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Evaluation of reproductive performance in camels

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Authorship declaration

I, Hana Čelakovská, hereby declare that I have elaborated my thesis " Evaluation of reproductive performance in camels " independently and all the sources have been quoted and acknowledged by means of complete references.

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In the Prague on 27th April, 2018

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Signature

Hana Čelakovská

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Abstract

This study describes the evaluation of reproductive performance of camels in the zoological gardens. Camels play an important role in everyday life of people from Africa and Asia, however the biggest problem in management is low reproductive performance. Even in good management in the zoological garden the reproduction is limited by late age of puberty, long lasting gestation period and other environmental factors.

The aim of the thesis was to analyze the low reproductive performance in camels (*Camelus* sp.) kept under different breeding systems and managements by literature review and by data analysis of animal records. The data were collected in the zoological gardens in Prague, Brno, Ostrava, Ústí nad Labem, Liberec and Plzeň. The total number of 288 animals was included in the statistical assessment.

Based on our results, most of the calves were born in spring season (75.89%). The highest number of dead calves was in the first month of its age (20.16%). The mean lifespan in camels was 13.83 (± 1.32) years, the oldest she-camel was Zulejka (29 years) from Liberec zoo. The percentage of female calves born in zoo was slightly higher (51.11%) than the percentage of male calves (48.59%). Based on our results, the highest mean age in leaving was in Brno 21.65 (± 5.44) months and in Ostrava 19.85 (± 3.35). Calves were moved to another zoological garden or private farm.

Finally, the mean calving interval for all zoological gardens was 25.22 (± 1.44) months. Generally, the calving interval was approximately same, except for Ostrava zoo where the mean calving interval was 49.07 (± 15.3) months. Study concludes that calving interval cannot be reduce up to 18 months and the Trivers-Willard hypothesis was not proved.

Key words: *camelus,* calving interval, herd management, sex ratio, zoological garden

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1. Introduction and Literature review

Camels belong to family Camelidae, even-toed ungulates and genus *Camelus* (Payne 1990). Camels are mainly used for transport, milk, meat and hide (Rateb et al. 2015). According to FAO (2017) the global camel population is estimated 27 million head. The maximum longevity reported by Faye (2014) in captivity was 35.4 years. The genus *Camelus* has two species, one-humped camel found in Africa, Arabia, Iran, Afghanistan and India and two-humped camel found in Central Asia (Jadhav 2007). And one wild species living in Mongolia and China, which was distinguished from the domestic two-humped camel (Ji et al. 2009).

Information founds on camel management system and its impact on reproductive performance is inadequate (Azhar, 2016). Tibary and Anouassi (1997) estimated that nutrition, diseases and environment are the main factors affecting productivity. The reproductive efficiency of camels under the natural conditions is regarded as low.

Aboul-Ela (1997) reported that factors responsible for the poor reproductive performance are: relatively limited breeding season; delayed puberty; long gestation period lasting 13 months; prolonged lactation period leading to a long inter-calving interval (24 months). Djellouli and Saint-Martin (1992) reported that calving rate for 30 herds in Tunisia is 40 % and a mortality rate between birth and the first year of age is 17%.

Trivers and Willard (1973) suggested that an ability to adjust sex ratio of offspring should be favored by natural selection. The purpose of the thesis was to prove that there is a positive correlation between conditions of the pregnant female and her offspring. Good condition increases male reproductive success more than female reproductive success. The mother influences offspring´s sex ratio toward males when in good condition and towards females when in poor condition (Trivers & Willard 1973).

1.1 General overview of the characteristics of Old World Camels

The Old World camels are divided into two species; the Arabian (*Camelus dromedarius*) and the Bactrian (*Camelus bactrianus*) as shown in Table 1. There is shown interesting morphological and physiological characteristics that allow them to live in very dry environment (Yusupov 2004). These characteristics including long eye lashes (protection from sand) and control of opening and closing of nostrils. The body structure allow camels to stand on hot sand. They do not overheat and they can metabolize fat storage in the hump in times of feed and water deprivation (Maillard 2007). Camels can sustain a loss of up 25% of their body weight. They can also rehydrate very quickly (Kadim 2008).

There are still Bactrian camels (*Camelus Bactrianus ferus*) that exist in the desert of China and Mongolia, as wild species. But they are critically endangered (Mason 1999).

Table 1: The comparison between *Camelus* spp. Available from www.sandiegozoo.com

Characteristic	*Dromedary* Camelus dromedarius	*Bactrian* Camelus bactrianus	*Wild Bactrian* C. bactrianus ferus
Breeds/types	50 different breeds recognized Draft type: heavy body, stocky legs Riding type: Slim body, long legs Racing type: Similar to riding	Geographical differences	Single type
Weight kg/lb	300–650*/661–1432	450–700/992–1543	450–690/992–1521
Weight of newborn kg/lb	26–45/57–100	35–54/55–120	?
Height at shoulder cm/in	180–210/71–83	180–195/71–77	180–200/70.8–78.7
Body length cm/in	120–200/40–80	120–200/40–80	140–156/55–61
Shape	1 firm, upright hump	2 large humps, may be flopped over	2 small, conical humps
Color	Cream to tan to dark brown	Cream to tan to dark brown	Cream to gray–brown
Unique anatomy	Male has a soft palate diverticulum (dulaa) which may protrude from mouth	No dulaa, ears 15 cm	No dulaa, prominent toenail, small foot and flat sole for rapid gait to escape predation. Able to drink salty water, face narrow, ears 10 cm
Fiber/hair	Diameter 20–50 μ	Diameter 10–40 μ, long staple, primary source for camel hair garments	Short fiber
Special adaptations	Adapted to heat, aridity, and sparse vegetation	Adapted to cooler, arid environments	Adapted to the deserts of northern China and Mongolia.
Running speed	21.6–40.3 kph (13.4–25 mph)	15–20 kph (9.3–12.4 mph)	40 kph (24.9 mph)

1.2 Taxonomy

Taxonomy (Wiegl 2005):

Class: *Mammalia*

Order: *Artiodactyla*

Family: *Camelidae*

Genus: *Camelus*

Camels are ruminants along with the deer, cattle, giraffe, antelopes, sheep and goats. They have few unique features as an antlers absence and walking on pads (Faye, 2014).

According Helgen and Asher (2010), the cetaceans belong in the order *Artiodactyla*, the study sad that if the *Cetacea* belong into group *Artiodactyla*, the name *Certiodactyla* would be appropriate (Helgen 2003). Groves and Grubb (2011) prefer the order *Artiodactyla* and they classify it into four suborders (*Tylopoda, Suina, Whippomorpha, Ruminantia*).

1.3 Origin of domestic Bactrian camel (*Camelus bactrianus*)

The Bactrian camel (*Camelus bactrianus)* is usually known as two or double humped camel living in cold desert habitat. The domestication of the Bactrian camel has improved progress in economic and cultural development of human societies, representing a big opportunity for human civilization (Shaller 1998).

The origin habitat of the wild Bactrian camel was extended from north-western China trough Mongolia to Kazakhstan (Bannikov 1976). Domestication occured in the East around 5 000 years ago, then Bactrian camels were spread towards the Central Asia (Han et al. 2002).

The domestic Bactrian camel may be divided according to the morphological characters into the following six subspecies; *Camelus bactrianus xinjiang, Camelus bactrianus sunite, Camelus bactrianus alashan, Camelus bactrianus red, Camelus bactrianus brown, Camelus bactrianus brown* and the last one *Camelus bactrianus normal* (Faye 2014).

They are mainly bred in the cold desert areas of China and Mongolia and contributing to the local economy (Indra et al. 2003).

1.4 Wild Bactrian camel

The wild Bactrian camels (*Camelus ferus*) are listed as a critically endangered species by the International Union for Conservation of Nature (IUCN) and surviving in few locations in China and in Mongolia (Hare 2008), see Figure 1. The wild Bactrian camel is now considered like a separate species (Hare 2008). Due to the increasing human activity, the habitat of wild camels was reduced and the population was decreased rapidly. The population estimate is 660 wild Bactrian camels in China and about 400 camels in Mongolia. The number of animals is alarming and it is caused by illegal hunting, predating or illegal mining in the Trans-Altai Gobi (Mongolia) (Liu 2001).

The wild Bactrian camels usually form a herd of twelve animals and they are isolated from domesticated ones. A lack of hybridization with domestic Bactrian camel makes their survival in the desert habitat very critical (Tulgat 1992). Han and Quan (1993) found out 3% basic difference in mitochondrial DNA of the wild camels and domestic ones. The Bactrian camels are genetically different.

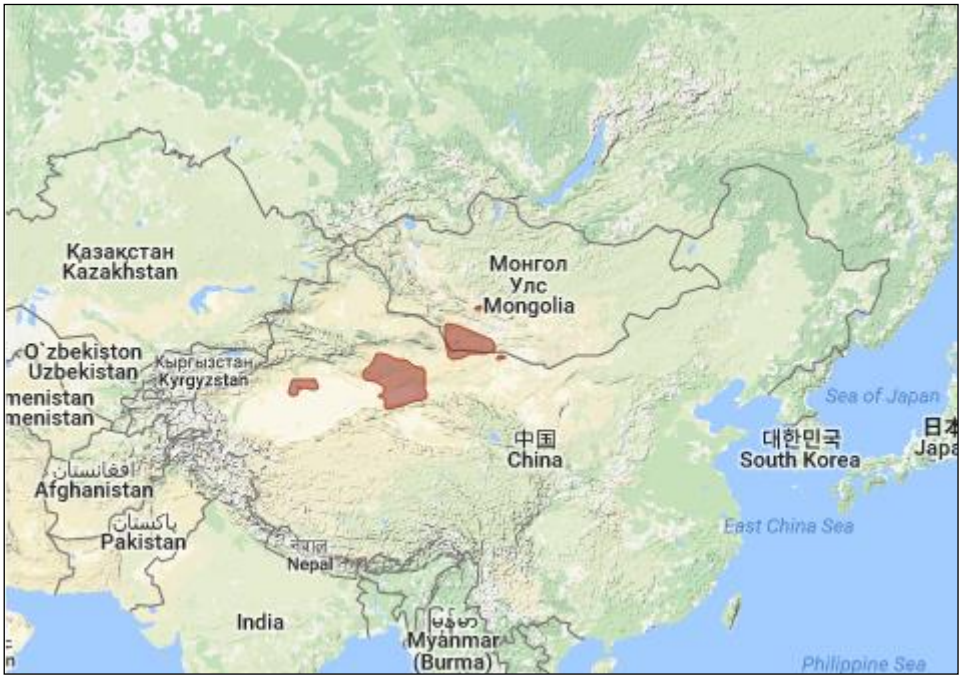

Figure 1: The distribution map of wild Bactrian camel (www.wildcamel.com)

The wild Bactrian camels are mammals capable of drinking salty or slightly salty water, because of their adaption on dessert conditions (Chuluunbat 2014).

The wild camel is smaller and slender then the domestic one. They have sandy greyish-brown coat while the domestic camels have a dark brown coat. The main difference between them is in the shape of the hump. The humps of the wild camels are smaller and pyramid-like while the domesticated ones have irregular and large humps (Clark 2006).

China and Mongolia initiated several actions to conserve wild Bactrian camels. There are two programs; the first one is located in Great Gobi reserve in Mongolia and the second one is Lop Nur Wild Camel National Nature reserve in China. These reserves provide safe habitat to another endangered species of animals and plants. These reserves are assisted by The Wild Camel Protection Foundation (WCPF), their aims are to increase the population of endangered camel trough captive breeding (Hare 2004).

Programs of education are needed to raise the public. To show them the potential negative effect of crossbreeding (wild camel x domestic one). The reserves need to be enforced to prevent encroachment and illegal mining. Some individuals migrate from Mongolia to China where are killed by hunters or dies from eating poisoned vegetable. The WCPF have proposed the establishment of second reserve in China to protect wild Bactrian camels (Tulgat 1992)

The Dromedary camel (*Camelus dromedarius)* is also called Arabian camel or one-humped camel. This camel was domesticated in Arabian Peninsula. The Dromedary camels are found in most of arid and semi-arid regions of Africa and Asia see Figure 2. They have very important socio-economic and ecologic importance. They have also an ability to survive in hot dry desert. They have long eyelashes and nictitating eye membrane to protect the eyes from sand (Ghazi 1993).

The population of Dromedary camel is more numerous than the Bactrian population. The population constitutes 90% of the genus *Camelus* in the world. The majority of the Dromedary camel is found in Africa and is forming an important livestock population. In Asia camels are found in the South Arabian peninsula, Afghanistan, Turkey, Turkmenistan (Ripinski 1982). The number of camels in Pakistan is decreasing,

its existing number is around 0.7 million and in India the number of camels is also in decline: 0.4 million (Rahman 2010).

Their height is 1,7m. The Dromedary has lighter frame, short hair and longer limbs than the Bactrian camel, which is better adapted to low temperatures. The head is smaller according to body size. Dromedary camels were also exported to the Canary Islands, they survive there until today (Wilson 1984).

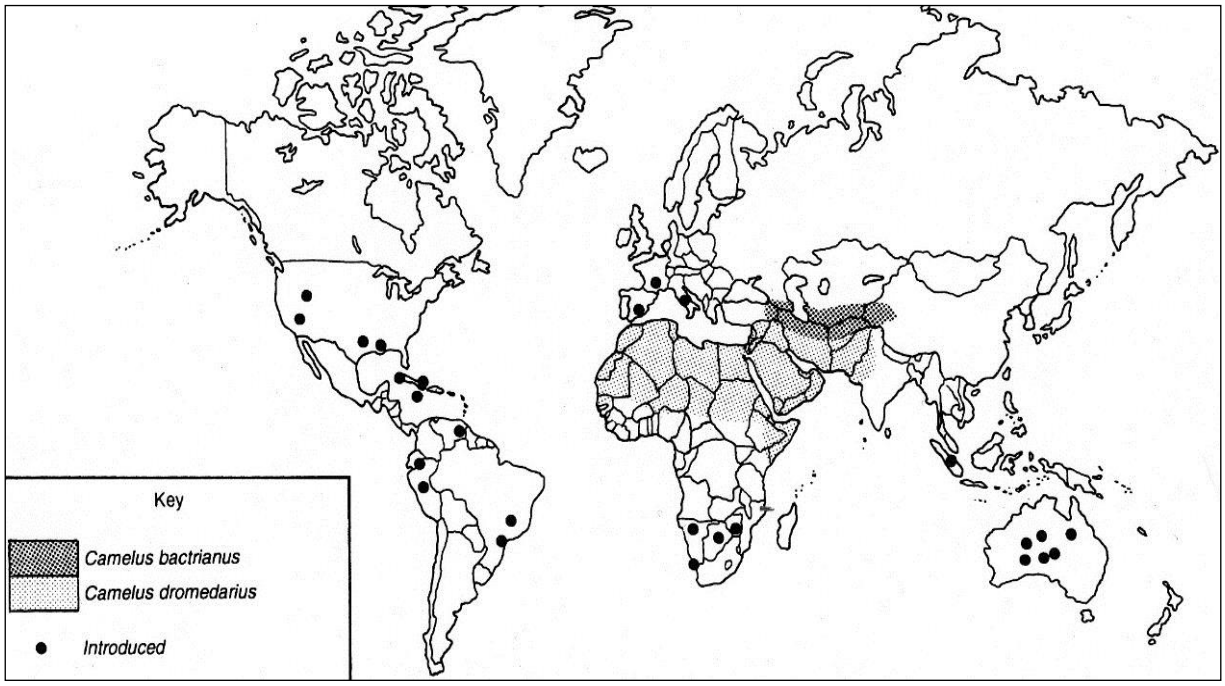

Figure 2: Distribution map of the Dromedary camel. Available from www.library.sandiegozoo.com

1.5 Production system of camels in Africa and Asia

Table 2 shows the traditional systems of management of camels in Asia and Africa. In arid regions, camels are herd by Nomads. The land of arid regions is covered by annual grasses, bushes and acacias. This type of pasture permits only extensive production. Camels with their high mobility and water regulation are absolutely adapted to this environment (Jasra 2004).

According to Farah (2001) the female population constitute about 80% of the herds. This high percentage of female animals is needed for milk requirement of nomads. The male animals are reduced by slaughtering at birth, this allows more milk for female calves, or they grow until 4 years then they are castrated, fattened and sold for meat.

The primitive management of camels (in all types of production system) was manifested in poor feeding, slow growth rate, late maturity, low calving rate. Mean pubertal age of females was five years and average calving rate between 70-80% (Wardeh 1996). The camel is major component of the agro-pastoral system in Asia and Africa. Wardeh (2004) classified camels into classes: dairy purpose, meat purpose, dairy-meat purpose and race camel.

Table 2: Production systems (Schwartz 1991).

Production system	**Climate type**
Mixed farming, irrigation farming	Sub-humid to arid
Agro-patoralism	Dry sub-humid
Sedentary pastoralism including ranching	Dry sub-humid
Semi-sedentary pastoralism	Semi-arid
Migratory pastoralism including transhumance	Arid to very arid
Off-farm system, commercial transport	All climate types

1.6 Production system in Africa

In the desert and semi-desert parts of Africa, camels play a great role in socio-economic importance for nomadic people living in the desert, see Table 3. In these lands, the camel is the only survivor from all other livestock species (Farah 2004). For nomadic people camel breeding is a cultural heritage (Abbas 1992). In Africa three main types of production system are adopted:

- Traditional nomadic system: This system is dominant in Africa. The camel herders are on the move continuously. Milk is most important camel product as a food for nomads. During the searching of new pasture, nomads can live up to one month in the desert only on camel milk (Majid 2000).
- Transhumant or semi- nomadic system: This system is found in southern regions, practiced by semi-nomadic people. The rainfed agriculture is practiced during the rainy season for food production. The crop residues provide feed for camel's herd (Bakheit, 1999). Several tribes practice a transhumant model. Following certain migratory routes, they move from one to another area. The areas are depending on types of season: dry or rainy (Abbas 1999). During the transhumance, camels are affected by many limiting factors such as pasture deficiency, water deficiency, diseases, calf mortality and security problems (Ali et al. 2006).
- Sedentary system: This system is practiced in eastern part of Africa. Almost 50% of the people get involved in sedentary system that constitutes the major household income. They are involved in rearing camels and also they convert the by-products into useful products for sale (Baloch 2001).
- Pastoral management: The Somali camel has higher production in milking and growing. The reproductive performance is slightly better than for the other population. The Somali camels from Kenya are kept under better environmental conditions such as higher feed intake, water availability and low risk of drought. The production and reproductive performance are stable (Kaufman 2005).

Figure 3: Camel farm of Beduins (www.nina-travels.com)

1.7 Production system in Asia

Camel has been a food security animal of pastoralists in very arid and semi-arid conditions. The camel emerged as an animal of cold and hot desert. The Bactrian camels are inhabited in the cold arid deserts because of specific adaptations. The annual precipitation in central of Asia is 120 mm, there is extremely arid climate where winters are very cold. The Bactrian camel is not found in temperature over 21 °C. (Blench 1997).

The production systems are determined by climatic conditions, plant availability, water sources and socio-cultural norms. In Asia two types of productions are adopted:

- Nomadic production system: Nomads are found in mountainous regions in Afghanistan, Iran and Pakistan. The nomads follow seasonal forage production. They migrate between Afghanistan during summers and Pakistan during winters. There are three types of nomadic production (Schmidt- Nielsen 1996):
    1. Nomadic camel herds: pure herd of camels, see Figure 4.
    2. Mix camel herds: camels with small ruminants (goat, sheep)
    3. Nomad pastoralist: based on small livestock production with one camel for transportation.
- Transhumant production according FAO (2004): Transhumance is semi-nomadic and migratory production system. Producers move between specific locations hence. They follow fixed annual routes (Khan 2003).

Figure 4: Nomadic camel herd from Kazakhstan (www.footage.framepool.com)

1.8 Production system in Saudi Arabia

According FAOSTAT (2015) the total number of camels in Saudi Arabia was estimated as 848 000 heads in which the number of females was higher. The camel population is periodically growing by 5.2% per year. The camel population represented more than 50% of total livestock unit in Saudi Arabia (FAO, 2015).

As we have mentioned camels have various adaptive mechanisms for living and sustaining in the arid lands, but there is few published information on camels management in Saudi Arabia (Abbas 2000). The camel management is closely connected with the life of rural people. The camel management in Saudi Arabia is affected by climate changes, urbanization and by the economy (Uerpmann & Uerpmann 2002). The increasing of the population growth is linked with the increasing of milk and meat productivity. The increasing of milk and meat production has similar proportion: around 5% per year (Faye & Bonnet 2012). Local camels are multipurpose animals. The main objectives of camel farming are meat and milk (Eisa 2011). According Ismail (1991) camels in Saudi Arabia are raised under traditional pastoral system.

The Range and Animal development research Centre shows the presence of 4 main camel breeds:

- Malhah- black colour
- Wadhah- white colour
- Safrah- dark brown colour
- Hamrah- light-brown red colour

The seasonal availability of food affect the quality of nutrition and health. With low management standards and insufficient animal health services the production system and performances are very low (Squires 2010).

Conclusion of production systems in Africa and Asia

The main reasons against raising camels is the long period without production, six years of waiting for sexual maturity, long calving interval (El-Hassanein 2003). According Knoess (1979) the calving interval can be shortened to 18 months. With good management the calving interval can be reduce to a year. If the calves are separated from mothers during the breeding season, the female will quickly come on heat (Dahl & Hjort 1979).

The climate and feeding have also effects on fertility of animals. Improved nutrition will increase the health status and the fertility of animals. The education in selection and well-balanced nutrition will reduce the period before maturity and will improve the birth weight and calving interval (Ji 2009).

1.9 Reproduction of camels

The season starts in beginning of September and ends in June, but the season can be affected by increasing or decreasing of daylight length (El-Bahrawi 2005). The study of Musa (1992) shows that decreasing of daylight appeared to be impulse to seasonality. Other studies reported that the breeding season can adapt to nutrition and climatic conditions (Arthur 1992). Results showed that environmental conditions have a big influence on breeding season (Arthur 1992).

The reproductive efficiency under natural conditions is generally low. Djellouli and Saint Martin (1992) reported a calving rate of 40% and mortality rate of 17% within

one year of age in 30 herds in Tunisia. The causes may probably be the short breeding season, a long pubertal period, long gestation period (13 months), long inter-calving period. These causes are the main obstacles to improved camel productivity and genetic progress (Chen 1984).

For example in Camel farm in Cusot in India, the camel management is on the beginning. At the farm the mating management is not regulated or selective. Only the rectal examination is done. There is need of research on reproduction, to reach the appropriate economic level and to be competitive on the market (Vyas et al. 2015).

1.10 Puberty and sexual maturity in male camels

The puberty is mainly affected by nutrition due to high influence of growth and weight of the animal. The sexual maturity is also affected by breed of the animal (Moslah 1992). Therefore, good nutritional and environmental conditions can help to reach early sexual development and breeding maturity (Rahim 1997). Puberty was defined as the stage when the animal is able to produce viable sperms (Rahim 1997). Male camel's puberty occurs at 3-4 years. One year old males show the interest in females, but they are not capable to mate (Beil 1994).

As a seasonal breeder, male camel comes in rut in breeding season. In breeding season the camel is sexually active and try to attract female camels by two tubule-alveolar glands (poll glands) on the back of his neck (between ears), these glands secret dark-brown substance and contains pheromone (Gordon 1997). Sexual behavior is also characterized by protrusion of the soft palate, known as the dulah, but it was only describe in Arabian camel (Vyas 2001).

The reproductive potential of male camels appears when they are 5-6 years old and decreases by 20 years of age (Merkt 1990). Testicular descend starts after birth and is completed during second year. The testes increase the size during the breeding season, it is associated with higher sperm output. Al-Qurawi (2005) reported that by 4-5 years of age, the males are capable of producing adequate numbers of sperm as an adult bull (to mate as many as females), but fertilizing capacity is not attained until 6 years of age. Anatomical changes are accompanied with increasing of hormonal level.

The increasing of testosterone produced from the testes facilitates the development of secondary sexual characteristics and it allows animal to growth (Marai et al. 2009).

The semen is whitish or creamy in color with specific odor. The semen has gelatinous structure and pH of 7.37. The volume of the ejaculate is variable between individuals. On average, 70-90% sperms are motile. Some irregularities of semen characteristics may be explained by deviation from normal mating behaviour. For artificial insemination it is important to use males with very good reproductive performance and high quality semen (Li 1998).

1.11 Puberty and sexual maturity in female camels

The sexual signs show the beginning of puberty. The puberty begins at the age of 2-3 years (Molash 1990). They are bred when they reach the physical maturity at about 5 years of age, some females do show the sexual signs in the second year. There is the possibility of early breeding until they reach at about 70% of their adult body weight, otherwise abortion rate is increasing (Al-Hozab 1999). The nutrition, photoperiod, season, body weight and water availability may influence the sexual activity (Wilson 1989).

All camelids are induced ovulators, it means that ovulation is initiated by coitus. The most common mechanism that induce ovulation is mating by intact male or by vasectomized male, but there is the risk of transmission of diseases (Hassanien et al. 2010). Skidmore (1996) shows that after using the ultrasonography we can divided follicular wave into three phases: the growth phase, a mature phase and regression phase. Follicles tend to regress when the mating does not occur (Adams et al. 1990). The corpus luteum is seen only in pregnancy or after an infertile mating (El-Wishy 1992). Females kept in arid and semi-arid regions show higher breeding activity during winter and spring. Changes in nutrition, mineral supplementation and photoperiod were responsible for productive performance and also for seasonal breeding pattern of female camels (Onjoro et al. 2006).

It has been stated that the ovarian activity is affected by breeding season, the ovarian activity is higher in spring and winter then in summer and autumn (El- Harairy 2010). The ovary is major source of progesterone, corpus luteum may be present

without pregnancy (Smith 1994). Ovulation will occur only when mating takes place. Outside the breeding season, the ovaries are inactive or have only few small follicles (Zeidan 2011).

1.12 Breeding season

The breeding season occurs in coolest winter months and shows endocrinological, morphological signs (Padalino 2014). The breeding season vary from 2 to 6 months, depending on the genetic and health status, location, environment and management. Usually the heat period is from November to March, for the differences in areas see Table 3. Out of the rutting season, male camels lose the libido, do not copulate with females, testicular size and weight are decreasing and the blood testosterone level is low (Deen 2008). Camels kept under good nutrition and good management in tropical regions would show estrus throughout the year (Al- Rahim 1982).

The breeding system is based on management of male camels. Selection of breeding males start at birth, they are selected according their ancestors. The breeders give them special care for quick growth and to become sexually mature earlier. Traditionally male camels were reared under semi-extensive conditions. But nowadays the male camels are reared in breeding centers to be able to improve their reproductive performance (Babu et al. 2004). On the other hand the intensive system of rearing can affect animal welfare, which is related with nutrition, reproduction and social environment (Waran 2007). One male camel can cover 20 to 50 female camels during breeding season (Elmi 1989).

Table 3: Breeding season in different areas (Merkt 1990)

Breeding season	Area
November-March	India
December-March	Pakistan
January-February	Iran
January-March	Israel
March-April	Egypt
December-May	Marocco
August-September	Mali
September-November	Somalia
Jun-September	Australia
October-January	Saudi Arabia
December-April	Mongolia and China

1.13 Mating

The act of mating in camels comes during the breeding season. The breeding season in males is also called “thoot”, “rutt” or “musth”. Usually the period is from November to March. Male attracts female by secretion from pole gland and female attracts male simply by the presence (McLean 2010). The duration of estrus cycle is from 16 to 22 days and heat duration is for 3-4 days. Camels do not come in heat in the summer season (Bhakat 2005).

The symptoms of estrus in female camel are: swollen vulva with mucous discharge, bleating, excitement and raised tail. Females try to smell urine and genitalia of the male. In most of cases the mating occurs naturally. The female sit down and allows the male to copulate. During the mating, male and female make grunting sounds (Fowler 2010). The whole mating act takes about 20 minutes, in nature the mating takes around one hour. After copulation, the male falls sideways, after few minutes stands with blowing out his soft palate (Yagil 1980).

The symptoms of rutting in camel are: gurgling sounds with grinding of teeth, throw out soft palate from mouth, protruding tongue, loss of hair, frequent urination, sometimes diarrhoea, wind sucking, fleshmen and tail flapping. The sexual activity in male camel lasts for 3-6 months, the rest of months the sexual instincts are suppressed. The male camels have the strongest and vigorous expresses of the rut (Narayankhedkar 1998). The major stimulus for expressing sexual behavior of the male is the presence of the female camel itself (Houpt 2011).

1.14 Reproductive disorders

The reproductive rate in *Camelidae* has been described as low, the reproductive rate is based mainly on management. The examination of males in their infancy may help identify infertility problems (Anouassi 1997). In male several abnormalities of the prepuce and penis were described. The most frequent are preputial swelling (parasitic infestation), phymosis (inability to exteriorize penis) and urolithiasis (Gahlot 1992). Scrotal and testicular trauma can be due to bites from other males. Cryptorchidism or failure of testicular descend into the scrotum is rare in *Camelidae*, but it has been described in dromedary camel (Hemeida 1985).

Reproductive disorders of female camels are associated with repeat breeding, early embryonic death, fetal loss and abortion. Repeat breeding is a reproductive problem which is caused by ovulation failure (Tibary 1998). Ovarian hypoplasia is characterized by absence of ovarian follicular activity due to genital and chromosomal abnormalities (Tibary 2001). The incidence of early embryonic death was reaching 23% and is due to uterine pathological conditions. Also cysts, abscess, metritis and uterine fibrosis are considered as uterine lesions resulting in infertility (Hegazy 2004).

1.15 Gestation period

The majority of pregnancies occur in left horn, the incidence of twins are rare, about 14%. The gestation period in camelids is different and varies from 12 to 14 months (Barnett & Dobson 2010). Female camels have a single young calf every second year, the reason for this long generation interval is the beginning of lactation which enables to extend lactation for 18 months (Rahim 1994).

The breeding season occurs at the same time as the calving period. During gestation period female camel needs special care to avoid abortions. Well-balanced nutrition and enough of water must be provided. This period is critical time in the development of the calf. If the conditions as environment, nutrition and management are low, then the calf will have low birth weight or may have some development problems (El-Bahrawi 2005).

Calving interval is time between the female camel delivers a calf until the next parturition. Richard (1995) observed calving interval of 15 months with well-balanced feeding. Contrariwise, calving interval according to Youssef (2015) was 18 months in semi-intensive systems and 25 months in traditional system. The calving interval is varying between 20 to 36 months. The calving interval in camels is prolonged by their limited breeding season and by the suppression of estrus for a long time after parturition (AbdAllah 2016).

Infertility in the female camel can be due to ovarian hypoplasmia, vaginal adhesion and perineal rupture, these are the most common. Cyst structure were observed in uterine tube of Old World camels. The absence of breeding records is the most important management deficiency which can results in infertility (Tibary 2000).

Infertility in the male camel can be due to poor libido, inability to copulate. Many breeders do not have a good strategy for selection of the animals for good fertility (Musa 1993).

1.16 Parturition

Parturition occurs at any time of the day. First signs of approaching parturition are separation from the herd, swelling of vulva, restlessness and vulva mucous discharge. Some of these signs can occur as early as 15 days before parturition (Sumar 2000). The second indication is usually enlarged vulva. But the most important sign is abdomen which subsides 2 or 3 days before parturition. During the day of parturition the female does not eat, keeps away from herd, walks and lies down (Faye 2001). During birth, the front legs appear first, the head is between front legs.

Primiparous female camels are susceptible to injuries of the perineum especially during parturition. If the calves die or the death is caused by abortion, the female camel become pregnant again and another calf is born next year (Kazemi et al. 2010). The average birth weight is 36 kg and lactation takes 18 months when the calves are weaned before the next parturition. The camels have good ability to survive and produce milk during dry and hot season. The young camels stay with mothers up to 5 years of age (Wernery 2006)

Rearing of camel calves under traditional systems have many challenges that can result in high death rates. The high mortality rate of camel calves is mainly caused by abortions. The critical period is especially in the first three months (Ziapour 2014). The major cause of calf mortality is also malnutrition resulting from competition between calf and farmer for milk (Bekele 2004). Camel calves come to life deprived of immunoglobulin and they are depending on colostrum. Failure of immunity transfer may expose calves to infectious diseases and may led to higher mortality rate (Ghazi 1994).

1.17 Importance of assisted reproductive technologies in camels

The interest in modern reproductive technologies has increased over the last years. The reason is the possibility of utilizing the productive potential for commercial application (Faye 2008). Camelids are not as well studied, but a lot of achievements have been made in reproductive biotechnologies (Tibary 2005).

The importance of biotechnologies is increasing due to the demand for increasing productivity. These techniques are challenged by lack of database on

indigenous species, production, reproduction and diseases. Another problems are high costs of these techniques, inaccessibility to the herd holders and also lack of expertise (Choudhary 2016).

Male camels have low mating efficiency (Rahim 1997). Low fertility in male camels is due to the breeding season, limited libido and the difficulty of collecting semen (Hassanenin 2003). Deen (2008) was reported unexplained sub-fertility and sterility in male camel.

The methods how to induce ovulation in female camel can facilitate the reproductive technologies such as artificial insemination and embryo transfer (Cooper 1992). Artificial insemination allows the preservation of semen by deep freezing and it helps eliminate aggressive behavior of male (Bravo 2000).

1.18 Semen collection

The efficient semen collection is important for artificial insemination and preservation program. Hurtgen (2000) reported that collection process may be the cause of poor fertility or inferior semen quality. Semen collection in male camel presents many difficulties, because copulation takes place in sitting position with long duration (from 5 to 20 minutes), with slow process of ejaculation (Pugh 1999). The two main techniques used for collection of semen are artificial vagina and more rarely the electro-ejaculation (Mosaferi 2005).

The electro- ejaculation is the method which use electro-ejaculator. This method uses lubricated rectal probe inserted into the anus and electric shocks are applied for stimulation of semen ejaculation. Collection of semen using these techniques requires tranquility of the animal (Jöchle et al. 1990). The elecro-ejaculation has many disadvantages: collection does not respect animal welfare, needs a lot of time and workers, sedation or anesthesia, injuries, inability to mate normally (Skidmore, 2013).

The artificial vagina is the most suitable technique for collection of semen from the male camel (Lichtenwalner 1996). The male camels are extremely territorial and defend the females, by this reasons the males are not disturbed by unknown persons. When collecting semen, the female is in a recumbent position (she cannot stand up

during mounting). If the male camel starts to copulate, it is important to direct the penis into the artificial vagina (Zhao 1994).

Modified methods for semen collection have been adopted for camels. Homeida (2001) describes safer semen collection. Semen is collected from underneath the male (underground room) thorough the loop hole. Semen is collected with artificial vagina using a teaser female. El- Hassanien (2003) describe another method for collection of semen in which a female model is similar (in shape, size) to the teaser female. These method provides safety of the operator and gives high quality semen.

1.19 Semen viscosity and preservation

Establishment and development of new techniques for storing and freezing camel semen have many advantages for prolongation of breeding season, cross-breeding and embryo transfer (Al- Eknah 2000). The nature of mucus of camel semen delay the reproductive technologies (Skidmore 2005). Determination of sperm concentration and motility is difficult because of the ejaculate viscosity. The high viscosity semen results in oscillatory movement of sperms (El- Zanaty et al. 2004). The absence of sperm motility has been also reported (Agarwal 2004). El-Bahrawi (2011) indicates that mucolytic agents may eliminate viscosity in camel semen and improve motility of sperm. Because sperm can develop motility only after liquefaction (Gorakh 2016).

Artificial insemination in camels became routinely used. Semen extender has been established since the results of artificial insemination reports 100% conception rate (Li 1998). Progress in semen preservation in camels has been slow in comparison to other domestic species (Bravo 2000). Niasari-Naslaji et al. (2006) was able to characterize the biochemical and biophysical properties of camel semen and introduce a suitable extender (SHOTOR diluent) for short- term preservation. Strict attention must be made to prevent damage to the spermatozoa due to chilling injury (Chen 1990).

1.20 Synchronization of ovulation

Ovulation in female camel occurs after a natural mating or is induced hormonally (Al- Sobayil 2003). Usually, gonadotropin-releasing hormone, luteinizing hormone or human chorionic gonadotropin are used to induce ovulation in non-spontaneous ovulators (Hafez 2000). According Musa et al. (1993) ovulation induction by GnRH or LH depends on the dominant follicle size and the time of injection. Equine chorionic gonadotropin has been used to stimulate follicular growth in female camel to accelerate the age of puberty, shorten the calving interval or induce ovulation out of the breeding season (Aboul- Ela 1994).

1.21 Artificial insemination

Artificial insemination is a routine technique with camels. The major problem of artificial insemination is the difficulties of the semen collection because of the aggression of the male (Manefield 1996). Skidmore (2004) noticed that the female camel can be inseminated in standing or sitting position and semen must be deposited in the cervix or through the uterine body. The success of artificial insemination technique depends on the semen quality, the precise induction of estrus (Zhao 2000).

1.22 Embryo transfer

Various factors are affecting embryo recovery rate. These factors include stimulation treatment, fertility of the donor and the male, collection time. Embryos are generally recovered on day 7 after ovulation (McKinnon 1994). The most widely applied method in camels is non-surgical approach. Embryo collection and transfer can be made in sternal line or while standing (Sumar 2013). Embryo transfer requires much more specialized equipment and training. (Tibary 2007).

2. Aims of the Thesis

The MSc Thesis goal was to evaluate reproductive efficiency in camels (*Camelus* sp.) kept under different breeding systems and managements by literature review and also by data analysis of animal records from zoological gardens mainly from the Czech Republic.

The aim was to analyze the low reproductive performance in camels kept in the Czech zoological gardens which is the most important factor affecting camel productivity.

The aims of my MSc Thesis were:

1. to analyze calving interval (the average time interval between successive calving, 24 months in camels)
2. to evaluate calves death in the first year/calves left in the first year
3. to determine the effect of age to death on season
4. to analyze the age at death in calves
5. to determine the birth season of calves and birth months
6. to examine the death season of calves and the differences between males and females
7. to evaluate the lifespan of animals
8. to find the difference in age at leaving between males and females

We predict that camels kept in zoological gardens receive good care and nutrition, so we hypothesise that:

H1: females in good condition and management will produce more male calves than females (Trivers & Willard 1973)

H2: calving interval under good management conditions can be reduce up to 18 months (Dioli 1992)

3. Material and Methods

The structure of the thesis was composed according to the Methodical Manual for the MSc Theses Writing of the Faculty of Tropical AgriSciences (2018), Czech University of Life Sciences Prague. References were cited according to the Citation Rules of the Faculty of Tropical AgriSciences (2017). Scientific names and taxonomy of camelids were written according to Wiegl (2005) and Groves and Grubb (2011).

3.1 Literature review

The literature review came out from the analyses of scientific publications, especially from the scientific database Web of Science, dealing with this topic. Scientific articles were searched by following key words: camelus, calving interval, herd management, sex ratio, and zoological garden.

3.2 Study areas and subjects

The data were evaluated from different zoological gardens from the Czech Republic. The data were collected by zoo keepers. Animal husbandry and reproduction records were provided by zoological gardens or published in annual report. The oldest data are from the year 1959 (female camel Šereda, born in Prague zoo) up to the present. The zoological gardens were as follows:

- The Brno City zoological garden
- The Liberec zoological garden
- The Ostrava zoological garden
- The Plzeň zoological garden
- The Prague zoological garden
- The Ústí nad Labem zoological garden

The number of 288 animals from zoological gardens was concluded in the evaluation. The total number of animals born in mentioned zoos was 230. Detailed information about the animals is provided in Table 4.

Table 4: Detailed information about the data from zoological gardens (author).

Locality	Season	Total number of individuals
Prague	1959-2012	72
Brno	1990-2007	16
Ostrava	1970-2011	32
Ústí nad Labem	1960-2012	30
Liberec	1964-2013	60
Plzeň	1977-2011	15

The data of the evaluation of reproductive efficiencies were rewrited into Excel tables. They mainly include:

- camel name or camel identification number
- the sex of the animal
- Birth season and season of death
- date of birth and date of the death
- age during leaving and death age
- the actual location or place of birth
- month at birth/death

The management in mentioned zoos was similar. Camels were fed once or twice a day by hay and grasses *ad libitum,* supplemented with grains and vegetables. Access to water was also provided *ad libitum.*

The zoo outdoor enclosure did not differ much, they were similar in structure and management. In all zoos the indoor (stables) and outdoor enclosures were present. The outdoor enclosures had grassy or sandy surfaces. Camel males were not separated from females, they were present in the herds throughout the year. In some cases females were separated before parturition and spent up to one month together. Camels

are kept in zoos for many reasons such as conservation (reservoir and return), education and research program.

Individual zoos are described in following chapters.

3.2.1 Prague zoo

Prague zoological garden is a zoo in the district Troja in the north of Prague, in the Czech Republic.

History of camel breeding is dated back to 1932. Since the 1930s up to 1950s the data are incomplete. But since the 1950s the data were comprehensive, the Prague zoo was a transit zoo. The animals from Soviet Union had been traveling through the zoo. The first calf was born in 1934 (Zoo Praha 2016)

In 2016 the head of herd is Jepe, he replaced a male Kňábert and shares an enclosure with herd of females and their calves. Jepe has sired more than 15 calves.

Last 25 years the breeding managements is the same. The whole herd is together, the male was not separate but only in case of extraordinary events such as sickness of the animal. In some cases females are separated after parturition. Reproduction management never been affected (Zoo Praha 2016).

3.2.2 Brno zoo

Zoological garden is situated in the north-western part of Brno, in the Czech Republic.

In 1997-2007 thirteen calves were born at the Brno zoo. Three female camels were used in the reproduction process. The Brno zoo practices three kinds of breeding: natural breeding, breeding with additional feeding and artificial breeding. In natural breeding female camels takes care of the young calf since the birth up to the weaning. Breeding with additional feeding is also natural type of breeding. Young calves are sometimes unable to accept mother's milk. Young camels are separated and fed artificially in three ways:

a) additional feeding from the fixated mother
b) additional feeding from a bottle, female camel and calf are in the herd
c) additional feeding from a bottle, female camel and calf are out of the herd

The last breeding strategy is artificial breeding, a person takes the calf from its mother and suckles him then the relationship between mother and young is interrupted. Breeding of Sára was first successful artificial breeding in Brno zoo (Zoo Brno, 2015).

3.2.3 Ostrava zoo

Zoological garden is situated in Stromovka park, located in Ostrava in the Czech Republic. This is the second largest zoo in the Czech Republic in terms of area. The enclosure with camels opened in 2002 (Zoo Ostrava 2017)

The breeding management is the same as in Prague. Females and male are bred together in one enclosure. Females are not separated, only in extraordinary cases. The peak of breeding management started in 2011, the health status of the animals was stabilized. They had a first calf after four years, however the father was not a male from the herd but the breeding male from Zoo Bratislava. According the zoo report the behavior of male camel was changed. Throughout the year 2016 the male camel from the herd was sexually active, however due to the long gestation period, the breeding management cannot take the advantages of this situation (Zoo Ostrava 2017).

From 2011 to 2016 the breeding management was influenced by using a breeding male from another herd.

3.2.4 Ústí nad Labem zoo

Zoological garden is situated on the edge of Krásné Březno, close to the centre of Ústí nad Labem, in the Czech Republic.

Till the year 2000 the female camels were separated from March to November in big enclosure and the male camel was in other one. The pregnant females were separated, the reproduction was affected from the point of view of parturition, season of parturition and frequency of parturition.

Nowadays, the whole summer females and male are together in one grassy enclosure. Grassy enclosure is used for grazing but it is not sufficient. They provide them with additional feeding. During the winter animals are closed in indoor stables (Zoo Ústí nad Labem 2016).

3.2.5 Liberec zoo

The Liberec zoological garden was founded in 1919, zoo is located in Liberec in the Czech Republic. History of camel breeding is dated back to 1957. The first imported camel was three years old female Bezděchodka from Soviet Union, five years later the herd was completed by the male Fridolín. Two years later, their calf was born (Vendelín).

Nowadays, there are two females and one male in the same paddock with Shetland pony (Zoo Liberec 2016).

3.2.6 Plzeň zoo

The Plzeň zoo was established in 1926, in 1963 it moved to its current location in Lochotín where it merged with a botanical garden in 1981, since 1996 the zoo has been transformed into a zoo-geographical bio-park.

The modern breeding management started in 1994 with the male Haštal which was replaced by Mulisák because of rejuvenation of the herd. Since the beginning of the breeding have been born 19 calves and 36 camels have been bred in the zoo. Nowadays, the herd is composed by 4 camels- Mulisák, Josefína, Gorgína and Lojzička. Theire are in one enclosure, they don’t separate the animals. The breeding management is natural, artificial breeding is not used (Zoo Plzeň 2016).

4. Data analyses

The data were statistically evaluated in the StatisticaCz 12 program (StatSoft Inc. 2013). For all calculations significance level $\alpha = 0.05$ was established. All calculated numerical values were rounded off to two decimal places.

Normality analyses were performed to applying appropriate statistical tests. The data did not show the normal distribution (Kolmogorov-Smirnov, $p < 0.05$). Following non-parametric tests were used for data analyses: Kruskal-Wallis test, Mann-Whitney U test, Person's chi-squared test, Spearman's correlation.

Camels born in the zoological gardens were included in statistical analyses of the breeding season and for the determination of sex of animals. In the data analyses of calves dead in the first year were excluded calves older than one year. Calves younger and older than 1 year were evaluated in statistical analyses of Death distribution in different seasons. For the analyses of Calves death or left in the first year and for the calving interval we included calves born in the zoological gardens. For the analyses of the age at leaving we used the data about animals born in above mentioned zoos. The animals were moved to another zoological garden or to private farm. Total number of animals included in statistical assessment of calving interval was 159 individuals.

The seasons were sorted according to Barnett & Dobson (2010), where March, April and May are considered as spring; June, July and August as summer; September, October and November as autumn; December, January and February as winter. The data from all seasons were included in the statistical assessment.

5. Results

5.1 Birth season of camels

Most calves were born during the spring season 75.98%. In the following seasons there was a decrease in birth rate (summer 6.99%, winter 17.03%)

There were no born calves during the autumn season (September, October, November), as shown in Figure 5.

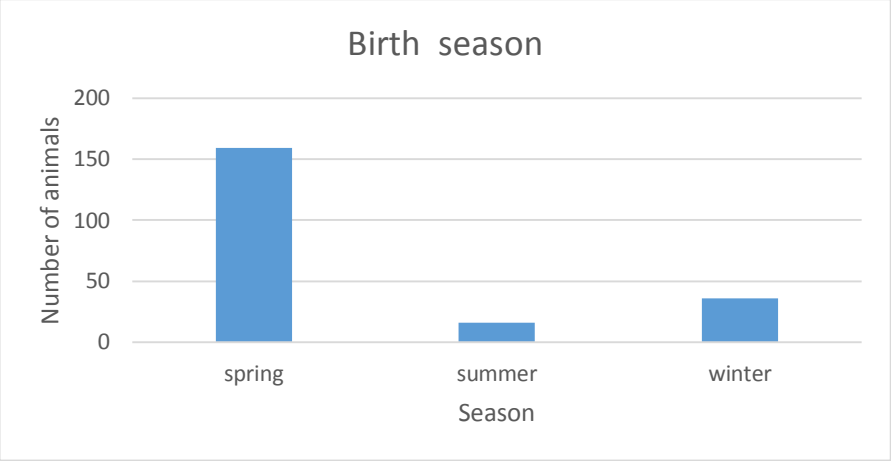

Figure 5: Birth season of camels

The Figure 6 shown the number of calves born in different months. There were no born calves during the August, September and October.

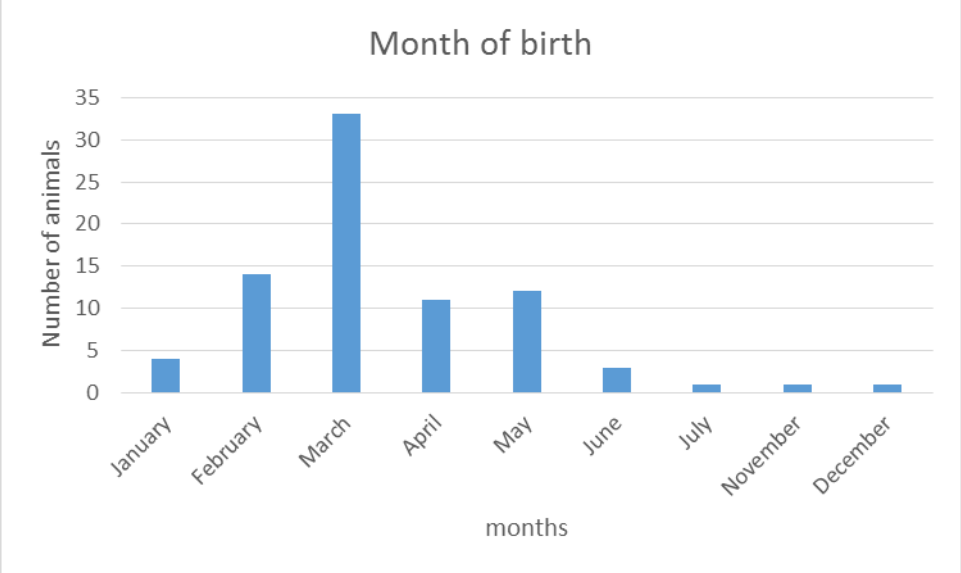

Figure 6: Number of calves born in different months

5.2 Calves dead in the first year

The Figure 7 shown that the majority of deaths in calves within first year of its lives occurred in the first moth of age.

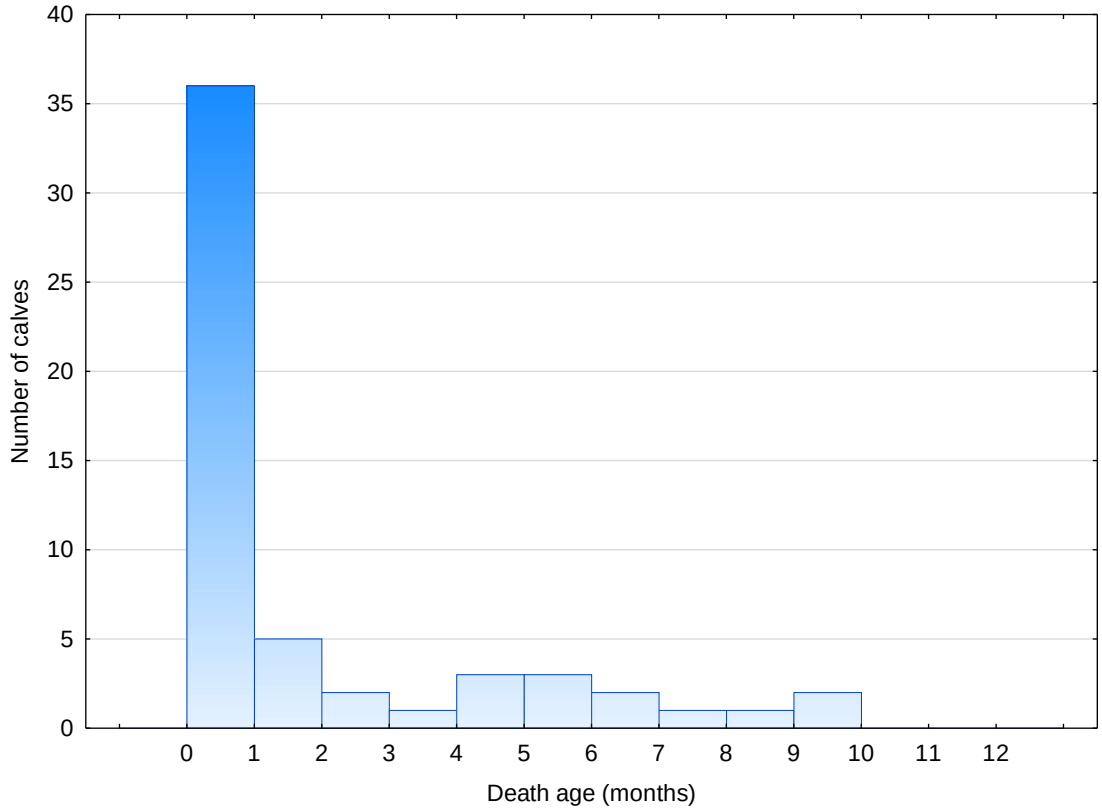

Figure 7: Calves dead in the first year of age

There was no significant difference between males and females death in the first year (Pearson's Chi-square test: $\chi^2 = 0.94$, df = 1, p = 0.33). It was evaluated that 26.36% of males and 20.87% of females died in the first year of age.

5.3 Death distribution in different seasons

The highest number of dead calves younger than 1 year was in spring 47.37% (N = 27) and in summer 22.80% (N = 13).

The highest number of dead animals older than 1 year was in autumn 29.0% (N = 17) and in winter 29.0% (N = 17).

There was significant difference in death distribution across seasons between calves younger than 1 year and animals older than 1 year and season (Pearson's chi-square test: $\chi 2 = 11.05$, df = 3, p = 0.01), see Figure 8.

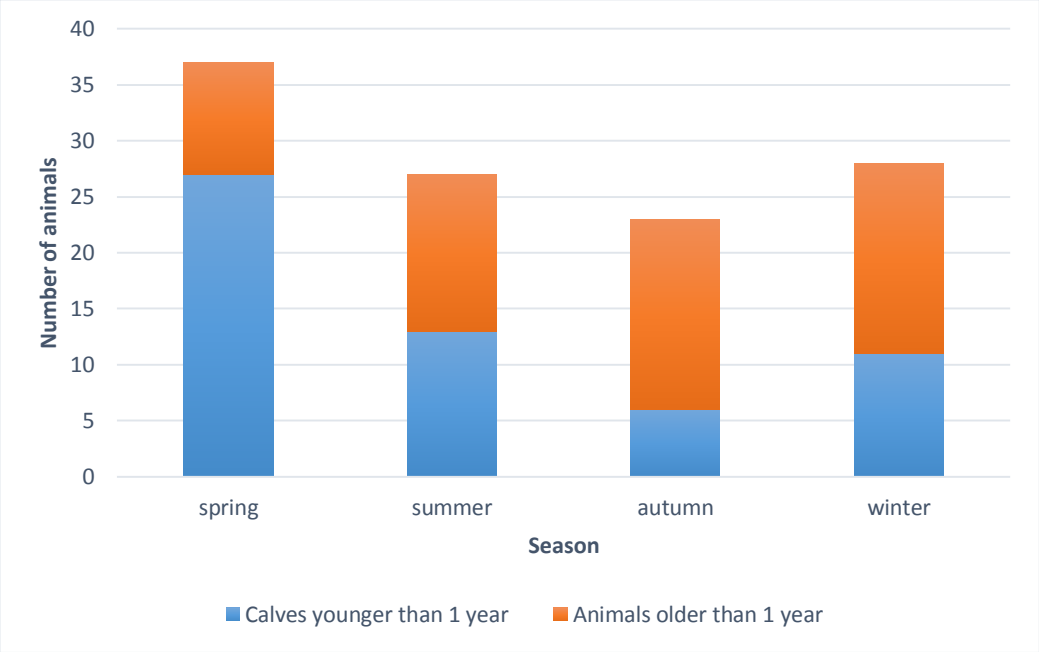

Figure 8: Death distribution in different seasons

5.4 Lifespan of camels

The mean of lifespan in camels was 13.83 ± 1.32 years. The maximum longevity was 29.18 years (Zulejka from Liberec zoo).

There was no significant difference in the average age of death between male and female camels (Mann-Whitney U test: U = 157.00, Z = -1.62, p = 0.05). In male camels the mean age was 10.80 ± 1.99 years and the mean age in female camels was 15.34 ± 1.67 years.

The Figure 9 shown the differences between the lifespan of male and female camels.

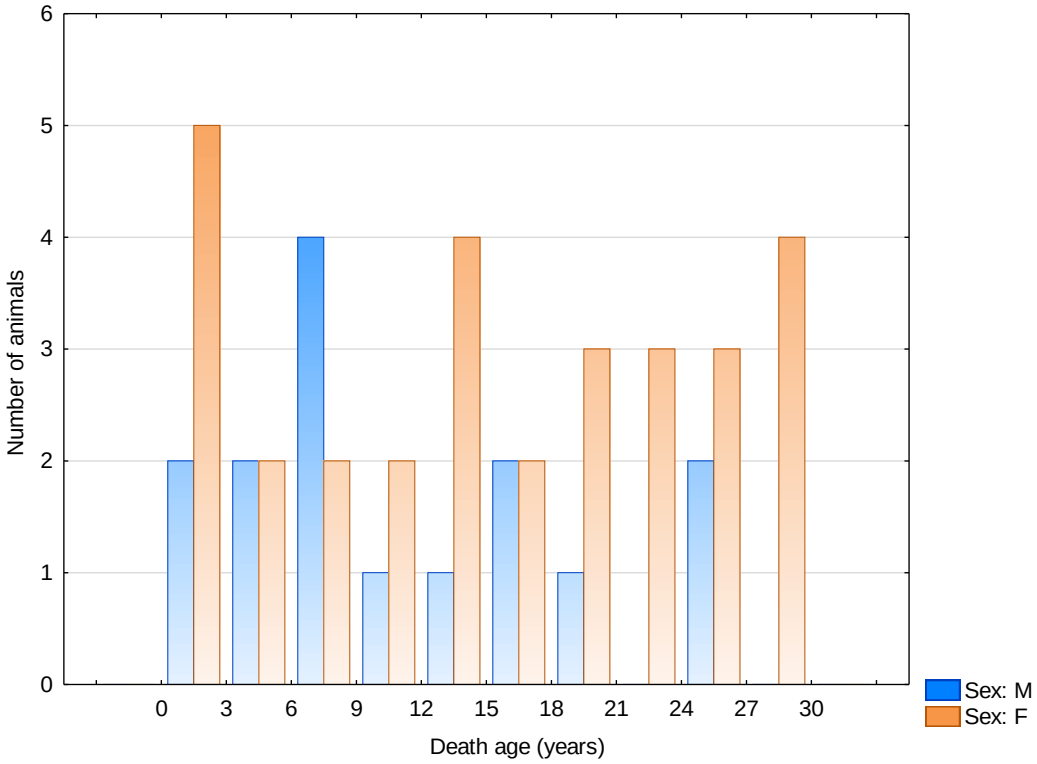

Figure 9: Lifespan of camels

5.5 Age at leaving

The mean age at leaving in camels was 15.63 ± 0.96 months. There was no significant difference between males and females in the age of leaving (Mann-Whitney U test: U= 1141.50, Z= 0.06, p = 0.95). The average age leaving was 15.66 ± 1.27 months in males and 15.61 ± 1.43 months in females.

There was no significant difference in age at leaving in zoological gardens (Mann-Whitney U test: U = 18.00, Z = 0.61, p = 0.54).

5.6 Sex of born animals

The Figure 10 shown the difference between a male calf and female calf born in the zoological gardens.

The total percentage of born male calves was 48.59% and the total percentage of female calves was 51.11%. There was no significant difference in sex ratio between zoological gardens (Pearson's chi-squared test: $\chi^2 = 9.06$, df = 5, p = 0.10).

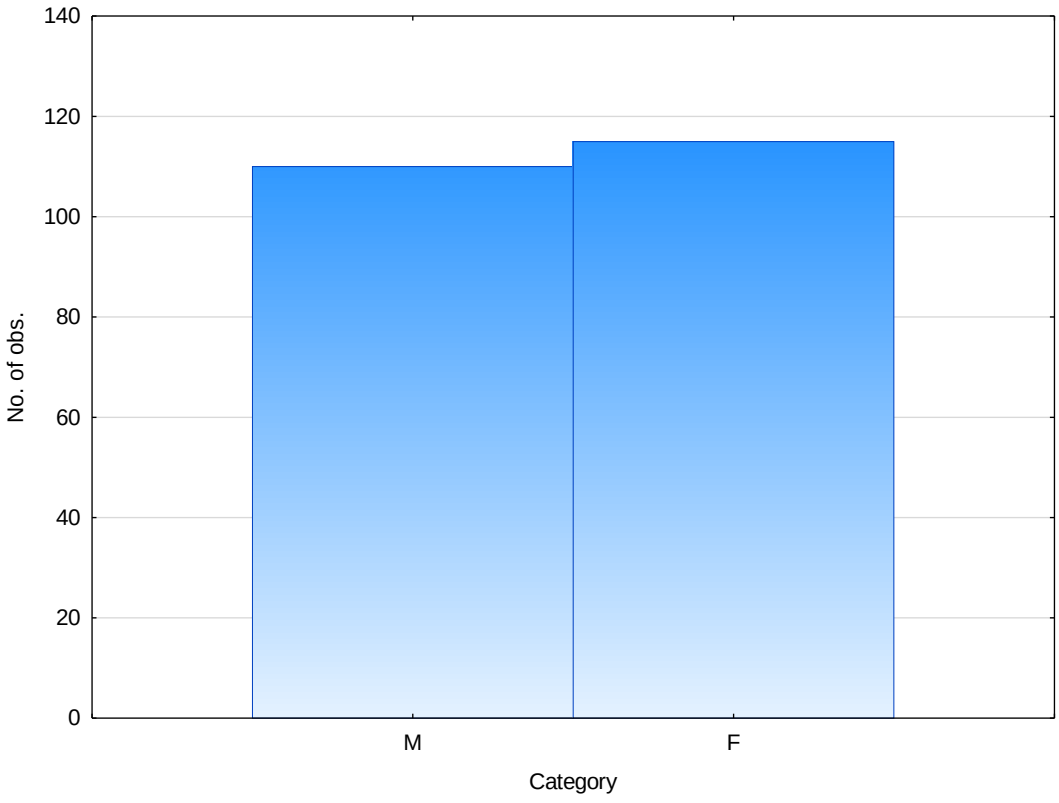

Figure 10: Differences between males and females

5.7 The effect of calves dead or left in the first year of age

Calving interval of females was not affected by calves death or left in the first year (Mann-Whitney U test: U = 3101.00, Z = 0.20, p = 0.84), see Figure 11.

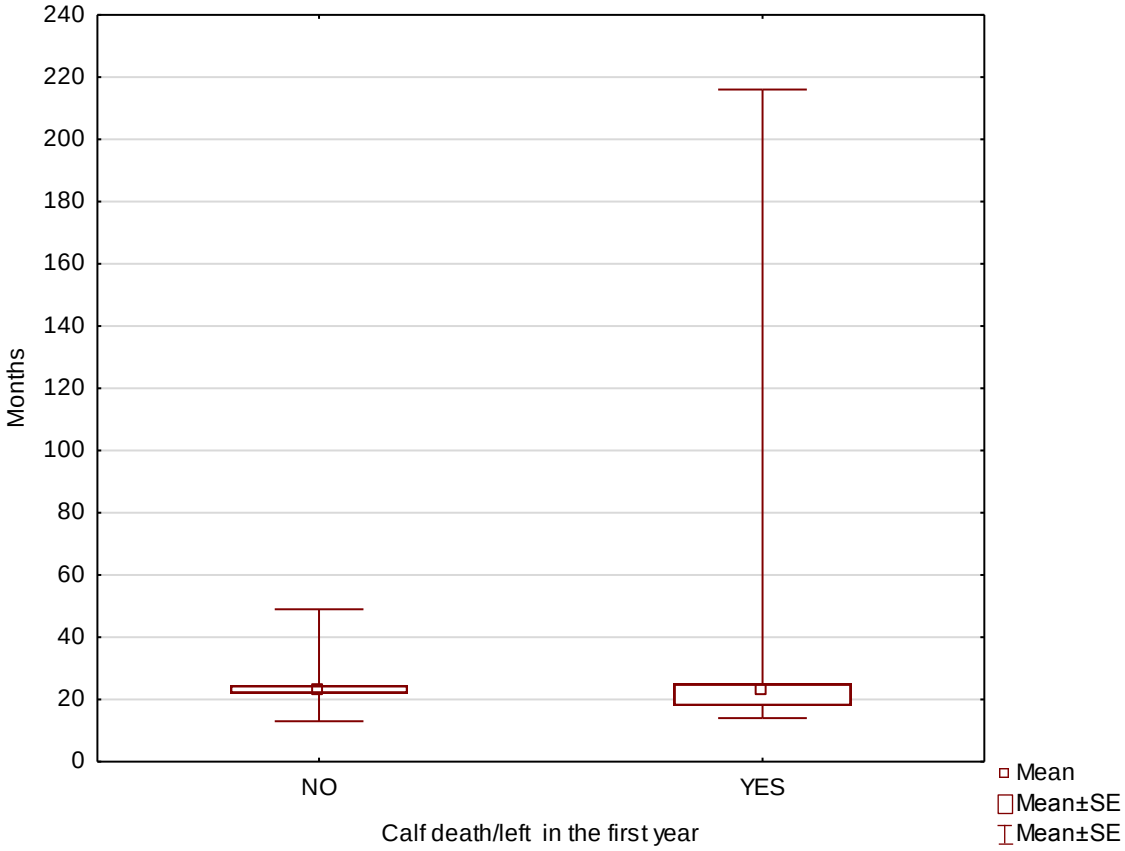

Figure 11: The effect of calves dead or left in the first year on calving interval

5.8 Calving interval

The mean of calving interval was 25.22 ± 1.44 months.

The highest mean rank was in the Ostrava zoo 49.07 ± 15.38 months, and the lowest was in the Prague zoo 22.32 ± 0.94 months. In the Ústí nad Labem the mean ran was 24.58 ± 2.34 months, in the Brno zoo 22.80 ± 2.00 months, in the Plzeň zoo 23.53 ± 1.94 months, and in the Liberec zoo the mean rank was 23.40 ± 0.85 months (Spearman rank order correlation: d = 0.33, p = 0.01), see Figure 12.

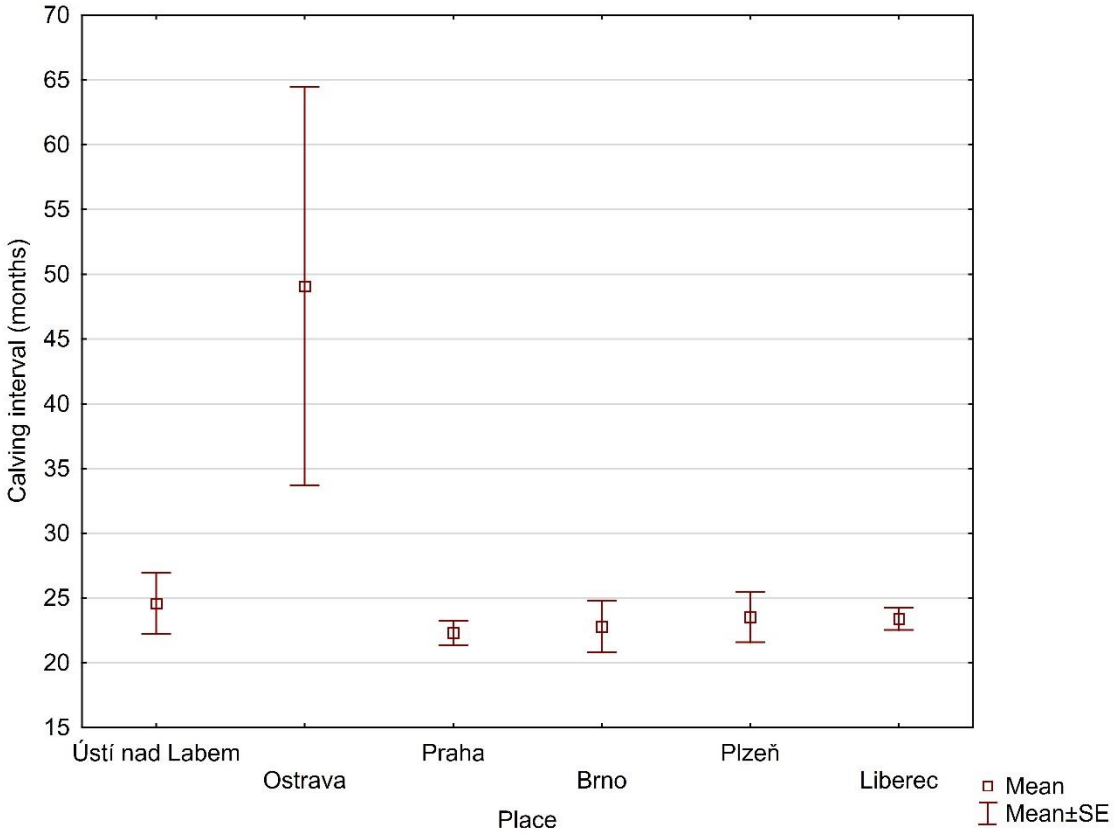

Figure 12: Calving interval

6. Discussion

6.1 Birth season

In present study, the majority of births occurred in March, April and May. This results correspond with other studies (see Table 3). The delivery season was reflected in spring (cooler months) which may have been a reason of mortality rate.

The act of mating was not assisted in zoological gardens, so mating was spontaneous unlike Babu et al. (2004), in his study the act of mating was assisted.

The birth season can be affected by management, animal welfare and nutrition (Waran 2007). The birth season is also affected by the breeding season occurring in winter months: December, January, February (Barnett & Dobson, 2010) and long gestation period varying 12-14 months (Khanvilkar 2009)

6.2 Calves dead in the first year

Mortality in camel calves was reported to be affected by breeding season and length of gestation period. There were no differences between male and female camel calf dead in the first year of age. In present study the death rate of camels was found to be higher in calves under first two months of age, which is considered as a critical period (Ziaopour 2014). The monthly distribution of calf mortality is shown in Figure 7, where is shown the decreasing of claves mortality with increasing age of calves.

The results of dead calves in the first year in this research did not differed from the results of AbdalAllah (2016). In studies, the death rate was found to be higher in calves under first 6 months of age. Similarly, Musa (1992) reported occurrence of calf mortality during the first month of its age. In Africa and Asia high calf mortality was due to the competition of herder and calf for milk, malnutrition was major cause of deaths (Schwartz, 1991). On the other hand, these problems do not occur in the zoological gardens. The mortality risk in zoos could be higher in calves born to older females, as it was in the study of Khyne (2012).

6.3 Death distribution in different season

Mortality in camel calves younger than 1 year was found to be higher in spring and in summer. This was due to the seasonality of reproduction and the duration of gestation period (Babu et al. 2004). In most cases the death causes were abortion, trauma, hearth diseases, sepsis and hypothermia. This causes of death are affected by many factors such as weaning age, milk quantity, season, nutrition and management (Kadim 2008).

In this study, the highest mortality rate in camels older than 1 year was recorded in autumn and in winter. In older camels the main causes of death were euthanasia, pneumonia and hearth diseases, similarly as Khan et al. (2003) described. These causes could be caused by the age of animals and weakness in colder months. Similarly, Björklund (2013) reported wasting, sudden death, weakness and inappetence as most common symptoms of death. In her study, the most common cause of death in adult animals was circulatory failure. We also reported some circulatory failure in adult animals for example heart failure and kidney failure.

6.4 Lifespan of camels

In this thesis, it was not proved that there was a difference in the age of death between males and females. The maximum longevity was reported in Liberec zoo, Zulejka was the oldest females with the age of 29 years. It is very interesting that males have only reached the age of 27 years, while females have reached the age older than 27 years (see Figure 9: Lifespan of camels).

However, domesticated camels have never been recorded to live for more than 35.4 years and the wild camels 30 years (Faye 2014). On the other hand, Weigel (2005) was reported that animals have a longer life expectancy in the zoological gardens than in the wild. This could be due to good veterinary services, well-balanced diet and welfare of animals.

6.5 Age at leaving

The study also represent the analysis of connection between the age at leaving and the sex of animal and difference in zoological gardens. It was not proved that there is a significant difference. The mean age was 16 months, it could be due to the sell of young calves. For example Ústí nad Labem zoo sold the camel calves on spring.

There were no relevant study on age at leaving. However according to study of Farah (2001), in Africa and Asia the male calves are reduce by slaughtering at birth, this allows more milk for females calves (intended for production).

6.6 Sex ration of camel calves

The Trivers-Willard hypothesis (1973) predict, that females in good conditions and under good management and nutrition will produce more male offspring than female offspring. This interpretation is documented by the title of original study: “Natural selection of parental ability to vary the sex ratio of offspring”. The base of the hypothesis is that the male sex ration is more successful than female sex ratio.

In the present study, there was significant difference between males and females born in the zoological gardens. On the other hand, the total number of female calves (N = 115) was higher than male calves (N = 110). In all the above mentioned zoological gardens the number of female calves was higher than male calves.

In the zoological gardens and also in the traditional system, this results was considered as a positive, because females are used for other production (Farah, 2001). According to study of Majid (2000), the milk production play a big role in the livelihood in Africa and China because milk is an important component in human diet, this is also another benefit to have more female camels in the herd.

6.7 Calving interval

Calving interval is a time between the birth of calf and the birth of subsequent calf, from the same she-camel. Generally the calving interval was varying between 20-36 months (Aboul-Ela 1997).

In the present study the mean calving interval in the zoological gardens was 25 months. The highest calving interval was in Ostrava 49 months, it could be due to the absence of male camel in the herd. Calving interval could be affected by the nutrition, diseases and environment (Richard, 1995).

Calving interval according Youssef (2015) was 18 months in semi-intensive systems and 25 months in traditional systems. On the other hand, Richard (1995) observed calving interval of 15 months with well-balanced feeding.

In this thesis, calving interval was marginally affected by calves dead or left in the first year. On the other hand, Djellouli and Saint-Martin (1992) reported that the calving interval was affected by the mortality rate of calves younger than one year.

The assumption of the thesis was that females kept in the zoological gardens are in better conditions than in the wild. However, the condition of female could be affected by allosuckling. The study of Brandlová et al. (2003) proved that allosuckling occurred in camels in captivity.

7. Conclusions

This master's thesis evaluated reproductive performance in camels kept under different breeding management in the zoological gardens. Research demonstrated the relationships between camel calves and adult camels from the Czech zoological gardens.

The assumption was that animals kept in the zoological gardens showed better results than animals kept under traditional system. Generally, results did not differed too much as in the studies reported in the literature review. On the other hand, both hypotheses were rejected. There are many reasons, however well-balanced diet and good management can play significant role in the improvement of reproduction.

The first hypotheses was rejected because it was not proved that females in good conditions and good management produce more male calves than female calves. It was found that the number of female calves born in zoological gardens is slightly higher than the number of born male calves.

The second hypotheses was also rejected because it was not proved that the calving interval under good management and conditions can be reduce up to 18 months. As well as the effect of calves dead or left in the first year of age on calving interval was not found.

Camels are interesting animals offering a lot of possibilities for studying. Future studies could focus on the use of assisted reproductive technologies in zoological gardens.

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