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RESEARCH ARTICLE

# A Visual System for Scoring Body Condition of Asian Elephants (*Elephas maximus*)

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A body condition score (BCS) may provide information on the health or production potential of an animal; it may also reflect the suitability of the environment to maintain an animal population. Thus assessing the BCS of Asian elephants is important for their management. There is a need for a robust BCS applicable to both wild and captive elephants of all age categories based on the minimum and maximum possible subcutaneous body fat and muscle deposits. The visually based system for scoring the body condition of elephants presented here satisfies these criteria and is quick, inexpensive, non-invasive and user-friendly in the field. The BCS scale correlates ($P < 0.05$) with morphometric indices such as weight, girth, and skin fold measures. Zoo Biol. XX:XX–XX, 2014. 

**Keywords: health care; body weight; shoulder height; skin fold thickness**

## INTRODUCTION

Body condition score (BCS) is a subjective tool to assess the amount of metabolizable energy stored in body fat (primarily subcutaneous) and muscle tissues of a live animal [Edmonson et al., 1989; Burkholder, 2000; Alapati et al., 2010]. Body condition is an index of an animal's health [Terranova and Coffman, 1997]. An increase or decrease in body condition may signify a change in quality of management or environment in which an animal lives.

Riney [1960] underlines the need for the development of a non-invasive method to study the BCS of animals of both sexes and all age groups under the existing game laws. In this publication we introduce a detailed, non-invasive, visually based, and user friendly, 10-point scale to assess the body condition of the Asian elephant (*Elephas maximus*) in the wild and in captivity.

Both Wemmer et al. [2006] and Fernando et al. [2009] have already proposed visually based body condition scoring systems for Asian elephants. However, Wemmer et al. [2006] developed their scale based on observations on captive elephants while Fernando et al. [2009] have established their scale only for wild elephants in Sri Lanka. Ideally, as Burkholder [2000] points out, the minimum and maximum BCS should correspond to the minimum and maximum body fat for the particular species under study. The 10-point scale that we have developed is based on the observations made

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both in the wild and in captivity of emaciated and extremely obese Asian elephants of both sexes and all age categories.

## METHOD

In order to develop the BCS scale, direct observations were carried out on elephants in the wild and in captivity (in Sri Lanka, $n = 27$ and in the USA, $n = 31$). Each elephant was photographed and scrutinized closely to develop the BCS scale by the principal author. Information on weight and morphometric measurements was collected from captive elephants in Sri Lanka and in the USA to support the BCS scale. Elephants were weighed (in kilograms), using a portable electronic scale in Sri Lanka [Wijeyamohan et al., 2010] and on standard scales in the USA. The height and length of elephants were measured (in centimeters) using the parallel laser beam photogrammetric technique [Wijeyamohan et al., 2012]. Whenever possible, morphometric measurements, such as neck girth, chest girth, hind girth, were obtained (in centimeters) using a flexible tape measure. In addition, skin fold measurements from below the neck, angle between foreleg and body, angle between body and hind leg and from the "V" shaped skin fold below the anus were obtained (in millimeters) using the Lange Skin fold Caliper.

Our body condition scoring system is based on the extent of visibility of depressions around bone structures when an elephant is viewed laterally. Depressions around bones become prominent as an animal loses its subcutaneous fat deposits and muscles in the region concerned, thereby making bones appear more prominent. Notable bone structures observed include skull, vertebral column, ribs, and the bones of the pelvic and pectoral girdles. On the head, we observed a depression between the eye and the frontal ridge. On the body, anterior and posterior margins of the scapula, along the vertebral column, space in between the ribs and anterior margin of the ilium were observed for depressions (Fig. 1).

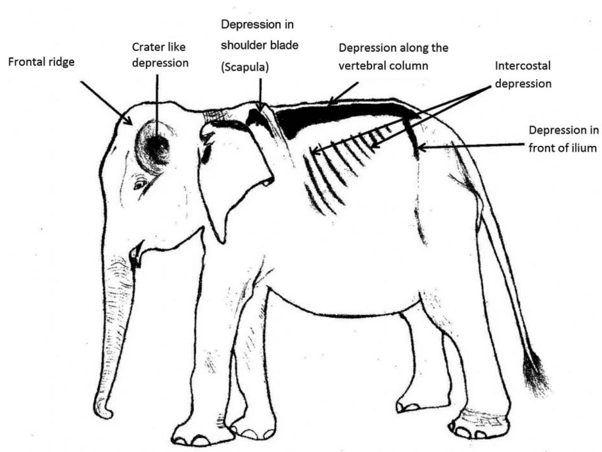


Fig. 1. Sketch of an emaciated elephant showing all the depressions, bones, and spines.

Fig. 2. Body condition score 1, for a captive adult female elephant in Sri Lanka.

Following Fernando et al. [2009], a photo-index of the body condition scoring system based on the photographic data (Figs. 2–11) was prepared.

**Body condition 1 (Fig. 2):** The spaces between the ribs are sunken (intercostal depression), thereby making the ribs very prominent. More than five ribs can be counted very easily. Both pectoral and pelvic bones are prominent and the edges of the scapula and ilium are very well defined. The vertebral column is very prominent and there is a deep depression beneath the anterior end of the vertebral column just behind the scapula. The forehead can be seen with deeply concaved frontal ridges and they form a crater-like deep depression around the temporal region.

**Body condition 2 (Fig. 3):** The spaces between the ribs are not deeply sunken, yet they can still be seen (intercostal depression). The ribs are visible and at least up to five of them can be counted easily. Both pectoral and pelvic bones are prominent and the edges of the scapula and ilium are well defined. The vertebral column is very prominent and the depression at the anterior end of the vertebral column just behind the scapula is somewhat

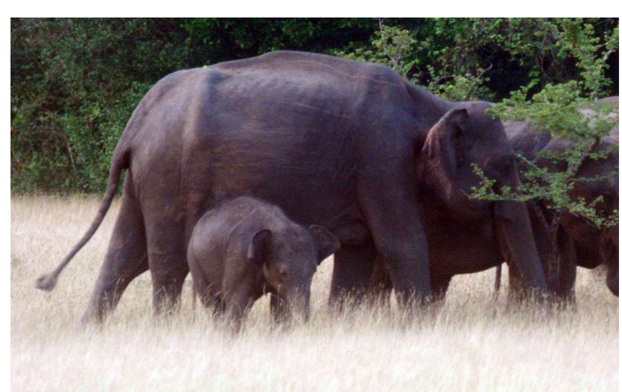

Fig. 3. Body condition score 2, a wild female elephant with her calf in Uda Walawe National Park, Sri Lanka.

Fig. 4. Body Condition Score 3, an adult bull in Uda Walawe National Park, Sri Lanka.

filled. The forehead features a deeply concaved frontal ridge and a crater-like depression around the temporal region.

**Body condition 3 (Fig. 4):** Intercostal depressions are not easily visible. One or two ribs are still prominent. The anterior edge of the scapula is not well demarcated but the posterior margin can still be seen. The pelvic bones can be seen and the anterior margin of the ilium is still prominent. Thus there is a cavity observed along the anterior margin of the ilium. The vertebral column is still prominent and the depression at the anterior end of the vertebral column just behind the scapula is almost filled. The crater-like depression on the head is shallow and the frontal ridge can be easily seen.

**Body condition 4 (Fig. 5):** No ribs are seen. Both the scapula and the pelvic bones are still visible. There are depressions at the posterior edge of the scapula and at the frontal edge of the ilium. The depression in the shoulder blade is still clearly visible. The vertebral column is still prominent. The crater-like depression on the head is very shallow but the frontal ridge could still be easily seen.

Fig. 6. Body condition score 5, an adult bull along electric fence in Uda Walawe National Park in Sri Lanka.

**Body condition 5 (Fig. 6):** Both pectoral and pelvic bones can be seen. The depression in the shoulder blade is not visible. There are depressions seen at the posterior edge of the scapula and frontal edge of the ilium. The crater-like depression on the head is almost filled but the frontal ridge can still be seen.

**Body condition 6 (Fig. 7):** Both pectoral and pelvic bones can be seen but the edges cannot be demarcated properly. There is no cavity or depression at the posterior edge of scapula and anterior edge of the ilium. The vertebral column is almost continuous with the rest of the body. The forehead does not have a crater like depression but the frontal ridge is still visible.

**Body condition 7 (Fig. 8):** Neither the pectoral nor the pelvic bones are prominent. They become visible only when the animal walks. The vertebral column is slightly

Fig. 5. Body condition score 4, an adult bull in Wasgamuwa National Park, Sri Lanka.

Fig. 7. Body condition score 6, an adult female with her new-born calf among the herd in Uda Walawe National Park, Sri Lanka.

Fig. 8. Body condition score 7, an adult bull in Minneriya National Park, Sri Lanka.

Fig. 9. Body condition score 8, an adult bull in full musth in Kaudulla National Park, Sri Lanka.

apparent along the body. No concave areas of the forehead and the frontal ridges are seen.

**Body condition 8 (Fig. 9):** No bone structures are visible even when an elephant is moving. Thick skin folds are seen under the neck. The skin is not wrinkled on the body.

**Body condition 9 (Fig. 10):** Fatter than body condition 8. Very thick, three to four centimeters of skin folds appear while they walk in angle between foreleg and body and below neck.

**Body condition 10 (Fig. 11):** Extremely abnormal obese body condition. Very thick rolls of skin fold below neck, which may measure up to five centimeters.

In parallel, a dichotomous key has also been prepared based on the visible skeletal structures to minimize confusion, particularly when scoring elephants in the wild.

| | | |
|---|---|---|
| (I). | a. Depressions on the skin, skeletal parts visible………… | Go to (II) |
| | b. Skeletal parts not visible………………………………. | Go to (IX) |
| (II). | a. Ribs visible………………………………………………… | Go to (III) |
| | b. Ribs not visible……………………………………………… | Go to (V) |
| (III). | a. More than five ribs visible………………………………. | **BCS 1** |
| | b. Five or less ribs visible…………………………………… | Go to (IV) |
| (IV). | a. Up to five ribs visible……………………………………. | **BCS 2** |
| | b. One or two ribs visible………………………………… | **BCS 3** |
| (V). | a. Scapula and pelvic bones are still visible……………. | Go to (VI) |
| | b. Scapula and pelvic bones are not visible……………… | Go to (VIII) |
| (VI). | a. Depression visible on the scapular blade………………. | **BCS 4** |
| | b. No depression on the scapular blade………………… | Go to (VII) |
| (VII). | a. Depressions behind scapula and in front of the ilium… | **BCS 5** |
| | b. No depression behind scapula and in front of the ilium… | **BCS 6** |
| (VIII). | a. Vertebral column is still visible……………………… | **BCS 7** |
| | b. vertebral column is not visible………………………… | Go to (IX) |
| (IX). | a. No bone structures are seen………………………… | **BCS 8, 9, or 10** |

When there is a confusion between subsequent BCS, the heigher value was always assigned.

All statistical analysis was carried out using SPSS. Correlation coefficient was used to study the relationship between BCS and ratios of various morphometric measurements. Single factor ANOVA was used to study biasness of the BCS between sexes. Significance was defined as $P < 0.05$ and $P < 0.01$.

## RESULTS

Distribution of the BCS is shown in Figure 12. As expected, BCS of the captive elephant population is not normally distributed (Kolmogorov–Smirnov test; $P > 0.05$) with median BCS of 7. However, when the data were split, the Sri Lankan population had median and mode BCS as 6 and the USA population had median and mode BCS as 8.

Change in the weight is the best predictor for change in the BCS, as the latter depends on the subcutaneous fat and muscles. In the meantime, as an elephant grows older, body weight increases with increasing body dimensions such as height, length, girth; around the neck, chest, and hind legs. Therefore weight cannot be directy related with BCS among elephants of diferent ages. Thus the BCS was correlated with the ratios between weight and other morphometric

Fig. 10. Body condition score 9, an adult female elephant in captivity in a fasility in the USA.

Fig. 11. Body condition score 10, a privately owned adult female elephant in captivity in Sri Lanka.

measurements (Table 1). However, BCS can be correlated directly with skin fold measurements irrespective of age categories. As the data were not normally distributed the Spearman rank test was conducted to correlate various variables with BCS (Table 1).

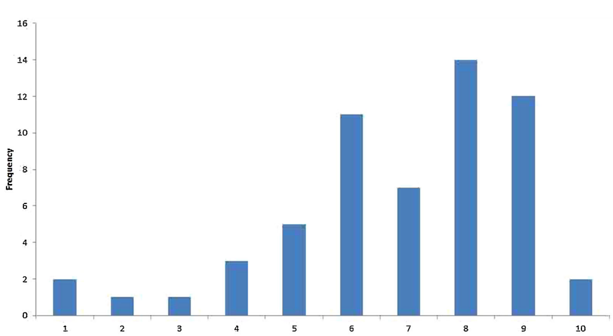


Fig. 12. Frequency histogram of BCS of captive elephants in Sri Lanka and USA ($n = 58$, median $= 7$).

The relationship between height and weight has been studied by many groups without considering BCS [Kurt and Nettasinghe, 1968; Sreekumar and Nirmalan, 1989; Sukumar et al., 1988]. Hile et al. [1997] reported heart girth (chest girth) is the single best parameter to predict body weight. As the BCS is the assessment of the subcutaneous deposition of fat and muscles, when height remains constant, increasing chest girth is an indication of increasing BCS and in turn increasing the body weight. Therefore, we checked the correlation between BCS, weight and chest girth on elephants with same height. In order to group animal by height, we considered elephant height within 4cm difference as similar height elephants. In this category the highest number of individuals that we could group, for meaningful statistical analysis, was between 249 and 252 cm ($n = 7$). Within this group there was a strong correlation between weight and BCS ($P = 0.954$, $P < 0.01$), weight and chest girth (correlation coefficient $= 0.955$, $P < 0.01$) and BCS and chest girth (correlation coefficient $= 0.859$, $P < 0.05$).

Of the two captive populations, the sex ratio (m:f) of the Sri Lankan captive population was 1:1.25. ANOVA (single factor) revealed that the BCS was not biased towards any sex ($P = 0.535$; $f = 4.24$).

## DISCUSSION

A body condition scoring system provides a subjective measure of body fat and energy reserves independent of body weight and frame size [Wildman et al., 1982; Gerhart et al., 1996]. Body condition of a population reflects the status of its habitat. The quantity and quality of food and availability of water are the primary factors determining body condition of elephants in the wild and in captivity. Nevertheless, other factors, such as diseases, inter- and intra-species competitions, behavioral activities and age also play a role. BCS provides valuable information such as health condition, energy reserve, body fat and fitness for reproduction to managers, especially in the case of mammals [Alapati et al., 2010]. Therefore, to monitor an elephant population, whether in captivity or in the wild, BCS is one of the important tools in elephant management.

As pointed out by Alapati et al. [2010], Buckley et al. [2003], and Domecq et al. [1995] non-invasive body condition scoring is universally accepted as it is a quick and inexpensive method to estimate the degree of fatness in domestic animals. However, more invasive methods are availble to study body condition which provide more direct measures. For example, kidney weight [Choquenot, 1991], adrenal weight, fat deposition on ribs, packed cell volume and bone marrow dry weight [Gallivan and Culverwell, 1995]. These techiniques might be used to validate visual assessment systems. Malpas [1977] used the kidney weight and dry bone marrow weight to study the body condition of African elephants.

There are different ways in which animals may be assigned BCSs [Henneke et al., 1983; Edmonson et al., 1989]. For dairy cows, although 1–5 point visual system is in use,

**TABLE 1. Spearman rank correlation with BCS and other variables**

| BCS correlated against | $n$ | Correlation coefficient | Significant level |
|---|---|---|---|
| Weight/height | 54 | 0.626 | 0.000 |
| Weight/height$^2$ | 54 | 0.547 | 0.000 |
| Weight/(height × length) | 47 | 0.677 | 0.000 |
| Weight/neck girth | 49 | 0.308 | 0.031 |
| Weight/chest girth | 49 | 0.454 | 0.001 |
| Weight/hind girth | 49 | 0.604 | 0.000 |
| Thickness of the roll of hanging neck skin fold | 53 | 0.526 | 0.000 |
| Thickness of the skin fold where forearm meets the abdomen | 53 | 0.542 | 0.000 |
| Thickness of the hanging skin fold where hind leg meets the abdomen | 50 | 0.513 | 0.000 |
| Thickness of the “V” shaped skin fold below the anus | 55 | 0.261 | 0.054 |
| Average skin fold | 55 | 0.602 | 0.000 |

internationally, countries adopt different systems [Bewley and Schutz, 2008]. For horses, a nine point scale (1–9) system introduced by Henneke et al. [1983], is adopted widely and uses a visual and palpation assessment [Cartmill et al., 2003; Carmalt et al., 2004; Gentry et al., 2004; Suagee et al., 2008]. Similarly, a nine-point visual and palpation scale is the widely accepted system for cats and dogs [Laflamme, 1997; German et al., 2006]. All these scoring systems involve captive animals, however, when it comes to wild animals, a quick visual method appears to be most practical.

The 11-point body condition scoring system by Wemmer et al. [2006], while cost and equipment free, requires assessment and summing of multiple individual body regions rather than taking into consideration all the regions of the body at the same time. The system presented in this paper is more convenient, quick, easy to learn and applicable to both wild and captive elephants. Wemmer et al. [2006] pointed out that their method would take more time to assign a BCS to an elephant in the wild. Therefore, a quicker method, which could also incorporate photographic images, is especially important in Sri Lanka, when herd sizes can be more than 20 individuals in many instances [Santiapillai et al., 2003].

For Asian elephants, we adopted a scale of 1–10 to include both captive and wild elephants in preference to the 10 point (0–9) scale [Fernando et al., 2009] only for wild Asian elephants, 11-point (1–11) scale [Wemmer et al., 2006] only for captive Asian elephants, or 6-point (1–6) scale that was used on African bull elephants [Poole, 1989]. Furthermore, we found it unrealistic to assign a BCS of 0 as some authors have referred to that score as being at the point of death [Jefferies, 1961; Russel, 1984].

The dichotomous key was very quick and based on visible skeletal structures. However, we were unable to use the key to differentiate BCS of 8, 9, and 10 as no skeletal structures were visible. In the meantime, BCS of 8 is easily identified with no skeletal structures seen. We depend on the photo-index to differenciate BSC of 8, 9, and 10 which is purely visual and comparative. Very thick rolls of skin folds below neck can be a good clue to differenciate BCS between 8, 9, and 10. Other methods such as ultrasound scanning, measuring the thickness of the skin with skin fold calipers, and obtaining the ratio between weight and height, could also be employed to verify the difference between BSC of 8, 9, and 10 in captive animals. In the meantime, we never found wild elephants with BCS of 9 and 10 in Sri Lanka. The BCS 10 as we found is actually an extreme obese condition, which is not very common even in captivity, but should be included as it provides the biological potential of the organism.

The crater-like depression on the head is a very good indication of elephants reaching the extreme end of the BCS. It is very visible at the BCS of 1, 2, and 3 and not at all visible from BCS 8, however, in the middle range of BCS individual variability exists.

The correlations between this BCS system and morphometric estimates of body fatness (Table 1), supports the appropriateness of our BCS system. Furthermore, the BCS applies to all sex and age classes, and our BCS system is not sex biased.

## CONCLUSIONS

1. Visual body condition scoring estimates the energy stores (muscle and subcutaneous fat) of an animal based on changes in the appearance of tissue accumulation over skeletal landmarks.
2. The combination of a dichotomous key and photographic assessment of body condition scoring is a rapid, practical, effective, and user-friendly method, for evaluating BCS of elephants in the wild and in captivity.
3. The body condition scoring system presented here is applicable to all sex and age categories.

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