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Weight Development of Captive Malayan Sun Bears (*Helarctos malayanus*) in the Malaysian Wildlife Rehabilitation Centre

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ABSTRACT

This study documents a cost-effective strategy for managing Malayan sun bears (*Helarctos malayanus*) in the captive, focusing on their weight at the National Wildlife Rescue Centre (NWRC), Perak, Malaysia. The weight and development of captive bears' average aged of two months were assessed using data collected over 18 months. Asymptotic bear weight was estimated using the von Bertalanffy equation. The growth curves significantly differed between male and female bears, with males growing much larger than females from early to later growth stages. This study has determined three types of age classes of bears, where the age of adult Malayan sun bears are fully grown at 11 years and six months for males and eight years and nine months for females. Sub-adult bears ranged between one and six years old for males and one and four years for females, while cubs ranged from zero to one year old. Furthermore, the ideal weight for captive Malayan sun bears by age was also successfully determined. Such information is important for the management of this species in captivity. Ensuring the correct weight and age stage, among other criteria, could be useful for successfully releasing rehabilitated sun bears into their natural habitats.

Keywords: Captivity, ideal weight, National Wildlife Rescue Centre (NWRC), von Bertalanffy equation, weight estimation

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INTRODUCTION

The National Wildlife Rescue Centre (NWRC) is part of the central government agency of the Department of Wildlife and National Parks (DWNP). As a government agency, the DWNP was entrusted to handle human-wildlife conflict in Peninsular Malaysia. This agency operates based on the 3R approach: rescue, rehabilitation, and release. In particular, this refers to rescuing wildlife and providing shelter, treatment, and rehabilitation before being released into their natural habitat. The NWRC has kept many wildlife species (i.e., birds and large mammals), including the Malayan sun bear (*Helarctos malayanus*).

Malayan sun bears are the smallest species of bear on earth and the only bear inhabiting the lowland forests of Peninsular Malaysia. Malayan sun bears are threatened by ongoing habitat destruction, degradation, and forest fragmentation, leading to human-bear conflicts (Sethy & Chauhan, 2012). According to the Department of Wildlife and National Park Malaysia (2014), <1% of wildlife conflicts reported were from human-bear conflicts throughout Peninsular Malaysia. However, this figure does not entirely represent the actual human-bear conflict occurring in Peninsular Malaysia since such cases are rarely reported (Department of Wildlife and National Parks, 2017) and can be considered "silent wildlife conflict". Moreover, increased poaching and illegal trade (domestic and international) in sun bears have become potential threats to their populations in Peninsular Malaysia (Shepherd & Shepherd, 2010). These issues must be considered in the sun bear conservation strategies; otherwise, the Malayan sun bear may shift from a vulnerable to an endangered species.

In managing and conserving wildlife in captivity, animal welfare is compulsory and must be prioritised (Bousfield & Brown, 2010). Apart from providing adequate treatment to injured animals, assessing their physical features and body weight provides extra information regarding their health and helps avoid the possibility of obesity among wildlife in captivity (Brook et al., 2014). At the NWRC, three tracks based on the 3R framework (rescue, rehabilitation, and release) are used for sun bear rehabilitation. All rescued sun bears are assigned to one of the following tracks: (1) immediately released after rescue (Track 1), (2) released after undergoing treatment and a short quarantine period (45 days) (Track 2), or (3) released after undergoing a long (18 months) rehabilitation process (Track 3) (Nabilah et al., 2018).

Weight and age data are often used to examine the growth patterns of captive animals, particularly in the Ursidae family (bears) (Kingsley et al., 1983; Kingsley et al., 1988; McDonough & Christ, 2012). However, information on the weight growth curve of the Malayan sun bear remains scarce, especially in the context of rehabilitation centres. Moreover, captive Malayan sun bears ideal and mature weights are also scarce, and these factors are evolving into a commonly debated issue related to release criteria. Therefore, to inform the management and successful release of captive Malayan sun bears, this study

examined the growth patterns of male and female bears to determine their ideal weight in captivity according to age.

METHODS

Data Collection

Weight data for eight sun bears (four males and four females) were collected under anaesthesia to ensure data accuracy and avoid bias. The age of each sun bear was estimated based on their physical appearance and previous history. Also, it was confirmed by a cross-section of the tooth root by trained veterinarians from DWNP (for certain individuals). Sun bears with an average age of two months were assessed using data collected over 18 months. Throughout the assessment, every individual was weight once every month. Most sun bears in this study had a conflicting background (Table 1).

Table 1
The backgrounds of individual sun bears received by the NWRC

Individual name	Sex	Background conflict
Ibam	Female	Previously kept by indigenous people from Kg. Ibam (Pahang). Experienced hydrocephalus that affected herbalance, movement, and vision.
Rina	Female	Previously kept by local people from Pahang.
Tebang	Female	Previously kept by local people and surrendered to NWRC at the age of 2 months.
Muaz	Female	Previously kept by local people from Pahang.
Ampang	Male	Previously surrendered to the Society for the Prevention of Cruelty to Animals in Ampang. One of the legs wasamputated due to a serious injury from a snare.
Bani	Male	Previously kept by illegal traders before being confiscated by PERHILITAN.
Bukit Mertajam	Male	Previously kept by local people from Bukit Mertajam, Pulau Pinang.
Damak	Male	Previously kept by indigenous people from Perlok, Pahang.

All study individuals were fed up with 10% of their body weight per day. Diets for cubs, sub-adults, and adults in captivity were based on NWRC guidelines (Nabilah et al., 2018). Sub-adults and adults were fed various foods, including commercial fruit, wild fruit, fresh meat (chicken, beef and fish), honey, and eggs. Cubs were fed 15% of their total body weight in reconstituted milk daily, which did not exceed 5% per feed. Cubs were fed milk every 2–3 hours, and the feeding frequency was reduced until cubs reached a total weight of 20 kg. It is the standard feeding procedure for both genders of Malayan sun bear at NWRC (Nabilah et al., 2018). The body weight of bears was maintained at the optimum body condition score (body score 3), in which the body appears to be corpulent, with an obvious layer of fat covering the pelvis and shoulder region and a sunken area between the ribs and rump being absent (Beecham et al., 2016).

Data Analysis

We used the von Bertalanffy method to determine the growth rate of Malayan sun bears. This method is widely used to measure the growth of many animal groups, particularly among the Ursidae family (Kingsley, 1979; Kingsley et al., 1983; Swenson et al., 2007; McDonough & Christ, 2012). This method estimates the length or weight of wild and captive animals (de Lima Amancio et al., 2014). As such, the von Bertalanffy method is useful for estimating bears' maximum growth (mature growth). Furthermore, the calculated parameter equation can determine other parameters, such as the rate parameter, *k*, and the weight or length at early ages (t = 0).

Thus, in the present study, we used the von Bertalanffy equation for best fit to determine the weight-age relationship pattern of sun bears in captivity.

The weight-age equation is:

$$W_t = W\infty[1-\exp(-k(t-t0))]^3$$

where W_t is the weight at age t; $W\infty$ is the limiting or final weight; k is the rate parameter; and $t0$ is the weight at $t = 0$.

Moreover, the standard error and confidence interval were calculated for both male and female sun bears. All analyses were conducted using the statistical program R (v 3.4.3) using the FSA and nlstools packages.

The ideal weights of Malayan sun bear according to age were grouped based on the age percentile growth of the population. This method was adapted based on the classification of age percentile growth patterns of human children and teens in the United States (CDC, 2000), which includes the following categories: underweight (5% confidence interval), overweight (85% confidence interval), and obese (95% confidence interval) while the mean curve represents the optimum weight for the population.

A comparison of weight growth between male and female Malayan sun bears was performed based on information produced by the von Bertalanffy models. In order to compare weight growth between sexes, extrapolation growth curves were plotted for both sexes, and comparisons were based on the confidence intervals of both growth curves (McDonough & Christ, 2012).

RESULTS

The parameters based on the von Bertalanffy equation are provided in Table 2, while the extrapolation of fitted curves is presented in Figure 1. The estimated final weight of male Malayan sun bears is significantly greater compared to females, as male weight ranged from 59.16–71.54 kg, and female weight ranged from 59.10–53.74 kg. Although the average male weight is greater than the female's, all parameters showed no significant sex-based differences.

Table 2
Estimated male and female sun bear parameters were calculated using the von Bertalanffy method, with the standard error and upper/lower confidence intervals

	Final Estimation	Std. Error	5% LCI (kg)	95% UCI (kg)
W_∞ (male)	65.35	6.185	58.03	83.65
W_∞ (female)	51.92	1.824	49.71	55.31
K (male)	0.067	0.018	0.035	0.102
K (female)	0.094	0.009	0.076	0.111
t_0 (male)	-11.626	4.276	-24.315	-6.51
t_0 (female)	-5.943	1.017	-8.387	-4.375

Note. W_∞:limiting or final weight; k: rate parameter; t_0: weight at t = 0

Growth curves for both males and females increased greatly during the initial year of growth, and the growth rate gradually began to decrease in the second year and then became much slower until reaching an asymptote. However, males reached an asymptote of the estimated mature adult weight slightly later (11 years and 6 months) than females (eight years and nine months). Comparing growth curves based on the confidence intervals between male and female bears indicated that males differed significantly from females, growing much larger than females from early until final growth stages (Figure 1).

The findings suggest that bears aged zero to one year can be considered juveniles, a stage with a higher growth rate. After one year, both male and female bears tend to exhibit the sub-adult growth pattern, where weight growth begins to develop slowly. For male

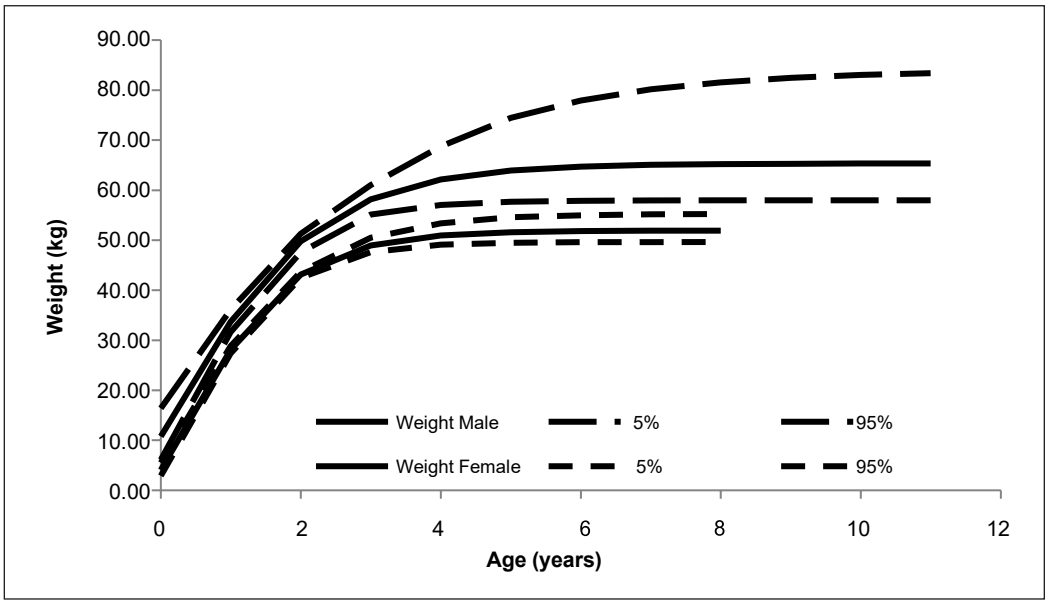

Figure 1. Growth weight curve for male and female Malayan sun bears at the NWRC

bears, the sub-adult growth pattern occurs from one to six years of age, with males reaching the adult stage at six years of age or more. However, males were estimated to reach the mature adult stage at 11 years and six months, where growth reaches an asymptote. The sub-adult growth pattern was evident for females between one and four years of age. After that, females reach the adult stage at four years old and then the mature adult stage at eight and nine months.

The ideal weight of Malayan sun bears in captivity was determined based on the von Bertalanffy model, with confidence intervals of 5%, 85%, and 95% (Table 3). Five per cent of the confidence interval will represent underweight, an 85% confidence interval will represent overweight, and a 95% confidence interval will represent obese. The mean middle curve indicates the optimum weight for the population.

DISCUSSION

The weight development patterns between male and female sun bears were similar to that of polar bears (*U. maritimus*) (Kingsley, 1979), grizzly bears (*U. arctos horribilis*) (Kingsley et al., 1983), Asiatic black bears (*U. thibetanus*) (Skripova, 2007), and brown bear (*U. arctos*) (Swenson et al., 2007), where males are heavier than females. Such findings correspond with the higher aggressiveness of males compared to females. It could be due to sexual dimorphism in ursids, where males are commonly larger, heavier, and more aggressive and competitive for food and territory. For example, due to competition over mates, evolutionary effects on the weaponry and body size of males have made them more aggressive, larger, and heavier than females (Lindenfors & Tullberg, 2011). Therefore, this finding supports the obvious sexual dimorphism observed in Malayan sun bears.

Based on the growth curves in this study, growth rates are highest between 0–1 year for both genders, then become slower between years 1–6, and are slowest at six years and above before reaching an asymptote for male, while females become slower between years 1–4, and are slowest at four years and above before reaching an asymptote. This study recognised three growth stages: juvenile, sub-adult, and adult. These three growth stages were based on growth rates, with juvenile stages characterised by the highest growth rates and adults being the slowest than sub-adults (Begall et al., 1999).

This information is important for ex-situ conservation programmes and wildlife management, where more intensive care is needed at the present stage. At 12 months of age, we determined that Malayan sun bears can be considered in a transition stage from juvenile to sub-adult, with the transition from milk to fully solid food being recognised as the end of the weaning stage (Hayseen & Orr, 2017). However, weaning in captivity could be different from wild conditions since it involves the introduction of solid foods. Lintzenich et al. (2006) reported that juvenile sun bears consuming a solid food mix with reconstituted milk could begin as early as two months old, while the process can last until

they are 11 months old. This observation is congruent with our findings, in which the end of the weaning stage occurs at less than 12 months of age and involves these individuals being considered sub-adults. At this stage, solid foods of high nutrient content are important for maintaining the health and growth development of Malayan sun bears, as the growing juvenile-sub-adult stage (increasing in size) has greater caloric requirements compared to the adult stage.

Males reach the adult stage at six years old, while females reach it at four years old. The adult stage is characterised by the slowest growth rates or a lack of growth, following Begall et al. (1999). This result could provide useful information for sun bear management in both wild and captive conditions and inform the optimal timing for the release of rehabilitated individuals back into the wild. Releasing wildlife following rehabilitation has become a hot topic among conservation and rehabilitation centres, with the success of conservation or rehabilitation programmes being measured on the survivability of released wildlife (Grogan & Kelly, 2013). Thus, the timing of releasing sub-adult and adult bears has become an issue of concern currently being debated among conservation practitioners.

The present study provides important information for wildlife management programmes, such as the Malayan sun bear release programme practised by the NWRC. Choosing suitable individuals with accurate age stages for release is critical for ensuring the survivability of Malayan sun bears in the wild. Previous studies have indicated that young bears or cubs rarely survive after being released (Beecham et al., 2016) due to being prone to predation by large carnivores and relatively defenceless against human threats such as poachers. Furthermore, young bears' lack of survival skills also contributes to their low survival in natural habitats (Fagen & Fagen, 2004). Therefore, it is crucial to ensure that they develop appropriate skills for foraging for food, climbing, and nesting in rehabilitation centres so that they possess the capacity to explore their surroundings and adapt to a new habitat. Thus, releasing juveniles into the wild is not the best option for release programmes. However, releasing adults is also not the best option, as the more time bears are kept captive, the more habituated they become towards keepers, thereby decreasing their possibility of survival in the wild (Beecham et al., 2015). Thus, the present study suggests that the optimal time for releasing sun bears is at the sub-adult stage (one to six years for males; one to four years for females). In addition, individuals' physical characteristics and behaviour are also important factors to consider (Beecham et al., 2016).

Furthermore, the ideal weight of a captive Malayan sun bear was established according to sex (Tables 3 and 4). Food and weight management are crucial to successfully managing wildlife in captivity. Notably, the establishment of an optimal weight is very important in managing captive bear health and monitoring food requirements since too much food causes obesity and an increased risk of health problems such as coronary heart disease and diabetes (Goodchild & Schwitzer, 2008), while the presence of underweight individuals

potentially indicates a diet of poor nutritional value, underfeeding, parasites, diseases, or dental issues. Thus, the guidelines provided in the present study can increase the efficiency of managing the welfare and health of captive Malayan sun bears, particularly at the National Wildlife Rescue Centre (NWRC).

Table 3
The ideal weight of male Malayan sun bears from early to late growth stages

Age/year	Weight (kg)	Underweight 5%	Overweight 85%	Obese 95%
0	10.85	6.16	14.49	16.43
1	33.75	31.7	35.44	36.16
2	49.78	47.62	50.69	51.31
3	58.17	55.19	60.24	61.06
4	62.13	57.09	66.19	68.82
5	63.92	57.73	69.49	74.47
6	64.72	57.94	71.37	77.94
7	65.08	58	72.4	80.2
8	65.23	58.03	72.98	81.61
9	65.30	58.03	73.3	82.5
10	65.33	58.03	73.48	83.07
11	65.34	58.03	73.57	83.42
11.5	65.35	58.03	73.62	83.65

Note. Weight stage indicators: underweight (5% confidence interval), overweight (85% confidence interval), and obese (95% confidence interval)

Table 4
The ideal weight of female Malayan sun bears from early to late growth stages

Age/year	Weight (kg)	Underweight 5%	Overweight 5%	Obese 95%
0	4.07	2.92	3.04	5.55
1	28.09	27.44	27.59	28.86
2	43.13	42.55	42.65	43.73
3	48.96	47.66	47.82	50.59
4	50.95	49.16	49.29	53.44
5	51.6	49.56	49.72	54.63
6	51.82	49.67	49.86	55.06
7	51.89	49.7	49.91	55.23
8	51.91	49.71	49.92	55.29
8.75	51.92	49.71	49.92	55.31

Note. Weight stage indicators: underweight (5% confidence interval), overweight (85% confidence interval), and obese (95% confidence interval)

CONCLUSION

The present study supports that weight data cannot be neglected in managing captive wildlife. A reliable model to determine the sub-adult stage is important for release. This model is important for creating work plans to handle wildlife, prioritising animal welfare until their release into natural habitats. We propose that the present findings can be used to inform captive wildlife management, rehabilitation, and release programmes.

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