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Original Research Article

Evaluating the application of scale frequency to estimate the size of pangolin scale seizures

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ABSTRACT

All eight species of pangolin are principally threatened by overexploitation, both for international trafficking and local use. Much illegal trade involves scales, but there is an absence of robust conversion parameters for estimating the number of different pangolin species in given seizures. Such parameters are critical in order to accurately characterize pangolin trafficking and understand the magnitude and impact of exploitation on populations. In this study, we calculated the number of scales on 66 museum specimens representing all eight extant pangolin species from the genera *Manis*, *Phataginus*, and *Smutsia*, and developed a method for estimating the number of pangolins in given seizures of scales based on scale frequency. Our statistical analyses found significant variation in scale number in inter-species terms (ranging from 382 for Temminck's ground pangolin to 940 for the Philippine pangolin), and in intra-species terms, with substantial variation in the giant pangolin (509−664 scales) and minimal variation in the Chinese pangolin (527−581 scales). We discuss application of the developed sampling method in a real world context and critically appraise it against existing methods. The knowledge generated in this study should assist in understanding pangolin trafficking dynamics, though there remains a need for accurate conversion parameters for estimating the number of pangolins in illegal trade, especially for the Indian and African species.

1. Introduction

The global wildlife trade involves a diverse range of animals, plants and fungi, including products from exotic pets, through food fisheries and timber, to cosmetics and traditional medicines (Harfoot et al., 2018). The trade is driven by international demand for these products as well as local use and contributes to household income in many parts of the world (Shairp et al., 2016; Robinson et al., 2018). It can involve whole organisms (e.g., in the pet trade and fisheries) or their parts and derivatives (e.g., scales, bones and powders), or a combination (Nijman, 2010; Rosen and Smith, 2010). Where trade in parts or derivatives is concerned, species identification and estimation of the numbers of individuals harvested and traded is challenging (Duffy,

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2016). This is particularly acute where trade is illegal because it is clandestine (Hansen et al., 2012). The illegal wildlife trade is a global conservation issue that poses a major threat to the survival of many species and ultimately the integrity of functional ecosystems (Duckworth et al., 2012). Despite the challenges involved, accurately quantifying the number of individuals of species in illegal trade is crucial to understanding the magnitude of such trade in order to inform conservation interventions and appropriate policy at multiple levels (Challender et al., 2015).

Pangolins (Pholidota: Manidae) are poached and trafficked in high volumes in Africa and Asia, and trafficked from Africa to Asia (IUCN SSC Pangolin Specialist Group, 2016). They are placental mammals covered in individual, overlapping scales comprised of keratin, and are the world's only truly scaly mammals. Native to Asia and sub-Saharan Africa there are eight extant species, each of which is threatened with extinction due to overexploitation for international trafficking and local use (Boakye et al., 2015; Challender et al., 2015; IUCN SSC Pangolin Specialist Group, 2016). The four Asian species comprise the Philippine pangolin (*Manis culionensis*), Indian pangolin (*M. crassicaudata*), Sunda pangolin (*M. javanica*), and Chinese pangolin (*M. pentadactyla*) and the African species are the black-bellied pangolin (*Phataginus tetradactyla*), white-bellied pangolin (*P. tricuspis*), giant pangolin (*Smutsia gigantea*), and Temminck's ground pangolin (*S. temminckii*) (Gaubert, 2011).

Due to the threat from overexploitation, all pangolin species were included in CITES Appendix I in 2016 (CITES, 2016). However, illegal trade continues with the animals primarily targeted for their meat and scales. Pangolin meat is consumed as a luxury product in urban metropolises in East and Southeast Asia (e.g., Shairp et al., 2016) and valued as bush meat in African range states (e.g., Boakye et al., 2015). Pangolin scales are used as an ingredient in traditional medicines on both continents, purportedly to treat a range of ailments, but in the last decade there has been a perceptible increase in the trafficking of African pangolins, almost exclusively scales, to Asian markets (Challender and Waterman, 2017). Recent seizures are symptomatic of the transfer of poaching pressure from parts of Asia to Africa. They include multiple seizures in a five-day period in April 2019 involving 25.6 tonnes of scales (12.9 and 12.7 tonnes respectively), that were exported from Nigeria and bound for Vietnam (The Strait Times, 2019).

Trafficking of pangolins for their meat normally involves whole animals, though they may be descaled and eviscerated (see Sopyan, 2008), and quantifying the number of individuals is simple − they can be counted (Challender et al., 2015). However, estimating the number of pangolins being trafficked when only scales are involved is more challenging. Once scales have been removed from an animal they may be dried, and are typically collated in sacks or other containers, seemingly regardless of size or species, and are transported internationally (Sopyan, 2008; Nijman et al., 2016). With exceptions for specific species (e.g., black- and white-bellied pangolins), scales from which may be identified by experts, it is difficult to visually identify the species of pangolin involved from scales alone. Importantly, there is also a lack of capacity among law enforcement personnel to correctly identify the species and their derivatives in illegal trade (see Challender and Waterman, 2017). This makes converting seizures of scales to estimated numbers of specific species problematic.

The current method of estimating the number of pangolins in illegal trade to inform international policy is weight-based. It comprises dividing the weight of a given seizure or trade volume by the weight of scales from a specific species, or in the absence of robust parameters for specific species, for an 'average' pangolin (based on the Sunda pangolin; see Challender et al., 2015; Challender and Waterman, 2017). However, robust estimates of the weight of scales only exist for the Chinese and Sunda pangolins (see Zhou et al., 2012). Wet weight (i.e., the weight associated with moisture content of a scale) is more variable than dry weight, and the rate of desiccation varies due to a number of environmental factors, including temperature and humidity. As such, a more robust approach to estimating the number of animals from quantities of scales is to use dry weights (Zhou et al., 2012). Zhou et al. (2012) estimated the dry weight of scales from Chinese and Sunda pangolins and proposed a conversion parameter of 573.47 g and 360.51 g of scales respectively; a combined dry weight of 467 g (0.47 kg) per animal was also proposed. These proposed conversion parameters have since been applied to derive the number of animals found in seizures globally (see Challender et al., 2015; Challender and Waterman, 2017). However, the difference between dry and wet weight of scales complicates this conversion method. Zhou et al. (2012) noted that differences in rate of scale desiccation between animals was associated with body size and length meaning the dry weight of scales varies between animals and species and over time. As there is no systematic method for determining how long a scale has been in trade (i.e. how long since the scale was removed from the animal), and therefore scale desiccation rate, the effectiveness of this conversion method may be limited by unknown and potentially confounding factors. Moreover, there have been no specific scientific studies on the dry weights of scales among the Philippine, Indian, or any of the African species, which limits the accuracy of weight-based methods. Recognizing the need for more robust conversion parameters for pangolins, we calculated the number of scales on each of the eight species and developed a new method for estimating the number of pangolins in given seizures of scales based on scale frequency. We discuss application of this method for estimating the number of pangolins in illegal trade in a real world context and critically appraise it against existing methods.

2. Materials and methods

2.1. Specimens

We sampled 66 pangolin specimens (both mounted specimens and skins) representing all eight pangolin species (Philippine pangolin, n = 3; Indian pangolin, n = 9; Sunda pangolin, n = 11; Chinese pangolin, n = 10; white-bellied pangolin, n = 9; black-bellied pangolin, n = 10; giant pangolin, n = 8; Temminck's ground pangolin, n = 6) at the Natural History Museum in London (BNHM), National Museum of Scotland (NMS), the Powell-Cotton Museum (PCM), Kent, UK, The Beaney

House of Art & Knowledge (BHAK), Kent, UK and the American Museum of Natural History (AMNH), New York, USA (see Supplemental Materials for a complete list of specimens). We collected data from 98 specimens (BMNHM, n = 67; NMS, n = 12; PCM, n = 14; BHAK, n = 1; AMNH, n = 4), but included 66 in our final sample, having excluded specimens that were either incomplete (e.g. missing partial or full limbs/tail) or mounted on a display object, thus obstructing the view of ventral scales. While the number of scales pangolins possess does not change with age (with the exception of occasional losses due to, for example, burrowing activity), for ease of counting (due to scale size) and limited time and resources, only adult specimens were included in this study.

2.2. Scale counting and data collection

Specimens were photographed using a Nikon COOLPIX P900 digital camera. Each specimen was photographed laterally, dorsally, and ventrally, to ensure all scales were captured in photographs for counting. When provided, the specimen's museum identification number was recorded. Species names were recorded reflecting current taxonomic classification (following Gaudin et al., 2009) and including the Philippine pangolin. Adobe Photoshop Windows 10 was used to count the number of scales each specimen possessed. To assist in this process, the scales on the following sections of each specimen were counted separately and marked using a different coloured mark: head, forelimbs (right and left), hind limbs (right and left), tail, and body. The number of scales from each section was then summed to calculate the total scale count per specimen. Where a scale was missing, but it could be determined with confidence that a scale was once present, i.e. there was an obvious scale bed, it was counted and included (Fig. 1). All data were recorded in Microsoft Excel Version 16.16.4.

2.3. Statistical analyses

Descriptive statistics were used to examine intra- and inter-species variation in the mean number (and standard deviation) of scales. As the data did not meet the assumption of homogeneity required for a traditional analysis of variance (ANOVA) test, a Welch's ANOVA was used to test for significant differences in the total number of scales across the eight sampled species groups; Welch's ANOVA does not require meeting this assumption because it accounts for differences in the small and varied sizes of each sample (MacDonald, 2008). A Games-Howell's post hoc comparison test (95% confidence level) was used to identify where significant differences occurred between species groups. Variation in the mean (and standard deviation) number of scales between Asian (n = 33) and African species (n = 33) was also examined, and a two-sample *t*-test was used to test for a significant difference in the number of scales between the two groups. All statistical analyses were carried out in IBM SPSS Statistics 24.

3. Results

The number of scales per species ranged from 382 ± 31.87 (mean ± SD; n = 6) in Temminck's ground pangolin to 940 ± 76.18 (SD; n = 3) in the Philippine pangolin. Mean number of scales across all species was 649.4 ± 178.97 (SD; n = 66) (Table 1: Fig. 2). Intra-species variation in number of scales was observed in all sampled groups (Fig. 2). Specimens of giant pangolins varied the most, ranging between 509 and 664 scales (574.4 ± 60.54, n = 8); specimens of Chinese pangolins varied

Fig. 1. Photograph of Sunda pangolin tail section (pictured laterally) showing scale beds where scales used to be present.

Table 1
Mean (±SD) number of scales for each species of pangolin, divided by continent, and derived for an 'average' pangolin.

Species	n	No. of scales	Continent	n	No. of scales	Total sample	n	No. of scales
Philippine pangolin	3	940.00 ± 76.18	Asia	33	677.64 ± 184.75	'Average' pangolin	66	649.42 ± 178.97
Sunda pangolin	11	867.45 ± 42.94						
Chinese pangolin	10	554.40 ± 18.01						
Indian pangolin	9	495.11 ± 24.19						
white-bellied pangolin	9	859.00 ± 48.65	Africa	33	621.21 ± 171.14			
black-bellied pangolin	10	588.20 ± 27.68						
giant pangolin	8	574.38 ± 60.54						
Temminck's ground pangolin	6	382.00 ± 31.87						

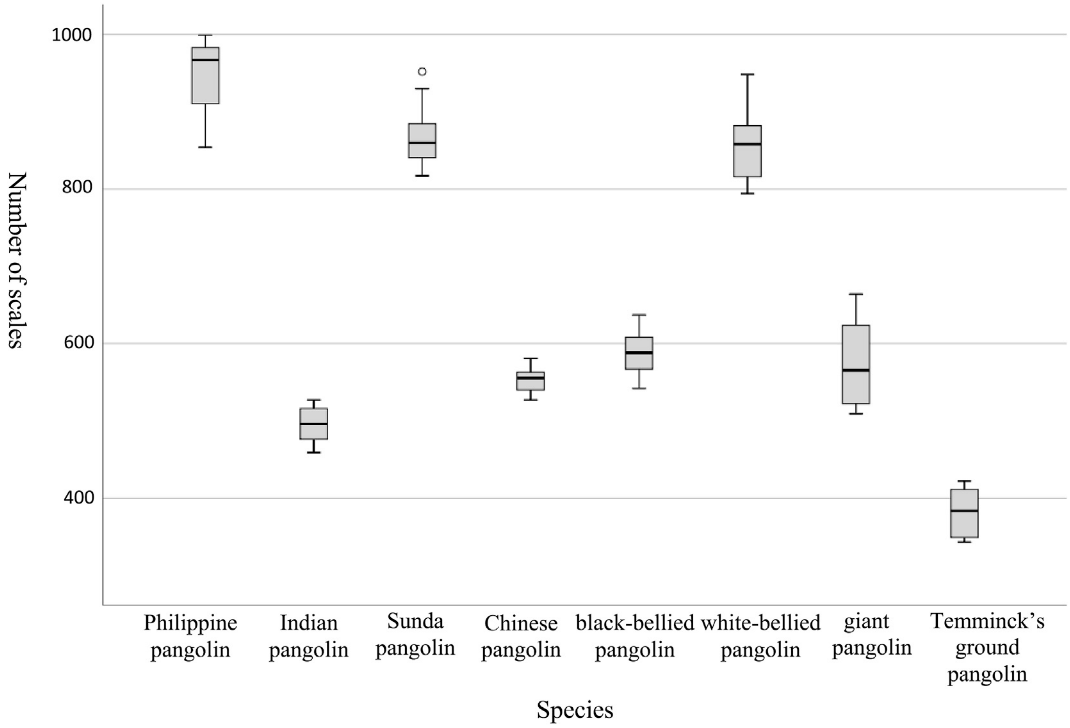

Fig. 2. Box-and-whisker plot showing intra- and inter-species variation in scale number between species. Each box displays the median (bold black line), first and third quartiles (bottom and top of box), the minimum and maximum range below and above the quartiles (whiskers), and outlier data points (open circle).

the least, ranging between 527 and 581 scales (554.4 ± 18.01, n = 10). Substantial variation was also observed in the Sunda, Philippine, and white-bellied pangolins compared to other species (Fig. 2). At the continental level, the mean number of scales for African species was 621.2 ± 171.14 (SD; n = 33), while the Asian species had a mean of 677.6 ± 184.75 (SD; n = 33) scales (Table 1: Fig. 2).

A Welch's ANOVA of the mean number of scales across the eight sampled groups revealed significant differences between species ($F_{7,17.57} = 141.84$, $p < 0.001$) (Table 2). A post hoc comparison, performed with the Games-Howell test, revealed significant differences ($p < 0.05$) in the number of scales between specific species and groups (Table 2). A two-sample *t*-test revealed that the difference in the mean number of scales between African and Asian species groups was not statistically significant ($t_{64} = 1.287$, $p = 0.202$).

Table 2
Results of Games-Howell post hoc comparison test. Presented are *p* values and significant differences ($p < 0.05$).

Species	*p* values in Games-Howell post hoc							
	Philippine pangolin	Sunda pangolin	Chinese pangolin	Indian pangolin	white-bellied pangolin	black-bellied pangolin	Giant pangolin	Temminck's ground pangolin
	n = 3	n = 11	n = 10	n = 9	n = 9	n = 10	n = 8	n = 6
Philippine pangolin	–							
Sunda pangolin	.750	–						
Chinese pangolin	.052	.000*	–					
Indian pangolin	.037*	.000*	.001*	–				
white-bellied pangolin	.693	1.000	.000*	.000*	–			
black-bellied pangolin	.058	.000*	.078	.000*	.000*	–		
giant pangolin	.030*	.000*	.977	.084	.000*	.998	–	
Temminck's ground pangolin	.018*	.000*	.000*	.001*	.000*	.000*	.000*	–

*denotes significant difference ($p < 0.05$).

4. Discussion

Our results demonstrate substantial variation in the frequency of scales between the eight pangolin species, and in some cases statistically significant differences between species (Table 2). Quantifying the number of scales at the individual (by species), continental, and family (Manidae) level has potential application for law enforcement purposes as well as for characterizing, and estimating, the magnitude of pangolin trafficking, to inform management and policy decisions from the local to international level (e.g., in CITES). Knowledge of scale frequency for an ‘average’ pangolin means it is possible to estimate the number of individual animals involved in any given seizure of scales. This will be particularly useful for large seizures involving substantial quantities of scales, not only in terms of estimating the number of animals involved, but also for informing judicial proceedings. For example, estimating the financial value of scales being trafficked commercially to inform penalties during prosecutions (see also Zhou et al., 2012). Knowledge of inter-species variation means it will also be possible, at least theoretically, to estimate the number of pangolins of specific species in given seizures, either if only one species is involved and its scales can be confidently identified, or if more than one species is involved and scales can be identified and separated.

More specifically, this method would allow for the number of individual animals represented in any given seizure to be extrapolated from the total weight of the seizure. This would use the weight and quantity of a sample of scales combined with the scale frequency for an ‘average’ pangolin (combined mean for all 66 specimens in this study; see Table 1). It would involve the following steps, including a step to account for potential sampling bias, for example, a law enforcement officer only taking a sample of scales from the top of a sack or container of scales. The varied size of pangolin scales (e.g., large dorsal scales versus small scapular scales), which varies between species, means that smaller scales end up at the bottom of a sack or other container when in transit. The six steps comprise the following:

(1) weigh the consignment of scales [e.g., 1 000 kg];
(2) remove sampling bias by mixing the scales of one bag or container;
(3) take a nominal sample of 200 g of scales from the sampled container and count the number of scales in the sample;
(4) calculate the weight of an individual scale from the sample (200 g/number of scales in sample = average weight of 1 scale) [e.g., 200 g/40 scales = 5 g per scale];
(5) calculate the number of scales in the entire consignment (weight of entire consignment/average weight of a single scale = estimated number of scales in consignment) [e.g., 1 000 kg (1 000 000 g)/5 g = 200 000 scales];
(6) use the mean number of scales on a pangolin (649.4 scales) to calculate the estimated number of animals represented in the seizure [e.g., 200 000/649.4 (mean scale frequency on ‘average’ pangolin) = 308 animals].

In theory, this method could be used in three main scenarios, the selection of which will depend on what is known about a particular seizure; Scenario A: extrapolation at the species level – where one or more species can be identified and the corresponding scale frequency means could be used; Scenario B: extrapolation at the continental level – where species identification is not possible, but the origin of the consignment is known (e.g., Africa); and Scenario C: where neither the species nor origin is known (as per the above example). Scenarios B and C are most likely at present: in some cases it is known that seizures originated from African countries, but for other seizures, countries of origin and export are not known, and as noted there remain recognized difficulties in identifying pangolin scales at the species level among front-line law enforcement personnel (Challender and Waterman, 2017). The variety of applications this method offers reflects the complexity of sampling seizures of scales in a real world context.

This method offers an alternative morphometric parameter for estimating the number of individual pangolins in a consignment of scales. While there was no significant difference in scale frequency overall between the African and Asian species, continental means could be used to estimate the number of animals with a known continent of origin. For example, where a consignment is seized in or originated from an African pangolin range state, the mean number of scales for the African species (621.2 scales) could be applied rather than the combined mean for an average pangolin (649.4 scales). The lack of statistically significant difference between scale frequency in the African and Asian species could perhaps have been expected in the knowledge that African pangolins are both larger (giant pangolin and Temminck's ground pangolin) and smaller (black- and white-bellied pangolins) than the Asian species (Gaubert, 2011). Application of the continental means could make estimates more accurate.

Despite theoretical application of this method, there are a number of limitations hindering its immediate real world application. This method involves six steps as outlined, i.e. an additional four steps compared to the weight-based method currently used (see Challender and Waterman, 2017). This translates into an additional time investment and workload for frontline law enforcement personnel if and when seizures are made, and thereby likely reduces the probability that it would be implemented in reality. The current lack of capacity to identify species of pangolin from scales among frontline law enforcement personnel in many parts of the world has the same effect, and would limit the ability to implement this method in Scenario A. As this method requires a greater time investment for sampling, counting and weighing scales, our expectation is that law enforcement personnel, particularly in developing countries, would favor the current weight-based method, which involves a simpler, two-step calculation. The additional steps in the scale frequency-based approach also increases the probability of sampling bias and miscalculation. The solution to the sampling bias we proposed (i.e., mixing scales from one container before sampling scales) presents scope for inaccuracy because there would likely be variation in the degree of mixing between enforcement agents and different agencies. While these problems could potentially be overcome with the development of detailed guidance on sampling from scale seizures (e.g., on taking unbiased and systematic samples), other problems discussed, including the additional workload could preclude widespread application. This is compounded by the scale frequency-based method potentially underestimating the number of pangolins represented in seizures. The worked example above using this method produced an estimate of 308 pangolins, which contrasts starkly with an estimated 2 774 pangolins using the weight-based approach applied to the same seizure (1 000 kg/360.51 kg = 2 774 pangolins). Both methods require validation. Controlling for the potential biases in the scale frequency-based method would be extremely challenging, but would be required, especially if the intention was for the resulting data to be used to inform judicial proceedings and/or international policy decisions (e.g., in CITES).

There remains a clear need for more accurate and robust species-specific parameters to complement those that do exist (see Zhou et al., 2012) for application of current weight-based conversion methods for pangolins. In the absence of accurate estimates of the dry weight of scales for each species, we explored how knowledge of scale frequency could be used to develop an alternative sampling method for estimating the number of pangolins found in illegal trade. As with the weight-based method, the variability in size and respective weight of scales on pangolins makes extrapolating accurate estimates of the number of animals in a given seizure from a sample of scales challenging. While the wet weights of scales for the Sunda and Chinese pangolin have been derived (see Zhou et al., 2012), they do not yet exist for the remaining six species. This measurement should be quantified in future studies in addition to dry weights, which could be derived from recently deceased individuals, for example, those held in rehabilitation centers and/or fatalities in illegal trade. Recognizing that the proposed scale frequency-based method is both more labor-intensive, requires additional steps of sampling, weighing and counting scales, and potentially underestimates the number of individuals due to sampling biases, the current weight-based method still offers the most convenient and reliable approach to estimating the number pangolins in illegal trade from seizures of scales. However, as noted this method requires validation.

Further research could ensure more accurate estimates of scale frequency and inter- and intra-specific variation with which to inform conservation parameters for understanding illegal pangolin scale trade. Future studies of this nature could benefit from an alternative method to using multiple photographs of each specimen to assist counting, such as photogrammetry software (e.g., Agisoft PhotoScan). This could be used to create a three-dimensional image of an entire specimen to make the counting process faster and more efficient. Another avenue to explore is the use of batch-counting software; a visualisation tool which uses ridge regression to estimate object (in this case, scales) density through images (Arteta et al., 2014). The small and varied size of our sampled species groups was due in large part to time constraints, but also to the quantity and availability of certain species in the collections visited. Indeed, a lack of representation of Philippine pangolins in museum collections worldwide has been noted (see Gaubert and Antunes, 2005). Moreover, the advanced age of the majority of specimens meant that some could not be included in the study due to their degradation over time (e.g., missing limbs). While the use of museum specimens was appropriate for the purpose of this study, continuation of this research would benefit from the use of recently seized, deceased individuals. Determining parameters in this way would yield a more accurate representation of the number of scales on the different species of pangolins as estimates could benefit from larger sample sizes (see Zhou et al., 2012). This would also allow for the inclusion of other morphometric variables, including scale size and length, to investigate relationships with scale frequency and weight. Additional research is also necessary to better understand the factors contributing to differences in dry and wet weights of pangolin scales. The collection of robust data on the dry weights of scales across all pangolin species (i.e., rate of desiccation) would serve to improve the conversion parameters used in the weight-based sampling method.

To the knowledge of the authors this is the first study to estimate scale frequency in pangolins, knowledge that could increase understanding of the scale and impact of illegal trade involving all eight pangolin species. Given the observed transfer of trafficking pressure to African pangolins in the last decade, it could also help improve understanding of the growing threat to African pangolins specifically. With larger sample sizes, the means derived in this study could be made more robust and could serve to improve the development of tools to effectively monitor the illegal trade of pangolins, a need currently recognized by CITES (CITES, 2017). However, this would need commensurate improvements in the identification ability of front line enforcement personnel, especially in pangolin range states and key transit and destination countries. The variation observed in scale frequency also provides new insights into the morphological diversity of pangolins, and could help bolster global efforts, both within the law enforcement and scientific community, to protect these scaly and threatened mammals.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gecco.2019.e00776.

Appendix

Institution	Identification N°	Genus	Species epithet
ANHM	92745	*Manis*	*culionensis*
ANHM	103340	*Manis*	*culionensis*
ANHM	203298	*Manis*	*culionensis*
NMS	Z.1914.28	*Manis*	*crassicaudata*
BMNHM	50.29	*Manis*	*crassicaudata*
BMNHM	57.487	*Manis*	*crassicaudata*
BMNHM	57.488	*Manis*	*crassicaudata*
BMNHM	76.138	*Manis*	*crassicaudata*
BMNHM	76.139	*Manis*	*crassicaudata*
BMNHM	32.3.3.9	*Manis*	*crassicaudata*
NMS	*Not available*	*Manis*	*crassicaudata*
NMS	Z.1818.17	*Manis*	*crassicaudata*
NMS	*Not available*	*Manis*	*javanica*
NMS	*Not available*	*Manis*	*javanica*
NMS	*Not available*	*Manis*	*javanica*
BMNHM	26.10.4.199	*Manis*	*javanica*
BMNHM	55.3260	*Manis*	*javanica*
BMNHM	79.11.21.647	*Manis*	*javanica*
BMNHM	79.11.21.648	*Manis*	*javanica*
BMNHM	85.8.1.366	*Manis*	*javanica*
BMNHM	92.9.4.12	*Manis*	*javanica*
BMNHM	98.38.3.6	*Manis*	*javanica*
BMNHM	*Not available*	*Manis*	*javanica*
BHAK	1999.240	*Manis*	*pentadactyla*
BMNHM	14.7.19.238	*Manis*	*pentadactyla*
BMNHM	1938.9.7.57	*Manis*	*pentadactyla*
BMNHM	1938.9.7.58	*Manis*	*pentadactyla*
BMNHM	33.4.1.506	*Manis*	*pentadactyla*
BMNHM	33.4.1.507	*Manis*	*pentadactyla*
BMNHM	63.360	*Manis*	*pentadactyla*
NMS	*Not available*	*Manis*	*pentadactyla*
BMNHM	21.8.2.27	*Manis*	*pentadactyla*
BMNHM	8.4.1.58	*Manis*	*pentadactyla*
BMNHM	1995.250	*Phataginus*	*tetradactyla*
BMNHM	1998.301	*Phataginus*	*tetradactyla*
BMNHM	1998.302	*Phataginus*	*tetradactyla*
BMNHM	1.11.21.35	*Phataginus*	*tetradactyla*
BMNHM	46.498	*Phataginus*	*tetradactyla*
PCM	823	*Phataginus*	*tetradactyla*
PCM	364	*Phataginus*	*tetradactyla*

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Institution	Identification N°	Genus	Species epithet
PCM	241	*Phataginus*	*tetradactyla*
PCM	247	*Phataginus*	*tetradactyla*
PCM	349	*Phataginus*	*tetradactyla*
BMNHM	28.9.8.37	*Phataginus*	*tricuspis*
BMNHM	46.888	*Phataginus*	*tricuspis*
BMNHM	8.10.27.5	*Phataginus*	*tricuspis*
BMNHM	*Not available*	*Phataginus*	*tricuspis*
PCM	281	*Phataginus*	*tricuspis*
PCM	461	*Phataginus*	*tricuspis*
PCM	282	*Phataginus*	*tricuspis*
PCM	365	*Phataginus*	*tricuspis*
PCM	340	*Phataginus*	*tricuspis*
BMNHM	61.1095	*Smutsia*	*gigantea*
BMNHM	69.371	*Smutsia*	*gigantea*
BMNHM	29.5.29.38	*Smutsia*	*gigantea*
BMNHM	61.1096	*Smutsia*	*gigantea*
BMNHM	64.12.*XX*	*Smutsia*	*gigantea*
BMNHM	*Not available*	*Smutsia*	*gigantea*
PCM	11	*Smutsia*	*gigantea*
PCM	224	*Smutsia*	*gigantea*
BMNHM	25.1.2.262	*Smutsia*	*temminckii*
BMNHM	25.5.9.1	*Smutsia*	*Temminckii*
BMNHM	35.9.1.847	*Smutsia*	*temminckii*
BMNHM	35.9.1.848	*Smutsia*	*temminckii*
BMNHM	96.1.10.1	*Smutsia*	*temminckii*
NMS	*Not available*	*Smutsia*	*temminckii*

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