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Weight and body condition relationship in captive giraffe

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled “Weight and body condition relationship in captive giraffe” independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 15.5.2020

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Barbora Žilková

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Abstract

This master's thesis deals with weight and body condition (BCS) relationship in captive giraffe *(Giraffa camelopardalis).* BCS is a system for assessing the body condition, the amount of stored fat and muscles in animals. By comparing the real weight data and BCS of giraffe we aim to better understand the fluctuations of giraffe weights and to test the reliability of BCS use to monitor changes in giraffe condition. The aim of this thesis was to find out the relationship between BCS and real weight of the animal and to record changes that affect it. To capture this relationship we tried to find a suitable condition index that would be able to describe it. This condition index was designed using the first tested factors that had the greatest effect on the weight and body condition of individuals. During the two years from January 2018 to January 2020, the weight was measured together with the recording of BCS and with other factors (sex, season, age category-age, taxon, height, contraception, parity, lactation). The mean weights of males, females and pregnant females were 801.51 ± 64.38 kg, 746.84 ± 9.6 kg and 908.18 ± 19.17 kg. The mean BCS of males, females and pregnant females were 4.8 ± 0.17, 4.6 ± 0.05 and 4.3 ± 0.26. Data were processed from 35 individuals in the R software for statistical computing. Sex, age and height most affected weight and BCS. Of the observed condition indices, BMI (weight/height^2) (P= < 0.001) was most significant in relation to BCS. When using this condition index, the mentioned factors must be taken into account (sex, age and height) of the animal. We have found that the relationship between weight and BCS is more complex. The juveniles with the lowest weight and height had the best body condition. The weight and height increased with increasing age, but this increasing weight trend stopped and began to decline at a certain age (around 20 years) in adults. Body condition deteriorated with increasing age. The results of this study could contribute to improving the quality of life of giraffe in captivity. The weight of the giraffe does not have to correspond to actual body condition, the animal's body condition can deteriorate without losing weight (see lactating females). Zoos that regularly weigh their giraffe should also do BCS regularly. Even those zoos that do not weigh their giraffe can use a condition index (BMI) to estimate weight, knowing the height and BCS of an individual.

Key words: *Giraffa camelopardalis*, BCS, weight, condition indices, captivity, conservation, husbandry

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List of the abbreviations used in the thesis

ANOVA- Analysis of variance

AZA- Association of Zoos and Aquariums

BCI- Body Condition Index

BCS- Body Condition System

BMI- Body Mass Index

EAZA- European Association of Zoos and Aquaria

EEP- European Endangered Species Programmes

GLM- General Linear Model

GOSG- Giraffe and Okapi Specialist Group

ID- Identification

IUCN- International Union for Conservation of Nature

SDBC- Statistically Controlled Density Body Condition index

SE- Standard Error

SFA- Serous Fat Atrophy

SLBL- Straight-line Body Length

SMI- Scaled Mass Index

SSC- Species Survival Comission

TBM- Total Body Mass

WHO- World Health Organization

ZIMS- Zoological Information Management Software

1. Introduction

Data from weighing of giraffe are available in only a handful of zoos as regular weighing of giraffe is time, effort and equipment demanding. On the other hand, Body Condition Score (BCS) can be obtained easily in each institution holding giraffe if an appropriate method is used. BCS is a system for assessing the body condition, the amount of stored fat and muscles in animals (Ferguson et al. 1994; Wright et al. 2010). The use of the BCS system in zoo animals is associated with overweight or obesity but also poor body condition (mostly in browsers) due to insufficient or incorrect nutrition issues in human care, which is considered a serious health problems and causes various complications (Bray & Edwards 2001). Assessment of condition using the BCS system can be done visually or by palpation or as a combination of these two techniques (Wright et al. 2010). In the case of giraffe *(Giraffa camelopardalis),* visual observation is used to assess body condition. Advantage is, that there is no need to disturb an animal and no technique is necessary to use. Other factors such as, height, sex, frame size, age of the animal, gestation, lactation, parity, age within parity, seasonal changes, diet type and level of feeding, husbandry or overall health status including information about contraception should be considered in the condition assessment (Van den Houten & Fidget 2011; Roche et al. 2009). Knowledge of the growth and individual weight fluctuations of endangered species regularly kept in captivity can be a useful tool for improving the quality of conservation and husbandry (Gloneková et al. 2016). By comparing the real weight data and BCS of giraffe we aim to better understand the fluctuations of giraffe weights and to test the reliability of BCS use to monitor changes in giraffe condition.

2. Literature Review

2.1. Body Condition Score (BCS)

Body Condition Scoring (BCS) is a system for assessing the body condition, the amount of stored fat and muscles (Ferguson et al. 1994; Wright et al. 2010) or as a measure of fatness (Boudreau et al. 2014). Body condition, or fat cover, is an indication of the energy reserves in an animal (Ockert 2015). Assessment of condition using the BCS system can be done visually or by palpation or as a combination of these two techniques (Wright et al. 2010). Palpation is commonly used in domestic animals and visual observation in wild animals, where the palpation would be difficult. It is important to become familiar with both the palpation and observation methods for introducing animal condition issues. But in the practical part of this thesis I will only focuse on the observation method for the evaluation of condition in giraffe. The palpation method in giraffe is not an option as it would be necessary to subject the animal to regular complete anesthesia.

BCS according to visual observation is understood as a non-invasive method to assess the deposition of muscle and fat cover on different parts of the animal's body, based on body shape, contour and also bone recesses, such as on the chest or on the back and hips. Advantage is, that during the condition assessment only by observation there is no need to disturb an animal and no technique is necessary to use.

The first BCS system was developed in the UK as a tool for determining the condition of sheep and their fleece. It was based on palpation of the last dorsal and first lumbar vertebrae (Russel et al. 1969). Later BCS began to be used for other domestic animals such as horses, goats, cattle and pigs mostly as a combination of palpation and visual observation. In recent years, BCS has been established for a wider range of species as a tool for improving animal care (Wright et al. 2010) and also to evaluate the nutritional status of animals (Ockert 2015).

The exact definition and understanding of the BCS concept varies depending on the category of animals and the specific purpose of the assessment. The ideal BCS system should be simple, repeatable and easy to understand for people who use it

(Ferguson et al. 1994; Brooks et al. 2014). Because changes in body fat occur in a coordinated way throughout the body, it follows that changes in the appearance of body areas are not independent (Wright & Russel 1984; Butler-Hogg et al. 1985). Change within specific body regions can indicate score categories, rather than description of all body regions at a given BCS. There may be unique descriptions that distinguish each BCS characteristic and easy for training and improve repeatability between observers (Ferguson et al. 1994).

Other factors such as: animal body weight, height, sex, frame size, age of the animal, gestation, lactation, seasonal changes, husbandry or overall health status including information about contraception should be considered in the condition assessment (Van den Houten & Fidget 2011). Several other factors influencing BCS have been reported to affect BCS including parity, age within parity, season of calving, diet type and level of feeding (Roche et al. 2009).

2.1.1. **Grades of BCS**

The BCS system for different animal species differs in the degree of condition assessment. Typically, it is numbered. Lower numbers generally express leaner condition than higher numbers, which usually near to obese condition. The BCS can be supplemented with drawn pictures, animal's photographs or computer models for better assessment (Brooks et al. 2014). Here I chose several examples of BCS systems used in domestic and wild animals divided on the basis of the scoring point used.

BCS is usually divided into five categories as in bovids, Wildman et al. (1982) created system for dairy cattle evaluate the basis of back and pelvic regions. Emaciated cows has 1; thin cows 2; average cows 3; fat cows 4; obese cows 5. For other ungulates as in the bongo (*Tragelaphus eurycerus isaaci*) BCS differs only in the description of each category 1-emaciated, 2-thin, 3-good, 4-fat and 5-obese and for deer, 1 is for very poor condition (cachexia), 2- poor condition (leaness), 3- moderate condition, 4- good condition and 5 for very good condition (fat) (Audige et al. 1998). BCS can also be used with 0.5 increments as in goats and sheep (Mendizabal 2011). It could be very helpful when an animal's condition is not clear (Thompson & Meyer 1994). Healthy goats should have a condition between 2.5 to 4.0. Goats with a body condition of 1.0, 1.5 or 2.0 determine a management or health problem. A body condition of 4.5 or 5 indicate an excessive amount of fat stores that could be detrimental to the goat's health. These scores are very rarely observed in goat herds under a standard management system (Ockert 2015). In most typical sheep herds, over 90 % of the animals should have a body condition score of 2, 3, or 4. The optimal BCS in sheep differs for the various stages of the production. In breeding stage, the optimum score is from 3 to 4. For early–mid gestation is 2.5–4. Lambing, singles: 3.0–3.5 and for twins: 3.5–4. For weaning is 2 or higher condition stage (Thompson & Meyer 1994). The Central Texas Animal Hospital (2018) also introduced a 5-point system for feline (cats) and canine (dogs), in which 1 is for very thin and 5 is for obese condition. The BCS system for lions (*Panthera leo*) and for cheetahs (*Acinonyx jubatus*) was created by the AZA Lion Species Survival Plan (2012); (Dierenfeld et al. 2007) and modified by (Reppert et al. 2011) and the five-point scale chart for tigers (*Panthera tigris*) was designed by Gremlicová (2016). Five categories are also used to assess the condition of polar bears *(Ursus maritimus)* with the following descriptions, skinny (1), thin (2), average (3), fat (4) and very fat (5) (Stirling et al. 2008). Reuter and Adcock (1998) developed five point scoring system for black rhinoceros *(Diceros bicornis)* ranging from 1.0 (emaciated) to 5.0 (heavy). Ideally, 0.5 points can be used to assess the relative condition of an individual. In this case, it should be noted that Reuter and Adcock (1998) created BCS for wild rhinoceros, where score 5 is rated excellent. While in zoos we can see overweight animals and hence the ideal BCS category is considered as 4. BCS system with five categories is also used in african elephants *(Loxodonta africana)* and was created by Morfeld et al. (2014).

Another frequently used rating scale is BCS systems with nine categories as in the case of horses, this system was designed by Henneke et al. (1983). 1-poor; 2- very thin; 3- thin; 4- moderately thin; 5- moderate; 6- moderately fleshy; 7- fleshy; 8- fat and 9 is for extremely fat animals. The ideal range for most horses is from 4 to 6. The BCS system for dogs (canines) and cats (felines) has many variable, because the 9 categories are also used. In canine is 1-3 for too thin condition; 4-5 for ideal condition; 6-9 for too heavy (obese) condition. For feline is from 1 to 4 for too thin condition; 5 is ideal condition; from 6 to 9 is for too heavy (obese) condition. These scoring tables have been developed in cooperation with the veterinary trade brands such as Nestlé Purina, Royal Canin etc.

2.1.2. **Body areas and their examination**

The choice of body areas is important for estimating the score, depending on the type of interest and also the animal taxon on which the observation is made. With respect to practicability of using a visual scoring system, the body areas evaluated need to be easily visible. Which is also associated with the hair density in the mammalian species, for example dense hair coat of caribou and other cervids species prevents any visual evaluation of body silhouettes, because the thick coat can disguise actual body condition (Gerhart et al. 1996; Audige et al. 1998). Whereas in ungulates from warm regions, visual assessment of body parts is widely documented (Schiffmann et al. 2017). But generally the most suitable areas are: the forelegs, neck, shoulders, the sternum (breastbone) and withers, thoracic and lumbar vertebrae, the ribs and hips, the abdominal and the pelvic region, ness of ilium (largest and uppermost bone of the pelvis) and ischium (paired bone forming the lower and back part of the hip bone) and tail vertebrae (Bray & Edwards 2001). These assessment areas are most commonly used in bovids and equids. As I mentioned before, most of the assessments are based on a combination of observation and palpation as in goats, sheep, horses, cats, dogs and in deers.

In wild animals only visual observation is used as in big cats and includes evaluation of head, legs to body ratio, spine, pelvis, tail head and silhouette for tigers. Head, legs to body ratio, pelvis, ribs and abdomen, spine and tail for lions (Gremlicová 2016). Other examples of critical body areas of wild animal evaluations would be mentioned, for example, vertebrae, ribs and hipbones as in polar bears (Stirling et al. 2008). Neck, shoulder, ribs, spine, rump, abdomen and tailbase as in black rhinoceros (Reuter & Adcock 1998). And the backbone, pelvic bone and ribs are scored in african elephants according to Morfeld et al. (2014).

2.1.3. **Reliability of BCS**

The BCS belongs among the assessments made by observers. The observer's outcome has a variable use. Observer ratings are sometimes questioned as too prone to bias (Meagher 2009).

Important reliability indicators for BCS evaluation are shown in the results of a multi-observer survey that independently evaluated the same individual. And also an agreement between the results of the observers' evaluation and the consistency between the items on the scale (e.g. pictures, videos) to measure the same variable (Meagher 2009). A clear prerequisite for obtaining valid data is the clarity and appropriate choice of terms. The results may be distorted due to the emotional meanings of the characteristics used. For example, using a scale with points labelled 'fat' or 'poor' for the evaluated animals that rated their keepers. These results are more likely to be distorted than using a scale with points called 'extremely high' or 'low' with no pejorative subtone (Reppert et al. 2011). This type of bias in the BCS assessment is typical of situations where a close relationship between an observer and an animal can be expected (Cook et al. 2005; Clingerman & Summers 2012).

2.1.4. **Practical use of BCS**

The use of the BCS system in zoo animals is associated with overweight, obesity or malnutrition issues in human care, which is considered a serious health problem and causes various complications (Bray & Edwards 2001). The main reason for introducing BCS systems into zoos was to assess the impact of changes in dietary habits in animals (Van den Houten & Fidget 2011). Regular scoring of the condition along with food intake monitoring could prevent excessive waste (Bray & Edwards 2001) and also serve as an early warning system in health monitoring of wild and captive animals (Schiffmann et al. 2017). BCS allows non-invasive data on the overall appearance of the animal, which, in combination with body mass information (e.g., BMI) or weight data, could provide new information about the correlation between these parameters (Woolnough et al. 1997; Noyce et al. 2002; Lane et al. 2014). Body condition is also considered to be closely related to reproductive success in non-domesticated animal species in captivity (Bray & Edwards 2001; Noyce et al. 2002; Morfeld et al. 2014). Due to its low cost and unassuming on time and material, the BCS method is widely used to study wildlife populations or is used as an alternative to other body condition indices (Woolnough et al. 1997; Lane et al. 2014).

2.2. BCS in giraffe

The BCS assessment in captive giraffe was based mainly for improving the husbandry, to keep the animals in healthy condition. The problem is that wild animals can mask health problems, malnutrition or weakness as long as possible (EAZA Giraffe EEPs 2006). However, it is difficult because body weight, an essential healthcare factor, cannot be measured in many zoos, mostly because of the lack of money to get the scale or time needed to weigh regularly (Kido et al. 2018). And it is also problematic in terms of space to place the weighing scale and animal safety. Not all pavilions have a suitable corridor and construction work can be more costly and complicated than the weighing scale itself. Therefore BCS is a good alternative to animal health assessment (EAZA Giraffe EEPs 2006).

BCS system for giraffe may vary. Five point scale is used, but also 8 point scale. In this thesis I use the European BCS system for evaluation condition of giraffe. It was developed by Kearney and Ball (2001) and published in EAZA Husbandry and Management Guidelines for *Giraffa camelopardalis* (EAZA EEPs 2006). This BCS system uses an 8-point rating scale, when point 1 is for 'emaciated' and point 8 for 'obese'. The areas of the body to be evaluated are: ribs, spine, blades, cervical vertebrae, neck, depressions on the skull, hips, legs, shoulders, back, and chest. When monitoring the body condition, the most attention should be paid to the neck, especially its base, which should be rounded and massive. Furthermore, flanks and pelvic area. Sunken flanks or prominent hip bones imply that the animal is losing condition. Attention should also be paid to the colour, texture and general appearance of the pelage of the coat as an indicator of overall health. And last, the condition of the hooves should be evaluated (Fennessy et al. 2019). The second condition assessment for giraffe that I have already mentioned was created by AZA giraffe holders in collaboration with the Lincoln Park Zoo and Dr. Deb Schmidt in 2005. Condition is evaluated here based on five categories with very brief descriptions of body parts. Added silhouette sketches for each category, but for each category from a different perspective. This system is used mostly in North America.

As I mentioned before, the BCS in giraffe is evaluated by visual observation. The evaluation by palpation is almost impossible both in captivity and in the wild. In the wild, where sources and time that animal can afford to feed is limited, obese giraffe do not occur. For giraffe in general, what might seem obese, because of the body shape, is rather well muscled animal. Final BCS of individual is evaluated based on all observed parts of the body and assigned to the category according to the description.

In recent years many new techniques are appeared for BCS rating. Kido et al. (2018) states that the Kanazawa Zoological Gardens in Japan was the first to test a three-dimensional laser measurement device to evaluate giraffe somatotype in detail. Giraffe were scored using a handheld three-dimensional laser simultaneously from the left and right sides. Two measurements device were placed 2 meters away and took pictures in 2 minutes, then it was converted to computer model which was able to evaluate the whole giraffe body. This image analysis technique can eliminate the human bias during visual observation but further studies of this technique are required, such as increasing the number of measurements in different situations and species. I will focus more on the issue of BCS system in giraffe in the chapter Methodology.

2.3. Giraffe growth

Knowledge of the growth and individual weight fluctuations of endangered species regularly kept in captivity can be a useful tool for improving the quality of conservation and husbandry (Gloneková et al. 2016). Information about weight and height at certain age categories may also be useful for assessing the condition of the animals and could lead to early detection of anomalous growth in newborns in captivity and in the wild (Yerga et al. 2014). In polygynous species such as giraffe, the both sexes exhibit widely divergent rate of growth in relation to reproduction. In general it leads to sexual dimorphism in size (Ralls 1977; Jarman 1983).

Juveniles grow very rapidly in the first months of life, up to 23 cm in height per week (Dagg & Foster 1976). The biggest growth is in the neck area (Backhaus 1961). In the second year of life, the growth slows down (Dagg & Foster 1976). Male calves grow faster and are usually heavier than female calves due to differences in maternal investment which is common in dimorphic animals (Hewison & Gaillard 1999). Size dimorphism begins to manifest in roughly 1-2 years of an individual (Dagg & Foster 1976). The difference in weight begins to occur in the period when males enter adolescence and at the beginning of sexual maturity (Festa-Bianchet et al. 1996). These differences between the sexes may appear due to approaching sexual maturity and development of other features, for example development of gonads, growth of horns, coat colouring and changes in heights (CÔté et al. 1998). The weight of individuals can also change in their adulthood. The biggest weight fluctuations in females, are usually connected with pregnancy and parturition (Russel et al. 1968; Thorne et al. 1976) and that also be caused by hormonal changes during estrus (Holand et al. 2005). Weight in males can decrease during the breeding season (Yoccoz et al. 2002; Mysterud et al. 2003, 2005). Adult males reach up to 154% of adult females (Bashaw et al. 2003) and they reach their adult height at 4-5 years (Dagg & Foster 1976). Weight and its associated body condition of both sexes is dependent on season, weather, amount of movement and qualities of feeding ratios as well (Festa-Bianchet et al. 1996) We can assume that individuals will be heavier in the winter season when they feed on more concentrated food and move less. Nowadays, in the zoos where they have the right feeding, the winter ratios are increased. Because in the past, giraffe lost their weight during winter season and died of Serous Fat Atrophy syndrome (SFA). SFA is associated with poor nutrition, long-term malnutrition, stress or higher energy requirements due to lower outdoor temperatures and the giraffe's efforts to cope with it (Clauss et al. 2006).

2.3.1. **Weight and height**

The information we have about giraffe weight and height are very variable, although it is based on very few sources. Giraffe grow almost to their full height at the age of four, while gaining weight until they are seven or eight (Herbison & Frame 2020). Newborns in captivity weigh between 55 kg (Dagg 2014) and 64 kg (Reason & Laird 2004) but weights can be quite variable, for example, at the Prague Zoo they weighed 85-95 kg in week-old calves of Rothschild's giraffe. Newborns in captivity measure 1.8 meters tall, less than a calf in the wild (Dagg & Foster 1982), where their weight range from 77 kg and 101 kg (Wilson 1969; Kingdon et al. 2013). Adult males in the wild weigh from 800 to 1950 kg and reach a height up to 5.5 meters, while females from 700 to 1200 kg with 4.3 meters height (Bush 2003). The average weight for males is about 1200 kg and for females 800 kg (Bush 2003). Giraffe in captivity are often smaller due to unnatural living conditions, seldom over 5 meters tall (EAZA Giraffe EEPs 2006).

2.3.2. **Weight and differences in giraffe taxonomy**

Giraffe have been described by Linnaeus (1758) as *Giraffa camelopardalis*, belongs to order Cetardiodactyla and family Giraffidae. There are many differences in giraffe taxonomy. Currently is recognized a single species, *Giraffa camelopardalis* by the IUCN SSC Giraffe and Okapi Specialist Group (GOSG) (Muller et al. 2018). According to Dagg (2014) nine subspecies are currently recognized. However, on the basis of nuclear and mitochondrial DNA analyses gathered from almost every major giraffe population in Africa, in 2016 some of the subspecies were subdivided from the original species *Giraffa camelopardalis*. The result should be the division of the giraffe into four separate species with five subspecies. These species with their subspecies are thus divided, Northern giraffe (*Giraffa camelopardalis)* with this subspecies: Kordofan giraffe *(G.c. antiquorum)*, Nubian giraffe (*G.c. camelopardalis)* and West African giraffe (*G.c. peralta)*; Southern giraffe *(Giraffa giraffa)* with this subspecies: Angolan giraffe (*G.g. angolensis)* and South African giraffe (*G.g. giraffa)*; Reticulated giraffe (*Giraffa reticulata)* and Masai giraffe (*Giraffa tippelskirchi)*. Rothschild's giraffe *(G.c. rothschildi)* is genetically identical to the Nubian giraffe (Fennessy et al. 2016). According to new study by Petzold et al. (2020) based on larger amounts of data. They have analysed all multi-locus DNA sequences available for giraffe species. Result from this study is 3-species hypothesis, which recognizes Northern giraffe, Southern giraffe and Masai giraffe as three separate species. In this thesis, in collecting data, I followed Fennesy's taxonomy.

Also very little is known about the differences of weight in species and subspecies. All subspecies have similar standards but there are different variations as the Reticulated giraffe are usually much smaller than Rothschild's. Gloneková et al. (2016) was the first to describe and provide the information in detail about the weight of the Rothschild giraffe. This study assumes that Rothschild's may be heavier than other subspecies. This was confirmed by the fact that all published weight data came from other subspecies. And it can also be confirmed in terms of researching the morphology of giraffe by Groves and Grubb (2011). They noticed the difference in skull between the larger Northern and smaller Southern giraffe taxa. They found that Rothschild giraffe which belongs to Northern taxa had a larger skull dimension than other taxa.

2.4. Condition indices

Body condition is an important factor of an individual animal's health or as an indicator of an individual's quality (Labocha et al. 2014). Wilson and Nussey (2010) defined the quality of an individual as an axis of phenotypic variation which best explains the differences in individual condition. Morphometric condition indices are very popular in determining condition in animals, because they are easily counted from variables, such as mass and body length, that are simple and inexpensive to measure (Labocha et al. 2014). Techniques for assessing body condition among many animal species are used for monitoring long-term fluctuations of food availability in the given environment (Thomas et al. 1976; Costa et al. 1989; Hellgren et al. 1993; Stirling et al. 1999) and of animal ecology (Messier & Crete 1984; Ryg et al. 1990; Atkinson & Ramsay 1995).

2.4.1. BCS and weight relationship

Monitoring of body reserves is very important in managing the breed (Stockdale 2001). Body weight alone is not a good indicator of body reserves. For example, in cows at the same weight, they can vary in body proportions, may be tall and thin or short and fat (Roche et al. 2004). Andrew et al. (1994) and Gibb et al. (1992) found out that energy stores differs by almost 40 % in cows of the similar weight. It can prove that the body weight itself is not a good index for condition estimation. Wright and Russel (1984) noticed a strong positive relationship ($r^2 = 0.86$) between BCS and the proportion of physically dissected fat in friesian cows. Consequently, the visual observation or palpation of body and BCS provides a good assessment of body reserves, ignores or minimizes the influence of frame size. Animals in better condition are predicted to have greater energy stores (usually fat) than animals in poorer condition (Dobson 1992; Schulte-Hostedde et al. 2001).

Condition indices based on mass and morphometric variables are generally divided into two categories, ratio indices (ratio of body mass divided by body length-BMI, which is also used in humans) and residual indices (residuals from regression of body mass on body length) (Labocha et al. 2014).

2.4.2. **Ratio indices**

Ratio indices are usually correlated with body size. This fact affects (reduces) the value of these indices when the conditions of animals of different sizes are compared (Jakob et al. 1996; Hayes & Shonkwiler 2001). For example, statistically controlled density body condition (SDBC), this index is depend on variation in density among tissues (Moya-Laraño et al. 2008) and scaled mass index (SMI) is size dependent and it can be used to compare across populations (Peig & Green 2009, 2010).

This index category also includes the Body Mass Index (BMI). BMI as a new term was firstly published by Keys (1972), who found that BMI is the best representative for body fat percentage among ratios of weight and heights in humans. BMI is the tool to assess the relative body weight, which is based on the weight and the height of the individual. Today is used for classification of underweight, overweight and obesity. It is calculated by dividing individual's weight in kilograms by his height to second in metres (Kolimechkov 2014). WHO (1995) created the BMI chart for human, underweight: BMI<18.5; normal range: BMI 18.5-25; overweight BMI 25-30; obese: BMI>30.

To determine BMI in children age and sex specific percentiles are used because of the amount of body fat changes with age and also the amount of body fat differs between boys and girls (Kuczmarski 2000). The method for estimating the % fat in the body was created specifically for children and adolescents and it was based on only two skin folds (triceps and scapula) (Boye et al. 2002). BMI is a good indicator of variability in energy reserves in individuals (human) but not in athletes, because BMI does not distinguish between muscle and fat (WHO 1995). In such cases, it would also be appropriate to record other data, for example anthropometric data (% fat, skin folds) and strength indicators (data for muscle hypertrophy and dynamometers) (Kolimechkov 2014). BMI also does not indicate where fat is distributed on the body. There is a difference between belly and peripheral fat. Belly fat is not healthy, it increases the risk of certain diseases, such as diabetes, heart diseases. In contrast, peripheral fat, fat stored under the skin, anywhere on the body, is rather beneficial. BMI also fails because it does not take into account differences in race, gender and age. However, BMI in humans is widely used because it is easy to take the height and weight of an individual (Lewis 2013).

2.4.3. **Residual indices**

On the other hand, residual indices must meet these following criteria (Green 2001). Residual indices must be independent of body size (Cattet et al. 2002; Labocha et al. 2014). The relationship between mass and length must be linear, the indicator of body size must be a precise index of total structural size and residual indices cannot be compared among populations (Jakob et al. 1996). Select of the appropriate regression model could be very difficult (Kotiaho 1999; Green 2001). Labocha et al. (2014) says the best index in mice (*Mus musculus)* is for females log body mass/log body length and for males is residuals from regression of pelvic circumference on body length. Although, despite exploring many indices, both ratio and residual, only one of those indices was evaluated as effective for evaluation of a significant amount of variation in percent body fat. This index is named the residual condition index (resPLC/BL), residuals from linear regression of pelvic circumference on body length, and it is used for both males and females (Labocha et al. 2014). Another example of residual condition index is in case of ursids, Cattet et al. (2002) developed body condition index (BCI) for polar bears, black bears (*Ursus americanus*) and grizzly bears (*Ursus arctos*), based on residuals from regression of total body mass (TBM) against a linear measure of size. Straight-line body length (SLBL) was determined as the straight line distance from the tip of the nose to the end of the last tail vertebrae. Residuals offer a practical and reliable index of true body condition that could be measured easily and used to compare individual bears of the same species, irrespective of age, sex, reproductive state, geographical population, date or capture. True body condition was defined as the combined matter of fat and skeletal muscle of the animal compared to its body size (Cattet et al. 2002).

In general, external morphometric measurements may not be good indicators of fat content or energy deposits in body. However, fat is only one constituent part of energy reserves and it is also possible that morphometric indicators can be better indicates of total energy reserves than they are of body fat (Schulte-Hoestedde et al. 2005). Labocha et al. (2014) recommends, when using condition indices, that they should be validated. Optimally, this validation should be introduced for each population of interest because relationship between these indices and fat content may differ among populations (Kaufman et al. 2007). In small mammals Labocha et al. (2014)

recommends measuring pelvic circumference or some other measure of girth, whenever possible and considering multiple regression as an alternative to condition indices. Quantity and study of condition indices is large and still growing.

3. Aims of the Thesis

The aim of this thesis was to find out the relationship between BCS and real weight of the animal and to record changes that affect it. By comparing the real weight data and BCS of giraffe we aim to better understand the fluctuations of giraffe weights and to test the reliability of BCS use to monitor changes in giraffe condition. To capture the relationship between BCS and weight in captive giraffe, we tried to find a suitable condition index that would be able to describe this relationship. This condition index was designed using the first tested factors that had the greatest effect on the weight and body condition of individuals. Our results will clarify the most likely explanations of the BCS fluctuations, ultimately leading to improvement of giraffe husbandry in zoos.

4. Methodology

4.1. Materials

For the evaluation of giraffe condition in this thesis I used the BCS system presented in EAZA husbandry and management guidelines for *Girafa camelopardalis* (EAZA Giraffe EEPs 2006) (Figure 3). We chose this rating system based on the fact that the evaluation areas are well described here. And unlike the AZA BCS system, which is complemented with sketches of animal body shapes for each category, but for each category from a different perspective, which can be very confusing. For better evaluation of condition I created sketches of animal body shape from one side and back side (Table 1), red lines in draws highlight the body areas to focus when evaluating condition. When the resulting condition seemed to be between the two categories, I also used half a point. I used a camera to record the condition of an individual if necessary. When the giraffe were at a greater distance from me as observer, for example in the summer months, I used a binoculars. And a weighing scale, to get a weight record that was specific to each zoo. The weighing scale in Prague Zoo is shown in Figure 2. To give an idea, the materials used in Zoo Emmen are shown in Figure 1.

Figure 2: weighing scale in Prague Zoo

(Photo: Barbora Žilková 2018)

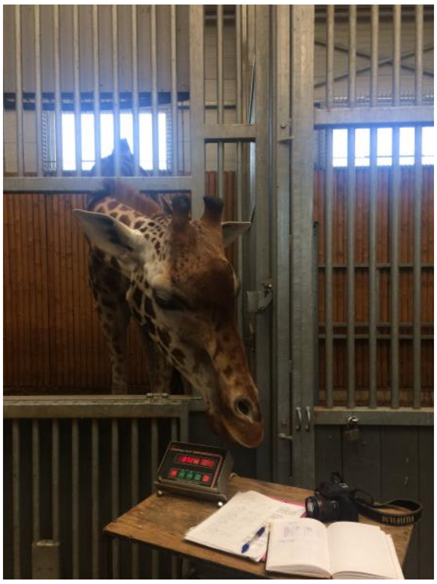


Figure 1: used materials in Emmen Zoo

(Photo: Barbora Žilková 2019)

EAZA Husbandry and Management Guidelines
Giraffa camelopardalis

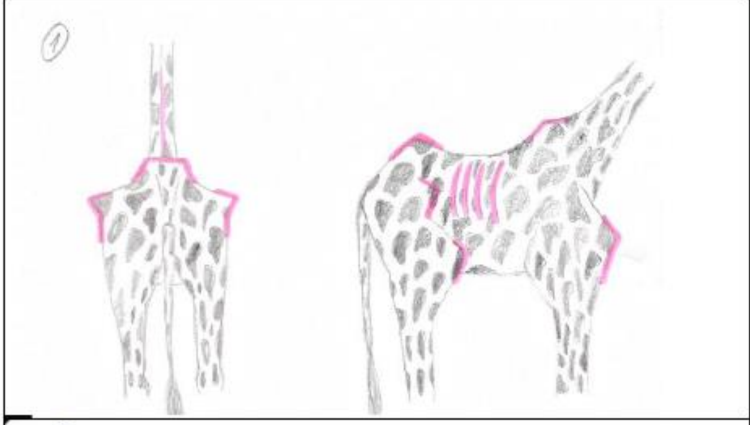
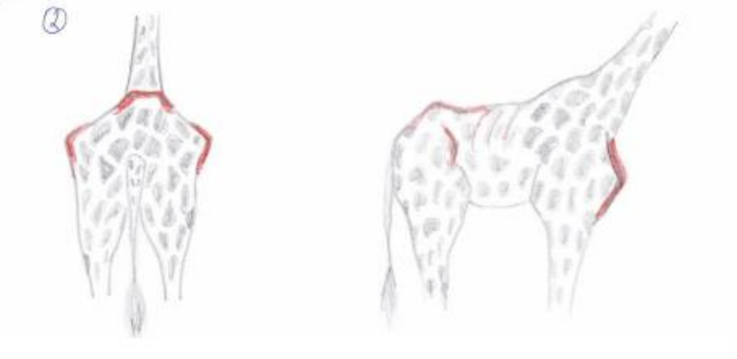
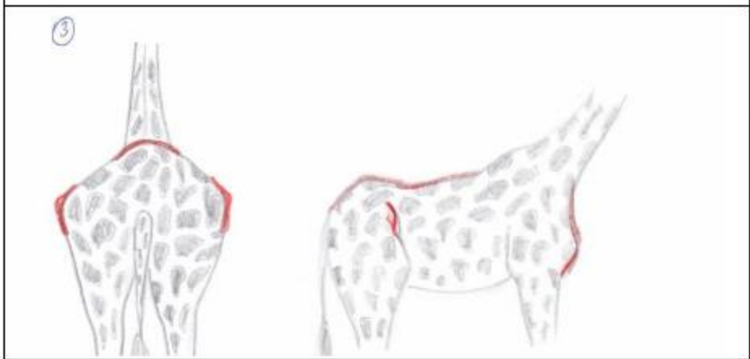
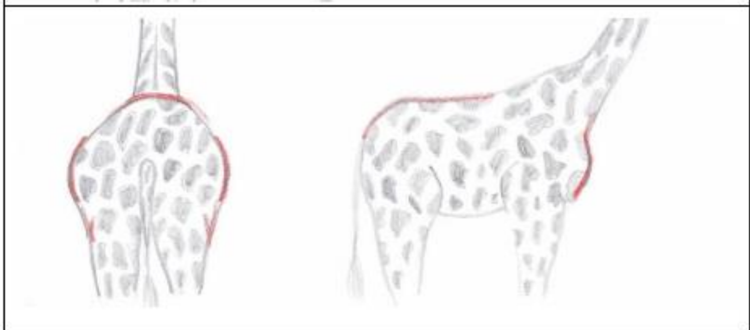
Table 2-5: Giraffe body condition score (Kearney and Ball, 2001)

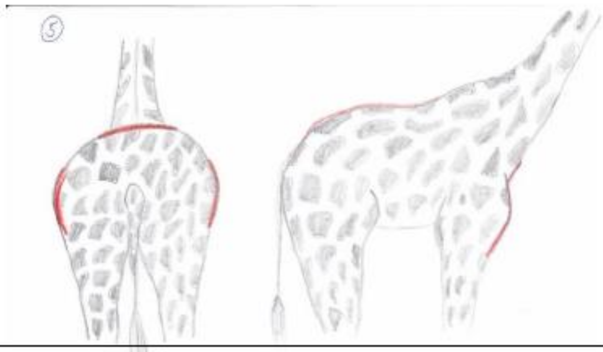
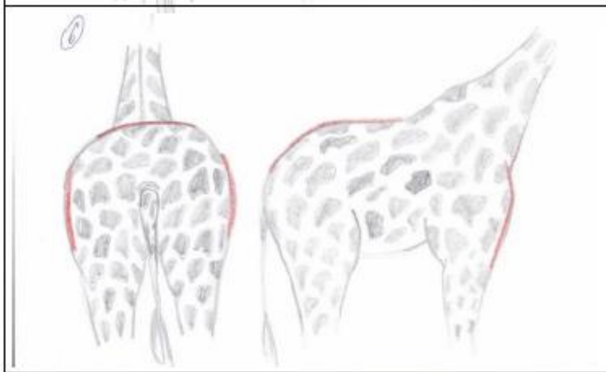
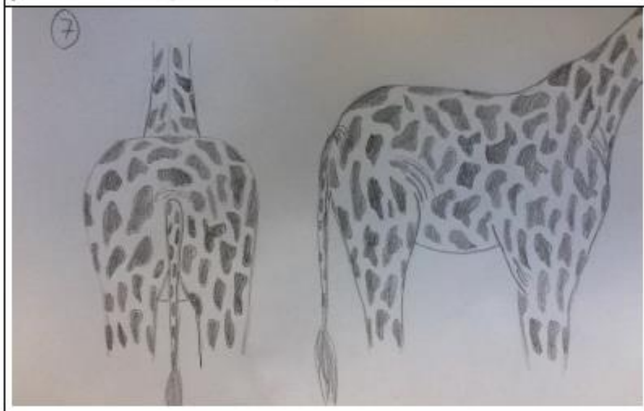
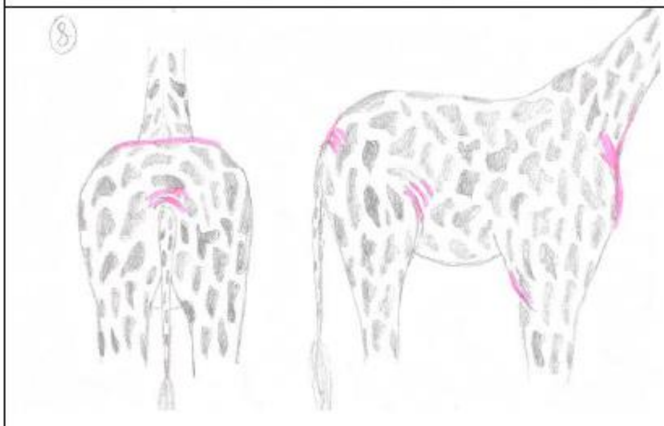
Score	Description	Notes/Comments
1	No fat can be palpated. Ribs and spine of scapula may be visible. Muscle wasting has occurred.	Emaciated.
2	Cervical vertebrae are visible. Protruding spine. Distinct hollows cranial to hipbones. Crest of illium is visible. Outline of scapula is visible. Thin legs. Hips appear sunken and shoulders are slim.	Poor condition. Cause for concern.
3	Hipbones prominent. Definite outline of spine. Sacrum is visible. First two cervical vertebrae visible. Chest may appear sunken.	Occasionally seen following a growth spurt in young adults.
4	Tailhead is noticeable and point of hipbone is visible. Slight hollow in center of chest. Sufficient muscling in hindquarters, shoulders, and neck.	Nicely muscled, but with little fat. Commonly seen in growing giraffe over 1.5 years of age.
5	Back and hips rise smoothly to topline with no visible outline or denting along backbone. Some palpable fat around tailhead. Point of hipbone just visible.	Good condition.
6	Back is level and wide. Hipbone not visible, but easily palpated. Smooth chest. Visible thickening in lower neck.	Good condition. Ideal for calves under 1&1/2 years.
7	Slight crease along backbone. Hipbones difficult to palpate. Smooth chest and thick neck.	Overweight.
8	Definite crease along backbone. Tailhead no longer clearly visible. Soft fat palpable along tailhead. Thick neck.	Obese.

Figure 3: BCS system for giraffe

(Source: EAZA Giraffe EEPs. 2006. EAZA Husbandry and Management Guidelines for Giraffa camelopardalis. Arnhem, the Netherlands: Burger's Zoo)

Table 1: BCS chart with sketches

	**1-emaciated** Not fat can be palpated. Ribs and spine of scapula may be visible. Muscle wasting has occurred.
	**2- poor condition** Cervical vertebrae are visible. Protruding spine. Distinct hollows cranial to hipbones. Crest of ilium is visible. Outline of scapula is visible. Thin legs. Hips appear sunken and shoulders are slim.
	**3- in young adults** Hipbones prominent. Definite outline of spine. Sacrum is visible. First two cervical vertebrae visible. Chest may appear sunken.
	**4- in growing giraffe over 1.5 years of age** Tailhead is noticeable and point of hipbone is visible. Slight hollow in center of chest. Sufficient muscling in hindquarters, shoulders and neck.

	**5- good condition** Back and hips rise smoothly to topline with no visible outline or denting along backbone. Some palpable fat around tailhead. Point of hipbone just visible.
	**6- good condition, ideal for calves under 1 and 1.5 years** Back is level and wide. Hipbone not visible, but easily palpated. Smooth chest. Visible thickening in lower neck.
	**7-Overweight** Slight crease along backbone. Hipbones difficult to palpate. Smooth chest and thick neck.
	**8- obese** Definite crease along backbone. Tailhead no longer clearly visible. Soft fat palpable along tailhead. Thick neck.

(Source: by the author)

4.2. Methods

In order to get as much data as possible, we created a leaflet of our project describing what we ask for (shown in Appendices). In the leaflet we asked the zoo whether they weigh their giraffe or whether they have weight data available. Then we contacted Jörg Jebram, the EEP Coordinator Giraffe *(Giraffa camelopardalis)*, who sent our request to giraffe holders in Europe. Table 2 lists all the zoos and animals that were included in the research. The methodology in this thesis could be divided into two parts. One-time or single weighing and then a regular long-term weighing.

Table 2: Zoos and animals included in the research

Institution	♀	♂
Beauval ZOO (FRA)	4	1
Colchester ZOO (GBR)	4	
Dublin ZOO (IRL)	4	2
Flamingo Land (GBR)	7	2
Gaia ZOO (NLD)	3	1
Nürnberg ZOO (DEU)	3	5
Prague ZOO (CZE)	10	2
Rotterdam ZOO (NLD)	7	1
Safaripark Beekse Bergen (NLD)	18	
Vienna ZOO (AUT)	2	1
West Midland Safari Park (GBR)	5	5
Wildlands Adventure ZOO Emmen (NLD)	5	1

(Source: by the author)

4.2.1. Single weighing

At our request we were contacted by several zoos, which weigh irregularly but could provide weight data. We were provided with the requested informations by these institutions: Beauval Zoo, France; Colchester Zoo, United Kingdom of Great Britain; Dublin Zoo, Ireland; Flamingo Land, United Kingdom of Great Britain; Gaia Zoo, Netherlands; Nürnberg Zoo, Germany; Rotterdam Zoo, Netherlands; Safaripark Beekse Bergen, Netherlands; Vienna Zoo, Austria; West Midlands Safari park, United Kingdom of Great Britain. As the aim of the thesis was to find out the relationship between BCS and real weight of the animal and to record changes that affect it. We asked the zoos for the following information in individuals, which could affect the weight and body condition of giraffe: ID (for example, in the ZIMS database), sex, species (subspecies), date of birth, weight records (date of weighing), height, BCS, reproduction status (parity in females, lactation, month of pregnancy), use of contraception (for example, use of Improvac), health status, husbandry (herd composition, range size, diet composition). Not all of these zoological gardens have had BCS experience. To get valuable results, I visited some of these zoos to observe BCS in person. As condition scoring can be very subjective and could lead to misleading results when there are more observers. Weighing and BCS observations were made at the same time in these zoos: June 27, 2019 Vienna Zoo (Figure 4; height observation Figure 5); September 18, 2019 Colchester Zoo; September 20, 2019 West Midland Safari Park.

Figure 4: BCS observation in Vienna Zoo

(Photo: Jakub Kurtev 2019)

Figure 5: height observation in Vienna Zoo

(Photo: Eveline Dungl 2019)

4.2.2. **Long-term weighing**

The second way to get valuable results was long-term data from regular weighing to compare weight and BCS fluctuations in longer time period. In this study we have included these zoological gardens with which we had been working for a longer time because they weighed their giraffe regularly. We cooperated with these zoos (Prague Zoo, Czechia; Wildlands Adventure Zoo Emmen, Netherlands).

4.2.2.1. Prague Zoo

The giraffe weighing was carried out regularly, during their normal daytime operation and under the supervision of the keeper. Giraffe entered individually the weighing platform, which is placed in the corridor, which the giraffe passes from the inner stable to the pavilion during the winter and to the outdoor enclosure during the summer season. The weighing system is called TONAVA VT6220 TM3000 and can carry up to 3000 kg. Giraffe were trained to walk through the corridor individually and the entire weighing process was adapted to the individual animal needs.

Studied animals

Nine fully grown individuals of the Rothschild's giraffe *(G. c. rothschildi)* (1 male and 8 females), 1 subadult female and 2 juveniles (male and female) were included for the present study, herd information is shown in the table 3. For the purpose of this study we distinguished juveniles up to 12 months included, subadults from 1 year to 4 years and adult individuals older than 4 years. Health status of the animals was known. None of the animals were during the research on contraception. Two females were pregnant and then lactating (Eliska first nursed Anna until 20.10.2017 and then Matyas; Faraa nursed Nela). Female Kleopatra was euthanized 6.2.2018 due to her high age and worsening health.

Table 3: Giraffe in Prague Zoo

Name	Date of birth	Sex	Age category
Kleopatra	13.1.1993	♀	adult
Faraa	30.10.2007	♀	adult
Eliska	6.10.1995	♀	adult
Nora	27.6.1999	♀	adult
Diana	6.1.2003	♀	adult
Nsia	19.4.2010	♀	adult
Gabina	8.3.2009	♀	adult
Justyna	9.10.2013	♀	adult
Anna	5.8.2016	♀	subadult
Johan	20.12.1999	♂	adult
Nela	25.1.2019	♀	juvenile
Matyas	13.2.2019	♂	juvenile

(Source: by the author)

In the winter and under less favourable conditions, the giraffe were kept in the indoor exposition. The interior pavilion occupied 475 m². Giraffe could be seen through the glass wall. The exposition was divided into two sections to separate individuals. The male was kept separately from the females, but had contact with them through the wooden wall. He was allowed to the females only for mating purposes. Feed was served either from feeding racks and hanging basket, or it was freely suspended, such as branches. As enrichment they got pieces of vegetables or fruits in a special box with holes. During the summer, giraffe were released into the outdoor enclosure. The exposition was 2.2 hectares wide with earthy, sandy and grassy substrate. In the paddock there was a waterhole and feeding racks, which were attached to the high trunks, ending with roofs that gave the animals shade. The outdoor enclosure giraffe shared with other animal species such as, lechwe antelopes *(Kobus leche)*, common ostriches *(Struthio camelus),* blesbocks *(Damaliscus pygargus phillipsi),* beisa oryxes *(Oryx gazella beisa)* and Grevy’s zebras *(Equus grevyi).* The feeding ratio that animals were exposed during the summer and winter regimen differed in the amount of feed served as well as in its composition. The summer feed mainly consists of dried alfalfa and fresh browse as branches (of fruit tree or willow) ad libitum and then with limited amount of green alfalfa and granulate for browsers, fresh fodder, such as apples, carrots, leafy vegetables and mash containing bran, linseed and oatmeal. In the winter, giraffe are fed mainly with the browser granules, alfalfa hay, haylage and branches (for example willow, dried oak and fir tree as enrichement) and supplements. The green alfalfa was replaced by alfalfa hay during the winter months. The transition from summer feeding ratio to winter was in November and from winter to summer was in April. Access to water was ad libitum from self-drinkers inside and from basin (waterhole) in the paddock.

Data collection

The data were collected regularly within two years from 12 giraffe. During each weighing we assessed indirectly (by observation method) BCS of giraffe (before weighing to avoid the influence of the already known weight), ID (name) of the individual, sex, species (subspecies), date of birth, age category, date of weighing, season of weighing (spring, summer, autumn, winter), feeding ratio (winter, summer), age of animal in days, height, health status, parity and lactation record in females and record of contraception. For pregnant females, month of pregnancy was also recorded. Weighing and observation data were collected from January 2018 to January 2020, 17 measurements were performed. Weighing took an average of 20 minutes. Observations were recorded and then inserted into an Excell table.

4.2.2.2. Wildlands Adventure Zoo Emmen

Giraffe were weighed in their indoor exposition, the weighing scale was placed in one of the closable part of the stable (Figure 8) and the animals were trained to enter the scale. Weighing was carried out in the presence of the keeper.

Studied animals

At the time of observation, 4 adults (all females) and 2 subadults (male and female) of the Rothschild's giraffe *(G. c. rothschildi)* were bred in Emmen, individual information is shown in Table 4. None of the females were pregnant or nursing. Owenza female had a laminitis problem in September 2018. Also during the observation two females (Abidemi, Owenza) were on Improvac injection contraceptive since 28.12.2018. Animals were bred together. Giraffe spent winter in a stable with an area of 200 m², which can be divided into 4 parts, in one was placed weighing scale. The stable was equipped with feeding racks, hanging basket for alfalfa, hanging device for branches, self-drinkers and also box with holes for pellets. During the summer season, giraffe spent 8 hours a day in an outdoor enclosure called Serenga, 25 000 m² wide. Several feeding racks, hanging branches, waterponds and self-drinkers were placed in the enclosure. Paddock was shared with other animals species such as, Grevy's zebras, blue wildebeests *(Connochaetes taurinus),* impalas *(Aepyceros melampus),* defassa waterbucks *(Kobus ellipsiprymnus defassa)* and white rhinoceros *(Ceratotherium simum).* The feeding ratio consisted mainly of lucerne hay, fresh browse (birch, willow branches), pellets for browsers (Kasper and Boskos) and several mineral licks were placed in both the outdoor and indoor enclosures to supplement the minerals.

Table 4: Giraffe in Wildlands Adventure Zoo Emmen

Name	Date of birth	Sex	Age category
Azizi	10.2.2013	♀	adult
Abidemi	11.4.2007	♀	adult
Ayana	31.8.2015	♀	adult
Hidaya	4.5.2007	♀	adult
Owenza	22.1.2016	♀	subadult
Bakari	7.1.2017	♂	subadult

(Source: by the author)

Data collection

I collected data from 6 individuals. Wildlands Adventure Zoo Emmen have weighed its giraffe regularly. I first got data from 28 measurements from January 2018 to January 2019. Two observations were added with the BCS records made by keepers. During my stay in Emmen, we weighed from October 2019 to December 2019, 10 measurements were performed at a regular interval of 1 week. For each weight record I noted BCS and other information about individuals as it was at the Prague Zoo, weight observation is shown in Figure 6. Weighing took an average of 40 minutes, the observations were recorded and then put into an Excell table as well. To compare the condition of individuals, we took pictures of each animal from three sides (front, side and back) at the beginning (9.10.2019), demonstration of BCS in one individual (Figure 7) and at the end of my visit (4.12.2019).

Figure 6: weight observation in Emmen Zoo

(Photo: Vincent Van Dalen 2019)

Figure 7: Owenza, BCS 4

(Photo: Vincent Van Dalen 2019)

Figure 8: weighing scale in Emmen Zoo

(*Photo: Barbora Žilková 2019)*

4.2.3. **Data evaluation**

All data from both single weighing and long-term weighing were analyzed in the R software for statistical computing. We divided the dataset (excell table) into males and females and created the separate dataset with pregnant females only. The data had non normal distribution. Data evaluation could be divided into two parts, first we analyzed the factors that could affect the weight and condition of the animals. We used a GLM (Generalized Linear Model) for data analysis. We tested the effects of both external (season) and internal (age category-age, taxon, height, contraception, parity, lactation) factors on animal weight and body condition. In pregnant females we analyzed the dependence of weight on BCS and BCS on month of pregnancy. In the second part, we created condition indices from the most significant factors that could describe the relationship between weight and BCS. We tested the following condition indices depending on the BCS:weight/height; weight/height^2 (BMI); weight*height*age; (weight*height)/age. We used one-way ANOVA for testing condition indices. We used these tests for analysis, because the dataset was robust enough. Mean values were reported with Standard Error values (SE), the number of measurements was given after the each SE value.

5. Results

The results were processed from 35 individuals, 9 males and 26 females, for which we have reported all data. In total, data from 221 measurements, were processed.

We first analyzed the factors that affect weight and whether or not they also affect body condition (BCS). Weight was influenced by age category, height and taxon in all individuals (males and females) and contraception and lactation in adult females. BCS was influenced by age category in all individuals (males and females) and by height in females only and parity and lactation in adult females. These analyzes were performed for all males and females, without pregnant females. In pregnant females we analyzed the dependence of weight on BCS and BCS on month of pregnancy.

From the most significant factors (weight, height, age-in days), we tried to create an suitable condition index that would best capture the relationship between weight and BCS. We analyzed these condition indices (weight/height; weight/height^2 (BMI); weight*height*age; (weight*height)/age) depending on the BCS in order to be able to retrospectively estimate the actual body weight of the animal from the index.

The mean weight of males (n= 9) was 801.51 ± 64.38 kg (n=40), mean BCS was 4.8 ± 0.17 (n=40). The mean weight of females (n= 26) was 746.84 ± 9.6 kg (n=181), mean BCS was 4.6 ± 0.05 (n=181). Mean weight of pregnant females (n=2) was 908.18 ± 19.17 kg (n=17) and mean BCS was 4.3 ± 0.26 (n=17).

5.1. Relationship between BCS and weight

BCS was influenced by weight in females (P= < 0.001; Figure 9) and in males (P= 0.001). The female in the best condition (6) (n=1) had the lowest weight (417 ± 16.86 kg) in range (390-448 kg, n=3) and females in the worst condition (2-2.5) (n=2) had the highest weight (789 ± 0.11 kg) in range (750-818kg, n=6).

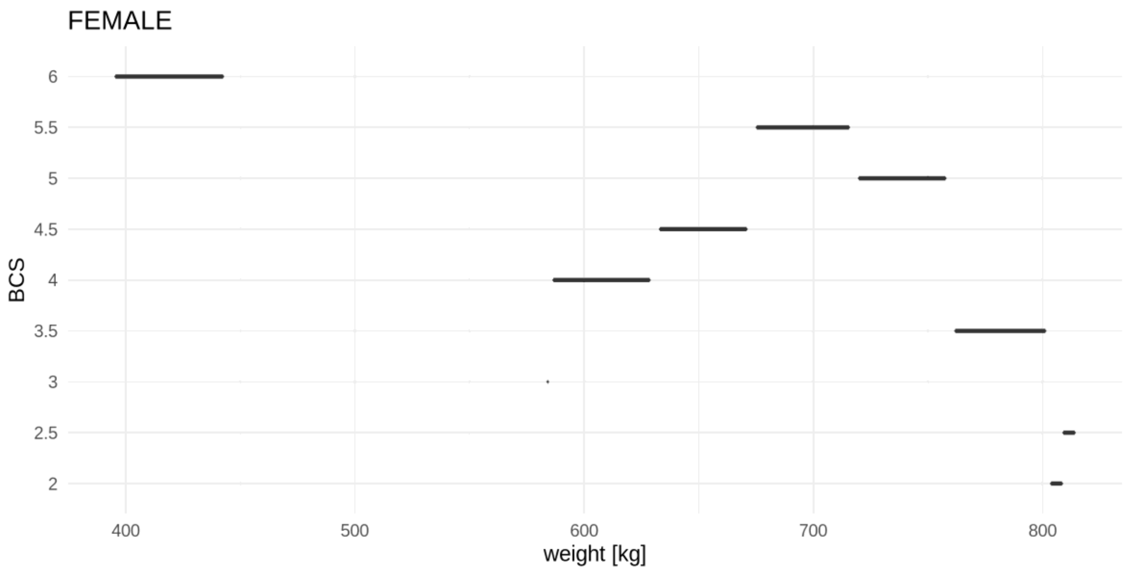


Figure 9: BCS dependence on weight in females

5.1.1. **Factors affecting weight**

5.1.1.1. Age category

Age category factor was in relation to weight significant in females (P= <0.001; figure 10) and in males (P= <0.001; Figure 11). With increasing age the weight of the individual increased. Mean weight of juvenile females (n= 1) was 417 ± 16.86 kg in range (390-448 kg, n=3). Mean weight of subadult females (n= 4) was 575 ± 11.22 kg in range (487-724 kg, n=32) and in adult females (n= 22) was 791 ± 7.89 kg in range (556-910 kg, n=146). Mean weight of juvenile males (n= 2) was 329 ± 55.4 kg in range (161-447 kg, n=5). Mean weight of subadult males (n= 3) was 444 ± 8.15 kg in range (374-493 kg, n=15) and in adult males (n= 4) was 1188 ± 31.42 kg in range (866-1310 kg, n=20). Figure 12 shows the weight dependence on age in adult females. We reported this dependence only in females, for larger amounts of data.

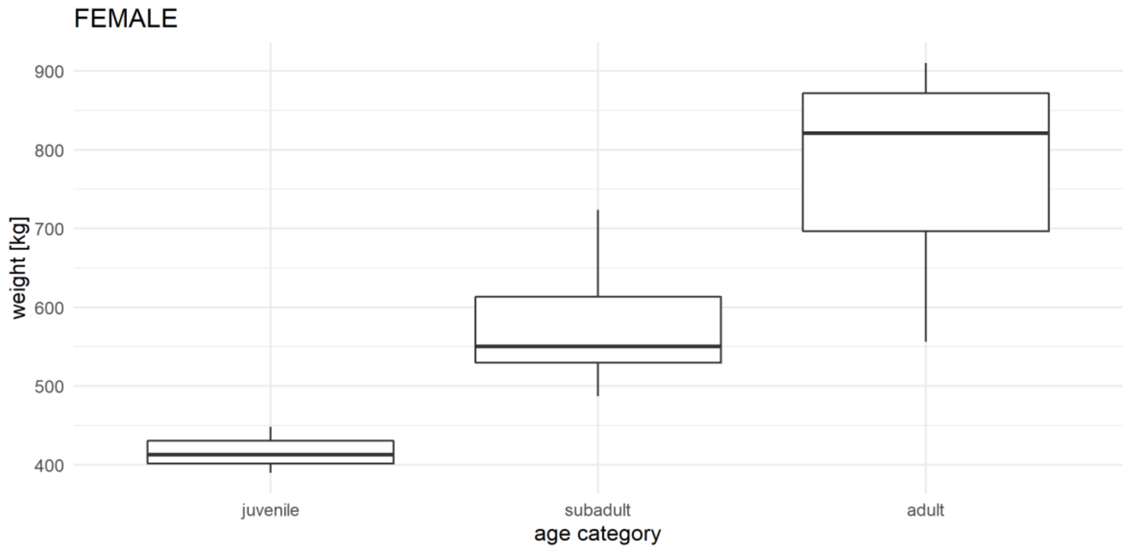


Figure 10: weight dependence on age category in females

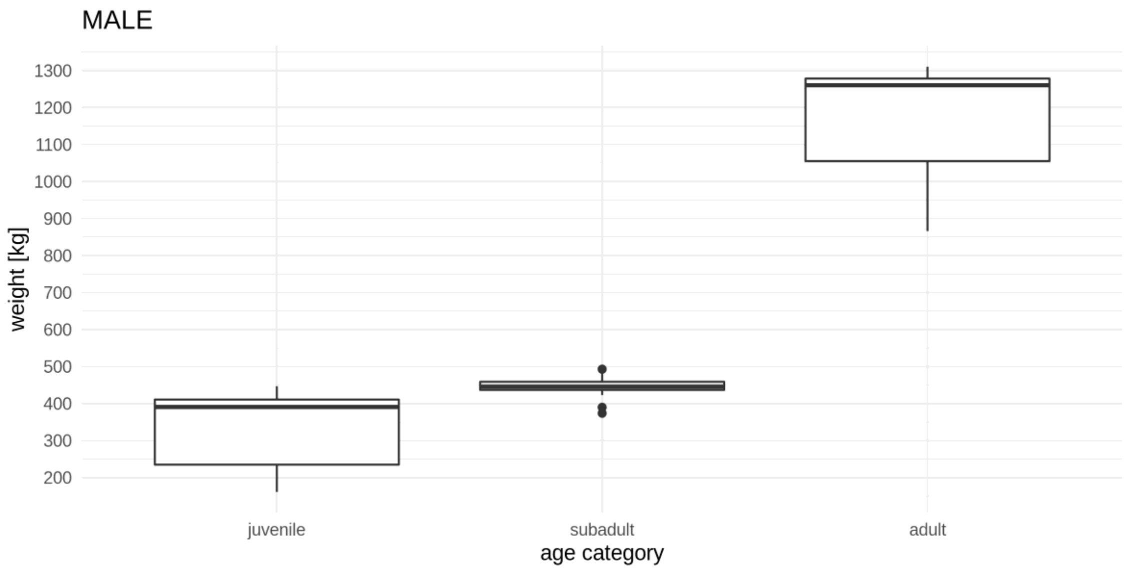


Figure 11: weight dependence on age category in males

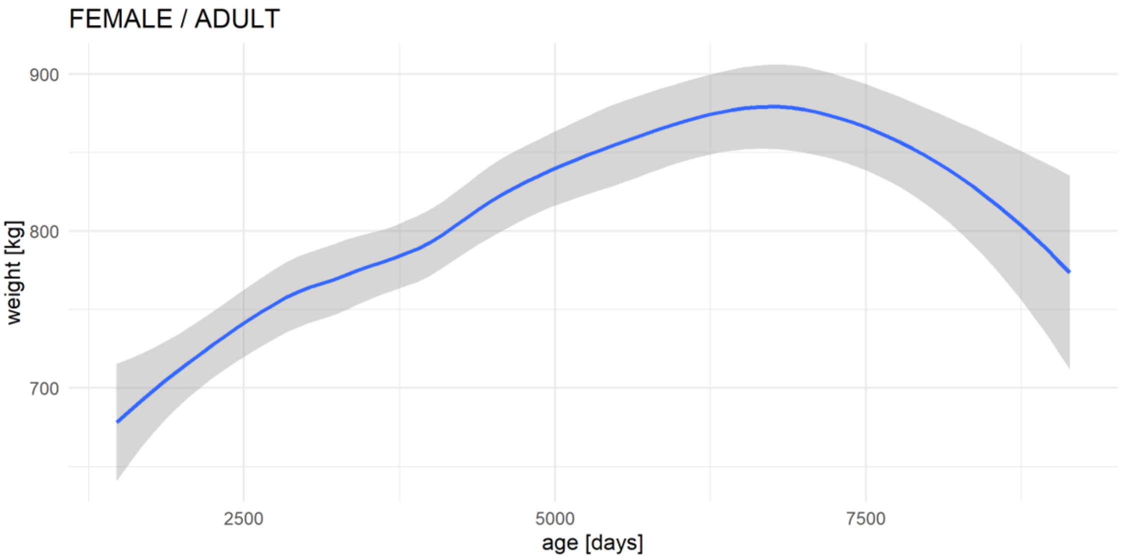


Figure 12: weight dependence on age in adult females

5.1.1.2. Height

Height factor was in relation to weight significant in females (P= <0.001; Figure 13) and in males (P= 0,001; Figure 14). Figures 13 and 14 show the height dependence of the weight in all males and females (all age categories). As the height increased, the individual's weight increased. Males reached higher height than females and up to 5.1 m. Mean height of adult females (n= 22) was 3.9 ± 0.02 m (n=146) and of adult males (n=4) was 4.8 ± 0.04 m (n=20). But mean height of all females (n= 26) was 3.9 ± 0.02 m (n=181) and of all males (n= 9) was 3.8 ± 0.14 m (n=40).

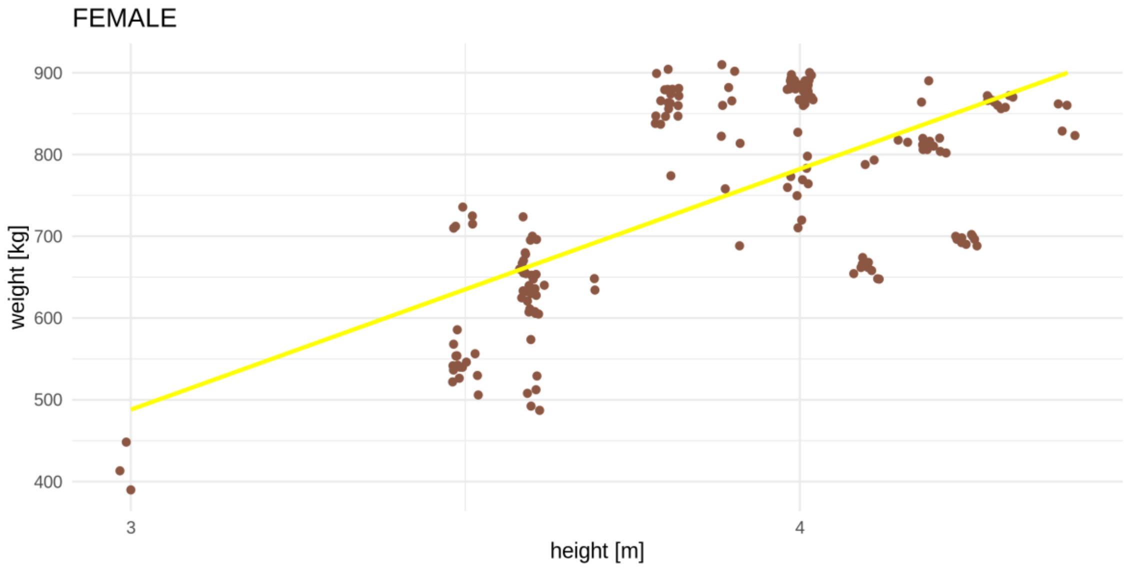


Figure 13: weight dependence on height in females

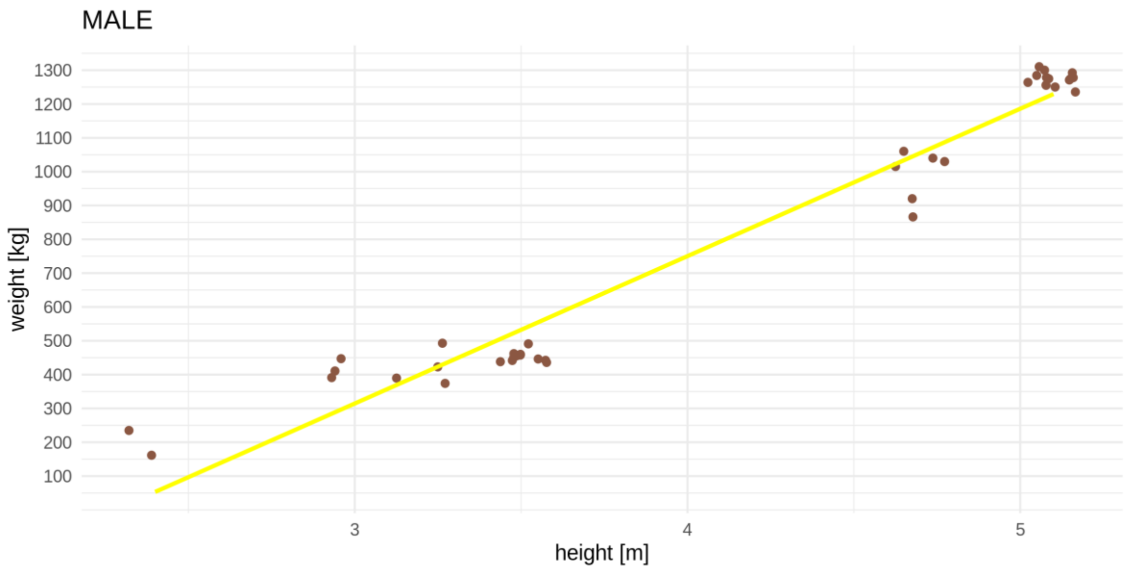


Figure 14: weight dependence on height in males

5.1.1.3. Taxon

Taxon factor was in relation to weight significant in females (P= <0.001) and in males (P= <0.001). In females and also in males, Rothschild's giraffe *(G.c rothschildi)* had the highest weight. Mean weight of hybrid males (n=2) was 969 ± 45.65 kg (n=4). Mean weight of females Rothschild's giraffe (n= 20) was 746 ± 10 kg (n=171) (adult females (n=16) 791 ± 8.11 kg (n=136)) and of males (n= 6) 791 ± 72.35 kg (n=35). Mean weight of females (all adult) Reticulated giraffe *(Giraffa reticulata)* (n= 6) was 762 ± 33.8 kg (n=10) and of males (subadult) (n= 1) 491 ± 0 kg (n=1).

5.1.1.4. Contraception

Weight was influenced by contraception in adult females (without pregnant females) (P=<0.001) Mean weight of adult females on contraception (n=4) was 715 ± 13.73 kg (n=19), mean age was 8.75 years. Adult females without contraception (n=18) was 802 ± 8.4 kg (n=127), mean age was 10.8 years. BCS of adult females was not influenced by contraception (P= 0.5).

5.1.1.5. Lactation

Lactating adult females (n=2) were significantly heavier 829 ± 17.34 kg (n=11) (P= 0.001) than non-lactating adult females (n=20) 768 ± 8.38 kg (n=135).

5.1.2. **Factors affecting BCS**

BCS was influenced by age category in all males and females (without pregnant females) and by height in all females, without pregnant females. And by parity and lactation in adult females. Mean BCS of juvenile females (n=1) was 6 ± 0 (n=3); subadult females (n=4) had 4.6 ± 0.09 (n=32) and adult females (n=22) had 4.5 ± 0.06 (n=146). Mean BCS of juvenile males (n=2) was 5.7 ± 0.2 (n=5); subadult males (n=3) had 4 ± 0.18 (n=15) and adult males (n=4) had 5.1 ± 0.24 (n=20).

5.1.2.1. Age category

Age category factor was in relation to BCS significant in females (P= <0.001; Figure 15) and in males (P= 0.001; Figure 16). Figure 16 is not shown by a Box Plot graph, due to the small amount of data in males. Juvenile females was in the best body condition (higher number-category 6) and kept it all the time. Also adult males reached the 6 category. While the condition of the subadult and adult has changed. The data obtained during the observation assumed that the condition of the subadult had an increasing trend. Figure 17 shows the weight dependence on age in adult females, where the condition in adults of high age has decreased rapidly. We reported this dependence only in females, for larger amounts of data.

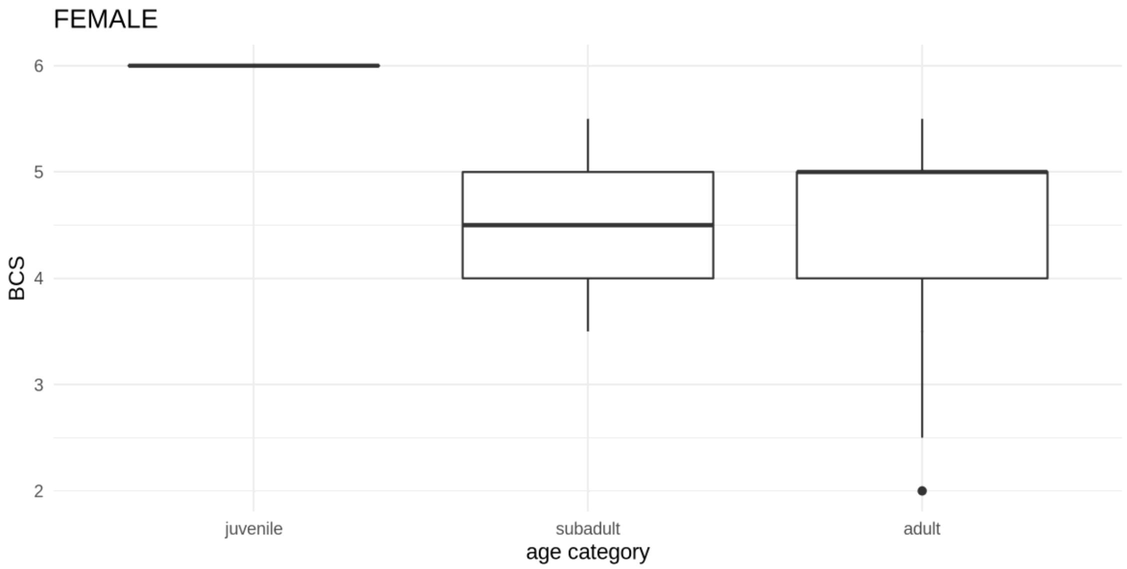


Figure 15: BCS dependence on age category in females

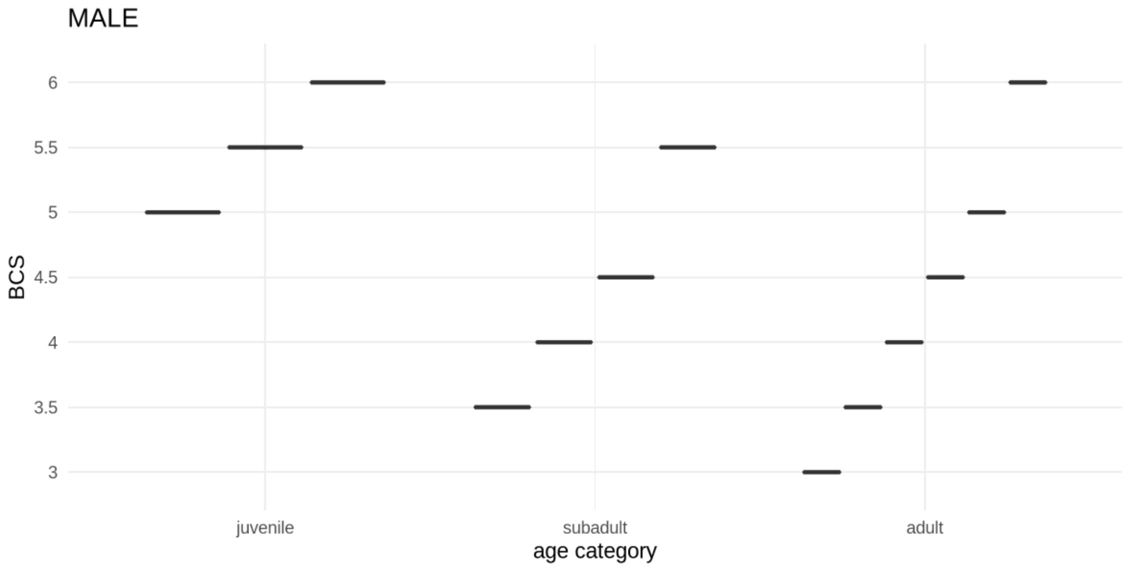


Figure 16: BCS dependence on age category in males

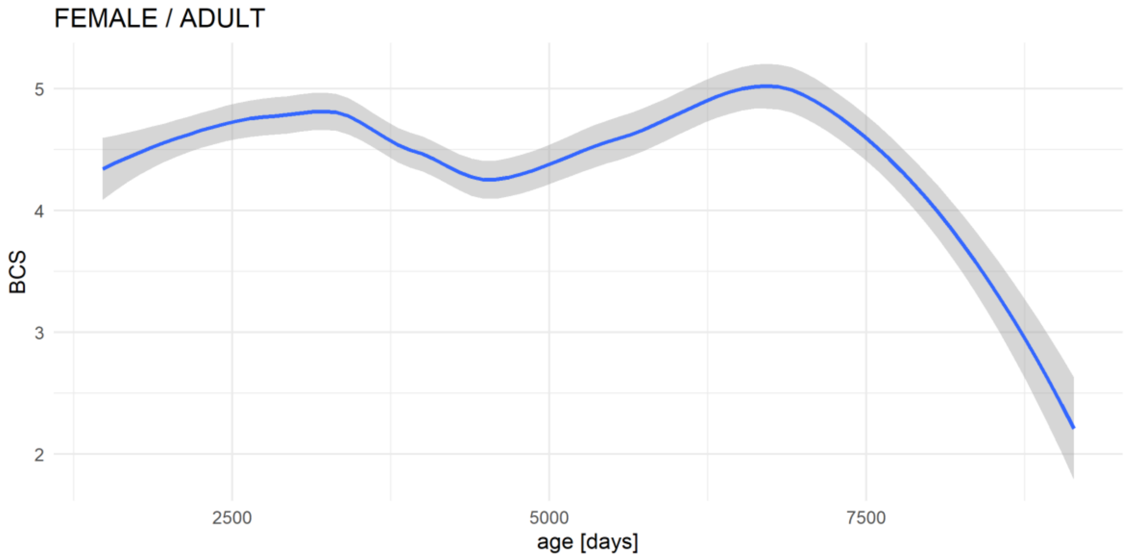


Figure 17: BCS dependence on age in adult females

5.1.2.2. Height

Height factor was in relation to BCS significant in females (P= <0.001) and nearly significant in males (P= 0.05).

5.1.2.3. Parity

Parity (number of offspring) in adult females was in relation to BCS significant (P= 0.001) and nearly significant in relation to weight (P= 0.02). The observed females had the following parities: 0,1,2,3,5,6,9,11. Zero parity females (n=12) had mean BCS 4.7 ± 0.05 (n=70). Females with parity 0-6 had good condition in range (4-5.5). Females with 9 offspring and more began to lose body condition. Adult females with parity 9 and 11 (n=2) had mean BCS 2.7 ± 0.25 (n=8), poor condition.

5.1.2.4. Lactation

Lactation factor was in relation to BCS significant (P= <0.001). Lactating adult females had significantly worse BCS than non-lactating adult females. Mean BCS of lactating females (n=2) was 3.3 ± 0.26 (n=11) and of non-lactating (n=20) was 4.6 ± 0.06 (n=135).

5.1.3. **Pregnant females**

During the observation, only two females were pregnant. So, due to the small amount of data we could not use the GLM to analyze, these results have only a graphical representation. Figure 18 shows the dependence of weight on BCS in pregnant females, females in better condition (higher BCS point) had higher actual body weight. Figure 19 shows the dependence of BCS on month of gestation, specifically in these two females. With increasing stage of pregnancy, the BCS of females increased. Mean weight of pregnant females (n=2) was 908.18 ± 19.17 kg (n=17) and mean BCS was 4.3 ± 0.26 (n=17).

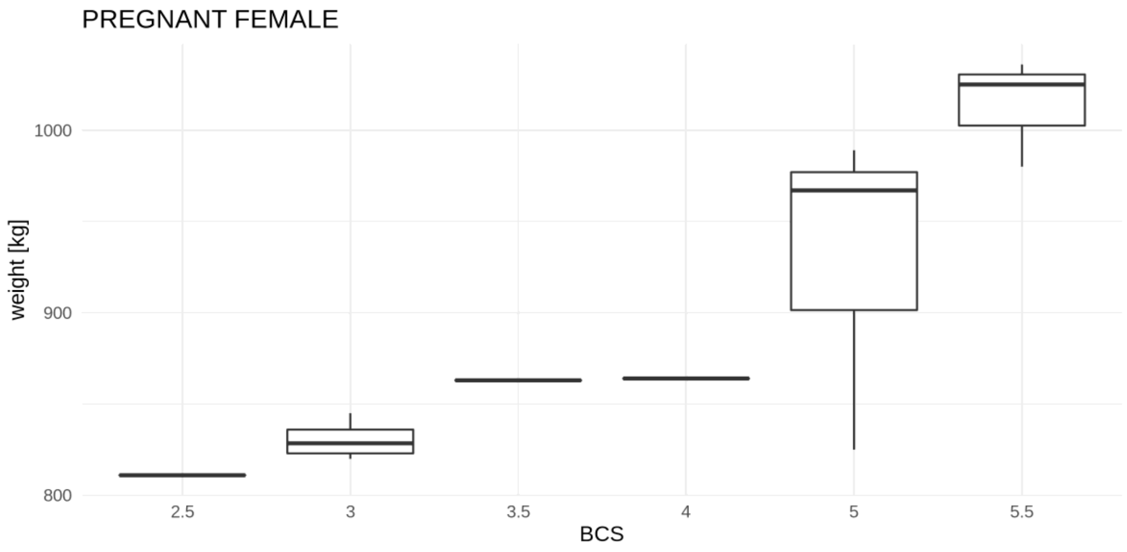


Figure 18: weight dependence on BCS in pregnant females

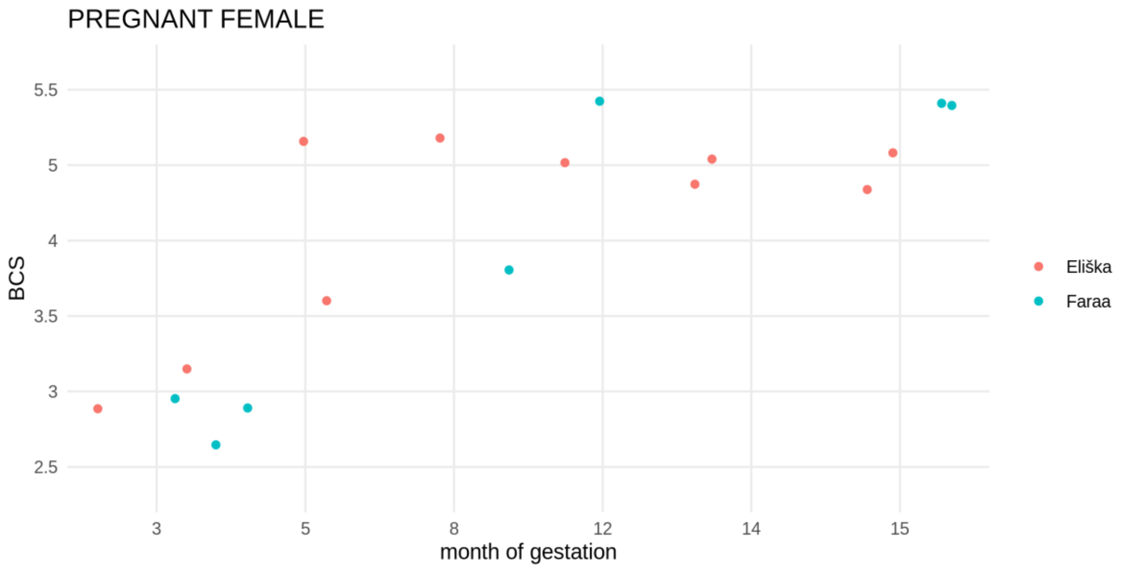


Figure 19: BCS dependence on month of gestation in pregnant females

5.1.4. **Condition indices**

Of the observed condition indices, only weight/height² (BMI) was significant in relation to BCS in males (P= < 0.001; Figure 20) and in females were significant all observed indices weight/height (Index 1) (P= < 0.001; Figure 21); weight/height² (BMI) (P= < 0.001; Figure 22); weight*height*age (Index 2) (P= < 0.001; Figure 23) and weight*height)/age (Index 3) (P= < 0.001; Figure 24). Table 5 shows the weights of males assigned to BCS categories based on BMI and Table 6 shows females.

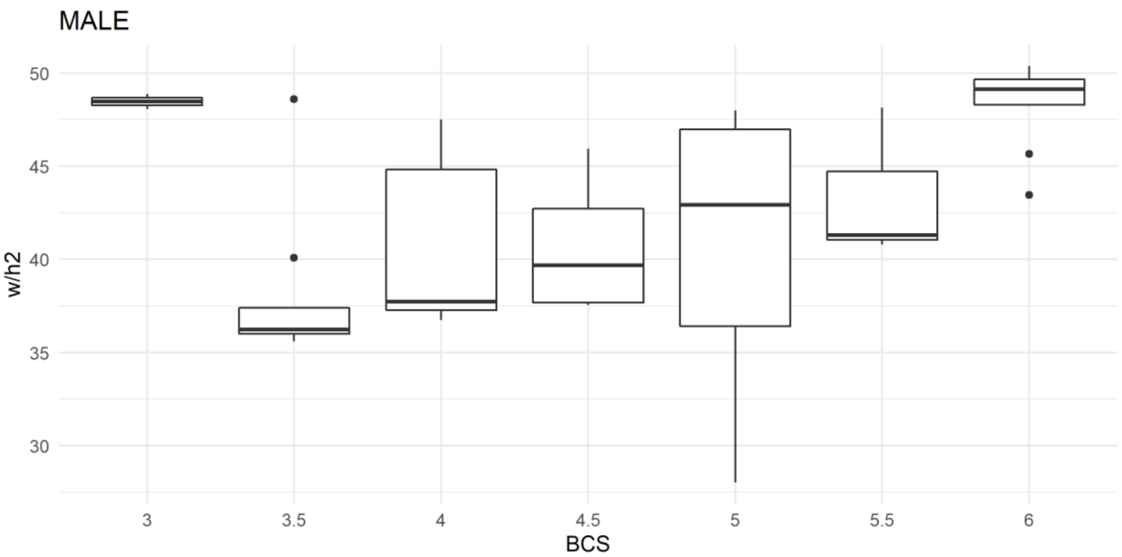


Figure 20: BMI dependence on BCS in males

Table 5: Back weight estimate based on BMI in males

BCS	height (m)	BMI	weight (kg)
3	5,1	48	1250
3,5	3,2-5,1	36-48 (ø42)	360-1250
4	3,2-5,1	37-47 (ø42)	370-1230
4,5	3,5-4,7	37-46 (ø41,5)	450-1000
5	2,4-4,7	28-47 (ø37,5)	160-1000
5,5	2,4-3,2	42-48 (ø45)	240-500
6	3-5,1	44-50 (ø47)	400-1300

(Source: by the author)

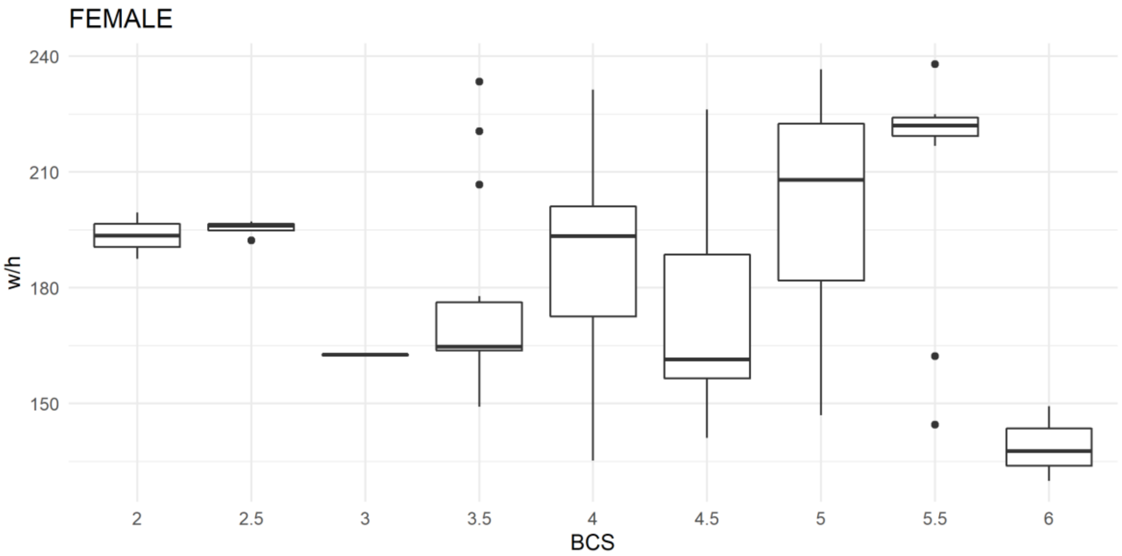


Figure 21: Index 1 dependence on BCS in females

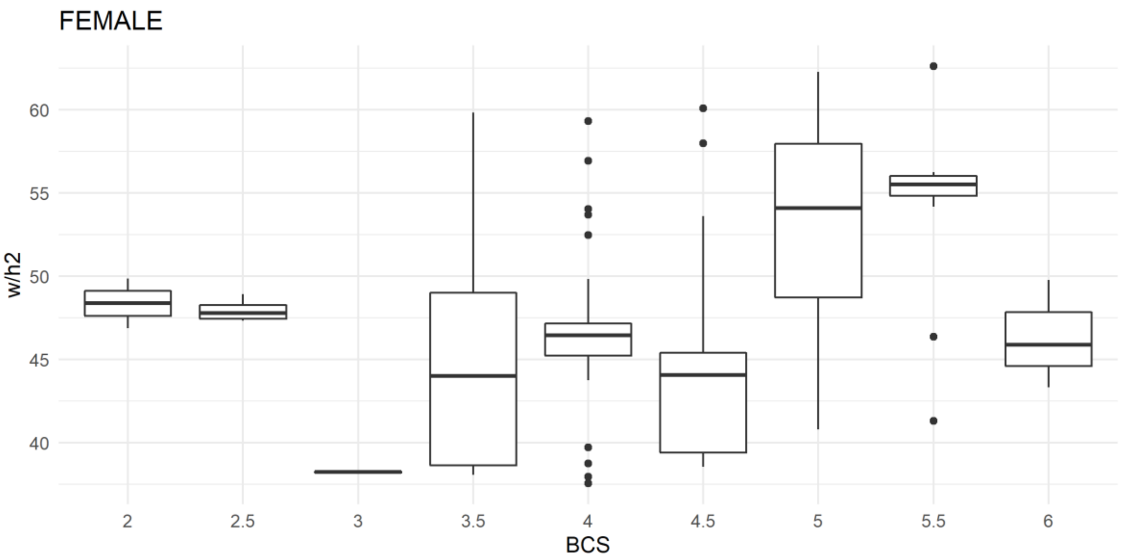


Figure 22: BMI dependence on BCS in females

Table 6: Back weight estimate based on BMI in females

BCS	height (m)	BMI	weight (kg)
2	4	47-50 (ø48,5)	750-800
2,5	4	47-48 (ø47,5)	750-770
3	4,25	38	690
3,5	3,5-4,25	38-60 (ø49)	460-1000

4	3,5-4,3	37-59 (ø48)	450-1050
4,5	3,5-4,4	39-60 (ø49,5)	480-1150
5	3,5-4,4	41-63 (ø52)	500-1200
5,5	3,5-4	42-63 (ø52,5)	510-1000
6	3	44-50 (ø47)	400-450

(Source: by the author)

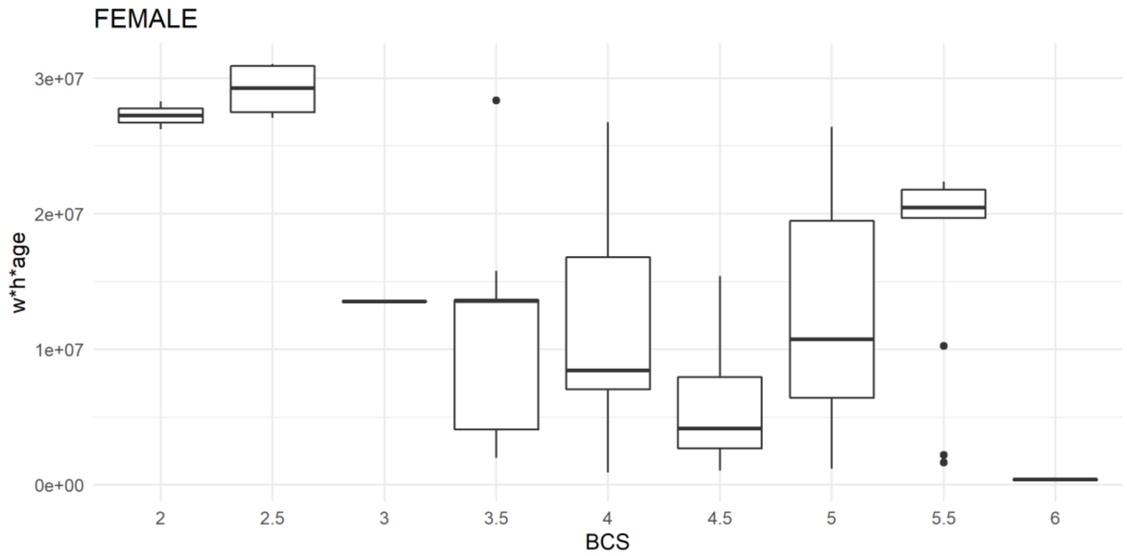


Figure 23: Index 2 dependence on BCS in females

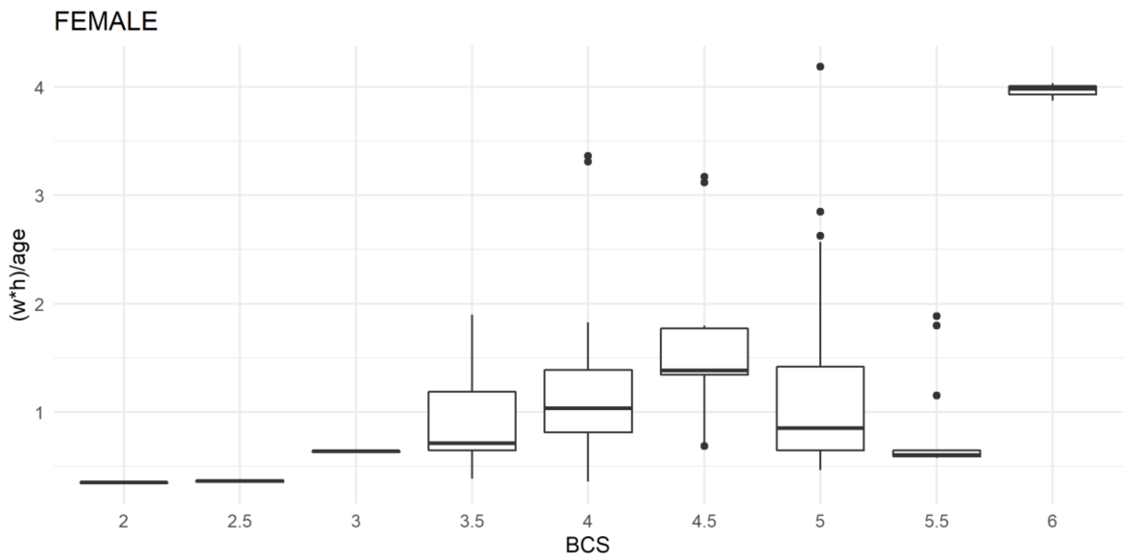


Figure 24: Index 3 dependence on BCS in females

6. Discussion

This thesis examined the influence of various factors affecting the weight and body condition and try to captured the relationship between weight and body condition in giraffe *(Giraffa camelopardalis)* in captivity using a suitable condition index. We assumed the influence of internal factors, such as the effect of sex and pregnancy in females that could affect weight and BCS. For this reason, we have divided the dataset into males and females and removed pregnant females.

As I mentioned before, we have separated males from females because giraffe are sexually dimorphic animals and that could effect the results. Generally, in dimorphic polygynous species, sexual dimorphism is characterized as a higher mass and postnatal growth rate in males compared to females (Lee & Moss 1986). Adult giraffe males are substantially taller and heavier than adult females. The average weight for males is about 1200 kg and reach up to 5.5 meters and for females 800 kg with 4.3 meters height (Bush 2003). Giraffe in captivity are often smaller due to unnatural living conditions, seldom over 5 meters tall (EAZA Giraffe EEPs 2006). In our study, the mean height of the adult males was 4.8 meters and 1188 kg and for adult females was 3.9 meters and 791 kg. The results showed that with increasing height the weight of both sexes increased, which could also be related to the influence of age on weight. But the weight began to decline, at an higher age (around 20 years) in adults.

Weight and BCS in females was also greatly influenced by pregnancy, therefore, we separated the pregnant females from the dataset with the rest of the females. del Castillo et al. (2005) states that, the average gestation period of giraffe is 446-457 days, whilst Lueders et al. (2009b) observed, that the Rothschild's pregnancies lasted for 470 days in captivity. In our study, two females were pregnant and their pregnancy lasted for 15 months (± 450 days). From the results came out that with increasing stage of pregnancy the body condition of females improves and at the same time the weight increased with better condition. It could be related to gaining fat and energy stores and preparing for parturition and subsequent care of calf. Due to the fact that females during the pregnancy gain fat (their belly grows), their condition is rated higher. Thus, in our study, both female condition improved.

The results showed that the weight and BCS were significantly dependent on age category. While weight increased with increasing age (only until a certain age in adulthood), BCS decreased. The mean weight of juvenile males was 329 kg and of females was 417 kg. In the subadult category, from 1 year to 4 years included, the mean weight of males was 444 kg and of females was 575 kg. The research included 3 juveniles (2 males and 1 female). The lower average weight in males was affected by the male Gerald, who weighed 161.5 kg in 6 months and 235 kg in 11 months. The weights of Nela and Matyas were similar. We can even notice that the male Matyas had almost the same weight at all measurements, on the same days as the female Nela and he is about 3 weeks younger. We cannot base any conclusions on this example because there were few individuals in the categories, but it could be related to several studies showing that mothers put more into male offspring and this will also be reflected in their weight at birth, the delivery of more milk at nursing or delayed weaning. These factors could lead to faster growth in the male (Lee & Moss 1986; Wolff 1988; Birgersson & Ekvall 1997; Landete-Castillejos et al. 2004). The growth rate may positively correlate with suckling rate in juveniles (Lavigueur & Barrette 1992), however these differences in maternal investment in case of nursing of calves have not been reported in giraffe (Gloneková et al. 2016). In subadult individuals, females were heavier than males, it could be influenced by the number of individuals and age at the time of weighing. There were 4 subadult females and 3 males included in research and females were predominantly older than males during weighing. In adults, males were heavier than females. Which is associated with sexual dimorphism. Weight had an increasing trend with increasing age in adult females (from 700 to 900 kg). But around the age of 20, it began to decline. Age category factor was in relation to BCS of individuals also significant. Mean BCS of juvenile females was 6; subadult females was 4.6 and adult females was 4.5. Mean BCS of juvenile males was 5.7; subadult males was 4 and adult males was 5.1. Juveniles were in the best body condition (category 6) and kept it all the time. This category is typical for giraffe under one and one and half year. Also adult males reached this category, probably because of the good muscling and visible thickening in the lower part of the neck. Calves were nursed throughout the observation period, which had a positive effect on its development, and thus BCS was higher and unchanged compared to subadult and adult individuals. Suckling of calves begins within an hour and continues for an approximately 9 months, but it can also last for 1.5-2 years (Dagg & Foster 1976; Langman 1977). Giraffe milk has more fat (13-17%), total protein (6%) and ash content, but less lactose than bovine milk, which is probably reflected in the rapid growth of the calves (Dagg 2014). The data obtained during the observation assumed that the condition of the subadult had an increasing trend. In adult females, the condition ranged from 4 to 5 (good condition) and around the age of 20 began to decline sharply and up to condition 2 (poor condition). Deteriorating condition at higher individual's age could be related to loss of muscle mass, decreased food intake or decreased physical activity or health problems. Longevity in giraffe in the wild has been recorded just over 20 years, while in captivity live longer, up to 25 years, with the exceptions (Dagg 2014). We could observe the deterioration and in these elderly individuals. Muscle loss was clearly visible in these individuals. Female Kleopatra, born in 1993, with body condition numbered 2.5. She had to be euthanized 6.2.2018 due to her high age and worsening health. Male Johan, born in 1999, his condition deteriorated from 6 to 3 in two years (2018-2020). In addition, female Eliska, born in 1995, had a worse body condition (2-2.5). Her age has contributed to her condition deterioration, but also because she was just after parturition and at the time of lactation.

Lactation is the most energy intensive part of the reproductive cycle. The energy received from food is inserted into milk production (McNeilly 1994; Tucker 1994). Females produced between 2.5 and 10 litres of milk daily (Dagg 2014). Thus, lactation also significantly affects body condition and weight of adult females. The results confirmed that lactation is a very energy intensive period, BCS of lactating females was worse than non-lactating females. While the weight of lactating females was on average higher than non-lactating females. Higher weight of lactating females could be caused by weight gain during pregnancy.

Taxon (a subspecies of giraffe) influenced the weight of individuals. From the obtained data we found out that Rothschild’s giraffe reach higher weight than Reticulated giraffe. When I focus only on females with more measurements, the mean weight was higher in Reticulated giraffe, but because there were only adult females and younger individuals in Rothschild’s giraffe. When I filtered out young individuals and averaged ones the weight only for adult females, Rothschild’s were heavier (mean weight 791 kg) than Reticulated giraffe (mean weight 762 kg). There are not many scientific articles about the differences in weights between giraffe species. But the study

I have already mentioned focuses on this issue and states that. All subspecies have similar standards but there are different variations as the Reticulated giraffe are usually much smaller than Rothschild’s. Gloneková et al. (2016) assumes that Rothschild's may be heavier than other subspecies. This was confirmed by the fact that all published weight data came from other subspecies. And it can also be confirmed in terms of researching the morphology of giraffe by Groves and Grubb (2011). They noticed the difference in skull between the larger Northern and smaller Southern giraffe taxa. They found that Rothschild giraffe which belongs to Northern taxa had a larger skull dimension than other taxa.

Nowadays it is hard to deal with the growing number of giraffe in captivity. Therefore, some zoological gardens keep males separately from females or they can use a different types of contraceptives. Because, they have space limitations that sometimes require the use of contraception to reduce reproductive rate of animals and also to prevent inbreeding in captive herd (Patton et al. 2007). In this study some individuals (only females) were on contraception. The results showed that contraception affected the weight of females. At the time of measurement, 5 females were on contraception, 1 of them was subadult. The reason was breeding regulation controlled by European Endangered Species Programmes (EEP). For better results we compared weights in adult females. Mean weight of adult females on contraceptives (n=4) was 715 kg and of adult females without contraception (n=18) was 802 kg. In one female the Improvac injection was used as a contraceptive. It turned out that in our research, adult females without contraception mean weighed more than adult females on contraception. This may have been influenced by the number of the observed animals and also by age, as contraceptive females were on average younger than non-contraceptive females. The use of contraception did not affect the body condition of the females.

Parity (number of offspring) was significant in body condition of adult females. Due to the influence of young females without calves, we filtered out the juvenile and subadult females and compared parity with the weight only in adult females. It turned out that the BCS of females with different numbers of calves was very variable. Nevertheless the adult females with zero parity had mean BCS 4.7. Giraffe females come into oestrus for the first time in their three years and nine months old, their cycle is repeated until they become pregnant. Females mate with males only during the oestrus (Bercovitch & Berry 2013). Female can return to oestrus in three weeks after giving birth. So in theory, a female giraffe can bear 10 calves for her life if she gives birth every 18 months (Leuthold & Leuthold 1978b). In the study, we also had a female with 11 calves. In human care, where the giraffe are under medical supervision and they are not in danger, for example, from predators. So they can have more calves. From the results we can see that the females with parity 9-11 started to lose body condition. BCS could be also influenced by higher age of females.

We also tested the influence of external factors on BCS and weight, in this case the season, which proved inconclusive. Which meant that the changing seasons of the year had no effect on the weight and condition of the individuals, which could be related to the feeding ration or housing as well. Our result was in contrary to Gloneková et al. (2016), where they showed the weight dependence on the season in adults. In our study, in summer months, giraffe had access to outdoor enclosures, which they often shared with other animal species and were housed in indoor pavilions to meet their needs in winter. Which is also related to their feeding ration, which was properly adapted to their needs and movement throughout the year, so that the giraffe do not suffer from malnutrition or fatten. Giraffe is one of the most difficult species in the breed in terms of nutrition (EAZA Giraffe EEPs 2006). Giraffe have special dietary needs, they eat 99 % of browse in the wild, but this diet is impossible to offer in zoos, primarily in winter months. Nowadays, they must be fed a suitable diet that meets their energy requirements (Valdes & Schlegel 2012; Dagg 2014). Likewise, a giraffe without enough alfalfa, browse or bushes to consume can show oral disorders in an effort to fill their time that is not filled with foraging and proper feeding. Browse, as an enrichment of time, prolongs the time of foraging and increases the production of saliva. Higher occurrences of routine, stereotypical activity can contribute to a reduction in body condition and can therefore be particularly detrimental to individual giraffe already suffering due to nutritional deficiencies (Rose 2013). Although the provision of fresh browse in captive facilities during the winter months is logistically difficult (Nijboer et al. 2003). Some zoos are able to produce and store browse silage, as a substitute for fresh wild diet, in the winter months (Prettejohn 2008). Ideally, the giraffe should have the same diet as in the wild (Schmidt et al. 2009). As a substitute browse can be silage of willow and other plants, especially in colder weather when they have higher energy requirements (Dagg 2014). We can therefore conclude that the observed individuals had the right feed rations that suited their energetic requierements during the year. The feed composition was almost the same for most of the zoos for most of the year. The summer feed mainly consisted of dried alfalfa and fresh browse as branches (of fruit trees or willow) ad libitum and then with limited amount of green alfalfa and granulate for browsers, fresh fodder, such as apples, carrots, leafy vegetables and mash containing bran, linseed and oatmeal. In the winter, giraffe are fed mainly with the granules for browsers (Boskos, Kasper), alfalfa hay, haylage and branches (for example willow, dried oak and fir tree as enrichement) and supplements. The green alfalfa was replaced by alfalfa hay during the winter months.

Finally, we analyzed the relationship between weight and BCS in giraffe. The assumption was that animals in better condition are predicted to have greater energy stores (usually fat) than animals in poorer condition (Dobson 1992; Schulte-Hostedde et al. 2001). This means that the animals in better condition (higher numbers) had a higher body weight. However, as predicted that, this relationship is not so simple and is influenced by other factors, such as the height or age of the individual. Only in pregnant females in this study it was shown that the BCS of individuals also increased with increasing weight during pregnancy. BCS dependence on weight was significant in all individuals. During our observation, females in the best condition were in categories from 4 to 5.5, weighed ranched between 700 kg and 900 kg, which is the optimal weight in adult females. On the other hand, we can notice that the females in category 6 had a noticeable mean weight 417 kg. Females in categories 2 to 2.5 (poor condition) had mean weight 789 kg. These females therefore had the highest mean weights. From the results we can note that it does not apply and with increasing body weight does not necessarily increase the body condition (higher number) of animals. In our study, the best-condition females had the lowest weights and the worst-condition females had the highest weights. And from the previous results we can conclude that the weight and BCS of animals depend on many factors. In this case, we proved the influence of the individual's age, height but also for example lactation. Whereas nursed juveniles were in category 6, with the lowest weight. Elderly females were in categories 2-2.5 and one of them was in a period of lactation, which is very energy demanding.

As the relationship between weight and BCS has been shown to be more complex and dependent on several factors. It was important first to understand these factors, how they affect weight and BCS in captive giraffe. So then we could try to create a suitable condition index that captures this relationship.

We used the observed factors to create an suitable condition index, those that affected weight the most, namely the sex, age and height of the individual. With increasing age and height, the weight of individuals also increased. But the relationship of weight with BCS is not so linear, but it changes. Thus, it is not true that the higher the weight, the higher the BCS category (more fat/muscle). Since juveniles (up to one year old) usually have the best BCS (6), good musculature and with increasing age BCS deteriorates. Thus, age has a great influence on physical condition. Therefore, we used factors such as weight, height and age to create suitable condition indices. We used ratio condition indices that usually correlated with body size. This fact affects (reduces) the value of these indices when the conditions of animals of different sizes are compared (Jakob et al. 1996; Hayes & Shonkwiler 2001). Of all tested indices, BMI (ratio of body mass divided by body length) proved to be the most significant in relation to BCS in both males and females. We tested the males and females separately, as we assumed the effect of sex on weight because the amount of body fat differs between males and females. In our study, when we retrospectively estimate the weight from the BMI for the BCS categories, the weights had a large range and intermingled in the categories. It follows that while BMI can detect the relationship between weight and BCS in giraffe, but it is not applicable in practice for retrospective weight estimation in giraffe. We should also take into account that each giraffe has a different body type, some are stocky, others more athletic. They may have the same height and similar weight, but BCS may vary. BMI is widely used and it is a good indicator of variability in energy reserves in humans because it is easy to take the height and weight of an individual (WHO 1995; Lewis 2013). Even so, that BMI does not distinguish between muscle and fat (WHO 1995) and where the fat is stored in the body. BMI also fails because it does not take into account differences in race, gender and age. In such cases, it would also be appropriate to record other data, for example anthropometric data (% fat, skin folds) (Kolimechkov 2014). While the morphometric condition indices are very popular in determining condition in animals, because they are easily counted from variables, such as mass and body length, that are simple and inexpensive to measure (Labocha et al. 2014) but from the acquired knowledge we can deduce that the relationship between weight and BCS is more complex and it would be appropriate to use residual indices for practical use, to back-test the weight from the appropriate condition index to the relevant BCS category.

7. Conclusions

The aim of this thesis was to find out the relationship between BCS and real weight of the giraffe *(Giraffa camelopardalis)* in captivity and to record changes that affect it. This relationship was recorded based on appropriate condition indices. These indices were created from the various factors that most affected the weight, but also the body condition of the giraffe. Weight was influenced by age category, height and taxon in all individuals (males and females) and contraception and lactation in adult females. BCS was influenced by age category in all individuals (males and females) and by height in females only and parity and lactation in adult females. The most significant factors were sex, height and age. Of all tested indices, BMI (ratio of body mass divided by body length) proved to be the most significant in relation to BCS in both males and females. When using this condition index, these factors need to be taken into account. We have found that the relationship between weight and BCS is more complex. The juveniles with the lowest weight and height had the best body condition. The weight and height increased with increasing age, but this increasing weight trend stopped and began to decline at a certain age (around 20 years) in adults. Body condition deteriorated with increasing age. The results of this study could contribute to improving the quality of life of giraffe in captivity. The weight of the giraffe does not have to correspond to actual body condition, the animal's body condition can deteriorate without losing weight (see lactating females). These results might help keepers to recognize the visible changes in an animal’s body. Zoos that regularly weigh their giraffe should also do BCS regularly, as the weight itself does not indicate the body condition of the animal. Even those zoos that do not weigh their giraffe can use a condition index (BMI) to estimate weight, knowing the height and BCS of an individual.

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Appendices

List of the Appendices:

Appendix 1: Leaflet of project "Weight and Body condition relationship in captive giraffe"

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Weight and body condition relationship in captive giraffe

Description and aims: Data from weighing of giraffe are available in only a handful of zoos as regular weighing of giraffes is time, effort and equipment demanding. On the other hand, body condition score (BCS) can be obtained easily in each institution holding giraffe if an appropriate method is used. We use the BCS system presented in EAZA husbandry and management guidelines for *Giraffa camelopardalis* (EAZA Giraffe EEPs, 2006). By comparing the real weight data and BCS of giraffe we aim to better understand the fluctuations of giraffe weights and to test the reliability of BCS use to monitor changes in giraffe condition. As a further step we will analyse factors influencing the weight and/or condition of giraffe in zoos.

Methodology: We are currently using a long-term dataset of weight records form Prague Zoo (Gloneková et al. 2016, Zoo Biology) extended by current weight records from as much EAZA and AZA zoos as possible. We will directly or indirectly assess the BCS of giraffes from which the weigh records are actually obtained and will test how the weight fluctuations, both sudden and gradual, are reflected in BCS.

Your Profit: Our study will improve the reliability of BCS in giraffe which is or can be routinely used in all giraffe keeping facilities, enabling the fast assessment of the giraffe condition. Our results will clarify the most likely explanations of the BCS fluctuations, ultimately leading to improvement of giraffe husbandry in zoos. All participating institutions will receive the full processed output and final results and will be acknowledged in all publications and presentations related to this project.

Join us! Do you weigh giraffes in your zoo? Do you have weight records available? Contact us and join the project!

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Appendix 2: Article about our project in Dutch newspaper

Giraffen wekelijks op de weegschaal

Dierenpark Wildlands zet als een van de weinige Europese dierentuinen op regelmatige basis haar giraffen op de weegschaal.

FRANK JEURING

Barbora Zilkova en Vincent van Dalen wegen giraffe Hidaya. FOTO BOUDEWIJN BENTING

Het lijkt allemaal zo soepel te gaan. Na wat bemoedigende woordjes van dierverzorger Vincent van Dalen (41) koerst giraffe Hidaya richting de weegschaal in het binnenverblijf van de dieren. Wat gerammel met een bak voer geeft het laatste zetje en kordaat plaatst ze haar vier lange poten op het stalen weeginstrument. Ze steekt haar hoofd door de opening in de tralies richting de gevulde hand van de dierverzorger: smak-smak. Haar gewicht wordt genoteerd. Missie geslaagd. Of het altijd zo makkelijk gaat? „Nou, ik heb wel de dapperste giraffe uitgekozen omdat er nu andere mensen bij zijn", verklapt Van Dalen.

Het wegen van een giraffe is volgens de dierverzorger een crime gelet op de aard van de dieren. Ze zijn eenkennig en schrikken bij het minste of geringste. „Het is zelfs zo erg dat als er een snoeppapiertje in de gang van het binnenverblijf ligt, ze het hok al niet meer binnenkomen." Toch besloot Van Dalen enkele jaren geleden dat hij de Emmer langnekken wilde trainen om plaats te nemen op de weegschaal. En dat ging makkelijker dan hij vooraf had gedacht. Na twee dagen oefenen had hij de eerste al zover.

Volgens Van Dalen is het belangrijk om het gewicht van de dieren bij te houden. „Vroeger wogen we ze eigenlijk alleen als ze op transport gingen of als een giraffe was overleden", vertelt hij. Terwijl een exacte meting van het gewicht volgens hem juist van levensbelang kan zijn. „Hierdoor zien we direct wanneer een dier afvalt, wat een teken kan zijn van ziekte of dat een giraffe in de kudde wordt verdrongen. Daarnaast kunnen we veel exacter doseren met medicijnen. Vooral als een giraffe onder narcose moet, is het van belang dat dit zo kort mogelijk duurt. Gelet op hun lange nek hebben deze dieren een aangepaste bloedsomloop om bloed bij hun hersenen te krijgen. Als ze plat liggen, dan wordt dat tegengewerkt."

Toch wegen volgens Van Dalen weinig andere Europese dierentuinen hun giraffen op regelmatige basis, omdat het veel tijd en moeite kost en je een geschikte weegschaal in huis moet hebben. Emmen doet dit al wel enige tijd. Het is ook direct de reden dat de Tsjechische Barbora Zilkova (24) bij Wildlands is terechtgekomen. De student van University of Life Sciences in Praag doet voor haar scriptie al twee jaar lang onderzoek naar de dieren en loopt nu twee maanden mee in de Emmer zoo.

Ze houdt over langere tijd het gewicht van de giraffen bij, beoordeelt aan de hand van een puntensysteem hoe ze er lichamelijk voorstaan en analyseert wat effect heeft op hun gezondheid. „Ik onderzoek wat de invloed is van factoren als problemen met de hoeven, een zwangerschap of juist het gebruik van anticonceptie op het dier. Als een giraffe borstvoeding geeft aan haar kalf, dan kan dat bijvoorbeeld een nadelig effect hebben op haar eigen gezondheid", vertelt Zilkova. „Met mijn thesis wil ik dierenparken betrouwbaarder inzicht geven hoe gezond hun giraffen zijn, waar gewichtstoename of -verlies door wordt veroorzaakt en ook wat de parken kunnen doen om hun gezondheid te verbeteren. Eigenlijk hoop ik dat dit een soort handboek wordt."

Bij Hidaya noteert Zilkova 860 kilo. Of dat goed is? „Ja hoor, ze verkeert in goede gezondheid, net als alle andere dieren hier." Na Hidaya meldt al snel de tweede giraffe zich voor een weegbeurt. Inmiddels heeft Van Dalen de langnekken zo goed getraind dat hij ze alle zes binnen een kwartier kan wegen. Daarom werkt hij inmiddels aan een nieuw doel. Hij traint de dieren nu om ze bij bewustzijn hun hoeven te vijlen. „Dat is een van de meest voorkomende ingrepen, waarvoor ze nu nog onder narcose moeten worden gebracht. Gelet op die risico's willen we dat zoveel mogelijk voorkomen."