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BODY CONDITION SCORING AND OBESITY IN CAPTIVE AFRICAN SIDE-NECK TURTLES (*PELOMEDUSIDAE*)*

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Abstract

African side-neck turtles (*Pelomedusa subrufa* and *Pelusios castaneus*) are popular in captivity, in many parts of the world. Their natural tendency to accumulate body fat reserves may be a reason for many health issues. For keepers and veterinarians body condition scoring is an important tool in the process of management and care of the animals. Therefore the main aim of the study was to formulate a single mathematic formula for allometric equations and simple body condition scoring method which can be used in juvenile, sub-adult and adult specimens of *Pelomedusa subrufa* and *Pelusios castaneus*. Twelve healthy turtles (7 *Pelomedusa subrufa* and 5 *Pelusios castaneus*) – 4 males, 4 females and 4 immature were measured and weighed for 52 weeks (624 measurements). The obtained data were used to formulate equations of estimated body weight and compared to results of measurements of 73 turtles from private keepers. Additionally, visual assessments of their body condition were made. The results showed that body weight is significantly (P=0.001) correlated with straight carapace length of turtles. In the assessed population of 73 captive *Pelomedusidae* kept as pets, no emaciated turtles were recorded, and 10% of them were underweight. In the case of 68% of the animals, body condition was identified as optimal, and in 15% and 7% as overweight and obese, respectively. The population of African side-neck turtles seems to be in quite good body condition. However, a high percentage of overweight and obese animals suggests the need for continuous monitoring of pet turtles for body condition.

Key words: turtles, obesity, body condition scoring, *Pelomedusa subrufa*, *Pelusios castaneus*

Overweight and obesity is increasingly becoming a serious health issue in humans (Ogden et al., 2006), companion dogs, cats and rabbits (German, 2006; Courcier et al., 2012). However, there is very little relevant data on captive reptiles, even though they

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are becoming very popular pets. Obesity is defined as an accumulation of excessive amounts of adipose tissue in the body. The main reason for excessively high body condition is a positive energy balance in the organism, when its intake is higher than expenditure (Hand et al., 2000). Improper diets and unfit environmental conditions are the main causes of body weight disturbances in captive reptiles (Mader, 2006). *Pelomedusa subrufa* and *Pelusios castaneus* are commonly kept as pet turtles in captivity. *Pelomedusidae* tend to build up body fat reserves very quickly (Prokop, 2010). This tendency may be a good reason for frequent body condition score assessment to avoid health issues caused by overweight and obesity in these turtles. The majority of condition assessment methods in chelonians is based on the comparison of straight carapace length and body weight of animal (Jackson, 1980; Hailey, 2000; Willemsen and Hailey, 2002). To the authors' knowledge, no information is available about correlations between straight carapace length and body weight in *Pelomedusa subrufa* and *Pelusios castaneus* or data regarding other biometric factors, which can be used for their body condition and health evaluation. The best possibility for development of body condition assessment methods for African side-neck turtles would be usage of wild population as reference of body weight to carapace length relationship and optimal weight estimation. However in the available literature there is no data on this topic for earlier mentioned species. There are several studies showing faster growth of captive chelonians without differences in body condition in comparison to wild specimens (Willemsen et al., 2002; Ritz et al., 2010; Jones et al., 2011). Thus for keepers and veterinary practice, data collected in a long (52 weeks) study may be also very useful. Therefore, the main aim of the study was to formulate a single mathematic formula for allometric equations and body condition scoring method, easy in practical use, for *Pelomedusa subrufa* and *Pelusios castaneus* kept as pets. It was our hypothesis that there is a general trend for overweight and obesity in the population of these species in captivity.

Material and methods

Ethics statement

This study was carried out in strict accordance with the recommendations of the National Ethic Commission (Warsaw, Poland). All procedures and experiments complied with the guidelines and were approved by the Local Ethic Commission of the Poznan University of Life Sciences (Poznań, Poland) with respect to animal experimentation and care of animals under study (Permit number: 22/2012), and all efforts were made to minimize suffering.

Body condition scoring

The first stage of the study was one-year-long monitoring of body weight and straight carapace length of twelve captive African side-neck turtles (four males, four females, and four unsexed specimens), including seven African helmeted turtles (*Pelomedusa subrufa)* and five West African mud turtles (*Pelusios castaneus*). Detailed characteristics of the experimental animals

are described in Table 1. All animals were kept in the same conditions of water and air temperature (26–28°C) in semi-aquatic enclosures, fed 3 times per week. They were measured and weighed at weekly for 52 weeks by the same person, always 24 h after feeding. Straight carapace length (SCL) was evaluated using electronic callipers (Neiko Tools Pro-Grade 12, USA). For animals up to 150 mm of SCL, the measurement accuracy was 0.01 mm, and for larger turtles it was 1 mm. Body weight was measured using laboratory weights (Radwag PS 200 and PS 8000, Poland) with up to 0.01 g accuracy for animals lighter than 100 g and 1 g for heavier specimens. Based on the collected data, the estimated body weight was calculated using formula described by Labrada-Martagón et al. (2010):

$$\textit{Estimated body weight} = aSCL^{b}$$

where SCL was straight carapace length, while a and b were estimated using weight-length relationship regression curve of measurement results. The next stage was measurement of 73 pet African side-neck turtles (35 of *Pelomedusa subrufa* and 38 of *Pelusios castaneus*) from 15 private keepers kept in different parts of Poland. Empirical body weight results from these animals were compared with values estimated for their carapace length. A five point body condition scoring scale was developed. Overweight and obesity were defined as body weights higher than the estimated by more than 15 and 30%, respectively, in accordance with the methods used for pet cats and dogs. Animals whose weight was lower than the estimated by more than 30% and 15% were assessed as emaciated and underweight, respectively (Hand et al., 2000). Additional visual evaluation was made to find visible diagnostic features characteristic of different scores in the area of rear legs between the shell bridge and the tail surrounded by anal, femoral, abdominal and marginal scutes (Figure 1), where soft tissue of turtle abdomen can be seen. Statistical analyses were made using SAS 9.1. For the evaluation of the data, Pearson linear correlation and Student t-test with significance accepted at $P \leq 0.05$ were used (SAS, 1990). Body mass was treated as the dependent variable and carapace length as the independent variable.

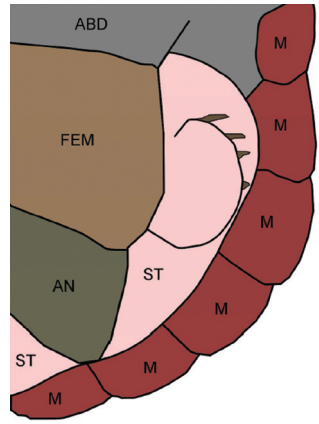

Figure 1. Scheme of area used for visual examination (AN – Anal scute, ABD – Abdominal scute, FEM – Femoral scute, M – Marginal scutes, ST – Soft tissue)

Table 1. Herd of turtles measured formulation of estimated body weight equations

Number	Species	Sex[1]	Origin[2]	SCL[3]	BW[4]
1	*P. castaneus*	U	CB	46.55	17.22
2	*P. castaneus*	U	CB	48.06	19.23
3	*P. subrufa*	U	LTC	74.48	58.84
4	*P. subrufa*	F	LTC	76.79	85.24
5	*P. castaneus*	U	LTC	78.60	75.46
6	*P. subrufa*	M	LTC	102	147
7	*P. subrufa*	F	LTC	106	179
8	*P. subrufa*	F	CB	114	239
9	*P. subrufa*	F	CB	125	299
10	*P. castaneus*	M	CB	127	293
11	*P. castaneus*	M	CB	145	444
12	*P. subrufa*	M	LTC	158	488

[1]Sex: F – Female, M – Male, U – juvenile/unsexed; [2]Origin: CB – captive breed, LTC – long term captive; [3]Straight carapace length (mm) in the first measurement; [4]Body weight (g) in the first measurement.

Results

The results of the study are presented in Figures 1–8 and Table 2. Body weights in the 52-week-long study were significantly correlated ($P<0.001$, $r^2=0.98$) with straight carapace length (Figure 2). Calculated limiting values and equations of body weight for each condition score are given in detail in Table 2. The estimated and empirical values of body mass (Figure 3) in the examined pet turtle population did not differ significantly ($P=0.40$). Body condition of 68% of African side-neck turtles kept in captivity in Poland was described as optimal. Only 10% of them were underweight, and no emaciated animals were found. The condition of 22% of turtles was assessed as too high, 15% – as overweight and 7% – as obese (Figure 4). Visible differences among scores were found in areas of rear legs between the shell bridge and the tail (Figures 5–8). In the underweight turtles, no extending tissue was visible in the area of rear legs. The line of skin was in contact with marginal scutes, but it did not cover them. In area of anal scute, it was in one line with soft tissue. Animals assessed as optimal weight turtles had soft tissue, which did not cover rear legs. Skin extended beyond outline of anal scute but it did not cover marginal scutes. In overweight turtles, wrinkles of skin and tissue covered legs. There were visible curved profiles of soft tissue, which began to cover marginal scutes. In the case of obese specimens, large amounts of tissue surrounded rear legs almost completely. Soft tissue covered almost the whole surface of marginal scutes, in extreme cases extending beyond the shell.

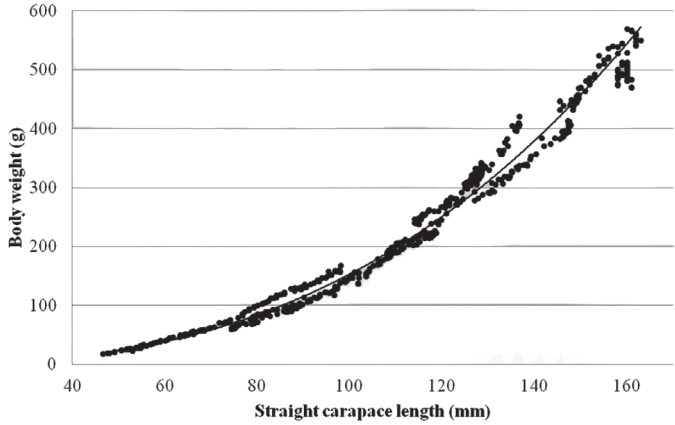

Figure 2. Relationship between body weight and straight carapace length ($P<0.001$, $R^2=0.98$, n=12, Body weight=$0.0006 \times SCL^{2.6989}$)

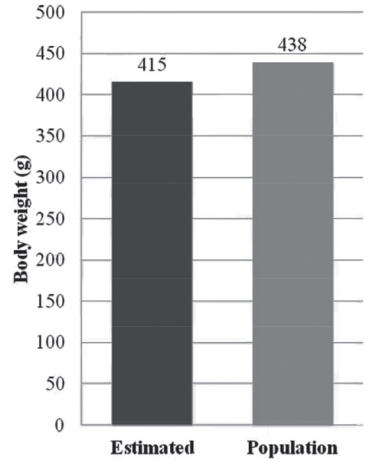

Figure 3. Values of body weight estimated and measured in the population in grams (P=0.40, n=73)

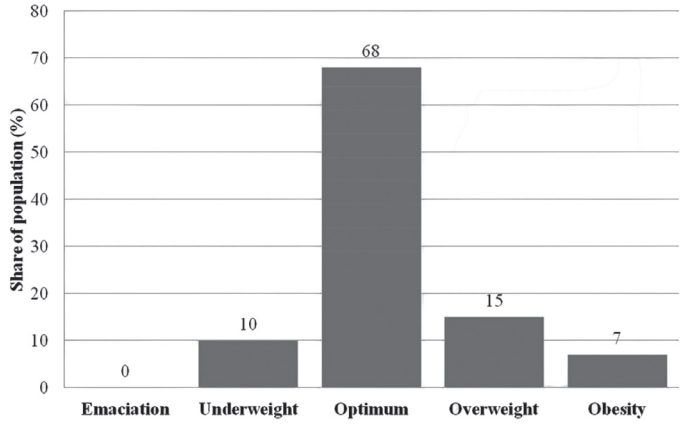

Figure 4. Share of each body condition score in assessed population (n=73)

Figure 5. Underweight male of *Pelomedusa subrufa*

Figure 6. Optimal weight female of *Pelusios castaneus*

Figure 7. Overweight juvenile of *Pelomedusa subrufa*

Figure 8. Obese female of *Pelomedusa subrufa*

Table 2. Estimated values of body weight (g) for African side-neck turtles in captivity

SCL[1]	Emaciation[2]	Underweight[3]	Optimum[4]	Overweight[5]	Obesity[6]
40	8.90	10.8	12.7	14.5	16.5
50	16.2	19.6	23.1	26.6	30.0
60	26.4	32.1	37.8	43.4	49.1
70	40.1	48.7	57.3	65.9	74.4
80	57.5	69.8	82.1	94.4	106
90	79.0	95.9	112	129	147
100	105	127	150	172	195
110	136	165	194	223	252
120	172	208	245	282	319
130	213	259	304	350	396
140	260	316	372	428	483
150	314	381	448	515	582
160	373	453	533	613	693
170	440	534	628	722	816
180	513	623	733	842	952
190	594	721	848	975	1102
200	682	828	974	1120	1266

[1]Straight carapace length; Equations for body weight in each body condition score: [2]Body weight=0.0004× ×$SCL^{2.6989}$, [3]Body weight=0.0005 × $SCL^{2.6989}$, [4]Body weight=0.0006 × $SCL^{2.6989}$, [5]Body weight=0.0007 × $SCL^{2.6989}$, [6]Body weight=0.0008 × $SCL^{2.6989}$.

Discussion

A wide spectrum of body condition scoring methods is used in animals to evaluate energetic reserves of organisms in fat tissue and muscles (Stevenson and Woods, 2006). In many species, they are based on visual evaluation of the fat tissue layer on selected body parts of animals. In cattle, goats, horses and dogs, a five-point body condition score scale (BCS) is used (Carroll and Huntington, 1988; Edmonson et al., 1989; Kearns et al., 2002; German, 2006). The anatomy of turtles – the shell covering greater part of their body – makes it difficult to assess their body condition only on the basis of their appearance. It was assumed that the weight to carapace length ratio should be used as its indicator in chelonians and the visual assessment should be treated as assistant criteria. In the previous studies, 60% of sick tortoises were classified as underweight (Jackson, 1980). Moreover, other researchers suggested that body mass lower than 80% of optimal value for the species and size might be an indicator of poor health in tortoises (Hailey, 2000). In green turtles (*Chelonia mydas*), body condition was different between healthy and injured animals and in conjunction with blood parameters, it was described as a useful biomarker of their physical and nutri-

tional status (Labrada-Martagón et al., 2010). However, most of the studies mentioned above were conducted on wild or free-range turtles and tortoises, and in their case the most important thing is to evaluate whether or not the animal is in too low condition. In available literature there is no reference in the body weight to method of estimation of body weight or its ratio to carapace length in *Pelomedusa subrufa* or *Pelusios castaneus* in the wild or semi-natural conditions. Earlier publications reported that body condition of wild chelonians does not differ from that of captive specimens (Willemsen et al., 2002; Jones et al., 2011). Therefore, in the present study a captive herd of clinically healthy, visually non emaciated or obese African side-neck turtles was used to create model of body condition scoring in this group of reptiles. Due to lack of data about limiting values of deviation from estimated body weight values in turtles, BCS scoring rules used for dogs and cats were proposed. Lack of statistically significant differences between estimated body weight with its empirical values are accuracy signal of this estimation. Thus the present results are probably the first of its kind dealing with body condition scoring of captive *Pelomedusidae*. Moreover, the data obtained indicate that most of the examined turtles (68%) seem to be in optimal BCS. No emaciated animals were found in this population, 10% of them were qualified as underweight, and 22% turtles were assessed as overweight (15%) or obese (7%). The results did not support the hypothesis about the presence of a general trend for overweight and obesity in the entire population of *Pelomedusidae* in captivity. It may be interpreted as a sign of good health condition of the whole population, but shows that overweight and obesity may be a serious problem in the case of some specimens. There is high probability that it should be considered as an issue caused by environmental conditions and diet in the case of part of the keepers and should be a reason for continuous monitoring of body condition in pet turtles.

In reptiles, a large part of adipose tissue is found in subcutaneous sites (Mader, 2006). This trait was used for visual assessment of body condition in the examined turtles. The results suggest that visual assessment may be a useful tool, which has not been used in the past. Numerical values of estimated body weight should be formulated for each morphologically similar group of turtles and tortoises. However, the appearance of animals representing each body score should be similar among most of turtle species. That indicates that description of morphological features may be also used for other turtles than *Pelomedusidae*. Predispositions of side-neck turtles to build up fat reserves are risk factors, which make them more overweight and obesity-exposed than other turtle species in improper conditions.

In captivity, growth rates of chelonians are mostly diet-dependent and significantly higher than in conditions of free-range or wild animals (Ritz et al., 2010). High caloric diet may be a reason for too fast growth in young and for obesity in adult pet reptiles. It is considered as one of the reasons for improper shell mineralisation and pyramidal growth of carapace bones (Mader, 2006). Therefore, body condition scoring may be a helpful tool in turtle breeding and reintroduction programmes. Long-term studies showed that females of turtles in better condition were able to produce higher quantities of larger eggs in comparison with females characterised by poor body condition. Moreover, females in poorest condition were not able to pro-

duce eggs every year (Litzgus et al., 2008). It was recorded that immune responses of western pond turtles (*Emys marmorata*) were not linearly correlated with body condition (Polo-Cavia et al., 2010). Thus body condition scoring should be used only for preliminary basic assessment of health in turtles and tortoises and it cannot be the only method for health evaluation in captive chelonians. This is caused by six factors that should be considered when the used methods are based only on body mass – carapace length relationships (Jacobson et al., 1993) These factors comprise: sex, weight of eggs present in female organisms before oviposition, weight loss during hibernation and weight gain during activity seasons, specific shape of the shell or bone thickness in different populations, weight gain after drinking or feed intake, weight loss caused by urination or defecation. However, in the case of African side-neck turtles, most of the above-mentioned factors can be eliminated. Their sexual dimorphism is quite weak in comparison with many other species of tortoises and turtles. *Pelomedusa subrufa* and *Pelusios castaneus* do not hibernate, they are able to estivate but in captivity most specimens are kept in the same conditions for the whole year. Both species, similar in terms of physique, are now considered as monotypic without subspecies or morphological forms (Fritz et al., 2011). In the present study, to eliminate weight disturbances related with the level of gastrointestinal tract and bladder filling, turtles were measured 24 hours after feeding and handled very carefully to avoid stress related defecation or urination. In the case of overweight or obesity diagnosis, a comprehensive physiological examination should be done to exclude body mass gain caused by diseases that mimic obesity (Mader, 2006). *Pelomedusidae* are considered as sedentary animals described more as bottom walkers than open water swimming turtles which makes them more exposed to excessively high weight gains. Moreover, many species of turtles kept in captivity are able to learn that high activity when the keeper is present may be a reason for a "food reward". That explains why even sedentary turtles actively swim along the front windowpane of the tank when they see the keeper. As a result, owners often assume that they need to be fed. Similar mechanisms were observed also in pet – keeper relations of other animal species, including dogs and cats (Kienzle et al., 1998; German, 2006). That indicates that their body condition and feed intake should be carefully monitored.

Methods used in the present study may be suitable for other turtle genera and could be helpful for reptile veterinarians and breeders. Estimated body weight values should be assessed separately for each group of morphologically similar turtles. Visual assessment of body condition probably is more common for other turtle species, but it should be also investigated in terms of species-specific features. The examined population of side-neck turtles in Poland seems to be in quite proper body condition; however, a high share of overweight and obese animals should be a reason for paying higher attention to diets and environmental conditions for reptiles in captivity. In conclusion it could be stated that the used method of obesity detection could be an easy and practical tool in the management of captive *Pelomedusidae* as well as other turtle species.

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