Table S1 Overview of research conducted on body condition scoring in elephants

Albl (1971)	Investigating 240 carcasses of African elephants during cullings in Zambia, this researcher detected a linear negative correlation between the kidney-fat index and the depth of the lumbar depression. Although conducting several morphometric measurements, lumbar depression with the adjoining ridge of the wing of the ilium was the only body region correlating with an elephant´s physical condition. During dry season elephants showed a poorer condition compared to the wet season. No universal body condition score index was defined.
Poole (1989)	Used a simple visual method focused on the shoulder blade, the pelvic bone and the backbone to determine changes during musth. No universal body condition score index was defined.
Godagama et al. (1998)	Applied a previous version of the index subsequently published by Wemmer et al. (2006) in 140 (68 females, 72 males) captive elephants in Sri Lanka. These elephants were private owned or temple elephants and covered all age categories (3-75 years). The authors reported a significant difference in BCS between females and males with higher scores in females. No significant correlations of BCS with age or husbandry circumstances were detected.
Foley et al. (2001)	Evaluating effects of stress in free-ranging African elephants, body condition was categorized from 1 (emaciated) to 5 (no bony structures visible). According to the findings from Albl (1971) scoring was based mainly on the lumbar region. A correlation pattern between body condition and season was demonstrated with lower values during the dry season. Lowest scores occurred in late dry season. Foley et al. (2001) explain this pattern with seasonal variation of diet quality and availability.
Wemmer et al. (2006)	Worked out a method to assess body condition in Asian elephants, deriving a numerical index by separate visual assessment of six different body regions (head, scapula, thoracic region, flank area, lumbar vertebrae, pelvic bone). Thus a total score between 0 and 11 can be obtained and interpreted. She tried to correlate the measured body condition scores with morphometrically determined variables for the amount of subcutaneous fat, but could not find any location that closely parallels the numerical index. Application of the scoring system on a sample of 119 juvenile and young adult Asian elephants in Forest camps in countries of origin. No significant correlations between body condition score and age or sex of the elephants were detectable.
Harris et al. (2008)	Investigated, during the report on the welfare of zoo elephants in the United Kingdom, beside numerous other variables, the body condition. They did so without former protocol and based their interpretation on comparisons with photographs from the wild and experience of the examiner. Thereby they focused on the rear view of the elephant and chose the spinal protrusion, hip visibility, roundness of the body and the thighs as expressive features. Scores from 1-5 were assigned to pictures, considering a value of 3 to be normal. Doing so, only 6 of the 70 scored individuals were found in desirable condition. Subsequently the group tried to correlate body condition scores with species, sex, age, origin, management system and measured cortisol metabolites. Only management system showed a significant correlation with lowest scores in free contact and highest ones in no contact systems. The authors do not formulate any explanation for this correlation. Any other variable seemed to be independent from body condition.

Thitaram et al. (2008)	Evaluated the body condition of 22 female Asian elephants in two Elephant camps in Thailand during their study on estrous cycle lengths. They used the protocol formulated by Wemmer et al. (2006) and found scores ranging from 6.5 to 10. Thitaram et al. (2008) found no markedly different body condition of normal and irregularly cycling elephants. They report the absence of an estrous cycle in the elephant cow with the lowest BCS (6.5) of the studied population.
Velthuizen (2008)	Applied Wemmers method in the investigation of body condition changes in seven African elephants kept in a training facility in South Africa. The investigation led to no reliable results, which is due to a suboptimal study design according to the researcher.
De Klerk (2009)	Used Poole's (1989) method during her study on free-ranging populations in the Eastern Cape Region, South Africa to show correlations with resource qualities. In doing so, lower body condition scores in populations with limited dieatry resources, during seasons with lower primary productivity, and in lactating females were demonstrated.
Fernando et al. (2009)	Used a simplified version of Wemmer et al.'s (2006) index in order to assess the body condition of free-ranging Asian elephants involved in the human-elephant-conflict. The researchers took 5 reference photographs of free-ranging individuals representing almost the entire spectrum of body conditions. They assigned the scores 1, 3, 5, 7, 9 to the pictures. In that way the scale can be extended by 0 and 10 if necessary and conditions localized between the given photographs will be evaluated with 2, 4, 6 or 8. Considering its simplicity and the inevitable subjectivity in assessing, they found a comparatively small error in the application of the method.
Pinter-Wollman et al. (2009)	In order to monitor physiology of translocated elephants in Tsavo East National Park, Kenia, a modified protocol of Wemmer´s index was applied. Scores of 544 adult individuals revealed significantly higher values for local compared to translocated elephants. Females showed a significantly lower condition than males. During wet season BCS´s were significantly higher than during dry season.
Ramesh et al. (2011)	Used Wemmer et al.'s (2006) body condition score index as basis, modifying and combining it with the technique described for ungulates in general by Riney (1960). In doing so, they added a seventh body region to Wemmer et al.'s (2006) index and determined a total score range from 1-14. With this protocol they assessed the body condition of 1622 free-ranging elephants in Mudumalai Tiger Reserve, Western Ghats, India. The results show a significant correlation between the assigned values and the season, with higher scores during the wet and decreased ones in the dry season. As cause for this phenomenon the changes in availability of food resources for the elephants ar mentioned. The authors conclude that body condition scores may be useful as sensitive health indicators in elephants and encourage such studies over larger populations to develop reference values.
Treiber et al. (2012)	Took the correlation between body condition and several diseases for granted and used a 9-point scale for her evaluations on Asian elephants. Their index corresponds well with the previously published indices, although trying to enhance details. Moreover they correlate body condition scores to and validate them with ultrasonic rump fat measures.

Morfeld et al. (2014)	Published the development of a new visual body condition scoring index for the assessment of body fat and condition in female African elephants. Compared to Wemmer et al.'s (2006) method, they reduced the observed body regions from 6 to 3, which they chose by their correlation with the local ultrasonic subcutaneous fat thickness. These areas are the backbone, the pelvic bone and the ribs. The developed method was subsequently applied in a comparison of body condition scores assigned to photographs from samples of female zoo elephants and their free-ranging counterparts. The comparison revealed significant lower values in the free-ranging elephants. Following previous studies, the authors expected a relationship between high body condition scores and the poor reproductive activity in zoo elephants (Clubb et al., 2009; Dow et al., 2011; Freeman et al., 2009; Taylor and Poole, 1998). They recommend the use of body condition scores in the medical management and optimization of husbandry practices in zoo elephants, potentially leading to a more healthy and sustainable population.
Kumar et al. (2014)	Ascribed a BCS to the 12 (4 males, 8 females) zoo-kept Asian elephants investigated during their endocrinological study in southern India. Using the index from Wemmer et al. (2006), they report values ranging from 4 to 9. They could not find any significant correlation between the body condition and any of the measured faecal hormones. Moreover they could not find any significant variation of the body condition with the age or facility of the individual elephants.
Romain et al. (2014)	Used the index described by Fernando et al. (2009) to measure the body condition of captive Asian elephants in Thailand, but laying their study emphasis on the diet composition and food intake, the body condition score values were of minor interest.
Wijeyamohan et al. (2015)	Took the indices from Wemmer et al. (2006) and Fernando et al. (2009) as basis for the development of a visual system for Body Condition Scoring of Asian elephants. They demonstrated the applicability of this system in free-ranging as well as in captive elephants and provided an exemplary photograph for every score. Moreover they proved the significant correlation between BCS values and morphometric estimates of body fatness. According to this publication, the developed system facilitates the reliable assessment of Asian elephants independent of age and sex. Investigating captive elephants in the USA and a Sri Lankan population, they found on average a two point higher BCS in the American population.
Morfeld et al. (2016)	Being part of the project “Using science to understand zoo elephant welfare”, body condition of 240 elephants in North American zoos was assessed. Before applying the established 5-point score for the African elephant in the Asian species, biological validation was performed by measuring serum triglyceride levels. Results found 34% of the assessed zoo elephants in the highest score (=5) and 40% with a BCS of 4. This means that 74% of zoo elephants showed a physical condition considered as overweight or obese. Increased diversity in feeding methods and being female occurred as risk factors for an elevated score. In contrast, an unpredictable feeding schedule and staff-directed walking for more than 14 hours per week were associated with a decreased risk for elevated scores.
Schiffmann et al. (2017)	This study reviewed existing visual body condition score protocols for elephants. Additionally a test based on pictorial documents compared different scoring approaches. Results led to the conclusion that body condition scoring in elephants may be best completed using overview and/or algorithm methods.

Pokharel et al. (2017)	Investigation of 653 free-ranging Asian elephants in India revealed a correlation of BCS and season with higher scores during the wet season. In females BCS was negatively correlated with feacal glucocorticoid metabolites. BCS development of nine adult females was observed over the course of seven years with the detection of distinct annual changes.
Chusyd et al. (2018)	This research group investigated the relationship between adiposity and reproductive cycling in 20 female African elephants living in North American zoos. They checked for patterns of BCS as well and found positive correlations with age, body mass and fat mass. No significant influence on cycling could be found.
Ranjeewa et al. (2018)	Body condition of adult female (N=218) and sub-adult and adult male (N=329) elephants in the Udawalawe National Park were assessed by a protocol modified from Wemmer et al. (2006). A mean score in the middle of the range was determined (7.68 ± 3.04). Scores of females and males showed a significant difference with higher values in males. Considering various age-size classes of the latter, mature-adult males had the lowest scores and young-adult males the highest with sub-adult males ranking between them. The authors demonstrate a significant inverse correlation of elephant body condition with reservoir water level. They explain this phenomenon by the lush grass growing on the banks of the reservoir in times of low water levels.

Table S2 Overview of research conducted on body condition scoring in elephants and reported correlation with further parameters (Table modified and extended from Schiffmann et al. (2017))

African elephant (*Loxodonta africana*)								
Living conditions	**Applied Index (scoring range)**	**N**	**Average score**	**Standardized average score (average score/scoring range)**	**Correlating parameters**	**Kind of correlation**	**Remarks**	**Reference**
Free-ranging								
free-ranging	kidney-fat index, depth of lumbar depression, (good, fair, poor)	240	-	-	season	lower condition during dry season	especially well developed fat reserves in pregnant cows	Albl (1971)
free-ranging	new developed (1-6)	22	-	-	stage of musth	body condition decreases during musth phase	exclusively males in musth considered	Poole (1989)
free-ranging	concavity around lumbar depression and scapula (1-5)	not indicated	mean: 2.8-4.01	0.56-0.80 (mean)	season	lower body condition during dry season	sample size and composition not indicated	Foley et al. (2001)
free-ranging	extended the index from Poole (1989) (1-8)	4-107 (depending on season and category)	mean: 3.2-5.6 (depending on season and category)	0.40-0.70 (mean)	season	lower scores during seasons with decreased primary productivity	-	De Klerk (2009)
					limitation of nutritional resources	lower scores in population with limited resources	-	
					lactation	lower scores in lactating females	-	
free-ranging	modified from Wemmer et al. (2006) (0-2)	544	-	-	season	lower scores during the dry season	only adults considered	Pinter-Wollman et al. (2009)
					sex	lower scores in females	only adults considered	
					history of translocation	lower scores in translocated elephants	only adults considered	
free-ranging	new developed (1-	57	3 (1-5)	0.60 (median)	captive vs.	significantly higher in	investigation on	Morfeld et al. (2014)

5)	free-ranging	captive elephants	female elephants only

Semicaptive and captive								
semicaptive[a]	Wemmer et al. (2006) (0-11) and a digital index (not published)	7	mean and median: 10	0.83 (mean and median)	-	-	suboptimal study design lead to no reliable results	Velthuizen (2008)
captive[b]	own index (5-1)	not indicated	mean: 2.0	0.60 (mean)	handling method	significantly thinner when managed in free contact compared to no contact	-	Harris et al. (2008)
captive[c]	new developed (1-5)	50	median: 4 (2-5)	0.80 (median)	captive vs. free-ranging	significantly higher in captive elephants	investigation on female elephants only	Morfeld et al. (2014)
captive[c]	Morfeld et al. (2014) (1-5)	132	median: 4; mean: 4.00	0.80 (mean and median)	sex	higher scores in females	-	Morfeld et al. (2016)
					staff-directed walking exercise	decreased risk for higher scores	only significant if exercise exceeds 14 hours per week	
					unpredictable feeding schedule	decreased risk for higher scores	-	Morfeld et al. (2016)Morfeld et al. (2016)
					diversity in feeding methods	increased risk for higher scores	-	
captive[c]	Morfeld et al. (2014) (1-5)	20	median: 4; mean: 3.85	0.77 (mean), 0.80 (median)	age	positive	females only	Chusyd et al. (2018)
					body mass	positive		
					fat mass	positive		

Asian elephant (*Elephas maximus*)								
Living conditions	**Applied Index (scoring range)**	**N**	**Average score**	**Standardized average score (average score/scoring range)**	**Correlating parameters**	**Kind of correlation**	**Remarks**	**Reference**
Free-ranging								
free-ranging	new developed (0-10)	-	-	-	-	-	-	Fernando et al. (2009)
free-ranging	combined indices from Wemmer et al. (2006) and Riney (1960) (14-1)	1622	-	-	season	decrease in body condition during dry season	significant differences between age-classes	Ramesh et al. (2011)
					sex	higher body condition in males	demonstrated for adult elephants only	
free-ranging	new developed (1-10)	27	6 (median and mean)	0.60 (median and mean)	captive vs. free-ranging	higher in captive elephants	application of index recommended independently of age and sex	Wijeyamohan et al. (2015)
free-ranging	Morfeld et al. (2014) (1-5)	653	-	-	season	lower scores more frequent during dry season	-	Pokharel et al. (2017)
					faecal glucocorticoid metabolites (fGCM)	fGCM levels highest in individuals with lowest BCS		
free-ranging	modified from Wemmer et al. (2006) (0-14)	3175 (containing 526 individual elephants at different points of time)	mean: 7.68	0.51 (mean)	reservoir water level	higher condition during season with lower water level	only adult and sub-adult elephants considered	Ranjeewa et al. (2018)
					sex	higher scores in males	only adult and sub-adult elephants considered	
Semicaptive and captive								
semicaptive$_d$	previous version	140	Median: 7; mean:	0.58 (mean and	sex	higher body condition	-	Godagama et al. (1998)

	of the index by Wemmer et al. (2006) (0-11)		6.95	median)		in females		
semicaptive[e]	new developed (0-11)	119	mean: 7.3	0.61 (mean)	-	-	no correlation with further parameters detected	Wemmer et al. (2006)
captive[b] and semicaptive[f]	own index (5-1)	semicaptive: 42; captive: not indicated	semicaptive mean: 3.25; captive mean: 2.1	semicaptive: 0.35 (mean); captive: 0.58 (mean)	captive: handling method	captive: significantly thinner when managed in free contact compared to no contact	-	Harris et al. (2008)
semicaptive[g]	Wemmer et al. (2006) (0-11)	22	median: 8.75; mean: 8.70	0.73 (mean and median)	-	-	mature females only; the female with lowest score (6.5) was the only one not cycling	Thitaram et al. (2008)
captive[c]	new developed (1-9)	12	median: 6.25	0.69 (median)	rump fat thickness	positive linear	fat thickness measured by ultrasound	Treiber et al. (2012)
captive[h]	Wemmer et al. (2006) (0-11)	12	median: 8; mean: 7.25	0.60 (mean); 0.67 (median)	-	-	-	Kumar et al. (2014)
captive[i]	Fernando et al. (2009) (0-10)	10	median: 6; mean: 6.3	0.57 (mean); 0.55 (median)	-	-	-	Romain et al. (2014)
captive[c]	new developed (1-10)	31	8 (median and mean)	0.80 (mean and median)	captive vs. free-ranging	higher in captive elephants	application of index recommended independently of age and sex	Wijeyamohan et al. (2015)
captive[c]	new developed (1-5)	108	median: 4; mean: 4.05	0.81 (mean); 0.80 (median)	sex	higher scores in females	-	Morfeld et al. (2016)
					staff-directed walking exercise	decreased risk for higher scores	only significant if exercise exceeds 14 hours per week	
					unpredictable feeding schedule	decreased risk for higher scores	-	
					diversity in feeding methods	increased risk for higher scores	-	
semicaptive[g]	Wemmer et al. (2006) (0-11)	5	median: 8; mean: 7.6	0.63 (mean); 0.75 (median)	-	-	exclusively males considered , no effect of GnRH-vaccination on BCS detected	Somgird et al. (2016a)
semicaptive[j]	Wemmer et al.	9	median: 8; mean:	0.69 (mean); 0.75	duration of	Positive	exclusively males	Somgird et al. (2016b)

(2006) (0-11)	8.33	(median)	musth phase		considered
			age	positive but not significant	exclusively males considered

c: investigated animals live in captivity, sc: investigated animals live in semi-captive conditions in countries of origin, f: free-ranging individuals were investigated a: Elephant training facility in South Africa; b: UK zoos; c: North American zoos; d: Private owned and temple elephants in Sri Lanka, e: Forest camps in India, Nepal and Myanmar; f: Indian working camp and Wildlife rehabilitation centre; g: Elephant camps in Thailand; h: South Indian zoos; i: Zoos in Thailand; j: Elephant conservation center in Thailand

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