The Pangolin Universal Notching System (PUNS): A Foundational Scale Marking Methodology for Pangolins

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Abstract Due to significant anthropogenic pressures, all eight established species of pangolin are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the highest level of international protection possible. Pangolin population status assessments are incomplete, particularly in areas with high exploitation and limited field assets. Currently, there is no universal scale marking methodology available for pangolins despite half of pangolin programs marking scales, with each program creating and managing its own systems, leading to inefficiencies and inconsistencies, as well as limited data sharing. Therefore, the creation and implementation of a universal marking code is essential for effective pangolin conservation efforts. Pangolins comprise a unique animal order, with many morphological and behavioural characteristics that make simply adopting a coding system used for other species impractical. Pangolins have keratinized scales, similar to hard-shelled turtles; a drilling system like that used for scutes would be effective. However, given the potential volume of pangolins that could be encountered, a numerical system similar to what is used in hoofstock and capable of generating a large quantity of codes is also necessary. The Pangolin Universal Notching System (PUNS) is a standardized, large-volume, numerical-based system for marking all pangolin species. It will provide the ability to address critical knowledge gaps in the areas of pangolin aging, reproduction, survivorship, trafficking patterns, and migration. Further, it is neither resource nor training intensive–factors which facilitate accessibility and implementation globally–while minimising stress and health risks to individual pangolins.

Keywords: *Pangolin, Scale Marking, Tracking, Wildlife Conservation, Endangered Species, Smutsia, Phataginus, Manis*

Introduction

Pangolins, their name being derived from “peng-goling” which means “ones that roll up,” are unique species with distinct morphology and behaviour. They have been referred to as walking pinecones, scaly anteaters, and even perambulating artichokes due to their primary diet of ants, long tongues, lack of teeth, and unique keratin-based scale “armour” used for protection. They live primarily in burrows, are known to dig, climb, walk, and swim throughout their native habitats and when threatened, curl into a defensive ball allowing their thick scales to serve as their primary source of protection (Kingdon, 1977; Vickaryous & Hall, 2006). There are eight extant established species of pangolin, four of which are native to Africa: Cape or Temminck’s ground pangolin (*Smutsia temminckii*), giant ground pangolin (*Smutsia gigantean*), long-tailed or black-bellied pangolin (*Phataginus tetradactyla*), and tree or African white-bellied pangolin (*Phataginus tricuspis*) (Zanvo et al., 2020) and four native to Asia: Chinese Pangolin (*Manis pentadactyla*), Indian Pangolin (*Manis crassicaudata*), Philippine Pangolin (*Manis culionensis*), and Sunda Pangolin (*Manis javanica*) (Cota-Larson, 2017). A ninth cryptid Asian species, *Manis mysteria,* was identified through genomic sequencing of scales confiscated from trafficking in Hong Kong by Gu, et. al. (2023) in late 2023. This species' home range and ecology is not yet known; however, it should be considered in future research. Due to *Manis mysteria*’s nascent discovery and timeline of this research, the authors want to acknowledge the species discovery but the data is not yet available to be analysed and compared to the other species in this document.

Due to high demand for pangolin products in both food and medicine, and their ease of collection, all eight established species of pangolin are listed on Appendix I of the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora, which is the highest level of international protection a species may be granted (Challender & O’Criodain, 2020). Pangolin population status assessments are incomplete, particularly in areas where there is high exploitation and limited field assets. Further, there is currently no ability to recover information about individuals or their site of origin when intercepted during trafficking, unless a tracking device is present, which is likely rare. This prevents detailed record keeping and their successful return after rehabilitation. Effective methods of monitoring and tracking pangolins will be essential to understanding the extent of population declines and, hopefully, recovery following conservation efforts, including rehabilitation of individuals and reintroduction into the wild. One key non-invasive method of identifying and tracking individuals is notching or marking, which entails using a tool, such as drill, punch, or file, to remove a portion of a series of scales or scutes in order to permanently identify the individual.

Conventional and high accessibility marking systems using dye, paint, number tags, or notching have been employed in many species. When advanced technology is available, these other systems are used as a complement to them and often are the only thing that remains when these technologies fail, are lost or damaged, or reach their functional endpoint. These simple notching or marking systems have been incredibly successful in other species and date back to the early 20th century when Cagle (1939), described a simple scute notching system in hard-shelled turtles where shells were assigned a number and then notched with files or scissors. This provided a permanent marking and tracking system that was effective for individual

identification for longitudinal studies where the individual may be recaptured. This foundational system has been revised throughout the decades with minor adjustments being made for species or project needs (Bury et al. 2012; CPS, 2023; Ernst, et. al. 1974; Holland 1994; Plummer & Ferner 2012; Nagle, et.al, 2017). The ability to permanently identify a species in longitudinal studies that does not disrupt their natural behaviour is critical for identifying information on growth and aging, reproduction, survivorship, and migration pattern (Cagle, 1939; Plummer & Ferner 2012). All these data gaps exist in the pangolin research community, and due to trafficking, there is the additional opportunity for pangolins to be encountered by a wide range of individuals from law enforcement to the lay public.

Currently, there is no universal scale marking methodology available to those in the pangolin community (Willcox, et al., 2019; Morin, et al., 2020). Half of practising pangolin research programs are utilising scale marking of some variety, with each program creating and managing its own notching codes (EWCL Pangolin Trackers, 2023). This creates inefficiencies and inconsistencies in pangolin tracking and research across the global pangolin conservation science community, impeding the ability to share data and assess trends. As such, the timing for the creation and implementation of a universal marking code is ideal and will be essential in effective pangolin conservation efforts moving forward.

The Pangolin Universal Notching System (PUNS) was created to address this lack of uniform protocol and does so in a way that accommodates both the unique features of pangolins and the need for a large volume of codes. Specifically, PUNS was designed to be accessible and understandable to the scientific and lay audiences regardless of program or project budget. It also has the ability to be universally applied across all pangolin species while being highly flexible and adaptable for specific program goals or needs.

Methods

From May 2021 to November 2023 marking systems available across a broad range of species were reviewed, current pangolin researchers surveyed, and the PUNS was created, by adapting and combining existing hard-shell turtle and hoofstock marking methodologies. It is intended for pangolins of all species in good health and body condition that are not obviously pregnant, lactating, or young enough to be nursing. In the PUNS, the first scale immediately left of the midline scale row at the pectoral girdle (shoulder) and the first scale immediately right of the midline scale row at the pectoral girdle are always labelled 1 and 100, respectively. The pectoral girdles and specifically the scapula can be palpated beneath the scales to identify the starting location. This location can also be identified by locating the change in scale morphology that delineates the head and trunk scales. Once the starting point is identified, the first eight scales on each side of the midline row are then numbered. Moving toward the tail from the starting location on the left side, the scales are numbered 1, 2, 4, 7, 10, 20, 40, and 70. Moving toward the tail from the starting location on the right side the scales are numbered 100, 200, 400, 700, 1000, 2000, 4000, and 7000. The scale numbers are marked cumulatively to attain the number required. The midline scale row is used for indicating pangolin sex. The first scale in the midline is marked for males, with the fifth scale being marked for females. Codes are assigned and read viewing the individual with the head facing

away and the tail toward the researcher (Figure 1).

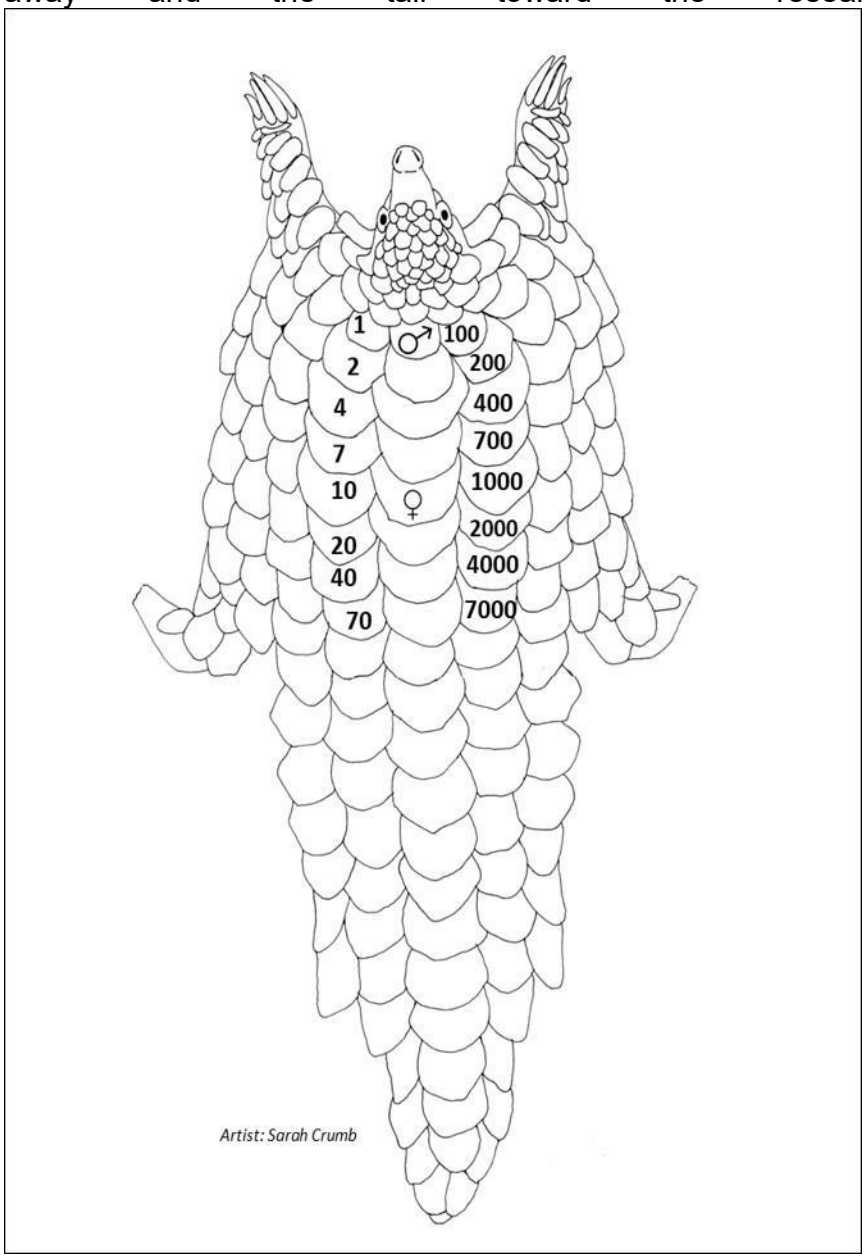

Figure: 1: Pangolin Universal Notching System (PUNS) applied to a Temminck's pangolin (*Smutsia temminckii)*, also known as the ground pangolin, as viewed in anatomical position: Dorsal view: on its stomach with anterior end at top of image. The first scale immediately left of the midline scale row at the pectoral girdle and the first scale immediately right of the midline scale row at the pectoral girdle are always 1 and 100, respectively. The first midline row scale is male, and the fifth midline row scale is female

For example, if a male individual is to be marked 7238, the 7000, 200, 20, 10, 7, and 1 scales as well as the first scale in the midline indicating male would be marked (Figure 2).

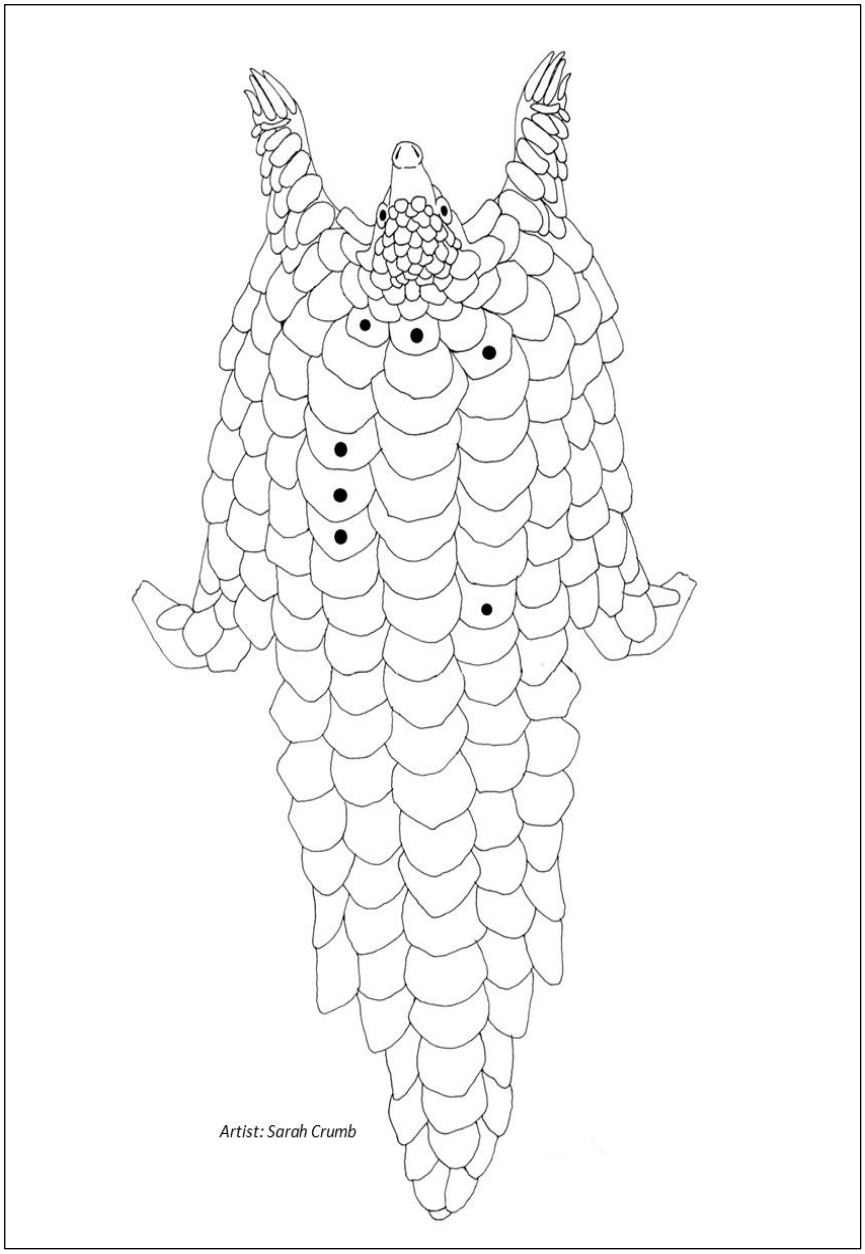

Figure: 2: Male Individual #7238 marked with the Pangolin Universal Notching System (PUNS).: To identify number 7238, the 7000, 200, 20, 10, 7, and 1 scales as well as the first scale in the midline indicating male are marked.

Once the individual pangolin code has been identified, needed scales should be marked with a wax pencil or marker, cleaned of debris and then drilled with a standard drill and drill bit. Drill marks should be placed centrally in the scale and drill bit diameter should be no greater than ⅓ the total width of the narrowest part of the scale to prevent damage to the scale margins or underlying soft tissue. For programs without access to drills, files, leather punches, scissors, or even nail clippers could be utilised to notch the scales. Regardless of the tool used, covering the pangolin's eyes with a cloth or small towel to minimise stress and adding a barrier between the scale and soft tissue is recommended. Should the pangolin curl into a defensive

position, marking should be completed while curled rather than forcing the animal to straighten.

Discussion

Establishing a universal scale marking system for pangolins is critical in order to eliminate inefficiencies and confusion among researchers creating separate protocols and to facilitate the consistent gathering and sharing of pangolin conservation data globally. Overall, this proposed system seeks to establish an accessible and broadly applicable notching protocol that could be implemented globally with minimal resources and training. Due to high scale count variability among pangolin species (Cota-Larson, 2017), it was important to have a specific anatomical landmark for the starting point and a limited set of numbers on each side of the animal to ensure that the protocol could be applied across all species. Several species may have more than eight scales in the first lateral row; therefore, to ensure uniformity any additional scales would not be used. The area posterior to the pelvic girdle was avoided to eliminate confusion from traditional satellite transmitter placement locations (Pagès, 1975; Lim T-Lon, 2008; CPCP, 2014; Pietersen et al., 2014; Schoppe, 2015; Sun, et. al., 2019) and to ensure that if an individual was curled into a defensive posture, the code could still be read.

Multiple considerations factored into the determination of whether to utilise an alphabetic or numeric code. Numeric codes are often used as identification for individuals in wildlife research, particularly mammalian species (Sikes, et. al, 2016). Further, species housed in rehabilitative and captive situations are often assigned an accession number as part of their permanent record that is then used to track interactions and procedures performed upon them (Species360, 2023; White Light Computing, 2023). Alphabetical codes can perform similar functions, but without using multiple marks per scale, approximately only 1,000 codes could be generated for pangolin marking. Given the potential volume of pangolins encountered through trade recovery, rehabilitation, and research, the PUNS numerical coding system allows for far more individuals to be notched and thus available for longitudinal study. This code could easily be the individual's primary number for its lifetime being tracked.

In addition to being highly accessible to practitioners with resource or training constraints, a significant advantage of the PUNS is that the simplicity of the code makes it easily adapted for individual program needs and goals. Programs could use the same code for each species, thereby expanding the number of animals marked. Programs could also identify specific codes to be used per year, i.e., 2300 series numbers could be for the 2023 tagging year, 2400 could be for the 2024 tagging year. This annual series approach would then enable researchers to quickly identify what year that individual was tagged, however it may also reduce the total amount of numeric codes available given that any unused numeric codes within the full span for a given year (i.e., 2300 through 2399 for the year 2023) would not be available for use in subsequent years. Further, programs could assign codes to different geographic regions to provide additional detail about where the individual was originally encountered and marked. Notch adornments could also be used to increase visibility to researchers in the field or by camera trap. These adornments could include: Beaded wires or reflective paints like what is used in iguanids (Rodda, et. al, 1988), cattle ear tags, coloured bird leg bands (Silvy, et. al, 2012), or any other

materials that could be used as visual cues. Of course, any adornment techniques should be evaluated by each program to ensure animal safety is not compromised through increased predation, poaching, or entanglement risks.

Code management and organisation could be completed at the project, regional, national, or international levels. Each research program likely has its own unique data and animal management structure; however, given the distribution of pangolins in multiple countries, their status as the most trafficked mammal in the world (Aisher, 2016), and the reality that a trafficked animal may be intercepted and rehabilitated far from where it was originally marked (Wright & Jimerson, 2020), the authors recommend utilising a centralised database system to serve as the primary communication tool to look up used marking codes, this allows for individual data to be more readily available, and facilitate data sharing. These systems could be modelled after existing species tag data sharing systems and their respective organisation types (i.e. non-profit, private business, academia, governmental), such as: the Sea Turtle Tag Inventory managed by the Archie Carr Center for Sea Turtle Research (ACCSTR) at the University of Florida (ACCSTR, 2023) and the TagFinder program through Seaturtle.org (SeaTurtle.org, 2023), the thoroughbred horse Interactive Registration™ Tattoo Lookup and Tattoo Research programs managed by the Jockey Club (The Jockey Club, 2023), the Monarch Tagging Program managed by Monarch Watch (Monarch Watch, 2023) or the Bird Banding Laboratory managed by the United States Geological Society (USGS) (USGS, 2023). Finally, a centralised coding system has the ability to potentially assist in new species demographic identification especially if that species were discovered through genomics after recovery from trafficking, similar to *Manis mysteria.* While genomics is able to determine if the individuals are a new species, maternal lineage, and a general continental range, they are not able to provide information about that animal's place of origin or ecology. If the individual were also marked with a PUNS code, some of those data gaps could be able to be eliminated simply by retroactively referencing the database, thus providing critical species ecological data much faster. The combination of these two methods will be tremendously impactful in pangolin conservation.

As a foundational system, it will not–nor is it intended to be–a panacea that is appropriate to apply in every circumstance. First, the animal must be healthy enough to be handled long enough to be marked, either in the wild or in a post rehabilitation setting. While the time needed to drill the holes is less than what would be needed to attach a very high frequency (VHF) radio transmitter or other tracking device, animal health and stress would still need to be taken into consideration. Second, if an animal were to lose or damage a marked scale over the course of its lifetime, only a partial code would be able to be identified when recaptured. Therefore, unlike in hard-shelled turtles, or tattooing in certain mammals, notching in pangolins may be vulnerable to some uncertainty with scale wear. Third, if an individual marked with a customised code was intercepted by another program or from trafficking, program-specific adaptations may not be immediately known. However, in this circumstance, the code for that pangolin could still be identified and traced. Finally, while the marked code could be read from a short distance or a camera trap photo, this notching system does not facilitate visibility across long distances. If using a camera

trap to read the code, mud caking or other debris could also obscure one or more of the marks.

In conclusion, PUNS is a standardised, accessible, and customizable system for marking pangolin species that does not currently exist within the pangolin conservation community. Although the implementation and ubiquitous adoption of PUNS could inaugurate a large-scale provenance and identification of rescued and released pangolins, a governing entity to oversee a centralised database would be ideal. If implemented, it could aid in addressing critical knowledge gaps in the areas of pangolin ageing, reproduction, survivorship, trafficking patterns, and migration through longitudinal study data, especially paired with other tracking types and technologies. Further, it is neither resource nor training intensive–factors which facilitate accessibility and implementation globally–while minimising stress and health risks to individual pangolins.

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Conflicts of interest None

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