such, well developed milk veins may reflect greater milk secreting potential. Wardah et al. (1990) reported that in new system for classification of camels. Dairy camels are characterized by the development of the udder and milk veins.

Zayeed et al. (1991) studied the udder measurement in Libyan dairy camel and they reported that, udder length 24 cm, width in the fore teat 36 cm, depth in the fore quarters 17 cm, depth in the rear quarters 13 cm. The distance between the fore teats 22 cm, and between the rear teats 12 cm, they also reported that the fore teats is less in size than the rear teats, and their length are between 3.2-1.3 and 5-1.8 cm., respectively. The diameter of the fore and rear teats (in the base of the teats) were 4.5-1.8 and 4.9-2.1 cm, respectively.

They have also studied the udder measurements before milking and during milk stimulation and reported that, the length of fore right, fore left, rear right and rear left teats were 12, 12, 13 and 13 cm, respectively. The diameters of the teat in the upper were 8, 7, 11 and 11 cm, respectively and in the lower 10, 9, 13 and 12 cm, respectively. Udder depth with teat were 36, 36, 39 and 40 cm, respectively, and without teat 25, 25, 26 and 28 cm, respectively. The distance between fore right and left teat 18 cm, and rear right and left teat 12 cm. The width of the udder between the fore, rear, right and left teat were 22, 24, 16 and 14 cm, respectively, (from the middle of the teats). The width of the udder in the upper and lower were 27 and 25 cm, respectively. Zayeed et al. (1991) demonstrated that, there is great variation in teat size and length in camels, and this is due to some reasons such as camel type, lactation stage, parity number, the ability of the she-camel to milking procedure and udder and teat disease. The author’s furtherly revealed
Photo 2.4 Well developed milk vein. M.O.Eisa, field study (Al-Showak, 2004).
that, the same reasons have an affect in the udder size and milk production. On the another study in Libyan camel by Zayeed et al. (1985), they postulated that, the udder depth was 16-13.5 cm, udder width was 20-17 cm, the distance between the fore teats was 18-15cm, and between the rear teats was 12-9 cm, the length of the fore and rear teats (dry) were 3-2.5 and 3.5-3 cm, respectively. The length of the fore and rear teats (full of milk) were 8.5-7 and 9-8 cm, respectively. In India, Mishra et al. (1978) investigated the relation of mammary measurements with milk yield in three types of dairy cows: Red Sindhi, Hariana and crossbreed (F: Jersey x Indigenous). They postulated that, the horizontal circumference of the udder before milking were 90.74± 1.51, 74.94±1.36 and 80.16±2.24 cm, respectively, and after milk were 79.10± 1.18, 68.89±1.19 and 67.83±1.65 cm, respectively. Verticals semi-circumference of the udder before milking were 55.93±0.66, 44.14±0.81 and 49.30±0.98 cm, respectively, and after milking were 47.39±0.62, 40.36±0.64 and 38.46±0.92 cm, respectively. Depth of the udder before milking were 19.20±0.48, 16.60±0.24 and 14.77±0.37 cm, respectively, and after milking were 15.63±0.19, 14.33±0.22 and 10.87±0.30 cm, respectively. Linear lengths of milk vein were 30.31±0.14, 33.42±0.58 and 32.55±0.79 cm, respectively. Tortuous lengths of milk vein were 36.41±0.50, 37.28±0.36 and 37.38±0.98 cm, respectively. The authors furtherly revealed that, the correlation coefficient values of differences in the udder measurements before and after milking with the yield obtained during the time of measurement were positively significant (P<0.01) in all the breeds of cows under study excepting the value in respect of the difference of vertical semi-circumference in Hariana cows. Moskovskaja (1976), and Bogatyreva (1970) also reported positive and significant correlation between udder size and milk in exotic cows. On the other hand, the regression coefficient values showed that the milk yield was...
dependent on the linear and tortuous lengths of milk vein. Also it was observed that, the amount of milk obtained in a particular milking was almost similarly dependent on the differences in the horizontal circumference, vertical semi-circumference, depth and size of udder before and after milking in all the breeds of cows under study. Furthermore, Bhadauria and Johar (1985), investigated udder measurements in lactating Jersey cows, they postulated that, udder length, depth and width averaged 57.65±1.09, 20.92±0.51 and 39.91±0.59 cm, respectively. Mali et al. (1986) recorded about udder measurements in relation to milk yield in Bos taurus x Gir crosses they revealed that, all of udder length, width and depth were significantly correlated with milk yield. Sharma et al. (1983) reported that, udder length ranged from 49.39 cm, in Haryanas to 61.43 cm, Holstein Friesian, udder width from 41.22 cm, in Haryanas to 55.64 cm, in HF, s and udder depth from 15.07 cm, in Haryanas to 80.98 cm, in HF, s and udder volume from 754.59 cm³, in Haryanas to 1596.56 cm³, in HF, s. For all traits the effects of parity and stage of lactation were significant.

Hafeez and Naidu (1981) reported that, in buffaloes daily milk yield and udder depth were significantly affected by stage of lactation. Lactation milk yield, udder length, udder width and udder score increased from 1st to 3rd lactation, after which milk yield decreased but udder traits remained the same. Correlations among udder traits were significant (P<0.01), as were correlations for milk yield traits with udder traits (P<0.01) and teat length (P<0.05). The correlations for previous lactation milk yield with udder length, width, depth, teat length and udder score were 0.450, 0.452, 0.458, -0.227 and 0.399. The multiple correlation coefficients from equations to calculate daily and peak yields from udder traits were 0.933 and 0.407. Manguarkar and Desai (1981) also studied
udder measurements in buffaloes and they reported that udder length 35.47 cm, and the distance from the ground to the udder 59.0 cm.

Saiyed and Patel (1989) reported that, on F1 and F2, (Jersey x Kankrje) crossbreds, udder length were 61.25±1.98 and 52.84±0.89 cm, respectively, udder width were 67.15±2.28 and 58.32±1.06 cm, respectively, and udder depth were 23.88±1.06 and 19.40±0.61 cm, respectively. Milk yield was significantly correlated with udder length, width, depth and circumference (0.64, 0.59, 0.35 and 0.62, respectively). Akhtar and Thakuria (1998) revealed that, on swamp buffaloes, values of udder length, width, depth and circumference were 40.56±0.15, 35.11±0.16, 6.55±0.07 and 56.07±0.14 cm, respectively. All udder measurements were positively correlated with test day and 105-day milk yield (0.408-0.787; P<0.01). Furthermore, Prajapati et al. (1998) studied the association of udder and teat measurements with milk yield in Kankrej cows. They found significant correlations between udder (length, width, and depth) and teat (length and diameter). Milk yield was significantly correlated with udder measurement only.

On the other hand, different Indian investigators studied udder and teats measurement and their relation with milk yield in goats, such as, Kumar and Singh (1983) reported that, in Black Bengal, Jamnapari and Saanen females, the effect of milking was significant in udder length, width, teat length, teat diameter and the distance between the 2 teats, in all groups, except for teat length in Sannens. Kumar et al. (1983) reported that, in first lactation Black Bengal goats, daily milk yield was significantly correlated with udder length, width and teat length (r = 0.44, 0.66 and 0.40). For the 2nd lactation goats milk yield was correlated with udder width and depth and teat length and diameter (r = 0.41, 0.36, 0.57 and 0.44, respectively). Similarly Narain et al. (1986) reported that, in Jumunapri goat’s milk yield was significantly correlated with udder
length, circumference and width and with teat length and circumference
\( r=0.964,0.955,0.449 \) and 0.955, respectively.

In Czechoslovakia, Chrenek (1983) reported that, for Slovakian Pied (SP) cows, and SPs with 50, 62.5 and 75% of Red-and-white Holstein inheritance, udder length averaged 50.6, 61.6, 64.9 and 69.7 cm, respectively, udder depth 37.9, 46.2, 47.9 and 50.4 cm, respectively, and udder circumference 101.7, 114.2, 118.0 and 121.7 cm, respectively. The distance between the fore teats averaged 13.2, 15.5, 16.4 and 17.2 cm, respectively, that between the rear teats 6.7, 8.4, 9.2 and 9.2 cm, respectively, fore teats length 5.4, 5.2, 5.2 and 5.1 cm, and rear teats length 5.0, 4.6, 4.4 and 4.4 cm, respectively. The correlations among udder measurements were mostly significant (0.25-0.95). In Slovakian Pied cows, Chrenek and Plensnik (1986) found that, udder depth was 32.5-46.4 cm, udder length 45.3-60.3 cm, udder circumference 91.8-114.6 cm, distance between fore teats 12.5-19.9 cm, distance between rear teats 5.7-10.9 cm, distance between fore and rear teats 5.8-9.5 cm, fore teat length 5.0-6.8 cm, rear teats length 4.8-6.8 cm, and teat ground clearance 51.2-59.3 cm.

In Brazil, Mello et al. (1998) investigated udder morphometry in goats. They reported that, the udder circumference had significant effect \( P<0.01 \) on daily milk yield. The correlation of udder circumference with daily milk yield was 0.78.

In Poland, Kamieniecki (1980) studied udder characteristics of polish Black-and-white low land cows. They found that, udder length, width, depth and teat length all increased with advancing lactation from 1 to 5 \( P<0.01 \). The space between teats also tended to increase, the distance from udder to ground < 45 cm.

In USSR, for Russian Simmental (RS), Ayrshire x RS, and Dutch Black Pied x RS cows, udder circumference 102, 110 and 105 cm, udder
length 30, 32 and 31 cm, udder width 26, 27 and 27 cm, (Aban et al., 1985) Furthermore, Yakusevich and Glytov (1982) evaluated udder characters in 2 groups of Russian Black and 2 groups crosses with Holstein Friesian. They mentioned that, udder depth were 20.5, 24.0, 21.4, and 24.8 cm, udder length were 32.1, 26.0, 35.5 and 28.5 cm, respectively. Treus (1982) studied udder characters in elands and reported that, udder conformation is characterized by a fore teats distance of 7.5-8.5 cm, versus 4.5-4.8 cm, for rear teats, and the rear half udder depth is 50% of that for the front half. Udder length averaged 23.3 cm, width 14.7 cm, circumference 42.7 cm, and depth 7.7 cm. Teat diameter averaged 1.5 cm, fore teat length 2.8 cm, rear teat length 2.6 cm, and teat circumference 3.9 cm. On an experimental farm in the Moscow regions, DzhiKiya (1987) studied, udder conformation of Holstein-Friesian cows of different origins. Canadian, USA, Soviet, Denmark and German. He found that, udder length averaged 30.68, 30.15, 28.64, 28.78 and 31.96 cm, udder width 30.30, 30.12, 29.57, 28.03 and 30.00 cm, and udder depth 26.08, 24.80, 27.24, 24.96 and 24.16 cm, respectively. Furthermore, Yokusevich and Bud (1958) reported that, in Holstein-Friesian, Russian Black Pied and their crossbreds cows, udder length averaged 40.6, 30.7 and 36.1 cm, udder width 33.6, 28.1 and 31.8 cm udder depth 28.1, 23.7 and 25.8 cm, udder ground clearance 60.0, 56.0 and 58.8 cm., front teat length 6.6, 6.0, and 6.3 cm, rear teat length 5.5, 5.3 and 5.4 cm, front teat diameter 2.0, 2.2 and 1.97 cm, rear teat diameter 2.0, 2.3 and 2.0 cm, distance between front teats 18.7, 15.9, and 17.8 cm, and distance between rear teats 10.8, 8.1 and 10.2 cm, respectively.

In Turkey various udder characteristic and their relationship with milk yield in Simmental cattle from Kazova farm, were determined by Sekerder et al. (1997) they reported that, statistically significant partial
correlation coefficients, (P<0.01) and (P<0.05), were found between 305 day milk yield and various udder and teats characteristics, particularly for udder length and width of front udder.

Ozbeyaz et al. (1998) reported that, in Brown Swiss cows, udder length decreased as lactation number increased. Differences between mean rear teat length, rear teat diameter, fore teat diameter, distance between fore and rear, were significantly correlated with lactation number. 305 day milk yield was negatively correlated with udder length and positively correlated with distance between fore and rear teats. Average fore and rear teat length and diameter at 150 days of lactation were 6.65, 5.40, 2.67 and 2.51 cm, respectively. It was concluded that teat dimension did not significantly affect milk yield. However, udder length significantly affected yields.

In Germany, Weies et al. (2004) studied teats in dairy cows in relations with quarter and milk. They found that, for left front, right front, left rear and right rear, teats length were 66±1.5, 67±1.6, 57±1.5 and 56±1.6 mm, respectively. Teat diameter were, 27±0.4, 27±0.4, 28±0.4 and 28±0.3 mm., respectively (P<0.05). Furthermore, they mentioned that, milk yield was higher and milking time was longer in rear compared with front quarters. No relationship was observed between teat length, teat diameter and teat canal length. But teat length was negatively correlated with milk yield. Teat length and teat diameter were similar to result found by (Grindal et al., 1991; Rogers and Spencer, 1991; Le Du et al., 1994, and Neijenhuis et al., 2001). Earlier investigations reported longer and thicker teat, Ardreae (1968) and Loppnow (1959), indicating changes due, the breeding progress of the last decades.

2.5.2 Camel milk
Milk is defined as normal secretion of mammary gland of all mammals to nourish their young’s. In many arid areas, camels play a central role as milk suppliers. The comparative advantage of the camel as a dairy animal over the other species in the same environment is difficult to quantify; however, it is widely recognized that in absolute terms, the camel produces more milk and for a longer period of time than any other milk animal held under the same condition (Farah, 1996). Camel’s milk is generally opaque white, it has a sweet and sharp taste, but sometimes it can be salty. The test generally depends on the type of fodder and availability of drinking water. Compared to cow’s milk, camel milk sours slowly and can be kept longer without refrigeration (Farah, 1996).

In East Africa, where 60% of the world camel population are held, the consumption of camel milk is not limited to only the pastoral nomads, but camel milk is also commercialized and sold in the urban areas (Schwartz and Dilo, 1992). Furthermore, camels, milk constitutes the sole diet of camel herders for considerable periods, and they rely completely on camel’s milk for more than month without having drinking water especially during the migratory routes (Al-Amin, 1979). With regard to the nutritive value of camel milk, Mares (1954) observed that, colostrum is often consumed by the Somali, who regard it as a laxative. Camel milk is very rich in vitamin C (5 mg/100 ml), according to Leupold (1968), a vital ingredient when fruits and green scarce (Knoess, 1976), and contains 70 calories per 100 gm. It is also high in water and mineral contents (Al-Amin, 1979). Dahl and Hjort (1976) calculated that, 4 kg of camel milk would be needed to satisfy the daily calory requirements of one adult Human beings, while a consumption of 1.8 kg would meet his protein needs.

The most striking feature of camel’s milk is the variation of water content with acidity and environmental temperature change. It has been
reported that camels can maintain milk production and dilute their milk during water deprivation (Yagil and Etzion, 1985a,b).

The nomads of the Ahaggar in Sahara depend on milk to given them a balanced diet (Gast et al., 1969). They have a saying “water is the soul, milk is life,” and hungry people say “ I have lost the test of milk.”

### 2.5.3 Milk letdown

Milk is stored within two compartments of the mammary gland: the cistern (including teat and gland cistern and large milk ducts), and alveoli (small milk ducts and alveoli). The cisternal milk can be easily removed by sucking, hand or machine milking, without any previous stimulation. On the contrary, the alveolar milk can only be removed if milk ejection has occurred. Tactile stimulus on the mammary gland activates a neuroendocrine mechanism resulting in the release of oxytocin into the blood stream. Oxytocin causes the contraction of the myoepithelial cells that surround the alveoli, forcing the expulsion of the milk into the cisternal compartment (Bruckmaier and Blum, 1998). There are wide species differences in the physiology of milk ejection reflex (Ellendroff et al., 1982).

For instance, it has been shown that suckling has either stranger (Bar-Peled et al. 1995; Samuelsson and Svennrsten-Sjaunja 1996, and Lupoli et al. 2001); weaker ( Akers and Lefcourt, 1982). On similar, (de Passile et al., 1997; Tancin et al., 2000, and Negrao and Marnet 2002), effect in stimulating the milk letdown compared with cows milked by machine without the presence of the calf. Nevertheless, most authors (Akers and Lefcourt 1982; de Passile et al., 1997, and Tencin et al. 2001) agree that there is a higher oxytocin release in response to suckling as compared with in the presence of the calf.

In camel, the presence of the calf is considered imperative for milk let down, and hand massaging is also used to enhance this response. Milk
Letdown in this species is easily noticeable after a short period of suckling (1.5 min) when the teats suddenly swell, becoming much larger than before. Milking needs to be performed soon after the teat swelling, since the duration of the milk letdown response is also very short, approximately (1.5 min). Because of this fact, some authors have assumed that camels do not have mammary cisterns. It has been reported that camels are able to refill their udder in about 30 minutes after complete milking by hand, to suckle their calves, (Yagil et al., 1999).

### 2.5.4 Milking procedure

Camels in most pastoral societies are milked by men. Before milking, the calf is allowed to suckle until the milk starts to flow and the camel can be milked. If a calf dies, the dam dries up if milking is not stimulated. Often it is sufficient for the dam to see the skin of her calf for milk secretion to be stimulated (Farah, 1996). Because of the height of the udder the milking is done standing. The milker stands on one leg and balances the milking bowl on his bent left leg. The left hand holds the bowl, while the camel is milked with the right hand. Another method is to tie the bowl around the milker’s neck so it hangs low enough to be held while the camel is being milked (Yagil, 1982). Some times both udder halves are milked at the same time by two herdsmen and some times one half of the udder is milked and the other one left for the calf. 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 (Farah, 1996).

Camels have successfully been machine milked. The animals were gradually changed from hand to machine milking in the presence of their calves (Baimukanov, 1974). Milking camels are usually very docile and gentle animals, which accept milking easily (Farah, 1996).
In the horn of Africa, milking of camels is not only an act of work, but has become an integral part of the local culture and heritage. Only boys, unmarried women or ritually clean men are allowed to milk the animals. It is usually practiced to allow two teats for the calf and to milk the others two teats. The calf may be restrained, or the she-camel may be restrained by an attendant. A good herdsman can usually milk his camels single-handed (Hartley, 1974).

2.5.5.1 Milk yield

Data on the actual amount of milk produced by camels are not very accurate for judging the milk yielding capability of camels. Mainly because camels exist in desert areas with difficult accessibility, the calf are still suckling and, therefore, the actual volumes of milk secreted are higher than the figures presented among the different herds studied. On the other hand, milking frequency varies among the different groups. Camel may be milked once a day among the Murah of Arabia (Cole, 1975), from two to four times among the Somali (Bremaud, 1969; Hartley, 1979), and the Rendile of Kenya (Spencer, 1973), and even as many as six or seven times a day among the Afar of Ethiopia (Knoess, 1977). The latter may also leave their animals un milked for a whole day, which may account for sporadic very high daily yield estimates.

Values of daily milk yield ranging from one to 35 kg, were reported in the literature:

In Egypt, Elbahy (1962), and Shalash (1979), revealed that, daily milk production of camel herds managed under good feeding regimes amounted to a range of 10-15 kg, where as with poor feeding daily milk yield declined to only 4 kg.

In Eritrea, Gebrehiwet (1997), studied production parameters of camel, and found that daily milk yield ranged from 3.6-5.8 liters.
In Ethiopia, Yagil et al. (1975) postulated that, a yield of 8 liters. While Knoess (1977), reported that, in dams maintained on natural rain-fed grazing lands, and milked twice a day, yielded a daily average of 7 kg. Whereby, they yield up to 13 kg/day when they are fed on improved irrigated pasture.

In India, Rao (1974) reported average daily milk yield 7-18 kg. Similar finding were also reported by Ghol (1979) he recorded that, and the yields rose the 2.5-6.5 kg, to 15 kg, when feeding conditions of the herd were improved.

In Kenya, Sato (1976) estimated the daily milk production under nomadic conditions as 1.3 liters. Furthermore, in North Kenya the camels produce far more milk than the local cows. Field (1979a, 1979b) reported that, daily milk production reach 21 kg in the first week, declining to 4.8 kg in the 16th week of lactation, (average 13 kg/day).

In Algeria, the lactating camel produces 4-5 kg/day, on good pasture, for the first three months. A good milker can even provide up to 10 kg/day. After the third months of lactation the yield averages about 2 kg/day, (Yagil and Etzion, 1980).

In Pakistan, daily milk yields of 15-40 liters were recorded, (Knoess, 1977). When the camels were well fed, there was an average milk yield of 10-15 kg/day, (Yasin and Wahid, 1957). As much as 22 kg/day were obtained from some camels. In the area with poor feeding the daily average was 4 kg. The heavy Pakistan camels produced up to 35 kg/day (Knoess, 1979).

In Saudia Arabia, Knoess (1979) postulated that, the daily milk production was 5 kg. While, Ismail and Al-Mutiari (1990) studied camels milk yield under traditional conditions and found that, milk yield could varied between 6-7 kg/day.
In Somalia, Hartely (1979) postulated that, daily milk yield ranged from 3-9 kg. Mariam (1988) reported that, camels are milked three times per day viz. in the morning, afternoon and evening. During dry seasons the estimated yields were 1-1.4, 0.7-1.4 and 1.4 liters, for the morning, afternoon and evening, respectively. On the other hand, the three milking during wet season yielded 1.75-3.5, 1.4-3.5 and 1.4-3.5 liters, respectively, the daily average yield during the wet season was 2.4 liters.

In Sudan, Al-Amin (1979) revealed that, average milk production was 5-10 kg/day, less than these; Bakheit (1999) reported that, in three herds of Western Sudan camel, the mean daily milk yield was 2.36 liters. On the other hand, Salman (2002) studied camel milk yield in Butana area and he found that, camels milk yield can reach 8 liters per day in the rainy season and good conditions, but at the end of summer the amount of milk decreases to 1.38 liters/day.

In Tunisia, Burgmeister (1974) revealed that, the daily milk production was 4 kg.

In Israel, Yagil et al. (1980) reported that, no actual recordings of milking have been made. Estimates of milk production range from 7 to 15 kg daily.

In new world camels, little is known about the milk production of these members of the camel family. The alpaca, when kept on good pasture, can produce up to 0.5 kg of milk daily (Novoa, 1970).

### 2.5.5.2 Milk yield per udder quarter

Studies on the yield of milk of the dairy animal have shown that great variation occur in both yield and composition of the milk of different individual, and from the same individual due to stage of lactation, gestation and various environmental conditions. The causes for these variations have been ascribed to numbers of factors viz.,
inheritance, environment and certain physiological and pathological condition. Furthermore, Ramet (2001) studied camels milk production. He mentioned that some factors might influence milk production such as: camels breeds or individuality of animals, nutritional factors and stage of lactation, milking practices, such as calf sucking, milking frequencies, milking performance method and drinking water availability can also influence milk production.

The relative yield of milk of the different quarters of the udder although has been thoroughly studied by many investigators in the cases of different breeds of dairy cattle. Yet, little or non-is Known in this consideration in the camels.

According to the earlier studies, Kulaeva (1979) reported that, in the camel, slightly more milk was received from the back-quarters, 56.4 percent to 43.6 percent from the forward-quarters. On the other hand, and according to the cases of dairy cattle. Ingle (1903) found an appreciable difference in the production of milk from different quarters of the same udder. Mattick and Hallett (1930), and Turner (1934) reported, a marked variation in milk yield from different quarters of the same udder.

Turner (1934), and Harbans Singh and Dave (1953) stated that, the hind half of the udder gave more milk than the fore half. Kenneth Miller and Peterson (1940) reported that, the order of milking the quarters was to a certain extent responsible for variation in quantity and quality of milk from different quarters of the same udder. Harbans Singh and Dave (1953) found no effect on yield of milk from different quarters of the same udder due to the order of milking. Fitch and Copeland (1924) observed no significant difference in production from individual quarters. Mannar et al. (1956) showed that, there was considerable variation of milk yield from different quarters of individual cows. However, the average milk yield of the cows over the whole experimental period
indicate that, the production was greater in the hind right quarter than the other quarters. There was no much difference between the front quarters, and the hind left quarters, each amounting to nearly 24.5% of the total production; whereas the yield from the right hind quarter was slightly more, (26.5% of the total yield) which was found to be statistically significant. They also reported that, a comparison of the average milk yield of the rear half and front half showed that, the hind half produced nearly about 2% more milk than the front half. However, this difference was found to be not statistically significant. Harbans Singh and Dave (1953) reported that, hind quarter yielded 33% more milk than front quarters. Right quarters yielded 12.2% more milk than left quarters, they concluded that right hind teat is common in giving higher yield.

Matthews et al. (1941) reported that, the fore quarters gave on the average 38.8, 43.7 and 42.1% of the total udder yield for grade and registered and Jersey cows, respectively. Turner (1934) found very little differences in the yield from the right and left halves of the udder. Kudrashov (1954) found that, these differences were greatest in Friesian cows, followed by the Khalmogor, Kastroma and Yarashavl breeds in decreasing order. Johnosn and Korkman (1952) showed that, the difference between the fore and rear quarters production was highly significant, whereas, that of the right and left halves of the udder was practically the same. Skradel (1936) found that, the right rear quarter was the highest yielding one. Ragab et al. (1969) revealed that, the fore quarter delivered 28.7, 39.8 and 38.3% of the total, morning milk yield in buffaloes, Egyptian and Friesian cows, compared to 32.2, 44.8 and 38.7% of the evening milk yield in the same animals, respectively. And, the right rear quarters was the highest yielding part of the udder and also the second quarters in the order of milking. The relative milk yields of the
separate quarters of the udder remained fairly constant throughout the lactation period.

Patel and Patel (1963) reported more milk in front quarter (58%) in Kankrej cows. On the contrary, many workers (Ilieva and Ivanov, 1971; Zakharyan, 1972; Baumgartner and Kalberer, 1972; Ruegesegger, 1972, 1973) found that, front quarters produced less milk than hind quarters. Oger (1960); Zakhariev (1962) and Ilieva and Ivanov (1971) observed left quarters producing more milk than the right quarters, while others reported right half to produce more than left half (Furtherman, 1962; King, 1966). Gawali and Bhatangar (1975) demonstrated that, the milk produced by hind quarter and left quarters was comparatively more than the front quarters and right quarters, respectively in Red Sindhi, Sahiwal and Karan Swiss cows. The quarter yield particularly in Red Sindhi and Sahiwal did not appear to vary much from the ideal ratio, though there were indications that the yield on percentage basis in Karan Swiss cows might differ from quarter to quarter (P<0.0). The milk produced by left hindquarter was significantly more than the right hind and right front quarters.

According to recent studies. Yokusevic and Glytov (1982) mentioned that, for 2 groups of Russian Black Pied and 2 group of their cross with Holstein Friesian, the percentage of milk from the front quarters averaged 45.4, 43.6, 43.3 and 43.0%. Nema and Dave (1995) studied the effect of udder quarters on milk yield of crossbred cows, and they found that, the milk yield of different udder quarters differed significantly (P<0.01). Hamann et al. (1997) showed that, the milk yield from different udder quarters varying greatly for different cows at different stage of lactation.

2.5.6.1 Milk composition
Camels can produce an adequate amount of milk in drought areas where other domestic animals have very low production. Of prime importance for the young camel, and especially for man who drinks the milk, is the composition. Cows exposed to heat, especially if drinking water is scarce, produce milk that has a much higher dry-matter content than normal (Bianca, 1965). The fat content is especially high. This milk would certainly not provide a suitable diet for man or animal exposed to the same climatic and water stress. Data concerning the composition of camel milk vary greatly. This can be partly attributed to the inherited capabilities of the animals, but the stage of lactation, age, and the number of calving also play a role. Of especial significance to the quality of the produced milk are the feed and water quantity and quality (Yagil, 1982).

Fresh camels milk has a high pH, (Grigoryants, 1954; Ohri and Joshi, 1961). The pH of milk is between 6.5-6.7 (Shalash, 1979). This is similar to the pH of sheep’s milk. Similar result found by Bakheit (1999) 6.65. While, Abdel-Rahim and Auru (1987) demonstrated that, pH of camel’s milk ranged from 6.0-6.5, and similar finding was also reported by Al-Kanhal (1993), 6.49 as pH value. Sheriha (1986) and C.R.T (1988) demonstrated that, during the first 6 months of lactation the pH witnessed decline. Furthermore, Sahani (1998) investigated camel’s milk pH in early and late lactation. And he reported the following value 6.38± 0.03.

In Egypt, El-Bahy (1962) studied milk composition of camel, and revealed the following values 3.8, 3.5, 3.9, 0.8 and 87.9% for fat, protein, lactose, ash and water, respectively. Davis (1963) demonstrated that, camel’s milk contains 3% fat, 3.5% protein, 5.5% lactose and 0.9% ash. Recently, Frag and Kebary (1992) reported that, the mean composition of camel’s milk were 12.36% total solids, 3.9% fats, 3.10% protein and 0.8% ash. And the mean levels of the major minerals Ca, N and Mg were 106.7, 13.15 and 8.81 mg/100ml milk, respectively.
In Ethiopia, Knoess (1977) reported that, camel’s milk contained 85.6% waters, 5.5% fat, 4.5% protein, 0.9% ash and 8.9% solid not fat.

In Israel, Yagil and Etzion (1980) reported that in, Plentiful drinking water, the camels milk composition was 4.3% fat, 14.3% solid not fat, 4.6% protein, 4.6% lactose, 0.6% ash and 85.7% water. While, in the scarce drinking water, they demonstrated the following value: 1.1%, 8.8%, 2.5%, 2.9%, 0.35% and 91.2% for the fat, solid not fat, protein, lactose, ash and water, respectively.

In India, Ohri and Joshi (1961) reported the following values of camel milk composition, 3.87% fat, 9.59% S.N.F, 4.0% protein, 4.9% lactose and 0.95% ash. Khan and Appora (1964) reported, 3.08 %, 9.92 %, 3.8%, 5.4% and 0.7% fat, S.N.F, protein, lactose and ash, respectively. Sahani (1988) investigated the composition of camel’s milk in early and late lactation. And he found the following values, fat % (3.1±0.15), SNF% (8.22±0.25), total solid % (11.32±0.36), and Mg % (5.18±0.36).

In North Kenya, Nawito et al. (1967) reported that, the fat, protein, and lactose in dromedary’s milk were, 3.8%, 3.5% and 3.9%, respectively.

In Libya, Gnam and Shereha (1986) reported, 3.3 to 3.6% fat, 13% dry matter, 87% water, and 3.3 to 3.6 % for protein of camels milk. Furthermore, Zayeed et al. (1991) reported that, in Libyan camels. The values of camel Ca and P ranged 312.5-137.5 and 152.7-39.6 mg, respectively. And the mean of the minerals in the first six months of lactation were, N (27.4±5.2 mg/100g), K (45.0±8.0 mg/100g), Ca (131.6 ±3.1mg/100g), Cl (158.0 ±18.0 mg/100g), and P (51.5±8.5mg/100g) of camel milk.

In Pakistan, Yasin and Wahid (1957) reported that, camels milk contained 2.9% fat, 10.1% S.N.F, 3.7% protein, 5.8% lactose and 0.7% ash. Furthermore, Kon and Cowsie (1961) reported, 4.2% fat, 8.7% S.N.F, 3.7% protein, 4.1% lactose and 0.8% ash. While, Knoess (1977) mentioned, 85.6% moisture, 0.9% ash, 4.5% protein,
5.5% fat, 3.4 (mg/100g) solids not fat, 4.0% lactose, 138 (mg/100g) Calcium, 0.5 
(mg/100g) Phosphorus and 8.9% total solids.

In Saudia Arabia, Sawaya et al. (1984) reported the following value: 11.7% total solids, 3.0% protein, 3.6% fat, and 0.8% ash. Minerals as mg/100g were: 106±2.0, 12±0.2, 106±63 and 104±84 for Ca, Mg, P 
and Na, respectively.

In Sudan, Al-Amin (1992) investigated camels milk composition, and he found that it contain 3.15% fat, 2.81% protein, 4.16% lactose, 10.95% total solids, 0.83% ash and 88.33% moisture. Bakheit (1999) reported that, the mean values of camel’s milk were, 3.41% protein, 3.36% fat, 3.60% lactose, 0.81% ash, 10.9% total solids and 89.26% moisture. Salman (2002) revealed the following results of chemical analysis for Butana camels milk, 3.84% protein, 3.72% fat, 88.67% moisture, 0.71% ash, 0.59% Na and 0.88% P.

In Tunisia, Illauze and Kamoun (1989) reported that, camel’s milk contained 2.29% protein, 88.60% water, 0.90% ash and 3.5% fat.

Furthermore, several investigators studied the chemical composition of camels milk, such as: Wilson (1984) reported that, milk composition of camels milk ranged between 2.9% to 5.4% fat, 3.0 % to 3.9% protein, 86.3% to 87.3% waters and 0.6 % to 0.8% ash. Lambert (1988) showed that, camels milk contained 87% water, 13.10% dry matter, 3.02% fat, 3.6% protein and 0.70% ash. Abdel-Rahim and Auru (1987) revealed that, in camels milk fat contents ranged from 2.8-3.6%, protein from 3.3-4.7%, lactose from 4.0-5.2%, ash from 0.7 to 0.79% and total solids 9.2-15%, in the same years Bachmann and Schulthess (1987) demonstrated that, total solids ranged between 10.3-13.0% and fat between 2.8-4.2%.

Jardali and Ramet (1991) postulated that, camel’s milk contained, 85.6% water, 3.70% fat, 3.45% protein and 0.74% ash. While, Al-Kanhal
(1993) reported, 88.86%, 2.22%, 2.89% and 4.32% for moisture, fat, protein and lactose, respectively.

On the point view of minerals contents in camel’s milk, Farah (1996) stated that, the mineral content of camel’s milk expressed in ash ranges from 0.6% to 0.8%. There is still little information about it. Data available however, indicate that camel’s milk is rich in chloride and phosphorous and low in calcium. Furtherly, it is influenced by factors such as health status of the udder and stage of lactation.

Gnon and Sheriha (1986) postulated that, camel milk contained 36, 60, 132, 16 and 58 (mg/100 ml) for Na, Ca, Mg, and P, respectively.

Hasan et al. (1987) investigated mineral content of camel’s milk, and they reported 36 mg/100ml Na, 62 mg/100ml K, 116 mg/100ml Ca, 8 mg/100ml Mg and 71 mg/100ml P. Also, Abu-lehia (1987), reported the following values for camels milk minerals: 59, 173, 115, 14, and 84 (mg/100ml) for Na, K, Ca, Mg and P, respectively. Furthermore, Mehaia and Al-Kahnal (1989) stated that, mineral contained of camels milk were: Na (69 mg/100ml), K (156 mg/100ml), Ca (106 mg/100ml), Mg (12 mg/100ml) and P (63 mg/100ml). Elsewhere, Farah and Ruegg (1989) recorded 157 mg/100ml for Ca, 8 mg/100ml for Mg, and 104 mg/100ml for P.

The author furtherly revealed that, the major mineral constituents of camel milk seem to be similar to those of cow milk. (Yogil and Etzion, 1980; Hasan et al., 1987; Farah, 1996).

2.5.6.2 Milk composition per udder quarter

The camel, like the cow has a four-quartered udder. It is firmly suspended from the abdomen, with out deep cuts (Sharma, 1963). Camel’s milk is a complex mixture of water, fats, protein, lactose, minerals and vitamins.

The four quarters of the udder function independently and it is desirable that any milk contained in all the four quarters should be equal.
in the ratio of 25:25:25:25 of the total composition, or 50:50 in any udder halves for better milkability (Gawali and Bhatnar, 1975).

Studies on the composition of milk of dairy animal have shown that great variations occur in the composition of milk of different individuals and from the same individual due to stage of lactation, gestation and various environmental conditions. The causes for these variations have been ascribed to a number of factors, viz., inheritance, environment and certain physiological and pathological condition (Ramet, 2001).

The literatures on the variation in composition of milk from different quarters are insufficient in cattle, and also very lacking in camels.

In camels, Ohri and Josh (1961) demonstrated that, the milk of all quarters appears to have the same composition.

On the other hand, in the cattle, Ingle (1903) found on appreciable difference in the solids not fat and fat from different quarters of the same udder. Rice and Markley (1929) and Benten (1929) reported variability in hydrogen-ion-concentration of milk from different quarters of the same udder. Mattich and Hallett (1930) also found an appreciable variation in the acidity and fat % in milk from different quarters of the same udder.

Mannar et al. (1956) reported that, the fat% of the milk from different quarters showed slight fluctuations, which was not statistically significant. Whereas, in the fat production, the right hind quarter excelled all others. Similarly, Murthy et al. (1951) found that, butterfat from different quarters of the udder does not reveal any significant difference.

Hamann et al. (1997) studied the variation in major and minor milk components. They showed that, the composition of milk from different udder quarters varying greatly for different cows at different stage of
lactation. Minor variations were found in levels of K, CL, milk protein, and lactose per udder quarters.

2.5.7 Milking time and flow rate

The time spent in milking animals if unduly lengthened could be a serious source of loss of time and money, whether animals are milked by hand or machine. This points is still of interest to the herd manager. Although, many investigators have studied this subject in dairy cattle, yet very little or practically none is known about it in camels.

Elting and La Master (1936) reported that, the milking time for cows was 5.32 min, on the average. Matthews et al. (1941) showed that, the milking times were 7.24, 8.85 and 8.55 minutes for Grade, Registered Holsteins and Jersey cows, respectively, with a mean of 8.2 minutes. Dalbery (1943) revealed that, the milking time varied from one milking to the next, the range being 3 to 18 minutes. Sheldon (1944) demonstrated the wide variation in milking time by machine from farm to farm, being from less than 5 minutes to more than minutes, with an average of 6.5 minutes. In hand milking the time ranged from 4.2 to 8.9 minutes per cows, with an average of 6.8 minutes. Helmstatt (1955) showed a direct relation between milk yield and milking time. Eisenreich (1950) stated that, there was some relation between milking time and milk yield in slow milking cows, but in quick milking ones the time remained nearly constant throughout the lactation.

Shafie et al. (1969) reported that, the mean period of time spent in the morning milking was 5.6, 3.4 and 3.4 minutes, in buffaloes, Egyptian cattle and Friesians, respectively compared to 3.5, 2.9 and 2.4 minutes in the evening milking. And there was strong relation between milk yield and milking time in the three breeds.

Schamas and Mayer (1984) reported that, milking time with and without pre-stimulation were 7.6 and 9.2 minutes, respectively.
Aban and Aban (1985), reported that, in crossbreds of Simmental cows with Black-pied and Ayrshire bulls. Milking rate were 1.8, 1.40 and 1.26 kg/min., respectively.

Yakusevich and Glytov (1982) revealed that, in 2 groups of Russian Black pied and 2 groups of their cross with Holstein-Friesian cattle. The milking times were 3.35, 3.33, 3.38 and 3.55 minutes. Treus, (1982) reported that, the milk flow rate averaged 85 ml/ minutes, during suckling and 67 ml/minutes during hand milking.

Dzhikiya (1987) reported that, milking time for Canadian, U.S., Soviet, Denmark and German Holstein Friesian cows, averaged 9.93, 10.14, 10.53, 8.56 and 8.32 minutes, respectively. And milking rate 2.03, 2.06, 1.88, 2.40 and 1.96 kg/min, respectively.

Roth et al. (1998) demonstrated that, average and highest milk flows as well as duration of milking were reduced as lactation progressed, but were increased between consecutive lactation.

Mello et al. (1998) reported that, the udder circumference had a significant effect (P<0.01) on milking time and milking rate.

Weiss et al. (2004) revealed that, milk yield was positively correlated with main milking time. And peak flow rate was negatively correlated with main milking time.

On the other hand, Kulaeva (1964) reported that, in the Bactrian camel, rate of milk flow was optimum for high producing female.
CHAPTER THREE

Experiment One

Relationship Between Udder, Teats and Milk Vein

Measurements with Daily Milk Yield
CHAPTER THREE

Experiment One

Relationship Between Udder, Teats and Milk Vein Measurements with Daily Milk Yield

3.1 Introduction

The udder of the she-camel like that of cattle consist of four quarters, each with its own teat. A well developed mammary system comprises one of the major component of the dairy animal score card (Mishra et al., 1978). Furthermore, dairy camels are characterized by the development of the udder and milk veins (Wardeh et al., 1990). As such, well developed milk veins may reflect a greater milk secreting potential. Elsewhere, Zayeed et al. (1991), demonstrated that, there is a great variation in udder and teat size and length in the she-camel. These variations may be attributed to variable factors including, camel type, lactation stage, parity number and disease.

Studies correlating udder, teat and milk vein measurements with those of milk yield are very scarce if not available at all. The present study was therefore initiated to investigate the correlation between several udder and teat measurements including length, width, height together with milk vein diameter on milk yield with the ultimate goal to secure a valid indicator of dairying potential of the she-camel.

3.2 Materials and methods

3.2.1 Study area

The present study was conducted at Al-Khalefa Hawa Alnabi rain-fed mechanized scheme (30 km. North West of El-Showak). Which is located in Al-
Gadaref state, within the 14°3′ N and 35°8′ E latitudes. The area is surrounded by the rain-fed mechanized sorghum and sesame fields. The vegetation of the area is comprised of annual grasses, acacias, euphorbias and dwarf bushes. The annual rainfall varies between 400 to 600 mm, and the maximum temp. between 40°C-45°C. during the dry season (December – June). El-Showak is dominantly inhabited by two camel owning tribes Rashaida and Lahween. Both tribes are ancient camel breeders and have maintained pastoralist life for centuries. In El-Showak area camel serve primarily as milk producers, but are also used as pack and meat animals.

3.2.2 Experimental animals

16 lactating she-camels of type (Arabi-Lahwai), with different parities, stage of lactations and age, (Table 3.1), were randomly selected from the village herd. They all represent the typical features of the Arabi camel such as heavy weight, big hump, long neck, big head with long hair on the hump and shoulder and sandy gray or fawn colour.

3.2.2.1 Identification

Each of the experimental selected females was identified by a plastic tag with a numerical No. placed round the neck. A record for each she-camel contain age, parity order, calving date, chest girth, udder, teats, and milk vein measurements and daily milk yield were compiled.

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</table>

S.C. No: She-camel number
A-L: Arabi – Lahwee

### 3.2.2.2 Herd managements

The camel herds are managed by husbandry system deeply rooted in the society based on superstition and practices that were founded down by father to son over the ages. The herds are managed in a pastoral system (Transhumant) dictated by the prevailing ecological habitat. The area is characterized by a long dry season (December – June), fluctuation in rainfall and scarcity of pasture especially during the dry season created a practice of transhumant mode of range utilization where nomad move with their herd from one area to another following certain migratory routes. The herd spends the dry season at Al-Khaleda scheme grazing sorghum residues and some *Acacia sp.* They move to Alfeel forest to spend the rainy season. The herd is driven to hafeers (constructed water reservoirs) once every three days. The young calves were allowed to run
freely with the mothers, and were only separated at milking time, which was practiced three times a day.

3.2.2.3 Milking practice

Because of the height of the udder the milking process is done in standing position with one knee raised to support the plastic pail. The milker stands on one leg and balancing the plastic pail in his bent other leg and uses both hands for milking.

3.2.3 Data collection

3.2.3.1 Daily milk yield

Daily milk yield was estimated using 2 measuring cylinders, each of (500 ml).

3.2.3.2 Age, parity order and date of calving

The data pertinent to the above parameters were offered by the herd men, who seem to be very knowledgeable about these parameters.

3.2.3.3 Udder measurements

Each measurement in the present study was taken twice and the average of the two reading was then adopted as the base of calculations.

**Udder Depth**: In this study udder depth was considered as the distance between the abdominal wall at the base of the udder and the base of the teat. 4 such measurements were taken and averaged to represent the depth of the udder.

**Udder Horizontal circumference**: The widest horizontal circumference across the udder was taken as the udder circumference. It was measured by matching the tape to the surface distance of right half from the median suspensory ligament between the fore quarters extending along the right udder half till the median point between
the rear quarters. The same procedure was done with the left half of
the udder and the sum of the two readings was considered as the
udder circumference.

**Udder Size**: The size of the udder was estimated by multiplying it’s
horizontal circumference with the udder depth (Maskovskaja, 1967).

**Udder vertical semi-circumference**: the vertical semi-circumference of
the udder was measured by the surface distance from the abdominal
wall at the base of the udder on one side extending along the udder
between the fore and rear teats till the abdominal wall on the other
side of the udder.

Photo 3.1 Measurement of udder height. M.O.Eisa, field study
(El-Showak 2004).
Photo 3.2 Measurement of teat length. M.O.Eisa, field study (El-Showak 2004).
Udder height: Is defined as the distance from the ground to the base of the teats, and was measured as the distance from the ground to udder floor at the points directly in front of the fore and rear teats.

Udder Levelness: Levelness of the udder floor was measured as the difference between the fore and rear udder heights.

3.2.3.4 Teat measurements

Teat length: was measured as the distance between the bases of the teat to the tip of the teat, by stretching the tape along the teat.

Teat Diameter: Was measured with a vernier caliper at the middle point of the teat.

Distance Between Teats: Is defined as the distance between:
   a- Fore teats.
   b- Rear teats.
   c- Right teats
   d- Left teats.

And were estimated by measuring the distance between every two teats from the middle point of the teats.

3.2.3.5 Milk vein measurements

Milk vein length: The linear length of the milk vein was recorded by measuring the linear distance in straight line covered by the milk vein visible in front of the fore quarters up to the milk well where the vein entered into the abdomen.

Milk vein diameter: Was measured with a vernier caliper.

3.2.3.6 Body weight estimation

Estimation of body weight was calculated according to Wilson (1984): Formula for linear regression of chest girth

\[ Y = 5.071X - 457 \]
Where: \( Y = \) Body weight in kg.
\( X = \) Animal chest girth in cm.

### 3.2.4 Statistical analysis

The data were compiled according to the lactation number of the experimental animal in to three groups:

- A: 3\(^{rd}\) lactation,
- B: 4\(^{th}\) lactation
- C: 5\(^{th}\) lactation.

The collected data was subjected to statistical analysis program (SPSS), to find out the pearsons correlation between udder, teats, and milk vein measurements with the daily milk yield.
3.3 Results

3.3.1 Daily milk yield

The means and standard deviation of daily milk yield (liter) according to the parity order are presented in Table 3.2. The results indicated that, the daily milk yield for A, B, and C groups were 2.2±0.94, 2.9±0.45 and 3.5±2.16 liters, respectively. The statistical analysis of the Data revealed non-significant effects (P > 0.05).

Table 3.3 showed that group C was superior than both A and B and produced 6.8 liters as maximum daily milk production. Group A yielded the least daily production 0.96 liter as compared to 1.4 and 2.4 liter, for groups C and B, respectively.

3.3.2 Udder measurements

The data describing the udder measurements in (cm) are tabulated in Table (3.4) It was evident from the data that, the udder depth value for A, B and C groups were 15.3±1.3, 16.0±1.9 and 19.9±1.1 cm, respectively. Concerning the udder circumference, the data documented that, the maximum value was recorded in group C (100.9±8.9 cm), followed by 91.1±3.6 cm and 85.7±7.8 cm for B and A, respectively. The data also revealed that, udder semi- circumference measurements were 48.1±3.1, 54.0±1.0 and 57.0±6.1 cm, for A, B and C, respectively.

The data in Table (3.4) also indicated that the maximum udder size in group (C) was 2018.6±271.6 cm$^3$, followed by group B and A, the value for which were 1454.9±230.3 and 1311.8±200.7 cm$^3$, respectively.
Table 3.2 Means and standard deviation of daily milk yield (liter)

<table>
<thead>
<tr>
<th>S.C.G</th>
<th>Parity</th>
<th>N</th>
<th>Means</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>8</td>
<td>2.2\textsuperscript{a}</td>
<td>0.94</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>3</td>
<td>2.9\textsuperscript{a}</td>
<td>0.45</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>5</td>
<td>3.5\textsuperscript{a}</td>
<td>2.16</td>
</tr>
</tbody>
</table>

S.C.G = she-camel group.

Table 3.3 Minimum and maximum daily milk yield (liter)

<table>
<thead>
<tr>
<th>S.C.G</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.96</td>
<td>4.13</td>
</tr>
<tr>
<td>B</td>
<td>2.42</td>
<td>3.32</td>
</tr>
<tr>
<td>C</td>
<td>1.40</td>
<td>6.81</td>
</tr>
</tbody>
</table>
Concerning the udder height of fore quarters the measurements for the three groups A, B and C scored 114.6±5.2, 108.0±3.0 and 106.8±9.0 cm, respectively, and 114.3±4.4, 107.0±3.0 and 104.8±10.0 cm, respectively for rear quarters, while the levelness of udder for A, B and C groups were 1.4±0.9, 1.0±0.0 and 2.4±2.6 cm, respectively (Table 3.4).

3.3.3 Correlation between udder measurements and daily milk yield

The pearsons correlation between udder measurements and daily yield for the three groups are given in Table (3.5), which indicated that
Udder depth was positively and significantly (P<0.05) correlated (r = 0.623) with milk yield in group A. The result, however indicated non-significant correlation between the two traits in both group B and C, (r = 0.622 and 0.048, respectively). On the other hand, measurements including circumference, vertical semi-circumference, size and levelness of the udder did not reveal significant correlation with milk yield in the three groups. The height of the udder measured for both fore and rear quarter was only negatively correlated with daily milk yield in group B (r = −0.990; P< 0.05), while the correlation was negative and non-significant in groups A and C.

3.3.4 Teats measurements

Data pertaining to the teats measurements, in Table (3.6) showed that, fore teats length for A, B and C groups were, 3.4±0.8, 4.1±1.0 and 6.0±0.7 cm, respectively, while rear teats length scored 3.4± 0.6, 4.1±0.9 and 6.1±1.3 cm, respectively. Measurements of fore teats diameter indicated values of 1.7±0.3, 1.7±0.2 and 3.1±0.4 cm, for groups A, B and C, respectively.

Table 3.4 Udder measurements (cm)

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Udder depth</td>
<td>15.3±1.3</td>
</tr>
<tr>
<td>Udder circumference</td>
<td>85.7±7.8</td>
</tr>
<tr>
<td>Udder vertical semi-circum.</td>
<td>48.1±3.1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Udder size (cm³)</td>
<td>1311.8±200.7</td>
</tr>
<tr>
<td>Udder height of fore quarter</td>
<td>114.6±5.2</td>
</tr>
<tr>
<td>Udder height of rear quarter</td>
<td>114.3±5.2</td>
</tr>
<tr>
<td>Levelness of udder</td>
<td>1.4±0.9</td>
</tr>
</tbody>
</table>
Table 3.5 Pearsons correlation between udder measurements and daily milk yield

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Udder depth</td>
<td>0.623*</td>
</tr>
<tr>
<td>Udder circumference</td>
<td>0.378</td>
</tr>
<tr>
<td>Udder vertical semi- circumference</td>
<td>0.165</td>
</tr>
<tr>
<td>Udder size (cm³)</td>
<td>0.578</td>
</tr>
<tr>
<td>Udder height of fore quarter</td>
<td>-0.068</td>
</tr>
<tr>
<td>Udder height of rear quarter</td>
<td>-0.168</td>
</tr>
<tr>
<td>Levelness of udder</td>
<td>-0.260</td>
</tr>
</tbody>
</table>

* significant (P < 0.05), ** = significant (P < 0.01).
and rear teats diameter were 1.9±0.4, 2.3±0.4 and 3.7±0.5 cm, respectively, indicating that rear teats in the three groups maintained a larger diameter compared to fore teats. The data in Table (3.6) also showed that, for A, B and C groups, the distance between fore teats were 12.9±2.9, 13.2±1.2 and 13.5±2.9 cm, respectively, while that between rear teats were 9.9±1.9, 10.1±1.1 and 10.2±1.9 cm, respectively, suggesting that fore teats are generally positioned widely a part compared to rear teats. The distance between right teats were 2.6±1.3, 3.3±0.2 and 3.7±2.9 cm, while that between left teats were 2.6±1.7, 2.4±0.6 and 3.7±1.3 cm, for the three groups, respectively.

### 3.3.5 Correlations between teats measurements and daily milk yield

The data in Table (3.7) showed that, the teat measurements including fore and rear teats length, rear teat diameter and distance between left teats did not score any significant correlation with daily milk yield in all groups. The fore teat diameter was found to be negatively correlated with daily milk in group C, (r = –0.816; P<0.05). The distance between fore and between rear teats were also found to be negatively correlated with daily milk yield in group A, (r = –0.697 and –0.678, respectively, P<0.05). On the other hand the distance between right teats was positively correlated with daily milk yield in both B and C groups (r = 0.990 and 0.899, respectively P<0.05).

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Fore teat length</td>
<td>3.4±0.8</td>
</tr>
<tr>
<td>Rear teat length</td>
<td>3.4±0.6</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Fore teat diameter</td>
<td>1.7±0.3</td>
</tr>
<tr>
<td>Rear teat diameter</td>
<td>1.9±0.4</td>
</tr>
<tr>
<td>Distance between fore teat</td>
<td>12.9±2.9</td>
</tr>
<tr>
<td>Distance between rear teat</td>
<td>9.9±1.9</td>
</tr>
<tr>
<td>Distance between right teat</td>
<td>2.6±1.3</td>
</tr>
<tr>
<td>Distance between left teat</td>
<td>2.6±1.7</td>
</tr>
</tbody>
</table>
Table 3.7 Pearson's correlation between teats measurements and daily milk yield

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Fore teat length</td>
<td>0.404</td>
</tr>
<tr>
<td>Rear teat length</td>
<td>0.605</td>
</tr>
<tr>
<td>Fore teat diameter</td>
<td>0.394</td>
</tr>
<tr>
<td>Rear teat diameter</td>
<td>0.359</td>
</tr>
<tr>
<td>Distance between fore teat</td>
<td>-0.697*</td>
</tr>
<tr>
<td>Distance between rear teat</td>
<td>-0.678*</td>
</tr>
<tr>
<td>Distance between right teat</td>
<td>-0.249</td>
</tr>
<tr>
<td>Distance between left teat</td>
<td>-0.500</td>
</tr>
</tbody>
</table>

* = significant (P < 0.05), ** = significant (P < 0.01).
3.3.6 Milk vein measurements

The measurements of milk vein length and diameter are shown in Table (3.8) Regarding the length of milk vein in group C and which was the longest (93.3±1.8 cm) followed by B (87.5±5.6) and the shortest milk vein was found in group A (84.9±9.3), pointing out that milk vein length increases with parity order. Similarly, for milk vein diameter group C scored 2.2±0.2 cm, followed by A and B, which recorded 1.6±0.4 and 1.5±0.4 cm, respectively.

3.3.7 Correlations between milk vein measurement and daily milk yield

Pearsons correlation between milk vein measurements with milk yield are presented in Table 3.9 no significant correlation was found between neither milk vein length nor diameter with daily milk yield in all groups (P>0.05).
Table 3.8 Milk vein measurement (cm)

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Length</td>
<td>84.9±9.3</td>
<td>87.5±5.6</td>
<td>93.3±1.8</td>
</tr>
<tr>
<td>Diameter</td>
<td>1.6±0.4</td>
<td>1.5±0.4</td>
<td>2.2±0.02</td>
</tr>
</tbody>
</table>

Table 3.9 Pearson's correlation between milk vein measurements and daily milk yield

<table>
<thead>
<tr>
<th>Measurements</th>
<th>S.C.G</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Length</td>
<td>0.369</td>
<td>0.369</td>
<td>−0.147</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.172</td>
<td>0.4491</td>
<td>−0.176</td>
</tr>
</tbody>
</table>

* significant (P < 0.05), ** = significant (P < 0.01).
3.4 Discussion

The actual milk secreted is higher than the recorded values in this study, because calves were freely joining their dams and no sucking preventing measure were adopted. Moreover, milk yield was calculated from only three milking episodes, with consideration that the she-camel can be milked five time or more. The daily milk yield in the present study coincide with values reported by Mariam (1988); Bakheit (1999) and Salman (2002) who referred that, daily milk yield under nomadic husbandry varied from 1.4 to 5 liters. The three referees practiced milking 2 to 3 time/day. Other authorities Rao (1974); Al-Amin (1979) and Knoess (1979) reported higher daily milk yield ranging between 5 to 18 kg. The daily milk yield showed progressive increase with the advancement of parity order. The daily milk yield in group A (parity 3) was 2.2±0.94 liters, which increase to 2. 9±0.45 liters in group B (parity 4) and which further increased to 3.5±2.16 liters in group C (parity 5). This phenomenon may be attributed to the normal physiological growth and development of the mammary gland. Kulaeva (1979) and El-hag (2003) postulated similar justification for this trend. The difference in milk yield between the three parities, however did not indicate statistical significance, which may be referred to the small size of observation (only 8, 3 and 5 observation for each parity). The majority of the udder measurements evaluated in the present study seemed to increase with increasing parity order. Kamieniecki (1980) reported that, in Polish Black -and-White low land cows, udder measurement increase with advancing lactation from lactation 1 to lactation 5. Tibary and Anouassi (2000) also confirmed this trend by reporting that, conformation of the udder can change according to breed, age and stage of lactation. The depth of the udder was reported to be highly correlated with milk yield in exotic cows as reported by the study of Mali et al. (1983), and Saiyed and Patel
Their results is further confirmed by the present data, especially for group A, which proved that milk was significantly correlated with udder depth ($P < 0.05$), while, for the other two groups (B and C) the analysis revealed non-significantly impact of udder depth on milk yield. The small number of observation in both groups, may be responsible for the discrepancy, since only 3 and 5 observation were recorded for groups B and C, respectively. Significant correlation between udder depth and milk yield was further confirmed by Akhtar and Thakuria (1998) in their study on Buffaloes. Despite the fact that the cited authorities investigated udder depth and milk yield in cattle and not in camel as the present study, yet the difference of breeds in the present study and others in cattle does not jeopardize the value of the result. Depth of the udder is considered as one of the external feature on which selection of dairy cattle is based on, and its positive correlation with milk yield is justified. The reasons underlying why comparisons are cited with cows was the scarcity of such studies on camels. The impact of udder size on milk yield was found to be positive but non-significant, which is in disagreement with Maskovskaja (1967) and Bogatyreva (1970), who reported positive and significant correlation between udder size and milk yield in their study of exotic dairy cows. Furthermore, the measurements on udder vertical semi-circumference also verified non-significant correlation with milk yield. Mishra et al. (1978), however postulated contradicting evidence in their finding that, udder vertical semi-circumference was positively and significantly correlated with milk yield.

In this study, no correlation was found between daily milk yield and teat length. This finding is incompatible with the findings reported by Hafeez and Nadiu (1981) in buffaloes and Narian et al. (1986) in Jamunapari goats. Both authors documented the positive correlation between teat length and milk yield in the two species studied. The present
result however coincides with the data reported by Wojcik and Czaja (2002), and Weiss et al. (2004) who emphasized the negative correlation between teat length and milk yield in dairy cows.

CHAPTER FOUR

Experiment Two

Variations in Milk Yield and Composition Between
Fore and Rear Udder Halves
CHAPTER FOUR

Experiment Two
Variations in Milk Yield and Composition Between Fore and Rear Udder Halves

4.1 Introduction

Milk is among the most important products of camel (Schwartiz, 1992). Studies on the yield and composition of camels milk indicated a wide range of variations stemming from different factors including breeds, individuality, nutritional, stage of lactation, milking practices, calf suckling, availability of drinking water and frequency of milking (Ramet, 2001).

The camel, like the cows has a four quartered udder (Yagil, 1982). It is firmly suspended from the abdomen, without deep cuts (Sharm, 1963). The four quarters of the udder function independently, and it is desirable that any yield or components of the milk from both fore and rear udder halves should be in the ratio of 50:50 for better milk ability (Gawali and Bhatngar, 1975).

Literature on variations in milk yield and composition from different udder halves is scarce in camels. According to earlier studies, Kulaeva (1979), reported that in the camel, slightly more milk was received from the rear-quarters, (56.4%) compared to (43.6%) from the fore quarters. Ohari and Joshi, (1961) demonstrate that, the milk of all quarters appears to have the same composition.

The present study was initiated to investigate milk yield and composition of the fore and rear udder halves in 16 she-camel at different lactations, and to testify the indigenous belief among camel herders that
calves reared by the rear quarters show better performance than their counterparts maintained on milk from fore quarters.

4.2 Material and methods

4.2.1 Study area

The present study was conducted at Al-Khalefa Hawa Alnabi rain-fed mechanized scheme (30 km. North West of El-Showak). Which is located in Al-Gadaref state, with the 14°3’N and 35°8’E latitudes. The area is surrounded by the rain-fed mechanized sorghum and sesame fields. The vegetation of the area is comprised of annual grasses, acacias, euphorbias and dwarf bushes. The annual rainfall varies between 400 to 600 mm, and the maximum temp. between 40°C-45°C. during the dry season (December – June). El-Showak is dominantly inhabited by two camel owning tribes Rashaida and Lahween. Both tribes are ancient camel breeders and have maintained pastoralist life for centuries. In El-Showak area camel serve primarily as milk producers, but are also used as pack and meat animals.

4.2.2 Experimental animals

16 lactating she-camels of type (Arabi-Lahwai), with different parities, stage of lactations and age (Table 4.1), were randomly selected from the village herd. They all represent the typical features of the Arabi camel such as heavy weight, big hump, long neck, big head with long hair on the hump and shoulder and sandy gray or fawn colour.

4.2.2.1 Identification

Each of the experimental selected females was identified by a plastic tag with a numerical No. placed round the neck. A record for each
she-camel contains age; parity order, calving date, chest girth, udder and teats measurements and daily milk yield were compiled.

4.2.2.2 Herd managements

The camel herds are managed by husbandry system deeply rooted in the society based on superstition and practices that were founded down by father to son over the ages.

The herds are managed in a pastoral system (Transhumant) dictated by the prevailing ecological habitat. The area is characterized by a long dry season (December – June), fluctuation in rainfall and scarcity of pasture especially during the dry season created a practice of transhumant mode of range utilization where nomad move with their herd from one area to another following certain migratory routes. The herd spends the dry season at Al-Khalefa scheme grazing sorghum residues (Tables 4.2 and 4.3) and some Acacia sp. They move to Alfeel forest to spend the rainy season. The herd is driven to hafeers (constructed water reservoirs) once every three days.

The young calves were allowed to run freely with the mothers, and were only separated at milking time, which was practiced three times a day.

4.2.2.3 Milking practice

Because of the height of the udder the milking process is done in standing position with one knee raised to support the plastic pail. The milker stands on one leg and balancing the plastic pail in his bent other leg and uses both hands for milking.

<table>
<thead>
<tr>
<th>She Camel ID.</th>
<th>Type</th>
<th>Age/yr</th>
<th>Parity order</th>
<th>Body w.t kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>188</td>
<td>A.L</td>
<td>13</td>
<td>5</td>
<td>471.0</td>
</tr>
<tr>
<td>128</td>
<td>,,</td>
<td>11</td>
<td>4</td>
<td>491.0</td>
</tr>
</tbody>
</table>

*Table 4.1 Details of the She-camels used for the study*
<table>
<thead>
<tr>
<th>Moisture</th>
<th>Dry mater</th>
<th>Ash</th>
<th>C.P.</th>
<th>E.E</th>
<th>C.F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4</td>
<td>96.6</td>
<td>5.1</td>
<td>16.0</td>
<td>3.6</td>
<td>9.2</td>
</tr>
</tbody>
</table>
Table 4.3 Minerals contents of sorghum residuals

<table>
<thead>
<tr>
<th>Na%</th>
<th>K%</th>
<th>P%</th>
<th>Ca%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.039</td>
<td>0.5</td>
<td>0.6</td>
<td>0.3</td>
</tr>
</tbody>
</table>
4.2.3 Data collection

4.2.3.1 Age, parity order and date of calving

The data pertinent to the above parameters were offered by the herd men, who seem to be very knowledgeable about these parameters.

4.2.3.2 Body weight estimation

Estimation of body weight was calculated according to Wilson (1984): Formula for linear regression of chest girth

\[ Y = 5.071X - 457 \]

Where: 
\( Y \) = Body weight in kg.
\( X \) = Animal chest girth in cm.

4.2.3.3 Udder measurements

Each measurement in the present study was taken twice and the average of the two readings was then adopted as the base of calculations.

**Udder Half Depth:** Was considered as the distance between the abdominal wall at the base of the udder and the base of the teat. Two such measurements were taken for fore and similarly for rear half and the averaged represent the depth of udder half.

**Udder Half Height:** Defined as the distance from the ground to the base of the teats, and was measured as the distance from the ground to udder floor at the points directly in front of the fore and rear teats.

**Distance Between Teats:** Were estimated by measuring the distance between the fore teats and that between the rear teats, from the middle point of every two teats.

**Teat Length:** Was measured as the distance between the bases of the teats to the tip of the teat, by stretching the tape along the teat.

**Teat Diameter:** Measured with a vernier caliper at the middle point of the teat.
4.2.3.4 Milk yield determinations

First of all to be noted here, the calves with their dam during the experimental periods, and the teats of the dams not tied up, the calves are allowed to suckle their dams to stimulate milk secretion, until the milk start to flow, then the calves are removed.

For milk yield determination two plastic pails in different colour and two milkers were used. The milking is done standing. The milker stands on two legs, hold the pail by his left hand and use the right hand to evacuated the udder half as quickly as possible in to the pails. Every udder half milked in different plastic pail, and then the milk yield per udder half was estimated using two measuring cylinders (each of 500ml).

4.2.3.5 Milk composition determinations

A representative sample from fore and rear udder halves of individual she-camel was collected (30 ml). And each sample given the number of the animal plus a sign of the udder half (F = fore; R = Rear). The samples were stored in an insulated container using freeze packs. All milk samples were transferred to the central laboratory (suba).

4.2.3.5.1 Determination of protein

The method used to calculate Nitrogen was Micro Kjeldahl method (Marshall, 1993). Ten ml of milk sample were weight and transferred to kjedahl digestion flask 20 ml of sulfuric acid (\(\text{H}_2\text{SO}_4\) Concentrated, 98%
Photo 4.1 Milking practice: two labor with two plastic pails in different colour, M.O.Eisa, field study (El-Showak) 2004
W/N, d: 1.84) was added to the flask. Two tablets of catalyst (Kjel tabs: each tablet containing 5 g of potassium sulphate (K₂SO₄) and 0.35 g of mercuric oxide (HgO) were put in the flask. The flask was transferred to digestion block and attached to exhaust cap for the two hours. The vacuum pump was turned on. After two hours the solution observed until it becomes clear and the exhaust pump was put off. The flask was left to cool room temperature. Then contents were diluted to 100 ml by distilled water. Five ml of the digested sample was taken and transferred to distillation unit, ten ml of 40% sodium hydroxide were added. The distillate was collected in a flask containing 50 ml 2% Boric acid and 4 drops of screened methyl red as indicator. The distillate was titrated with 0.1 N H₂SO₄ to a mauve - gray end point

Calculation:

\[
\text{Crude protein} = \frac{N \times T \times 0.014 \times 20 \times 6.38 \times 100}{W.S}
\]

Where:

\[
N = \text{Normality of H}_2\text{SO}_4
\]

\[
T = \text{Titrant volume}
\]

\[
W.S = \text{Weight of sample}
\]

4.2.3.5.2 Determination of fat

Fat content was determined using Gerber method (Marshall, 1993). Ten ml of sulfuric acid (specific gravity 1.820 at 15.5°C) were transferred to Gerber butyrometer. Ten ml of sample were added carefully. Then one ml of amyl alcohol (sp.g. 0.814) was added. The butyrometer was stoppered tightly, and then was shaken until all the contents digested and then inverted more than once to mix the sample well. The butyrometer was transferred to a 60°C water bath, and left for 5 to 10 minutes. The content of the butyrometer was pushed up gently until the fat column coincided with the nearest whole percent mark.

Calculation:
The upper and the lower value of the fat columns were read accurately. The sample fat contents were calculated as the difference between the two readings.

4.2.3.5.3 Determination of lactose

The lactose content was determined by subtracting total proteins\%, fat\% and ash\% from total solids\%.

\[
\text{Lactose}\% = \text{T.S}\% - (\text{Proteins}\% + \text{Fat}\% + \text{Ash}\%).}
\]

4.2.3.5.4 Determination of moisture and total solids

Total solids content was determined by forced Draft oven method (Marshall, 1993). Clean dishes were heated a like in an oven for 1 hour at 105°C. Then they were transferred and stored in clean desiccators to cool. Three grams of milk sample was weighed accurately in to each dish. The dishes were heated in the oven for 3 hours at 105°C. After that they were transferred to a desiccators with lid on, and allowed to cool at room temperature then the dishes were weighed.

Calculations:

\[
\text{Moisture} \% = \frac{W_1 - W_2}{W_1} \times 100
\]

\[
\text{Total solids} \% = \frac{W_2}{W_1} \times 100
\]

Where:  
\(W_1\) = Weight of the sample before drying.  
\(W_2\) = Weight of the sample after drying.
Photo 4.2 Milk samples preparation. M.O.Eisa, field study (El-Showak) 2004
4.2.3.5.5 Determination of ash

A clean crucible was heated for one hour, then cooled and weighed. 2 ml of milk sample were weighed with crucible and placed in a furnace (500°C) and left to (incinerate) overnight then the crucible transferred to desiccators to cool at room temperature and weighed.

Calculations:

\[
\text{Ash}\% = \frac{\text{weight of residue}}{\text{weight of sample}} \times 100
\]

4.2.3.5.6 Determination pH

The pH of the milk was determined as described by Newlander et al, (1964) with a pH meter model. L. Two pH determinations were made for each samples, and the average was calculated.

4.2.3.5.7 Determination of sodium (Na)

Ash extract of the milk sample was prepared by adding 10 ml Hcl (28% conc.) to the sample ashed in a clean dish, and then the solution was put for 10 minutes in a water bath. The solution was filtrated through a 41 cm³, No. 1 filter paper, then the filtrate was completed to 100 ml and the samples were prepared by adding 9.9 ml distilled water to 0.01 ml of sample.

The flame photometer was prepared by adjusting the fuel to obtain clear blue flame and read deionized water to adjust the instrument to zero and the samples were read in the flame photometer (F.F.S.R, 1976).

4.2.3.5.8 Determination of potassium (K)

Ash extract of the milk sample was prepared by adding 10 ml Hcl (28% conc.) to the sample ashed in clean dishes, and then the solution
was put for 10 minutes in a water-bath. The solution was filtrated through 41 cm$^3$, No. 1 filter paper, then the filtrate was completed to 100 ml and the samples were prepared by adding 9.9 ml distilled water to 0.01 ml of sample.

The flame photometer was prepared by adjusting the fuel to obtain clear blue flame and read the deionized water to adjust the instrument to zero and the sample were read in the flame Photometer. (F.F.S.R., 1976).

4.2.3.5.9 Determination of phosphorus (P)
Phosphorous was determined by atomic absorption spectrophotometer method described by Hanson (1950).

One gm of milk was ashed, then 10 ml of HCl (28% conc.) were added, then the mixture was placed in a sand bath for one hour, then it was filtrated in 100 ml flask and completed to 100 ml with deionized water. After that, 15 ml of the mixture were transferred to a 25 ml volumetric flask, and then 10 ml of ammonium molybdate were added to the flask. For the preparation of the standard curve 2, 4, 6, 8, 10 and 12 ml of phosphorus standard solution (50 mg p/m) were placed in series of 25 ml volumetric flasks, then 10 ml of ammonium molybdate were added to each one of the flasks and all flasks were completed to 25 ml with deionized water. The blank solution was prepared by diluting 10 ml of ammonium molybdate to 25 ml with deionized water. The results were obtained by using atomic absorption spectrophotometer at 440 nm by which the standard curve was prepared (phosphorous concentration on the X-axis and the absorbance on Y-axis). Then the samples concentrations were read from the graph.

Calculation:

$$P \text{ (mg/g)} = \frac{\text{Sample concentration} \times \text{Dilution Factor}}{\text{Sample weight}}$$
4.2.3.5.10 Determination of calcium (Ca)

Calcium was determined by atomic absorption spectrophotometer method described by Hanson (1950).

One gm of milk was ashed, and then 10 ml Hcl (28% conc.) were added. After that, the mixture was placed in a sand-bath for one hour, then it was filtrated in 100 ml flask and completed to 100 ml with deionized water. There after, 15 ml of the mixture were transferred to a 25 ml volumetric flask then 10 ml of La Cl₃ 10% solution were added to the flasks for the preparation of the standard curve 2, 4, 6, 8, 10 and 12 ml of Ca⁺² standard solution were placed in series of 25 ml volumetric flasks, then 10 ml of La Cl₃ 10% were added to each one of the flasks and all flasks were completed to 25 ml with deionized water. The results were obtained by using atomic absorption spectrophotometer at 420 nm. Standard curve was drawn (Calcium concentration on the Y-axis and the absorbance on the Y-axis). Then the sample concentration was read from the graph.

Calculation:

\[
\text{Ca (mg/g)} = \frac{\text{Sample concentration} \times \text{Dilution Factor}}{\text{Sample weight}}
\]

4.2.4 Statistical analysis

The collected data was subjected to statistical analysis program, Minitab 12.1(1997), paired T. Test was used to find out the variation between fore and rear udder halve in measurements, milk yield and composition.

4.3 Results

4.3.1 Udder measurements

The data in Table (4.4) showed that the mean depth of the fore quarters was 20.9 ± 0.75 cm, and which was significantly (P<0.01) deeper than the rear quarters (13.1 ±0.75 cm). The results also indicated
significant differences (P<0.05) between the heights of fore and rear udder halves (110.9 ± 0.36 versus 110.2 ±0.36 cm, respectively). The arrangement of teats as measured by the distance between teats in the fore and rear quarters also varied significantly (P<0.01). The distance between teats in the fore quarters was 13.2 ± 0.36 compared to 9.9 ± 0.36 cm, in the rear quarters. The teat diameter was also found to be significantly different (P<0.01). The teat diameter of the rear teats was significantly (P<0.01) greater than the diameter of the fore teats (2.5 ± 0.1 and 2.1 ± 0.1 cm, respectively). Teat length on the other hand showed non-significant differences between the tow halves.

4.3.2 Milk yield and composition

The data pertaining to milk yield and composition of the fore and rear udder quarters is presented in Tables 4.5, 4.6 and 4.7. The result clearly indicated that the rear quarters out yielded significantly (P<0.01) more than the fore quarters. The udder rear half produced 57.5% of the total milk yield, whereas the fore quarters yielded only 42.5% (as shown in Fig 4.1).

<table>
<thead>
<tr>
<th>Measurements (cm)</th>
<th>Mean</th>
<th>d.f</th>
<th>±S.E</th>
<th>t.value</th>
<th>Level of sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fore</td>
<td>Rear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth</td>
<td>20.9</td>
<td>13.1</td>
<td>15</td>
<td>0.754</td>
<td>10.31</td>
</tr>
<tr>
<td>Height</td>
<td>110.9</td>
<td>110.2</td>
<td>15</td>
<td>0.359</td>
<td>2.09</td>
</tr>
<tr>
<td>Distance bet. teat</td>
<td>13.2</td>
<td>9.9</td>
<td>15</td>
<td>0.356</td>
<td>9.04</td>
</tr>
<tr>
<td>Teat length</td>
<td>4.3</td>
<td>4.4</td>
<td>15</td>
<td>0.182</td>
<td>0.31</td>
</tr>
<tr>
<td>Teat diameter</td>
<td>2.1</td>
<td>2.5</td>
<td>15</td>
<td>0.094</td>
<td>4.26</td>
</tr>
</tbody>
</table>

n.s= non sig.; *sig.(P<0.05); ** sig.(P<0.01).
Figure (4.1): Milk yield percentage per udder halves.

- Fore half: 42.5%
- Rear half: 57.5%

Sig. (P < 0.01)
The quality of milk produced by the two udder halves, also seem to differ. The rear quarters produced milk, which was significantly (P<0.01) richer in proteins compared to fore quarter’s milk (3.38 ± 0.02 versus 3.31 ± 0.02%). The lactose content on the other hand of the fore-quarter milk was significantly higher (P<0.010) than the rear quarter’s milk (3.25 ±0.3 versus 2.43 ±0.3%). The fat content in rear quarter’s milk was also higher than milk from fore quarters but with non-significant variation (3.31 ± 0.02 versus 3.28 ± 0.02%).

Similarly, both the Na⁺ and Ca⁺⁺ content of the milk from fore and rear quarters were not significantly different, however milk obtained from rear quarters contained significantly higher values of K⁺ and P⁺⁺ which were 1.25 ±0.03 and 7.17 ±0.03%, respectively, compared to 1.17 ± 0.03 and 7.15 ±0.03%, respectively obtained from fore quarters milk. Furtherly, the milk pH of the rear quarter was significantly higher (P<0.05) than the fore quarter (6.38 ± 0.04 versus 6.28 ±0.04).

The amount of nutrients contained in the milk from fore and rear quarter is tabulated in Table (4.8). the data indicated that milk from rear quarter provided higher amount of nutrients compared to milk of fore quarters.
Table 4.5 Paired T.test for milk yield, portion, fat and lactose

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>±S.E</th>
<th>t.value</th>
<th>level of sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fore</td>
<td>rear</td>
<td>d.f</td>
<td></td>
</tr>
<tr>
<td>Milk yield (ml)</td>
<td>387.6</td>
<td>524.6</td>
<td>15</td>
<td>48.8</td>
</tr>
<tr>
<td>Protein %</td>
<td>3.31</td>
<td>3.38</td>
<td>15</td>
<td>0.0191</td>
</tr>
<tr>
<td>Fat %</td>
<td>3.28</td>
<td>3.31</td>
<td>15</td>
<td>0.0186</td>
</tr>
<tr>
<td>Lactose %</td>
<td>3.25</td>
<td>2.43</td>
<td>15</td>
<td>0.3</td>
</tr>
</tbody>
</table>

n.s = non sig.; *sig.(P<0.05); ** sig.(P<0.01)
Table 4.6 Paired T.test for moisture, T.S, ash and pH

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>d.f</th>
<th>±S.E</th>
<th>t.value</th>
<th>level of sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>89.65</td>
<td>15</td>
<td>0.343</td>
<td>2.24</td>
<td>*</td>
</tr>
<tr>
<td>Total solid %</td>
<td>10.44</td>
<td>15</td>
<td>0.312</td>
<td>2.47</td>
<td>*</td>
</tr>
<tr>
<td>Ash %</td>
<td>0.59</td>
<td>15</td>
<td>0.0268</td>
<td>1.68</td>
<td>n.s</td>
</tr>
<tr>
<td>pH</td>
<td>6.28</td>
<td>15</td>
<td>0.0433</td>
<td>2.17</td>
<td>*</td>
</tr>
</tbody>
</table>

n.s= non sig.; *sig.(P<0.05); ** sig.(P<0.01)
Table 4.7 Paired T.test for $\text{Na}^+$, $\text{K}^+$, $\text{P}^{++}$ and $\text{Ca}^{++}$

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Mean</th>
<th>±S.E</th>
<th>t.value</th>
<th>level of sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fore</td>
<td>rear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na %</td>
<td>0.643</td>
<td>0.639</td>
<td>0.0116</td>
<td>0.38</td>
</tr>
<tr>
<td>K %</td>
<td>1.169</td>
<td>1.246</td>
<td>0.0318</td>
<td>2.44</td>
</tr>
<tr>
<td>P %</td>
<td>1.016</td>
<td>1.077</td>
<td>0.0215</td>
<td>2.85</td>
</tr>
<tr>
<td>Ca %</td>
<td>7.153</td>
<td>7.169</td>
<td>0.034</td>
<td>0.48</td>
</tr>
</tbody>
</table>

n.s= non sig.; *sig.(p<0.05); ** sig.(p<0.01)
Table 4.8 Total nutrients supplied by milk of the fore and rear quarters

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount in fore quarter milk (g/kg)</th>
<th>Amount in rear quarter milk (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>1.28</td>
<td>1.77</td>
</tr>
<tr>
<td>Fat</td>
<td>1.27</td>
<td>1.73</td>
</tr>
<tr>
<td>Lactose</td>
<td>1.26</td>
<td>1.27</td>
</tr>
<tr>
<td>Na⁺</td>
<td>0.25</td>
<td>0.34</td>
</tr>
<tr>
<td>K⁺</td>
<td>0.45</td>
<td>0.65</td>
</tr>
<tr>
<td>P⁺⁺</td>
<td>0.39</td>
<td>0.57</td>
</tr>
<tr>
<td>Ca⁺⁺</td>
<td>2.77</td>
<td>3.76</td>
</tr>
</tbody>
</table>

4.4 Discussion

In the present study the rear quarters produced more milk than the fore quarters. The rear quarter’s milk yield was calculated to be 15% more and which was significantly (P<0.01) higher than the milk yield of the fore quarters. These results comply with the data reported by Johanson and Korkman, (1952) who testified that rear quarters produced
significantly more milk than fore quarters. The finding of Kulaeva, (1979) that, rear quarters produced 56.4% of the total milk yield compared to 43.6% by the fore quarters is in line with the present study.

Comparative studies in cattle by a number of authors confirmed that rear quarters produced greater yields of milk than fore quarters. Iliva and Ivanova (1971); Zakharyan (1972); Baumgartner and Kalberer (1972); and Ruegesgger (1972,1973). Others workers, however reported contradicting data that fore quarters excelled the rear quarters in milk yield. Patel and Patel (1963) stated that the fore quarters produced 58% in Kankerj cow. Other authors postulated non-significant differences in milk yield from rear or fore quarters (Mannar et al., 1956).

Concerning the milk composition the analysis of milk samples from rear and fore quarters revealed that rear quarters milk is significantly higher in protein, K+ and P++ while the fore quarters is significantly higher in lactose percentage.

The current result does not comply with the data reported by Ohri and Joshi (1961) who stated no differences in milk composition of the different udder halves. On the other hand some researchers pointed out that slight but non-significant fluctuation in milk constituents existed between fore and rear milk (Turner, 1934; and Mannar et al., 1956). The differences in percentage milk composition between the two udder halves documented in the present study could not be readily extrapolated to variation in udder measurements.

The causes of variation of milk yield and composition is of a very complex nature. This might be due to either increased growth and number of secretory cells, or increased secretory activity of the mammary tissue of the rear quarters (Manner et al., 1956). Also, the results of this study can be justified by the finding of Zayeed et al. (1991) who reported
that, each quarters of she-camel udder consist of two mammary glands and some time the rear quarters might have three glands.

The differences in total amounts of nutrients supply between the rear and fore quarters milk may emphasis the indigenous belief among camel herder, that, calves that rear the rear quarters perform better than their counterparts that rear the fore quarters. This however warrants a furthers detailed study on calves rearing and the anatomy of she-camel udder to strengthen the indigenous belief on a scientific base.

CHAPTER FIVE

Experiment Three
CHAPTER FIVE

Experiment Three

Study on Milk Stimulation Interval Using the Nomadic Traditional Method

5.1 Introduction

In the she-camel as in others dairy animals, milk is stored within two compartments of the mammary gland: the cistern (including teat and gland cisterns and large milk ducts) and alveoli (small milk ducts and alveoli lumini). The cisternal milk, which comprises only a small portion, can be easily removed by suckling, hand and or machine milking, without any previous stimulation. In contrast, the alveolar milk can only be removed under milk ejection reflex activation. Tactile stimuli on the teat initiate a neuroendocrine mechanism resulting in the release of oxytocin from the posterior lobe of the hypophysis into the blood stream. Oxytocin causes the contraction of the myoepithelial cells that surround the alveoli, thus forcing the alveolar milk into the cisternal compartment (Bruckmair and Blum, 1998).
In she-camels, the presence of calf is considered imperative for milk let-down, and hand massaging of the teat plays a complementary role to enhance milk let-down responses. If a calf dies, the dam dries up if milking is not stimulated (Mares, 1954). For this a foster calf or conditioning of the mother is necessary. Often arranging for the dam to see the skin of her dead calf is enough to stimulate let-down of milk. Milk let-down response in the she-camel is easily noticeable shortly following the introduction of the calf manifested by sudden swelling of the teats. This necessitates a quick removal of milk because of the short duration of response, which last only for 1.5 minutes according to Yagil et al. (1999).

Data on the actual milk yield of she-camels are not very accurate for judging the milk potential, because the calf must be allowed to suckle and how much the calf drinks varies with its age, size and health. The amount of grazing and water available to the dam will also determine the amount of milk suckled by calves.

Epstein (1971) documented that the amount of milk the calf is allowed is determined by its needs and the milking capacity of the mother. He continued that when calves have finished suckling the amount left for consumption by the tent dwellers can vary from 1 to 4kg. This aspect, no doubt, result in giving erroneous estimates of actual milk yield of camel herds especially under traditional husbandry system where calves run freely with their dams.

The present study was thus initiated to identify the actual interval needed to stimulate the milk let-down reflex by introduction of the calf and to investigate on the effect of parity orders, dams body weight and time of milking on milk stimulation interval.
5.2 Materials and methods

5.2.1 Study area

The present study was conducted at Al-Khalefa Hawa Alnabi rain-fed mechanized scheme (30 km. North West of El-Showak). Which is located in Al-Gadaref state, within the 14°3 N and 35°8 E latitudes. The area is surrounded by the rain-fed mechanized sorghum and sesame fields. The vegetation of the area is comprised of annual grasses, acacias, euphorbias and dwarf bushes. The annual rainfall varies between 400 to 600 mm, and the maximum temp. between 40°C – 45°C. during the dry season (December – June). El-Showak is dominantly inhabited by two camel owning tribes Rashaida and Lahween. Both tribes are ancient camel breeders and have maintained pastoralist life for centuries. In Al-Showak area camel serve primarily as milk producers, but are also used as pack and meat animals.

5.2.2 Experimental animals

16 lactating she-camels of type (Arabi-Lahwai), with different parities, stage of lactations and age, (Table: 5-1), were randomly selected from the village herd. They all represent the typical features of the Arabi camel such as heavy weight, big hump, long neck, big head with long hair on the hump and shoulder and sandy gray or fawn colour.

5.2.2.1 Identification

Each of the experimental selected females was identified by a plastic tag with a numerical No. placed round the neck. A record for each she-camel contains age, parity order, calving date, chest girth, udder and teats, measurements and daily milk yield were compiled.

<table>
<thead>
<tr>
<th>S.C.ID</th>
<th>Type</th>
<th>Age/yr</th>
<th>Parity order</th>
<th>Body w.t kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>188</td>
<td>A.L</td>
<td>13</td>
<td>5</td>
<td>471.0</td>
</tr>
<tr>
<td>128</td>
<td>„</td>
<td>11</td>
<td>4</td>
<td>491.0</td>
</tr>
<tr>
<td>107</td>
<td>„</td>
<td>10</td>
<td>3</td>
<td>552.1</td>
</tr>
</tbody>
</table>
5.2.2.2 Herd Managements

The camel herds are managed by husbandry system deeply rooted in the society based on superstition and practices that were founded down by father to son over the ages. The herds are managed in a pastoral system (Transhumant) dictated by the prevailing ecological habitat. The area is characterized by a long dry season (December – June), fluctuation in rainfall and scarcity of pastures especially during the dry season created a practice of transhumant mode of range utilization where nomad move with their herd from one area to another following certain migratory routes. The herd spends the dry season at Al-Khalefa scheme grazing
sorghum residues and some *Acacia sp*. They move to Alfeel forest to spend the rainy season. The herd is driven to hafeers (constructed water reservoirs) once every three days. The young calves are kept in isolation from dams and were allowed to their dams only at milking times, which was performed twice a day in the morning and the evening, since the presence of the calf is imperative for milk let-down in the she-camel.

### 5.2.2.3 Milking practice

Because of the height of the udder the milking process is done in standing position with one knee raised to support the plastic pail. The milker stands on one leg and balancing the plastic pail in his bent other leg and uses both hands for milking.

### 5.2.3 Data collection

#### 5.2.3.1 Age, parity order and date of calving

The data pertinent to the above parameters were offered by the herd men, who seem to be very knowledgeable about these parameters.

#### 5.2.3.2 Udder measurements

Were monitored throughout the experimental period on a monthly basis, pre and post milking to assess changes associated with MSI, and including the following:

**Udder Depth (UD):** In this study udder depth was considered as the distance between the abdominal wall at the base of the udder and the base of the teat. 4 such measurements were taken and averaged to represent the depth of the udder.

**Udder Horizontal circumference (UC):** The widest horizontal circumference across the udder was taken as the udder circumference. It was measured by matching the tape to the surface distance of right half from the median suspensory ligament between
the fore quarters extending along the right udder half till the median point between the rear quarters. The same procedure was done with the left half of the udder and the sum of the two readings was considered as the udder circumference.

Udder Size (US): The size of the udder was estimated by multiplying it’s horizontal circumference with the udder depth (Maskovskaja, 1967).

Teat Length (TL): Was measured as the distance between the bases of the teats to the tip of the teat, by stretching the tape along the teat.

Teat Diameter (TD): Was measured with a vernier caliper at the middle point of the teat.

5.2.3.3 Body weight estimation

Estimation of body weight was calculated according to Wilson (1984): Formula for linear regression of chest girth

\[ Y = 5.071X - 457 \]

Where:

- \( Y \) = Body weight in kg.
- \( X \) = Animal chest girth in cm.

5.2.3.4 Monitoring of milk stimulation interval (MSI)

For determining the MSI, the calves are introduced to their respective dams just before milking time. Once the calf is introduced to his mother certain behavioral signals seem to be involved in the initiation of milk let-down. These signals can be summarized as follows:

(i) Once the calf is introduced and finds his way between the mothers rear legs, the mother first smells the calf back and the latter will raise his tail upward. This is considered as the beginning of milk let-down response and is recorded using a stopwatch.

(ii) The calf start wiggling his tail in an up and down movements in a quick manner and simultaneously grasp with his tongue all the teats in a very fast way. The teats then start to swell.

(iii) Eventually the calf will end up with suckling one teat and maintain his tail horizontally with the end piece in an S- shaped. Signaling that it received milk. This was considered as the terminal point for the MSI. This time was recorded by means of the stopwatch.
This procedure was adopted to measure the MSI (Time lapse between step (i) and step (iii) in the experimental animals, in the morning and evening milking through a 6 month period).

5.2.3.5 Determination of milk yield (MY), milking duration (MD) and milk flow rate (MFR)

The (MY) is taken as the total milk yield (in mls) obtained from the four quarters per milking. MD is the time required to obtain that amount of milk (in seconds by stopwatch). MFR is the amount of milk (ml/second) obtained by dividing MY/MD.

5.2.4 Statistical analysis

The data was subjected to statistical analysis programme described by Minitab 12.1 (1997). Analysis of variance (ANOVA) was used for variables affecting the MSI (Parity order, body weight, and milking time), while persons correlation was adopted to describe the relationship between MSI with MY, MD, MFR, body weight and udder measurements.

5.3 Results

5.3.1 Parity order

The data describing the mean MSI as affected by parity order is presented in Table 5.2. The results indicate that, the MSI in the three parities studied were 116.4±21.5, 127.0±42.8 and 109.8±7.7 seconds for the 3rd, 4th and 5th parities, respectively. The data reflect a non-consistent pattern. The shortest MSI was secured by the group in the 5th parity, followed by the third parity group, while the longest MSI was in the 4th parity group. The statistical analysis showed a non-significant (P > 0.05) effect of parity order in MSI. When the minimum and maximum MSI were considered
Table 5.2 Average milk stimulating interval/sec according to parity order

<table>
<thead>
<tr>
<th>Parity order</th>
<th>N</th>
<th>Mean</th>
<th>±S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>3\textsuperscript{rd}</td>
<td>8</td>
<td>116.4\textsuperscript{a}</td>
<td>21.5</td>
</tr>
<tr>
<td>4\textsuperscript{th}</td>
<td>3</td>
<td>127.0\textsuperscript{a}</td>
<td>42.8</td>
</tr>
<tr>
<td>5\textsuperscript{th}</td>
<td>5</td>
<td>109.8\textsuperscript{a}</td>
<td>7.7</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>116.3</td>
<td>12.7</td>
</tr>
</tbody>
</table>

Table 5.3 Minimum and maximum milk stimulating interval/sec according to parity order

<table>
<thead>
<tr>
<th>Parity order</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3\textsuperscript{rd}</td>
<td>55\textsuperscript{a}</td>
<td>240\textsuperscript{a}</td>
</tr>
<tr>
<td>4\textsuperscript{th}</td>
<td>59\textsuperscript{a}</td>
<td>206\textsuperscript{a}</td>
</tr>
<tr>
<td>5\textsuperscript{th}</td>
<td>82\textsuperscript{a}</td>
<td>128\textsuperscript{a}</td>
</tr>
</tbody>
</table>
the result in Table 5.3 showed that, the minimum MSI in the three parities were 55, 59 and 82 second, respectively while the maximum values were 240, 206 and 128 seconds for the 3rd, 4th and 5th parities, respectively (show Figure 5.1). Table 5.3 also indicated that, maximum MSI decreases with the increase in parity order. The differences, however maintained a non-significant value (P > 0.05).

5.3.2 Body weight group
The data in Table 5.4 concerning the effect of body weight of the dams on MSI revealed non-significant effect (P>0.05). However, the lighter females (<500 kg) secured shortest MSI than the heavier (>500 kg). The lighter group mean MSI was 113.8±18.2 second as compared to 118.9±18.9 seconds for the heavier group.

In Figure 5.2 the minimum and maximum MSI for the two body weight group were 55, 206, 59 and 240 for the lighter and heavier groups, respectively.

### 5.3.3 Udder measurements

The results on udder measurement monitored pre and post milking are presented in Table 5.5 the obtained values indicate a highly significant difference in all measured parameters (P < 0.01). The udder depth (UD) before milking was 16.9± 0.109 cm, which declined to 15.9± 0.109 post milking the udder circumference (UC) was 91.4± 0.688 cm prior to milking, and which declined to 85.3± 0.668 cm after milking. The udder size (US) too witnessed a sharp decrease, 1559.5± 18.5 cm³ before milking compared to 1375.1± 18.5 cm³ after completion of milking. The teat length (TL) and diameter (TD) also showed significant (P < 0.01) increase when compared before and after

**Table 5.4 Average milk stimulating interval/sec according to body weight groups**

<table>
<thead>
<tr>
<th>Body w.t</th>
<th>N</th>
<th>Mean</th>
<th>±S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 500 kg</td>
<td>8</td>
<td>113.8a</td>
<td>18.2</td>
</tr>
<tr>
<td>&gt; 500 kg</td>
<td>8</td>
<td>118.9a</td>
<td>18.9</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>116.3</td>
<td>12.7</td>
</tr>
</tbody>
</table>
Table 5.5 Udder measurements before and after milking

<table>
<thead>
<tr>
<th>Measurement (cm)</th>
<th>Mean Before</th>
<th>Mean After</th>
<th>±S.E</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udder depth</td>
<td>16.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.109</td>
<td>6.3</td>
</tr>
<tr>
<td>Udder circumference</td>
<td>91.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>85.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.688</td>
<td>7.2</td>
</tr>
<tr>
<td>Udder size (cm&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>1559.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1375.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.5</td>
<td>13.4</td>
</tr>
<tr>
<td>Teat length</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.106</td>
<td>12.8</td>
</tr>
<tr>
<td>Teat diameter</td>
<td>2.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.057</td>
<td>15.0</td>
</tr>
</tbody>
</table>
milking. The results showed that UD, UC and US increased by 6.3%, 7.2% and 13.4% during the pre-milking and post-milking event, respectively.

Similarly, the teat length and teat diameter increased by 12.8% and 15.0% when compared during pre and post-milking episodes.

5.3.4 Milking time

The data pertaining to MSI as affected the morning and evening milking, are presented in Table 5.6. The result indicated that, the MSI
during the morning milking (6–9 am) was 68.1±5.4 sec, while that of the evening milking (8 – 11 pm) was 70.9 ±7.3 second with non-significant (P > 0.05) differences, and minimum and maximum morning and evening milk stimulation interval shown in Figure 5.3 suggested that time of milking did not influence MSI.

5.3.5 Correlation with milk yield and milk traits

In Table 5.7 The milk yield (MY) per-milking of the four quarters averaged 912±119.6 ml, while mean milking duration (MD) was 78.2±4.2 seconds. Both traits showed negative and non-significant (P > 0.05) correlation with MSI. The average MFR measured in ml/second secured a value of 11.7±1.3 ml/second and was found to be positively with non-significant (P > 0.05) correlation with MSI (r = 0.048).

5.5.6 Correlation with body weight (w.t) and udder measurements

The correlation between body weight of the dam and MSI was found to be positive and significant (P<0.05) (Table 5.8). The udder measurement before milking, including US, UD, UC, TL and TD have negative and insignificant correlation with the MSI.

Table 5.6 Average morning and evening milk stimulation interval/sec

<table>
<thead>
<tr>
<th>Time</th>
<th>Hours</th>
<th>N</th>
<th>Mean</th>
<th>±S.E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>6 – 9 am</td>
<td>16</td>
<td>68.1²</td>
<td>5.4</td>
</tr>
<tr>
<td>Evening</td>
<td>8 – 11 pm</td>
<td>16</td>
<td>70.9³</td>
<td>7.3</td>
</tr>
</tbody>
</table>
Table 5.7 Average milk yield and milk traits and their correlation with milk stimulation interval

<table>
<thead>
<tr>
<th>Parameters</th>
<th>N</th>
<th>Mean</th>
<th>±S.E</th>
<th>(r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield/milking, ml</td>
<td>16</td>
<td>912</td>
<td>119.6</td>
<td>-0.154n.s</td>
</tr>
<tr>
<td>Milking duration/second</td>
<td>16</td>
<td>78.2</td>
<td>4.2</td>
<td>-0.454n.s</td>
</tr>
<tr>
<td>Milk flow, ml/sec</td>
<td>16</td>
<td>11.7</td>
<td>1.3</td>
<td>0.048n.s</td>
</tr>
</tbody>
</table>

n.s = non-significant (P < 0.05).

N = number of observation
Figure (5.3) Minimum and maximum milk stimulation interval/sec. (according to milking time).

Table 5.8 Average body weight and udder measurement and their correlation with milk stimulation interval

<table>
<thead>
<tr>
<th>Parameters</th>
<th>N</th>
<th>Mean</th>
<th>±S.E</th>
<th>(r)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight/kg</td>
<td>16</td>
<td>517.9</td>
<td>19.3</td>
<td>0.600*</td>
</tr>
<tr>
<td>Udder size/cm³</td>
<td>16</td>
<td>1559.5</td>
<td>97.1</td>
<td>-0.311 n.s</td>
</tr>
<tr>
<td>Udder depth/cm</td>
<td>16</td>
<td>16.9</td>
<td>0.63</td>
<td>-0.298 n.s</td>
</tr>
<tr>
<td>Udder circumference/cm</td>
<td>16</td>
<td>91.4</td>
<td>2.5</td>
<td>-0.317 n.s</td>
</tr>
<tr>
<td>Teat length/cm</td>
<td>16</td>
<td>4.4</td>
<td>0.35</td>
<td>-0.182 n.s</td>
</tr>
<tr>
<td>Teat diameter/cm</td>
<td>16</td>
<td>2.3</td>
<td>0.20</td>
<td>-0.108 n.s</td>
</tr>
</tbody>
</table>

n.s = non-significant (P < 0.05).
* = significant (P < 0.05).
N = number of observation

5.4 Discussion

A few authors documented that, the presence of the calf is imperative to milk let-down in the she-camel. In the present study, which allowed close observation of the behavioural signals from both the mother and calf following the introduction of the calf prior to milking and the subsequent activation of milk let-down response emphasizes the importance of the calf presence to initiate milk ejection reflex. Mares (1954) postulated that, if a calf dies the dam dries up if milking is not stimulated. The adoption of a foster calf by arranging for the dam to see the skin of her dead calf is enough to stimulate let-down of milk. In the
present study and due to the close observation and recording of the dam and calf behaviour it can be anticipated that both a visual and olfactory stimuli are important for milk ejection reflex to be initiated. This is also true for tropical breeds of dairy cattle, which are usually milked with the calf penned at the rear quarters of the dam.

The release of oxytocin from the posterior pituitary gland is essential for the contraction of the myoepithelial cells surrounding the alveoli, thus forcing the alveolar milk into milk ducts. This is reflected by the swelling of the udder and teats. The measurements of udder depth, size and circumference and teat length and diameter witnessed significantly higher values during the evoke of the MSI as compared to their values after milking, suggesting the flow of milk following the introduction of the calf and initiation of milk ejection reflex. This result emphasizes previous reported claimed by Akers and Lefcourt (1982); Bruckmaier and Blum (1996). The oxytocin is released in response to tactile stimulation of the teat (Bruckmaier and Plum, 1996). In camel the smell of the young by his mother is an important psychosomatic stimulation, which may cause increased release of oxytocin and facilitate milk ejection. This fact is emphasized in the present study by the significant (P < 0.01) increases in udder and teat measurement during the pre milking interval.

The mean MSI found in this study was 116± 12.7 seconds falls well within the range reported by Yagil et al. (1999) who found that MSI in the she-camel is initiated shortly after suckling start (1.5 seconds) and is easily noticeable through the engorgement of udder and teats.

The present results highlighted that parity order does not affect significantly the MSI, despite the fact that it decreases with increasing
parity. The high value of MSI recorded for the 4th parity group may be attributed the small number of observation in this group (only 3 animals). The results also indicated non-significant effect (P<0.05) of body weight on MSI. However, the lighter group (<500 kg) maintained a shorter MSI (113.8±18.2 seconds) as compared to the heavier group (>500 kg) MSI (118.9±18.9 seconds).

The MSI during day milking was slightly shorter in the morning than that of night-milking (68.1±5.4 versus 70.9±7.3) seconds. The difference was insignificant. The milk yield /milking amounted to 912±119.6 mls, while the milking duration averaged 78.2±4.2 second. Both parameters showed negative and non significant (P>0.05) correlation with MSI. The MFR on the other hand was 11.7±1.3 ml/seconds and was positive and non-significantly correlated with MSI. These traits (MY, MD and MFR) are beyond doubt affected by the milker and milking interval. In the present study the milking intervals were maintained constant whereby, the morning milking was practiced between 6 – 9 am, while the evening milking between 8 – 11 pm.

The present study could have provided more solid data on interval of time needed to evoke the milk ejection reflex if oxytocin profiles in the plasma were monitored.
CHAPTER SIX

General Discussion
CHAPTER SIX

GENERAL DISCUSSION

She-camel milk has been a source of nutrients for millions of people in African, Middle Eastern and Asian countries. According to Yagile, (1982) one of the biggest problems confronting mankind today is malnourishment. Camel milk can certainly play a far more important role in the prevention of malnutrition than it does today.

The daily milk yield in the present study coincides with the values reported by Mariam (1988); Bakheit (1999) and Salman (2002) who referred that, daily milk yield under nomadic husbandry varied from 1.4 to 5 liters. Both of daily milk yield, udder, teats and milk vein measurements showed progressive increase with the advancement of parity order, similar findings were reported by El-hag et al (2003) and Kamieniecki (1980). This phenomenon may be attributed to the normal physiological growth and development of the mammary gland.

From the results of the this study, parameters like udder depth, height of fore and rear quarters, fore teat diameter and distance between teat clearly indicated sig. (P<0.05) correlation with daily milk yield. These measurements may be of use in selection and judging of dairy she-camel.

Morphologic changes in the udder measurements before and after milking were statistically sig. (P<0.01) and may be reflect to a greater milk secretion potential. Mishra et al (1978) reported the greater the shrinkage of an udder after milking, the more would be the content of the
secretory tissue in the mammary gland resulting in a higher capacity of synthesis of milk.

In the present study the rear quarters produced more milk than the fore quarters. The rear quarters milk yields was calculated to be 15% more and which was sig. (P<0.01) higher than the milk yield of the fore quarters. This result complies with the data reported by Johanson and Korkman (1952) who testified that rear quarters produced significantly more milk than fore quarters. The finding of Kulaeva, (1979) that, rear quarters produced 56.4% of the total milk yield compared to 43.6% by the fore quarters is in line with the present study.

Concerning the milk composition the analysis of milk samples from rear and fore quarters revealed that rear quarters milk is significantly higher in protein, K⁺ and P⁷⁺ while the fore quarters is significantly higher in lactose percentage. The current result does not comply with the data reported by Ohri and Joshi (1961) who stated no differences in milk composition of the different udder halves. On the other hand some researchers pointed out that slight but non-significant fluctuation in milk constituents existed between fore and rear milk (Turner, 1934; and Mannar et al., 1956).

The causes of variation of milk yield and composition is of a very complex nature. This might be due to either increased growth and number of secretory cells, or increased secretory activity of the mammary tissue of the rear quarters (Manner et al., 1956). Also, the results of this study can be justified by the finding of Zayeed et al. (1991) who reported that, each quarters of she-camel udder consist of two mammary glands and some time the rear quarters might have three glands. The differences in total amounts of nutrients supply between the rear and fore quarters milk may emphasis the indigenous belief among camel herders that,
calves that rear the rear quarters perform better than their counterparts that rear the fore quarters.

The mean milk stimulation interval (MSI) found in this study was 116± 12.7 seconds falls well within the range reported by Yagil et al. (1999) who found that MSI in the she- camel is initiated shortly after suckling start (1.5 seconds) and is easily noticeable through the engorgement of udder and teats.

It can be concluded that the Lahween she- camel is potential dairy animals with promising milkability characters and worth furthers investigation to promote milk yield in this breed.
CHAPTER SEVEN

Conclusions and Recommendations
CHAPTER SEVEN
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

From the results of this study it can be concluded that some of the measurement of the she-camel udder proved to have an impact on milk yield. Parameters like udder depth, height of fore and rear quarters, fore teat diameter and distance between teats clearly indicated significant correlation between these traits and daily milk yield. Though, the results were not uniform in the three groups concerning these traits, it is likely that, the small number of observations recorded for groups B and C might have exerted their influence on the results obtained. The impact of milk vein measurements in milk yield need to be studied in large populations to verify more in this aspect.

It is very interesting to note that in camel, milk yield, protein%, fat%, moisture%, pH, K%, P%, and Ca% of the rear half excelled the fore half. Where as the lactose%, total solids%, ash% and Na% of the fore half were more than the rear half. On the other hand, the total nutrients contained in the milk from rear quarters were higher than that of milk from fore quarters. This may justify the indigenous belief among camel herders, that calves reared on rear quarters perform better than those reared by the fore quarters.

In these studies non-significant effects of parity order, body weight and time of milking on milk stimulation interval. On the other hand +ve relationships with milk flow and body w.t and –ve relationships with udder measurements, milk yield, and milking duration were observed.

The meager and scanty research in the literature dealing with these
topics in the camel added another facet of difficulty in the discussion chapter. Nevertheless, the present results offer a good base data upon which more studies and investigations are welcomed.

7.2 Recommendations

1. The udder depth, height, teat diameter and distances between teats may be used to select and improve dairy camel.

2. To strengthen the indigenous belief among the camel herders about the variation in milk yield and composition between fore and rear udder quarters. A further detailed study is recommended on:
   (i)  Anatomical and histological feature of she-camel udder.
   (ii) Effect of suckling different udder halve in the growth and development of young calves.

3. The proper time to remove the calf and start milking the she-camel when the calf stop moving his tail and stop his mouth in one teat.

4. Because of sensitivity of camels against the foreign people searcher must be careful especially in the measurements taking.

5. Dairy camel should be given a new impetus to ensure it rightful place in the livestock. And research should be in the camel habitat under the nomadic traditional system.

6. In the rain fed agriculture the camel can provide more milk for home consumption and sale than any another domestic animals, however milk camel manufacture must be introduced.

7. In order to increase the production of camel milk breeding, management, disease control, and improve feeding are necessary.

8. The creation of camel milk marketing channels should enable the breeders to get a good price for his livestock.
9. Milking of she-camel without the presence of the calf should be adopted.

10. Camel herdsmen are very simple people, so searcher should deal with them simply.
REFERENCES


Rao, C.K. (1974) Scheme for the improvement of Indian camels : to what extent camels are milked and what the approximate yield is. New Delhai: Mimeo Item No. 12


