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Body Condition Score of Big Cats

Master Thesis

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Declaration

I hereby declare that this thesis entitled “Body Condition Score of Big Cats” is my own work and all the sources have been quoted and acknowledged by means of complete references.

Acknowledgement

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Body Condition Score of Big Cats

Abstract

Body Condition Score is a non-invasive method of estimation of the level of the muscle and fat cover of animal's body.

The objective of this thesis was to develop a BCS system for selected species of felines, Tiger (*Panthera tigris* Linnaeus, 1758) and Lion (*Panthera leo* Linnaeus, 1758) and to test its reliability and versatility.

Identification of the features to be assessed was based on sets of digital pictures (n = 100 per category) of tigers, lions and lionesses and BCS Cards for visual assessment containing the illustrative drawings and descriptions were created.

Testing of the Inter-Observer Reliability of BCS Cards was carried out from February 2016 to April 2016 at 7 breeding institutions, total number of 15 adult tigers and 14 lions was included into the testing and total number of 38 observers with different initial experience with BCS participated. Data were treated by Kappa statistics and Kendall's coefficients. The values reached were showing variability in the absolute agreement among observers (Kappa 0.25-0.75, $p < 0.01$), but moderate to strong association among observers' assessments (Kendall's coefficient 0.63-0.97, $p < 0.1$) and between the individual observer's assessments and institutional MBCS (Kendall's coefficient 0.60-1.0, $p \leq 0.01$).

For the testing of the Intra-Observer Reliability two observers were assessing sets of digital pictures (n = 10 per category) repeatedly, three times in three months with randomised order of the pictures to be assessed. Fleiss' Kappa and Kendall's Coefficient of Concordance were used for data treatment and were showing moderate to high agreement (0.59-0.84, $p < 0.01$) and strong association (0.85-0.98, $p < 0.01$) among the scores given by each observer.

Even though there appeared variability in the level of agreement among observers, regarding the fact that the most of them were naïve to practical application of BCS and had various theoretic background, the results reached did confirm the reliability of the BCS Cards, as well as the comparison with studies of other authors with similar objectives.

Keywords

Panthera tigris, *Panthera leo*, BCS, Inter-Observer Reliability, Intra-Observer Reliability

Body Condition Score u velkých kočkovitých šelem

Abstrakt

Body Condition Score je neinvazivní metoda posuzování množství svalové a tukové tkáně uložené na těle zvířete.

Cílem této práce bylo vytvořit BCS systém pro vybrané druhy kočkovitých šelem, tygra (*Panthera tigris* Linnaeus, 1758) a lva (*Panthera leo* Linnaeus, 1758) a otestovat jeho spolehlivost a univerzálnost.

K výběru posuzovaných znaků byly využity sestavy digitálních snímků (n = 100 pro každou kategorii) dospělých tygrů, lvů a lvic. Vytvořené BCS karty byly určené k vizuálnímu posouzení kondice zvířat a obsahovaly ilustrativní kresby a popisy posuzovaných znaků.

Testování shody mezi hodnotiteli probíhalo od února 2016 do dubna 2016 v 7 chovatelských zařízeních na 15 dospělých tygrech a 14 lvech a zúčastnilo se ho celkem 38 posuzovatelů s rozdílnou počáteční zkušeností s BCS. Ke zpracování dat byly využity Kappa statistiky a Kendallovy koeficienty. Výsledné hodnoty ukazovaly variabilitu v míře absolutní shody mezi posuzovateli (Kappa 0.25-0.75, $p < 0.01$), ale střední až vysokou úroveň provázanosti jejich hodnocení (Kendallův koeficient 0.63-0.97, $p < 0.1$) a také hodnocení jednotlivých posuzovatelů a MBCS (Kendallův koeficient 0.60-1.00, $p \leq 0.1$).

Pro testování konzistentnosti hodnocení byly dvěma posuzovateli opakovaně, třikrát v průběhu tří měsíců, hodnoceny sestavy digitálních snímků (n = 10 pro každou kategorii). Ke zpracování dat bylo využito Fleissovo Kappa a Kendallův koeficient shody. Výsledné hodnoty ukazovaly střední až vysokou míru shody (0.59-0.84, $p < 0.01$) a vysokou míru provázanosti (0.85-0.98, $p < 0.01$) mezi jednotlivými hodnoceními obou posuzovatelů.

I přes variabilitu v míře shody mezi posuzovateli, s ohledem na skutečnost, že většina z nich neměla žádné praktické zkušenosti s BCS a jednotliví posuzovatelé se lišili mírou teoretických znalostí, získané výsledky potvrdily spolehlivost vytvořených BCS karet a byly ve shodě s hodnotami uváděnými jinými autory, kteří se zabývali obdobnou problematikou.

Klíčová slova

Panthera tigris, *Panthera leo*, BCS, shoda mezi posuzovateli, konzistentnost hodnocení

Contents

List of Charts and Graphs

1. What is Body Condition Score?

The exact definition and understanding of the concept of Body Condition Score varies depending on the category of animals and concrete purpose why the scoring is carried out. In production or laboratory breeding the aim of the scoring is to identify the ideal individual or ideal condition and maintain this stage, to avoid food wasting or health problems associated with the breeding technology and therefore the BCS is understood as a tool for identification of such problems. Ferguson et al. (1994) defined BCS as a tool to assess the body fat stores, Boudreau et al. (2014) even as a measure of a level of the fatness.

In breeding of companion animals or exotic animals the emphasis is either also on identification of the ideal individual, for either health or welfare purposes (Reuter and Adcock, 1998; Dierenfeld et al., 2007; Clauss et al., 2009), or the BCS is understood as an objective parameter of animal individual's appearance (Reppert et al., 2011; AZA Lion Species Survival Plan, 2012; Morfeld et al., 2014).

In the field studies BCS is often included among the indices of body condition besides the body mass, kidney fat index or bone marrow fat index and put in a relationship with reproductive parameters or behaviour patterns (Gaidet and Gaillard, 2008; Lane et al. 2014, Giles et al., 2015).

In this thesis Body Condition Score is understood as non-invasive method of estimation of the level of the muscle and fat cover of animal's body based on body shape, outline or silhouette and the prominence of bones and jaws.

1.1. Body Condition Score System

1.1.1. Systems establishment

Evaluation of animal's condition dependent on experience and talent of observer could not bring information reliable enough to be accepted as an exact, so the BCS itself is from its development considered to be of subjective nature (Russel et al. 1969; Ferguson et al., 1994; Clingerman and Summers, 2012). Need for generalizing ability to recognize changes in animal's condition and for increasing of BCS reliability makes sophisticated systems start to appear.

Ideal BCS system should be simple, repeatable and easy to accept for people who would use it (Ferguson et al., 1994; Brooks et al., 2014) together with taking into account additional factors as the animal's body weight, frame size, pregnancy and lactation, seasonal changes or general health (Van den Houten and Fidget., 2011).
Existing BCS systems deal with these requirements variously, they do differ in techniques how to determine animal's condition, in number of scale's grades and their presentation and in body areas chosen for condition changes recognition.

1.1.2. Body areas and their examination

Selection of body regions important for score estimation depends on species of interest, but generally the most suitable areas are forequarters (neck and shoulders), back and withers (thoracic and lumbar vertebrae), ribs and flanks, abdominal area and hindquarters (pelvic region), ness of ilium and ischium and a tail head (Bray and Edwards, 2001). BCS systems work with multiple body regions or only with one significant. Changes on these selected areas can be examined visually or by palpation (or as combination of both possibilities).

The very first BCS system was developed in UK as a tool for identifying of condition of sheep in fleece and it was based on palpation of the last dorsal and first lumbar vertebrae and the issues surrounding them examining the amount of the fat cover and thickness of the *musculus longissimus dorsi* (Russel et al., 1969).
According to the widely used and modified BCS system for dairy cattle presented by Wildman et al. (1982) animals are scored on the basis of appearance and palpation of back and hind quarters only.
Body Condition Score system for horses designed by Henneke et al. (1983) uses combination of palpation and observation of six body regions, tail head, down back, ribs and area behind the shoulder, along the withers and along the neck.
System used for estimation of body condition of wild American Black Bears (*Ursus americanus* Pallas, 1780) is based on palpating prominence of bones at five body regions, front of shoulder at the junction of the *humerus* and *scapula*, backbone midway between shoulder and rump, ribs halfway down right under the area of palpation of the backbone, anterior point of the pelvis and posterior point of the pelvis (Noyce et al., 2002).
System prepared for Asian Elephants (*Elephas maximus* Linneaus, 1758) uses visual assessment of appearance of six body regions, head (temporal depressions), *scapula*,

thoracic region (ribs), flank area (right in front of pelvic girdle), lumbar vertebrae and pelvic bone (Wemmer et al., 2006).

1.1.3. Scales and grades descriptions

Following remarkable changes on selected body areas scales are set. Commonly scales of five, six or nine points are used for BCS. For the own condition estimations using of halves or even quarters of points could be allowed (Azzaro et al., 2011; Ferguson et al., 1994) as precise and reliable enough, but these auxiliary grades are not described separately in scale characteristics. Descriptions of each scale's grade could be supplemented by drawn pictures or animal's photographs.

Only written descriptions of grades are used in nine-point scale for exotic equids (Bray and Edwards, 2001) or Mediteranean buffaloes (Negretti et al., 2007) or in five-point scale for tapirs (*Tapirus indicus* Desmarest, 1819 and *Tapirus terrestris* (Linnaeus, 1758)) in human care (Clauss et al., 2009).

Nine points scales are commonly used for dogs and cats BCS estimations with grades descriptions followed by drawn pictures or computer models (Brooks et al., 2014), nine points scale for domestic carnivores with illustrative photos was adapted for cheetahs (*Acinonyx jubatus* (Schreber, 1775)) (Reppert et al., 2011) or with drawings for lions (*Panthera leo* Linnaeus 1758) (Daigle et al., 2015).

The BCS scales for sheep and goats have traditionally six points, for sheep supplied by drowned pictures of lower back, for goats by pictures of sternal region (Mendizabal, 2011).

Five-point scale with photos is used for African elephants (*Loxodonta africana* (Blumenbach, 1797)) (Morfeld et al., 2014), with drawn pictures for Black Rhinoceros (*Diceros bicornis* (Linnaeus, 1758)) (Van den Hauten and Fidget, 2011).

1.2. Reliability

Body Condition Score belongs among observer ratings, which means the observer scores a variable using non-standardized units of measurements defined by researcher. Observer ratings are sometimes questioned as too prone to biases. The controversy is generally

caused by two main reasons: firstly, there appears scepticism against studying animal behaviour and welfare, because they operate with inner experiences of others, which cannot be directly, empirically investigated and secondly there exist a fear of anthropomorphism (Meagher, 2009).

The essays how to make observer ratings (and hence BCS) scientifically valuable go again different directions depending on the category of animals of interest. In livestock (intensive production) breeding development tends to eliminate human factor from scoring process and replace observers by computer programs (Azzaro et al., 2011; Bewley et al., 2008). BCS systems prepared for extensive breeding, for companion or wild and Zoo animals became to be statistically treated for reliability and validity to improve their status in terms of exactitude and also the demands on their terminological clarity and exactitude increased (Brooks et al., 2014; Morfeld et al., 2014; Edwards et al. 2015).

Important indicators or reliability for BCS charts are inter-observer reliability, agreement among multiple people independently rating the same individual, and intra-observer reliability, agreement among observers' ratings of the same individual on multiple occasions (strictly ratings of the same sample, e.g. pictures or video sequences) and internal consistency, agreement among individual items on scale designed to measure the same variable (Meagher, 2009).
Even though the reliability of various BCS systems was already tested (e.g. Ferguson et al., 1994; German et al., 2006; Kristensen et al., 2006; Clingerman and Summers, 2012; Morfeld et al. 2014) some scales, especially the ones originally prepared for single use in a concrete study, are used without validation (see Woolnough et al, 1997; Clauss et al. 2009; Daigle et al., 2015).

Inter-observer reliability could be increased ensuring the unambiguousness of phrasing and questions. Essential precondition for receiving valid data is clarity and proper choice of terms. However even when all observers interpret used terms the same way, wrongly chosen terminology can lead to personification of observed individuals and misinterpretations caused by anthropomorphisms or the results can be biased due to emotional meanings of used characteristics. For instance, using a scale with grades labelled "fat" or "poor" for condition estimations by keepers of examined animals has higher

probability of distortion of results than scale operating with terms “extremely high” or “low” which doesn’t have any pejorative undertone (see Reppert et al., 2011).

This kind of assessment bias is typical for situations when close relationship of the observer and animal individual could be expected. BCS systems created for wildlife or for animals in production breeding commonly operate with previously mentioned terms (Berman and Schwartz, 1988; Cook et al., 2005; Clingerman and Summers, 2012).

1.3. Application of BCS system

1.3.1. Observers

From the very beginning of scale creation character of future observers should be taken into the consideration. Generally, the most important is observer’s experience with a scale (experienced or naïve) and relationship to scored animals professional as well as personal (owner, keeper, veterinarian, researcher, student, visitor). In ideal case BCS system should allow all the mentioned categories of observers to work with it and receive relevant information. Although character of observer determines parameters of scale like terminology or need for illustration.

In case of BCS, observer’s level of experience with the animals and with scoring system could influence reliability of estimations. Kristensen et al. (2006) found great difference in intra-observer reliability between group of observers experienced with scoring system and group without practice in scale using. Contrary Morfeld et al. (2014) received during the testing of BCS system for African Elephants high degree of reliability and great agreement between observers from which one was developer of BCS system, another one was elephant keeper with more than 30 years of experience with animals and also with BCS system used for Asian Elephants (*Elephas maximus* Linnaeus, 1758) and the last one was behavioural biologist with no previous experience with BCS.

Scores given by observers are correlated with internalized norms for a species or population, which depend on observer’s range of experience. This can interfere with possibility to compare results between studies or limit the extent to which conclusions can be generalized for whole species. For instance, animals in human care are globally in higher conditions than individuals of the same species living in nature (Reppert et al., 2011; Morfeld et al., 2014), due to that there exist probability that score given to the same individual would be different in observer who has no experience with wild population and observer who has some. Or using the same scale the same individual could receive

different scores in study interested only in captive animals and in study including wild animals as well. Therefore, clear description of what is considered to be normal or extreme expression of features to be assessed should be provided to reduce this effect (Meagher, 2009).

As was already mentioned observers closely related to the animals, especially owners and keepers, are in risk of "self-enhancement" or "social-desirable" biases, partially because of their emotional connection with scored individuals (it is hard to assume cared animal is in different than "proper" condition) but also because of the fact, that through the scoring their work is indirectly evaluated.

Among all categories of observers there exists also the risk of the biases in behalf of the hypothesis concern in any scientific study or generally in behalf of expected results (e.g. subconscious expectation that animals from certificated professional breeder should be in appropriate shape). For this reason, if the results of scoring should be used as a part of research and not only as a tool for breeding management, observers should not be familiar with the hypothesis, if possible (Meagher, 2009)

1.3.2. Scoring schedule

Frequency of estimation of body condition depends on aim of the scoring.

Studies comparing situation between wild and Zoo population, among breeding institutions or monitoring the wildlife (e.g. Clauss et al., 2001; Noyce et al., 2002; Morfeld et al., 2014) often use disposable scoring.

If focused on relationship between reproduction parameters and body condition in breeding for production as well as in conservation breeding or even in natural conditions multiple scores are estimated for each individual (or group of individuals). Cook et al. (2004, 2005) checking the body condition of both sexes in American Elk (*Cervus canadensis* Erxleben, 1777) estimate body condition at the beginning and at the end of mating season, at the time of calving and at the weaning. Mendizabal et al. (2011) mention as essential moments for body condition control in goats in extensive production systems the situation before mating, the last stage of pregnancy and the weaning. BCS at the conception, at the end of pregnancy and at the weaning recorded also Boudreau et al. (2014) in study about reproduction of American Mink (*Neovison vison* (Schreber, 1777)).

Body condition scoring mentioned as a tool for monitoring the mobilization and development of body tissues or helping with establishment of balance between economical

feeding and welfare demands should be run periodically and with equal interval between scorings (Bray and Edwards, 2001).

1.4. Practical use of BCS in wild and Zoo animals

1.4.1. Food management

Using of BCS systems in Zoo animals is commonly associated with problematics of overweight or obesity of animals in human care which is considered to be a serious health issue causing various complications like higher risk of complications during the surgery in obese animals, higher probability of injuries or higher stress on inner organs and joints (Bray and Edwards, 2001; AZA Lion Species Survival Plan, 2012; Whitehouse-Tedd, 2014).

Original reason of introduction of BCS systems into many Zoos was assessing the impact of dietary changes (Van den Houten and Fidget, 2011). There are various reasons for change of feeding rations or regime, like transport of animals between collections, new findings in species nutrition, economic situation or healthy problems. And the effect of such a change could be continuous, long-lasting or poorly visible, which could cover its seriousness till the condition change is very dramatic, especially since the nutrient demands and nutrition digestibility of many species are still not determined (Vester et al., 2010). Introduction of BCS system could increase probability of early identification of problem.

Regular body condition scoring could also together with monitoring of food intake prevent the unnecessary wasting (Bray and Edwards, 2001).

1.4.2. Condition check

For the most of the Zoo species regular weighing or handling including palpation is not manageable and even if it is, weighing itself does not provide information complex enough, as there is no evidence about average body weight for life stages like growth or pregnancy or about speed and rate of seasonal body mass changes or about changes connected with aging (AZA Lion Species Survival Plan, 2012).

In these terms BCS provides non-invasively reached data about animal's overall appearance, which, if combined with information about body dimensions (e.g. BMI) or data from weighing, could provide new information about correlations between these parameters (Woolnough et al., 1997; Noyce et al., 2002; Lane et al., 2014).

Body condition is also considered to be closely correlated with reproductive success of many non-domesticated species in human care (Bray and Edwards, 2001; Morfeld et al., 2014; Noyce et al., 2002).

1.4.3. Research

Research support

As a part of cooperation between breeding institutions, laboratories and researchers, samples are commonly collected and examined by different people. And in many cases researchers do not have any idea about appearance of examined individuals, which could result to bias or decrease of reliability of their results.

For instance, in case of studies concentrated on changes of hormonal levels in Zoo animals should be taken into consideration that especially sexual hormones are closely connected with fat metabolism, so condition close to any of extremes have a direct influence on hormonal levels in animal's body (Boudreau et al., 2014). Receiving together with samples also information about BCS of tested individual, researchers would have a possibility to modify interpretation of their results.

Field studies

Thanks to its low cost and low demands on time and material, the BCS is widely used in studies of wild population of species which are impossible to handle without capture and immobilisation or as a non-invasive alternative to other body condition indices (Woolnough et al., 1997; Lane et al., 2014).

The relationship of BCS and reproductive parameters was examined in American Black Bears (*Ursus americanus* Pallas, 1780) regarding the influence of maternal nutrition on litter size and survival rate of the offspring (Noyce et al., 2002) or in impalas (*Aepyceros melampus* (Lichtenstein, 1812) regarding the BCS dependence on the population density (Gaidet and Gaillard, 2008).

Another study on this species was interested in its ruminal morphology responses to changes in diet during the wet and dry season and was using the BCS as one of the condition indices (Lane et al., 2014) as well as team of Cook and Cook (2004, 2005), who was running extensive research on American Elk (*Cervus canadensis*) in Yellowstone National Park focused on body condition of the animals and Woolnough et al. (1997) were examining potential of BCS as a predictor of amount of body fat or body protein for body

composition analysis in Southern Hairy-Nosed Wombats (*Lasiorhinus latifrons* (Owen, 1845)).

Ethological study of Giles et al. (2015) tested and confirmed a relationship of dominance rank and BCS in free ranging horses *Equus caballus*.

1.5. Body Condition Score in Big Cats

Big carnivores generally and big cats especially tend to be prone to overweight or obesity in human care. This tendency might be partially explained by their natural feeding strategy (Vester Boler et al., 2009), but also by the technology of the captive breeding and the frequency and amount in which food is provided to them (Dierenfeld et al., 1994; Vester et al., 2010, AZA Lion Species Survival Plan, 2012).

When there appeared the attempts to adapt existing or create specific BCS Charts for exotic animals in human care, who are in risk of body condition fluctuations, it seemed natural that big cats would be one of the first aims of such efforts besides the ungulates for whom exists huge variety of BCS systems on which it is possible to build. Surprisingly so far there is available validated systems only for Lions BCS developed by AZA Lion Species Survival Plan (2012) and advised as a management tool and for Cheetah BCS developed by Dierenfeld et al. (2007) and modified by Reppert et al. (2011).

2. Aims

The aims of the master thesis were to create a Body Condition Score Cards for selected species of felines, Tiger (*Panthera tigris* Linnaeus, 1758) and Lion (*Panthera leo* Linnaeus, 1758), to test their reliability and versatility.

Based on the visual records of the physical dimensions and modifications of appearance connected with the changes of body mass of the animals, models of the ideal animals and of the manifestations of changes of the level of muscle and fat cover of their body were assembled and the Body Condition Score Cards were prepared. The reliability and versatility of cards were evaluated by testing whether there was an agreement among scores given to concrete animals by different observers (Inter-observer Reliability) and whether there was an agreement among scores given to concrete animals in the same situation by the same observer repeatedly (Intra-Observer Reliability).

3. Material and Methods

3.1. Body Condition Score Cards Creation

3.1.1. Material

Digital pictures of captive tigers (*Panthera tigris*) and lions (*Panthera leo*) of different subspecies, age, sex and condition were collected from private photographers and breeding institutions from Europe. Minimum number of 100 pictures for each species was set. Modifications of animal's appearance connected with the changes of body mass were considered as an object of interest, so also pictures of one individual from different life periods (growth, proven pregnancy, aging etc.) were incorporated, when were substantial. Additional sets of pictures of specific body areas were collected and used as supportive material.

3.1.2. Methods

Collected pictures were ordered from the ones showing animals appeared to be the most skeletal to the most rounded ones. Ordered pictures were sorted by general appearance of animals into the five categories representing level of the muscle and fat cover of body of animals included; 1 ~ extreme low, 2 ~ low, 3 ~ moderate, 4 ~ high and 5 ~ extreme high. Body regions with the most significant changes among the categories were chosen and described as well as the general appearance of animal belonging to each category.

Based on these descriptions illustrative pictures were drawn. In case of lions pictures for both sexes were drawn separately for each category from the side-view, and from the back-view. In case of tigers pictures from the side-view, back-view and top-view were drawn.

Illustrations and descriptions were put together into the cards and supplemented by description of the assessment procedure and additional notes to the assessed features focused on specific life situations (growing up, pregnancy or aging), intersexual differences or variability among subspecies.

3.2. Testing of the BCS cards reliability

3.2.1. Material

The testing of the BCS cards was conducted from February 2016 to April 2016.

Total number of 15 adult tigers and 14 lions from 7 breeding institutions was included into the testing of the BCS cards.

Total number of 38 observers was participating on the testing of the BCS cards.

Zoo Brno, Czech Republic

Two Sumatran Tigers (*Panthera tigris sumatrae* Pocock, 1929), 4 years old male and 12 years old female, were kept in Brno Zoo.

Animals had an access to the inside enclosures and outside expositions, both accessible for visitors to observe the animals. Barrier between animals and visitors was made up by the glass, barrier between keepers and animals (manipulation corridor, access door to the inside enclosures) was made up by mesh. Inside enclosures were equipped by shelves offering opportunity to jump. Animals alternated in inside enclosures as well as in outside expositions, which were both of fully natural type (covered by vegetation). Neither the inside enclosures or the outside expositions did offer the opportunity to climb, the outside expositions did offer the opportunity to swim. Elements of enrichment (balls, carton boxes) were given to the animals occasionally. No special training was conducted. During the main season and holiday the commented feeding was performed. Animals were fed four times a week (Tuesday, Thursday, Saturday and Sunday) by beef-based diet including also goat meat and rabbit's carcases in amount of 24 kg per week for tiger male and 18 kg per week for tiger female.

Seven observers participated on BCS cards testing, all of them employees of Brno Zoo (zoologist, 2 keepers of carnivores and 4 keepers from other departments).

Zoo Hodonín, Czech Republic

Two Siberian Tigers (*Panthera tigris altaica* Temminck, 1844), 5 years old male and 8 years old female, two South African Lions (*Panthera leo krugeri* (Roberts, 1929)), 2 years old male and female and Barbary Lion (*Panthera leo leo* (Linnaeus, 1758)), 11 years old female, were kept in Hodonín Zoo.

The female tiger was at the time of the scoring right after weaning of cubs. Siberian Tigers and South African Lions had an access to the inside enclosures and to the outside

expositions, both accessible for visitors to observe the animals. Barrier between animals and people was made up by glass. Inside enclosures were two dimensional. Siberian Tigers alternated in outside expositions from which one was of fully natural type (covered by vegetation) and offering opportunity to climb, jump and swim, while the other one was two dimensional handling exposition with a clay surface. South African Lions shared the outside exposition of fully natural type (covered by vegetation) offering opportunity to climb and jump. Elements of enrichment were given to the animals occasionally. No special training was conducted. Animals were fed three to four times a week by beef-based diet including also goat meat and rabbit's carcases in amount of 30 kg per week for tiger male, 20 kg per week for tiger female, 30 kg per week for lion male and 25 kg per week for lion female.

The Barbary Lion female had an access to the inside enclosure in the background and outside exposition, which was accessible for visitors to observe the animal. Barrier between animal and people was made up by mesh. Inside enclosure was equipped by shelf offering opportunity to jump. Outside exposition was equipped by natural elements (logs, gravel) and a shelf offering opportunity to jump. Elements of enrichment were given to the animal occasionally. No special training was conducted. Animal was fed four times a week by beef-based diet including also goat meat and rabbit's carcases in amount of 25 kg per week.

Five observers participated on BCS cards testing, two of them employees of Hodonín Zoo (zoologist, keeper of carnivores), three of them employees of other zoological gardens (2 zoologists, keeper from other department).

Zoo Jihlava, Czech Republic

Two Sumatran Tiger (*Panthera tigris sumatrae*) females, 11 and 3 years old were kept in Jihlava Zoo.

Animals had an access to the inside enclosure (Cat's pavilion) and to the outside exposition, both accessible for visitors to observe the animals. Barrier between animals and people was made up by the glass. Inside enclosures were two dimensional. Animals shared the outside exposition, which was equipped by natural elements (grass, logs). The outside exposition did offer the opportunity to jump and to climb, but did not offer the opportunity to swim. Elements of enrichment were given to the animals occasionally. No special training was conducted. Animals were fed five times a week by beef-based diet including

also goat meat and rabbit's carcase. The fixed amount of kg per week per individual was not set, animals were fed according to their appearance and appetite.
Fife observers participated on BCS cards testing, all of them employees of other zoological gardens (zoologist, 4 keepers from other departments).

Zoo Liberec, Czech Republic

Two tigers (*Panthera tigris*, white form), 11 years old male and 8 years old female, and two 3 years old Barbary Lion males (*Panthera leo leo*) male were kept in Liberec ZOO.
The female tiger was at the time of the scoring nursing cubs. Animals had an access to the inside enclosures (Big Cat's pavilion) and outside expositions, both accessible for visitors to observe the animals. Barrier between animals and people was made up by the glass (only exception was the manipulation corridor bounded by mesh). Inside enclosures were three dimensional offering opportunity to jump. Animals alternated in outside expositions, from which one was of fully natural type (covered by vegetation) and two others were equipped by natural elements (logs, woodchips, sand, gravel). All of the outside expositions did offer the opportunity to climb and to swim. Elements of enrichment (balls, carton boxes, smells) were given to the animals on a regular basis. No special training was conducted. Animals were fed five times a week (starving during the weekends) by beef-based diet including also goat meat and rabbit's carcases in amount of 42.5 kg per week for tiger male (with a bone), 25 kg per week for tiger female and 30 kg per week for lion male.
Five observers participated on BCS cards testing, three of them employees of Liberec Zoo (nutritionist, 2 keepers of carnivores), one of them employee of other zoological garden (keeper from other department) and one of them university student.

Zoo Olomouc, Czech Republic

Two Siberian Tigers (*Panthera tigris altaica*), 4 years old male and 5 years old female, and two Barbary Lions (*Panthera leo leo*), 11 years old male and 8 years old female, were kept in Olomouc Zoo.
The tiger female was at the time of the scoring nursing two cubs. The lion female was at the time of the scoring in the final stages of pregnancy. Animals had an access to the inside enclosures (Big Cat's pavilion) and outside expositions, both accessible for visitors to observe the animals. Barrier between animals and people was made up by the glass. Inside enclosures were three dimensional offering opportunity to jump. Siberian Tiger male's

outside expositions was of fully natural type (covered by vegetation), Siberian Tiger female's outside exposition and outside exposition shared by the Barbary Lions were equipped by natural elements (grassy surface, logs). All of the outside expositions did offer the opportunity to climb and to jump, but not to swim. Elements of enrichment (balls, carton boxes, smells) were given to the animals occasionally. No special training was conducted. Animals were fed five times a week (starving during the weekends) by beef-based diet including also goat meat and rabbit's carcases in amount of 30 kg per week for tiger male, 25 kg per week for tiger female, 30 kg per week for lion male and 30 kg per week for lion female.

Five observers participated on BCS cards testing, two of them employees of Olomouc Zoo (zoologist, keeper of carnivores) and three of them employees of other zoological gardens (2 zoologists, keeper from other department).

Zoo Plzeň, Czech Republic

Two Siberian Tigers (*Panthera tigris altaica*), 4 years old male and 16 years old female, and three Barbary Lions (*Panthera leo leo*), 5 years old male and two 2 years old females, were kept in Plzeň Zoo.

Barbary Lions had an access to the inside enclosures and outside exposition, both accessible for visitors to observe the animals. Barrier between animals and people in the inside enclosure was made up by the glass, the outside exposition was separated from people by natural barriers and electric fencing. The inside enclosures were two dimensional. The outside exposition was of fully natural type (covered by vegetation) offering the opportunity to jump, but not to climb either swim. At the time of the scoring the outside exposition was under reconstruction and animals had access only to two dimensional handling exposition with a clay surface. Elements of enrichment were given to animals occasionally. No special training was conducted. Animals were fed 2 times a week by beef-based diet including also goat meat and rabbit's carcases in amount of 60 kg per week for lion male and females (fed together twice a week 30 kg per feeding).

Siberian Tigers had an access to the inside enclosures in the background and they alternated in the outside expositions accessible for visitors to observe the animals. Barrier between animals and people was made up by mesh. The inside enclosures were two dimensional. The outside expositions were of fully natural type (covered by vegetation) offering the opportunity to jump and to climb and one of them did offer the opportunity to

swim. Elements of enrichment (balls, carton boxes) were given to the animals occasionally. No special training was conducted. Animals were fed 3-4 times a week by beef-based diet including also goat meat and rabbit's carcases in amount of 30 kg per week for tiger male, 25 kg per week for tiger female.

Five observers participated on BCS cards testing, three of them employees of other zoological gardens (2 zoologists, keeper from other department), one visitor (no biological education) and one university student.

Zoo Praha, Czech Republic

Two Sumatran Tigers (*Panthera tigris sumatrae*), 9 years old male and 10 years old female, three Malayan Tigers (*Panthera tigris jacksoni* Luo et al., 2004), 10 years and 9 years old males and 10 years old female, and three Asiatic Lions (*Panthera leo persica* (Meyer, 1826)), 4 years old male and 6 and 4 years old females, were kept in Praha Zoo.

Animals had an access to the inside enclosures and outside expositions accessible for visitors to observe the animals and to the handling corridors and expositions in the background. Asiatic Lions shared the inside enclosure and outside exposition, the Sumatran and Malayan Tigers alternated in the outside expositions. The inside enclosures were three dimensional offering the opportunity to jump. The outside expositions were of fully natural type (covered by vegetation) and did offer the opportunity to jump, climb and swim. Elements of enrichment (boxes, smells) were given to the animals occasionally. No special training was conducted. Animals were fed daily with semi-starving on Thursdays and starving on Sundays by beef-based diet including also goat meat and rabbit's carcases in amount of 20-30 kg per week for tiger male or female and 75 kg per week for lion male and two females.

Four observers participated on BCS cards testing, two of them employees of Praha Zoo (keepers of carnivores), two of them employees of other zoological gardens (zoologist, keeper from other department).

3.2.2. Methods

Statistics used for data treatment:[1]

Kappa Statistics

- measurements of absolute agreement of assessments made by two (**Cohen's Kappa**) or multiple (**Fleiss' Kappa**) observers assessing the same samples
- kappa <-1; 1>; the higher the value, the stronger the agreement

  Kappa = 1 ~ perfect agreement

  Kappa = 0 ~ agreement is the same as would be expected by chance

  Kappa < 0 ~ agreement is weaker than expected by chance

Kendall's Coefficients

- measurements of the association between the assessment made by individual observer and the reference value (**Kendall's Coefficient of Correlation**) or among multiple observers assessing the same samples or among the multiple assessments of the same samples made by individual observer repeatedly (**Kendall's Coefficient of Concordance**)
- Kendall's Coefficient of Correlation <-1; 1>; positive value indicates positive association, negative value indicates negative association; the higher the magnitude, the stronger the association
- Kendall's Coefficient of Concordance <0; 1>; the higher the value, the stronger the association

Inter-Observer Reliability - Institutional

In every institution included into the scale testing 4 to 7 observers with different experience with BCS and concrete animal individuals were chosen (e.g. nutritionists, zoologists, keepers, students). All the observers scored all the animals in their institution independently to the others but in the same time period (the maximum delay between the first and the last scoring in one institution was two weeks). Way how to use the BCS Card was explained and full understanding of terminology was checked, but no practical demonstration was done.

Normality of received data distribution was tested in "Statistica 12" program.

Mode or mean of the BCSs given to each animal was determined (MBCS) as well as the distances of observer's scores from the MBCS.

[1] Definitions of the statistic methods were formulated based on Landis and Koch (1977) and Meagher (2009).

Data were treated using the percent agreement, Kappa statistics (Cohen's and Fleiss' Kappa) and Kendall's Coefficient of Concordance and Correlation in "Statistica 12" program.

H_{01A}: There is no agreement among the observers.
H_{11A}: There is an agreement among the observers.

H_{02A}: There is no agreement between the scores given by the individual observer and the MBCS.
H_{12A}: There is an agreement between the scores given by the individual observer and the MBCS.

Inter-Observer Reliability – "Two Observers"

Two observers with the same initial experience with BCS (no previous experience) were chosen. Way how to use the BCS Card was explained to them and full understanding of terminology was checked, but no practical demonstration was done. Both of the observers scored all of the individuals (15 tigers and 14 lions) at all of the breeding institutions included into the testing independently to each other, but in the same time period[2].
Normality of received data distribution was tested in "Statistica 12" program.
Data were treated using the percent agreement, Kappa statistics (Cohen's and Fleiss' Kappa) and Kendall's Coefficient of Concordance and Correlation in "Statistica 12" program. The "institutional MBCS" was used as the reference value at each institution included into the testing.

H_{01B}: There is no agreement between the observers.
H_{11B}: There is an agreement between the observers.

H_{02B}: There is no agreement between the scores given by the individual observer and the MBCS.
H_{12B}: There is an agreement between the scores given by the individual observer and the MBCS.

[2] The date of scoring of the animals by the two selected observers fit into the two-weeks interval of scoring at each included institution.

Intra-Observer Reliability

Digital pictures of 10 tested tigers and 20 lions (10 males and 10 females) from the side-view, from the top-view and from the back-view were taken. Two observers with different previous experience with tested BCS cards and BCS generally were chosen (author of tested BCS cards, participant of the inter-observer reliability testing with no previous experience with BCS). BCS evaluation based on these digital pictures was done and repeated 3 times in three months with randomised order of pictures. Normality of received data distribution was tested in and data were treated using the percent agreement, Fleiss' Kappa and Kendall's Coefficient of Concordance in "Statistica 12" program.

H_{03}: There is no agreement among the scores repeatedly given by the individual observer to the same animal individual under the same conditions.

H_{13}: There is an agreement among the scores repeatedly given by the individual observer to the same animal individual under the same conditions.

4. Results

4.1. Body Condition Score Cards

4.1.1. Assessment Procedure

Each feature should be assessed and scored separately with scores 1-5 and the total score should be calculated as a mean of the partial scores.

Evaluation of the total score should depend on the purpose of the scoring: if the aim is to compare the individuals, the exact mean (x.2, x.4, …) should be recorded, whereas if the aim is to keep a record of individual's condition, the mean should be rounded to whole numbers and accompanied with symbols "+" and "-", if necessary.

Ex.:

Partial scores: 2, 2, 3, 2, 2	Partial scores: 4, 4, 4, 3, 4
Mean: 2.2	Mean: 3.8
Recorded score: 2+	Recorded score: 4-

Categories of total scores:

1 ~ **extremely low** (level of muscle and fat cover)

2 ~ **low** (level of muscle and fat cover)

3 ~ **moderate** (level of muscle and fat cover)

4 ~ **high** (level of muscle and fat cover)

5 ~ **extremely high** (level of muscle and fat cover)

The assessment should be done under the appropriate light conditions on individuals active, but calm, at the time long enough before or after feeding to minimize the bias.

4.1.2. Tigers

NOTES TO THE FEATURES TO BE ASSESSED

I) HEAD

Observing the general appearance of the individual, proportion of the head to the rest of the body should be assessed:

- considering the moderate condition to be the proportional stage, with the increasing level of muscle and fat cover of the body the head appears to be smaller than proportional, respectively with decreasing level of muscle and fat cover of the body the head appears bigger than proportional
- while the change in proportion of the head to the rest of the body might be less apparent in the individuals of low (2) or high (4) condition, in the individuals of extreme low (1) and extreme high (5) level of muscle and fat cover the disproportion is evident

Changes in the prominence of the facial bones are observable in close contact as additional feature of the individual's condition.

- prominent facial bones and sunken facial features typical for individuals of low (2) and extremely low (1) level of muscle and fat cover are also one of the signs of aging, when those do not have to be connected with the loss of condition

The existing differences in general appearance of the head and face between subspecies should be considered to prevent bias of the scoring:

- prolonged hair surrounding the face in male Sumatran Tigers (*P. t. sumatrae*)
- naturally more rounded head and face in Siberian Tigers (*P. t. altaica*)

II) LEGS TO BODY RATIO

The apparent changes in length of the legs are caused by moving of the abdominal outline:

- the outline of the abdomen of the individuals of moderate (3) level of the muscle and fat cover follows the level of elbows
- with the gradual abdominal tuck in individuals of low (2) and extremely low (1) level of muscle and fat cover the outline of the abdomen recedes above the level of elbows

- with the increasing level of the muscle and fat cover in individuals of the category high (4) an and extremely high (5) the outline of the abdomen drops under the level of elbows

Extending of the abdomen to the sides and its rounding is clear sign of increased, category high (4) and extremely high (5), level of the muscle and fat cover if followed by the changes in other assessed areas; extension of the abdomen without similar observable changes in other assessed areas does not have to be connected with the changes of the level of muscle and fat cover, possible explanations to be considered:

- parasitic invasion in sub-adult individuals
- pregnancy
- development of oncological disease, especially in case of asymmetric extension

In Siberian Tigers the presence of the abdominal fat pad is not (especially not during the winter season) a clear sign of increased overall level of the muscle and fat cover.

III) SPINE

For individuals of moderate (3) level of the muscle and fat cover is typical outward curving of the spine and dorsum in the lumbar area; with the changes of the level of the muscle and fat cover deviations from this outline of the dorsum may occur:

- in individuals of low (2) and extremely low (1) level of the muscle and fat cover the outward curving is getting more significant
- in individuals of high (4) and extremely high (5) level of the muscle and fat cover the straightening or even inward curving of the dorsum in lumbar area may occur

In Siberian Tigers the actual shape of the spine or the individual vertebrae might not be discernible because of the hair cover, but the changes in the shaping of the dorsum remain valid.

IV) PELVIS AND TAIL HEAD

The outlines of the pelvic bones and the tail head might not be discernible because of the hair cover (especially in Siberian Tigers), but the changes of the shape of the pelvic area remain observable.

V) SILHOUETTE

There is apparent waist behind the rib cage visible in individuals of moderate (3) level of muscle and fat cover.

- with decreasing level of muscle and fat cover the edges of the waist (outlines of the rib cage and pelvic bones) become more prominent
- with increasing level of muscle and fat cover the waist is disappearing

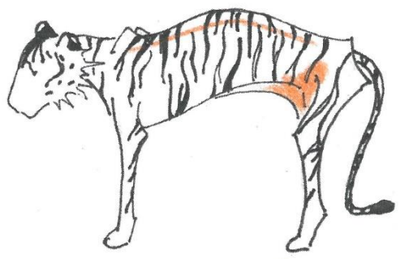
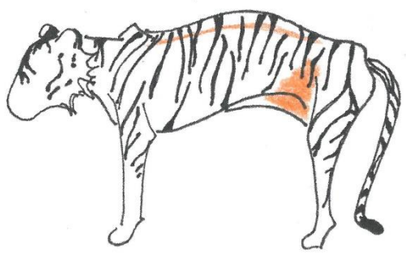
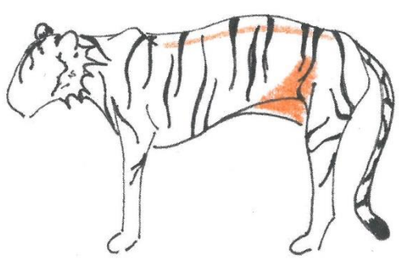
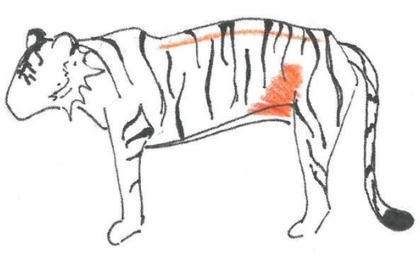
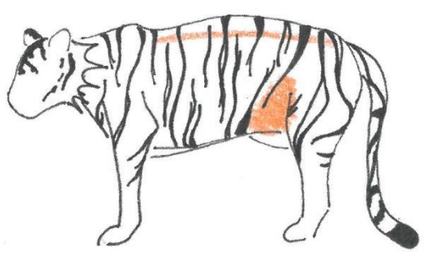
When observing of the individual from the top-view is not possible, extension of the abdomen in individuals of high (4) and extremely high (5) level of muscle and fat cover is observable also when the individual is viewed from behind, when the rounded outline of the abdomen is not overlapped by the outline of the pelvic area.

PANTHERA TIGRIS

I) HEAD

Head appears to be unproportionally big and heavy, facial bones sharply prominent, facial features sunken, large and bulging eyes, sharp pass between head and neck 1	Head appears to be bigger than proportional, cheekbones sharply prominent, cheeks sunken or not well muscled 2	Head appears to be proportional, cheekbones prominent but rounded, cheeks muscled, clearly discernible facial features, smooth pass between head and neck 3	Head appears to be smaller than proportional, cheekbones discernible, cheeks rounded 4	Head appears to be unproportionally small, facial features rounded, small and sunken eyes, pass between head and neck merged 5

II) LEGS TO BODY RATIO

				
Legs appear to be very long, ventral silhouette of the body strictly follows the shape of the rib cage 1	Legs appear to be long, ventral silhouette of the body follows the shape of the rib cage 2	Legs appear to be proportional, ventral silhouette of the body is parallel to the dorsal one or gradually rising toward hind legs 3	Legs appear to be short, ventral silhouette of the body is parallel or going lower toward hind legs 4	Legs appear to be very short, ventral silhouette of body is either convex or going lower toward hind legs 5

III) SPINE

Spinous processes of vertebrae all along the spine sharply prominent, spine noticeably curved outward 1	Spinous processes of vertebrae all along the spine prominent, but rounded, spine curved outward 2	Spinous processes of vertebrae discernible in thoracic and lumbar area, spine in the lumbar area curved outward 3	Spinous processes of vertebrae not discernible, dorsum in the lumbar area slightly curved outward 4	Shape of spine not discernible, dorsum in the lumbar area flat or curved inward 5

IV) PELVIS AND TAIL HEAD

				
Pelvic bones sharply prominent, tail vertebrae sharply prominent, tail head sharply emerges 1	Pelvic bones prominent, outlines of bones rounded, tail vertebrae discernible but rounded, tail head emerges 2	Outlines of the pelvic bones and bone points visible, tail vertebrae not discernible, tail head clearly discernible 3	Pelvic area rounded, bone points visible in movement, tail head discernible 4	Pelvic area rounded, bone points not visible, tail head hardly discernible 5

V) SILHOUETTE

				
Shoulders and hips the widest points of the silhouette, outlines of the body angular 1	Shoulders and hips the widest points of the silhouette 2	Outlines of the belly touch the imaginary connecting lines of shoulders and hips 3	Outlines of the belly follow the imaginary connecting lines of shoulders and hips 4	Outlines of the belly cross the imaginary connecting lines of shoulders and hips 5

4.1.3. Lions

NOTES TO THE FEATURES TO BE ASSESSED

I) HEAD

Observing the general appearance of the individual, proportion of the head to the rest of the body should be assessed:

- considering the moderate (3) level of the muscle and fat cover to be the proportional stage, with the increasing level of muscle and fat cover of the body the head appears to be smaller than proportional, respectively with decreasing level of muscle and fat cover of the body the head appears bigger than proportional
- while the change in proportion of the head to the rest of the body might be less apparent in the individuals of low (2) or high (4) level of the muscle and fat cover, in the individuals of extreme low (1) and extreme high (5) level of muscle and fat cover the disproportion is evident

Changes in the prominence of the facial bones are observable in close contact as additional feature of the individual's condition.

- prominent facial bones and sunken facial features typical for individuals of low (2) and extremely low (1) level of muscle and fat cover are also one of the signs of aging, when those do not have to be connected with the loss of condition

II) LEGS TO BODY RATIO

The apparent changes in length of the legs are caused by moving of the abdominal outline:

- imagining a rectangle with tops in hips, shoulders and front and hind paws of the animal, the abdomen of individuals of moderate (3) level of muscle and fat cover is filling the upper half of this imaginary rectangle with a slight gap in the inguinal area
- with the gradual abdominal tuck in individuals of low (2) and extremely low (1) level of muscle and fat cover the outline of the abdomen recedes this imaginary line
- with the increasing level of the muscle and fat cover in individuals of the category high (4) an and extremely high (5) the outline of the abdomen extends to the lower half of the imaginary rectangle; the exact shape of the abdominal outline varies individually (rounding of the abdomen leading to the convex outline, fat deposition in the inguinal area leading to decline of the abdominal outline towards hind legs,

even extension of the abdominal fat pad leading to the maintain of the straight outline of the abdomen)

III) SHOULDERS / PELVIS

Because of the presence of the mane in males, shoulders area is not suitable to be assessed in both sexes, while the changes on the pelvic area are the same valid for all individuals. Changes of the muscle and fat cover of the shoulders and pelvis are well observable also in sub-adult individuals

IV) RIBS AND ABDOMEN

Extension of the abdomen without similar observable changes in other assessed areas does not have to be connected with the changes of the level of muscle and fat cover, possible explanations to be considered:

- parasitic invasion in sub-adult individuals
- pregnancy
- development of oncological disease, especially in case of asymmetric extension
- filling of the abdomen with the food, especially in individuals with access to large carcasses and lower frequency of feeding

Extension of the abdomen in individuals of high (4) and extremely high (5) level of muscle and fat cover is observable also when the individual is viewed from behind, when the rounded outline of the abdomen is not overlapped by the outline of the pelvic area.

V) SPINE AND TAIL

Deviations from the straight outline of the dorsum may occur with the changes of the level of the muscle and fat cover:

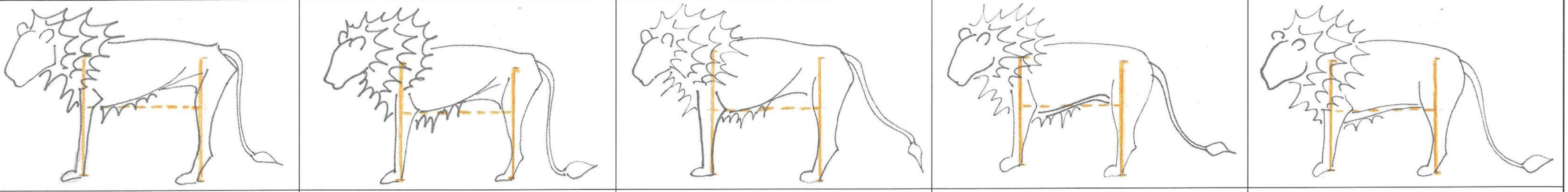
- in individuals of low (2) and extremely low (1) level of the muscle and fat cover the outward curving of the dorsum may occur
- in individuals of high (4) and extremely high (5) level of the muscle and fat cover the inward curving of the dorsum in lumbar area may occur

PANTHERA LEO - MALE

I) HEAD

Head appears to be unproportionally big and heavy, facial bones sharply prominent, facial features sunken, large and bulging eyes 1	Head appears to be bigger than proportional, cheekbones sharply prominent, cheeks sunken or not well muscled 2	Head appears to be proportional, cheekbones prominent but rounded, cheeks muscled, clearly discernible facial features 3	Head appears to be smaller than proportional, cheekbones discernible, cheeks rounded 4	Head appears to be unproportionally small, facial features rounded, small and sunken eyes 5

II) LEGS TO BODY RATIO

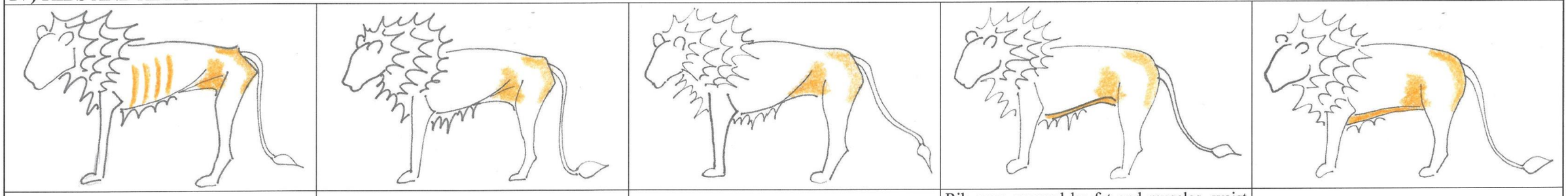


Legs appear to be very long, ventral silhouette of the body strictly follows the shape of the rib cage 1	Legs appear to be long, ventral silhouette of the body follows the shape of the rib cage 2	Legs appear to be proportional, ventral silhouette of the body is parallel to the dorsal one at the level of the breastbone 3	Legs appear to be short, ventral silhouette of the body is parallel or going lower toward hind legs 4	Legs appear to be very short, ventral silhouette of body is either convex or going lower toward hind legs 5

III) PELVIS

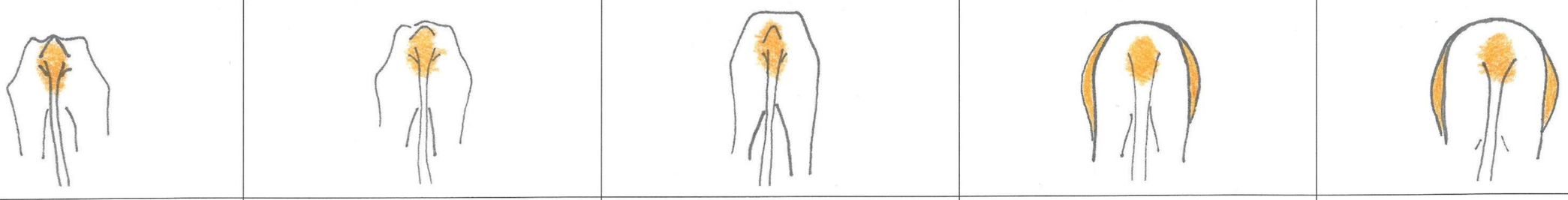
Pelvic bones sharply prominent 1	Pelvic bones prominent, outlines of bones rounded 2	Outlines of the pelvic bones visible in movement, bone points rounded 3	Pelvic area rounded, bone points visible in movement 4	Pelvic area rounded and covered by fat and muscles 5

IV) RIBS AND ABDOMEN



Ribs sharply prominent, abdominal tuck, waist behind ribs sharply visible 1	Ribs prominent in movement, waist behind ribs visible 2	Outlines of the rib cage visible in movement, waist behind ribs noticeable 3	Rib cage covered by fat and muscles, waist behind ribs barely visible, rounding of abdomen, abdominal fat pad 4	Waist behind ribs not visible, distention of abdomen, extensive abdominal fat pad 5

V) SPINE AND TAIL



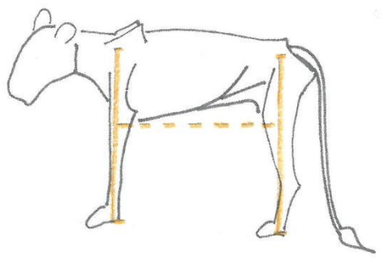
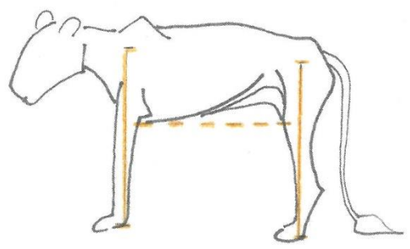
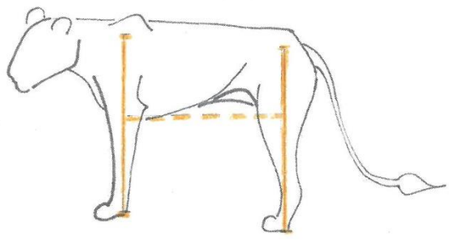
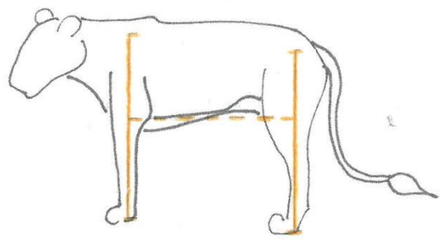
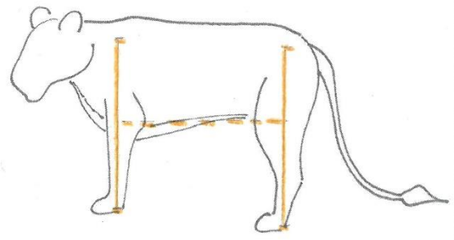
Spinous processes of vertebrae all along the spine sharply prominent, tail vertebrae prominent, tail head sharply emerges 1	Spinous processes of lumbar vertebrae prominent but rounded, tail vertebrae discernible but rounded, tail head emerges 2	Spinous processes of vertebrae not discernible, shape of spine prominent in lumbar area, tail head clearly discernible 3	Shape of spine merges with the outline of the body, tail head discernible but covered by fat 4	Shape of spine not discernible, tail head barely discernible 5

PANTHERA LEO - FEMALE

I) HEAD

Head appears to be unproportionally big and heavy, facial bones sharply prominent, facial features sunken, large and bulging eyes, sharp pass between head and neck 1	Head appears to be bigger than proportional, cheekbones sharply prominent, cheeks sunken or not well muscled 2	Head appears to be proportional, cheekbones prominent but rounded, cheeks muscled, clearly discernible facial features, smooth pass between head and neck 3	Head appears to be smaller than proportional, cheekbones discernible, cheeks rounded 4	Head appears to be unproportionally small, facial features rounded, small and sunken eyes, pass between head and neck merged 5

II) LEGS TO BODY RATIO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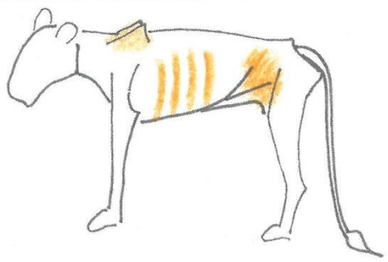
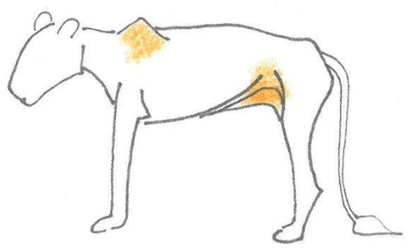
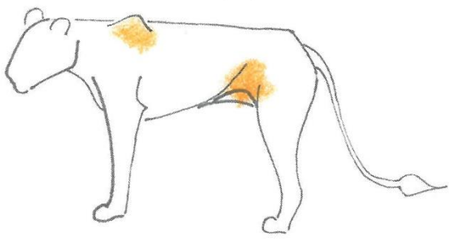
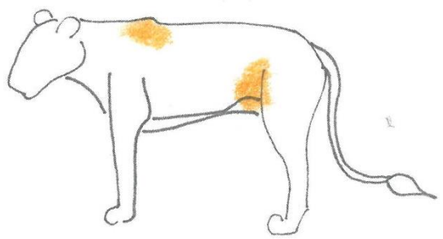
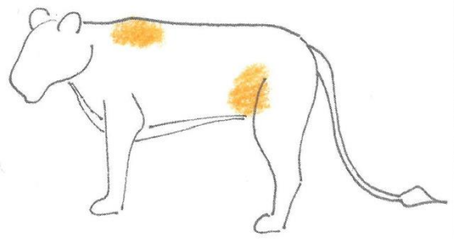
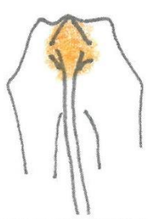
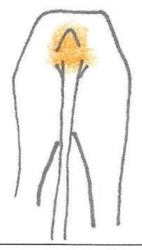
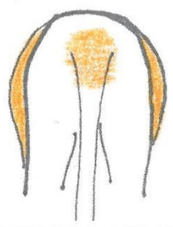
III) SHOULDERS

Shoulder blades sharply prominent 1	Shoulder blades prominent, outlines of bones rounded 2	Outlines of shoulder blades visible in movement, shoulders rounded by muscles 3	Outlines of shoulder blades not visible, shoulders rounded by fat and muscles visible in movement 4	Shoulders merge with the contour of body, fat folds between head and sholders 5

IV) RIBS AND ABDOMEN

				
Ribs sharply prominent, abdominal tuck, waist behind ribs sharply visible 1	Ribs prominent in movement, waist behind ribs visible 2	Outlines of the rib cage visible in movement, waist behind ribs noticeable 3	Rib cage covered by fat and muscles, waist behind ribs barely visible, rounding of abdomen, abdominal fat pad 4	Waist behind ribs not visible, distention of abdomen, extensive abdominal fat pad 5

V) SPINE AND TAIL

				
Spinous processes of vertebrae all along the spine sharply prominent, tail vertebrae prominent, tail head sharply emerges 1	Spinous processes of lumbar vertebrae prominent but rounded, tail vertebrae discernible but rounded, tail head emerges 2	Spinous processes of vertebrae not discernible, shape of spine prominent in lumbar area, tail head clearly discernible 3	Shape of spine merges with the outline of the body, tail head discernible but covered by fat 4	Shape of spine not discernible, tail head barely discernible 5

4.2. Testing of the BCS cards reliability

4.2.1. Descriptive statistics

Tigers

The mean total BCS of the animal individuals included into testing was 3.4 (SD = 0.64), the minimum 2.4 and the maximum 4.6. Modal BCS for tigers was 3.0.

Lions

The mean total BCS of the animal individuals included into testing was 3.8 (SD = 0.79), the minimum 2.2 and the maximum 5. Modal BCS for lions was not determined (multiple mode).

4.2.2. Normality testing

The Kolmogorov-Smirnov test was applied on all the datasets with the resulting $p < 0.01$, which indicate that data does not have the normal distribution.

4.2.3. Inter-Observer Reliability – Institutional

Tigers

H_{01A}: There is no agreement among the observers.

H_{11A}: There is an agreement among the observers.

Chart 1: Among-observers agreement - tigers

Tigers ZOO	Agreement	Fleiss' Kappa	p	Kendall's Coef. of Concordance	p
Brno	**40.00 %**	**0.46**	< 0.01	0.63	< 0.01
Hodonín	60.00 %	0.52	< 0.01	0.69	< 0.01
Jihlava	**30.00 %**	**0.47**	< 0.01	0.76	< 0.01
Liberec	60.00 %	**0.25**	0.01		
Olomouc	70.00 %	0.67	< 0.01	0.81	< 0.01
Plzeň	80.00 %	0.75	< 0.01		
Praha	72.00 %	0.60	< 0.01	0.76	< 0.01

H_{02A}: There is no agreement between the scores given by the individual observer and the MBCS.

H_{12A}: There is an agreement between the scores given by the individual observer and the MBCS.

Chart 2: Individual observers vs. MBCS - tigers

Tigers ZOO	Agreement	Cohen's/Fleiss' Kappa	p	Kendall's Coef. of Correlation	p
Brno	40.00 %	0.67	< 0.01	0.74	< 0.01
Observer A	100%	1.00	< 0.01	1.00	< 0.01
Observer B	70.00 %	**0.40**	**0.05**	0.60	0.01
Observer C	100%	1.00	< 0.01	1.00	< 0.01
Observer D	80.00 %	0.55	0.03	0.61	0.01
Observer E	90.00 %	0.78	0.01	0.80	< 0.01
Observer F	70.00 %	**0.44**	**0.05**	0.57	0.01
Observer G	80.00 %	0.58	0.03	0.58	0.01
Hodonín	60.00 %	0.66	< 0.01	0.71	< 0.01
Observer A	90.00 %	0.80	< 0.01	0.88	< 0.01
Observer B	90.00 %	0.78	0.01	0.80	< 0.01
Observer C	70.00 %	**0.21**	**0.25**	**0.22**	**0.20**
Observer D	90.00 %	0.74	0.01	0.76	< 0.01
Observer E	90.00 %	0.80	< 0.01	0.88	< 0.01
Jihlava	30.00 %	0.71	< 0.01	0.83	< 0.01
Observer A	70.00 %	0.50	0.02	0.78	< 0.01
Observer B	100%	1.00	< 0.01	1.00	< 0.01
Observer C	80.00 %	0.64	0.01	0.78	< 0.01
Observer D	80.00 %	0.64	0.01	0.78	< 0.01
Observer E	90.00 %	0.80	< 0.01	0.82	< 0.01
Liberec	60.00 %	0.54	< 0.01		
Observer A	90.00 %	0.74	0.01		
Observer B	80.00 %	**0.38**	**0.12**		
Observer C	90.00 %	0.62	0.02		
Observer D	90.00 %	0.62	0.02		
Observer E	80.00 %	**0.38**	**0.12**		
Olomouc	70.00 %	0.78	< 0.01	0.84	< 0.01
Observer A	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer B	80.00 %	0.62	0.03	0.75	< 0.01
Observer C	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer D	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer E	90.00 %	0.80	< 0.01	0.88	< 0.01
Plzeň	80.00 %	0.84	< 0.01		
Observer A	80.00 %	0.60	0.02		
Observer B	100%	1.00	< 0.01		
Observer C	100%	1.00	< 0.01		
Observer D	90.00 %	0.80	< 0.01		
Observer E	90.00 %	0.80	< 0.01		

Praha	72.00 %	0.77	< 0.01	0.81	< 0.01
Observer A	88.00 %	0.67	< 0.01	0.70	< 0.01
Observer B	96.00 %	0.89	< 0.01	0.91	< 0.01
Observer C	100%	1.00	< 0.01	1.00	< 0.01
Observer D	84.00 %	0.53	< 0.01	0.63	< 0.01

Lions

H_{01A}: There is no agreement among the observers.

H_{11A}: There is an agreement among the observers.

Chart 3: Among-observers agreement - lions

Lions ZOO	Agreement	Fleiss' Kappa	p	Kendall's Coef. of Concordance	p
Hodonín	73.33 %	0.71	< 0.01	0.82	< 0.01
Liberec	70.00 %	0.70	< 0.01	0.81	< 0.01
Olomouc	80.00 %	0.85	< 0.01	0.97	< 0.01
Plzeň	60.00 %	0.63	< 0.01	0.82	< 0.01
Praha	66.67 %	0.60	< 0.01		

H_{02A}: There is no agreement between the scores given by the individual observer and the MBCS.

H_{12A}: There is an agreement between the scores given by the individual observer and the MBCS.

Chart 4: Individual observers vs. MBCS - lions

Lions ZOO	Agreement	Cohen's/Fleiss' Kappa	p	Kendall's Coef. of Correlation	p
Hodonín	73.33 %	0.82	< 0.01	0.86	< 0.01
Observer A	86.67 %	0.71	< 0.01	0.79	< 0.01
Observer B	93.33 %	0.86	< 0.01	0.87	< 0.01
Observer C	93.33 %	0.86	< 0.01	0.92	< 0.01
Observer D	93.33 %	0.84	< 0.01	0.85	< 0.01
Observer E	93.33 %	0.84	< 0.01	0.85	< 0.01
Liberec	70.00 %	0.82	< 0.01	0.86	< 0.01
Observer A	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer B	80.00 %	0.64	< 0.01	0.74	< 0.01
Observer C	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer D	90.00 %	0.82	< 0.01	0.86	< 0.01
Observer E	100%	1.00	< 0.01	1.00	< 0.01

Olomouc	80.00 %	0.91	< 0.01	0.96	< 0.01
Observer A	100%	1.00	< 0.01	1.00	< 0.01
Observer B	80.00 %	0.70	< 0.01	0.88	< 0.01
Observer C	100%	1.00	< 0.01	1.00	< 0.01
Observer D	100%	1.00	< 0.01	1.00	< 0.01
Observer E	90.00 %	0.80	< 0.01	0.94	< 0.01
Plzeň	60.00 %	0.76	< 0.01	0.85	< 0.01
Observer A	85.00 %	0.74	< 0.01	0.84	< 0.01
Observer B	75.00 %	0.59	< 0.01	0.75	< 0.01
Observer C	85.00 %	0.74	< 0.01	0.80	< 0.01
Observer D	90.00 %	0.82	< 0.01	0.95	< 0.01
Observer E	95.00 %	0.91	< 0.01	0.95	<0.01
Praha	72.00 %	0.77	< 0.01	0.81	<0.01
Observer A	88.00 %	0.67	< 0.01	0.70	< 0.01
Observer B	96.00 %	0.89	< 0,01	0.91	< 0,01
Observer C	100%	1.00	< 0.01	1.00	< 0.01
Observer D	84.00 %	0.53	< 0.01	0.63	< 0.01

Brno: The maximal deviation of individual observer's score from MBCS was 0.4, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.4.

Hodonín: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.4.

Jihlava: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.4.

Liberec: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.2.

Olomouc: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.2.

Plzeň: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.2.

Praha: The maximal deviation of individual observer's score from MBCS was 0.2, the maximal difference among total (exact mean) scores given to the same animal individual by all of the observers was 0.2.

4.2.4. Inter-Observer Reliability – "Two Observers"

Tigers

H_{01B}: There is no agreement between the observers.

H_{11B}: There is an agreement between the observers.

The agreement on the scores between observers reached 78.46 %, Cohen's Kappa 0.65 ($p < 0.01$), Kendall's Coefficient of Concordance 0.89 ($p < 0.01$).

H_{02B}: There is no agreement between the scores given by the individual observer and the MBCS.

H_{12B}: There is an agreement between the scores given by the individual observer and the MBCS.

Chart 5: Two Observers – tigers

Tigers / Observer	Agreement	Cohen's/Fleiss' Kappa	p	Kendall's Coef. of Correlation	p
A	84.62 %	0.75	< 0.01	0.83	< 0.01
B	90.77 %	0.85	< 0.01	0.88	< 0.01

Lions

H_{01B}: There is no agreement between the observers.

H_{11B}: There is an agreement between the observers.

The agreement on the scores between observers reached 69.09 %, Cohen's Kappa 0.52 ($p < 0.01$), Kendall's Coefficient of Concordance 0.88 ($p < 0.01$).

H_{02B}: There is no agreement between the scores given by the individual observer and the MBCS.

H_{12B}: There is an agreement between the scores given by the individual observer and the MBCS.

Charts 6: Two Observers - Lions

Lions Observer	Agreement	Cohen's/Fleiss' Kappa	p	Kendall's Coef. of Correlation	p
A	87.27 %	0.81	< 0.01	0.89	< 0.01
B	81.82 %	0.72	< 0.01	0.83	< 0.01

4.2.5. Intra-Observer Reliability

Observer A - Tigers

The agreement among the scores given to the same animal individual by the observer B reached 60.00 %, Fleiss' Kappa 0.63 ($p < 0.01$), Kendall's Coefficient of Concordance 0.94 ($p < 0.01$).

The maximal difference among total (exact mean) scores given to the same animal individual was 0.6.

Observer A - Lions

The agreement among the scores given to the same animal individual by the observer A reached 60.00 %, Fleiss' Kappa 0.59 ($p < 0.01$), Kendall's Coefficient of Concordance 0.85 ($p < 0.01$).

The maximal difference among total (exact mean) scores given to the same animal individual was 0.4.

Observer B – Tigers

The agreement among the scores given to the same animal individual by the observer B reached 82.00 %, Fleiss' Kappa 0.84 ($p < 0.01$), Kendall's Coefficient of Concordance 0.98 ($p < 0.01$).

The maximal difference among total (exact mean) scores given to the same animal individual was 0.2.

Observer B - Lions

The agreement among the scores given to the same animal individual by the observer B reached 80.00 %, Fleiss' Kappa 0.81 ($p < 0.01$), Kendall's Coefficient of Concordance 0.94 ($p < 0.01$).

The maximal difference among total (exact mean) scores given to the same animal individual was 0.2.

5. Discussion

5.1. Body Condition Score Cards Creation

5.1.1. Examination of the individuals

Considering the character of species of interest, the standard way of keeping them and the impossibility of regular palpation without immobilisation of the individual, the visual BCS system was chosen as the most practical and the easiest to use.

Even though there exists a BCS system for American Black Bears (*Ursus americanus*) using the palpation as the examination technique (Noyce et al., 2002) or BCS system for lioness modelled after the Purina Body Condition Tool for the Domestic Cat *Felis catus* combining the visual assessment and palpation (Daigle et al., 2015), both were developed for a single use in research on relationship between maternal nutrition and reproduction parameters in female American Black Bears and in multi-institutional survey examining the effects of a breeding moratorium on *Panthera leo* population. The systems developed for regular assessment of BCS of larger carnivores, lions (AZA Lion Species Survival Plan, 2012) or cheetahs (Dierenfeld et al., 2007, modified by Reppert et al., 2011), are using the visual assessment only.

5.1.2. Representation of the categories

The combination of pictorial and descriptive representation of the categories appeared to support the best the effort to make the BCS Cards as illustrative as possible.

Scales based only on descriptions of changes on chosen body areas are practical in cases of examining animals by palpation (Woolnough et al., 1997; Bray and Edwards, 2001; Noyce et al., 2002; Negretti et al., 2007; Lane et al., 2014). Simplified schematic pictures of concrete animal's body parts are also suitable as instructive material for palpation or examination combining palpation and visual estimation of BCS (Mendizabal, 2011). However, for the visual assessment without the possibility to support the observation with palpation the description itself seems to be too prone to biases due to very high demands on observer's identification with the terminology and imagination (see Clauss et al., 2009).

Drawn pictures were preferred over the photographs because of the possibility to generalize the appearance of the model, eliminate the individual peculiarities of the displayed animal and emphasize the features to be assessed (see Reuter and Adcock, 1998;

Alberta Agriculture, Food and Rural Development, 2004; Dierenfeld et al., 2007; Clingerman and Summers, 2012). Even though the scales with photos, especially colourful ones, could be really illustrative (see Wemmer et al., 2006; Morfeld et al., 2014), the displayed animals are specific individuals and manifestation of the features to be assessed would not be necessarily fully representative. Also the way of taking photo, animal's position, light conditions or hair pattern could cause confusion in deciding about the score and reaching the photographic material of sufficient quality showing animals of low nutritional status would be barely possible in conditions of captive breeding (see Reppert et al., 2011; AZA Lion Species Survival Plan, 2012)[3].
The drawn pictures on the other hand certainly require higher level of imagination and determination of the observer.

Great attention was paid to the formulation of the descriptions of the features to be assessed and to the terminology used for each of the categories to prevent the systematic and emotional bias of the assessments. Terminology advised by Reppert et al. (2011) using the neutral terms without pejorative undertone was adapted for the BCS Cards created.

The vital importance of quality of illustrative pictures and descriptions of the categories of the BCS system stress also Reuter and Adcock (1998): "During the study it was apparent, that the subjectivity of a descriptive scale scoring system led to assessor bias, i.e. a tendency for some assessors to score consistently high or low. More detailed description of the body regions to be assessed and better pictures to illustrate the specific characteristics of each body condition score will help to minimise such assessor bias, thus providing a standardised reliable and repeatable body condition scoring system."

5.1.3. Choice of the features to be assessed

The identification of the body areas with the most significant changes among the categories was based on sets of digital pictures, because a direct observing of sufficient amount of individuals in various life stages and nutritional statuses would not be possible regarding the character of the captive population of the species of interest.
Similar technique was used by Wemmer (2006), Reppert et al. (2011), AZA Lion Species Survival Plan (2012) or Morfeld et al. (2014) while calibrating the BCS systems.

[3] Illustrative pictures (Picture I and II) are added in Annex.

5.1.4. Assessment procedure

Trying to reach the highest possible level of reliability and repeatability the BCS Cards were created so the observers would assess each feature separately and out of those scores the total BCS would be calculated (Reuter and Adcock, 1998). For the same purpose also detailed description of the assessment procedure and notes to the assessed features were included as a part of the cards.

5.2. Testing of the BCS cards reliability

5.2.1. Inter-Observer Reliability – Institutional

Agreement among observers

In case of Tiger BCS Card the percent agreement among observers at each institution included into the testing ranged between 30 % and 80 % and Fleiss' Kappa values were showing mostly low (0.25-0.47, $p \leq 0.01$) or moderate (0.52-0.67, $p \leq 0.01$) inter-observer agreement with only exception showing high inter-observer agreement (0.75, $p < 0.01$). When possible to be calculated, the Kendall's Coefficient of Concordance values ranged between 0.63 and 0.81 ($p < 0.01$) showing moderate to strong association of observers' assessments.

The p values lower than 0.01 allow the rejection of the H_{01A} and acceptance of the $H_{11A,}$ that there exists an agreement among the observers' assessments.

In case of Lion BCS Card the percent agreement among observers at each institution included into the testing ranged between 60 % and 80 % and Fleiss' Kappa values were showing moderate (0.60-0.63, $p < 0.01$) to high (0.70-0.85, $p < 0.01$) inter-observer agreement. When possible to be calculated, the Kendall's Coefficient of Concordance values ranged between 0.81 and 0.97 ($p < 0.01$) showing strong association of observers' assessments.

The p values lower than 0.01 allow the rejection of the H_{01A} and acceptance of the $H_{11A,}$ that there exists an agreement among the observers' assessments.

Individual observers vs MBCS[4]

In case of Tiger BCS Card the percent agreement of the individual observer's assessments and the institutional MBCS ranged between 70 % and 100 % and Cohen's Kappa values were showing mostly moderate to high (0.53-1.0; $p \leq 0.03$) agreement of the observer's assessments and the MBCS. When possible to be calculated, the Kendall's Coefficient of Correlation values were shoving mostly moderate to strong (0.60-1.0; $p \leq 0.01$) association between observer's assessments and the MBCS.

Those results would allow the rejection of the H_{02A} and acceptance of the H_{12A}, that there exists an agreement between the scores given by the individual observer and the MBCS. However there appeared five observers whose assessments were, according to the values of tests performed, not in agreement with the MBCS.

In case of Lion BCS Card, the percent agreement of the individual observer's assessments and the institutional MBCS ranged between 75 % and 100 % and Cohen's Kappa values ranged between 0.53 and 1.0 ($p < 0.01$) showing moderate to high agreement of the observer's assessments and the MBCS. The Kendall's Coefficient of Correlation values were showing moderate to strong (0.63-1.0, $p < 0.01$) association between observers' assessments and the MBCS. The p values lower than 0.01 allow the rejection of the H_{02A} and acceptance of the H_{12A}, that there exists an agreement between the scores given by the individual observer and the MBCS.

The lower absolute agreement (expressed by Kappa statistics) among observers than between individual observers and the MBCS and also the lower absolute agreement than the association among observers' assessments or between individual observer's assessments and MBCS (expressed by Kendall's coefficients) is influenced by the character of the tested BCS system itself and by the character of tests applied.

The BCS system is forcing the observers to choose between two levels of the muscle and fat cover of the animal individual's body with no possibility to use a half a scores. Therefore, if the Kappa statistics evaluating strictly the existence of an agreement, show lower agreement among the observers than between the individual observer's assessments and the MBCS, it could be assumed that even though not all of the observers always

[4] Illustrative graphs (Graph I-XII) are added in Annex.

agreed on the exact score given to the assessed feature, the agreement on total BCS of the individual was closer to consensus.

Unlike the Kappa statistics, the Kendall's coefficients evaluating the association of observers' assessments do not treat all the disagreements equally. The stronger associations implied by the Kendall's coefficients could indicate that even though the absolute agreement was not reached, the assessments of the individual observers are close to each other.

In practice, at any of the institutions included into the testing the total BCSs given to the same individual by multiple observers did not vary for more than 0.4 score as well as the individual observers total BCSs and the MBCS, which means a difference smaller than a half a score.

Regarding the reported cases of disagreement of individual observer's assessments and MBCS a breach of the BCS procedure is highly probable at least in one of the observers, whose assessments also did not show association with the MBCS (Zoo Hodonín, Observer C), and it could be an explanation in the other cases as well. To exclude the possibility of biased assessments even when the BCS procedure is strictly followed further investigation would be needed.

Kristensen et al. (2006), who was comparing an agreement of assessments of observers naïve and trained in BCS, discovered significant difference between those two groups of observers and also greater variability (Kappa values ranging between 0.17 and 0.78) in absolute agreement of the assessments of the naïve observers, than was detected in the testing of the Institutional Inter-Observer Variability, where basically all of the observers could be considered naïve, since only two of them had previous practical experience with BCS.

5.2.2. Inter-Observer Reliability – "Two Observers"

Agreement between observers

In case of Tiger BCS Card the percent agreement between observers (78.46 %), Cohen's Kappa (0.65, $p < 0.01$) and the Kendall's Coefficient of Concordance (0.89, $p < 0.01$) allow the rejection of the H_{01B} and the acceptance of the H_{11B} that there exists an agreement between the observers' assessments.

In case of Lion BCS Card the percent agreement between observers (69.09 %), Cohen's Kappa (0.52, $p < 0.01$) and the Kendall's Coefficient of Concordance (0.88, $p < 0.01$) allow the rejection of the H_{01B} and the acceptance of the H_{11B} that there exists an agreement between the observers' assessments.

As discussed above, while the Kappa statistics are showing rather moderate agreement of observers' assessments, the Kendall's Coefficient of Concordance is showing strong association of the assessments which would imply that the observers are applying the same standards when assessing the animals.

Individual observers vs. MBCS[5]

The high agreement (81.82-90.77 %; Cohen's Kappa values ranging between 0.72 and 0.85 with $p < 0.01$) and strong association (Kendall's Coefficient of Correlation values ranging between 0.83 and 0.89 with $p < 0.01$) between the observer's assessments and the institutional MBCSs in case of both Tiger and Lion BCS Cards allow the rejection of the H_{02B} and acceptance of the H_{12B}, that there exists an agreement between the scores given by the individual observer and the MBCS.

The results of the "Two Observers" Inter-Observer Reliability testing correspond with the results of the "Institutional" analysis regarding the lower absolute agreement among observers and strong association of their assessments and they are also comparable to results of experienced observers mentioned by Kristensen et al. (2006) (Kappa ≤ 0.75) or by Clingerman and Summers (2012) (Kappa ≤ 0.85).

5.2.3. Intra-Observer Reliability

In case of both observers the moderate to high agreement (60.00-82.00 %; Fleiss' Kappa values ranging between 0.59 and 0.84 with $p < 0.01$) and strong association (Kendall's Coefficient of Concordance values ranging between 0.85 and 0.97 with $p < 0.01$) among the scores given by each observer allow the rejection of H_{03} and the acceptance of H_{13} that there exists an agreement among the scores repeatedly given by the individual observer to the same animal individual under the same conditions.

[5] Illustrative graphs (Graph XIII and Graph XIV) are added in Annex.

Values reached by the Observer A, the lower absolute agreement but strong association of the scores, correspond with the results of the Inter-Observer reliability testing.

Clingerman and Summers (2012), who also tested the Intra-Observer reliability, reached percent agreement of 93.30 % up to 100 % and absolute agreement (Kappa) values ranging between 0.58 and 0.79. Morfeld et al. (2014) reached percent agreement of 88.00-95.00 % and absolute agreement (Kappa) ranging between 0.80 and 0.90.

The tests performed were in general showing lower absolute agreement than association of the assessments. Since the variability of the assessments was in all of the cases limited to the observers deciding between the same two categories, the absolute agreement might be increased by either allowing the observers to use half a scores (see Reuter and Adcock, 1998 modified by Edwards et al., 2015) or splitting the scale into subcategories (see Dierenfeld et al., 2007, modified by Reppert et al., 2011). Anyway, even without those modifications the assessments based on the BCS Cards created are showing little difference (max. 0.4 score for Inter-Observer Reliability and 0.6 score for Intra-Observer Reliability) in the total scores calculated for each animal (see Clingerman and Summers, 2012).

6. Conclusion

The aim of the thesis was to provide precisely described versatile BCS system which could be used by various observers uniformly across animals and facilities.

Even though there appeared variability in the level of agreement among observers, regarding the fact that the most of them were naïve to practical application of BCS and had various theoretic knowledge of the condition scoring and also of the species of interest, the results reached did confirm the reliability of the BCS Cards created, as well as the comparison with studies of other authors with similar objectives.

Ideally, if used as a breeding management tool, BCS should be assessed periodically with a regular time interval between scorings and to reach more detailed information understandable in context of animal individual's health, life stage and environment, the BCS should become a part of the routine observations done by the keeper or person responsible for the breeding.

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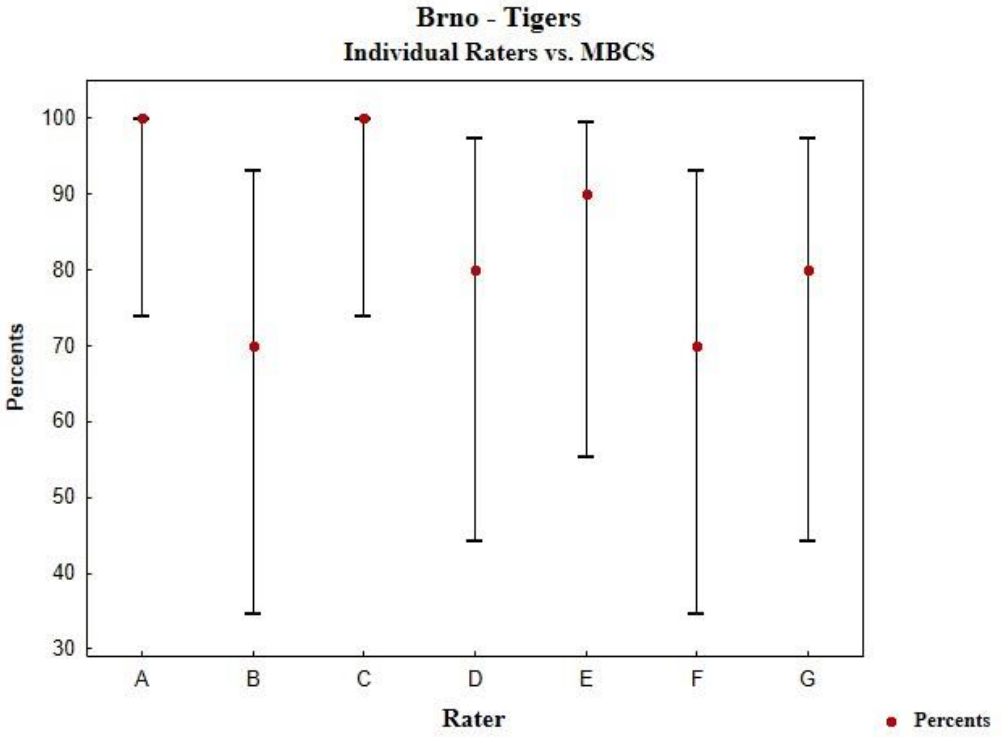
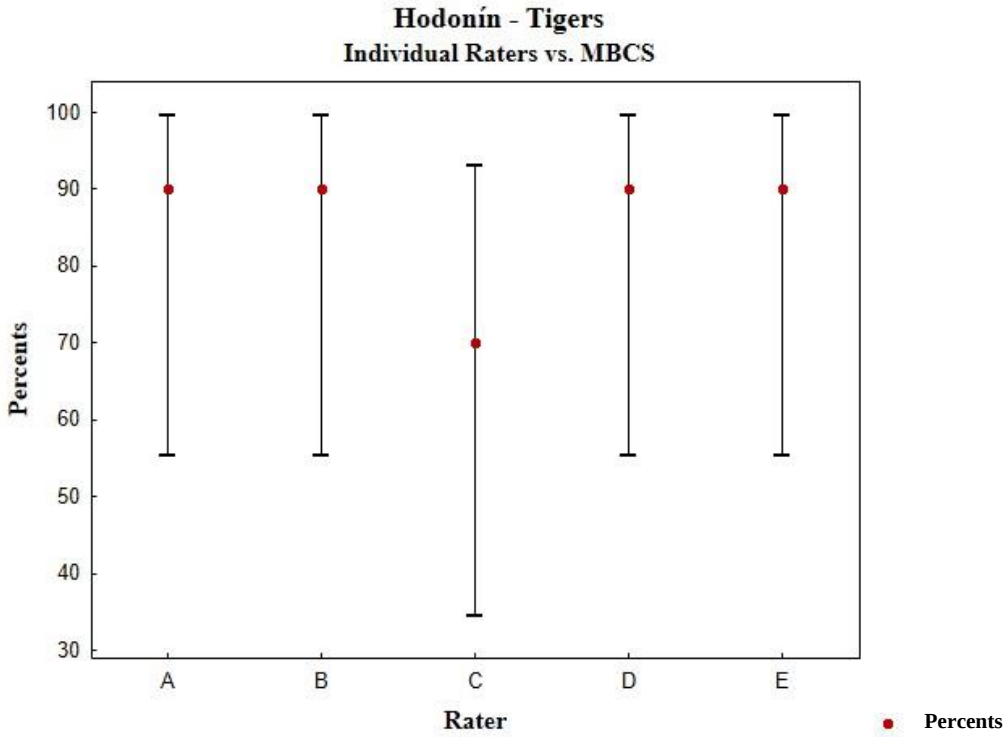
Annex

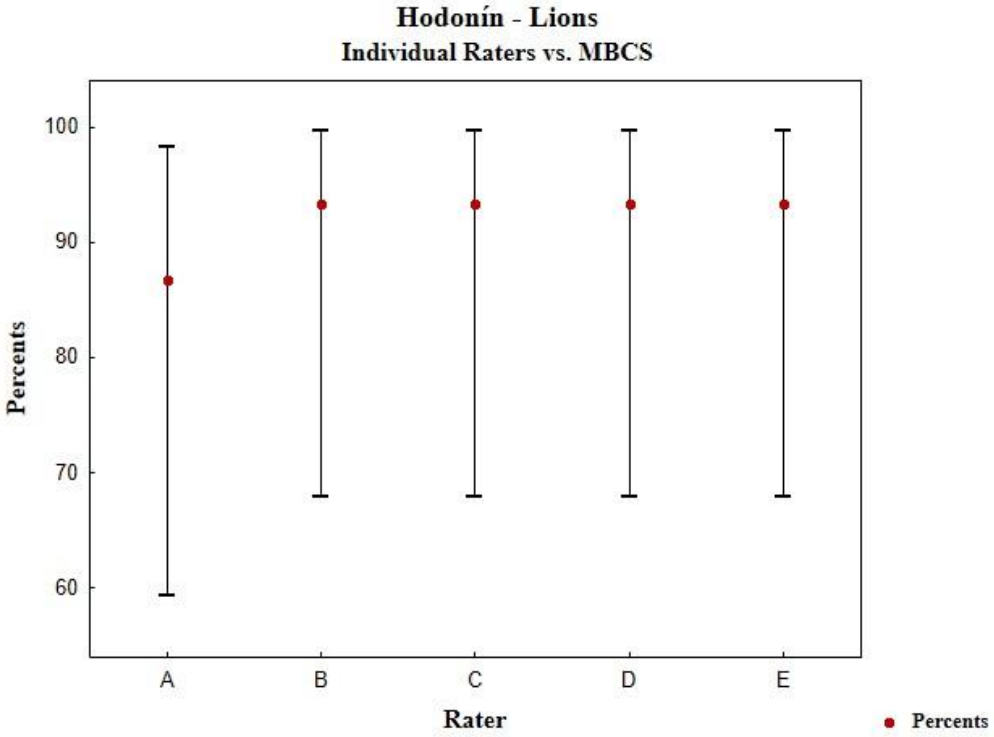
Individual observers to MBCS (institutional)



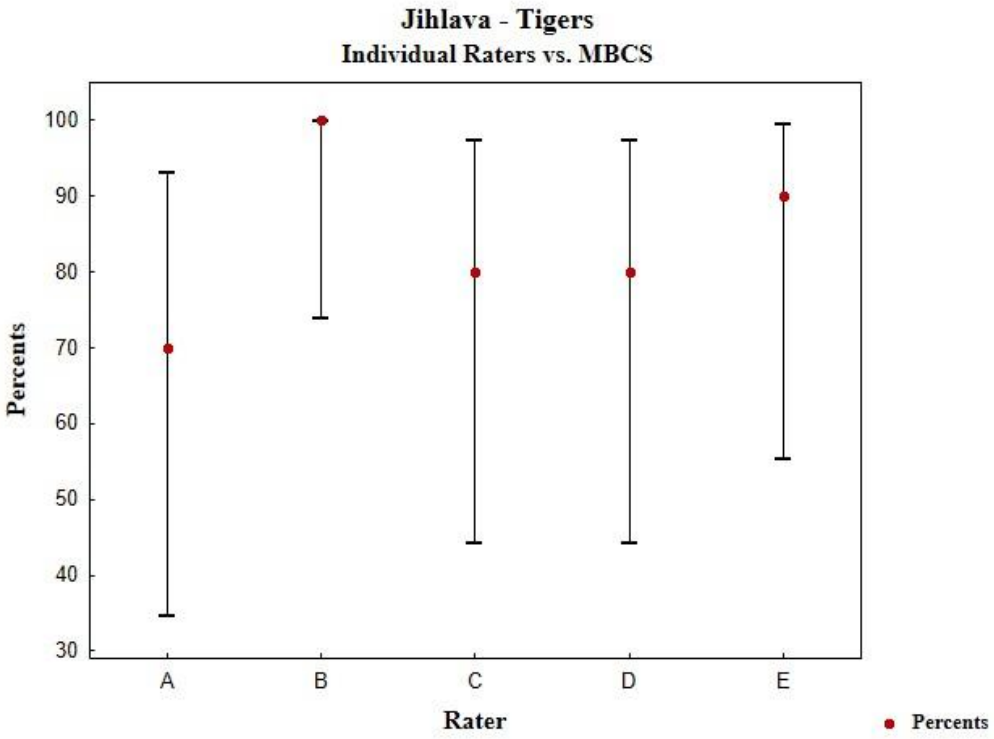
Graph I: Brno – tigers



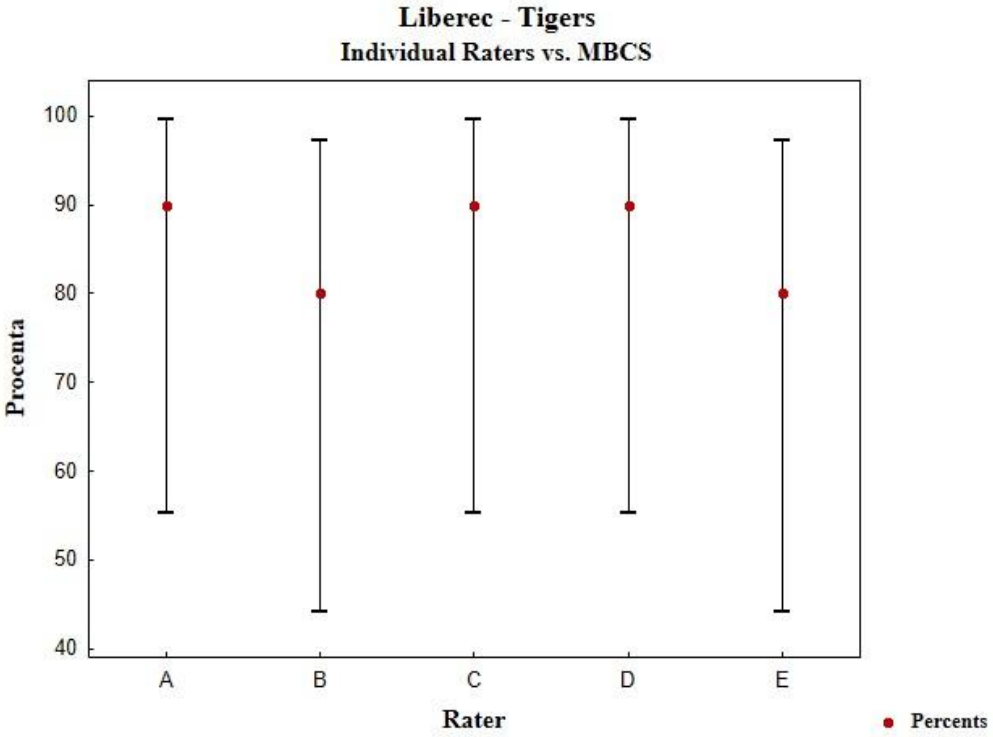
Graph II: Hodonín – tigers



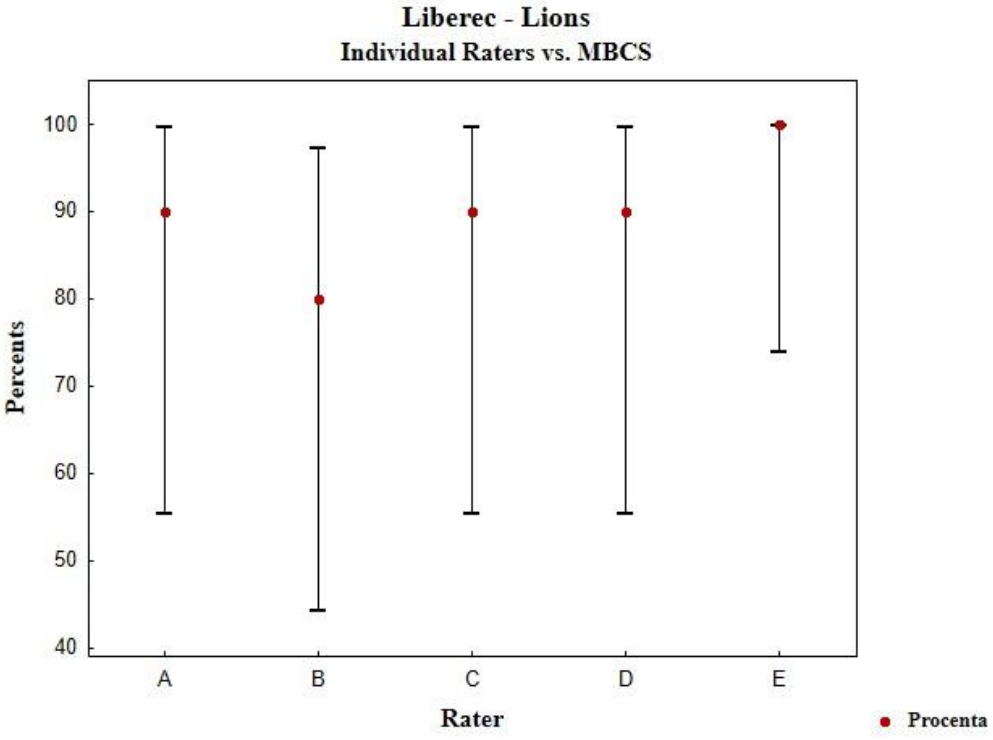
Graph III: Hodonín – lions



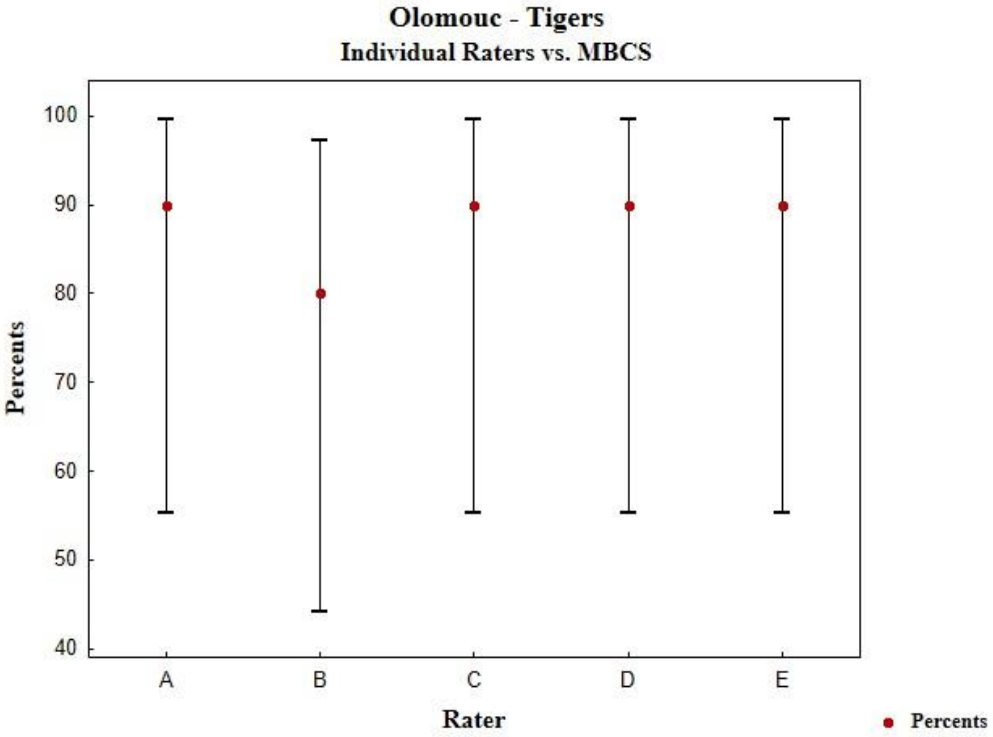
Graph IV: Jihlava – tigers



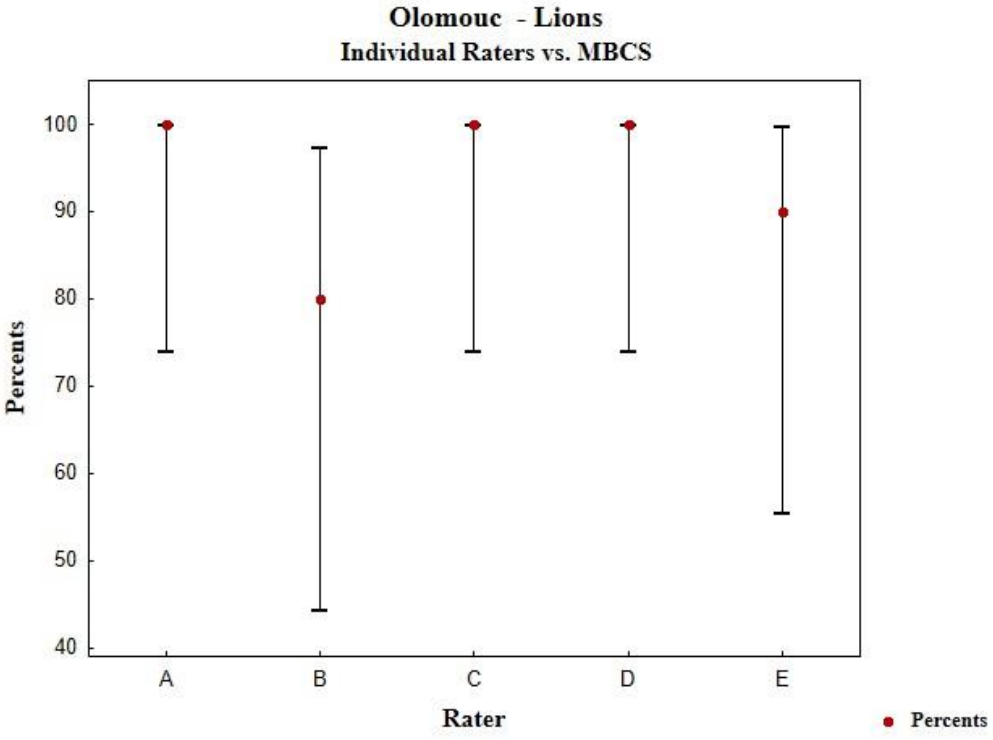
Graph V: Liberec – tigers



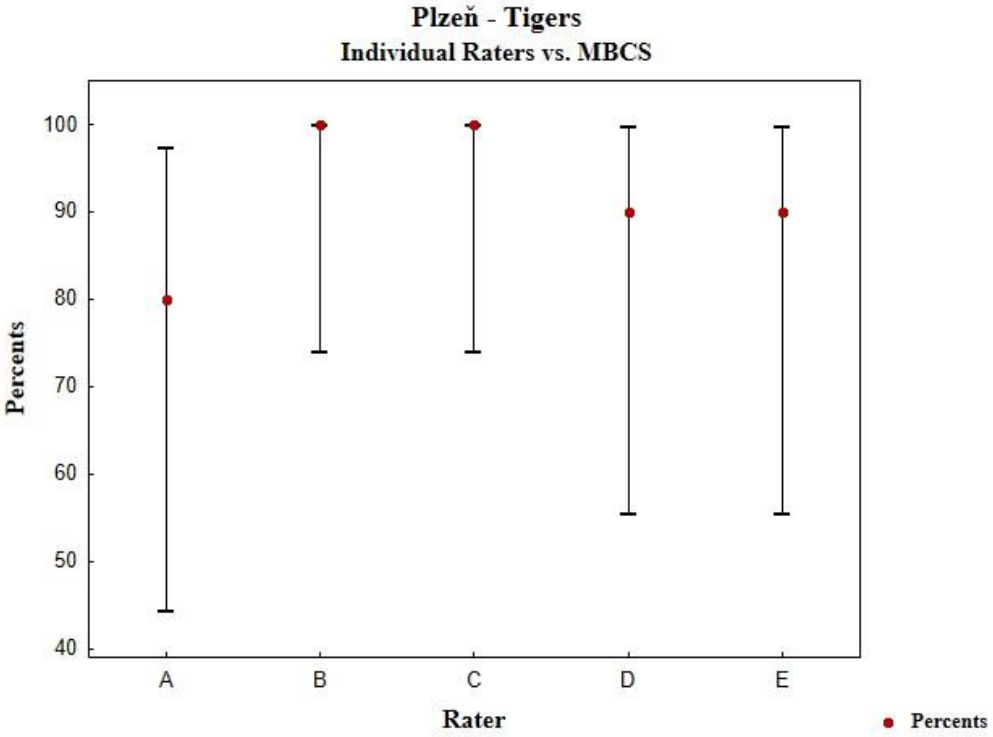
Graph VI: Liberec - lions



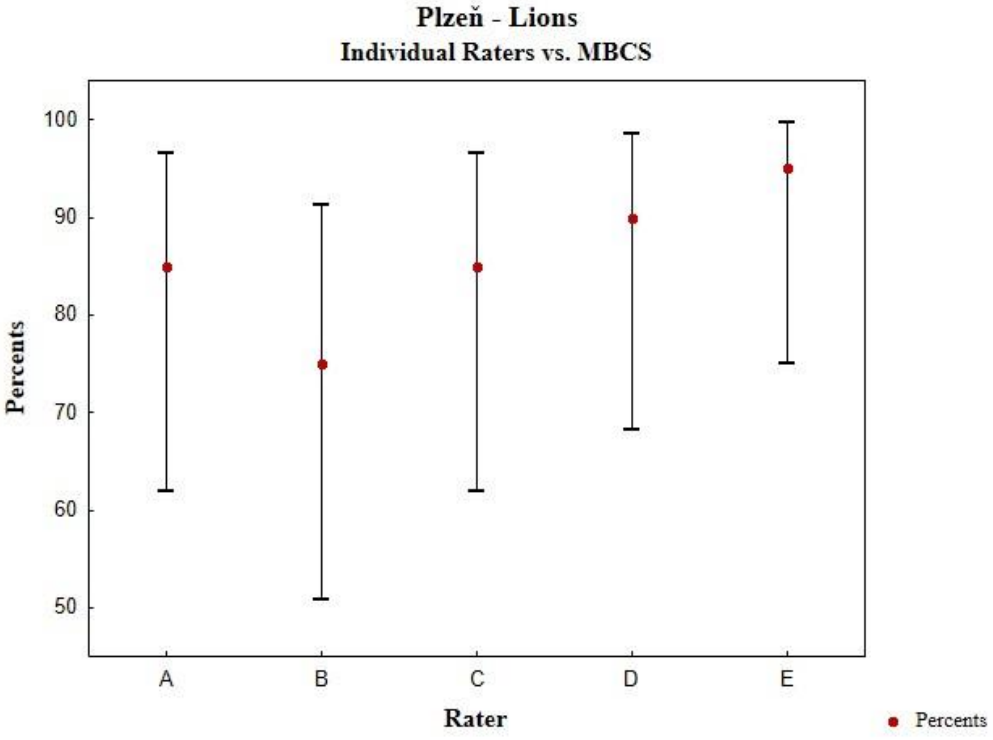
Graph VII: Olomouc – tigers



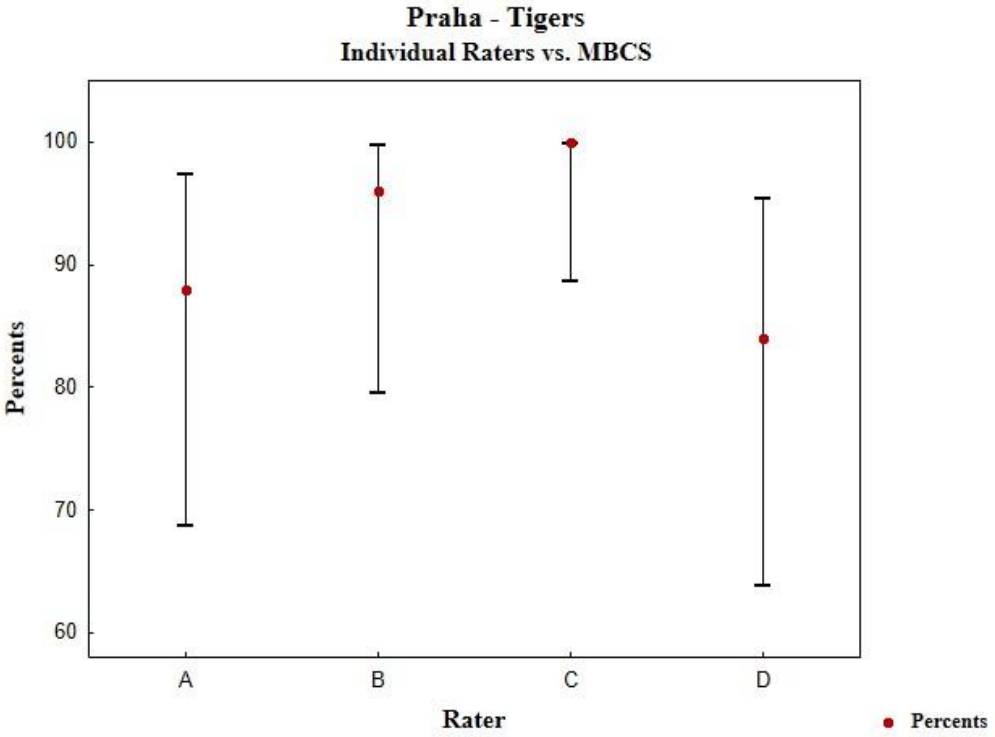
Graph VIII: Olomouc – lions



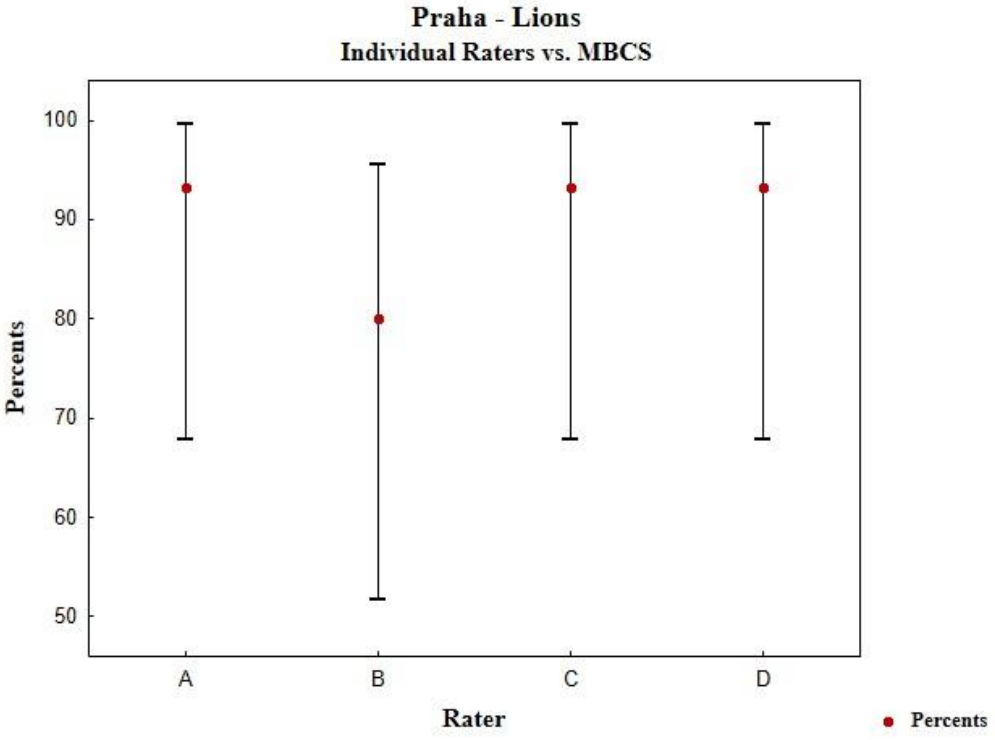
Graph IX: Plzeň – tigers



Graph X: Plzeň – lions

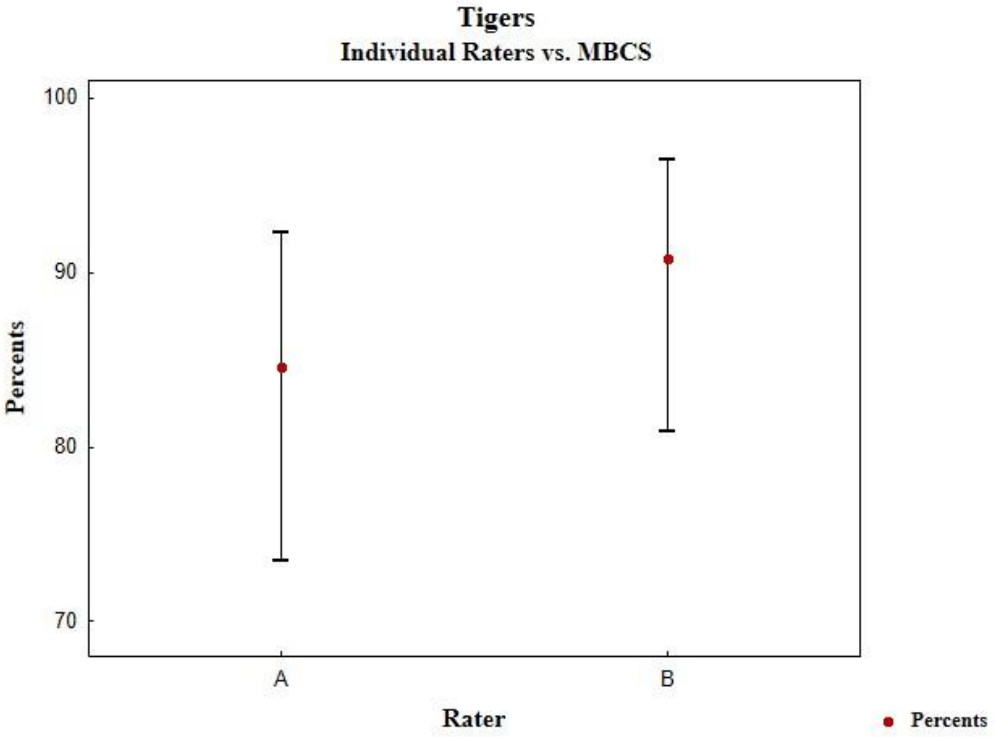


Graph XI: Praha – tigers

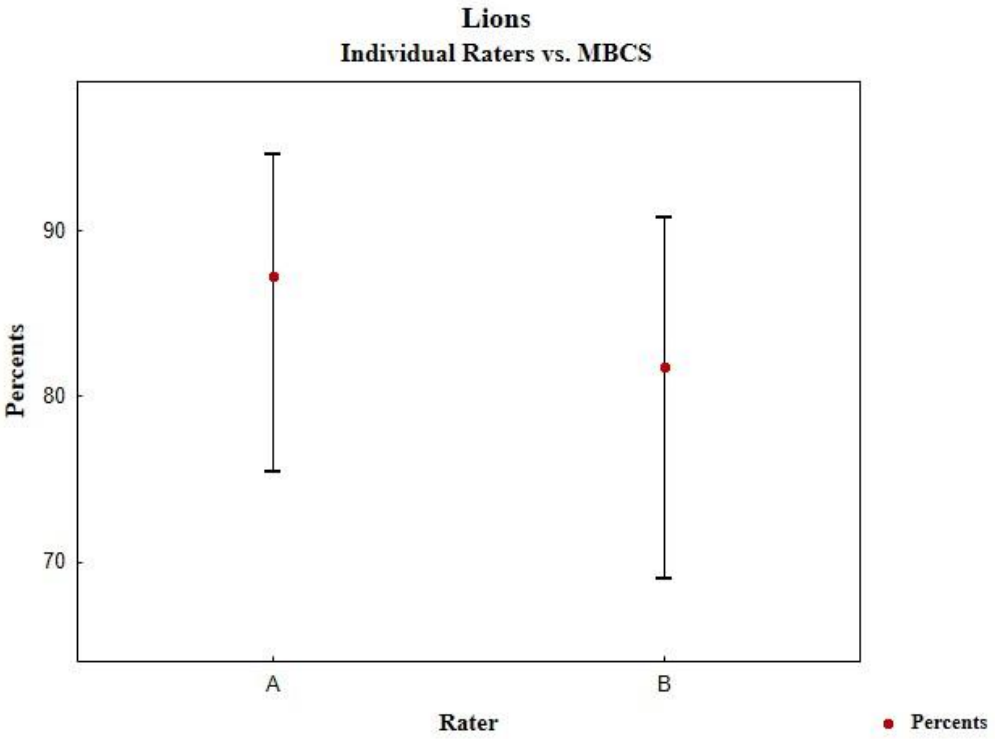


Graph XII: Praha – lions

Individual observers vs. MBCS ("Two Observers")



Graph XIII: Two Observers – tigers



Graph XIV: Two Observers – lions

Examples of BCS systems mentioned

(1) Extreme Low (emaciated, no fat covering, skeleton visible) 	**Forequarters:** Neck thin & deeply shrunken. Shoulder wasted, vertical line of scapula visible. Angles of shoulder blade & arm sharp. Bones & joints clearly visible. **Midsection:** Multiple ribs visible with deep depressions between. Individual vertebrae visible. Waist shrunken & tucked. Sharp angles dividing shoulder, torso & hip. **Hindquarters:** Point of hip & ischium sharp & clearly visible. Bones of leg (femur & knee) clearly visible. Flank sunken. Sacral vertebrae visible. Tail base protruding above hip.
(2–3) Low (minimal fat covering, articulations angular & some bones visible) 	**Forequarters:** Neck thin & shrunken, sinews apparent but flowing into shoulder. Angles & bones of shoulder & arm prominent but with slight covering. Peak of scapula prominent. **Midsection:** Multiple ribs visible; abdominal muscles may be apparent. Vertebrae may be visible. Waist/belly shrunken & tucked. Abdominal skin flap may be apparent but not filled. Clear definition between shoulder, torso & hip. **Hindquarters:** Point of hip prominent but slightly covered. Ischium visible but blunt. Muscle & bones of upper leg angular but softened by slight covering. Sacrum flat or slightly depressed. Tail base becoming visible.
(4) Moderate/Low (slight fat covering, bones barely noticeable, articulations apparent but smooth) 	**Forequarters:** Neck cylindrical but discernible from shoulder. Muscles of shoulder apparent but slightly smooth. Peak of scapula apparent. **Midsection:** Some ribs visible; abdominal muscles apparent. Vertebrae rarely visible. Waist evident. Abdominal skin flap may be apparent with nominal filling. Smooth but noticeable delineation between shoulder, torso & hip. **Hindquarters:** Point of hip visible but covered. Ischium noticeable but rounded. Muscles of upper leg apparent & smoothed by slight fat covering. Sacrum sloped, but beginning to fill & round.

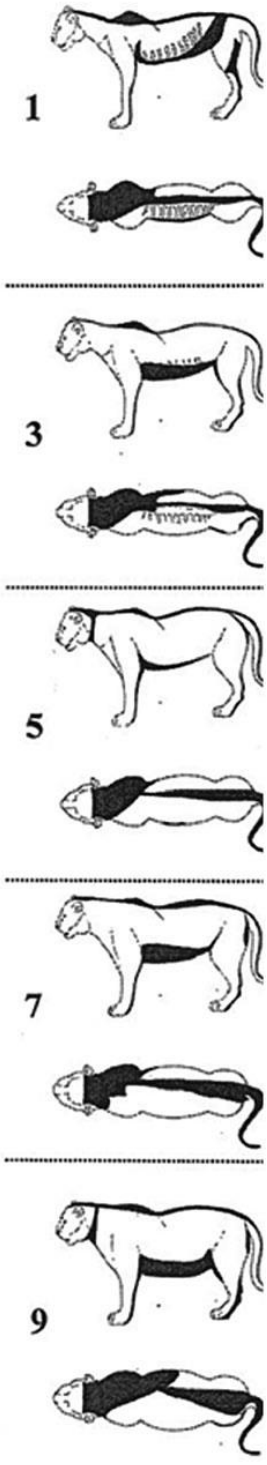
Picture I: Lowest categories of the Lion BCS system (AZA Lion Species Survival Plan, 2012)

(1) Extreme Low

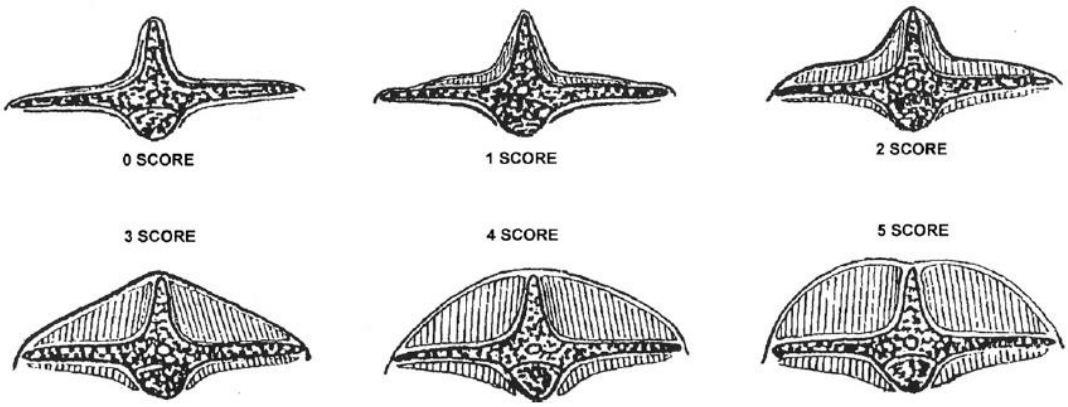
- Animal emaciated, skeletal, with noticeable muscle wasting and no visible fat covering.
- Torso expected to have no visible covering; ribs may be visible.
- Individual lumbar vertebrae are sharply apparent.
- Transitions between shoulder, torso, and hip are sharply exaggerated.
- Femur, point of hip, point of buttocks and tail head are sharply apparent.
- Bones of tail may be visible.

Picture II: Lowest category of the Cheetah BCS system (Reppert et al., 2011)

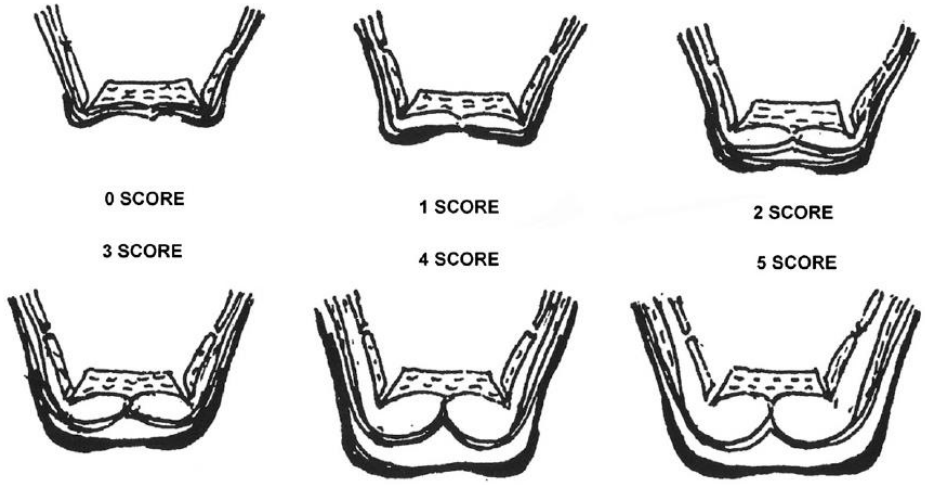
SCORE	DESCRIPTION
1	Ribs visible; no palpable fat; severe abdominal tuck; lumbar vertebrae and wings of ilea easily palpated
2	Ribs easily visible; lumbar vertebrae obvious with minimal muscle mass; pronounced abdominal tuck; no palpable fat
3	Ribs easily palpable with minimal fat covering; lumbar vertebrae obvious; obvious waist behind ribs; minimal abdominal fat
4	Ribs palpable with minimal fat covering; noticeable waist behind ribs; slight abdominal tuck; abdominal fat pad present
5	Well-proportioned; observe waist behind ribs; ribs palpable with slight fat covering; abdominal fat pad minimal
6	Ribs palpable with slight excess fat covering; waist and abdominal fat pad distinguishable but not obvious; abdominal tuck absent
7	Ribs not easily palpated with moderate fat covering; waist poorly discernible; obvious rounding of abdomen; moderate abdominal fat pad
8	Ribs not palpable with excess fat covering; waist absent; obvious rounding of abdomen with prominent abdominal fat pad; fat deposits present over lumbar area
9	Ribs not palpable under heavy fat cover, heavy fat deposits over lumbar area, face and limbs; distention of abdomen with no waist; extensive abdominal fat deposits



Picture III: BCS system for lioness modelled after Purina Body Condition Tool for the Domestic Cat *Felis catus* (Daigle et al., 2015)



Picture IV: Illustrative pictures for Sheep BCS (Mendizabal, 2011)



Picture V: Illustrative pictures for Goats BCS (Mendizabal, 2011)