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Current updates on the morphological measurements of the Malayan pangolin (*Manis javanica*)

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Abstract. In this study, morphological measurements of the Malayan pangolin, namely body mass, total length, tail length and head-body length, were investigated using samples of confiscated and wild pangolins. A high correlation between body mass and total length, for both male and female pangolins was recorded, with the correlation being much stronger for females (r-value = 0.8535) than males (r-value of 0.6342). A similar trend was found on the correlation between tail length and head-body length for both sexes. In addition, new records were generated for the physical measurements of maximum body mass (13.5 kg), head-body length (79 cm), tail length (72 cm) and total length (140 cm) respectively. Results and findings of this study will contribute to a better understanding of this critically endangered fauna for conservation and husbandry purposes.

Key words: body mass, total length, head-body length, weight, morphometry

Introduction

The Malayan pangolin or Sunda pangolin (*Manis javanica*) is one of eight extant pangolin species, the others being the thick-tailed pangolin (*Manis crassicaudata*), Philippine pangolin (*Manis culionensis*), black-bellied pangolin (*Uromanis tetradactyla*), Chinese pangolin (*Manis pentadactyla*), African white-bellied pangolin (*Phataginus tricuspis*), giant ground pangolin (*Smutsia gigantae*), and Temminck's ground pangolin (*Smutsia temminckii*) (IUCN 2017). Previously, populations of the Philippine pangolin were considered as Malayan pangolin until they were classified as Philippine pangolin (*Manis culionensis*) by Feiler (1998) and Gaubert & Antunes (2005). The Malayan pangolin is the only pangolin species found in Malaysia, however it is also found in Brunei, Thailand, Indonesia, Myanmar, Lao PDR, Cambodia, Vietnam as well as Singapore (Francis 2008, Lim & Ng 2008) and it is has been recorded in China too (Wu et al. 2005). It is known as *Tenggiling* in Malaysia, and the species shares similar physical features with other pangolin species such as overlapping scales on its body, a conical-shaped head, small eyes protected by thick eyelids, a slender mouth lacking teeth, a long and sticky tongue, sharp and powerful claws on its forefeet, a prehensile tail (Che Nor 1989, Heath 1992, Payne et al. 1998, Nowak 1999, Francis 2008) and a specialized stomach for grinding food (Nisa' 2005).

Historically, the Malayan pangolin was an abundant and common animal in Malaysia. However, their numbers are sharply declining due to excessive illegal hunting for the international wildlife trade as their scales and meat are used in traditional medicine and as exotic food (Gono et al. 2009, Challender et al. 2014). In addition, the Malayan pangolin is threatened by habitat loss due to deforestation and habitat modifications. With these increasing threats, in 2014, the Malayan pangolin was listed as "Critically Endangered" in the International Union for Conservation of Nature and Natural resources (IUCN) Red List of Threatened Species (Challender

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et al. 2014) and this was followed up in 2016 with the upgrading of the Malayan pangolin, together with other pangolin species into the Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), where trade in specimens of species threatened with extinction is only permitted in exceptional circumstances (CITES 2017).

The Malayan pangolin is secretive and solitary, and is considered a nocturnal animal (Payne et al. 1998, Francis 2008, Lim & Ng 2008), which adds to the difficulty of obtaining wild pangolins for sampling. In previous literature pertaining to the species, the only detailed study of the Malayan pangolin's morphometric measurements were conducted by Wu et al. (2004) which compared morphometric measurements of the Chinese pangolin (*Manis pentadactyla*) and the Malayan pangolin (*Manis javanica*) in China. Morphometric measurements included in the Wu et al. (2004) study comprised of body weight, total body length, the length of head and body, tail length, the length of protruding rim of external ear, hind feet length, the length of middle claws of fore feet and hind feet, the number of rows of scales round mid-body and the number of single flanking scales of tail edge. In Malaysia, there is only one study (Pantel & Noorainie 2010) which briefly touched on the physical measurements of the Malayan pangolin such as weight. Although Pantel & Noorainie's (2010) intention was to collect data regarding the trade of Malayan pangolins in Sabah, the data obtained is still useful as a basic record of the Malayan pangolin measurements in Malaysia.

This study focused on the basic physical measurements of the Malayan pangolin, namely body mass, total length, tail length and head-body length. As there are limited studies conducted on the morphological measurements of the Malayan pangolin, there is the pressing need to obtain more detailed information on these parameters as they will greatly assist in many aspects of the conservation of this critically endangered species. This is especially true in the treatment and rehabilitation of confiscated individual pangolins rescued from the illegal trade before release as many of these animals are severely dehydrated and malnourished when they were rescued. With this study, it is hoped that these measurements could contribute to the database of the species' age, sex and health status, especially to generate a basic growth chart of a healthy Malayan pangolin based on sex and age, which in turn will be useful for veterinarians treating individual pangolins rescued from the illegal trade.

Although the data obtained in this study was heavily influenced by time and manpower constraints, the findings in this study would be useful in comparing and determining the sex and age of Malayan pangolins based on physical parameters, which in turn will also improve knowledge in captive breeding and husbandry of the species.

Material and Methods

Subjects

In total, 62 live pangolins were sampled. However, due to manpower and time constraints, only a total of 31 live Malayan pangolin individuals were successfully sampled for all the morphological measurements. Pangolin samples consisted of those obtained from the wild and confiscated pangolins from the illegal trade by the Department of Wildlife and Nature Parks (DWNP) Kelantan and Penang, Malaysia. In regard to wild pangolin samples, the authors had applied and successfully obtained research permission via a special permit to handle, conduct research and to capture Malayan pangolins in the wild from the DWNP Peninsular Malaysia before this study commenced. For the wild samples, three individuals were sampled from three sampling sites namely Kampung Pos Pulat (PP) (05°54′22.6′ N, 102°43′98.2′ E) in Kelantan, Kampung Sungai Berua (KSB) (05°04′63.9′ N, 102°53′26.8′ E) in Terengganu, and Krau Wildlife Reserve (KWR) (03°35′34.4′ N, 102°08′37.7′ E) in Pahang.

Handling and physical measurements collection

Confiscated pangolins are usually were kept in a gunny sack or in a cage before being released to the wild. For pangolins in a gunny sack, it is advisable to obtain the body mass measurements while the pangolin is still in the gunny sack, as a more accurate weight can be obtained. As for those kept in the temporary cages of the DWNP, generally when the pangolin is bought out of its cage, it tends to curl up into a ball, and it is best to obtain the body mass measurement during this time. Body mass measurements were obtained using a portable weighing machine and recorded in kilograms (kg).

To obtain a reliable length measurement it is necessary to uncurl the pangolins. To uncurl the pangolin from its defensive tight ball-like body, the tail's tip was held tightly while applying slow yet continuous motion from up to down. Generally, the pangolin will uncurl its body after a short period of time once this motion is being applied. The pangolin was then carefully put down with only its front body touching

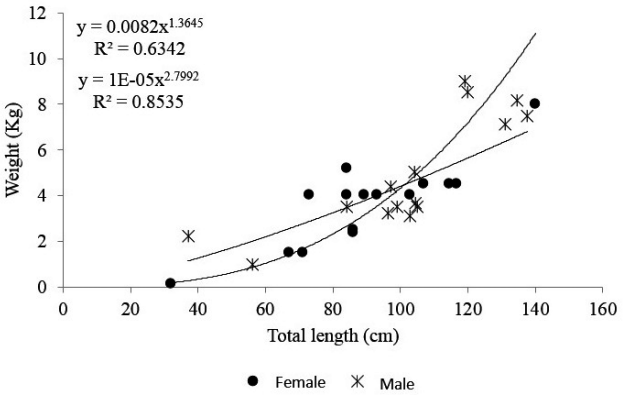

Fig. 1. The correlation between body-mass and total length for the male and female Malayan pangolin.

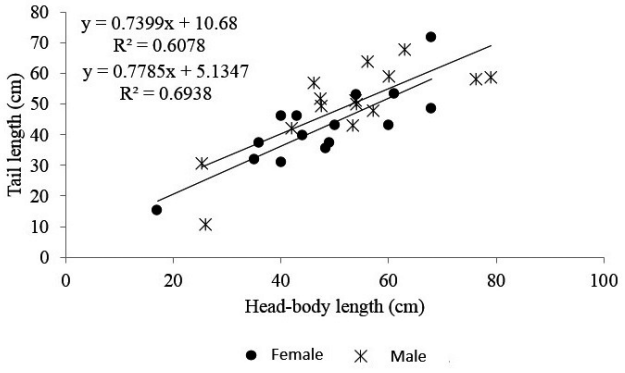

Fig. 2. The correlation between tail length and head-body length for the male and female Malayan pangolin.

the ground and the pangolin's tail and body length were measured. The measurement of length was taken along the ventral surface of the pangolin. Tail length is from the tip of its tail to the base of the tail (anus area), while body length is from the base of the tail to the tip of its snout. Precautions must be taken to avoid the pangolin's tail being wrapped on the researcher's arm or for its front legs to touch the researcher. Length measurement was taken using a measuring tape and recorded in centimeters (cm). Data of body mass and length were then recorded in a data sheet. A simple procedure was used to determine the pangolin's sex at the same time the length measurement was taken. The pangolin's genital area will be exposed when the pangolin uncurls its' body, with male pangolins having a distinctive penis. However, the testicles are enclosed in the abdomen, thus they are not visible. For the female pangolin, the sexual organ is like a small opening near the anus. All data were recorded in the same sheet used for body mass and length measurements.

The correlation graph for body mass *vs.* total length was plotted using Microsoft Excel 2010 and Regression Power type was used to generate the trend line. The correlation graph for head-body length *vs.* tail length used Regression Linear type to generate the trend line. A 2-way analysis of variance (ANOVA) was used for testing the significance level of correlation of body mass *vs.* total length, and head-body length *vs.* tail length. For the significant relationship analysis of variables parameters between sexes, Kolmogorov-Smirnov two sample test was utilized.

Table 1. Regression test of measurement association of male and female Malayan pangolin.

Variables	Sex	n	Association equation	r-value	F-value
Body-mass *vs.* total length	Male	15	$y = 0.0082x^{1.3645}$	0.6342	25.52
	Female	16	$y = 1E\text{-}05x^{2.7992}$	0.8535	40.36
Tail length *vs.* head-body length	Male	15	$y = 0.7399x + 10.68$	0.6078	20.15
	Female	16	$y = 0.7785x + 5.1347$	0.6938	28.87

Table 2. Kolmogorov-Smirnov test for comparison of morphological measurements between male and female Malayan pangolin.

Variables	Sex		D-value
	Male	Female	
Body weight (kg)	4.9 ± 2.47 (n = 15) 1-9 kg	3.66 ± 1.81 (n = 16) 0.1-8 kg	0.275 *
Head-body length (cm)	52.4 ± 14.9 (n = 15) 25.3-79	47.3 ± 13.2 (n = 16) 17-68 cm	0.3 *
Tail length (cm)	49.46 ± 14.2 (n = 15) 11-68 cm	42.2 ± 12.3 (n = 16) 15-72 cm	0.483 **
Total length (cm)	101.9 ± 27 (n = 15) 37-137.5 cm	89.7 ± 24.4 (n = 16) 32-140 cm	0.488 **

Note: (*) significant difference, (**) not significant. Note: Determination of significant done by $D_{31,1} = 0.438$ where $\alpha = 0.1$.

Table 3. Malayan pangolin measurement in the present study and previous studies.

Variables	This study	Previous studies	Source of previous studies
Body mass (kg)	4.81 ± 2.56 (n = 62) 0.1-13.5 kg	3.76 ± 1.67 (n = 20) 1.6-7 kg	Wu et al. (2004)
		5-7 kg	Lekagul & McNeely (1988)
		2.7-7.7 kg	Pantel & Noorainie (2010)
Head-body length (cm)	49.76 ± 14.07 (n = 31) 17-79 cm	52.4 ± 6.8 (n = 24) 40-62 cm	Wu et al. (2004)
		42.5-55 cm	Lekagul & McNeely (1988)
Tail length (cm)	45.8 ± 13.5 (n = 31) 15-72 cm	43.7 ± 6.8 (n = 25) 29.5-53 cm	Wu et al. (2004)
		34-47 cm	Lekagul & McNeely (1988)
Total length (cm)	95.6 ± 26.2 (n = 31) 32-140 cm	95.4 ± 12.9 (n = 25) 66-112 cm	Wu et al. (2004)
		76.5-102 cm	Lekagul & McNeely (1988)

Results and Discussion

The association between body mass and total length for the male Malayan pangolins was high (r-value = 0.6342) but it was much stronger (r-value = 0.8535) for the female Malayan pangolins (Fig. 1, Table 1). Additionally, results showed that when the total length of the Malayan pangolins increase, the body mass will also increase proportionally. Statistically, for body mass *vs.* total length, it was significant at 99.9 % of confidence level, with mean male weight = 4.89, mean male total length = 101.87, $F_{1,13} = 25.52$, $p = 0.11$ for male and mean female weight = 3.66, mean female total length = 89.68, $F_{1,14} = 40.36$, $p = 0.04$ for the female pangolins. The positive correlation of body mass and total length of the Malayan pangolins in this study is in agreement with Irshad et al. (2016) study on Indian pangolins in Pakistan.

Results of the Kolmogorov-Smirnov test on the male and female Malayan pangolin body mass showed significant difference at 90 % of confidence level ($D_{calculated} = 0.275$, $\alpha = 0.1$) for both sexes (Table 2). In this study, the maximum body mass recorded was 13.5 kg, while a previous study recorded a maximum of 7.7 kg (Table 3). In this study, we obtained a new born baby pangolin (neonate), which weighted 0.1 kg or 100 g. Our record for the neonate is in agreement with Breen (2003), who stated that the Malayan pangolin neonate weight ranges from 100 g to 500 g. For this study, it is certain that the baby pangolin was newborn as the placental was still attached with the mother and there was fresh blood on the floor when measurements were obtained. The mother and the neonate were confiscated Malayan pangolins waiting for release while at the DWNP Penang. As the mother was still weak, it was not brought out of its cage for any measurements.

As for tail length and head-body length correlation, both sexes exhibited a slight difference in the data obtained with the male having r-value of 0.6078 while the female was 0.6938 (Fig. 2). Although both sexes had quite similar readings, yet the female Malayan pangolins seemed to have a slightly stronger tail length and head-body length correlation as compared to the male pangolins.

For head-body length comparison between male and female Malayan pangolins, the male individuals had a much longer head-body measurement (Table 1), as supported by the Kolmogorov-Smirnov test whereas a significant difference was detected between male pangolins and female pangolins head-body length ($D_{calculated} = 0.3$, $\alpha = 0.1$). This might be influenced by one single female neonate who had a very low body weight and other measurements as both sexes seemed to have fairly similar body weight. Significant differences in the head-body length and tail length for male and female pangolins were recorded at 99.9 % of confidence level (mean male head-body length = 52.4, mean male tail length = 49.46, $F_{1,13} = 20.15$, $p = 0.2$ for male; mean female head-body length = 47.27, mean female tail length = 42.4, $F_{1,14} = 25.52$, $p = 0.186$ for female) (Table 2). The measurement of head-body length of the Malayan pangolins recorded in this

study differed with previous studies, as we managed to obtain a longer head-body length (Table 3).

In this study, the female Malayan pangolin recorded the longest tail measurements as compared to the males. However, the Kolmogorov-Smirnov test indicated that there was no significant difference for male and female pangolin tail length comparison ($D_{calculated}$ = 0.483, α = 0.1) (Table 2). In this study, a new record for the longest tail length was recorded as compared to the previous studies conducted by Wu et al. (2004) and Lekagul & McNeely (1988) (Table 3). Additionally, although the female individuals had longer total length than the male, no significant difference ($D_{calculated}$ = 0.488, α = 0.1) was detected in the Kolmogorov-Smirnov test (Table 2). As such it could be surmised that the male and female Malayan pangolins have similar tail and total length.

Findings of this study corroborates previous studies where the head-body length of the Malayan pangolin was found to be slightly longer than the tail length. For this study, the ratio of average head-body length to tail length is 1 to 1.1. The ratio for Wu et al. (2004) is 1 to 1.2 which is similar to Lekagul & McNeely (1988) who recorded 1 to 1.2, while Gaubert & Antunes (2005) record is 1 to 1.25.

The total length of the Malayan pangolin is obtained when the head-body and tail length are combined. We recorded 140 cm as the new longest total length. These measurements were out of the range recorded by Wu et al. (2004) and Lekagul & McNeely (1998), indicating that new morphological measurements of the Malayan pangolin could be recorded in the future.

In conclusion, we have sampled 31 specimens and some basic physical measurements of the Malayan pangolin have been updated. These results will be useful in obtaining an insight of the correlations of some physical measurements between and within sexes of the species. Due to manpower and time constraints, the researchers only managed to cover a small number of confiscated individuals for sampling. Therefore, future studies will help to obtain information useful for captive breeding and conservation.

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