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ORIGINAL ARTICLE

Estimating body condition of Apennine brown bears using subjective scoring based on camera trap photographs

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Abstract

The assessment of animal body condition has important practical and management implications for endangered wildlife populations. The nutritional condition of a population can be evaluated in a non-invasive way using photogrammetry techniques, avoiding direct manipulation. This study evaluates the utility of using body condition scoring (BCS) based on the visual assessment of subcutaneous fat and muscle from the body contour as a non-invasive method to quantify body condition in free ranging bears from camera trap photographs. Photographs of Apennine brown bears (*Ursus arctos marsicanus*), taken between 2007 and 2009 in the Abruzzo, Lazio and Molise National Park (PNALM, Italy), were used to evaluate the potential of this technique. BCS assessment was performed on 754 photographs representing 71 independent observations. Forty-eight of these photographs were selected to also score quantitative body ratios using a standardised measure of torso height. BCS varied seasonally, as expected by food availability and brown bear nutritional physiology, and it was also positively correlated to all three body ratios. Our findings indicate that BCS assessment is a good proxy for body condition, and that camera trap data can be effectively used to assess and monitor the nutritional condition of bear populations, such as the critically endangered one in central Italy.

Keywords Brown bear · Central apennine · Camera traps · Biometry · Body condition score

Hannah Lacy and Carlo Meloro contributed equally to this work.

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Introduction

Body condition, defined as the nutritional and energetic state based on relative fat composition, is an important determinant of the fitness of both terrestrial and marine mammals (Green 2001; Castrillon and Nash 2020; Shirane et al. 2020; Rode et al. 2021). Body condition influences an animal's reproductive success, vulnerability to predation, and ability to survive disease and food scarcity (Bourbonnais et al. 2014; Atkinson and Ramsay 1995; Shirane et al. 2021). Generally, poor body condition may reduce fecundity and increase mortality, and hence have negative impacts on population persistence (Stevenson and Woods 2006). Poor body condition may indicate poor habitat quality and resource availability (Ellis et al. 2012). As a result, assessment of body condition has important practical implications for wildlife conservation, informing effective management interventions (Stevenson and Woods 2006). Body condition often varies within the same individual in relation to year or season. Different species, however, may show different responses in body condition to similar environmental variation due to contrasting physiological adaptations such as variations in metabolic rates, allostatic load, and dietary preferences (Bourbonnais 2014; Shirane et al. 2021).

Body condition measurements initially involved highly invasive methods (Serrano et al. 2008), but non-invasive alternatives have been developed more recently. For instance, body condition has been assessed in cetaceans and pinnipeds from aerial photographs (e.g., Christiansen et al. 2016; Krause et al. 2017), and Black et al. (2019) highlighted that biometric data extracted from photographs could be used to assess body condition of wild terrestrial mammals. Of particular interest is the expansion of using camera traps, i.e. cameras remotely triggered using some passive sensor, to monitor terrestrial animals (O'Connell et al. 2011; Abraham et al. 2023). Recently, Shirane et al. (2020) proposed a non-invasive method of assessing body condition in brown bears by calculating body ratios from photographs of optimally oriented individuals. Rasmussen et al. (2021) similarly used photogrammetry to assess body condition within painted dog (*Lycaon pictus*) populations. However, these methods require photographs where the animals are in an ideal position for taking morphometric measurements, which rarely is the case for camera trapping data. An alternative to morphometric methods for assessing animal body condition from photographs is to assign body condition scores (BCS). This method uses a subjective visual assessment of subcutaneous fat and muscle based on body contour (Schiffmann et al. 2017) and does not rely as heavily on optimal positioning as quantitative morphometric measurements. Hence, more images can be used for scoring which, particularly for rare and elusive species, may be more practical.

Bears are large, mostly omnivorous carnivores within the family Ursidae. Of the eight extant species, six are threatened by global extinction, and one of the other two species has several small, fragmented and endangered populations (Penteriani and Melletti 2020). Previous approaches for the assessment of body condition in bears include the use of morphometric measurements and haematological analyses, both of which necessitate the capture of an individual on multiple occasions (Cattet et al. 2002; Boulanger et al. 2013; Tomiyasu et al. 2021; Lafferty et al. 2014). BCS has also repeatedly been proposed for bears (Noyce et al. 2002), but only for captured animals. Nonetheless, visual fatness indices for bears have been shown to be positively correlated with adipose lipid content, demonstrating that non-invasive methods may be a good estimator of the actual content of fat tissue and provide an accurate enough reflection of overall body condition (Stirling et al. 2008).

Many bear populations face threats such as excessive anthropogenic mortality, habitat destruction, and depletion of genetic diversity. Hence, monitoring body condition is an important part of effective long-term management and conservation of bear populations. Since live-trapping bears is difficult, labour-intensive, and stressful for bears, an efficient and reliable method to estimate body conditions from photographs could therefore greatly aid in sustainable bear management.

Here, we provide an evaluation of the use of BCS as a qualitative measure to assess the body condition of bears from photographs taken by camera traps. We used photographs from camera traps opportunistically collected for various purposes during non-invasive monitoring of the Apennine brown bear (*Ursus arctos marsicanus*) population in the Abruzzo, Lazio and Molise National Park (PNALM) (Ciucci et al. 2017). We quantified BCS across three seasons and applied the morphometric approaches proposed by Shirane et al. (2020). Photogrammetry-derived morphometric measurements are directly aligned with Body Condition Index (BCI, sensu Cattet et al. 2002) derived from true body mass and length values, which have a strong relationship with body condition in bears (Shirane et al. 2020). The objectives of the study were to determine: (i) if BCS detects predictable seasonal changes in brown bear body condition, (ii) if BCS relates consistently with photogrammetric methods to score body condition in free ranging bears from photographs taken by camera traps. Apennine bears form a relict and long isolated population (Benazzo et al. 2017), numbering about 50 – 60 individuals (Ciucci et al. 2015); they are classified as critically endangered according to regional IUCN criteria (Gervasi and Ciucci 2018).

Materials and methods

Data collection

The PNALM, including its external buffer area, covers approximately 1300 km^2, with elevations ranging from 400 to 2285 m above sea level and average temperatures ranging from 2°C in winter to 20 °C in summer (Ciucci et al. 2014). The dominant vegetation, which covers approximately 60% of the park, is beech (*Fagus sylvatica*) and oak (*Quercus cerris* and *Q. pubescens*) forests. The average human density is 14.6 inhabitants/km^2 (Cancellieri et al. 2020). Since it was established in 1923, the PNALM is one of the oldest National Parks in Europe (Idolo et al. 2010); yet, despite long-time efforts to protect the Apennine brown bear, only a small, isolated population remains in this area with no indication of significant recovery (Gervasi and Ciucci 2018; Benazzo et al. 2017; Ciucci and Boitani 2008). In the PNALM ecosystem, multiple use is allowed including tourism (including a ski resort built within the park), forestry, and agricultural activities (Gilkman et al. 2019). Other wildlife in the park comprises red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), and Apennine chamois (*Rupicapra pyrenaica ornata*) (Ciucci et al. 2014). The other large carnivores occurring in the study area at high density (approx. 5 individuals/100 km^2, Ciucci et al. 2020) are grey wolves (*Canis lupus*), while stray dogs and free-roaming unattended livestock are also present (Ciucci and Boitani 2008).

The images used for this study were sourced from a total of 36 camera traps opportunistically activated between 2007 and 2009 (3 in 2007, 19 in 2008, and 14 in 2009) at 26 different locations within the border of the PNALM (500 km^2, Fig. S1). Camera traps were used opportunistically for various purposes, including monitoring the occurrence of bears at trapping sites to facilitate live-trapping, to detect bear presence in remote and inaccessible areas, and to spot family groups (i.e., females with cubs) as part of systematic annual counts to assess reproductive rates (Tosoni et al. 2017a, b). Cameras were active on average 45 ± 37 (mean $\pm$ sd, range $3-129$) days per year, limited to the bear active period from mid-March to the end of November. The cameras were placed at approximately 50 cm above the ground, and their locations were optimised for monitoring bear presence, mostly in beech woodland habitats, and at the margins of clearings to spot family groups during summer. Edible baits (mostly carrots or apples) were laid out at some of the sites to maximise the chance of attracting bears for live trapping. Images were taken with different camera traps models using infra-red or flashlight for night vision (ScoutGuard SG550, Uovision UV572), with resolutions ranging from 1.38 to 2.45 megapixels. In all cases burst mode was employed to capture five still photographs with a ten second delay between triggers. This resulted in a high volume of photographs for a total of 2,667 bear images over a 3-years period.

Data formatting

Each photographed bear was thoroughly evaluated for the presence of morphological characteristics such as coat colour, markers from previous captures (i.e., ear tags or collars), or natural marks (e.g., dermatitis, Di Bari et al. 2022), that could aid in individual identification for 58% of the total data. Juveniles were defined as yearlings and cubs whose facial characteristics showed a relatively shorter muzzle and larger -more spherical- braincase than the adults. Limb proportion relative to torso length was equally considered to discriminate juveniles (shorter limbs relative to torso) from adults. In most cases, juveniles and adults could be distinguished with confidence if photographed in the same event, while in other instances we visually compared the camera traps images with reference photos of known individuals opportunistically photographed (De Persiis 2016). Of the 2,667 bear photographs, we regarded 754 (approximately 28%) to be of high enough quality for assessing BCS. Each photo was also judged as to whether it was suitable for scoring morphometrics following Shirane et al. (2020) on bear posture and position relative to the camera.

We regarded observations made at different camera stations or observations at the same camera stations taken at least 24 h apart or observations at the same station within 24 h but of different identified bears to represent unique independent observations in our analyses.

While such time filtering has been regarded as inappropriate for the estimation of temporal patterns in activity (Peral et al. 2022), and exceed what is usually recommended for estimating spatial occupancy (Linkie and Ridout 2011), we regard it appropriate in our case to reduce the pseudo replication introduced by repeated scoring of photos from the same observation event.

We assigned each observation to one of three seasons relevant to brown bear biology and the availability of their key foods (Ciucci et al. 2014): spring (March-May), which corresponded to den emergence and hypophagia; summer (June-September), which corresponded to the peak of the mating season and early hyperphagia; and autumn (October-mid-December), which corresponded to late hyperphagia and the availability of fleshy fruits.

Body condition scoring

Body condition was examined using a body condition scoring technique that has been described by Stirling et al.

(2008), with scores ranging from 1 (skinny) to 5 (obese). We adapted this methodology for visual assessment only, eliminating the need for physical touch or palpation (Table 1). We allowed scores to be in half units, hence creating an ordinal scale with 10 body condition grades, a common procedure for body condition scoring of dairy cows and sheep (Song et al. 2019; Morin et al. 2017; Phythian et al. 2012). A bear in healthy body condition would receive an intermediate score (3 to 4, Fig. S2), which has been shown to be consistent with the lipid content in body fat for a range of mammalian species, including polar bears (*Ursus maritimus*) (McKinney et al. 2014). The bear position was evaluated in every photograph. The ideal position for body condition scoring is a lateral standing position, however, this is hard to obtain with camera trap photographing (for a similar approach using videos, see Kanazawa et al. 2024). Photographs in which the bear position was not lateral but still allowed evaluation of important body regions (e.g., vertebral processes, hip bones) were therefore included. All photographs were scored by the same person (ADC) within three days to attain a high scoring consistency. Photographs that were scored on the first day, were scored a second time on the third day to ensure consistency between scoring techniques for all photographs.

These selected images were blindly scored for a third round by a different person (CM). The Intraclass Correlation Coefficient was then employed to measure the degree of agreement between scores and test the null hypothesis that patterns in BCS variation do not differ within and between observers (Zar 2014).

Morphometric measurements

From each photo regarded to be suitable for morphometric measurements, we took four measurements. The torso height (TH) was defined as the vertical distance between the lowest point of the abdomen and the corresponding dorsal point of the torso. Consistent with Shirane et al. (2020), we also measured the Euclidean straight-line body length (EBL) and the Polygonal-Line body length (PBL) (Fig. S3). In addition, we also measured Curve length (CL) as the distance from the tip of the tail to the tip of the nose across the contour of the top of the body (Di Bari et al. 2022). CL was resampled to consist of 100 points per photograph prior to calculating the length to ensure consistency. Following Bell et al. (1997), we made three replicate measurements for each metric to verify that the measurements were within a 5% confidence interval of one another. We used the average of these three measurements for further analyses. All measurements were taken using the software TPSDig (Version 2.31 Rohlf 2015).

Since there was no scale on the photographs, and bears were at various distances from the cameras, the morphometric measures were combined into body ratios, which are dimensionless and do not require scaling (Atchley 1978). Body ratios were calculated by dividing torso height (TH) by each length measure: TH: EBL, TH: PBL, and TH: CL. A higher ratio indicates a higher torso per body length and hence putatively a bear in a ‘more obese’ body condition, as experimentally validated for brown bears by Shirane et al. (2020).

We scored BCS values from a total of 754 photographs distributed across 71 independent observation events, 61 of adults and 10 of juveniles. Of these, 13 were recorded during the spring, 36 during the summer, and 22 during autumn. We applied morphometric measurements to 48 of the 754 photographs from which we also had BCS values. These 48 photographs were distributed among 28 independent observation events, 20 of adults only and 8 of juveniles (of which 2 also were with an adult individual in the same photo, i.e. mother with cubs).

Statistical analyses

We used mixed ordinal regression models (Cumulative Link Mixed Models, hereafter CLMMs; Christensen 2019) to compare BCS values among seasons and to relate the BCS values to the three body ratios. This is an appropriate class of models when the response variable is an ordinal factor. To assess seasonal variation in BCS values, we fitted a model using the BCS of each individual photo as a response and season as a fixed factorial predictor. This model was

Table 1 Methodology for subjective visual assessment of BCS for bear photographs, adapted from Stirling et al. 2008

Body Condition Score	Description
1	Skinny, emaciated appearance: vertebrae, ribs, and hip bones externally visible, no apparent fat between skin and muscle over the dorsal body, hips or lower rump.
2	Thin: vertebrae and hip bones (but not ribs) partially visible, little apparent fat between skin and muscle over the back and lower rump.
3	Average; healthy appearance: vertebrae and hip bones not visible, visually detectable layer of fat between skin and muscle over rear half of body and over lower rump.
4	Fat: vertebrae and hip bones visually undetectable, visually apparent thick layer of fat between skin and muscle over upper vertebrae and over the rump
5	Obese: vertebrae and hip bones visually undetectable, visually apparent very thick layer of fat between skin and muscle over the dorsal and lower rump.

fitted on the full set of observations that were used to assess BCS but restricted to only include adult bears. To evaluate the relationships between BCS's and morphometric ratios, we also fitted three models which used the median BCS values for each independent observation as a response, and each of the three morphometric ratios as a continuous fixed predictor. We opted to use the median BCS values for each independent observation rather than the raw BCS from each photograph, which were also used to score body ratios, since it provided a higher accuracy of the BCS scores, and hence a more robust evaluation of the body condition scoring method. These models were only fitted using the 28 independent observations for which we had both BCS and morphometric measurements, and included all 48 raw measurements of morphometric ratios. The morphometric ratios were standardised by dividing them with the standard deviation and centred around zero for ease of direct comparisons among ratios. All models were fitted using a logit link function, equivalent to a proportional odds model (McCullagh 1980), and unstructured thresholds. We added the identity of each independent observation event as a random effect to each of the models.

To compare the precision of the different measures, we calculated the coefficient of variation (CV) for each independent observation and each measure (Shechtman 2013), i.e. both the body condition score and the three body ratios.

Results

Body condition scoring for 84 random images was consistent across three independent rounds made by two observers (ICC $r = 0.695$, $F = 5.923$, $df = 81, 162$, $P < 0.001$) supporting significant agreement among scorers. The Intra Class Correlation coefficient varied between a minimum of 0.493 obtained when comparing "round 1" of ADH vs. CM, and a maximum of 0.811 ("round 2" ADH vs. CM). Two independent rounds made by the same observer (ADH) yielded an ICC $r = 0.549$.

The BCS dataset including 71 independent camera traps events based on 754 photos, supported significant differences among seasons in the BCS of adult bears ($\chi2 = 10.09$, $df = 2$, $p = 0.001$, Fig. 1), with the scores during summer (mean ± sd = 3 ± 0.53, range = 1.5–4) being significantly lower than during both spring (mean ± sd:= 3.69 ± 0.70, range = 2–4.5; β = -12.46, SE_β = 5.67, p_{adj} = 0.042) and autumn (mean ± sd = 3.87 ± 0.55, range = 2.5–4; β = -8.12, SE_β = 1.69, p_{adj} < 0.001) (Fig. 1). However, there were no significant differences between spring and autumn (β = -4.34, SE_β = 5.15, p_{adj} = 0.399).

The BCS values were positively related to all three body ratios, with a somewhat weaker relationship between the BCS and the ratio between thorax height and the curved body length ($\beta = 1.38$, $SE < 0.01$, $p < 0.001$, Fig. 2a) than the ratios between thorax height and Euclidean body length ($\beta = 8.26$, $SE < 0.01$, $p < 0.001$, Fig. 2b) and polygonal line body length ($\beta = 4.97$, $SE < 0.01$, $p < 0.001$ (Fig. 2c). The BCS was more consistent than each of the three body ratios

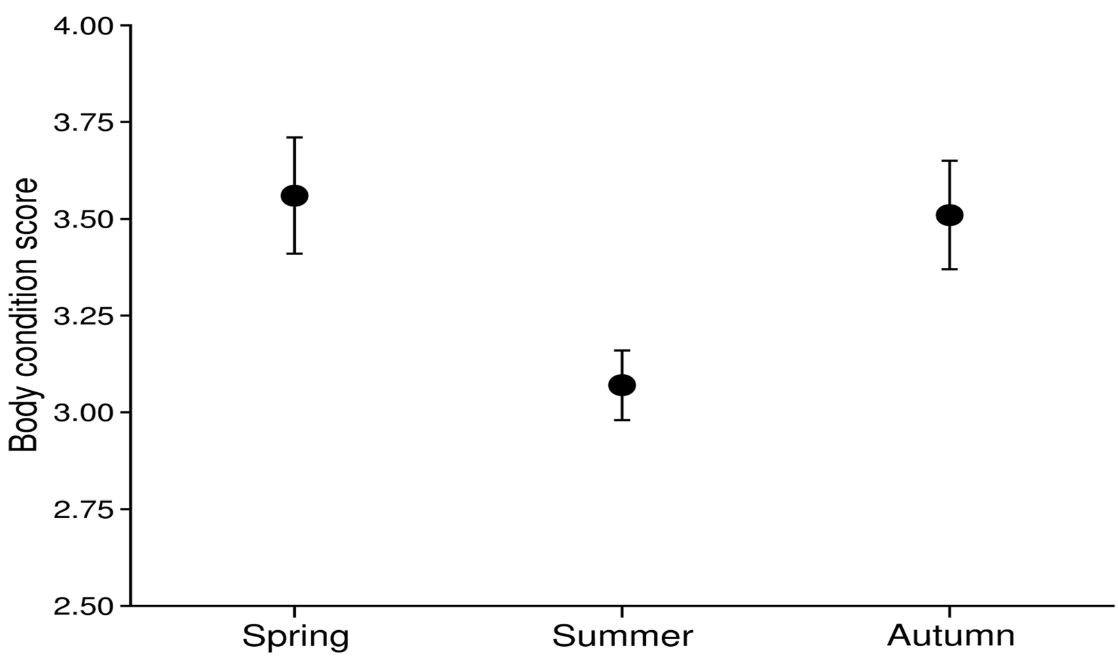

Fig. 1 Body condition scores for brown bears in the Apennines during spring (March-May), summer (June-September) and autumn (October-December). The figure presents means ± SE of average scores for 71 individual observation events

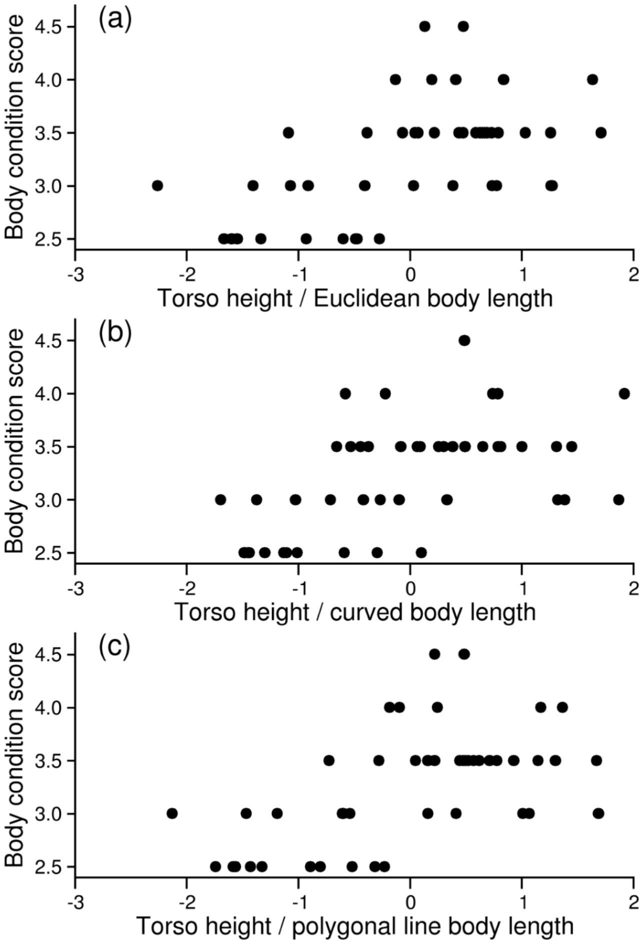

Fig. 2 Relationships between body condition scores and three morphological ratios measured for brown bears in the Apennines; torso height to Euclidean body length **(a)**, torso height to curved body length **(b)** and torso height to polygonal body length **(c)**. The figure presents median scores for individual observation events. The morphological ratios are normalized so they represent units of standard deviations, to enable direct comparisons

(Fig. 3). It was also based on more photographs per independent observation, with a median of five photographs (range 1–44) used for the BCS for each independent observation and a median of one photograph for the body ratios (range 1–6).

Discussion

Our study provides firm indications that BCS is a reliable indicator of bear body condition, since it showed seasonal variation expected from food supply and nutritional physiology, and also correlated well with independently verified body ratio indices. Furthermore, BCS can be assessed non-invasively using camera traps, and allowed for the utilisation of more than ten times the number of photographs compared to methods relying on quantitative body ratio indices (754

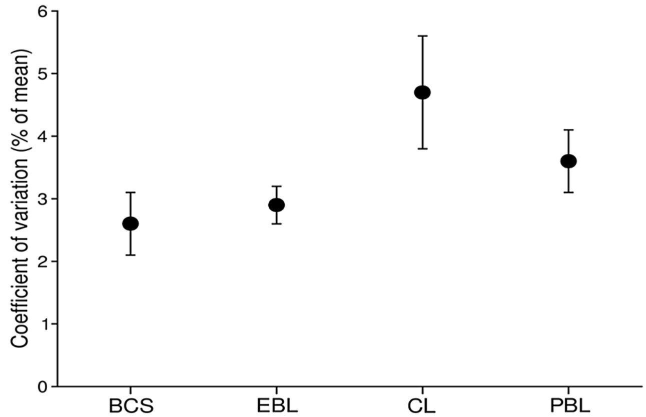

Fig. 3 Coefficients of variation for repeated measurements of the body condition scores (BCS), thorax height to Euclidean body length (EBL), thorax height to curved body length (CL), and thorax height to polygonal line body length (PBL) for brown bears in the Apennines. The measurements were from different photos of the same independent observation event, which ranged from 1 to 43 for the body condition scores (median = 5) and from 1 to 6 for the body ratios (median = 1). The figure presents mean ± SE of the CV for independent capture events

for BCS vs. 48 for body ratios). This also resulted in a greater number of independent observations to be included in the analysis of BCS ($n = 71$) when compared to the morphometric assessment of body ratios ($n = 28$). Such an increase in sample size does not only allow for more precise estimates, as indicated by the results in this study, but could also allow for the evaluation of comparisons that would not be possible using data requiring animal capture or the non-invasive estimation of body ratios, e.g., among habitats or different populations. Hence, assessing nutritional condition in critically endangered populations using a larger and potentially more representative sample may result in a better understanding of the appropriate management strategies to implement. Despite the possibility of minor errors due to subjectivity between scores as highlighted in BCS assessment for immobilised polar bears (Stirling et al. 2008), we argue that BCS represents a valuable asset in field studies due to its practicality and flexibility.

This is corroborated by the significant Intraclass Correlation Coefficient obtained not only from multiple scoring sessions by the same observer, but also when comparing BCS from different observers. Schiffmann et al. (2017) supported the reliability of visual BCS to assess health condition in captive elephants (*Elephas maximus* and *Loxodonta africana*) and our ICC are coherent with those from other study systems (i.e., dairy cows, Heuer et al. 1999). Peréz-Flores et al. (2016) proposed to first evaluate BCS on captive individuals before applying it to camera trap images of wild Baird's tapir (*Tapirus bairdii*). This is certainly valuable, and the support of automated computer systems (e.g., training sets for deep learning approaches, see Clapham et al. 2020) might provide a way forward as long as data on live trap or captive animals are used for validation.

We also highlight that BCS does not require a particular camera set up or calibration, which makes it applicable for the analyses of already available datasets. Kanazawa et al. (2024) recently applied a body condition scoring system to camera trap videos of brown bears from Hokkaido (Japan), however they implemented a standard wooden post necessary to calibrate bear relative size; video clips also provided more options to select optimal bear posture. In this regard, videos can be more effective at maximising sample size for body conditon scoring with 51% of events usable contra 28% based on our camera trap images.

The seasonal variation identified in Kazanawa et al. (2024) equally corresponds to the one we observed for the Apennine brown bear population with BCS average values dropping during the summer season. This variation is expected in bears, based on the impact of food availability and habitat conditions on their ecology, physiology, and behaviour. Galicia et al. (2019) reported that declines in polar bear body condition were caused by insufficient prey availability to meet energy demands. In the PNALM, bears have been observed to accumulate fat in autumn prior to the wintering period particularly from fleshy fruits and hard mast (e.g., beechnuts and acorns), which has been shown to enhance their reproductive success (Tosoni et al. 2017a).

Careddu et al. (2021) also noted for the Apennine brown bears high level of meat and hard mast consumption in spring following mast years. Our data mainly included records from late April and May (Apennine bears generally emerge from hibernation in mid-March, Ciucci unpublished data) and it is likely that the sampled individuals already accumulated enough fat in preparation for the high activity level of the summer reproductive season (Donatelli et al. 2022). Since female brown bears are pregnant mainly during hibernation (Spady et al. 2007), and produce exceptionally small neonates (Ramsay and Dunbrack 1986), it is unlikely that high body ratios are the result of ongoing pregnancy in females.

Furthermore, Kanazawa et al. (2024) reported high BCS values during late spring (May), and late autumn (November) for Hokkaido brown bears, whose omnivorous diet is equally dominated by vegetable matter (i.e., herbaceous plants, corns and fruits) and colonial insects (Matsubayashi et al. 2014; Sato et al. 2005; Aoi 1985).

The positive relationships we observed between BCS and the body ratios provide further support for BCS as a proxy for body condition of individual bears in situ. The three measures of body ratios used in the present study differed in their coefficient of variation. In particular, the TH: EBL ratio showed larger consistency within observations, and subsequently seemed to have been less impacted by bear body position. Therefore, if body ratios are to be used to quantify body condition from camera trap images, we suggest this measure as the primary choice. We employed torso height as the standardised measure to calculate the body ratios in accordance with the method described by Shirane et al. (2020). They demonstrated that body ratios are positively correlated with BCI (a proxy for percent of body fat independent of body mass) calculated from actual measurements of Hokkaido brown bears. Furthermore, torso height is not influenced by the degree of neck flexing or neck lateral bending, as long as the body straightness criterion is met (Shirane et al. 2020).

However, despite previous successes in the use of stringent posture conditions to measure body condition in whales using aerial vehicle photogrammetry with remarkable precision and accuracy (Christiansen et al. 2016), obtaining good-quality photographs from camera traps set up within a forested mountain range remains a challenge. Further assessment of skeletal morphology to determine body measurements may enhance precision of discrete morphometric reference points and mitigate the impacts of neck bending and flexing, as demonstrated for the painted dog (Rasmussen et al. 2021).

Management implications

Assessing nutritional condition may provide valuable insights into the ecology and population status of the Apennine brown bear. Such insights may include the identification of bears that might experience unequal access to high quality resources as a result of intraspecific social relationships or access to anthropogenic food (e.g., Oro et al. 2013). It could also include the identification of marked individual bears with poor body condition due to negative interactions with humans or having experienced a decreasing accessibility to high quality resource areas. Bruschi et al. (2015) discovered that the PNALM has one of the highest degrees of natural habitat fragmentation among the 24 Italian National Parks due to transportation infrastructure. However, on a landscape scale, the PNALM and its surrounding areas have been found to have an enhanced availability of bear-suitable habitats in recent years, and therefore land-cover suitability should not be considered as a factor in the populations' inability to increase in numbers (Ciucci and Boitani 2008; Falcucci et al. 2008, 2009). Providing a practical and non-invasive assessment of bear body condition may therefore be an important tool to monitor the general health condition of this endangered bear population and its potential for recovery.

BCS can equally be applied to other bear populations. For instance, it can be used to compare different populations across areas and seasons. Such comparisons would be particularly interesting in Europe, where fragmentation and isolation might have prominent impacts on the species (Zedrossed et al. 2011).

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Data availability All data obtained during the development of the work are attached as supplementary information along with the submission of the manuscript.

Declarations

Ethical approval The authors declare that the study followed the institutional and national ethical guidelines for scientific research in the sites where data were collected.

Consent to participate All the authors consent to participate in the development of the investigation.

Consent for publication All the authors consent for the publication.

Competing interests. The authors declare no competing interests.

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