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EX SITU CONSERVATION ASSESSMENT AND PLANNING FOR THE SUNDA PANGOLIN

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WORKSHOP REPORT

Ex Situ Conservation Assessment and Planning for the Sunda Pangolin



Wildlife Reserves Singapore Group



Wildlife Reserves Singapore
Conservation Fund



Workshop organised by:
Wildlife Reserves Singapore, IUCN SSC Conservation Planning Specialist Group, IUCN SSC Pangolin Specialist Group, and National Science Museum, Thailand.

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A collaboration between the IUCN SSC Pangolin and Conservation Planning Specialist Groups.

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W O R K S H O P R E P O R T

Ex Situ Conservation Assessment and Planning for the Sunda Pangolin

25-27 September 2019
National Science Museum, Bangkok, Thailand



Wildlife Reserves Singapore Group

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Preface

Pangolins are the most enchanting of creatures, but all eight extant species – the entire taxonomic Family comprising the Manidae – are threatened with extinction. This is primarily due to overexploitation for both local use in their parts and derivatives, mainly their meat and scales, and poaching for international trafficking to end markets, including China and Vietnam. The Critically Endangered Sunda pangolin (*Manis javanica*) is no exception, and for most of the past two decades it has been the most trafficked pangolin species globally.

In the last decade pangolins have received greater conservation attention than ever before, and they have become icons of the illegal wildlife trade. With an increasing profile has come increasing investment in pangolin conservation and, inherently, the need for these investments to be wise. In this vein, the IUCN SSC Pangolin Specialist Group and partners, including Wildlife Reserves Singapore, the IUCN SSC Conservation Planning Specialist Group, and Asian Species Action Partnership (ASAP), held a regional workshop in 2017 to develop a *Regional Sunda Pangolin Conservation Strategy* designed to guide conservation action for the species over the next decade. This strategy brings together the results of targeted discussions at that workshop and presents a vision, objectives and specific actions through which to conserve the Sunda pangolin. Goal 6 of this strategy is to establish successful systems for rescue, rehabilitation and release of pangolins confiscated from illegal trade. Within this goal, a key objective is to explore the conservation needs and benefits for managing and breeding of Sunda

pangolins in *ex situ* facilities, and specifically it identifies the need to conduct an *ex situ* needs assessment for the Sunda pangolin.

This *ex situ* conservation assessment could not be timelier. Sunda pangolins continue to be seized across Southeast and East Asia, both live and dead, as they have for many years, and are probably the pangolin species most frequently trafficked alive. Determining how these seized individuals can aid in the species' conservation is long overdue. This *ex situ* conservation assessment draws upon the *Regional Sunda Pangolin Conservation Strategy* and, as part of a One Plan approach to conservation of the species, uses the IUCN SSC *Guidelines on the Use of Ex situ Management for Species Conservation* to determine how *ex situ* populations can best serve Sunda pangolin conservation. It does by evaluating appropriate *ex situ* conservation activities and recommending 41 actions under 12 goals, which now need implementing. This assessment will serve as an important guide to pangolin conservation into the future.

I extend my gratitude to all those who took part in this assessment for their hard work, and partners of the IUCN SSC Pangolin Specialist Group who worked tirelessly to make this assessment a reality, the IUCN SSC Conservation Planning Specialist Group and Wildlife Reserves Singapore, and the National Science Museum of Thailand for generously hosting the workshop in which this assessment was conducted. I look forward to seeing the actions agreed to implemented in the future, which will contribute to our ultimate goal of conserving pangolins.

Dr. Daniel W. S. Challender

Chair

IUCN SSC Pangolin Specialist Group



Executive summary

The Sunda pangolin *Manis javanica* is one of eight extant species of pangolins and is listed as Critically Endangered on the IUCN Red List of Threatened Species™ due to overexploitation driven primarily by illegal trade. The *Regional Sunda Pangolin Conservation Strategy* published in 2018 by the IUCN SSC Pangolin Specialist Group and colleagues outlines a conservation action plan for the species in the face of ongoing threats. This strategy recognises the large number of confiscated and rescued Sunda pangolins that enter *ex situ* facilities across the species' range each year, and the potential for improving the conservation contributions of these animals. This workshop was organised following a recommendation in this regional conservation strategy for a thorough, informed assessment of potential *ex situ* conservation contributions.

About 40 *in situ* and *ex situ* pangolin experts from 11 countries met in Thailand in September 2019 for three days of *ex situ* conservation assessment and planning discussions. After reviewing the threats to the species and its conservation needs in the wild, the status of the *ex situ* population and facilities, and the challenges to Sunda pangolin releases and effective conservation actions, the participants identified seven potential conservation roles of Sunda pangolins held in *ex situ* situations. Using the decision-making process outlined in the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation*, participants discussed programme structure, challenges, feasibility and important data gaps with respect to these roles.

Working group discussions focused on four major areas: *ex situ* care guidelines and research to improve health, survival and welfare; guidelines and research to improve the conservation benefits of Sunda pangolin releases; priority research needs and opportunities provided by rescues or confiscated Sunda pangolins (or their parts); and an evaluation of value, feasibility, risks and data gaps of establishing a long-term *ex situ* breeding insurance population. These discussions resulted in a set of 12 goals and

The overall purpose of the workshop was to reach consensus among the stakeholders on whether *ex situ* activities or programmes should be established for the conservation of the Sunda pangolin and, if so, to identify the structure of any recommended *ex situ* programmes.

41 recommended actions to promote beneficial contributions of Sunda pangolins that end up in human care. These recommendations are designed to maximise conservation benefit while considering feasibility and minimising risks and so are specific to the programmes described in this document. While specific to Sunda pangolins, these discussions and recommendations may be applicable to other pangolin species.

This *ex situ* conservation assessment report complements the conservation recommendations in the *Regional Sunda Pangolin Conservation Strategy*. Taken together, these conservation planning efforts represent a One Plan approach to Sunda pangolin conservation. By involving *in situ* and *ex situ* pangolin experts in both aspects of Sunda pangolin conservation planning, *ex situ* programmes can be structured for maximal contribution to Sunda pangolin conservation needs, leading to more integrated and effective pangolin conservation actions across the *in situ-ex situ* spectrum for this species.



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Workshop rationale

The Sunda pangolin *Manis javanica* is one of eight extant species of pangolins and is native to mainland Southeast Asia and surrounding islands west of Sulawesi. The species' geographic distribution extends from central Myanmar to large parts of Thailand, lowland Lao PDR, central and southern Vietnam and Cambodia, to Peninsular Malaysia (Corbet and Hill, 1992; Challender et al., 2019a; Chong et al., 2020). It also occurs in Singapore and surrounding islands, Indonesia (Sumatra, Java and adjacent islands) and on Borneo (Malaysia, Indonesia and Brunei Darussalam) and surrounding islands. Wu et al. (2005) report that the species occurs in southwestern Yunnan Province, China, but there is uncertainty over distribution in the country. It occupies a variety of habitats, from primary and secondary tropical forest, including lowland dipterocarp forest, to artificial landscapes and cultivated areas including

oil palm, rubber plantations and gardens. However, research into its use of modified habitats and abundance in these habitats is needed.

Sunda pangolins have been valued through history by human beings, principally for consumptive use, and international trade has involved their meat, scales and skin. However, evidence indicates that such use and trade has been unsustainable or illegal in recent decades (Broad et al., 1988; CITES, 1992, 1999; Chong et al., 2020; Challender et al., 2020). Direct threats comprise of hunting and poaching for local use and international trafficking in the animals and their meat and scales, which has several drivers and facilitating factors. Indirect threats include habitat loss and degradation. These threats, combined with inadequate conservation action, are negatively affecting the viability of wild populations.



DATA EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Photo: ©Wildlife Reserves Singapore/David Tan; IUCN Red List Category - The IUCN Red List of Threatened Species™

The Sunda pangolin is classified as Critically Endangered on the IUCN Red List of Threatened Species™ based on past, ongoing and future population reductions based on actual or potential levels of exploitation (Red List criteria A2d+3d+4d; Challender et al., 2019a). In 2000, Parties to CITES established a zero export quota for wild-caught Asian pangolins traded for primarily commercial purposes, effectively enacting a proxy trade ban for the Asian pangolin species. Despite this measure, large volumes of illegal trade in Asian pangolins has continued. Hence, at CITES CoP17 (CITES, 2016), with the other seven species of pangolins, the Sunda pangolin was transferred from Appendix II to I in 2016, bringing about an international trade ban in wild-caught pangolins and their parts traded for commercial purposes. Currently, the Sunda pangolin is additionally designated as a protected species under national legislation in all but one range state (Brunei Darussalam).

A *Regional Sunda Pangolin Conservation Strategy* was developed at a workshop held in Singapore on 28-30 June 2017 and was published in 2018 (IUCN SSC Pangolin Specialist Group et al., 2018). Given the high volume of illegal trade in live Sunda pangolins, this regional conservation strategy recognises the importance of developing a conservation plan to address Sunda pangolins that are confiscated from illegal activities. A network of centres able to accommodate, rehabilitate and, where appropriate, release trade-confiscated Sunda pangolins is essential to achieving the vision of the regional conservation strategy.

Currently, the *ex situ* centres are not adequately equipped to fulfil this role. Key areas for development identified were: increased coordination, capacity-building, staff training and the development of standard protocols for care and management, including release. Inevitably, some pangolins will be unsuitable for release to the wild. At the time of the 2017 regional workshop, the role(s), if any, that these animals could play in supporting pangolin conservation were not evaluated due to time limitations. Given historical and ongoing challenges and sensitivities of maintaining pangolins in captivity, transparency and collaboration with all important



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stakeholders is essential to ensure synergy of *ex situ* management activities with *in situ* conservation goals (Parker and Luz, 2020).

Clarification, in form of a comprehensive *ex situ* conservation assessment, was therefore identified as a need in the regional conservation strategy. This led to the organisation of this *ex situ* assessment and planning workshop for the Sunda pangolin held on 25-27 September 2019 at the National Science Museum, Patumthani, Thailand. This international multi-stakeholder workshop focused on *ex situ* conservation assessment and planning for the Sunda pangolin, convened by the IUCN SSC Pangolin Specialist Group (PSG) and IUCN SSC Conservation Planning Specialist Group (CPSG). Pangolin specialists from both the field and from zoos and rescue centres, including several PSG members, participated to carefully evaluate potential conservation roles for pangolins held *ex situ*, using the decision-making process of the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation*.

The overall purpose of the workshop was to reach consensus among the stakeholders on whether *ex situ* activities or programmes should be established for the conservation of the Sunda pangolin and, if so, to identify the structure of any recommended *ex situ* programmes. Where appropriate, specific actions to promote recommended programmes were identified.



Ex situ conservation assessment process

Effective species conservation planning should consider all options when assessing actions to address the conservation pressures facing a particular species. In addition to actions directed at reducing or eliminating specific threats, such as habitat loss or illegal poaching, other management strategies may be needed to prevent severe decline or extinction, especially when wild populations are small and isolated. Addressing important knowledge gaps also can promote more effective conservation. *Ex situ* management is one possible option that can contribute to the conservation of threatened species. The range of *ex situ* scenarios and tools is diverse and can target different conservation needs and roles and, therefore, serve various purposes.

Ex situ conservation activities can support species conservation and prevent extinction in a variety of ways (Traylor-Holzer et al., 2013), by:

Offsetting the impact of threats

Ex situ activities can improve the demographic and/or genetic viability of a wild population by counteracting the impacts of primary or stochastic threats on the population, such as reduced survival, poor reproduction and genetic isolation – for example, through head-start programmes that remove juveniles from the wild for *ex situ* care and return them once they are less vulnerable, or through releases to genetically augment isolated populations.

Addressing the causes of primary threats

Ex situ activities can help reduce primary threats such as habitat loss, exploitation, invasive species, or disease through specifically designed research, training or conservation education activities that directly and effectively impact the causes of these threats – for example, through *ex situ* research to detect, combat or treat disease.

Buying time

Establishment of a genetically diverse and sustainable *ex situ* rescue or insurance population may be critical in preventing species extinction

when the wild population is declining and primary threats are not under control – for example, populations facing widespread disease epidemics or decimation by invasive species.

Restoring wild populations

Once the primary threats have been sufficiently addressed, *ex situ* populations can be used to re-establish wild populations.

This workshop focused on the assessment of *ex situ* activities for Sunda pangolins and the ability of such activities to contribute effectively to pangolin conservation. This assessment was developed in concert with recommendations in the *Regional Sunda Pangolin Conservation Strategy* (IUCN SSC PSG et al., 2018) as part of a One Plan approach to the conservation of this species (Traylor-Holzer et al., 2018). The workshop was structured around the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation*, which utilises a five-step decision-making process to determine if and which *ex situ* activities might be appropriate to be included in the overall conservation strategy for the species (IUCN, 2014; McGowan et al., 2016):

- 1) Conduct a thorough status assessment (of both *in situ* and any known *ex situ* populations) and threat analysis;
- 2) Identify potential roles that *ex situ* management can play in the overall conservation of the species;
- 3) Define the characteristics and dimensions of the programme needed to fulfil the identified potential conservation role(s);
- 4) Define the resources and expertise needed for the *ex situ* management programme to meet its role(s) and appraise the feasibility and risks; and
- 5) Make an informed and transparent decision as to which *ex situ* roles and activities (if any) to retain within the overall conservation strategy for the species.





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The following describes how this five-step process was adjusted and applied in the Sunda pangolin workshop. An essential element of this process is the involvement of both *in situ* and *ex situ* species experts in all stages of the evaluation.

Status assessment and threat analysis

Prior to the workshop, the following information was compiled: 1) status of and threats to wild Sunda pangolin populations; 2) existing conservation strategies for pangolins; 3) current *ex situ* populations, trends, and management expertise for zoos and rescue centres in the region (via survey); and 4) recommendations from previous *ex situ* assessments for pangolin species. These were shared as briefing materials and reviewed at the start of the workshop during plenary presentations. Participants were guided through the construction of a threat diagram to help identify Sunda pangolin conservation challenges and knowledge gaps that may benefit from *ex situ* management or activities.

Potential *ex situ* roles

Workshop participants reviewed the list of potential conservation roles for *ex situ* populations and identified seven roles that may be applicable to Sunda pangolins. Issues and challenges were generated for each role in rotating “world café”-style

short discussions, with all participants contributing to all topics.

Programme structure and feasibility evaluation

The generated challenges and issues were reorganised into four discussion areas, each of which related to one or more potential conservation roles. Working groups were convened for detailed discussions of relative benefits, challenges, feasibility and data gaps before making recommendations on which roles to pursue, specific goals, and next action steps. Periodic plenary reporting sessions enabled all workshop participants to provide feedback to each working group discussion throughout this process.

Ex situ recommendations

Final plenary discussions resulted in recommended actions to maximise feasible conservation benefits from confiscated or rescued Sunda pangolins (or parts), including appropriate actions for pangolins that can be released back to the wild as well as those that cannot.

The workshop concluded with discussion of the integration of the *ex situ* recommendations into the regional conservation strategy and the identification of country representatives for the Regional Sunda Pangolin Working Group.

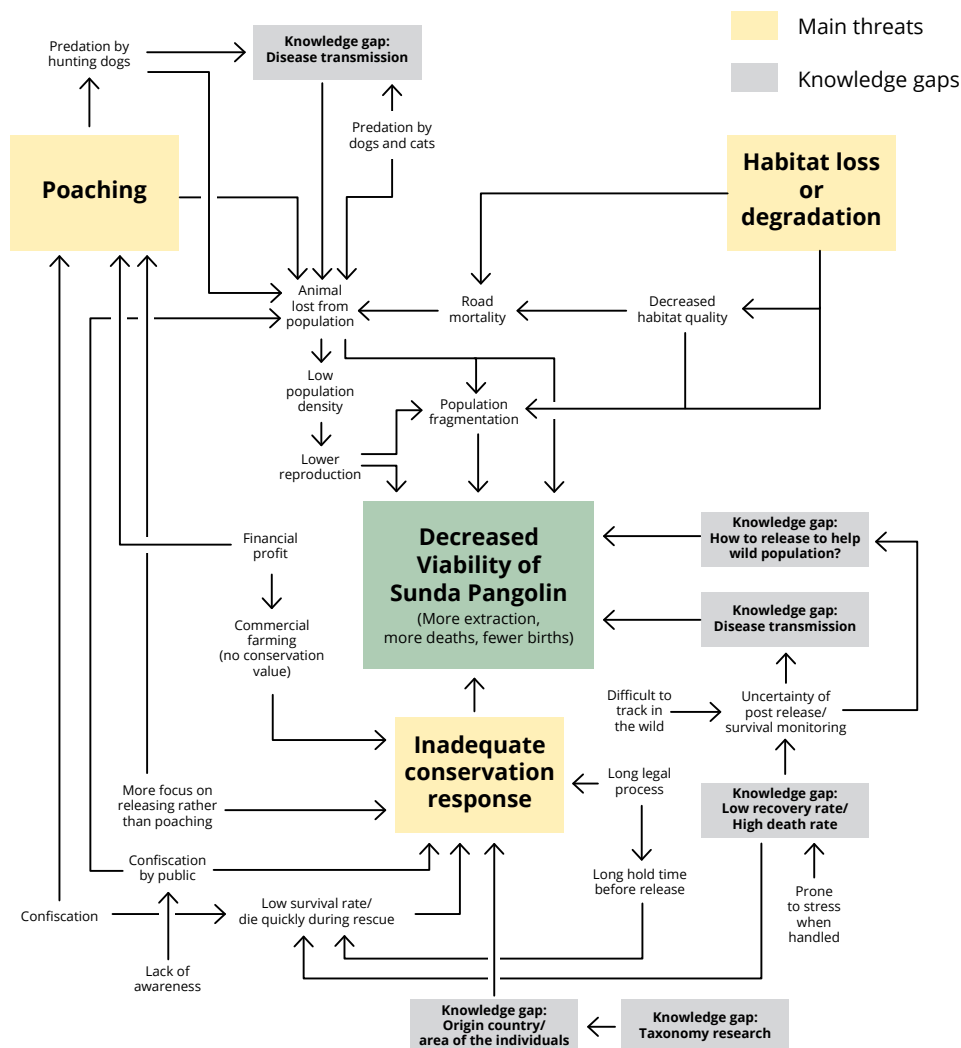


Threat analysis

An analysis of factors leading to decreased viability of the wild Sunda pangolin population was done through a facilitated plenary discussion involving all workshop participants. Participants first reviewed the threat analysis presented in the regional conservation strategy, which identified three major threats to wild Sunda pangolin populations: 1) poaching; 2) habitat loss or degradation; and 3) inadequate conservation response. Using this threat analysis as a basis, participants provided information on factors leading to these threats and

the impacts of these threats on Sunda pangolins. Important knowledge gaps were also identified in this process. This discussion resulted in the causal diagram in Figure 1, which is complementary to that presented in the regional conservation strategy. By understanding the factors and important data gaps that are obstacles to Sunda pangolin conservation (Step 1 of the IUCN *ex situ* guidelines), it is possible to consider how confiscated or rescued Sunda pangolins, or others held *ex situ*, may have a potential beneficial role in the conservation of this species.

Figure 1
Main threats to wild Sunda pangolin population viability, causal factors, and knowledge gaps



Current *ex situ* population status and challenges

Ex situ population status

A pre-workshop survey of the *ex situ* facilities in the region shows that there are at least 67 individuals (29 males, 38 females) that are housed in 10 institutions in Southeast Asia. The actual population size is most likely higher, as there are other institutions within and outside of the region that hold this species (Zhang et al., 2017). It is also uncertain if other range countries such as Brunei and Myanmar hold any *ex situ* populations.

Table 1 provides the known organisations that have had Sunda pangolins at some point in time. Efforts have been made by some of these organisations to breed this species in captivity; however, these efforts do not appear to have been particularly successful. Out of these 67 individuals, only 5 were bred in captivity. Figure 2 shows the age distribution of pangolins of known age currently in *ex situ* facilities and also indicates that the majority of individuals are of unknown age.

Table 1
List of *ex situ* institutions in Southeast Asia that currently or historically housed Sunda pangolins either in a long- or short-term capacity

CAMBODIA	Angkor Centre for Conservation of Biodiversity Wildlife Alliance
INDONESIA	Bali Zoo Batu Secret Zoo Cikananga Wildlife Centre Gembira Loka Zoo Taman Safari Indonesia
LAOS	Laos Conservation Trust for Wildlife
MALAYSIA	Department of Wildlife and National Parks Sabah Wildlife Department
SINGAPORE	Wildlife Reserves Singapore
THAILAND	Department of National Parks, Wildlife and Plant Conservation Mahidol University Wildlife Friends Foundation Thailand Zoological Park Organization
VIETNAM	Saigon Zoo Save Vietnam's Wildlife

Figure 2
Age distribution of current Sunda pangolin *ex situ* population

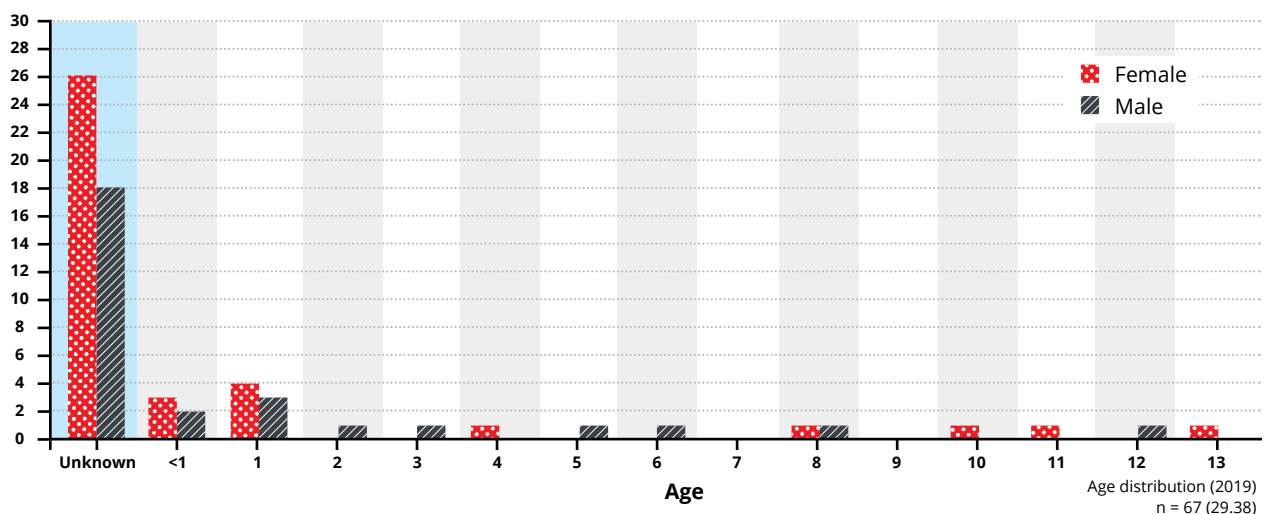


Figure 3
Rescue data on Sunda pangolins in Vietnam between 2015 – 2018

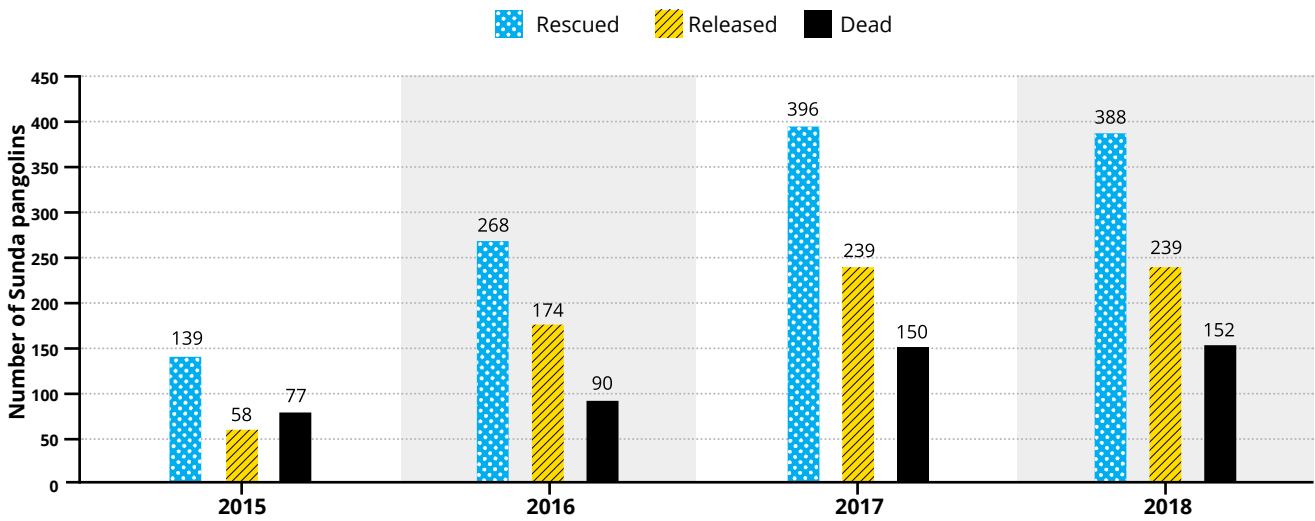
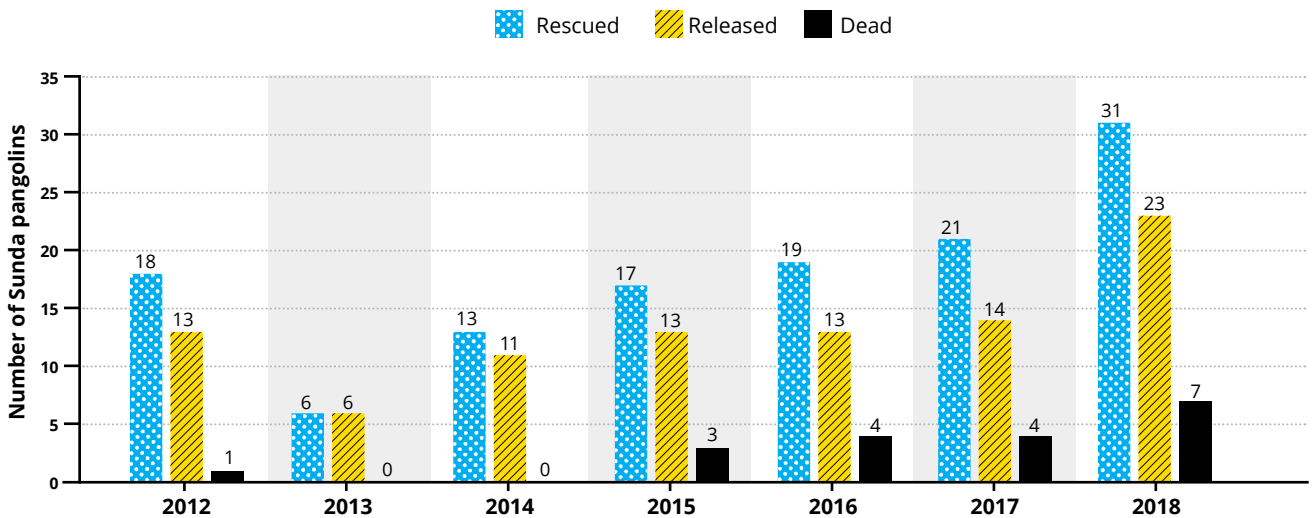


Figure 4
Rescue data on Sunda pangolins in Singapore between 2012 – 2018



Many of these pangolins, especially those in rescue centres, are transient individuals that were rescued and would eventually be released into the wild. As a result, the *ex situ* numbers are expected to fluctuate regularly. The majority of these individuals are rescued from confiscations. Due to poor handling of live animals in wildlife trade, and particularly the practice of force-feeding pangolins with cornmeal (Wright & Jimerson, 2020), many animals that are rescued in Vietnam are often in poor health condition and die upon arrival at the rescue centre. Figure 3 indicates that over 1000

Sunda pangolins were received from confiscations in Vietnam over three years (T.V. Nguyen, 2019, pers. comm.). On average, over 40% of rescued pangolins in Vietnam died due to health complications and about 60% of the individuals were able to be released back into the wild over these years.

Pangolins held *ex situ* in Singapore, however, are not confiscations from trade but are rescued pangolins found in urban areas and outside of forests. The main threats to the pangolin population in Singapore



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are primarily habitat loss, fragmentation and roadkill (Lee et al., 2018). Figure 4 provides details on the number of pangolins rescued in Singapore between 2012 – 2018. The numbers are much lower than those seen in Vietnam, with an average of 20 pangolins being rescued per year. Over 80% were successfully rehabilitated and released back into the wild. Data on confiscations/rescues were not available for countries other than Singapore and Vietnam during the workshop, and hence not presented here. Based on this limited finding, however, we expect that range states that are a source for either poaching or consumption may see a high volume of live rescues, which would require substantial rescue, rehabilitation and release capacity.

Challenges for *ex situ* care



Rescue, rehabilitation and release

Pangolins that are rescued from the illegal trade are often in a poor state of health. High mortality of rescued animals, particularly neonates and juveniles, is a common issue, which is further exacerbated by limited husbandry and veterinary experience. This issue is more pronounced when it involves a sizeable confiscation of many live animals at once.

Institutions may face medium- to long-term challenges if they house individuals that require an extended rehabilitation or that are not fit for release. These challenges include providing quality holding

spaces and providing a sustainable diet that is both affordable and meets the animals' needs.

At the release phase, identifying suitable release sites can be a problem and, in most cases, post-release monitoring remains a luxury that many institutions are unable to provide due to lack of funds and technical capacity.



Breeding of pangolins

While the low breeding success of this species can be attributed to a number of factors such as lack of knowledge and resources, the lack of a concerted effort that comes with a regionally managed programme should be acknowledged. Other issues were also noted, such as the lack of information on the origins and age of many of these pangolins.

Summary of *ex situ* situation

Many wild Sunda pangolins, or their parts, are brought into an *ex situ* situation each year as a result of confiscation or rescue. As outlined in the Workshop Rationale, the current *ex situ* facilities are not adequately equipped or skilled to accommodate, rehabilitate, maintain and/or release these pangolins. Key areas for development include increased coordination among facilities, capacity-building, and development of standard protocols for care and management, including release. These pangolins also represent a potential opportunity for *ex situ* contributions to pangolin conservation.



Potential *ex situ* conservation roles

A facilitated plenary discussion was held to review 11 common *ex situ* conservation roles, gleaned from the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation* (IUCN SSC, 2014), IUCN SSC *Guidelines for Reintroductions and Other Conservation Translocations* (IUCN SSC, 2013), and the Amphibian Ark Conservation Needs Assessment Process (amphibianark.org/conservation-programmes/assessment-results/) (see Appendix II for full list and definitions). Information and recommendations from a similar *ex situ* assessment for Chinese pangolins (*Manis pentadactyla*) in Taiwan, Province of China (Kao et al., 2019) were also considered.

Discussions focused on opportunities provided by the large number of Sunda pangolins (or pangolin parts) that result from confiscations of illegal trade and rescues. These animals pass through one or more *ex situ* stages: 1) initial confiscation/rescue; 2) short-term *ex situ* evaluation and care; 3) release to the wild; and/ or 4) long-term *ex situ* care.

Participants identified seven potential conservation roles to which pangolins (or parts) may contribute as they pass through these stages:

ROLE 1 **Ex situ training**
Source of individuals to gain important species-specific husbandry, handling and breeding expertise to improve short- and long-term *ex situ* care to maximise the contributions of these individuals to conservation of the species.

ROLE 2 **Conservation education**
Basis for an education and awareness programme that addresses specific threats or constraints to the conservation of the species or its habitat, such as addressing specific human behavioural changes that are essential to conservation.

ROLE 3 **Ex situ research**
Source of individuals or biomaterial for research that will benefit conservation of the species in the wild, either directly or through supporting other *ex situ* conservation roles.

ROLE 4 **Population restoration (Reinforcement)**
Source of individuals for population restoration to supplement an existing wild population (e.g. for demographic, behavioural or genetic purposes).

ROLE 5 **Demographic manipulation**
Source of individuals for release to improve a demographic rate (survival or reproduction) or status (e.g. balance a skewed sex ratio) in the wild, often of a particular age or sex.

ROLE 6 **Population restoration (Reintroduction)**
Source of individuals for population restoration to re-establish the species to part of its former range from which it has been extirpated.

ROLE 7 **Insurance population**
Long-term viable *ex situ* population to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies.

The potential roles of an Ark or Rescue population were not considered at this time, as wild populations still exist and are not known to be at high risk of imminent extinction that would necessitate population-level rescue. Ecological Replacement and Assisted Colonisation roles were not considered due to the availability of suitable habitats within the species' natural geographical range. Definitions of these roles can be found in Appendix II.

Participants were asked to identify challenges, risks, knowledge gaps and other issues for consideration for each of the seven potential *ex situ* roles. This was

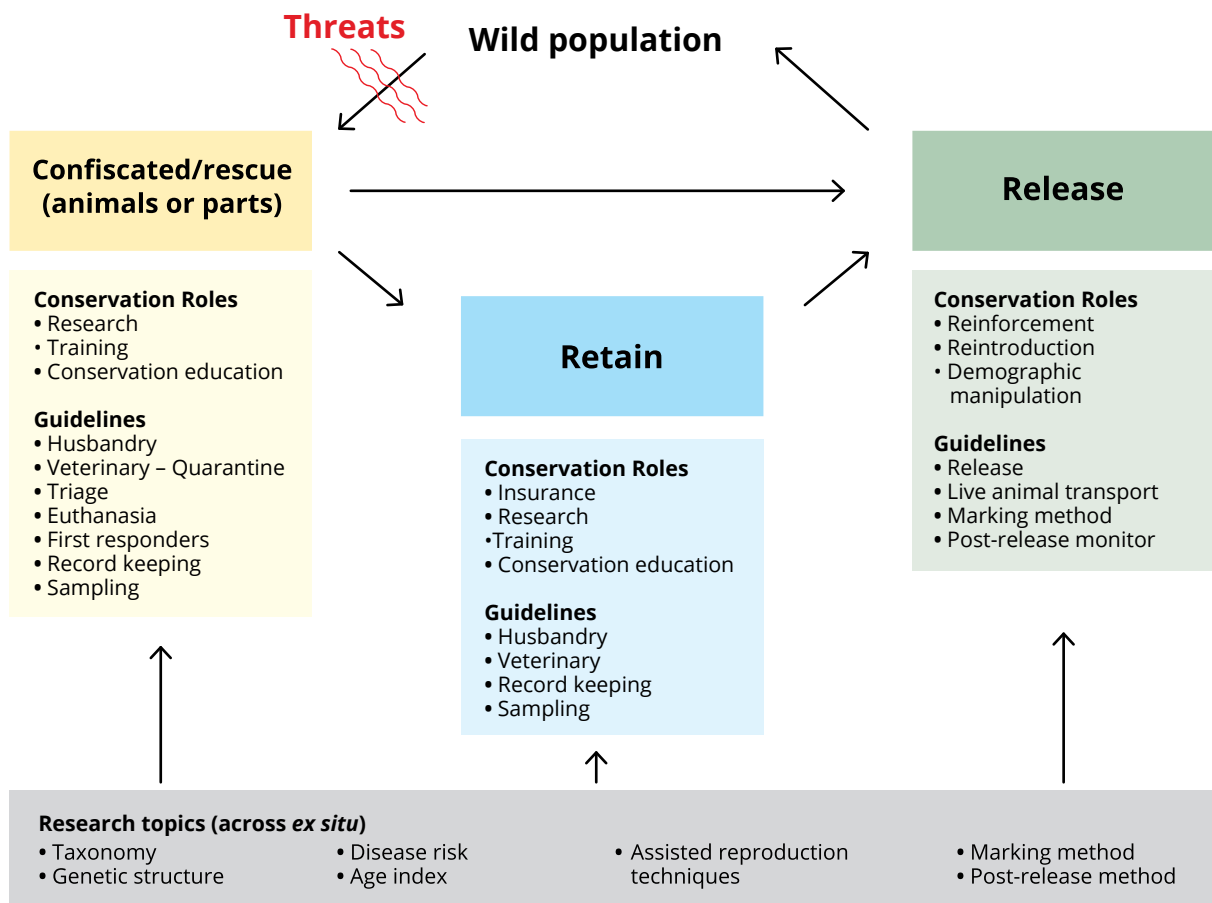
done using a “world café”-style process in which small groups of participants rotated among the various topics. The resulting lists of issues were combined and re-distributed to form three working groups for further discussion on important themes that emerged from the threats analysis and identified potential *ex situ* conservation roles. Each working group cuts across one or more of the seven roles.

One working group was convened to discuss the development of *ex situ* care-related guidelines for short- and long-term care. A second group focused on guidelines and research related to conservation beneficial releases of pangolins. The third group discussed the feasibility and knowledge gaps related to establishing a long-term breeding insurance population, as well as discussing the potential for pangolins (and pangolin parts) to support research

addressing knowledge gaps important for *ex situ* population management and other aspect of Sunda pangolin conservation. A summary of these working group discussions and recommended goals and action steps are provided in this report.

Figure 5 illustrates the *ex situ* stages through which Sunda pangolins may pass, from the wild to confiscation or rescue necessitated by threats, to *ex situ* care (temporary or long-term), to release back to the wild, if feasible. Coloured boxes identify the potential conservation roles associated with each stage, along with the guidelines and research needed throughout this process to address knowledge gaps and improve *ex situ* management. These coloured boxes approximate the four discussion areas addressed by the three working groups.

Figure 5
Movement of Sunda pangolins from the wild through *ex situ* situations, with coloured boxes indicating potential *ex situ* conservation roles and contributions



Working group: *Ex situ* care guidelines

Quality care is essential for all live pangolins that come into *ex situ* care, whether from confiscations or as rescues, both for their own welfare and to maximise their conservation contribution for the species. This working group focused on the development of *ex situ* care guidelines that will be useful for all institutions that house and care for Sunda pangolins either in the short or long term.

PROBLEM STATEMENT

Sunda pangolins face high mortality rates and poor welfare under human care due to lack of suitable knowledge on *ex situ* care.

The working group identified six areas where there is an existing need for expertise/protocols and prioritised their development. The topics include: (i) Husbandry; (ii) Breeding; (iii) Feeding/Nutrition; (iv) Veterinary Care/Disease; (v) Enclosures and (vi) Transport.

There was brief discussion on the terminology to use for the various documents that will be developed – whether they should be called ‘Guidelines’ or ‘Protocols’. It was agreed that the working group will develop ‘Guidelines’, as ‘Protocols’ could be misunderstood, by some, as being deemed approved by a government authority.

It was agreed by all that one master document encompassing all topics for *ex situ* care of Sunda pangolins will be developed. This can then serve as the basis to be adapted by various parties based upon country/resources/needs.

The working group listed all existing guidelines that have been developed by individual organisations for the *ex situ* care of pangolins. This helped identify the starting point as well as existing gaps that needed to be filled by the group.

Participants prioritised the various topics for guidelines that they deem will have maximum impact. In order of descending priority, they are:

1. Husbandry;
2. Veterinary care, including quarantine and euthanasia;
3. First response;
4. Record keeping; and
5. Live animal transport.

The working group discussed the need for a standard pre-rescue guideline. It was agreed by all that pre-rescue processes will vary considerably across countries due to their specific needs and national regulations (e.g. in Thailand, DNP is the sole entity that is responsible for confiscations). This pre-rescue guideline would likely have information that overlaps with other guidelines. For the purposes of this workshop, the working group did not include a pre-rescue guideline in the list of recommendations.

Pertaining to the circulation of these guidelines, the working group raised a concern that, given everyone in the group was not in support of the commercial farming of pangolins, it is important to ensure that the information remains within the conservation community and not be made widely available. Restricting access to these guidelines may however also be counterproductive and negatively impact those genuinely working for the conservation of the species. After much discussion, it was agreed that the guidelines should still be developed regardless of whether commercial farming (legal or otherwise) becomes a reality. It was also agreed that the guidelines would allow for better welfare and living standards for pangolins under human care as a whole, once disseminated and adhered by all institutions.

The working group identified six overall goals and associated actions to develop guidelines to improve *ex situ* care for Sunda pangolins:



GOAL
1

Reduce mortality rates of individuals under human care by improving husbandry.

- Action 1.1** Review current literature and develop standardised husbandry guidelines for the care of Sunda pangolins (to include categories/topics listed in Table 3, which can be adapted for use by all *ex situ* facilities).
- Action 1.2** Circulate the developed husbandry guidelines for review.
- Action 1.3** Translate husbandry guidelines into all relevant languages.
- Action 1.4** Disseminate husbandry guidelines to relevant *ex situ* facilities.

GOAL
2

Reduce mortality rates by improving standards of veterinary care, including quarantine guidelines.

- Action 2.1** Review current literature and develop standardised veterinary care guidelines, including details for quarantine and euthanasia, with input from veterinarians experienced in treating Sunda pangolins.
- Action 2.2** Review veterinary, quarantine and euthanasia guidelines.
- Action 2.3** Translate veterinary, quarantine and euthanasia guidelines into all relevant languages.
- Action 2.4** Disseminate veterinary, quarantine and euthanasia guidelines to relevant *ex situ* facilities.

GOAL
3

Reduce mortality rates by improving knowledge of country-specific first responders to cases involving Sunda pangolins.

- Action 3.1** Identify country-specific conservation partners with the purpose of reaching out to first responders.
- Action 3.2** Develop a short, illustrated template on instructions for first responders on what to do when encountering Sunda pangolins.
- Action 3.3** Convert the template into country-specific first responder guidelines and acquire relevant approvals for distribution.
- Action 3.4** Plan and conduct in-person training for first responders where relevant.

GOAL
4

Ensure accountability by standardising record keeping practices.

- Action 4.1** Create record keeping templates suitable for the various processes (e.g. inventory, health records).
- Action 4.2** Translate the templates to all required languages.
- Action 4.3** Disseminate templates within all range countries.
- Action 4.4** Identify or create a centralised database or platform to consolidate individual pangolin records from across the region.



GOAL
5

Ensure security and improve welfare of Sunda pangolins during live transport.

- Action 5.1** Develop guidelines with recommendations for:
- Preparation for transport
 - Crate design and transport process
 - Husbandry during transport (e.g. – temperature, light)
 - Feeding and watering during transport
 - Time frame/duration
- Action 5.2** Review live animal transport guidelines.
- Action 5.3** Translate live animal transport guidelines into all required languages.
- Action 5.4** Disseminate live animal transport guidelines within all range countries.

GOAL
6

Improve welfare of Sunda pangolins post rescue by standardising *ex situ* management triage procedures.

- Action 6.1** Develop guidelines for post rescue triage.
- Action 6.2** Review post rescue triage guidelines.
- Action 6.3** Translate post rescue triage guidelines into all required languages.
- Action 6.4** Disseminate post rescue triage guidelines within all range countries.



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For each of these recommended actions, responsible parties and timeframes were documented to help achieve these goals. (see Table 7).

The working group felt that the actions would not be effectively implemented without a designated person or entity who can follow up on progress and drive the tasks. Setting up a post workshop *Ex-situ* Conservation Working Group for the Sunda pangolin with representatives from all range countries taking responsibilities would be very important to help drive this.

The working group also recognised that some of these tasks could overlap with the actions identified in the *Regional Sunda Pangolin Conservation Strategy* (IUCN SSC Pangolin Specialist Group et al., 2018), for this species. Care must be taken to ensure that effort is not repeated for both groups.

Working group: Research priorities and biomaterial sampling

PROBLEM STATEMENT

Effective conservation of Sunda pangolins is not possible due to existing knowledge gaps about the species.

The lack of knowledge on pangolin biology was highlighted in the *Regional Sunda Pangolin Conservation Strategy* (IUCN SSC PSG et al., 2018) report. This working group built upon the previous conclusions and identified five specific research areas (Table 2). Out of these research areas, resolving the taxonomy of this species was identified to be the highest priority given the immediate implications to establishing the insurance population programme.

Live Sunda pangolins that come into *ex situ* facilities, and also pangolin parts, provide research opportunities for addressing these knowledge gaps. Given the nature of these research areas, the working group agreed that there is a need for an effective biomaterial sampling protocol. Further discussion will be required to identify specific collaborators for this objective.

Table 2
Research areas and aims

RESEARCH AREAS	AIMS
Taxonomy	To understand and define conservation units for <i>in situ</i> management (releases, reintroduction, reinforcement) and for the management of an <i>ex situ</i> insurance population
Forensics on geographic location	To understand origins of individual animals, which can be used for <i>in situ</i> management (law enforcement via identifying source locations of confiscations and poaching; release, reinforcement, reintroduction of pangolins) and for <i>ex situ</i> management
Population management (genetics)	To understand genetic sub-structure of individuals for an optimal management of the insurance population through identifying good founders and monitoring kinships and inbreeding
Reproduction and assisted reproductive technology	To increase success of the insurance programme via gamete preservation, artificial insemination, embryo transfer and in-vitro fertilisation
Health	To assess disease risk for <i>in situ</i> management of wild populations

Table 3
Biomaterial and data relevant for each research area

Research areas	Morphometrics	Buccal swabs	Blood	Skin cells & tissue samples	Gametes	Ecto-parasites	Gut content
Taxonomy	×	×	×	×			×
Forensics	×	×	×	×		×	×
Population management		×	×		×		
Reproduction				×	×		
Health				×		×	





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The working group identified seven actions linked to this goal on knowledge gaps about Sunda pangolins:

GOAL 7 **Identify and fill research gaps pertaining to taxonomy, population genetics and reproduction.**

- Action 7.1** Review existing and/or ongoing work on taxonomy in the region and follow up with the relevant stakeholders/experts.
- Action 7.2** Identify specific research gaps for the aforementioned topics in Table 2 (research areas and aims).
- Action 7.3** Develop protocols for biomaterial sampling.

- Action 7.4** Develop keys and protocol for collecting morphological data.
- Action 7.5** Develop centralised database accessible for regional partners.
- Action 7.6** Develop sperm banking/cryopreservation protocol.
- Action 7.7** Develop artificial insemination (AI) protocol.

For each of these recommended actions, responsible parties and timeframes were documented to facilitate successful implementation (see Table 7).

Working group: Conservation beneficial releases

According to the potential conservation roles identified by the workshop participants, Sunda pangolin releases may contribute to conservation through reinforcement or demographic manipulation of wild Sunda pangolin populations and through reintroduction into suitable unoccupied habitat. Sunda pangolin release projects and activities are conducted in several countries by government or private organisations. It is important that these releases are conducted in a way to have a positive benefit to the wild population and its conservation. Furthermore, releases should follow the *IUCN Guidelines for Reintroductions and Other Conservation Translocations* (IUCN SSC, 2013). This working group discussed how to maximise the conservation benefit of releases and minimise negative impacts on ongoing projects and activities.

PROBLEM STATEMENT

Rescue and release projects and activities for Sunda pangolins are led by government or NGOs in range countries. The number of individual animals in each rescue case varies between one to several hundred. The limited knowledge of husbandry and resources increase the pressure for releasing or translocating these pangolins. This may result in pangolins being released prematurely without proper evidence based pre-release evaluation and without good information records. Most releases have no associated habitat assessment and post-release monitoring. It is also very difficult to assess the success rate of these releases and its impact on the existing wild population, as there is no baseline population information for the release site. There are many issues with the current releases of Sunda pangolins across the various processes, and there is no existing standard operating procedure guiding releases and conservation translocation specific to this species.

Current knowledge gaps and issues were identified by all workshop participants in the brainstorming session prior to forming the working group. This working group reviewed these results and classified the issues into three broad categories:

- 1. Habitat suitability and capacity:** including protection level, threat level at release site, food resource/composition/seasonal suitability, species competition or predator, habitat connectivity, health/disease consideration, and seasonality assessment of release site.
- 2. Animal information:** including wild population numbers, density, home range, sex ratio, sex identification, age identification, gestation length, life history, genetic viability consideration, sustainable population parameters, cross boundary population, and taxonomy.
- 3. Management:** including suitable number, age, condition, size, health, behaviour, season, time for releasing, soft/hard release comparison, criteria of candidate animal, source population, criteria of release sites, post-release monitoring method and feasibility (including wild/released population), level of management, inbreeding avoidance, approval system/stakeholders, identification of the roles of stakeholders, protecting or increasing motivation of government/decision makers, develop toolkit/capacity building, funding, local community awareness, and economical support for locals.

The working group prioritised the issues based on two criteria: (i) Impact and (ii) Urgency. Table 4 provides details of the resultant prioritisation of issues. "Protection level of release site" had the highest score for impact and second highest for urgency. "Criteria of release site" had the highest score for urgency. "Wild population estimate" had the second highest score for impact. Due to insufficient data, the working group excluded taxonomic concerns during this process. "Identify roles of stakeholders" received the second highest score for urgency.



Table 4
Issues impacting conservation beneficial releases and their prioritised score

TOPIC	NUMBER OF VOTES FOR IMPACT	NUMBER OF VOTES FOR URGENCY
1. Habitat suitability and capacity		
Protection level	13	6
Threat level	0	1
Food resource	3	1
2. Animal information		
Wild population estimate	7	0
Genetic viability consideration	2	3
Sustainable population parameters	1	1
Taxonomy		
3. Management		
Identify individuals – age, condition, size, health, behaviour for releasing	3	0
Soft versus hard release comparison	0	3
Level of site management	1	4
Criteria of release site	0	7
Post release monitoring	3	4
Origin criteria of candidate animal	2	1
Identify roles of stakeholders	1	6
Local community awareness	0	1
Motivating government and decision makers	1	1
Economic support for locals	1	0
Develop toolkit	1	0
Food resource	3	1

Protection level of release habitat and criteria of release site

With regards to habitat suitability, protection from poaching was the most important criterion. Some release sites are also not ideal if they are close to the site where animals are frequently confiscated or poached. Release sites that do not have protected status and/or have weak enforcement of laws protecting pangolins are also not suitable. The proximity of the release site to urban areas may lead to higher poaching risk. In some countries, there may be occasions where the government does not allow pangolins to be kept in captivity, which, along with limited resources, may be a driving force to release pangolins prematurely. Considering all of these factors, the working group members identified the following three goals and associated actions:

GOAL 8

Identify safe and secure release sites, taking into consideration any government requirements.

Action 8.1 Develop criteria for evaluation of suitability and recommendations of suitable release sites in each range country.

GOAL 9

Provide a template for governments to customise and adopt as a national protocol for the release of pangolins.

Action 9.1 Develop a template, including a flow chart for the rescue-to-release process, and instructions for record keeping.

Action 9.2 Develop detailed release guidelines.

GOAL 10

Showcase best practice examples with proven success, to motivate future release and reintroduction work.

Action 10.1 Collate and present learnings from various past experiences by organisations (e.g. experiences related to pangolin transport – design, numbers, duration).

For each of these recommended actions, responsible parties and timeframes were documented to facilitate successful implementation (see Table 7).



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Wild population estimate

The need for good methods for monitoring populations of pangolins is widely recognised (IUCN SSC PSG, 2018; Morin et al., 2020). In this workshop, micro-chips, radio transmitters and camera traps were the main technologies recommended to collect data, not only to inform models to estimate population abundance and density, but also the distribution, home ranges and other ecological parameters of Sunda pangolins. Sun et al. (2019) elaborates on techniques used in tagging individual Chinese pangolins, which can be a good reference to be adopted for tagging Sunda pangolins as well.

Considering that such equipment is expensive, an alternative marking method was put forward. This method involves drilling holes in scales and using different positions, not only for individual identification but also as a “country code”. The codes can then help identify the origins of individual pangolins if they are found in the trade. Such information can then be used to advise the release process. The marking method can be easily and quickly adopted by rescue centres and eventually potentially be included into the CITES regulations as well.

The working group suggested the following goal and actions:

GOAL 11

Establish regional microchip/ marking protocol to standardise the marking methods used across all range countries.

- Action 11.1** Create a protocol for marking pangolins, including the proposed country coding method.
- Action 11.2** Test feasibility of marking methods on juveniles and visibility on camera traps.
- Action 11.3** Develop an index to help quick detection of a pangolin’s age (This could include morphometric measurements - size of particular scales, claw size, length and width of the head, foot length, circumference, etc.).

For each of these recommended actions, responsible parties and timeframes were documented to facilitate successful implementation (see Table 7).

Nick Sun volunteered to create the “marking protocol” as one of the working group actions. This was completed quickly and is provided in Appendix III.

Identify the roles of stakeholders

The roles played by the various stakeholders in rescue, rehabilitation and release of pangolins varies among different countries. Table 5 lists the various stakeholders and the potential role they can play. The participants unanimously agreed that the governmental institutions in each country are important stakeholders, and their support is necessary for the implementation of effective pangolin release programmes.

The working group also identified stakeholders that may have a negative impact or influence on the success of these release programmes. Private or unaccredited zoos that are not part of the insurance population programme may unethically acquire animals outside of an organised conservation effort that could otherwise have been potentially released back into the wild. Other stakeholders also include industries (e.g. palm oil companies) that significantly alter or destroy the natural habitats suitable for pangolins. This change of land use is often accompanied by the building of the roads, which causes further habitat fragmentation and could also increase poaching opportunities.

The working group identified the knowledge gaps with regards to the selection criteria for animals that are suitable for release:

- Health condition
- Suitable age/size (minimum age/size for successful release)
- Activity pattern/behaviour
- Life stage (such as weaning for infants)



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Table 5
Stakeholders and recommended potential roles of conservation beneficial release

STAKEHOLDERS	ROLES	NOTES
Government	Authority	Should follow guidelines/ protocols
Zoo/Rescue Centre (Government/Private)	Rescue, Research, Husbandry, Training	Proper husbandry, Should follow guidelines/ protocols
University	Research, Post-release monitoring	Should follow guidelines/ protocols
Managed areas	Research, Post-release monitoring	Should follow guidelines/ protocols
NGOs	Research, Post-release monitoring	Should follow guidelines/ protocols
Sponsors/donors	Encourage post-release monitoring (long-term)	
Local community	Post-release monitoring	Risk of increasing poaching level



Release protocol for government

Currently there is no release protocol specific to Sunda pangolins that can be followed by governments or private organisations when they conduct the release of pangolins back to the wild. The participants agreed on the need to create a release protocol during the workshop. Because the situation on the ground is very different in each country, the working group decided to put together a simplified release process template which can be followed and adapted based on the needs of the different entities.

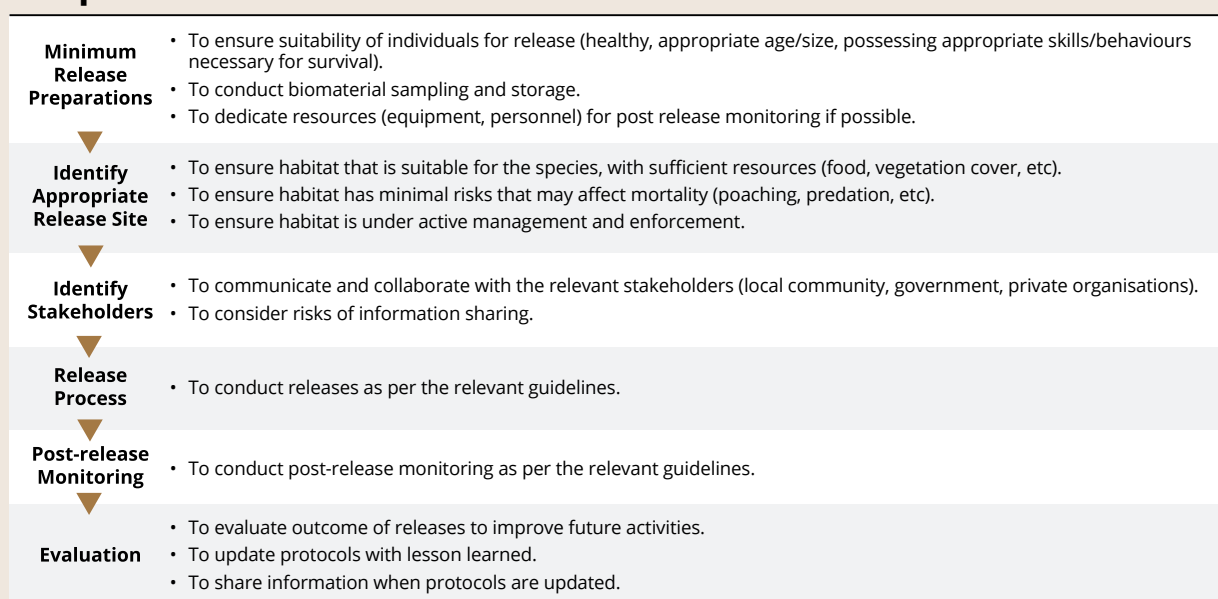
The resulting process involves six steps, which consists of **Minimum Release Preparations** → **Identify Appropriate Release Site** → **Identify Stakeholders** → **Release Process** → **Post-release Monitoring** → and **Evaluation** (Figure 6).

Each step listed has key actions that need to be taken and different guidelines associated with these actions that help pangolin research and conservation.

The working group identified several criteria for release guidelines:

- The key records should include: animal numbers, release site, location of confiscation and in future marking method applied.
- Live animal transport guidelines should be followed.
- Each pangolin should be transported in individual crates to the release site.
- Though further research is still needed, transportation time should be kept under 6 hours. Releasing at night is better than daytime. Knowledge gap: The maximum number that should be released at one location. Determining the suitable release dispersion pattern over the release site.
- The guidelines should include recommendations for the design of the transport crate including dimensions, materials and other necessary features.
- Releases could come with a high risk of transferring diseases to wild populations. Pre-release health checks that follow the relevant guidelines should be conducted.
- The information of release site should be published very carefully.

Figure 6
Simplified Release Process



Working group: Insurance population considerations

PROBLEM STATEMENT

The Sunda pangolin is classified under the IUCN Red List of Threatened Species™ as a Critically Endangered species (Challender et al., 2019a) at risk of extinction due primarily to overexploitation from hunting and poaching. Until these threats can be mitigated by effective conservation action in the wild, this species is at risk of being lost.

A well-managed, genetically diverse *ex situ* insurance population would guard against species extinction and provide options for restoring wild populations in the future and for research. In the plenary discussions, the workshop participants recognised the conservation value of an *ex situ* insurance population for Sunda pangolins. This working group considered the challenges, risks and feasibility of such an endeavour. The result was a recommended course of action, both short term and long term, to move towards the establishment of an insurance population for this species.

It should be noted that the working group was not in support of commercial farming of this species, as participants recognised that it does not offer the same conservation benefits and may incur different risks. This position is in alignment with the study on the feasibility of pangolin farming conducted by Challender et al. (2019b), which concluded that it is highly unlikely that commercial farming would displace the poaching of wild pangolins or have a positive impact on the conservation of wild pangolins. However, the authors also noted uncertainty over what may happen in the future recognising attempts to overcome barriers to captive breeding (see also 't Sas-Rolfes and Challender, 2020). The paper also suggested that the laundering of wild pangolins could potentially occur if commercial breeding were legalised and conducted on a larger scale.

Population goals and management

The continued influx of rescued and confiscated pangolins into *ex situ* facilities has resulted in a growing *ex situ* population of both transient and non-releasable individuals that require long-term care. While these pangolins provide a good opportunity to establish an insurance population, they are not considered to constitute an insurance population at this time, as there is no collaborative effort for demographic and genetic management at the population level. However, with the right framework and resources, this *ex situ* population can develop into an insurance population for the species. A thriving insurance population can support other conservation roles such as research and potential reinforcement/reintroduction of the species.

The working group began discussions on the topic of population management and the feasibility of an insurance population for the Sunda pangolin. A primary goal of an insurance population is to maintain high genetic diversity, ideally based on a large number of wild-caught founders from across the geographic range of the species. A common genetic goal for *ex situ* insurance populations is to maintain at least 90% gene diversity for at least 100 years (Foose et al., 1995). The PMx software programme (Ballou et al., 2019) was used to explore the characteristics of a potential conservation breeding programme needed to meet this genetic goal. The summary of the model outputs are as follows:

Starting founders and supplementation

The availability of a large number of wild-caught founders that represent high genetic diversity plays a fundamental role in the viability of any conservation breeding programme for insurance. Based on the current *ex situ* population numbers, the programme for this species would likely start with founder population of 30 wild-caught animals, assumed to be



unrelated to each other. The maximum population size was set at 100 as a reasonable estimate of future *ex situ* capacity in the region and a common heuristic for a minimum insurance population size.

Data from wild and captive pangolin populations were used to estimate a generation time of 6.3 years and a potential annual growth rate of 6%. The ratio of effective population size (N_e) to population size (N) was set at 0.3, which represents an *ex situ* programme with strong genetic management to maintain gene diversity and with good breeding success. Taken together, these inputs assume husbandry and veterinary care that promotes good health and reproduction along with population-level collaboration and management.

Under these conditions, a closed population with no additional founders would only maintain 90% genetic diversity for about 15 years (Fig. 7).

However, wild pangolins are periodically rescued and can provide a source of additional founder genetic lines. The periodic addition of unrelated founders can increase genetic diversity of the population, mitigating genetic drift and inbreeding issues. Using the same parameter inputs but with the addition of one new founder (that produces at least one surviving offspring) every two years, it is possible to maintain 90% genetic diversity for 100 years (Fig. 8). Note that cryo-banked gametes from unrelated individuals can also act as founders for this programme.

Figure 7
Projected population size (red line) and gene diversity (blue line) for closed population (no new founders) for 100 years

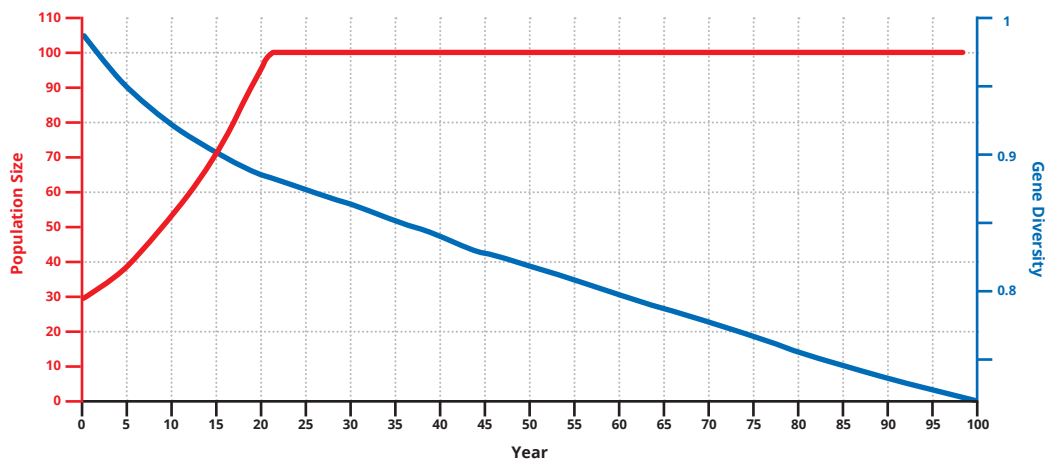
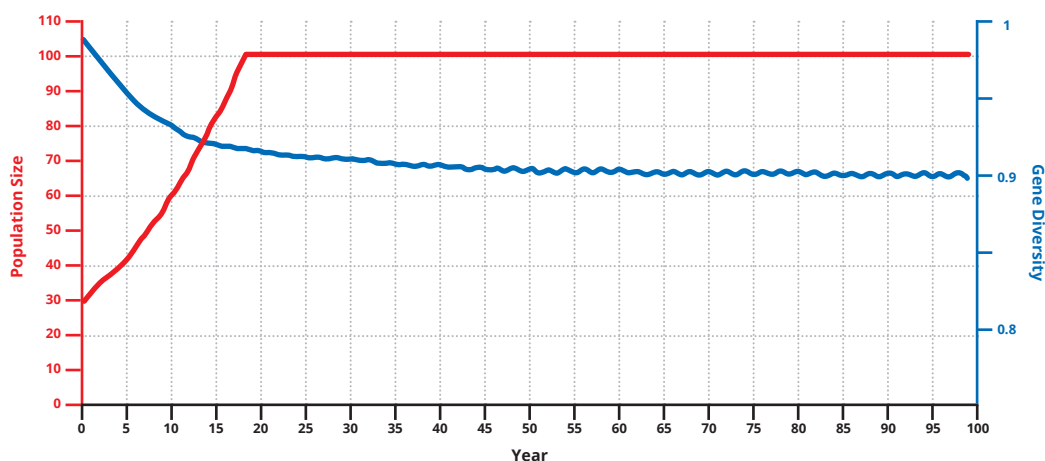


Figure 8
Projected population size (red line) and gene diversity (blue line) with the addition of one new reproductive founder every two years for 100 years





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Target population size

The *ex situ* carrying capacity, or the maximum number of animals that the population is allowed to reach, has a large impact on gene diversity and the viability of the programme. Small populations lose gene diversity more rapidly than large populations. The carrying capacity of potential current institutions is fewer than 50 pangolins. For a short-term programme (~20 years), this carrying capacity would suffice, provided that new founders are successfully added and good reproduction and population management occurs. At a growth rate of 6%, it would take about 8 years to reach 50 individuals, and the population could retain 90% gene diversity for 20 years provided good reproduction, effective management, and the addition of a new reproducing founder every two years (Fig. 9).

A long-term programme that would retain at least 90% gene diversity for 100 years requires a target population size of at least 100 pangolins, again with the same expected levels of reproduction, population management and supplementation (Fig. 8). While *ex situ* capacity for Sunda pangolins in the region should be increased in the short-term, suitable holding institutions outside range countries should also be explored for a long-term programme.

Overall programme management

Many management-related factors interact to impact the rate at which genetic diversity is lost from a population. As outlined above, larger population size slows the rate of loss, and periodic supplementation with new founders can counterbalance that loss. All of the above scenarios assume that at least a certain number of wild-caught and captive-born pangolins will thrive and reproduce. Another assumption is that institutions will collaborate with each other, contributing data and eventually exchanging animals to equalise founder lines and avoid inbreeding. These conditions will lead to a higher N_e/N ratio and slower loss of gene diversity. However, if pangolin survival or reproduction are lower than projected, and/or population-level management is less effective, then gene diversity will be lost more rapidly.

Figure 9
Projected population size (red line) and gene diversity (blue line) with the addition of one new reproductive founder every two years for 20 years. Population size restricted to 50 animals

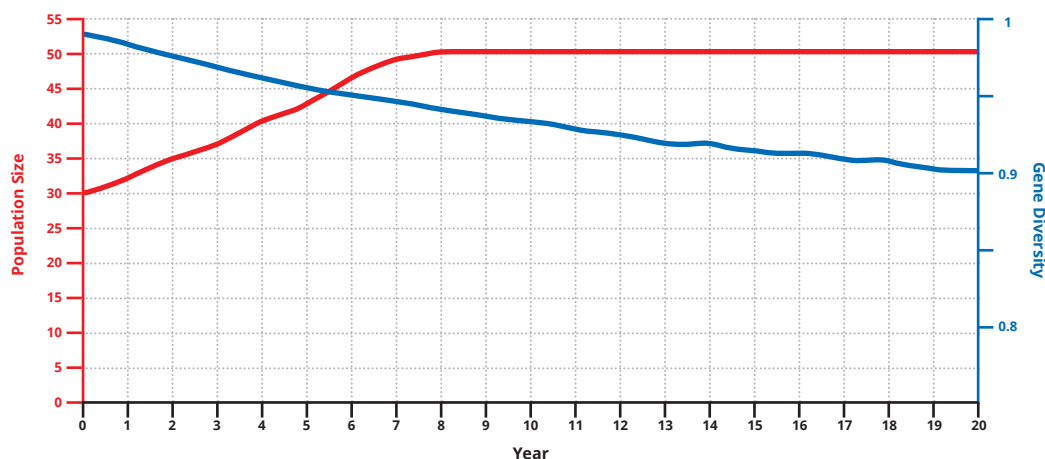


Table 6
Potential insurance programme structures and genetic outcomes.

Case	Starting N*	Max N (capacity)	Ne/N	Additional founders	Outcome
1	30	100	0.3	None	90% GD for only 15 years 72% GD for 100 years
2	30	100	0.3	1 new founder every 2 years for 100 years	Long-term success: maintains 90% GD for 100 years
3	30	100	0.3	1 new founder every 2 years for 20 years	90% GD for 26 years 74% GD for 100 years
4	30	50	0.3	1 new founder every 2 years for 20 years	Short-term success: maintains 90% GD for 20 years
5	30	100	0.2	1 new founder every 2 years for 100 years	90% GD for 10 years 88% GD for 100 years
6	30	100	0.2	1 new founder every year for 100 years	Long-term success: maintains 91% GD for 100 years

*assumes initial animals are wild-caught, reproducing founders

Table 6 shows the results of several combinations of PMx input values and the resulting gene diversity (GD). Comparison of cases 1 and 2 demonstrate the benefits of the periodic influx of additional founders, and cases 2 vs 3 show the importance of long-term vs short-term supplementation. Case 4 represents a smaller population size with short-term goals. Cases 5 and 6 show the impact of reduced effectiveness (lower Ne/N), resulting in the need for more frequent supplementation to achieve the long-term genetic goal. The working group also noted that there will be a need to occasionally consider absorbing healthy releasable pangolins (be it for short term or long term) for this programme. Non-releasable individuals may not always be ideal candidates for conservation breeding especially if they are sickly or have some condition that might affect reproduction.

These projections demonstrate the importance of improved husbandry and veterinary care, collaborative management among institutions, the effective incorporation of healthy, non-releasable pangolins into the programme, and the opportunistic banking and cryopreservation of gametes of pangolins that do not breed or are to be released.

Conservation units

The current *ex situ* population is most likely to have individuals of various origins. However, there is little work on the taxonomy and genetic substructure of Sunda pangolins. Nash et al. (2018) suggested that there are three genetic lineages of Sunda pangolins within the Sundaic region (Borneo, Java and Sumatra/Singapore). The authors recommended that the lineages should be treated as evolutionary distinct conservation units, pending further research. Clearly, there is a need to extend this research to include populations in the other range states (Cambodia, Laos, Myanmar, Peninsular Malaysia, Thailand and Vietnam).

Recent genetic research done on other small mammal species such as leopard cat, common palm civet, binturong, which have similar geographic distribution, found the occurrence of multiple subpopulations of the respective species across the range (Patel et al., 2017; Patou et al., 2010; Veron et al., 2020). These findings however may not necessarily agree with existing morphologically defined subspecies. Both *in situ* and *ex situ* conservation, for it to be effective and successful, require a consensus on the number of conservation units or management units (Wilting et al., 2015).



Based on the simple PMx population projection models, it is likely that long-term breeding insurance populations for multiple conservation units will not be feasible. Pending further taxonomy research, the participants agreed to be cognisant of the current and potential subpopulations while implementing the recommended actions. With this in mind, the structure of the programme could initially treat the species as one conservation unit but with breeding done nationally or based on the aforementioned lineages where applicable, using individuals of known origin (e.g. animals from localised rescues rather than from large confiscations). Breeding across subpopulations or range states would not be conducted unless inbreeding were to accumulate to problematic levels on a national or subpopulation level. It was also noted that localised inbreeding can potentially be delayed with the addition of new founders regularly from within this national or subpopulation group.

Holding institutions

Each current holding institution was evaluated for its suitability to the programme based on a number of parameters: its capability to receive pangolins in a rescue capacity, whether it currently holds or has held pangolins, current holding facilities, and its capacity to breed.

Several institutions were identified to be suitable as the initial contributors for this programme, namely: Bali Zoo, Batu Secret Zoo, Wildlife Alliance Cambodia, and Wildlife Reserves Singapore. A number of other institutions were flagged as potential partners in the medium to long term. While partnerships with institutions outside the region should be explored where applicable, the working group highlighted the need to prioritise building capacity within the region.

The working group identified one goal and three actions to initiate the development of an *ex situ* insurance population for Sunda pangolins:

GOAL 12

To establish a healthy, genetically diverse *ex situ* insurance population that provides a safeguard against the extinction of the species and provides the means to support the recovery of wild populations through reinforcement or reintroduction.

Action 12.1 Identify and contact potential institutions and country coordinators for *ex situ* insurance programme.

Action 12.2 Develop studbook for *ex situ* insurance programme under SEAZA.

Action 12.3 Share the outcomes of the workshop, including purpose and structure of the *ex situ* insurance programme, with zoological stakeholders, i.e., WAZA and regional zoo associations.

For each of these recommended actions, responsible parties and timeframes were documented to facilitate successful implementation (see Table 7).

The final design of the programme structure and management for the insurance population may be influenced by the results of taxonomic research recommended in this report. The implementation of the recommended improvements in *ex situ* care highlighted in aforementioned goals will also have an impact on achieving this goal. Novel reproductive methods such as artificial insemination and other assisted reproductive technologies should be explored as well. While addressing taxonomic knowledge gaps will facilitate development of the best long-term strategy, completion of the recommended actions will form the initial foundation of the insurance population programme.

Table 7**Goals and recommended actions from all working groups to improve overall *ex situ* management of Sunda pangolins, with responsible parties and timeframes**

Goals and Actions	Responsibility	Timeframe	
GOAL 1 Reduce mortality rates of Sunda pangolins under human care by improving husbandry care.			
Action 1.1	Review current literature and develop standardised husbandry guidelines for the care of Sunda pangolins (to include categories/topics listed in Table 3, which can be adapted for use by all <i>ex situ</i> facilities).	SWW – Thai Van Nguyen WRS – Ade Kurniawan TPZ – Flora Lo Mahidol University	Dec 2020
Action 1.2	Circulate the developed husbandry guidelines for review ready for circulation including ownership, copyright and usage concerns.	Tikki Hywood Foundation – Ellen Connelly PSG – Keri Parker	Feb 2021
Action 1.3	Translate husbandry guidelines into all relevant languages.	Laos – FTB Luke Brannon Indo Bali Zoo – Ade Diah Safitri Thailand – MU Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri Vietnam – Thai Van Nguyen Cambodia – ACCB	May 2021
Action 1.4	Disseminate husbandry guidelines to relevant <i>ex situ</i> facilities.	PSG All workshop participants	May 2021
GOAL 2 Reduce mortality rates by improving standards of veterinary care, including quarantine guidelines.			
Action 2.1	Review current literature and develop standardised veterinary care guidelines, including details for quarantine and euthanasia, with input from veterinarians experienced in treating Sunda pangolins.	WRS – Charlene Yeong, Sonja Luz MU, DNP vets, ZPO vets – Warisara Thomas SWW vets – Thai Van Nguyen TPZ – Jim Kao, Tina Chen	Dec 2020
Action 2.2	Review veterinary, quarantine and euthanasia guidelines.	WRS – Charlene Yeong, Sonja Luz SWW – Thai Van Nguyen, Leanne Wicker PSG – Keri Parker All workshop participants to connect to appropriate animal welfare reviewers	Feb 2021
Action 2.3	Translate veterinary, quarantine and euthanasia guidelines into all relevant languages.	Laos – FTB Luke Brannon Indo Bali Zoo – Ade Diah Safitri Thailand – MU Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri Vietnam – Thai Van Nguyen SWW Cambodia – ACCB	May 2021
Action 2.4	Disseminate veterinary, quarantine and euthanasia guidelines to relevant <i>ex situ</i> facilities.	PSG All workshop participants	May 2021



Goals and Actions

Responsibility

Timeframe

GOAL
3

Reduce mortality rates by improving knowledge of country-specific first responders to cases involving Sunda pangolins.

Action 3.1	Identify country-specific conservation partners with the purpose of reaching out to first responders.	Singapore – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SVW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	Dec 2019
Action 3.2	Develop a short, illustrated template for first responders on what to do when encountering Sunda pangolins, no longer than four pages.	SVW – Thai Van Nguyen FTB – Luke Brannon Warisara Thomas	Dec 2019
Action 3.3	Convert the template into country-specific first responder guidelines and acquire relevant approvals for distribution.	Singapore – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SVW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	June 2020
Action 3.4	Plan and conduct in person training for first responders where relevant.	Singapore – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SVW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	Ongoing



Goals and Actions	Responsibility	Timeframe	
GOAL 4 Ensure accountability by standardising record keeping practices.			
Action 4.1	Create record keeping templates suitable for the various processes (eg. inventory, health records, etc.)	WRS – Ade Kurniawan SWW – Thai Van Nguyen Other <i>ex situ</i> holders in the workshop	Dec 2019
Action 4.2	Translate the template into all relevant languages.	Singapore – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SWW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	Jan 2020
Action 4.3	Disseminate guidelines to all relevant <i>ex situ</i> facilities.	PSG All workshop participants	Feb 2020
Action 4.4	Identify or create a centralised database/platform to share all individual pangolin records from across the region.		
GOAL 5 Ensure security and improve welfare of Sunda pangolins during live transport.			
Action 5.1	Develop guidelines with recommendations for: <ul style="list-style-type: none"> • Preparation for transport • Process/crate design • Husbandry during transport (e.g. – temperature, light) • Feeding and watering during transport • Time frame/duration 	SWW – Thai Van Nguyen TPZ – Flora Lo WRS – Ade Kurniawan Bali Zoo – Ade Diah Safitri	Dec 2020
Action 5.2	Review live animal transport guidelines.	PSG All workshop participants	Feb 2021
Action 5.3	Translate live animal transport guidelines.	SG – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SWW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	May 2021
Action 5.4	Disseminate live animal transport guidelines.	All workshop participants	May 2021



Goals and Actions	Responsibility	Timeframe	
GOAL 6 Improve welfare of Sunda pangolins post rescue by standardising <i>ex situ</i> management triage procedures.			
Action 6.1	Develop guidelines for post rescue triage.	WRS – Sonja Luz, Ade Kurniawan, Dec 2021 Charlene Yeong SWW – Thai Van Nguyen <i>Ex situ</i> facility managers	
Action 6.2	Review post rescue triage guidelines.	PSG All <i>ex situ</i> facilities	Feb 2022
Action 6.3	Translate post rescue triage guidelines.	SG – Shawn Chia Laos – FTB Luke Brannon Indonesia – Batu Zoo Mariusz Lech, Cikananga Inge Tielen Thailand – Warisara Thomas, Bencharong Sangkharak (DNP) Myanmar – WCS/TSA Kalyar Platt Malaysia – Che Ku Zamzuri (all Malaysian government agencies) Vietnam – Thai Van Nguyen SWW Cambodia – ACCB, Wildlife Alliance – Nicole Leroux	Mar 2022
Action 6.4	Disseminate post rescue triage guidelines.	All workshop participants	Mar 2022

GOAL 7 Identify and fill research gaps pertaining to taxonomy, population genetics and reproduction.		
Action 7.1	Review existing and/or ongoing work on taxonomy in the region and follow up with the relevant stakeholders/experts.	WRS – Ade Kurniawan, Sonja Luz
Action 7.2	Identify specific research gaps for the aforementioned topics in Table 2 (research areas and aims).	ZSL – Eileen Larney
Action 7.3	Develop protocols for biomaterial sampling.	WRS Other partners (TBA)
Action 7.4	Develop keys and protocol for collecting morphological data.	WRS – Chia-Da Hsu, Sonja Luz
Action 7.5	Develop centralised database accessible for regional partners.	WRS & PSG
Action 7.6	Develop sperm banking/cryopreservation protocol.	WRS – Chia-Da Hsu, Abraham Mathew
Action 7.7	Develop artificial insemination (AI) protocol.	WRS – Abraham Mathew

Goals and Actions	Responsibility	Timeframe
GOAL 8 Identify safe and secure release sites, taking into consideration the various governments' requirements.		
Action 8.1	Develop criteria for evaluation of suitability and recommendations of suitable release sites in each range country.	Thailand – Eileen Larney Respective country coordinator/representative
GOAL 9 Provide a template for governments to customise and adopt as a national protocol for the release of pangolins.		
Action 9.1	Develop a template, including a flow chart for the rescue-to-release process, and instructions for record keeping.	Nicole Leroux (Wildlife Alliance) Working group 3 members October 2019 shared with working group Final version end of 2019
Action 9.2	Develop detailed release guidelines.	Nicole Leroux (Wildlife Alliance) Inge Tielen (Cikananga Wildlife Center) Working group 3 members Draft end of 2019 Finalised middle of 2020
GOAL 10 Showcase best practice examples with proven success to motivate future release and reintroduction work.		
Action 10.1	Collate and present learnings from various past experiences by organisations (e.g. - Experiences related to pangolin transport – design, numbers, duration etc).	Elisa Panjang along with working group 1 members Ongoing
GOAL 11 Establish regional microchip/marking protocol to standardise the marking methods used across all range countries.		
Action 11.1	Create a protocol for marking pangolins including the proposed country coding method.	Nick Sun Working group 3 members Draft finished by end of 2019
Action 11.2	Test feasibility of marking methods on juveniles and visibility on camera traps.	Nick Sun WRS 2020-2022
Action 11.3	Develop an index to help quick detection of a pangolin's age (This could include morphometric measurements - size of particular scales, claw size, length and width of the head, foot length, circumference, etc).	WRS Vietnam 2019-2021



Goals and Actions

Responsibility

Timeframe

GOAL 12	To establish a healthy, genetically diverse <i>ex situ</i> insurance population that provides a safeguard against the extinction of the species and provides the means to support the recovery of wild populations through reinforcement or reintroduction.		
Action 12.1	Identify and contact potential institutions and country coordinators for <i>ex situ</i> insurance programme.	WRS – Ade Kurniawan	
Action 12.2	Develop studbook for <i>ex situ</i> insurance programme under SEAZA.	WRS – Sonja Luz, Ade Kurniawan	Proposal was raised at SEAZA 2019 (November)
Action 12.3	Share the outcomes of the workshop, including purpose and structure of the <i>ex situ</i> insurance programme, with zoological stakeholders i.e., WAZA and regional zoo associations.	WRS – Sonja Luz SEAZA – Jim Kao	Oct 2019- done

Table 8
Categories to be covered in the Husbandry guidelines

<p>1 HOUSING REQUIREMENTS</p> <ul style="list-style-type: none"> 1.1. Enclosure design 1.2. Position of enclosures 1.3. Weather protection 1.4. Substrate 1.5. Furnishing 1.6. Cleaning requirements 1.7. Inter-specific compatibility 1.8. Recommendations for social housing 1.9. Lighting, temperature, humidity 1.10. Social housing 1.11. Breeding/non-breeding needs 	<p>2 HANDLING</p> <ul style="list-style-type: none"> 2.1. Timing of capture and handling 2.2. Tools and equipment for capture and handling 2.3. Capture and restraint techniques 2.4. Weighing, measurements and sexing 2.5. Initial introduction of a pangolin into an enclosure 2.6. Transport requirements 2.7. Immobilisation 	<p>3 BEHAVIOUR</p> <ul style="list-style-type: none"> 3.1. Habits 3.2. Feeding behaviour 3.3. Sleeping 3.4. Social behaviour 3.5. Bathing behaviour 3.6. Behavioural problems 3.7. Enrichment 3.8. Training/conditioning
<p>4 DIET</p> <ul style="list-style-type: none"> 4.1. Captive diet – Natural/Artificial 4.2. Nutritional Supplement 4.3. Food presentation 4.4. Water 	<p>5 BREEDING</p> <ul style="list-style-type: none"> 5.1. Identify suitable pairs 5.2. Courtship and mating behaviour 5.3. Nesting 5.4. Monitoring protocol 5.5. Dietary needs 5.6. Gestation, parturition and maternal care 5.7. Monitoring and weaning of young 	<p>6 HAND REARING</p> <ul style="list-style-type: none"> 6.1. Criteria (orphaned, rejected, health conditions) 6.2. Monitoring 6.3. Housing (temporary requirements) 6.4. Diet (milk formula, solids) 6.5. Hygiene, special requirements 6.6. Handling of neonates 6.7. Weaning

Note: The working group agreed that all *ex situ* facilities should have their own individual 'Facility Management Plan' identifying their capacity and resource availability. The husbandry guidelines cannot replace the Facility Management Plan.

Summary and conclusions

This workshop gathered almost 40 *in situ* and *ex situ* pangolin experts from 11 countries to examine the threats and conservation needs of the Critically Endangered Sunda pangolin, and to evaluate the potential role(s) that *ex situ* pangolins might contribute to conservation of this species. Specifically, attention was focused on the potential conservation contributions of the large number of confiscated or rescued Sunda pangolins in the region. The 2018 *Regional Sunda Pangolin Conservation Strategy* (IUCN SSC PSG et al., 2018) served as basis for identifying conservation needs, while the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation* provided a decision making framework to assess the feasibility and appropriateness of *ex situ* conservation contributions. This assessment was conducted in collaboration with, and at the request of, the IUCN SSC Pangolin Specialist Group.

Workshop participants identified several potential current or future conservation roles for Sunda pangolins held in *ex situ* care, for both pangolins that are held temporarily before release as well as for non-releasable individuals. Primary areas of discussion were guidelines and research to improve health, survival and welfare (both short-term and long-term care), guidelines and research to improve the conservation value of releases, research to identify priority knowledge gaps that impact conservation actions, and the feasibility of establishing a long-term *ex situ* insurance population based on non-releasable animals as a genetic reservoir and safety net against severe decline or extinction in the wild.

These evaluative discussions resulted in a set of 12 goals and 41 recommended actions to promote beneficial contributions of Sunda pangolins that end up in human care. These workshop recommendations are specific to the programme goals, structure and outcomes outlined in this document and should not be considered as a blanket endorsement of all *ex situ* activities for pangolins. Rather, these actions are designed to maximise conservation benefit while considering feasibility and minimising risks.

While specific to Sunda pangolins, portions of these discussions and evaluations may be applicable to other pangolin species.

The combined recommendations in the *Regional Sunda Pangolin Conservation Strategy* (IUCN SSC PSG et al., 2018) and the recommendations outlined in this report represent a One Plan approach to Sunda pangolin conservation. By involving both *in situ* and *ex situ* pangolin experts in conservation planning for wild pangolins and for those that come into human care, and by structuring *ex situ* programmes for maximal contribution to Sunda pangolin conservation needs, pangolin conservation actions are more effective and integrated across all individuals and population of this species.

Co-ordinated implementation

All participants of the workshop agreed that continued engagement between the different range countries, holding facilities and conservation organisations is essential to ensure that the actions are implemented in the best manner. The group identified suitable individuals and organisations from each range country that will take the lead in coordinating between all workshop participants, the IUCN SSC Pangolin Specialist Group and the government agencies in their respective countries. These people will form the 'Ex situ Conservation Working Group for the Sunda pangolin'. This working group will not only periodically update each other on the progress in implementation of the actions outlined in this report, but also share experiences to avoid repeating the same mistakes and overcoming challenges through effective collaboration. It was agreed that the working group will have regular online meetings and meet in person once a year. This working group will also play a key role in coordinating the relevant actions from the *Regional Sunda Pangolin (Manis javanica) Conservation Strategy 2018-2028*. It was also agreed by all participants that once the protocols and other materials described in this report are developed, the PSG shall share them with CITES Parties through appropriate processes and channels.



Literature cited

- Ballou, J.D., Lacy, R.C., & Pollak, J.P., 2019. PMx: Software for demographic and genetic analysis and management of pedigreed populations (Version 1.6.1). Chicago Zoological Society, Brookfield, Illinois, USA. Available from <http://www.scti.tools>
- Broad, S., Luxmoore, R., & Jenkins, M., 1988. Significant Trade in Wildlife: a review of selected species in CITES Appendix II. Volume 1: Mammals. IUCN/CITES.
- Challender, D., Willcox, D.H.A., Panjang, E., Lim, N., Nash, H., Heinrich, S. & Chong, J. 2019a. *Manis javanica*. The IUCN Red List of Threatened Species 2019. Available from <www.iucnredlist.org>. e.T12763A123584856. <https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T12763A123584856.en>. [24 August 2019].
- Challender, D.W.S., Sas-Rolfes, M., Ades, G.W.J., Chin, J.S.C., Ching-Min Sun, N., Chong, J.L., Nash, H.C., 2019b. Evaluating the feasibility of pangolin farming and its potential conservation impact. *Global Ecology and Conservation*, 20, e00714.
- Challender, D.W., Heinrich, S., Shepherd, C.R. and Katsis, L.K., 2020. International trade and trafficking in pangolins, 1900–2019. In *Pangolins* (pp. 259-276). Academic Press.
- Chong, J.L., Panjang, E., Willcox, D., Nash, H.C., Semiadi, G., Sodsai, W., Lim, N.T., Fletcher, L., Kurniawan, A. and Cheema, S., 2020. Sunda pangolin *Manis javanica* (Desmarest, 1822). In *Pangolins* (pp. 89-108). Academic Press.
- CITES, 1992. Review of Significant Trade in Animal Species included in CITES Appendix II, Detailed Review of 24 priority species, Indian, Malayan and Chinese pangolin. CITES, Geneva, Switzerland.
- CITES, 1999. Review of Significant Trade in Animal Species included in CITES Appendix II, Detailed Review of 37 species. World Conservation Monitoring Centre, IUCN Species Survival Commission and TRAFFIC, Cambridge, UK.
- CITES, 2016. Consideration of Proposals for Amendment of Appendices I and II, 17th Conference of the Parties, Proposal 11 (CoP17 Prop.11). Johannesburg, South Africa. Available from: <<https://cites.org/sites/default/files/eng/cop/17/prop/060216/ECOP17-Prop-11.pdf>>. [20 August 2017].
- Corbet, G.B. & Hill, J.E., 1992. Mammals of the Indo-Malayan Region: a Systematic Review. Oxford University Press, Oxford, U.K.
- Foose, T. J., de Boer, L., Seal, U. S., & Lande, R., 1995. Conservation management strategies based on viable populations. In *Population Management for Survival and Recovery*. (ed.) J. Ballou, M. Gilpin, and T. J. Foose, 273-294. New York, NY: Columbia Univ. Press.
- IUCN SSC., 2013. Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission.
- IUCN SSC., 2014. Guidelines on the Use of *Ex Situ* Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission.
- IUCN SSC Pangolin Specialist Group, 2018. Methods for monitoring populations of pangolins (Pholidota: Manidae). IUCN SSC Pangolin Specialist Group, % Zoological Society of London, London, UK.
- IUCN SSC Pangolin Specialist Group, IUCN SSC Asian Species Action Partnership, Wildlife Reserves Singapore, IUCN SSC Conservation Planning Specialist Group. Regional Sunda Pangolin (*Manis javanica*) Conservation Strategy 2018-2028., 2018. IUCN SSC Pangolin Specialist Group, % Zoological Society of London, Regent's Park, London, NW1 4RY, UK.
- Kao, J., Li, J.Y.W., Lees, C., Traylor-Holzer, K., Jang-Liaw, N.H., Chen, T.T.Y., Lo, F.H.Y., Yu, H.Y., & Sun, C.M. (Eds), 2019. 2017 Population and Habitat Viability Assessment and Conservation Action Plan for the Formosan Pangolin, *Manis p. pentadactyla*. IUCN SSC Conservation Planning Specialist Group, Apple Valley, MN, USA.
- Lee, P.B., Chung, Y.F., Nash, H.C., Lim, NT-L., Chan, S.K.L., Luz, S., & Lees, C., 2018. Sunda Pangolin (*Manis javanica*) National Conservation Strategy and Action Plan: Scaling up pangolin conservation in Singapore. Singapore Pangolin Working Group.
- McGowan, P.J.K., Traylor-Holzer, K., & Leus, K., 2016. IUCN guidelines for determining when and how *ex situ* management should be used in species conservation. *Conservation Letters*, 10, 361-366.
- Morin, D.J., Challender, D.W., Ichu, I.G., Ingram, D.J., Nash, H.C., Panaino, W., Panjang, E., Sun, N.C.M. & Willcox, D., 2020. Developing robust ecological monitoring methodologies for pangolin conservation. In *Pangolins* (pp. 545-558). Academic Press.
- Nash, H.C., Wirdateti, Low, G.W., Choo, S.W., Chong, J.L., Semiadi, G., ... Rheindt, F.E., 2018. Conservation genomics reveals possible illegal trade routes and admixture across pangolin lineages in Southeast Asia. *Conservation Genetics*, 19, 1083–1095.
- Parker, K. & Luz, S. 2020. Zoo engagement in pangolin conservation: contributions, opportunities, challenges, and the way forward. In Challender, D.W., Nash, H.C. and Waterman, C., 2020. *Pangolins: Science, Society and Conservation*. Academic Press. (pp. 505-516). Academic Press.

- Patel, R.P., Wutke, S., Lenz, D., Mukherjee, S., Ramakrishnan, U., Veron, G., Fickel, J., Wilting, A. & Förster, D.W., 2017. Genetic structure and phylogeography of the leopard cat (*Prionailurus bengalensis*) inferred from mitochondrial genomes. *Journal of Heredity*, 108(4), pp.349-360.
- Patou, M.L., Wilting, A., Gaubert, P., Esselstyn, J.A., Cruaud, C., Jennings, A.P., Fickel, J. & Veron, G., 2010. Evolutionary history of the *Paradoxurus* palm civets—a new model for Asian biogeography. *Journal of Biogeography*, 37(11), pp.2077-2097.
- Sun, N.C.M., Pei, K.J.C., & Lin, J.S., 2019. Attaching tracking devices to pangolins: A comprehensive case study of Chinese pangolin *Manis pentadactyla* from south eastern Taiwan. *Global ecology and conservation*, 20, 2019, e00700.
- † Sas-Rolfes, M., & Challender, D.W., 2020. Evaluating the impact of pangolin farming on conservation. In *Pangolins* (pp. 517-525). Academic Press.
- Traylor-Holzer, K., Leus, K., & Byers, O., 2018. Integrating *ex situ* management options as part of a One Plan Approach to species conservation. In: *The Ark and Beyond*. Minter, B. et al. (eds). University of Chicago Press.
- Traylor-Holzer, K., Leus, K. & McGowan, P., 2013. Integrating assessment of *ex situ* management options into species conservation planning. *WAZA Magazine*, 14, 6-9.
- Veron, G., Debruille, A., Kayser, P., Fernandez, D.A.P. & Bourgeois, A., 2020. Genetic diversity and structure of the binturong *Arctictis binturong* (Carnivora: Viverridae) – status of the elusive Palawan binturong and implications for conservation. *Zoological Journal of the Linnean Society*, 188(1), pp.302-318.
- Wilting, A., Courtiol, A., Christiansen, P., Niedballa, J., Scharf, A.K., Orlando, L., ... Kitchener, A.C., 2015. Planning tiger recovery: Understanding intraspecific variation for effective conservation. *Science Advances*, 1(5), e1400175–e1400175.
- Wright, N. & Jimerson, J., 2020. Chapter 30 - The rescue, rehabilitation and release of pangolins. In *Biodiversity of World: Conservation from Genes to Landscapes. Pangolins: Science, Society and Conservation*. Challender, D.W.S., Nash, H.C., and Waterman, C. (ed), 495-504. Academic Press.
- Wu, S., Wang, Y., & Feng, Q., 2005. A new record of Mammalia in China - *Manis javanica*. *Acta Zootaxonomica Sinica*, 30(2), 440–443.
- Zhang, F., Yu, J., Wu, S., Li, S., Zou, C., Wang, Q., & Sun, R., 2017. Keeping and breeding the rescued Sunda pangolins (*Manis javanica*) in captivity. *Zoo biology*, 36(6), 387-396.

Abbreviations used in this report

ACCB	Angkor Centre for Conservation of Biodiversity
CPSG	IUCN SSC Conservation Planning Specialist Group
DNP	Department of National Park, Wildlife and Plant Conservation, Government of Thailand
DWNP	Department of Wildlife and National Parks Peninsular Malaysia, Government of Malaysia
FTB	Free the Bears
IUCN	International Union for the Conservation of Nature
MU	Mahidol University
PSG	IUCN SSC Pangolin Specialist Group
SEAZA	Southeast Asian Zoos and Aquariums Association
SG	Depending on the context of use could refer to Specialist Group or Singapore.
SSC	Species Survival Commission (a Commission under the IUCN)
SVW	Save Vietnam's Wildlife
TPZ	Taipei Zoo
TSA	Turtle Survival Alliance
WAZA	World Association of Zoos and Aquariums
WCS	Wildlife Conservation Society
WFFT	Wildlife Friends Foundation Thailand
WRS	Wildlife Reserves Singapore
ZIMS	Zoological Information Management System
ZPO	Zoological Park Organisation of Thailand
ZSL	Zoological Society of London



APPENDIX I

Workshop participants and invitees



No	Name	Organisation	Country
1	Ade Diah Safitri	Bali Zoo	Indonesia
2	Ade Kurniawan	Wildlife Reserves Singapore, IUCN SSC Pangolin Specialist Group	Singapore
3	Benjamin Lee	National Parks Board Singapore	Singapore
4	Boripat Siriaroonrat	National Science Museum Thailand	Thailand
5	Boyd Simpson	Copenhagen Zoo	Malaysia
6	Che Ku Zamzuri	Department of Wildlife and National Parks Peninsular Malaysia, Government of Malaysia	Malaysia
7	Daniel Wilcox	Save Vietnam's Wildlife, IUCN SSC Pangolin Specialist Group, IUCN SSC Conservation Planning Specialist Group	Vietnam
8	Edwin Wiek	Wildlife Friends Foundation Thailand	Thailand
9	Eileen Larney	Zoological Society of London	Thailand
10	Elisa Panjang	Danau Girang Field Centre, IUCN SSC Pangolin Specialist Group	Malaysia
11	Ellen Connelly	Tikki Hywood Foundation, IUCN SSC Pangolin Specialist Group	Zimbabwe
12	Flora Lo	Taipei Zoo	Taiwan, Province of China
13	Inge Tielen	Cikananga Wildlife Rescue	Indonesia
14	Jim Kao	Taipei Zoo (facilitator)	Taiwan, Province of China
15	Josephine Vanda Tirtayani	Gembira Loka Zoo	Indonesia
16	Kalyar Platt	Turtle Survival Alliance/Wildlife Conservation Society	Myanmar
17	Kathy Traylor-Holzer	IUCN SSC Conservation Planning Specialist Group (facilitator)	US
18	Keri Parker	IUCN SSC Pangolin Specialist Group, Save Pangolins	US
19	Luke Brannon	Free the Bears	Laos
20	Mariusz Lech	Batu Secret Zoo	Indonesia
21	Michael Meyerhoff	Angkor Centre for Conservation of Biodiversity	Cambodia
22	Min Naing Thein	Nay Pyi Taw Zoo	Myanmar
23	Natthaya Tuaparakone	Zoological Park Organisation of Thailand	Thailand
24	Nguyen Manh Hiep	Dept. of Protected Areas Management	Vietnam
25	Nicharee Income	Mahidol University	Thailand
26	Nick Sun	National Pingtung University	Taiwan, Province of China
27	Nicole Leroux	Wildlife Alliance	Cambodia
28	Pair Wasinee	Mahidol University	Thailand
29	Podjana Wattananit	Mahidol University	Thailand
30	Roopali Raghavan	Wildlife Reserves Singapore (facilitator)	Singapore
31	Rubiah Ismail	Bali Zoo	Indonesia
32	Shawn Chia	National Parks Board Singapore	Singapore
33	Shine Hsu Hsu Naing	Wildlife Conservation Society	Myanmar
34	Sonja Luz	Wildlife Reserves Singapore, IUCN SSC Pangolin Specialist Group	Singapore
35	Sony Surbakti	Taman Safari Indonesia	Indonesia
36	Thai Van Nguyen	Save Vietnam's Wildlife, IUCN SSC Pangolin Specialist Group	Vietnam
37	Warisara Thomas	Freelance	Thailand
38	Yingboon Chongsomchai	Zoological Society of London	Thailand



Ex situ conservation roles

DIRECT Conservation Roles for *ex situ* management of species

These are situations in which living individuals (or their biological materials, such as a Genome Resource Bank) held in an *ex situ* environment play a direct conservation role. *Ex situ* management may take place either within or outside the species' geographic range, but is in a controlled or modified environment for some period of time (short term or long term) for a clearly defined conservation purpose at the population, species, or ecosystem level (see *IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation* for more detailed explanation).

Simply keeping and/or breeding threatened Sunda pangolins in captivity does not in itself equate to conservation. As part of a genuine Sunda pangolin conservation initiative, potential *ex situ* management strategies proposed should address the causes or consequences of one or more specific threats or constraints to the species' viability and conservation, as identified in a status review and threat analysis, and target improvement of its conservation status. This does not preclude these *ex situ* populations for conservation from having additional roles that are not necessarily, or only indirectly, related to conservation. Whenever an *ex situ* conservation role involves a conservation translocation, the *IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations* also apply.

In essence, *ex situ* management can support species conservation and prevent extinction by:

- 1) addressing primary threats and/or their causes;
- 2) counteracting the impacts of primary or stochastic threats on the population (such as reduced survival, poor reproduction and genetic isolation);
- 3) using *ex situ* populations for population restoration or conservation introduction; and/or
- 4) preventing extinction by gaining time in situations where threats are not under control or mitigation is not successful (enough).

INDIRECT Conservation Roles for the *ex situ* community

These are situations in which the *ex situ* community can contribute to conservation by:

- making available its expertise, knowledge, materials, staff, fund raising, etc. to help implement *in situ* conservation actions; and/or
- conducting general awareness and conservation education activities aimed at visitors.

Indirect conservation contributions can be made for a species regardless of whether or not it is held in captivity. Examples of indirect conservation roles include:

- Providing knowledge, experience or training to build capacity for veterinary care or handling of individuals in the field (e.g. radio collar application, transport) or in the context of law enforcement (e.g. rescue centres, human wildlife conflicts);
- Making available existing zoo education materials or education/behavior change expertise to teams developing awareness programmes for local communities *in situ*;
- Conduct education and awareness about the status of and threats to the species and increase interest in the species and its habitat/ecosystem;
- Networking and lobbying to influence opinions, legislation processes, etc.; and/or
- Small scale fundraising to contribute to high priority *in situ* projects or IUCN SSC Specialist Group activities



Common *ex situ* direct conservation roles

Based on a combination of the role descriptions in the IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation, IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations, and Appendix I of the Amphibian Ark Conservation Needs Assessment Process

Ark

Maintain a long-term *ex situ* population after extinction of all known wild populations and as a preparation for reintroduction or assisted colonisation if and when feasible.

Insurance population

Maintain a long-term viable *ex situ* population of the species to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies. These are typically species that are threatened and/or declining and for which it is unsure whether *in situ* threat mitigation will have the sufficient effect in a sufficient timeframe to prevent the extinction of the species or to prevent a dramatic decline in the numbers, populations and/or genetic diversity of the species. An *ex situ* population may be desired as an insurance population from which individuals can be taken for genetic and/or demographic supplementation or other conservation translocations as required, but these are not yet actively planned the foreseeable future.

Rescue population (temporary or long-term)

Establish an *ex situ* population for a species that is in imminent danger of extinction (locally or globally) and requires *ex situ* management, as part of an integrated programme, to ensure its survival. The species may be in imminent danger because the threats cannot/will not be reversed in time to prevent likely species extinction, or the threats have no current remedy. The rescue may need to be long-term or temporary (for example, to protect from catastrophes or predicted imminent threats that are limited in time, e.g. extreme weather, disease, oil spill).

Demographic manipulation

Improve a demographic rate (survival or reproduction) or status (e.g. skewed sex ratio) in the wild, often of a particular age, sex, or life stage. An example is a head-start programme that removes individuals from the wild to reduce high mortality during a specific life stage and then subsequently returns them to the wild.

Population restoration: Reintroduction

Serve as a source of individuals for population restoration to re-establish the species to part of its former range from which it has been extirpated.

Population restoration: Reinforcement

Serve as a source of individuals for population restoration to supplement an existing population (e.g. for demographic, behavioral or genetic purposes).

Conservation introduction: Ecological replacement

Introduce the species outside of its indigenous range to re-establish a lost ecological function and/or modify habitats. This may involve species that are not themselves threatened but that contribute to the conservation of other taxa through their ecological role.

Conservation introduction: Assisted colonisation

Introduce the species outside of its indigenous range to avoid extinction of populations of the species.

Ex situ research and/or training

Use an *ex situ* population for research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g. develop monitoring methods; address data gaps in disease transmission or treatment). The research or training must address specific questions essential for success of the overall conservation strategy for the species. This can include non-threatened species serving as a model for threatened species, or establishing *ex situ* populations of a threatened species to gain important species-specific husbandry and breeding expertise that is likely to be needed in the future to conserve the species.

Conservation education

Forms the basis for an education and awareness programme that addresses specific threats or constraints to the conservation of the species or its habitat. Education should address specific human behavioural changes that are essential for the success, and an integral part of, the overall conservation strategy for the species. This primarily involves *ex situ* locations visited by the intended human audience.

Sunda pangolin marking method and protocols

Sun, N.C.M., Simpson, B., Larney, E., Panjang, E., Willcox, D., Surbakti, S., Tielen, I., & Leroux, N.

1. Introduction

Sunda pangolins (*Manis javanica*) are principally threatened by overexploitation for the illegal wildlife trade. Many live pangolins are rescued and undergo reverent treatments for rehabilitation. However, most of the released pangolins are not properly tagged or marked for post-release monitoring, which impedes the evaluation of rehabilitation success. In addition, there is also an absence of a robust method for assessing the potential of released individuals being recaptured by poachers and re-entering the black-market overtime.

Here, we propose the marking methods and protocols for monitoring post-released individuals and seizures of Sunda pangolin. For the identification of released individuals, we will test the durability and reliability of tagging for camera trapping identification purposes. For tracking of animals seized from illegal wildlife trade, we will develop a protocol that proposes to make use of permanent scale marking which represents country codes and regional codes for tracking the potential trade to other areas.

2. Materials and method

2.1 Marking protocols

The marking method and protocols for Sunda pangolin follow the designs proposed by Sun et al. (2019) on the Chinese pangolin *M. pentadactyla*. Marking methods will be tested for detectability, durability and reliability. The locations of marking are proposed for the larger scale near underarm or scales near the base of the tail. Based on the rehabilitation monitoring purposes and detectability by camera traps, different methods



Figure 1. Materials for pangolin marking. Pan head screw A), Sling strap B) and radio transmitter C).

Citation:

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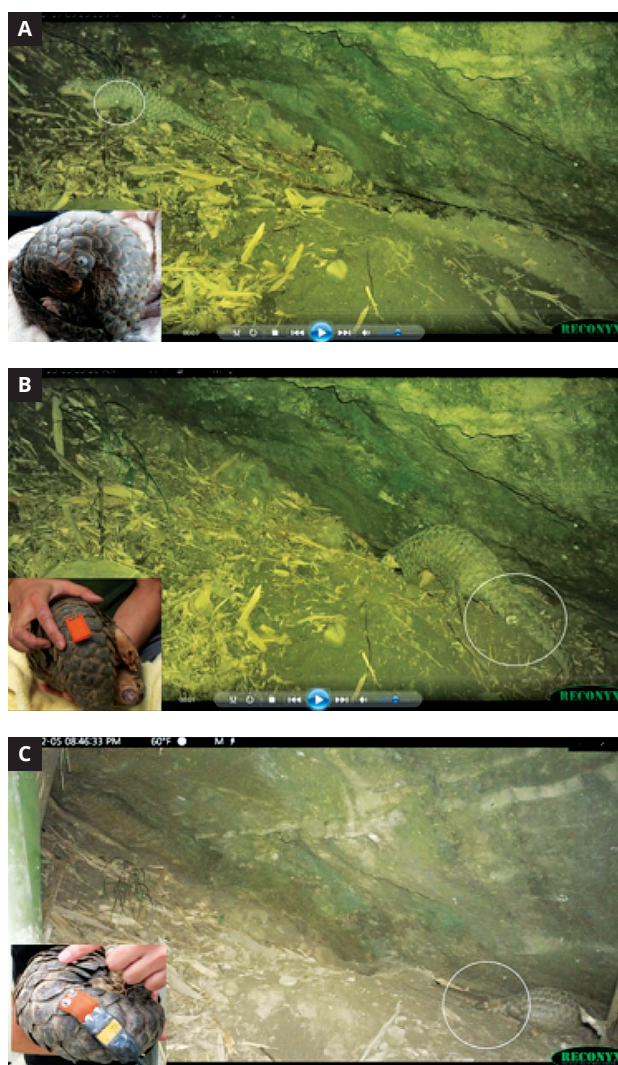


Figure 2. Demonstration of marking methods and individual identification from camera trapping using Chinese pangolin as the examples. Photo: Nick Sun

for the attachment are suggested for the marking scheme. Methods are (a) pan head screw (b) pan head screw plus sling strap, and (c) standard transmitter attachment (Fig. 1).

Using only a screw for the marking may allow a quick procedure but may also result in less detectability by camera trapping after release. Using a screw plus sling strap may have greater detectability by camera

trapping. A standard transmitter attachment can be used for collecting information on the spatial ecology, habitat preferences, activity patterns and mortality, however the disadvantages of radio tagging includes higher costs and the model and shape of tag need to be well-designed (see the demonstration of Chinese pangolin in Fig. 2).



Figure 3. Examples of country code or region code using the different locations of scale marker on the Sunda pangolin.

2.3 Country/regional code, year code and month code

For those countries/organisations may not want to (or be able to) put screws or sling straps or transmitters on - but may still want to mark the pangolins with permanent marks using just the holes. We propose marking a country code/region code, year scale code and month scale code by drilling and array of holes on the scales of Sunda pangolin. Different parts of the pangolin would need to be allocated for different marks, e. g. months (left flank), years (right flank) and Country (tail).

This would mean that any pangolin recaptured would tell us Country of release and also month/year. This might be useful to allow us to know how long it has been in the wild since recapture. This could also be useful if a country is releasing many pangolins over many years. The suggested locations of scales for coding are illustrated in Fig. 3. and Fig 4.

To better understand whether different diameter/size holes wear or break over time, we will also test a few different hole sizes (e.g. 2mm, 4mm, and 5mm) on pangolins to determine if they will remain as permanent marks.

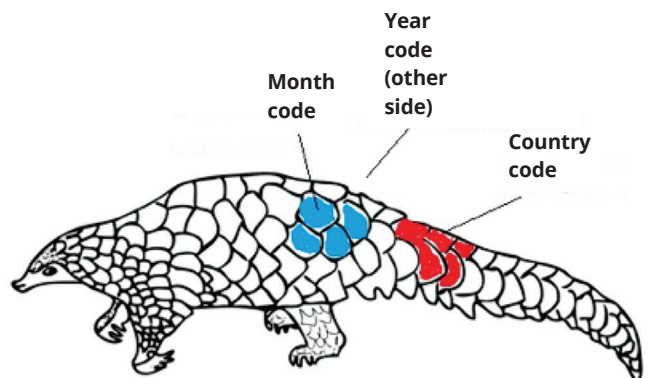


Figure 4. Examples of country code (tail), year scale code (right flank) and month code (left flank) using the different locations of scale marker on the Sunda pangolin.





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